FLORIDA INTERNATIONAL UNIVERSITY

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

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SENIOR DESIGN II FINAL REPORT

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WIRELESS 3D-SCANNING DEVICE FOR STL CREATION

TEAM NUMBER VII

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ACKNOWLEDGMENT

We want to express our deepest thanks to our project sponsor, Dr. Cheng-Yu Lai, for his generous financial support of $800, which will be instrumental in making our project possible. His contribution will enable us to acquire the required materials and components to develop our Wireless 3D-scanning Device for STL Creation.

We also sincerely thank our project mentors, Dr. Barreto, and Dr. Cheng-Yu Lai, for their guidance and insights. Their expertise will be invaluable in overcoming challenges and ensuring the success of this endeavor.

Additionally, we would like to thank the support provided by Florida International University's Engineering Center, which has served as the collaborative space for our team to work on the physical implementation of the project and its design. The resources and facilities available at the center, coupled with the mentorship provided, have greatly facilitated our progress.

ABSTRACT

Our project aims to ease the STL file creation process for designers and engineers by designing and fabricating a wireless 3D scanning device for STL creation. The device has several constraints, such as size and weight; it must be capable of being portable. Some assumptions were placed on where an efficient system could be fabricated without designing new components. There are limitations, such as technical challenges like needing to be more proficient in machine learning to implement it in our product. This project is about designing our product to be easy to operate, compact, and portable. We found our device to be highly marketable. We expected the operating environment to be controlled. Our device is intended for a market of engineers, designers, and hobbyists. Its intended uses are scanning objects for STL creation while using machine learning to remove any errors in the file creation. We found our product to be ethically sound and culturally acceptable. The device uses a Raspberry PI as its processing unit and an Intel RealSense D415 depth camera to scan. Numerous patents were considered that proposed similar ideas to ours, and we found that our concept differed sufficiently to present any threats to the patented inventions. Our product would succeed in the global marketplace as it is innovative, versatile, and applicable in bridging sectors within the industry.

I. EXECUTIVE SUMMARY

Wireless 3D-Scanning Device for STL Creation	
Team Number: 7	Team Name: Synapse3D
Mentor: Dr. Armando Barreto	Team Leader: Michael Keyack
Team Member: Karla Colmenares	Team Member: Carlos Touza
Team Member: Daniel Madiedo	Team Member: Eric Valdes

A. *Summarized Problem Statement*

In 3D printing and CAD modeling, accurately converting real-world objects into digital STL files is crucial yet challenging. Traditional methods involve manual measurements prone to errors, inefficiency, and time consumption. These shortcomings hinder professionals, including engineers, designers, and hobbyists, from achieving precision and efficiency in their workflows. Addressing this gap, our team proposes the Wireless 3D Scanning Device, a compact, portable, and user-friendly solution that generates accurate STL files using cutting-edge scanning technology.

B. *Objectives and Constraints*

1) *Objectives*

1. Ease of Use: Design a lightweight and handheld device.
2. Accuracy**:** Employ machine learning to ensure precise object differentiation.
3. Wireless Communication: Enable seamless data transfer to paired computers.
4. Sustainability: Minimize environmental impact through durable, recyclable components.

2) *Constraints*

1. The device must be cost-effective without compromising quality.

- The system must be able to transfer data effectively with seamless integration.

2. Compliance with global health, safety, and environmental standards is essential.

C. *Project Description*

Our Wireless 3D-scanning Device leverages state-of-the-art technologies to deliver exceptional performance. The Intel RealSense D415 depth camera ensures accurate data capture, while the Raspberry Pi bridges the scan data with the cloud platform. Users interact with the device through an intuitive LCD interface, receiving live feedback during scanning.

The system communicates wirelessly with a paired computer to process and store data, ensuring portability and user convenience. Its design accommodates engineers' desks and handheld use, providing flexibility across various applications. Additionally, the device integrates sustainable components, adhering to RoHS guidelines to reduce hazardous material usage and promote recyclability.

D. *Sections*

1) *Background*

Explores existing technologies and benchmarks, including a detailed comparison with competitive products like the Revopoint POP, Einscan-S, and Artec Eva. This analysis informs the design and innovation strategies for our project.

2) *Ethical Considerations*

It focuses on adherence to the IEEE Code of Ethics, addressing issues like user safety, data security, and sustainable design practices. These considerations ensure ethical integrity and global acceptance of the product.

3) *End Product Description*

Detailed functional and visual device representations using Level 0 and Level 1 diagrams, block diagrams, and flowcharts. This section outlines the product's capabilities, including scanning, processing, and communication.

4) Budget

Presents a comprehensive financial breakdown, covering material costs, labor, and other expenses while ensuring alignment with the $800 sponsorship budget.

5) Health and Safety

Emphasizes user and developer safety, incorporating ergonomic design, safe operating distances for IR components, and measures to prevent e-waste.

6) Conclusions

The Wireless 3D-Scanning Device for STL Creation redefines efficiency and precision in 3D printing and CAD modeling. It offers a portable, sustainable, and user-friendly solution to the limitations of manual measurements. Our device ensures reliability, accuracy, and environmental responsibility by integrating advanced technologies and adhering to ethical and safety standards. This project holds significant potential to enhance workflows for engineers, designers, and hobbyists, driving innovation in the digital modeling and 3D printing industries.

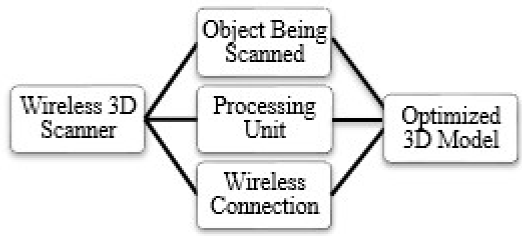


Fig. 1. Simplified module of the 3D wireless scanner

II. PROBLEM STATEMENT

In 3D printing, measuring the dimensions of a real-world object needed for a CAD model requires meticulous concentration and is susceptible to human error. It is expected to make mistakes in hand measurements, and the consequences of these errors can be amplified if the measurements are not adjusted to account for printing tolerances. It is critical to have a device that can obtain object measurements accurately and in a handheld manner and is capable of wireless communication with a computer that will be capable of analyzing the results and creating its file when the process is finished.

A. ***Project Objectives***

1) Ease of Use

The device should be small enough to fit on someone's desk comfortably and lightweight enough to be operated by a single person when scanning an object. A single person is expected to carry and scan an object using this device to obtain accurate information.

2) User-Friendly Design

The device should be able to scan and give the user the scan results in real-time. The scan results would be turned into a file ready to use.

3) Accuracy

The device should be capable of differentiating the object being scanned from the foreground, such as the floor or table on which the object is lying. This ensures the accuracy of the measurements being obtained.

B. ***Constraints***

1) Battery Power or Latency

Depending on how the measurements are calculated, there is an inverse relationship between the battery power and latency. If the device wirelessly communicates its data to a computer that will do the calculations with its hardware, processing would be latent that data. If the device oversees analyzing the data as it scans, it will decrease the latency but require better hardware to handle the computations and suffer worse battery life.

2) Weight and size

When designed, the device must be lightweight and small enough for a human of average strength to lift and scan an object. If it weighs too much or is too cumbersome to lift, then it is nearly impossible to use effectively in its task.

III. Assumptions and Limitations

Before diving into our project, we must consider the assumptions and limitations to overcome the obstacles in designing a Wireless 3D Scanning Device for CAD Model Design. We maintain several assumptions, and there are limitations and constraints that, if not correctly addressed, will not prevent the completion of our project.

A. ***Assumptions***

- Operating Environment: We assume that the operating environment will be able to maintain the accuracy of its scan independent of the user's hand movement. Slight hand vibrations would not significantly hamper the device's performance. The device will also operate at average operating temperatures of around 20 degrees Celsius, with more or less of that value being acceptable. It would not be subject to extremely low temperatures that would negatively impact the battery life and time it can operate.
- System Efficiency: The device would be efficient enough to scan an object within a reasonable distance and time. The object being scanned is within the range of its Scanner, the scanning is done fast, and the results are obtained in real time.
- Materials and Components: Some of the components to make the Scanner are available to purchase and do not require the novel invention of new components. The optical sensors, cameras, and hardware can be purchased.

B. ***Limitations***

- Materials: The cost of materials can make some aspects of the project prohibitively expensive, depending on the model of the purchased component. Purchasing cheaper components can also negatively impact the final performance of the project device.
- Technical Challenge: The objective of having the Scanner be capable of differentiating between the object it is scanning, and the rest of the background requires knowledge of machine learning. The team must become proficient enough in machine learning to implement it in the design.

Time: The project schedule must be structured in a manner that allows for enough time to acquire materials, gather and apply machine learning knowledge, and be able to test prototypes before the final product is produced

IV. NEEDS FEASIBILITY ANALYSIS

In this section, we conduct a Need Feasibility Analysis to assess our project idea's practicality and potential impact, ultimately determining if it is a viable pursuit. This analysis begins by defining the client's needs, clarifying immediate and long-term objectives, and establishing core requirements and constraints. By thoroughly understanding these elements, we can ensure that the design aligns with stakeholder expectations and industry standards. Additionally, this analysis allows us to gauge the potential marketability of our product by identifying user demands, potential adoption barriers, and competitive differentiators. The outcomes of the Need Feasibility Analysis will guide decision-making throughout the development process, helping us prioritize features that enhance usability, functionality, and commercial appeal. This structured approach provides a clear pathway to ensure the final design is technically feasible and aligned with market demand, making it a worthwhile project.

A. *Needs Analysis*

In Need Analysis, we establish the client's and user's needs. These include the expected attributes, cultural acceptance, and performance requirements. The Client's Needs Statement is further elaborated through the Client Interview and User Survey by establishing specifications based on their needs. The team participates in Brainstorming Sessions that introduce new needs not offered by the client or the users.

1) Client Interview

The client interview is conducted to extrapolate the root of the problem, why the customer will be using the product, and how the customer will be using the product. We shall be using object attributes to define the project. These object attributes are constraints, objectives, functions, and implementations. The table below summarizes the responses and labels the category under which they fall.

TABLE I. CLIENT INTERVIEW RESPONSES

Source	Attribute	Category
Client	Scanning measurements should be accurate by calibrating to its environment to tune measurements.	**Objective**
Client	It must be user-friendly, as the target audience wants the measuring process simplified.	**Objective**
Client	Utilize a microcontroller capable of handling computations for measurements and file conversion.	**Implementation**
Client	The device must be in desktop form.	**Constraint**
Client	It would be optimal if the device is handheld.	**Objective**
Client	The data must be processed in real-time.	**Constraint**
Client	The Scanner must be sufficiently accurate without costing more than the rest of the system.	**Constraint**

2) *User Survey*

The goal of the User Survey is to determine the needs of the users effectively. The insight these potential users provide can help us determine how to make our product more alluring and what should be added or removed to serve their needs better.

TABLE II. SURVEY RESPONSES

Source	Attribute	Category
User	The device should include machine learning to help differentiate between what is being scanned and everything else.	**Objective**
User	An LCD Display should be implemented to add user controls to device operations.	**Objective**
User	The device should be able to wirelessly communicate data to a PC that will analyze and do calculations with its hardware.	**Objective**
User	The device should be able to rest on an engineer's desk and not take up too much space.	**Objective**

3) *Team Brainstorming*

During the Team Brainstorming step, the team presented ideas that needed to be given by the client in the Client Interview or the users in the User Survey section.

TABLE III. BRAINSTORMING IDEAS

Source	Attribute	Category
Team	To implement a desktop device for the project, it would have a rotating bed with sensors behind the object to get a 360-degree scan of the object. Therefore, stepper motors/drivers and LIDAR/IR sensors are necessary.	**Implementation**
Team	An SD card reader can be added in case wireless communications fail.	**Implementation**
Team	A microcontroller for processing all the information is needed; specifically, one with many peripherals, Wi-Fi/Bluetooth capabilities, and a strong processing unit.	**Implementation**

4) *Problem Statement*

This project is about designing a Wireless 3D Scanning Device for CAD Model Design that is easy to operate, compact, man-portable, and operable. The device should be able to wirelessly communicate data collected to a computer that will analyze and do the calculations. The scanning measurements should be accurate by calibrating to its environment to tune measurements. An LCD Display should be implemented to add user controls to device operations. The device should include machine learning to help differentiate between what is being scanned and everything else. It should be capable of handling computations for measurements and file conversion. The device should be able to rest on an engineer's desk and not take up too much space.

5) *Objectives*

   1. *Technological Requisites*

      1.1. The device should be able to wirelessly communicate data to a PC that will analyze and do calculations with its hardware.

      1.2. Scanning measurements should be accurate by calibrating to its environment to tune measurements.

      1.3. An LCD Display should be implemented to add user controls to device operations.

      1.4. The device should include machine learning to help differentiate between what is being scanned and everything else.

      1.5. Utilize a microcontroller capable of handling computations for measurements and file conversion.

   2. *User Needs*

      2.1. The device should be able to rest on an engineer's desk and not take up too much space.

6) *Constraints*

   1. The device must be in desktop form.
   2. The data must be processed in real-time.
   3. The Scanner must be sufficiently accurate without costing more than the rest of the system.

Our comprehensive Needs Analysis has provided a clear roadmap for developing the Wireless 3D Scanning Device. By integrating insights from client interviews, user surveys, and internal brainstorming, we have defined key functional and performance requirements such as ease of use, compact design, real-time data processing, and effective integration of machine learning. These efforts have shaped a precise Problem Statement and a set of well-aligned objectives that address user priorities, technical demands, and design constraints.

This structured approach ensures a user-centered design that balances innovation with practicality, setting a solid foundation for a solution that meets stakeholders' expectations while pushing the boundaries of performance and usability.

B. ***Need Specifications***

Requirements specifications explain the criteria a product or service needs to meet to function appropriately and effectively satisfy users' needs and expectations. They cover both nonfunctional elements, like performance measures and user requirements, which help in the development or enhancement process. Requirements specifications act as a roadmap for designers, supervisors, and other stakeholders to ensure everyone working on the project is aligned with their goals and objectives for the outcome.

The significance of requirements lies in their capacity to reduce confusion and mistakes throughout the development process. Outlining a set of expectations upfront can prevent alterations and setbacks as well as align outcomes effectively. Delineated requirements guarantee that the product satisfies the client's demands and regulatory standards or industry norms, enhancing contentment and adherence. This organized methodology enhances effectiveness, decreases risks, and elevates the chances of project triumph. The following table presents the requirements for achieving the goals and their reasoning.

TABLE IV. SPECIFICATIONS

Objectives	**Specifications**	**Justification**
1.1	The device would need the following components: • Micro Controller • Wireless Communication Module • A Power source greater than or equal to 5V • Software • Antenna	These components allow the deceiver to process and transfer the data to a computer. The power source also has to reach a specific requirement to enable the user to transfer data and also allow longevity for the user.
1.2	The device must be equipped with machine learning and LIDAR/IR sensors.	The LIDAR/IR sensors allow for a more accurate scan of the object, and machine learning will allow for depth perception and knowing where the object begins and ends.
1.3	LSD display is present in the device.	This will allow for a more user-friendly device and give users valuable data such as battery life or whether the device is connected.
2.1	Dimensions should be no bigger than 12x12x5.	This will allow the device to be handheld and fit on an engineer's desk.

To summarize the argument, specific components and features are necessary to ensure that the new device works well for communication and is easy to use while handling data. For instance, 1) A microcontroller, 2) a Module for communication, 3) an Antenna, and 4) a power supply. These elements play a role in transmitting data and ensuring the device's durability. Furthermore, incorporating machine learning algorithms and LIDAR and IR sensors boosts the device's capability to scan objects precisely and enhances depth perception. Having an LSD screen would improve the user experience by showing updates on the device status, like battery levels and connectivity strength in time. The small design that fits within dimensions of 12 inches by 12 inches by 5 inches guarantees portability and convenient placement on a desk for use in engineering settings. These features make sure that the device meets its goals of being practical and easy to use.

C. *Feasibility Analysis*

Assessing the feasibility of a project is essential for its success as it helps stakeholders evaluate if the project is doable and practical. By examining critical factors like technical capabilities and constraints, availability of resources, financial sustainability, adherence to legal requirements, cultural implications, timely execution prospects, and market reception potential, the team gains valuable insights into the project challenges and possibilities. Each element of this assessment is crucial in understanding the strengths and weaknesses of the project to make informed decisions moving forward. The systematic evaluation employing weighted measures and calculations gives a basis for systematically organizing and ranking these elements. This report also includes feedback from user surveys to assess the viability of marketing strategies while ensuring they resonate with expectations and market needs effectively. Taking this approach showcases strengths and pinpoints potential risks that allow the team to strategize efficiently and increase the chances of project success.

1) Technical Feasibility

Ensuring feasibility involves verifying that the project has the needed technology that is both accessible and fitting for its intended use. It checks if the essential tools and systems are already in place, can be easily obtained, or must be developed. This examination also looks at how user-friendly the technology is and how smoothly it can be integrated into the project to ensure the product is user-friendly and easy to understand for users. In this scenario, you will find all the tools required to make the product easily accessible for purchase online. Moreover, the team has concluded that no groundbreaking innovations are essential, thus simplifying the project considerably. However, ensuring user-friendly operation demands deliberate design and testing to enhance efficiency and usability. The impressive rating of 4.75 indicates the project's preparedness, with few obstacles hindering its execution.

TABLE V. TECHNICAL FEASIBILITY

Technical Feasibility			
Attribute	***Score***	***Why?***	***Solution***
Does the technology exist?	5	The technologies needed to create our product currently exist.	Our group will research the necessary items to make our product functional.
Is the technology readily available?	5	The technology can easily be purchased online.	Converse with our sponsor to gather information on the items best suited for our device and buy them online.
Are new inventions required?	4	No new inventions are needed.	No solution is necessary.

The intuitiveness of the device?	5	The devices must be easy to operate and understand.	Create a device that can easily be operated and understood.
Total	19		
Average	4.75		

2) *Resource Feasibility*

Assessing resource feasibility involves checking if the project has skilled team members and resources like tools and equipment to carry it out successfully. The team for this project comprises five individuals with varying skill sets, which lays a foundation; however, some members feel they need to enhance their knowledge in machine learning and microcontroller programming. Targeted research and skill enhancement are required to fill these knowledge gaps and ensure success. Moreover, though the team has most of the equipment at their disposal, verifying the availability of any specialized tools may be wise. The rating of 4 out of 5 underscores a foundation in resources yet suggests that additional training and equipment procurement would be beneficial in further enhancing risk mitigation.

TABLE VI. RESOURCES FEASIBILITY ASSESSMENT

Resource Feasibility			
Attribute	***Score***	***Why?***	***Solution***
Do we have sufficient people?	5	Our team consists of five people.	No solution is needed.
Do we have sufficient skills?	4	Possible issues in our ability to properly connect the components and program the microcontroller.	Research further into the necessary topics, such as machine learning and task requirements.
How much resource risk is there?	3	Possible risk in programming the micro-controller and software to run the machine learning properly.	Research deeply into machine learning and different ways of programming and implanting different hardware and software to minimize faults in the system.
Total	12		
Average	4		

3) *Economic Feasibility*

Determining the viability of a project involves ensuring that it can be finished within the planned budget and accounting for any financial risks that may arise along the way. Furthermore, such an evaluation helps pinpoint ways to minimize expenses. In this scenario, the project's overall cost falls comfortably within the budget boundaries, indicating solid financial planning. Nevertheless, a risk associated with potential hardware damage could lead to additional expenses. Educating team members about the hardware limitations and enforcing handling protocols is vital to address this concern. Despite this setback/issue/challenge, the economic viability rating of 4/4 stars reflects assurance that the project is financially sound and can be completed within budget limits. This positive evaluation enhances the project's trustworthiness. Meets the sponsor's anticipations/ hopes/requirements.

TABLE VII. ECONOMIC FEASIBILITY ASSESSMENTS

Economic Feasibility			
Attribute	***Score***	***Why?***	***Solution***
Is the project feasible with the given budget?	5	The total estimated cost of the project is slightly under the budget.	No solution is needed.
How much economic risk is there?	4	There is a possibility of damage to one of the components or hardware.	Familiarize yourself with the components and limitations of each to avoid causing errors. Also, check extensively for minor mistakes which can cause unnecessary damage.
Total	9		
Average	4.5		

4) Schedule Feasibility

Assessing the scheduling feasibility involves determining if the project can be finished within the planned timeframe by considering obstacles like unexpected setbacks and the team's capacity to meet crucial deadlines. In the case of this project, "there are difficulties expected during the preliminary design review because of the intricate programming and integration of machine learning elements." Nonetheless," the team is confident about meeting the design review as they foresee only minor tweaks needed at that phase. "To deal with scheduling issues effectively, the team intends to have frequent meetings and set aside extra time to handle unforeseen setbacks. Their emphasis on proactive planning and task organization is underscored by a score of 3 stats," emphasizing the necessity for ensuring projects are completed on time.

TABLE VIII. SCHEDULE FEASIBILITY

Scheduling Feasibility			
Attribute	***Score***	***Why?***	***Solution***
Can we meet for a preliminary design review?	3	There are possible issues when programming the machine learning aspect to the microcontroller. Many different problems may also arise when developing our product.	Gathering information from mentors and research papers to understand better how machine learning works and can be applied to our product.

Can we meet the critical design review?	4	Only minor adjustments should be made to fine-tune the device.	Ensure significant aspects of the project are complete by the time the preliminary review comes along.
Are we accomplishing scheduled tasks?	4	The team has the behavior needs and skills to reach the scheduled milestone.	Be ahead of the schedule and leave little room for procrastination.
Total	11		
Average	3.7		

5) *Cultural Feasibility*

The evaluation of viability helps us assess if the product is socially accepted or not, which, in turn, significantly affects its adoption by consumers. TABLE IX's assessment is crucial as it enables the team to address the reception and global influence of the product effectively. The average score achieved for schedule feasibility stands at 4.3.

TABLE IX. CULTURAL FEASIBILITY

Cultural Feasibility			
Attribute	***Score***	***Why?***	***Solution***
Positive global Impact?	4	The project should globally benefit due to market study and interviews.	Although 3D printing is a niece market, it can be found worldwide.
Positive local Impact?	4	A positive impact is expected locally as it fits into the market demand.	Good marketing is needed to keep potential consumers in the loop and want to acquire our product.
Labor restrictions?	5	There is no labor restriction.	No solution is needed.
Total	13		
Average	4.3		

6) *Legal Feasibility*

Assessing the feasibility involves checking if the project aligns with current laws, regulations, and industry norms to ensure no legal obstacles in its development or implementation phase. In this case study, specifically focusing on standards and other relevant regulations is crucial, given the technical complexity of the product being developed. Although no legal barriers have been identified so far by the team involved in the project, they understand the significance of carrying out comprehensive patent searches to steer clear of any intellectual property conflicts that may arise. Moreover, the project must adhere to safety and policy requirements set forth by the sponsoring organization to obtain approvals for its deployment. The legal feasibility assessment aligns with regulatory and organizational expectations, scoring 4.

TABLE X. LEGAL FEASIBILITY

Legal Feasibility			
Attribute	***Score***	***Why?***	***Solution***
Are laws and regulations impeding the project?	4	Must comply with IEEE standards and other rules.	Make sure to comply with IEEE and regulation standards.
Organizational/ policy conflicts?	5	Our device has no organizational or policy disputes.	No solutions are needed.
Total	9		
Average	4.5		

7) Marketing Feasibility

Assessing marketing feasibility involves evaluating the market for a product by looking at factors like public approval and competition, as well as pricing strategies. Research findings show that the product is expected to be well received because of its perceived advantages. However, the market is intense with competition, and pricing might be complex due to expensive components. To overcome these hurdles, the team intends to conduct market studies to pinpoint distinctive selling features and reduce production expenses. The project shows promise with a rating of 4 out of 5 points, indicating market potential; however, a focused approach is needed to stand out in the market and draw in customers effectively.

TABLE XI. MARKETING FEASIBILITY ASSESSMENTS

Marketing Feasibility			
Attribute	***Score***	***Why?***	***Solution***
Competitiveness	3	The product should be competitive in an already vast and defined market.	Research similar products to gain a competitive edge in an already competitive market.
Cost acceptance	3	The high cost of the components may cause a high price.	Use only necessary parts and gather research on similar components to help cut as many costs as possible to lower the price.
Public acceptance	4	Acceptance from the public is needed for the success of our product.	Use marketing research and surveys to understand better what the public is looking for in this type of market.
Total	12		

Average	4

8) Ranking of the Feasibility Analysis

The team collectively agreed on the importance values assigned to each attribute, as shown in TABLE XII. These values represent the team's perspective on the relative significance of each attribute compared to others. The table also includes each attribute's computed geometric mean and normalized weight. The weights have been adjusted to ensure their total equals one.

When comparing attributes, a value of one is assigned when an attribute is compared to itself, as it holds equal importance in such cases. For comparisons between different attributes, the team determines the more significant attribute and assigns a value according to the following scale:

1 = Equal importance
3 = Moderately more important
5 = Strongly more important
7 = Extremely more important

The geometric mean for each attribute is calculated using the formula:

$$G.Mean = \sqrt[n]{(A_1 \cdot A_2 \cdot A_3 \cdot \ldots \cdot A_n)}$$

A represents the assigned importance value, and n is the total number of attributes.

The normalized weight for each attribute is determined using the formula:

$$Weight = \frac{G.Mean}{Total}$$

This approach ensures a systematic and quantitative assessment of the relative importance of the attributes.

TABLE XII. OBTAINING WEIGHT

Weights	Technical	Resource	Economic	Schedule	Cultural	Legal	Marketing	G. Mean	Weight
Technical	1	5	3	3	5	3	3	2.97	0.34
Resource	1/5	1	1	3	3	3	3	1.49	0.17
Economic	1/3	1	1	3	3	5	3	1.72	0.19
Schedule	1/3	1/3	1/3	1	5	5	3	1.16	0.13
Cultural	1/5	1/3	1/3	1/5	1	3	3	0.63	0.07
Legal	1/3	1/3	1/5	1/3	1/3	1	3	0.50	0.06
Marketing	1/3	1/3	1/3	1/3	1/3	1/3	1	0.39	0.05
							Total	8.86	

In TABLE XII, the team compared the importance of each feasibility type. The evaluation process utilized the same formulas to calculate the weight of each type, ultimately identifying that technical attributes are the most critical compared to the others.

1) Project Feasibility Assessment

TABLE XIII outlines the weight values assigned to each attribute and their corresponding scores. These parameters are combined to calculate the weighted score for each attribute using the formula:

$$Weighted\ Score = Weight \cdot Score$$

The overall weighted average is determined by summing all the weighted scores and dividing by the total sum of the weights. This calculation can be expressed as:

$$Weighted\ Average = \frac{\sum Weighted\ Score}{\sum Weight}$$

This method provides a systematic approach to assess the project's overall feasibility, emphasizing attributes with higher weights.

TABLE XIII. WEIGHTED SCALE

Weighted Score	**Weight**	**Score**	**W. Score**
Technical	0.34	4.75	1.6
Resource	0.17	4	.68
Economic	0.19	4.5	.85
Schedule	0.13	3.7	.48
Cultural	0.07	4.3	.30
Legal	0.06	4.5	.27
Marketing	0.05	4	.2
Total	1.01	29.75	4.38
Weighted Average			**4.34**

In TABLE XIII, we assigned weights to the attributes based on their respective contributions to the overall outcome, each with varying proportions. By summing these weighted scores, we calculated an overall score of 3.62 out of 5.0, indicating that the project is feasible.

This weighted average score of 3.62 suggests a substantial likelihood of project success. However, despite this positive outlook, potential challenges remain. Issues related to scheduling and economic feasibility have been identified as possible obstacles. Additionally, while we are confident in our team's capabilities and the availability of the required technologies, there are still critical steps to take to ensure that the project meets its objectives and is completed within the expected timeline. Proactive measures will be necessary to address these risks and ensure successful project delivery.

C. Marketability

The concept of marketability pertains to the success of a product or service in the market realm by gauging its appeal to the intended audience and considering factors such as demand for products and attributes like pricing and design that contribute to functionality. The viability of a product in the market hinges on its ability to meet consumer needs effectively while offering an edge. In business proposals, focusing on marketability necessitates presenting arguments on why a venture will prosper backed by insights from initiatives, current consumer preferences, and anticipated financial gains.

To enhance the marketability segment of the proposal content plan, we will explore Kickstarter.com to research pertinent projects centered on 3D scanning and printing technology. By examining campaigns on the platform, we can delve into the appeal by scrutinizing who supported those projects and for what reasons they did. Furthermore, Kickstarter offers insight into fundraising strategies, such as reward levels and promotional methods, which entice backers. Understanding the tactics employed by projects will help us craft a more efficient marketing and fundraising strategy for our proposal, thereby increasing its chances of success.

1) Revopoint POP High Precision 3D Scanner.

a. Project Summary

The Revopoint POP High Precision 3-D Scanner is a tool tailored for 3-D printing and various tasks that demand detailed design work specifically crafted by Revopoint 3 D Technologies Inc., introduced in March 2021. This initiative provides a scale and convenient Scanner with accuracy, including sophisticated depth sensing features. The Scanner offers flexibility, with applications spanning personal artistic endeavors and quick prototype development to industrial planning and medical purposes. Revopoint POP has attracted much attention on Kickstarter because of its scanning abilities and user-friendly design that caters to professionals and hobbyists at a price point.[1]

a) Funding Strategies

- **Tiered Reward System:** Offering multiple backer levels with increasing rewards, from discounted early bird pricing to bundles with additional accessories.
- **Stretch Goals:** Setting additional goals that unlock new features or improvements as more funds are raised, encouraging continuous support, such as reaching a goal of $350,000 to be compatible with MacOS, $700,000 for the product to use USB-C Cable, and $800,000 for the compatibility of IOS.
- **Limited-Time Discounts**: Providing early backers with limited-time offers and significant discounts such as 50 to 40 percent off their product.
- **Community Engagement**: Actively engaging with backers through updates, responding to comments, and showing prototypes to build trust and excitement.
- **Exclusive Offers**: Offer exclusive deals and add-ons available only to Kickstarter backers, making them feel part of an exclusive group. These offers included bundles with a POP 3D scanner, auto turntable, and phone holder.
- **Demonstration of Product Viability**: Using videos and real-world examples to demonstrate the effectiveness of the product, convincing backers of the product’s

The fundraising plan for the Revopoint POP 3D Scanner emphasizes a reward structure that provides diverse options for backers at various levels of support engagement. Initial supporter tiers offer appealing discounts to those who pledge early to encourage adoption and build excitement. As funding progresses, further milestones are unlocked by the company, which may include add-ons or enhancements to the Scanner; this encourages support from backers and promotes word-of-mouth recommendations. This strategy helps maintain enthusiasm and generates excitement throughout the campaign as important goals are achieved.

Furthermore, Revopoint 3D Technologies Inc. focuses on being open and communicative with its supporters by informing them about the project's advancement and addressing any inquiries they may have. This approach helps create a tight-knit community and builds trust among supporters by making them feel like active participants in the project's growth. The company also provides unique offers for backers on Kickstarter, including unique accessories or packages not offered in stores.

By presenting instances of the Scanner's abilities in videos and testimonials, they effectively show the product's practicality. This convinces supporters to pledge.

b) Technology Overview.

The Revopoint POP 3d Scanner uses light technology for 3d scanning by employing an infrared projector and RGB camera for precise depth sensing capabilities. It offers the convenience of dual-mode scanning that can be used both in turntable modes. The Scanner is equipped with a high-quality CMOS sensor that ensures accuracy up to zero. y mm for creating precise 3d models. It operates at a speed of up to eight frames per second while maintaining a power consumption level, making it portable and only requiring a USB connection for power input. The scanner can also promptly send scanned models to a connected device. It is compatible with various operating systems, like Windows, macOS, and Android.

TABLE XIV. REVOPOINT SPECIFICATION

Part Name	Technology Used	Functionality
CMOS Sensor	High-Precision Depth Sensing	Captures detailed 3D models with 0.3mm accuracy
Infrared Projector	Structured Light Technology	Project patterns to capture depth information
RGB Camera	Color Capture Technology	Captures the texture and color of objects
USB Interface	Power Supply and Data Transfer	Provides power and streams real-time data
Dual-mode Scanning	Handheld and Turntable Modes	Allows flexible scanning setups

c) System Description

The Revopoint POP 3D Scanner operates by projecting structured light patterns onto an object through its infrared projector. The high-precision CMOS sensor and RGB camera then capture these patterns. The infrared projector emits a series of invisible light patterns, distorted when they hit the surface of the scanned object. The CMOS sensor then measures the distortion of these patterns to determine the object's depth and shape, generating a highly accurate 3D model. The RGB camera simultaneously captures the color and texture information, overlaying it on the 3D model for a realistic representation.

The device uses a USB connection for power supply and data exchange. The captured information is analyzed instantly. Allows the model to be streamed directly to a linked device for editing or printing purposes. The Scanner offers two modes of operation. It also includes a mode for scanning while moving and a turntable mode for precisely scanning smaller objects in a static position. The system is designed to be energy-efficient and portable. It can be used in different settings without requiring additional power sources besides an essential USB connection.

d) Block Diagram and Picture

Below is a block diagram illustrating the flow of data within the Revopoint POP 3D Scanner:

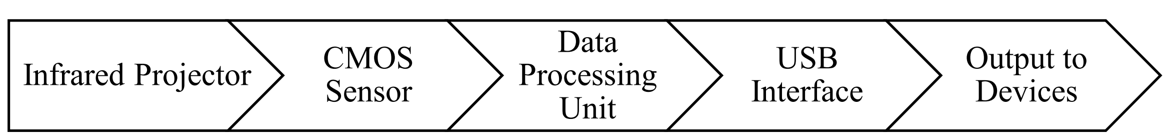


Fig. 2. Block diagram for Revopoint (Team Created)

Fig. 3. Revopoint[1]

Creating a fundraising pitch modeled after campaigns, like the Revopoint POP seen on Kickstarter, would involve using a strategy that includes offering reward tiers and encouraging community involvement like theirs. For instance, Providing discounted access to the production models for early supporters and setting stretch goals to add extra features or accessories as more funds are raised could be effective tactics. Additionally, utilizing real-life examples and testimonials can establish trustworthiness in the campaign. It is introducing rewards exclusively for backers, like customization choices. It could increase participation. Taking cues from known programs aired on CNBC network channels might lead us to think about presenting the product on a program such as Shark Tank to attract funding for expanding production and promotional activities.

2) Einscan-S 3D Scanner

e) Project Summary

The Einscan S 3d Scanner is a reliable device that can be used to create 3D prints of top-notch quality in settings. Developed by Shining 3d and introduced in May 2015, the Einscan S presents users with a scanning solution that can achieve accuracy levels as fine as zero. 1Mm. It is crafted to be easy to use, offering users the choice between manual scan modes to cater to the sizes and shapes of objects for scanning purposes. The Scanner prioritizes safety by utilizing technology that poses no harm to the eyes. This feature enables it to create three models efficiently, making it a valuable tool for the design, fabrication, and education sectors.

f) Fundraising Strategies

- **Early Bird Discounts**: Offering limited-time, heavily discounted pricing for the first batch of backers.
- **Tiered Reward Levels**: Providing multiple backer levels with increasing rewards, from discounted scanners to complete bundles with accessories. These tiers allowed anyone to back the product as the pledge began at $1, giving the backer one distinctive 3D model scanned by EINSCAN-S. The highest tier was $6,699, which allowed the backer to become a product distributor.
- **Stretch Goals**: Introducing additional features or upgrades unlocked when certain funding milestones are reached. This includes $80,000 for a color texture scan, $200,000 for a handheld scan, and a $500,000 publishing platform for 3D models.

- **Demonstrations and Testimonials**: Showcasing real-world uses of the product through detailed videos, images, and customer testimonials.
- **Community Involvement**: Allowing the consumer $6,699 to become a distributor. This price gave the consumer 10 EINSCAN-S 3D scanners and 100 distinctive 3D models, and it came with training on all the ins and outs of the product.

The fundraising plan for the Einscan S 3D Scanner centered on providing discounts to attract support from backers effectively. The time-limited deals enabled pioneers to buy the product at a higher rate than its regular retail price. This approach generated a feeling of urgency. It enhanced the funding. By introducing reward tiers, Sunshine 3E successfully catered to a group of supporters—from individuals interested in a simple model to those looking for a complete package with extra add-ons and benefits.

Moreover, the company implemented stretch targets to motivate contributions during the campaign. These stretch targets unlocked features that improved the products' worth as more funds were obtained. Keeping backers engaged with frequent updates, product showcases, and exclusive limited-time deals assisted in forming a robust community around the initiative. This approach not only spurred financial backing but also nurtured a dedicated customer following, contributing to the overall triumph of the campaign.

g) Technology Overview

The Einscan S 3D Scanner utilizes technology to achieve precise scanning results with an accuracy level of up to zero. Switching between an automatic turntable mode and a free scan mode for more oversized objects gives the user versatility during scanning sessions. It can complete scans quickly in three minutes using the turntable mode. The Scanner features a low-power design powered through USB connectivity for portability and energy efficiency. Moreover, the Scanner is equipped with a light that is easy on the eyes to ensure users can operate it without any health worries. [2]

TABLE XV. EINSCAN S 3D SPECIFICATIONS

Part Name	Technology Used	Functionality
CMOS Sensor	Structured Light Scanning	Captures high-precision 3D models (0.1mm accuracy)
Turntable	Automatic Scanning Mode	Provides 360-degree automatic object scanning
USB Interface	Power and Data Transfer	Ensures portable, low-power consumption operation
Structured Light	Light Projection	Projects safe, eye-friendly patterns for scanning
Free Scan Mode	Flexible Scanning	Allows scanning of larger objects without a turntable

h) System Description

The Einscan S 3D Scanner works by projecting patterns onto an object and capturing them with a high-quality CMOS sensor for accurate measurements of the dimensions and shape of the object with precision up to zero mm while in automatic mode, where the object spins 360 degrees placed atop a turntable. The structured light used in this device is eye safe. It poses no health risks to users while operating it. The Scanner also offers a mode option where users can manually adjust the scanning process to capture more prominent or intricate objects that may not fit on the turntable.

The information gathered from the CMOS sensor gets sent to the connected device using a USB connection and then transformed into a model through processing methods. The Einscan S enables users to observe the scanning process in time while the data is being gathered. The Scanner offers dual-mode scanning options: a mode for intricate items and a free scan mode for larger objects. This versatility makes it well-suited for purposes ranging from designs to sizable objects. The device consumes power. It only needs a USB connection for increased portability and convenience in different settings.

i) Block Diagram and Picture

Below is a block diagram showing the signal flow in the Einscan-S 3D Scanner system:

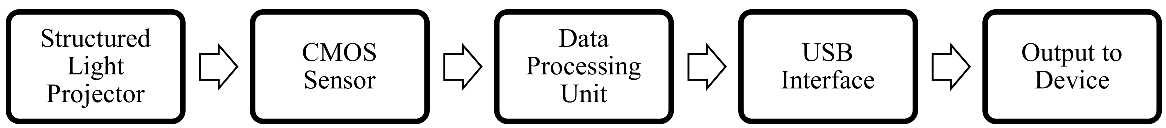


Fig. 4. Block Diagram for Einscan-S 3D. (Team Made)

Fig. 5. Einscan-S 3D [2]

If we were to create a funding pitch influenced by fundraisers, like the Einscan S, on sites like Kickstarter, we would set up a reward structure to attract supporters at various levels of commitment. Exclusive discounts for birds would be available to entice backers, giving them access to the Scanner at a discounted rate for a limited period. We would also include goals to unveil functionalities like advanced scanning options or exclusive add-ons to encourage ongoing support. Engaging with the community will be crucial by providing updates and showcasing product demos while hosting Q&A sessions to build trust and enthusiasm.

We might also draw ideas from known TV programs like Shark Tank on CNBC. They showcase how pitching a product to a group of investors could lead to securing funding successfully. The emphasis would be on illustrating the applications of the Scanner in fields like education and manufacturing industries. By blending a crowdfunding initiative with visibility on media outlets, we could develop a fundraising plan that raises the required funds and establishes a loyal customer base right from the start.

V. RISK ANALYSIS

Every endeavor comes with its set of uncertainties that could influence its outcome significantly; therefore, recognizing these uncertainties at an early stage is crucial for creating viable contingency plans that work effectively in problem-solving situations by conducting a risk assessment process focusing on technical challenges, with issues related to scheduling conflicts and financial limitations and the team's competency gaps. We have identified potential stumbling blocks that may arise during the project lifecycle. Each identified risk has been thoroughly evaluated, considering the likelihood of occurrence and its possible repercussions. It enables us to prioritize them for better management and resolution.

Understanding these risks and their Impact on the project allows us to take proactive steps to tackle them head-on. Your text mentions an approach involving early testing and contingency planning to minimize disruptions and boost our confidence in meeting project goals within set timelines and budgets.

*A. **Potential Risks***

The following list below includes all potential risks of the project under seven categories:

1) Technical

T1: Unexpected bugs when implementing the machine learning.

T2: Fine-tuning the Machine learning aspect of the project.

2) Resource

R1: Lack of experience using microcontrollers for machine learning.

R2: Acquire the essential data on the different components for the design.

3) Economic

E1: Component prices are high, causing an increase in the cost of the project.

E2: Destruction of hardware.

4) Schedule

S1: Delays due to learning new skills and techniques.

S2: Procrastination

S3: Other personal conflicts.

5) Cultural

C1: Low social acceptance.

6) Legal

L1: Compliance with IEEE standards.

L2: Potential patent infringement.

7) Marketing

M1: Competitiveness in the market.

M2: Appling to the consumer base.

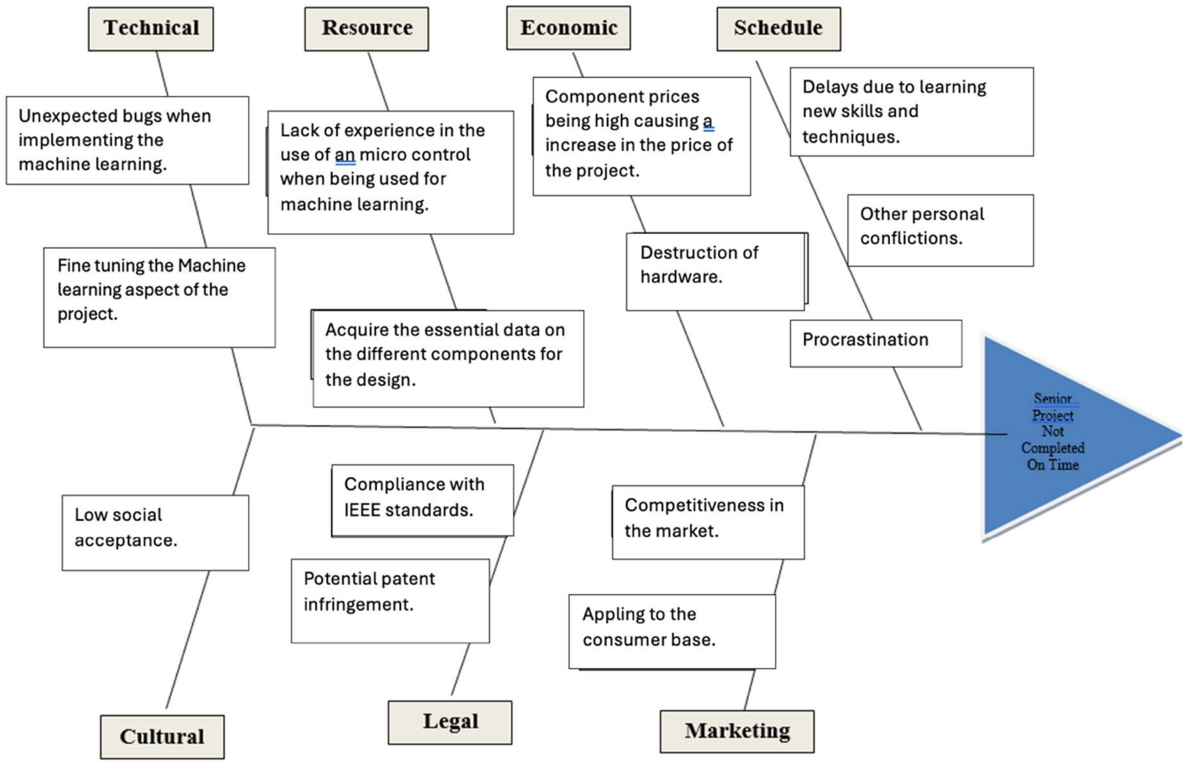


Fig. 6. Fault Tree Analysis

B. ***Risk Exposure Matrix***

In this part of the process, we use a risk assessment grid to analyze and categorize all known risks according to their seriousness, level, likelihood of happening, and nature of risk. By organizing risks into groups, the grid offers an approach to deciding which issues to focus on and how to tackle them efficiently. Each risk is assigned to one of four categories, enabling the team to focus efforts where they are most needed:

- **Low (Green):** Represents minimal risks that require regular monitoring but do not pose significant threats to the project.
- **Moderate (Yellow):** Reflects manageable risks that require proactive measures to prevent escalation.
- **Severe (Orange):** Indicates high-risk areas demanding detailed action plans and close oversight to mitigate impacts.
- **Catastrophic (Red):** Denotes critical risks requiring immediate and decisive action to avoid significant project disruptions.

This structured approach ensures that resources are allocated efficiently and that high-priority risks receive the required attention, fostering a well-prepared and resilient project framework.

TABLE XVI. RISK EXPOSURE MATRIX

Likelihood of Occurrence	Very Likely	Possible	Unlikely	Legend
Class IV		M1		Catastrophic
Class III	T2		T1	Severe
Class II		R1, R2	E2, C1, L1, L2	Moderate
Class I	S1, S3, L1, S2, M2	E1		Low

The Risk exposure matrix shows the most critical risk to maintain at the highest importance. Our technical issues are a class III, requiring proactive management to stay on schedule and complete the project on time. M1 and T2 can be catastrophic risks if we put little time into them, as this will be our biggest hurdle to overcome.

C. *Response to Risk*

The team has carefully. They systematically sorted the risks to develop tailored responses and solutions for each possible problem. This approach is crucial for minimizing interruptions and securing the project flow. By tackling dangers in advance, the team can decrease their chances or effects and keep moving steadily towards achieving project goals. Technical risks are handled by incorporating testing stages, finding substitute components, and seeking advice from specialists when necessary. To address schedule risks, timeline buffers are used along with progress evaluations to spot and resolve delays promptly. Addressing constraints involves setting aside emergency reserves and closely tracking expenses; mitigating team-related uncertainties entails enhancing skills and fostering teamwork.

Ensuring that the team is well prepared to handle any challenges that may come up during the project is critical to success. The team can adapt quickly and smoothly when unexpected problems arise by having strategies to deal with issues proactively. Having a risk management plan not only boosts the chances of project success but also instills confidence in the team's ability to manage uncertainties effectively. With a defined risk management strategy, the team is more ready to keep moving forward and achieve project objectives with minimal disruptions.

TABLE XVII. ACTION TO MINIMIZE RISKS

Risks	Responses
M1	We are continually researching the market and finding the most efficient and cost-effective way to create our device to achieve a competitive market price.
T2	Seek guidance from our mentor and also gather information through credible sources. We are also putting extra time into understanding different ways to implant machine learning.
R1, R2	Gather an extensive amount of information to tackle this issue in the most efficient way possible. To familiarize ourselves with the comments, we will use acquired data sheets to determine their limitations and operating parameters.
S1, S2	Develop a detailed project schedule with built-in buffers for learning and external commitments.
L1, L2	Conduct thorough patent searches and consult with legal experts to ensure no infringement issues. Regularly review and comply with all relevant regulations on electromagnetic emissions.

C1	Engage in early user testing to gather feedback on comfort and aesthetics, making adjustments as necessary.
E1, E2	Gathering data on the limitations and operating parameters for the desired components to ensure little to no damage is caused to any of the components. Research heavily into similar and more affordable comments without infringing on the quality.

In summary, our project assessment results show a comprehension of the possible obstacles and the necessary actions to lessen their effects. We have developed a plan by pinpointing risks in various vital aspects such as technology-related issues, resources, availability, financial concerns, project timelines, cultural differences, legal matters, and marketing strategies. This comprehensive approach enables us to manage and rank each risk based on probability and potential Impact. Utilizing a risk exposure matrix effectively categorizes risks into groups; this helps us prioritize our attention and resources on critical areas, like technical challenges and market competition, that could significantly influence the success of our project.

We take a stance by developing specific plans to address each risk we identify in our project work. By incorporating testing methods, allocating resources efficiently, ensuring compliance with laws and regulations, and creating backup plans, we strive to minimize uncertainties and keep the project on track. Regularly reviewing risks and response strategies allows us to adjust to possible obstacles. This detailed plan for managing risks not only boosts the chances of project success but also gives assurance in our capability to provide a high-quality product within the planned schedule and budget while meeting the requirements of both the team and the intended audience.

VI. OPERATING ENVIRONMENT

When developing a product, the designer must carefully consider the device's operating environment. In many cases, environments are wildly variable and can lead to many errors. When designing the Wireless 3D Scanning Device for STL creation, there is a high standard to which we want our product to operate. Our device will be handheld and lightweight, so the user(s) can hold and adjust the scanner as needed. The device must be within a specific range of a computer with Bluetooth capabilities to communicate back and forth while it develops the desired model. The processing should be done via software on the paired computer to minimize the device's size and build price. The software will be constructed with Python and compatible with any computer that can run Python.

The Wireless 3D Scanning Device for STL creation can be used on any moderately sized object within many environments. Using light detection and ranging, our device can perceive the environment (LiDAR). With machine learning via Python code, we will create a robust algorithm to distinguish between our desired model and the surrounding environment. While the model is being generated, the user can see the progress in real-time on their paired computer. The user must be careful to avoid exposing the device to direct and excessive amounts of liquid. Despite this, due to LiDAR's fast exposure time, the rain will be frozen and worked around within the software portion of the product.

When considering the many variables present within the diverse operating environments in which the Wireless 3D Scanning Device for STL creation will be used, we realized that several challenges will be present. The device will have to handle sudden movements by the user, diverse weather conditions, and simple functionality that does not require the user to be technically capable.

VII. Intended User(s) and Intended Use(s)

A. ***Intended user(s)***

Intended user(s) play a vital role in the design choices made throughout the development of a project. Intended user(s) are those whose opinions are considered when making choices on how the product will be used. Based on the intended users, designers will make choices that will determine price, level of technical knowledge needed to operate, and other vital factors.

The intended user(s) frequently use 3D models to print out objects they need. These include but are not limited to:

- Engineers working in separate labs.
- Designers create physical parts.
- Any individual who owns or has access to a 3D printer.

Focusing on the intended users allows product designers to optimize their thinking when making important decisions when creating their devices. With the consideration of the intended user(s), a product's likelihood for success dramatically increases, leading to the failure of the designer or even of the entire company in which the designer operates.

B. ***Intended use(s)***

The intended use(s) of a product arise from the initial idea that designers began to work with and are then molded to fit best the needs of the intended user(s) and the client who funds the project.

The Wireless 3D Scanning Device for STL creation will help our users by:

- Creating detailed and accurate models for the use of 3D printers
- Self-correcting the models via machine learning
- Differentiating between the desired object and the surrounding environment

In conclusion, the user(s) we have chosen are based on many factors, and the uses we have chosen are set to assist them in their everyday work and streamline their processes significantly.

VIII. BACKGROUND

Learning what is already on the market before tackling our own design is essential. 3D-scanning technologies have been around since the 1960s, before the advent of computer technologies. Early scanners utilized lights, cameras, and projectors to perform tasks, resulting in less accurate and time-consuming scans [3]. Modern 3D scanners can calculate complex geometries and develop real-time digital models. Capturing digital models of real-world objects is essential to many industries, including medical, automotive, academia, and engineering applications. The market for 3D scanning technologies has grown with its associated technologies, such as improved processing speed, higher resolution, and portability. We have gathered three products on the market of different form factors that provide real-time, accurate, and speedy scanning technology.

A. *EINSTAR Vega*

EINSTAR, initially founded as an independent R&D company under the parent company SHINING 3D, entered the 3D scanning sector in 2009. It was not until 2021 that the company would develop its first product, a handheld 3D scanner. [4] It was not until 2024 that EINSTAR would produce an improvement upon its predecessor, the EINSTAR Vega.

1) Summary:

EINSTAR Vega was developed to improve the company's past 3D scanning devices. It acts as a standalone device where the user can act upon most of its functionality within the device itself; there is no need to interface with a computer. The AMOLED display lends the user an intuitive experience. The scanned object begins to develop on the display, indicating green and red sections to notify the user if the scan is good or bad in that area. The Vega also offers different scanning modes through their two unique scanning cameras, which allow the user to choose what level of detail they want in their design. The HD Mode is for small- to medium-sized objects, using its VCSEL (Vertical-cavity surface-emitting lasers) camera to scan at closer distances. Operating in this mode comes at the cost of a scanning speed of around 15fps. However, Fast Mode is for medium- to large-sized objects, using its MEMS (Micro-Electro-Mechanical Systems) camera to scan further distances. This mode improves scanning speed to around 20fps at the cost of scanning resolution. The EINSTAR Vega is selling for USD 1,999.00, a hefty markup for its increased computational abilities and seamless user experience.

Fig. 7. EINSTAR Vega

2) Technology Overview

The EINSTAR Vega weighs 535g and is 180mm x 95mm x 26.5 mm (7.09in x 3.74in x 1,04). It is a lightweight and small device, making it conveniently portable. Other unique features of the EINSTAR Vega include:

i) CPU: 8-core, 2.4GHz clock speed
ii) RAM: 32GB LPDDR4 Memory, 32GB eMMC + 512GB SSD
iii) Internal Hard Drive:32GB eMMC + 512GB SSD
iv) Battery: built-in 5000mAh, 65W fast charging (supports PD/PPS protocols)
v) Interface: Wi-Fi 6, USB Type C
vi) Touchscreen: 6.4” 2K AMOLED
vii) Output Formats: PLY, STL, OBJ, ASC
viii) Supported OS: Recommended PC configuration: Windows 10/11 (64-bit) or macOS 11.0, Intel i7, 32 GB Ram

The EINSTAR Vega has two cameras: an infrared MEMS and an infrared VCSEL camera. The Infrared MEMS captures data at 15fps and works at 100-250mm (3.94in-9.84in). The Infrared camera resolution is 2mp (megapixels). The Infrared VCSEL captures data at 20fps and works at 350-1500mm (13.78in-59.06in). The Infrared camera resolution is 1.3mp.

3) System Description

Figure 8 describes the functionality and system analysis of the EINSTAR Vega. The user will interact with the AMOLED Display. The display allows the user to choose the mode (Fast, HD) they want to operate on. The information registered from the screen is sent to the microprocessor, which will handle user inputs and orchestrate the machine’s hardware. The microprocessor has the necessary storage for its operating system, essential drivers, and temporary storage before interfacing with an external PC. It also has a CPU capable of computing the onboard digital model synthesis with data captured by the two cameras. The microprocessor is connected to a Wi-Fi antenna and a USB Type-C connector to allow the modality of wireless or wired transfer of data. The EINSTAR Vega is powered by an internal lithium-ion battery rated at 5000mAh. A connector can interface with a 65W charging unit, per the EINSTAR Vega product specifications. The voltage from the battery is most likely regulated to a consumable voltage for the internal hardware to operate safely.

The infrared MEMS technology is used for short-range scanning projects, such as infrared light with mirrors. According to Wang et al., mirrors the size of 1-7mm can steer light and control its phase by reflecting off its surface [5]. On the other hand, the infrared VCSEL technology used for long-range scanning emits light perpendicularly from the top of its semiconductor surface [6]. The fabrication advantages of VCSEL technology also aid in easier manipulation of the emitted wavelength, which lends to its further scanning capabilities. Both cameras will interact with the microprocessor to interpret data collected by the sensors.

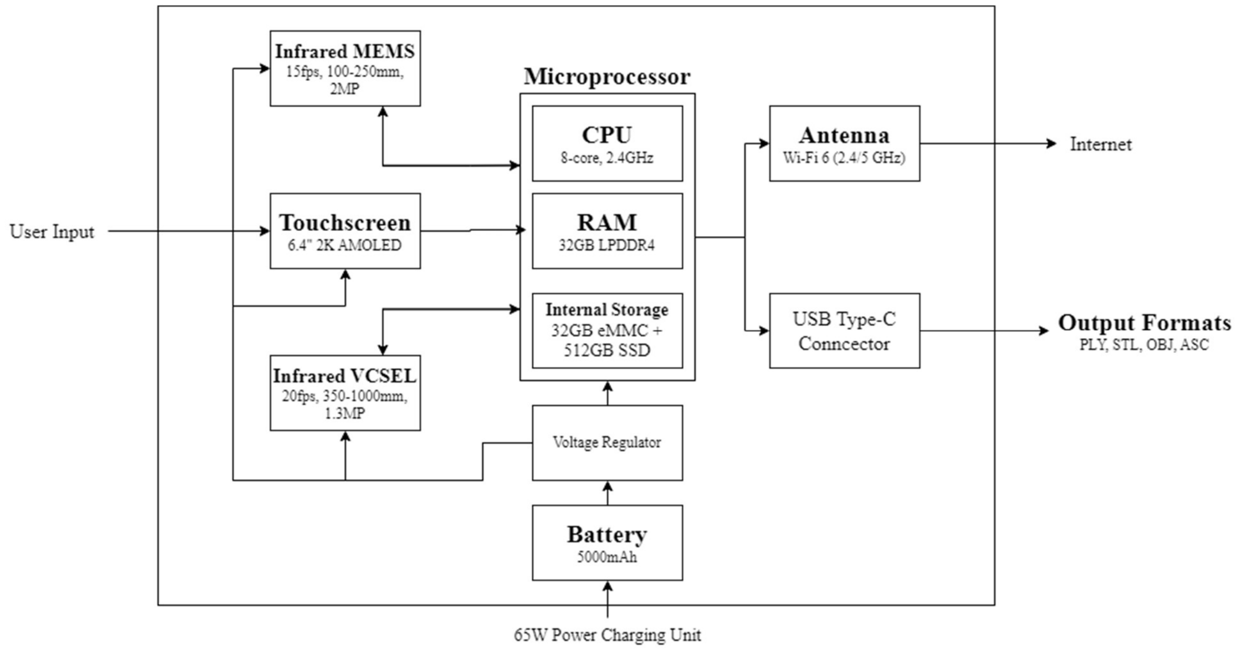


Fig. 8. EINSCAN Vega System Diagram

Aside from the machine's software, EINSTAR's hardware offers a post-processing software known as StarVision. While edits to the digital model can be made on the EINSTAR Vega before being sent to an external processing unit (i.e., a PC), StarVision is a streamlined post-processing software compatible with all EINSTAR 3D-scanning devices. With StarVision's intuitive approach, users can more easily manage files and digital models and integrate other modeling software (e.g., CAD, slicing). StarVision is downloadable on Windows 10/11(64-bit) and macOS.

B. *Artec Eva*

Artec Eva, released in April 2012, would be the first mainstream 3D scanning product that launched Artec into the 3D scanning market. Artec has satisfied many industry partners through its technologies, such as Apple, Microsoft, Nike, and others [7].

1) Summary

The Artec Eva is a professional scanner with a flat fee of USD 19,000, an initial payment of USD 11,000, and 5-year financing of $3,700 annually. The upscale cost delivers a device with powerful features that make it a valid competitor throughout its time in the market. The hardware can scan, but the actual data analysis of 3D modeling real-life objects comes from the complimentary software included in the purchase. Therefore, Artec can keep its older hardware alive by updating the software annually. Because of the hardware and software relationship, the Artec Eva must have a wired connection to a compatible PC during the scanning process to develop 3D models.

Nevertheless, the robust design of the Eva makes scanning portable, and it comes with an Artec battery pack that can last up to 6 hours when working on remote sites with no outlet access. The Artec is intended to scan medium- to large-sized with high accuracy and color. No calibration is needed before a scan as hybrid geometry and color tracking methods are used to produce more accurate scans. Additionally, the Artec is equipped with an AI neural engine that can utilize an HD mode for noise-free scans in a high resolution. During scanning, users must pay attention to the software on a nearby PC and analyze a depth meter, encouraging users to maintain a stable distance for the most accurate results. Users will be notified if they are too far or close with a warning on the software.

Fig. 9. Artec Eva

2) Technology Overview

The Eva sends all data directly to a PC. The Eva contains one USB 2.0 and one USB 3.0 interface. The analysis can be done on a compatible PC that meets one of the following requirements:

i) Supported OS: Windows 7, 8, or 10 (x64); no macOS support.

ii) Recommended computer specifications: Intel Core i7 or i9, 64+ GB RAM,

iii) NVIDIA GPU with CUDA 6.0+ and 8+ GB VRAM

iv) Minimum computer specifications:

a. HD: Intel Core i7 or i9, 32 GB RAM, NVIDIA GPU with CUDA 6.0+ and 2 GB VRAM

b. SD: Intel Core i5, i7 or i9, 12 GB RAM, GPU with 2 GB VRAM

The cornerstone technology of the Eva is the camera. It delivers a resolution of 0.2mm (0.00787in) and an accuracy of 0.1 ± 0.3mm/m (0.00393701 ± 0.0036 in/ft) over a distance. The standard working distance is 0.4-1m (1.31234-3.28084ft). At the device’s closest range, the linear field of view is 214x148mm (8.4252x5.82677in). At the device’s furthest range, the linear field of view is 536x371mm (21.1024x14.6063in). Overall, the angular field of view is 30 x 21°. The texture resolution is 1.3mp, and the color depth is 24 bpp (bits per pixel). The 3D reconstruction rate is 16fps, consistent across HD and SD modes. The Eva is powered by a lithium battery with 20,100 mAh (73Wh) capacity and 5-12V output. Charging time is approximately 2.5 hours, lasting up to 7 hours on continuous scanning.

The Eva also has multiple output formats:

i) 3D mesh formats: OBJ, PLY, WRL, STL, AOP, ASC, PTX, E57, XYZRGB

ii) CAD formats: STEP, IGES, X_T

iii) Formats for measurements: CSV, DXF, XML

3) System Description

Figure 10 describes the functionality and system analysis of the Artec Eva. Despite the Eva being a handheld device, the user must maintain a direct USB connection to a compatible PC equipped with Artec's 3D modeling software (Artec Studio). Before starting a new scan, users can indicate on Artec Studio if they wish to scan in High Definition (HD). If the user decides to do so, it will access more processing power from the PC. During the scanning process, the user will hold the device and begin to capture data around the object. The Eva uses a process known as structured light scanning to capture depth information. Unlike a light sensor that interfaces with a depth module, the scanner projects a grid pattern of light on the object that will wrap around its features (curvature, depressions, raised areas). This distortion (noise) in the scan is the data that gets interpreted and developed into a 3D digital model. According to Artec Learning Center, Artec Studio has "pattern-recognition and reconstruction algorithms" that can understand varying distortion levels throughout the light grid [8]. This data is streamed continuously to the PC, where the user watches the model develop on Artec Studio. Artec Studio has a 3D radar that instantaneously interprets the data and indicates to users if they are too close, too far away, or not scanning the object. The Eva can be directly plugged into AC or utilize its 20,100 mAh lithium battery pack in remote areas where portability is crucial. The hardware design is straightforward since the connected PC externally utilizes the processing power required by the device.

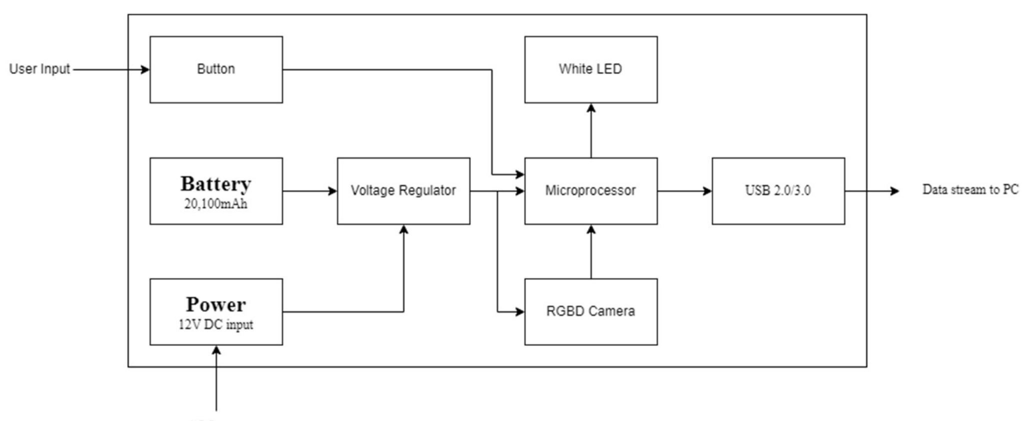


Fig. 10. Artec Eva System Diagram

Once the scan is finished, the Artec Eva will no longer be needed. All the data compiled through the scanning process is then used to develop a 3D object. Post-processing is done entirely through Artec Studio. Users can edit meshes, make feature adjustments, and smooth out objects. In Artec Studio, the user can decide which output format they need, which includes compatibility with industry 3D modeling software such as Autodesk and SolidWorks.

*C. **EinScan SP V2***

SHINING 3D, founded in 2004, is committed to the global commercialization of 3D digital and scanning technology. They offer low-cost and high-end 3D digital products for various applications, including healthcare, education, and engineering [9].

1) Summary

The EinScan SP V2 is a professional desktop 3D scanner valued at USD 2,099.00. It has a substantial scanning range for small- to medium-sized objects. The limitation of object scans results from its lack of free movement. It is not a handheld device; its scanning is primarily done through a turntable with automatic 360° rotation. If the user wishes to scan medium-sized objects, there is an attachable tripod to set the Scanner at a further working distance. The turntable has a calibration module on the rim, which results in faster scanning with no additional calibration protocols. The EinScan SP V2 can only scan with its RGBD (Red, Green, Blue, Depth) camera and must interface with a PC with complimentary software. On the software, the user can manage scan progress, smooth and sharpen data, and readjust coordinates. Additionally, the EinScan SP V2 is compatible with many industry 3D printers. The software auto meshes 3D data with OBJ, STL, ASC, PLY, and 3MF output formats.

Fig. 11. EinScan SP V2

2) Technical Description

The EinScan SP V2 sends all data directly to a PC via USB 3.0/2.0. The analysis can be done on a compatible PC that meets the following requirements:

i) Operating System: Windows 7, 8, 10 (x64); macOS

ii) CPU: Intel Dual Core i5 or higher

iii) RAM: >16GB

iv) GPU: Nvidia GTX660 or higher

v) Video Memory: >2GB

The EinScan SP V2 is a lightweight device (4.2kg; 5.29 lbs.) that takes up 570x210x210mm (22.44x8.27x8.27in) of desktop space. The device requires constant outlet connection with a 12V, 3.33A, 40W power supply. Generally, the minimum scan volume is 30x30x30mm (1.18x1.18x1.18in). In turntable configuration, the maximum scan volume is 200x200x200mm (7.87x7.87x7.87in), with the camera set at a fixed working distance of 290mm (11.42in). The turntable is capable of 360° and has a loading capacity of 5kg (11.02 lbs.). The turntable is equipped with coded targets that eliminate the need for manual calibration before a scan. In the fixed scan (tripod) configuration, the maximum scan volume is 1200x1200x1200mm (47.24x47.24x47.24in). The user must manually rotate the object to develop a full 360° scan. The EinScan SP V2 has a high-accuracy calibration board that can be calibrated in a fixed scan configuration. The camera on the EinScan SP V2 has the following specifications:

i) Accuracy: ≤0.05mm

ii) Scan speed of single shot: <1s

iii) Scan speed of single turn: <45s

iv) Light source: White LED

3) System description

Figure 12 describes the functionality and system analysis of the EinScan SP V2. The user will maintain a direct USB connection to a compatible PC with 3D modeling software (EXScan S). First, the user will ensure that the device is connected and readable by the PC. Next, the user will ensure that the device is recently calibrated. If not, the user will activate the calibration method, which is automatically done through the targets found either on the turntable or provided with the device (for fixed target scanning). Once the device is calibrated, the scanning variables, such as the brightness of the LED, HD mode activation, and turntable steps and speeds, can be adjusted. Now, the user can initiate the scanning process. If fixed target scanning is the method, the user must manually rotate the object and monitor the 3D model on the software. EXScan S also comes equipped with post-processing capabilities. The mesh of the 3D model can be edited, allowing the user to clean up the object, fill holes, refine textures, etc. The software also has export capabilities for popular industry CAD software with output formats such as STL, STEP, and DXF. The EinScan SP V2 has Wi-Fi connectivity that can interface with the PC by sending files to slicing software compatible with 3D printers.

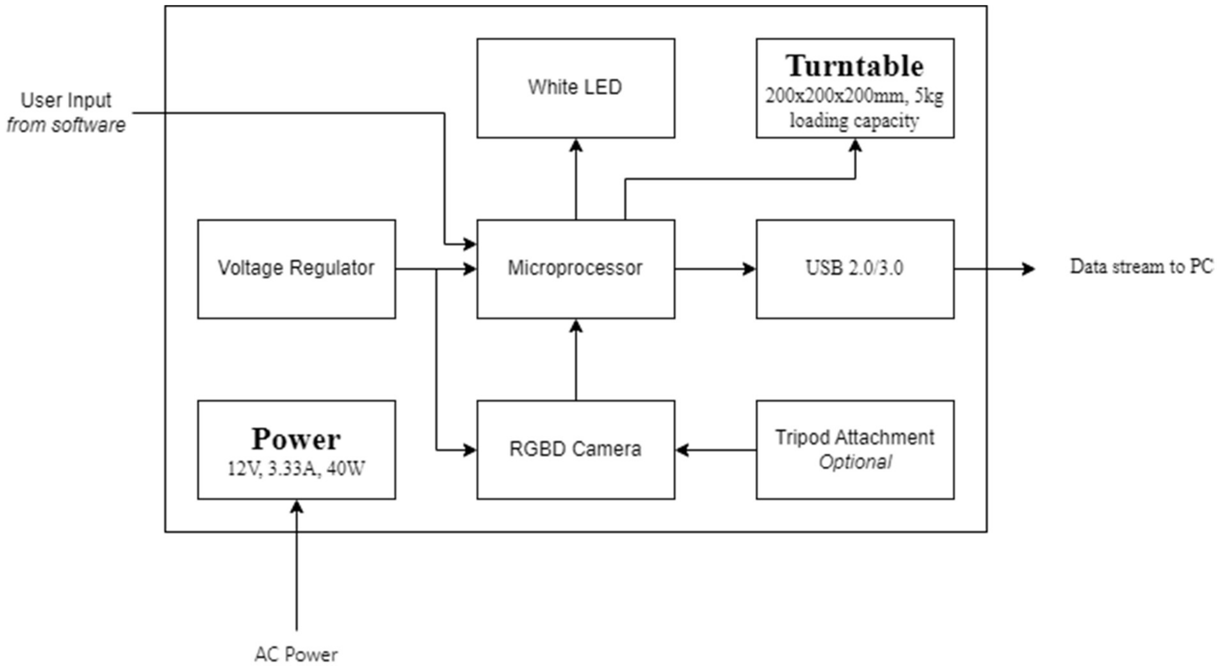


Fig. 12. EinScan SP V2 System Diagram

The three products present high-accuracy 3D-scanning techniques at different professional levels, from hobbyist applications to industry-grade usage. The breadth of 3D scanning applications lends to varying price points offering different experiences. A significant takeaway is developing a balance between the software and the hardware. The heart of 3D scanning technology is the depth camera, but how devices interpret data for 3D modeling varies. Affordability is a crucial factor in our design, so choosing whether we want to develop a more robust data-processing algorithm or invest in better hardware will be essential. Regardless, we want to build a scanner that is accessible to the industry at a price-point standard.

Additionally, 3D scanners need more seamless integration with existing 3D modeling tools such as CAD software and IoT devices. Our design aims to utilize its wireless capabilities to enhance this shortcoming in current devices. This requirement might make it more apparent whether we invest in premium hardware on the device itself or source it externally through a PC.

IX. Intellectual Property Considerations

Before a designer can develop their product, they must consider any previously created intellectual property related to their product. Once a designer has equipped themselves with the necessary knowledge, they will be able to navigate the creation of their product with the best chance at avoiding lawsuits or legal infringement. By analyzing surrounding patents, inventors can work on developing their patents, which will allow investors to use their money to supplement the innovative process with as minimal risk of legal trouble as possible. This extended funding will enable project designers to optimize their work and reduce budget constraints.

We will cover three existing patents in this section that relate to our project and are currently patented in the United States. These patents include *methods and apparatus for three-dimensional (3D) imaging*, *an Object recognition system based on machine learning and method thereof, a Structured light projection module, a depth camera, and techniques for manufacturing structured light projection modules.* These patents were obtained by our team via Google patent search while narrowing our search to include only patents that were filed within the United States. The main objective of this search was to find 3D scanning patents and those that have to do with machine learning in identifying objects.

A. ***Methods and apparatus for three-dimensional (3D) imaging: Patent #US11112503B2*** [10]

Dale G. Fried and Jonathan P. Frechette invented this patent. The Massachusetts Institute of Technology filed it. It was filed on January 25th, 2018, and granted on September 7th, 2021. It is set to expire in the year 2037.

1) Summary:

This invention outlines the method and apparatus for generating three-dimensional images using light pulses and photon detection techniques. The specific method involves using light bursts, each with many light pulses. The reflections of these bursts are then stored using a focal plane array to create point clouds. The point clouds contain information on the distance of specific points in the model from the focal plane array. Scenes created from these point clouds contain overlapping sections, which are then sorted to compile information into a complete 3D model. Figure 13 demonstrates how the apparatus receives the reflections of light sources.

The method includes ways overlapping scenes can reduce redundancy and noise through crucial features. These features include photon-counting detectors, FPGA or ASIC processors, and the ability to estimate the properties of surfaces.

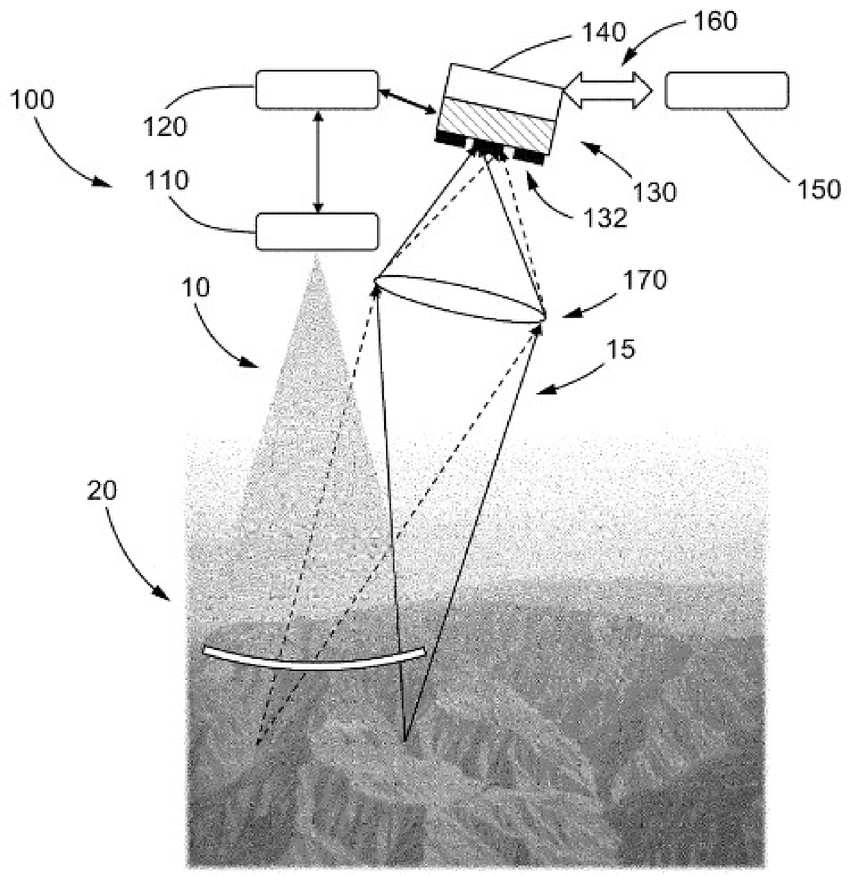


Fig. 13. Configurations for 3D scanning device components from US Patent US11112503B2 [10]

2) Claims Summary:

The patent has a total of eighteen claims; however, the claims that relate to our project include:

a. Claim 1: Apparatus for generating a 3D image.

b. Claim 10: Method for generating a representation.

3) Infringement:

This patent is for a device that gathers information from the surrounding environment using light bursts. The invention is different from ours, as the main focus of our device is taking information from a scan and developing it into a 3D model usable for STL creation. We will use publicly available LiDAR cameras to gather the information necessary for our 3D models.

B. ***Object recognition system based on machine learning and method thereof: Patent #US20210158556A1*** [11]

Ming Wu and Kun-Lung Tseng invented this patent. The Industrial Technology Research Institute filed the patent on January 17th, 2020.

1) Summary:

This patent includes the description of an object recognition system that integrates machine learning to bolster the accuracy and precision of said object detection. This is achieved by combining two-dimensional images and three-dimensional point cloud data. Various modules work together to capture, process, and analyze visual data. The main modules include a 2D image capture module, a 3D space capture module, a data alignment module, a feature capture module, and a detection module. The data captured by the first two modules is fed into the data selection module, which performs object segmentation and depth recognition to identify regions of interest. The following flow chart (Figure 14.) provides a clear overview of the logical steps in which the system operates.

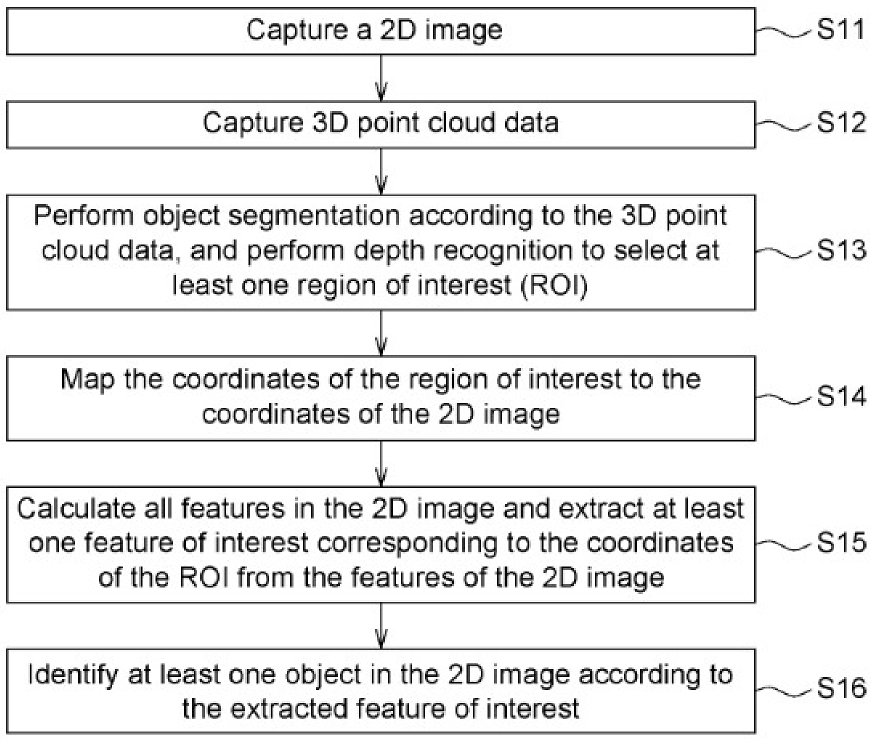


Fig. 14. Logical processing for object recognition

2) Claims Summary:

The patent has eleven claims based on the specific details in a system that performs object recognition. The particular claims that may relate to our project include the following:

a. Claim 1: An object recognition system based on two- and three-dimensional data.
b. Claim 2: Object segmentation using depth data.
c. Claim 4: Coordinate mapping between 2D and 3D data.

3) *Infringement*:

In this patent, objects are differentiated from their environment through many processing methods involving 2D images and 3D cloud points. Our project will incorporate machine learning; however, it will not use two-dimensional images and instead rely primarily on depth.

C. ***Structured light projection module, depth camera, and method for manufacturing structured light projection module: Patent#US11194171B2*** [12]

This patent was developed by Yuanhao Huang, Zhaomin Wang, Min Yan, Xing Xu, and Xu Chen. The patent was filed on May 5th, 2020, by Orbbec Inc.

1) Summary

This patent presents a structured light projection module, a depth camera, and a manufacturing method. The light projection module comprises a primary light source with multiple sub-light sources. These lights are arranged in a two-dimensional array that emits 2D patterned beams. The beams then pass through a lens that converges them, and then a diffractive optical element will project beams with a speckled pattern. This pattern can be seen in Figure 15. The depth camera then works with the structured light module to calculate the distance from specific sections of the captured image to the device itself. The distance is determined based on the distance between the speckles within the pattern, as the further the object is from the source, the further apart the dots will be.

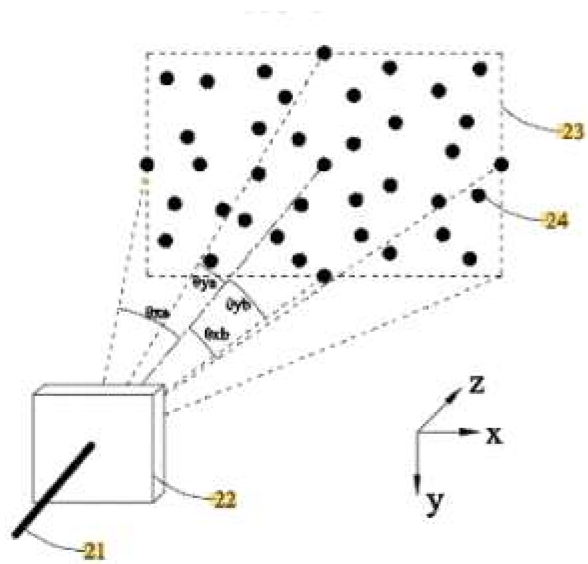


Fig. 15. Design specifications for a 3D scanning device from US Patent US11828954B2 [12]

2) Claims Summary

This patent has a total of eighteen claims having to do with depth detection and structured light detection. The claims that may relate to our project include the following:

a. Claim 1: Using a structured light projection module that emits 2D patterns.
b. Claim 8: This claim describes a depth camera that uses the previously mentioned structured pattern from the light module.

3) Infringement*:*

This patent is related to structured light projection, depth cameras, and patterned beams for depth sensing and 3D imaging. This differs significantly from our system since our primary objective is the creation of a three-dimensional scanner that develops STL models, assisted by machine learning to optimize creation. To avoid infringement, we will create a unique approach that does not rely on the same structured light methods described in the patent. Specifically, we will avoid using similar optical designs or speckle pattern methods for depth calculation.

This section clearly outlines how intellectual property is a vital consideration for any designer developing a project, as any ignorance on this front can lead to the downfall of the designer, their client, and the entire company. With this in mind, we found patents related to our project and took specific care in the design process to ensure we did not infringe upon any of the claims made within said patents.

X. Globalization

Our Wireless 3D Scanning Device for STL Creation will succeed in the global market because it is highly intuitive, versatile, and easily applicable when bridging sectors within the same industry. To find success in a highly competitive and scarcely forgiving market, the engineering behind a product has to derive from two main approaches: a theoretical and a technical approach. Above all, the two approaches must combine to create a product that fulfills the consumer's needs. This is where globalization stems from, as filling a niche in an ever-expansive market allows for widespread global success from a product. Another critical aspect of globalization is the standard requirement for products to be allowed into the market in the first place. A successful product meets various international criteria, reaches many demographics, and applies to every hemisphere. In addition to the team's goals on the technical front, the team must also consider the requirements of the World Trade Organization (WTO) and the International Organization of Standardization (ISO). If these requirements are met, then the odds of global success improve exponentially.

Our product will be an innovative blend of precise hardware and intuitive software, positioning it as an essential global tool in both the commercial and education sectors. Like other technological innovations that came before it, such as smartphones and operating systems, our wireless 3D scanning device will bridge complex technology with user-friendly design choices that will appeal to a broad range of applications. Our goal of accessibility in our product's use will ensure that it is effective in learning situations, such as labs within universities.

*D. **World Trade Organization (WTO)***

The World Trade Organization is a significant determinant in whether or not a product has international success. Trade on an international scale has been a fickle thing throughout history, with global powers able to adjust requirements to benefit their own needs. In today's day and age, with globalization being at its peak and only continuing to grow, an organization like the World Trade Organization is vital in promoting fair and free trade between nations and preventing economic cataclysm on a global scale. To facilitate trade, WTO members must adhere to standards presented by the International Organization of Standardization (ISO) and the International Electrotechnical Commission (IEC).

One fundamental principle that the WTO presents is the "Most-Favored-Nation" principle, which ensures that countries do not discriminate between trading partners. This will ensure that once our scanner enters the market, it will not face additional restrictions compared to similar products from other countries. Additionally, we will comply with Intellectual Property rights, as previously mentioned. This is especially important in a global market, as the WTO oversees the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), which sets the minimum standards for IP protection globally. This will also work to our benefit, as it will prevent unauthorized use or reproduction of our product.

*E. **Trading Barriers***

Trade barriers present a unique challenge for products entering global markets. These barriers, which include product compliance standards and import/export regulations, can limit the potential reach of even the most innovative devices. Because of this, we as a team have heavily considered complying with ISO and IEC standards to facilitate faster integration into the global market. By meeting these standards, we avoid unnecessary limitations that could restrict access to areas with high demand for three-dimensional scanning technology, such as Europe, Asia, and Latin America.

Standards are crucial in overcoming these barriers and facilitating our scanner's integration into international markets. For instance, ISO/IEC JTC 1/SC 42 addresses the standards for artificial intelligence technology, providing guidelines on AI's ethical and practical uses in products similar to our scanner. Meeting these standards ensures that our device aligns with global expectations for data privacy, security, and ethical AI use, making it suitable for international markets where these concerns are prioritized. Additionally, ISO 50001 addresses energy management, helping our scanner meet global standards for energy efficiency, reducing its environmental Impact, and aligning it with sustainable development goals.

*F. **Collaboration Tools***

The Wireless 3D Scanning device for STL Creation has five distinct members. Communication has been vital to our success during the development of this project. The primary method that was used to communicate was the phone application WhatsApp. The use of WhatsApp allowed us to discuss scheduling and organize ideas. We also used file-sharing platforms such as Google Drive and GitHub for the software end of our project. This allowed a seamless exchange of documentation, code, and design files. GitHub, in particular, greatly facilitated our iterative software development, enabling us to track, test, and update the scanner's machine-learning models and control software. By layering all these communication and collaboration techniques, the team created a positive working environment where complex challenges could be overcome via discussion and cooperation.

*G. **International Success***

Developing the Wireless 3D Scanning device for STL Creation represents a technological advancement and a step toward democratizing access to high-fidelity 3D modeling tools globally. The features present on the device are tailored to a broad range of potential users, ranging from professional designers and engineers to students and hobbyists. Additionally, the integration of machine learning algorithms further enhances the device's versatility, allowing it to autonomously optimize scan quality and accuracy based on the object and environment, making it user-friendly to beginners while also meeting the demands of more advanced users. Furthermore, we received feedback from individuals from Spain and Brazil to ascertain a more global perspective.

The individual who was mentioned to be from Spain is Armando Vizcaya, who is currently studying at the Complutense University of Madrid. He studies electronics, and when discussing his thoughts on our project, he noted the many fields in which it would be productive. He also pointed out that our device has the potential to bridge labs internationally, allowing for the easy transfer of models and grand facilitation to 3D printing things in different locations.

Joao Neto is our source from Brazil, a computer science major emphasizing machine learning. Joao has spent most of his life in Brazil. After a conversation with the student, it was apparent that he admired our project and hoped it would achieve its goal of bridging multiple industry sectors. He also noted that our project could have widespread success throughout universities and labs in South America if they have three-dimensional printing capabilities.

Global success comes from adhering to international standards as well as appeal within multiple markets across the globe. Our Wireless 3D Scanning Device for STL Creation will serve a niche within its several markets and be found with widespread success.

X. Standard Considerations

For a project to be met with widespread success, it must adhere strictly to standards that ensure quality within its market. Generally, three types of standards are addressed: de facto, de jure, and voluntary consensus standards. Within the industry, standards typically fall under the de jure and voluntary sections. Going against these standards would severely cripple a product's chance for success; however, strategically following them promotes the exact opposite effect.

Organizations such as the IEEE and the ISO serve as cornerstones in developing and acknowledging standards. These organizations create criteria that technological devices must meet in order to proceed into the international market. These criteria must be met to ensure a safe operating environment for inventors, manufacturers, and the intended users. These standards should be created in a way that is easy to understand for those familiar with the items being used and also easily translatable for international use. When considering the many variables present within the diverse operating environments in which the Wireless 3D Scanning Device for STL creation will be used, we realized that several challenges will be present. The device will have to handle sudden movements by the user, diverse weather conditions, and simple functionality that does not require the user to be technically capable.

*A. **IEEE P7006: Ethics with artificial intelligence [1]***

The first standard we chose to consider deals with the ethics of artificial intelligence and its implementation. Our Wireless Three-Dimensional Scanning Device for STL Creation incorporates machine learning to optimize its model generation. To comply with this standard, our device must clarify when machine learning is applied and where it gathers data.

This standard was created out of concern for situations where there is communication from machine to machine without human input and the ethical ramifications that arise from this scenario. This means ensuring that users remain in control of our device's data collection and model optimization processes. The machine learning techniques we employ, such as decision trees, DBSCAN (Density-Based Spatial Clustering of Applications with Noise), SVM (Support Vector Machines), and Kalman filters, will all adhere to this principle of user clarity and peace of mind. Moreover, our device will feature a data bank that the user modifies. This ensures that individuals can access, modify, or delete their data as needed. This feature will align with ethical best practices and comply very well with ISO P7006's emphasis on data ownership and security.

*B. **ISO 50001: Energy Management Systems [2]***

This standard has to do with the energy management and consumption of a device, helping organizations to reduce energy consumption and environmental Impact. This standard is increasingly important as energy costs gradually rise and consumers continue to seek environmentally friendly options. By adhering to this standard, we will optimize the energy use of our product and minimize the power requirements. Optimizing our Raspberry PI by turning off unused features is one method to achieve energy efficiency. We will also program the Raspberry pi to notify users if there is a spike in energy consumption or if the battery is low. Implementing battery management systems will also aid in the energy consumption of our product, ensuring that the battery does not overcharge or overly discharge. Through all of this, we will adhere to the ISO standard and develop a cost-effective and competitive product in the market.

C. ***ISO 14001: Environmental Management Systems [3]***

ISO 14001 is a globally recognized standard that outlines the criteria for establishing and maintaining an effective environmental management system. For our Wireless Three-Dimensional Scanning Device for STL Creation, aligning with ISO 14001 demonstrates our commitment to reducing ecological Impact throughout the lifecycle of our product. In developing our device, we aim to minimize its environmental footprint by employing sustainable practices. This includes optimizing energy efficiency using low-power components, such as our Bluetooth transceiver and LiDAR scanner, and implementing intelligent power management to extend battery life.

This standard emphasizes life cycle thinking, which requires organizations to assess the environmental impact of their products from production to disposal. We have prioritized using environmentally friendly materials to construct our device to meet this requirement. Additionally, our project incorporates a structured approach to identifying and mitigating potential risks, such as improper electronic waste disposal. To address this, our project will provide users with clear guidelines on responsibly recycling or disposing of the device. By adopting this standard, we demonstrate our dedication to sustainable innovation and the desire for innovation without jeopardizing our planet.

After discussing these standards and deliberating on their main aspects, the team will include them in the design process of our project. These standards are vital for the success of our project on an international scale. In conclusion, the standards we will comply with include:

IEEE P7006, ISO 50001, and ISO 14001.

XI. HEALTH AND SAFETY CONSIDERATIONS

In developing our Wireless 3D-scanning Device for STL Creation, health and safety considerations are critical to protecting users, developers, and the surrounding environment. Our design process adheres to global health and safety standards, aligning with principles that ensure physical well-being, operational safety, and environmental sustainability.

A. *User Health, Safety, and Device Sustainability*

1) User Health and Safety

Our wireless 3D-scanning device prioritizes user safety using non-invasive technologies and has a user-friendly design. Key measures include:

- Eye-Safe Technology: The device integrates sensors that operate within the limits set by international safety standards for light emissions. These technologies prevent harm to users, even with prolonged exposure.
- Ergonomic Design: Lightweight and compact, the device minimizes strain and fatigue during use. Its ergonomic structure ensures that users can comfortably operate the device for extended periods.
- Real-Time Feedback: The device provides real-time information, such as scan status and battery levels, reducing the risk of operational errors. Safety alerts notify users of improper handling or device overheating.

2) Sustainability and E-Waste Mitigation

Environmental responsibility is central to our project. Recognizing the challenges posed by electronic waste (e-waste), we have:

- Selected durable components are known for their longevity, such as the Raspberry Pi and Intel RealSense D415 camera, to reduce the frequency of replacements.
- Designed for recyclability, ensuring that components can be safely disassembled and reused at the end of the product's lifecycle.
- Minimized hazardous materials by adhering to RoHS (Restriction of Hazardous Substances) guidelines, eliminating harmful substances such as lead and mercury.

These efforts help limit e-waste generation, promote sustainability, and reduce the device's environmental impact.

B. *Developer Health and Safety*

Our development team's health and safety are protected through rigorous safety protocols:

- Protective Equipment and Training: Team members are equipped with anti-static gloves, goggles, and other PPE during assembly and testing. Training sessions on electrical safety and handling lithium-ion batteries are mandatory.
- Secure Work Environment: The workspace is organized to minimize risks, with well-ventilated areas for soldering and secure storage for hazardous materials.
- Emergency Procedures: Emergency shut-off mechanisms and fire safety equipment are readily accessible to address potential accidents.

By fostering a safe development environment, we ensure the well-being of our team throughout the project lifecycle.

C. ***Liability Management***

Liability considerations guide our device's design, testing, and implementation to prevent harm and ensure compliance with legal standards.

1) Standards and Compliance

We strictly adhere to IEEE safety standards and local regulations governing electromagnetic emissions and device safety, and we conduct regular audits to ensure that our device meets or exceeds industry benchmarks.

2) Risk Mitigation Strategies

To minimize liability risks, we have:

- Conducted rigorous testing of all components to identify and resolve defects before deployment.
- Implemented quality control measures during manufacturing to maintain consistent safety standards.
- Developed comprehensive user documentation, including installation guides, maintenance instructions, and safety warnings, to educate users on proper operation and handling.

3) Foreseeability and Proactive Measures

Anticipating potential risks, we incorporate features like automatic shut-off for overheating and safeguards against misuse. Clear customer support channels and repair/replacement policies address defects or malfunctions promptly.

Our approach to health and safety is holistic, encompassing user protection, developer well-being, and liability management while minimizing environmental impact. By adhering to stringent safety standards, integrating sustainable practices, and proactively addressing risks, we ensure that the Wireless 3D-scanning Device is safe, reliable, and environmentally responsible. This commitment reflects our dedication to engineering excellence and ethical responsibility.

XII. Environmental Considerations

It is crucial to evaluate the environmental impact of our Wireless 3D Scanning Device for STL Creation at every stage of its development and production. While creating our device, our team has taken many deliberate steps to minimize the adverse ecological effects while adhering to global sustainability principles and ensuring user safety. This section will outline the steps to ensure our product is not an environmental detriment.

Our 3D Scanner complies with the Restriction of Hazardous Substances (RoHS) directive, which restricts using hazardous materials such as lead, mercury, cadmium, and polybrominated compounds in electronic products. Despite the allowance for trace amounts of these elements (e.g., 1000ppm for most substances), we have eliminated these materials to avoid potential health and environmental hazards. We achieved this by sourcing all electronic components from RoHS-compliant sources, such as the microcontroller, Bluetooth transceiver, and LiDAR scanner. Additionally, we gave special consideration when choosing materials for the scanner's casing and support structures, balancing durability and recyclability.

Our design philosophy applied ease of disassembly and recyclability to enhance the product's sustainability. The scanner is constructed from modular components, facilitating repairs and replacements without requiring specialized tools or expertise. Instead of soldering, which reduces the ease of recycling, we employ screw-fastened connections and color-coded wiring harnesses for assembly. These features empower the user to replace faulty parts while creating minimal waste. This extends the scanner's lifespan and significantly reduces the environmental burden.

Another key aspect the team considered while developing our wireless 3D scanner is the Hannover principles. The main emphasis of these principles is coexisting harmoniously with the natural world and taking responsibility for the environmental consequences our design may have. For instance, we prioritized alternatives with reduced ecological footprints instead of using energy-intensive components or materials prone to creating superfluous waste. The scanner's user interface relies on the paired desktop, eliminating the need for separate displays. This serves the Hannover principles since having a separate display would significantly increase the difficulty of recycling our produce. Our decision to eliminate a separate display minimizes electronic waste and aligns with our objective of creating a long-lasting, environmentally considerate product.

To further quantify our environmental impact, we conducted a Life Cycle Assessment (LCA) comparing potential casing materials for the scanner. We evaluated Acrylonitrile Butadiene Styrene (ABS) and Polycarbonate (PC) for their environmental impact across several metrics, such as energy use, emissions, and end-of-life recyclability. Our analysis yielded better results for polycarbonate in several fields, meaning it has a healthier environmental impact than its alternative.

A core priority of our project is energy efficiency. The scanner integrates a rechargeable battery system optimized for low-power operation. By utilizing the ISO 50001 Energy Management System framework, we identified opportunities to minimize energy consumption through efficient hardware selection and firmware optimization. For example, the LiDAR scanner operates intermittently rather than continuously, reducing energy usage without compromising performance. Additionally, the modular nature of our design ensures that outdated components can be swapped out with more energy-efficient alternatives as they are developed, further emphasizing our scanner's long-term sustainability.

Finally, the project's user manual will guide the user in proper maintenance, responsible disposal of end-of-life components, and sourcing RoHS-compliant replacements. By including this, we emphasize the importance of educating users about sustainable practices. This will foster environmental awareness among users, and in turn, the scanner will contribute further to broader sustainability goals.

In conclusion, our Wireless 3D Scanning Device for STL creation reflects a conscientious environmental awareness and protection approach. Through adherence to RoHS, integration of the Hannover Principles, and the implementation of ISO50001 practices, we have designed a product that minimizes waste, maximizes recyclability and prioritizes energy efficiency. These efforts demonstrate our commitment to creating innovative technology that respects the planet and its inhabitants.

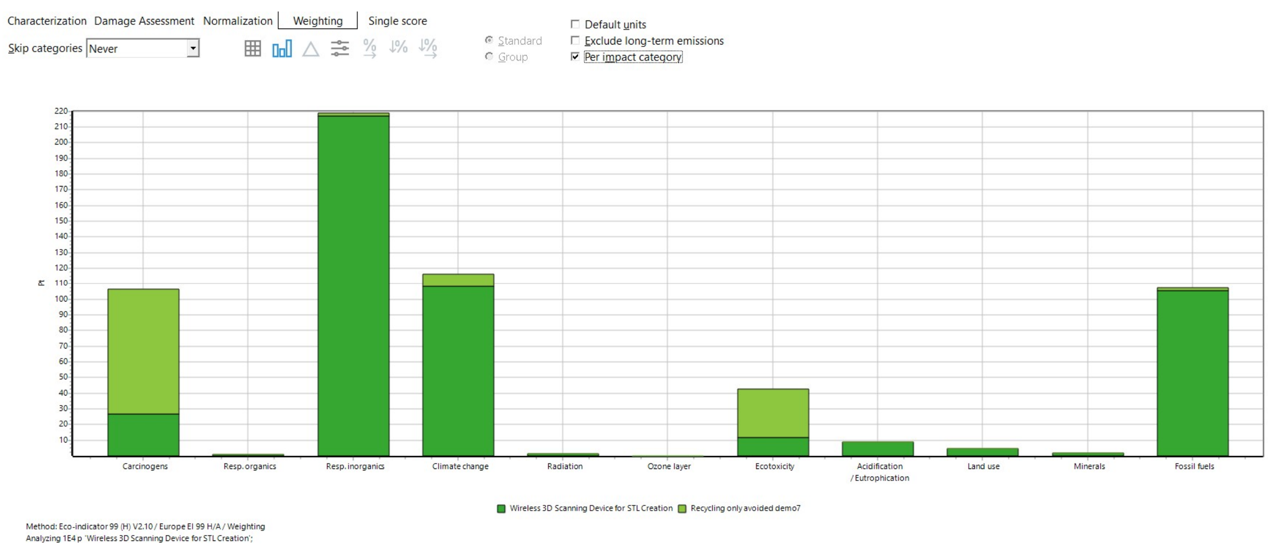


Fig. 16. LCA results for comparing ABS and PC ABS results.

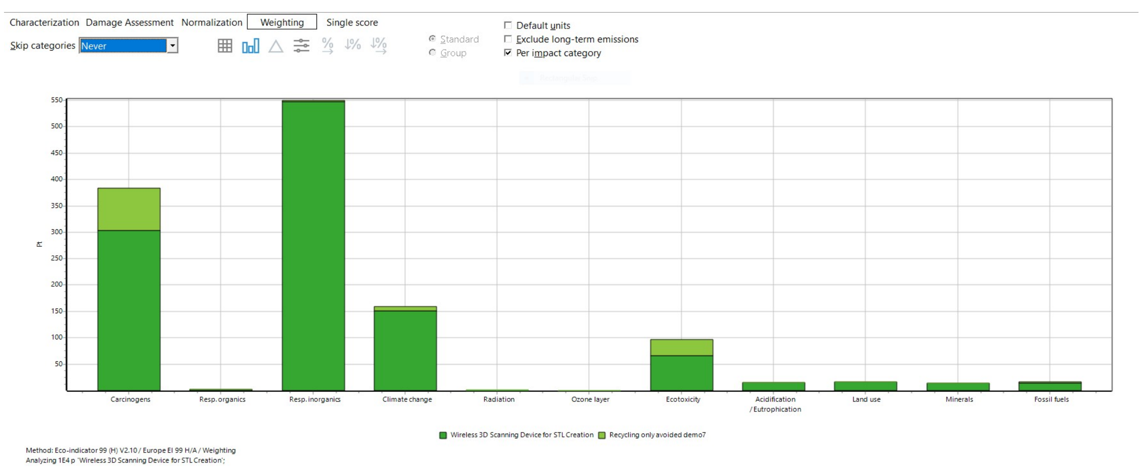


Fig. 17. LCA results for Polycarbonate.

XIII. Sustainability Considerations

Sustainability in design productivity is vital when designing a product to be long-lasting. This principle encompasses every phase of the 3D scanner's lifecycle, from its conceptual design to manufacturing, deployment, and eventual disposal. The objective is to minimize the environmental footprint and create a product that harmonizes with societal expectations for ethical and sustainable practices.

*A. **Hardware:***

As environmental concerns continue to elevate, the need for hardware sustainability grows exponentially. Our 3D scanner incorporates multiple interconnected devices such as a Raspberry Pi, LiDAR scanner, and Bluetooth transceiver, all selected for their energy efficiency and environmental capability. By employing several key strategies, we maximized the sustainability of our product. Firstly, we considered integrating components, combining multiple functionalities within compact hardware, minimizing resource use, and reducing the need for excess components. We also focused on energy conservation via a power-efficient processor and components to lower the system's energy requirements. Finally, we also focused on durability and modularity, allowing for easy repair and replacement. By employing all these strategies, we ensure that the hardware is efficient and aligned with best practices in sustainable product design.

*B. **Software:***

Software plays a vital role in reducing the environmental impact of the 3D scanner. By incorporating a thoughtfully designed code, the device's efficiency can be maximized while minimizing energy consumption. Our approach to sustainable software focuses on three key pillars: reliability, maintainability, and efficiency. We will reduce the need for frequent updates and resource demands over time by writing reliable code. In terms of maintainability, our product will have comprehensive documentation and a modular design philosophy. This will make the code easy for future engineers to understand, adapt, and improve. The efficiency of our algorithm will ensure that processing tasks are completed quickly and with minimal power usage.

When it comes to waste, the primary goal is to eliminate it as much as possible. The 3D scanner is engineered with a modular design that facilitates repair and reuse, reducing the likelihood of premature disposal. The battery and other consumable components are designed for easy replacement, and users are adequately instructed to recycle or dispose of them correctly. Materials were also chosen with the goal of a low environmental impact. The scanner's housing is made from a recyclable polycarbonate, selected for its durability and reduced emissions during production compared to other plastics.

By integrating sustainable practices throughout the design and development process, the 3D scanner sets a benchmark for eco-friendly engineering. It balances efficiency and innovation, creating a product that benefits users, engineers, and the environment. This holistic approach ensures that the scanner remains functional and sustainable throughout its extended life cycle.

XIV. MANUFACTURABILITY CONSIDERATIONS

When designing a product, considering manufacturability will allow the team to make the right choices early into the project. Combating manufacturing issues early on will shorten production time and cost and ensure a smoother transition into the market. Therefore, we will abide by specific manufacturing principles while we design our product:

1. *Simplify the design and reduce the number of parts*
2. *Standardize and use standard parts and materials*
3. *Design for ease of fabrication*
4. *Design for ease of assembly*
5. *Design for testability*

It is important to note that companies will approach their manufacturability considerations differently. While there are many other considerations that we will not discuss, these four provide the most benefit to our device. With these in mind, we will now delve into how each principle will support us in manufacturing a superior product.

1) Simplify the design and reduce the number of parts

Simplifying the design will lend a more user-friendly experience with our product and cut manufacturing costs by reducing the amount of materials needed. One of the project's goals is to enter the 3D-scanning market at a cheaper premium. To achieve this, we avoid data processing within the system and outsource it to an external PC (hardware specifications will be noted in a datasheet). This differs from existing devices where data processing is on the device itself, creating a higher cost. Therefore, the design is greatly simplified as the device is essentially just the camera with a direct USB connection to a microcontroller, and everything is powered via a power supply unit. The number of parts is also minimal. The tangible device has a camera, microcontroller, and power supply. This will contribute significantly to simplifying the overall design.

2) Standardize and use standard parts and materials

Using standardized parts and materials makes a product easier to market than a product with exclusive parts. A general rule of thumb is that if an essential part of your design can be found through another manufacturer, buying from them is better than creating it on your own. An example of our design is the power supply unit. Our team has expertise in power and could be capable of designing a power supply, but many are already in the market with various specifications. Experts design existing products on the market, and with the limited timeframe of this project, we don't share that same caliber of expertise. Therefore, finding one that meets our needs is easy, and we don't have to spend time designing and manufacturing a power supply.

3) Designing for ease of fabrication

Optimizing a product's design entails designing it to be manufactured as efficiently and cost-effectively as possible. Our product will be enclosed in a plastic casing, which can easily be manufactured via 3D printing with a cost-effective filament (e.g., PLA, BS, TPU). Lead times for 3D printing are significantly lower than for outsourcing manufacturing because we have immediate access to the campus. This will lead to faster prototyping of different enclosures to simplify geometries while optimizing the ergonomics of the design. Additionally, the peripheral devices, such as the camera, are connected via USB, making integrating the device with other components a seamless fabrication process.

4) Design for ease of assembly

Designing a product for ease of assembly is very important because it ensures ease of disassembly. This ensures that our product survives post-market by making parts replaceable and allowing users to disassemble the product for testing. Our design is highly modular, consisting of 3 major parts: a camera, a microcontroller, and a power supply. Applying this principle of manufacturability coincides with the environmental initiatives discussed in this proposal. The design's modularity will result in fewer parts, leading to less waste. The peripheral components require a unique disposal protocol, making the modular design even more crucial in aiding the environmental impact of our product.

5) Design for testability

During the manufacturing processes, many products undergo a testing phase. In this phase, the products are ensured to work correctly through a manual protocol or a bootup sequence. The device must verify that it is capturing within the specified resolution and working distance and linked to a wireless network for data transfer. Since every device has a camera and a microcontroller, this functionality must work as efficiently as possible before entering the market. If the user experiences an error with the product, the manufacturability principle for designing for assembly will immensely aid in testing the product due to the device's modularity.

Companies that employ their considerations for manufacturability can see substantial benefits such as reduced cost and lead times, improved product reliability, stronger competitive positioning, and overall quality and service improvement. However, as a company, money can be seen as the most crucial factor. Therefore, it's essential to consider these factors for manufacturing early on in the product's development. By the time 8% of a budget is spent on a product's design, 80% of the final cost has been determined. By addressing this, we can make crucial steps to mitigate the final cost while preserving the quality of our device.

XV. Ethical Considerations and Social Impact

The development of modern technology, particularly in engineering projects, comes with significant ethical responsibilities. In our project, the Wireless 3D-Scanning Device for STL Creation, ethical considerations are paramount due to the potential implications for data privacy, environmental sustainability, intellectual property rights, and the unintended consequences of widespread use. These issues are compounded by the growing societal reliance on digital tools and the emerging global challenges surrounding technology's role in daily life. Addressing these concerns in the initial stages of development is essential to ensure that the final product is both beneficial and ethically sound.

*A. **Ethical Considerations***

Our project aligns with the IEEE Code of Ethics, the foundation for our ethical decision-making. The code ensures that engineers uphold integrity, transparency, and accountability throughout the project lifecycle. We adhere to IEEE's Canon 1, which emphasizes the public's safety, health, and welfare, and Canon 3, which focuses on honest public statements and providing professional guidance based on facts. These principles guide the project's design, development, and potential societal impacts:

1) To hold paramount the safety, health, and welfare of the public, to strive to comply with ethical design and sustainable development practices, and to promptly disclose factors that might endanger the public or the environment;
2) To avoid real or perceived conflicts of interest whenever possible and to disclose them to affected parties when they do exist;
3) To be honest and realistic in stating claims or estimates based on available data;
4) To reject bribery in all its forms;
5) To improve the understanding by individuals and society of the capabilities and societal implications of conventional and emerging technologies, including intelligent systems;
6) To maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience or after full disclosure of pertinent limitations;
7) To seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit appropriately the contributions of others;
8) To treat fairly all persons and to not engage in acts of discrimination based on race, religion, gender, disability, age, national origin, sexual orientation, gender identity, or gender expression;
9) To avoid injuring others, their property, reputation, or employment by false or malicious action;
10) To assist colleagues and co-workers in their professional development and to support them in following this code of ethics.

One of the critical ethical concerns with our Wireless 3D-scanning Device is data privacy and intellectual property. Since the device can scan physical objects and convert them into digital files, there is a risk of users unintentionally or maliciously violating copyright and patent laws. Although our device will incorporate warning systems to alert users of potential legal infractions, more is needed to eliminate the ethical challenges of misuse.

Despite these measures, a significant ethical dilemma must be resolved solely by referencing the IEEE Code of Ethics.

The dilemma arises from the potential misuse of the scanning device to create unauthorized replicas of patented or copyrighted objects, leading to intellectual property infringement. Although users are responsible for following copyright laws, the availability of such technology lowers the barrier to unethical practices, creating an ongoing ethical concern about how much control we, as developers, should exert over how the device is used.

We apply the Theory Model to resolve this dilemma, which helps us weigh potential options based on their ethical consequences. Here are four options we considered:

TABLE XVIII. OPTIONS TO RESOLVE ETHICAL DILEMMA

Options	Description
1	Strict Control Mechanisms: object recognition software that flags copyrighted items and prevents the scan from being completed.
2	User Education and Responsibility: Allow users full access to the scanning features but require them to acknowledge ethical use guidelines and potential legal ramifications before using the device.
3	Moderate Control: Display a warning that flags potential copyright violations without blocking the scan but informs the user of possible consequences.
4	Third-Party Monitoring: Partner with legal authorities or organizations to monitor the use of the device for illegal activities.

TABLE XIX. SCORE DISTRIBUTION OF ETHICAL THEORIES

Option #	Utilitarianism	Ethical Egoism	Kantian Ethics	Rights Ethics	Total Score
1	0.75	0.50	0.75	0.50	2.50
2	0.50	0.75	0.50	0.75	2.50
3	0.75	0.50	0.75	0.75	2.75
4	0.75	0.25	0.50	0.50	2.00

TABLE XIX uses the Ethical Theory Model to evaluate each option's alignment with the IEEE Code of Ethics. After carefully considering Utilitarianism, Ethical Egoism, Kantian Ethics, and Rights Ethics, the Moderate Control approach (Option 3) offers the best. It allows users to explore the technology while promoting responsible use and offering guidance when ethical issues arise.

*B. **Social Impact***

Our project can make significant contributions to local and global communities. We have gathered valuable insights into how this technology could influence various cultural contexts based on feedback from surveys conducted with local students and faculty and conversations with different contacts.

Regarding local culture, our device empowers small businesses and academic institutions by democratizing access to advanced 3D scanning technologies. For instance, local artisans and manufacturers could use the Scanner for rapid prototyping and product development, accelerating innovation in the community. Schools and universities, particularly in underserved regions, could benefit from the affordable technology for teaching STEM subjects, enabling students to gain hands-on experience with cutting-edge tools.

Globally, the impact of this device extends to industries in developing countries where access to 3D scanning technology is limited. Our project could support economic growth in areas that rely on manufacturing and design industries by providing a low-cost alternative. Moreover, international collaborations in education, research, and small business development could be enhanced by this more accessible technology, fostering global innovation.

Sebastian Deterding's talk, "What your designs say about you," raises important questions about the intentions and values embedded in our design. At the core of our project is the desire to democratize access to 3D scanning technology. We envision an affordable, efficient, and ethically sound tool promoting responsible innovation. By offering this device, we encourage creativity and innovation in education, manufacturing, and healthcare.

However, with these intentions come both intended and unintended effects. While our primary goal is to provide a tool for innovation and education, there is the unintended risk of misuse in creating counterfeit products or bypassing intellectual property laws. To address this, we have designed mechanisms to promote ethical use, but it is essential to acknowledge that not all consequences can be foreseen.

The values driving our project—innovation, accessibility, and responsibility—guide our decisions at every stage of development. These values align with our vision of promoting a good life through technology: a life where individuals, businesses, and communities can use innovative tools to improve their quality of life and foster a culture of innovation while adhering to ethical principles. By reflecting on the societal impacts of our device, we aim to create technology that benefits all while minimizing harm and promoting the responsible use of modern technologies.

XVI. CONCEPT DEVELOPMENT

In developing any engineering project, mainly one as complex as our Wireless 3D-scanning Device, considering multiple design alternatives is essential. This section aims to allow us to identify the most effective solution by weighing the advantages and disadvantages of each option. For our project, we explored three potential design approaches, each focusing on different scanning technologies and wireless communication methods. This evaluation was crucial for determining the best way to meet our accuracy, cost-effectiveness, and efficiency goals.

Fig. 18 is our concept fan for the Wireless 3D-scanning Device, which illustrates the multifaceted nature of the project. It serves as a visual representation of the different components, technologies, and methodologies involved. The primary concept revolves around a wireless 3D scanning technology that creates accurate STL files from physical objects. The concept fan highlights the diversity of options and factors to consider in developing a comprehensive, practical, and user-friendly wireless 3D scanning device.

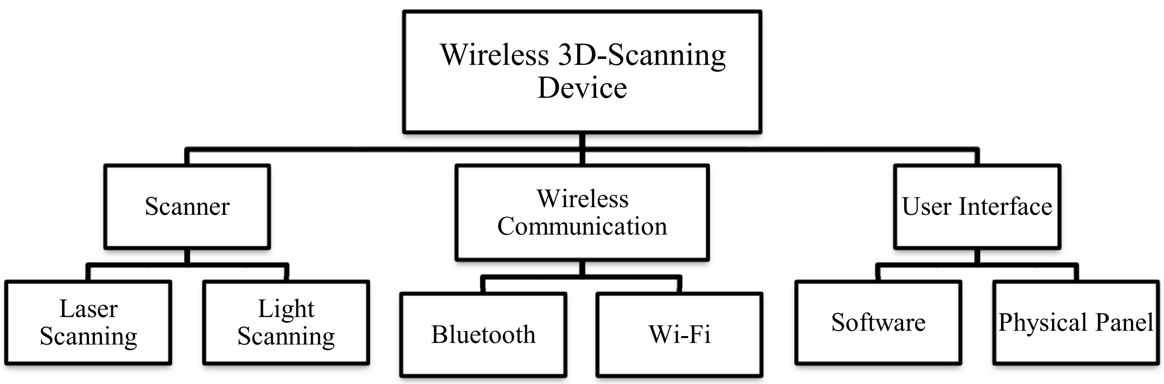


Fig. 18. Concept Fan

A. *Alternative Options*

While there are eight combinations, our team has decided to consider the four best combinations for our goal. The combination table is the second step in the concept development process. In the following figures, we will highlight the advantages and disadvantages of each approach.

1) Alternate Option 1

Alternate Option 1 combines the high accuracy and speed of laser scanning with the wireless flexibility of Bluetooth connectivity and the processing power of desktop software. Laser scanning is widely regarded as one of the most precise methods for 3D object capture, making it ideal for applications requiring detailed surface and geometric data. By pairing this with Bluetooth, users can conduct scans without being tethered to their desktops, increasing mobility and ease of use in various environments. Desktop software provides an intuitive platform for managing and refining scan data, ensuring the system is robust and user-friendly. This combination is particularly suitable for projects where both precision and flexibility are critical.

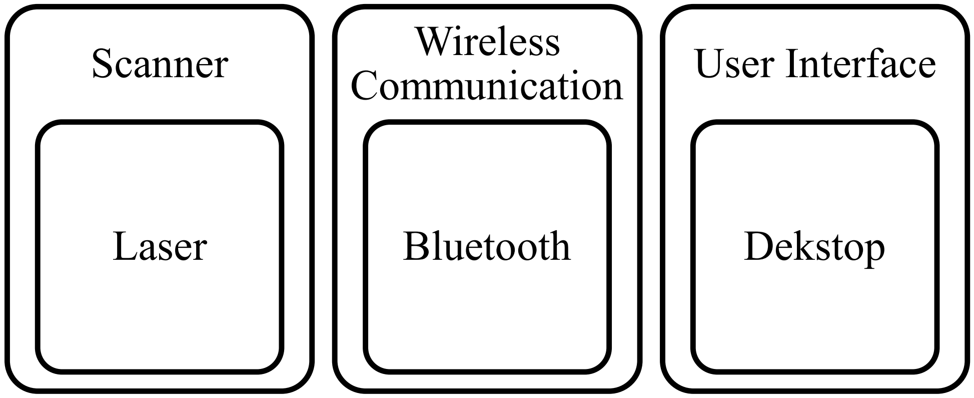


Fig. 19. Option 1

b. Advantages

Laser scanning offers high precision and rapid data acquisition, making it ideal for capturing complex geometries with minimal errors. Bluetooth integration provides wireless flexibility, allowing users to move freely around the scanning area without being hindered by cables. The desktop software offers a user-friendly interface for processing and refining 3D models, making it accessible even for those without extensive technical expertise.

c. Disadvantages

The setup for laser scanning can be complex, requiring calibration and technical knowledge, which may slow initial project progress. While offering wireless convenience, Bluetooth has a limited range and can suffer from interference or latency, which may hinder real-time monitoring or disrupt data transfer during more significant projects.

2) Alternate Option 2

Alternate Option 2 combines laser scanning, Wi-Fi connectivity, and a physical control panel. Laser scanning technology provides highly detailed and accurate scans, making it ideal for manufacturing, engineering, and design industries. The addition of Wi-Fi allows for seamless and fast data transfer, enabling real-time monitoring and analysis. Meanwhile, a physical control panel offers a tactile, hands-on interface for controlling the scanning process, giving users immediate feedback and greater control. This combination is well-suited for projects requiring precision and the ability to make real-time adjustments during scanning.

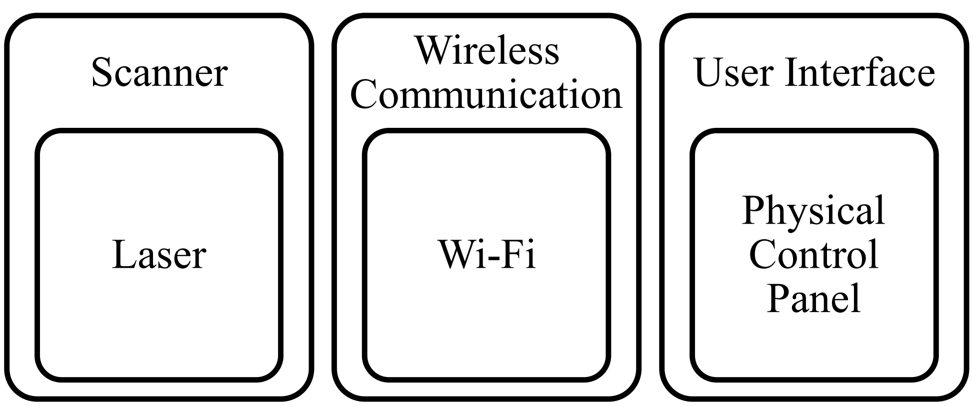


Fig. 20. Option 2

d. Advantages

Laser scanning combined with Wi-Fi allows for seamless, high-speed data transfer, making real-time monitoring and quick adjustments possible. The physical control panel offers a tactile, intuitive interface that enables precise, on-the-fly adjustments during scanning, enhancing control over the process and scan quality. Wi-Fi connectivity adds flexibility, allowing for a more mobile and streamlined scanning experience.

e. Disadvantages

Wi-Fi, while offering a broader range and faster data transfer compared to Bluetooth, is more susceptible to signal interference from other devices, which could disrupt connectivity. Additionally, the physical control panel takes up more physical space and can complicate the setup, making it less convenient in tighter or more mobile work environments.

3) Alternate Option 3

Alternative three focuses on combining the cost-effective nature of light scanning with the wireless convenience of Bluetooth and the processing capabilities of desktop software. Light scanning is less expensive than laser scanning, making it an appealing choice for projects with budget constraints requiring decent detail capture. Bluetooth offers wireless flexibility, allowing users to move around during scanning without being tethered by cables. Using desktop software ensures that the data collected can be processed efficiently and refined as needed. This setup is ideal for teams seeking an affordable yet functional solution for more straightforward 3D scanning tasks.

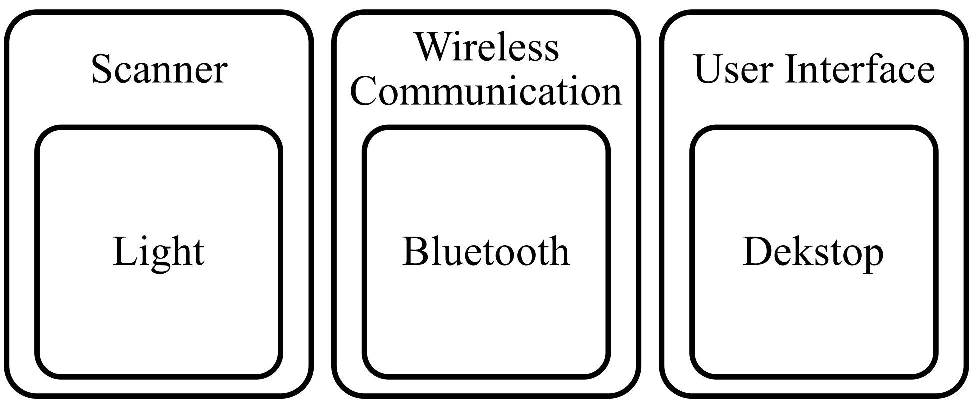


Fig. 21. Option 3

f. Advantages

Light scanning is a cost-effective alternative to laser scanning, providing decent detail capture at a lower price point. Bluetooth offers wireless freedom, allowing users to move around while scanning, and the desktop software ensures that data can be processed and refined quickly. The simplicity of light scanning makes it more accessible to users with less technical expertise, offering an intuitive setup.

g. Disadvantages

Light scanning needs to improve the precision of laser scanning, which can be a significant drawback for applications requiring high accuracy. Bluetooth's limited range and susceptibility to interference may also disrupt the scanning process, leading to delays or poor-quality data transfer.

Light scanners are also more sensitive to ambient light, affecting scan quality in specific environments.

4) Alternate Option 4

Option four's combination leverages the affordability of light scanning with the fast and reliable connectivity of Wi-Fi and the practical control provided by a physical panel. Light scanning offers a good balance of cost and detail capture, making it a popular choice for many applications, particularly those that do not require extremely high precision. With Wi-Fi, users benefit from faster data transfer and more excellent range than Bluetooth, which allows for a more fluid and efficient workflow. The physical control panel provides a hands-on interface that makes adjusting scanning settings in real time more effortless, enhancing user control and scan quality. This setup is ideal for projects that need cost-effective scanning with real-time control and monitoring capabilities.

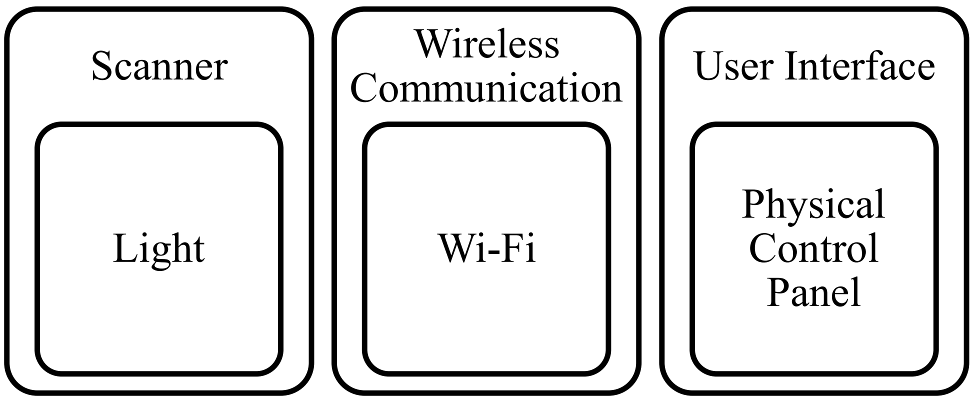


Fig. 22. Option 4

h. Advantages

The combination of light scanning with Wi-Fi provides faster and more reliable data transfer compared to Bluetooth, allowing for real-time adjustments and improved workflow. The physical control panel offers hands-on operation, giving users direct control over the scanning process, making it easier to adjust settings mid-scan and optimize results. Light scanning is also more affordable, making it accessible for smaller projects or budget-conscious teams.

i. Disadvantages

While more affordable, laser scanning offers a different level of precision than laser scanning, which may limit its applications. Though more stable than Bluetooth, Wi-Fi can still be vulnerable to interference, disrupting scanning operations. Additionally, a physical control panel adds to the equipment setup, requiring more space and potentially complicating the user's mobility during the scanning process.

To select the best alternative for our project, it is first necessary to compute the relative importance of each of the objectives, as TABLE XX shows. The G mean (1) is calculated to determine the relative importance of the objectives, with the higher number being the most important. Equation (2) is used to determine the weight/importance of each objective. Once we know the most important goals of our project, we can check the advantages and disadvantages once more and decide which is the best alternative for our project.

Importance Scale: 1 = equal, 3 = moderate, 5 =strong, 7 = very strong, 9 = extreme

$$G.Mean = (A_1 \times A_2 \times A_{3\ldots} \times A_n)^{\left(\frac{1}{N}\right)} \quad (1)$$

$$w = G.Mean/total \quad (2)$$

TABLE XX. WEIGHT CALCULATION TABLE

	Ease of Use	**User-Friendly Interface**	**Accuracy**	**Cost**	**Latency**	**Portability**	**G. Mean**	**w**
Ease of Use	1	7	3	5	3	7	3.61	0.22
User-Friendly Interface	7	1	1	5	1	5	2.37	0.14
Accuracy	3	1	1	5	5	3	2.47	0.15
Cost	5	1	5	1	3	5	2.69	0.16
Latency	3	1	5	3	1	3	2.26	0.14
Portability	7	5	3	3	3	1	3.13	0.19
Total							16.53	

TABLE XXI represents the concept selection method. Where we score each alternative based on how well it meets each criterion. The Concept Selection table is used in engineering design to systematically evaluate and compare different design alternatives based on predefined criteria. This approach ensures that the decision-making process is objective and transparent, allowing us to choose the best design option that fits the project's requirements.

TABLE XXI. CONCEPT SELECTION TABLE

Constraints		**Option 1**		**Option 2**		**Option 3**		**Option 4**	
Low-Cost		Yes		Yes		Yes		Yes	
Battery-Latency Balanced		Yes		Yes		Yes		Yes	
Portable		No		No		Yes		Yes	
Objectives	**w**								
Ease of Use	0.22	4	0.88	3	0.66	5	1.1	4	0.88

User- Friendly Interface	0.14	4	0.7	3	0.42	4	0.7	5	0.7
Accuracy	0.15	5	0.75	5	0.75	3	0.45	3	0.45
Cost	0.16	2	0.32	3	0.48	4	0.64	5	0.8
Latency	0.14	5	0.7	4	0.56	3	0.42	3	0.42
Portability	0.19	3	0.57	2	0.38	5	0.95	4	0.76
Total			3.92		3.25		4.26		4.01

According to TABLE XXI, the best option is Option 3, as it satisfies all constraints and provides the highest total score, making it the most viable approach to pursue out of the four options.

We explored a wide range of potential solutions for our 3D scanning device through concept development, starting with creating a concept fan to identify various scanning methods, communication technologies, and user interface options. This structured approach allowed us to visualize different combinations of technologies, gradually narrowing our focus to the most viable alternatives. We could pinpoint the combinations that aligned most closely with our project goals by systematically considering laser and light scanning technologies, Bluetooth and Wi-Fi connectivity, and desktop software and physical control interfaces.

The combination table, which followed the concept fan, enabled us to evaluate the performance of each alternative by breaking down how well each concept fit our design criteria—cost, accuracy, speed, and usability. This helped us see that while laser scanning offered higher accuracy, its cost was prohibitive compared to light scanning, which provided an acceptable level of precision while being more affordable and portable.

By employing these concept development tools, our team was able to take an iterative approach to refining our options. This structured development allowed us to quantify and compare various trade-offs, helping us balance performance and practicality. Ultimately, Option 3 emerged as the best choice. The decision was based on a combination of factors, including its cost-effectiveness, ease of use, and wireless flexibility, aligning with the project's objectives. The concept development process was invaluable in helping us navigate the complexity of our design choices and ensuring we selected the alternative that provided the most value for our project.

We selected the third option during our first semester, which employed Bluetooth and desktop software. It appeared to be the most viable approach as we advanced, but performance constraints, hardware availability, and optimization considerations forced us to change and pivot.

We selected the Intel Realsense D415 camera, which employs structured light scanning. This offered us a more professional resolution and was a better match for real-time depth map capture. Furthermore, after evaluating several different computing platforms, we changed our initial decision to employ the Jetson Nano to the Raspberry Pi 5. This was primarily due to procurement delays. It would take to procure it from the manufacturer would take over 5 months. Changing to the Raspberry Pi 5 enabled improved support and integration flexibility while keeping costs within budget.

While we initially investigated employing Bluetooth for its simplicity and portability, we ultimately had to pivot to using Wi-Fi and cloud integration via Azure. Employing Wi-Fi permitted us to achieve quicker, stable, and scalable data transfer, especially when working with a large point cloud generated by the RealSense camera. This change allowed us to better align with our original goals for portability and latency.

Initially, desktop software was selected as the medium for processing the scan data. However, as the design matured, we expanded the system to include a 7" touchscreen display connected directly to the Raspberry Pi for real-time monitoring and control of data. Data processing occurs by acquiring initial depth data locally, while machine learning and post-processing are done on the cloud. This offloads the intensive reconstruction work.

Machine learning for scan optimization has been employed to reduce noise and refine the captured data.

XVII. End Product Description and Other Deliverables

The Wireless 3D Scanning Device is a next-generation tool that provides accurate, efficient, and user-friendly scanning solutions for various applications. This section details the final product's functions, specifications, and deliverables, comprehensively understanding its capabilities and intended outcomes. The focus is on illustrating how the end product meets the identified needs of users and clients while adhering to technical constraints and market demands.

By adhering to these outlined parameters, we aim to deliver a product that meets the expectations of clients and users and sets a new standard for innovation and practicality in 3D scanning technology.

A. ***End Product Description***

An end product description provides a detailed overview of what the Wireless 3D Scanning Device does and how it achieves its functionality. This section aims to describe the device comprehensively, including its components and functions, to ensure clarity for designers and usability for end users who wish to understand its intricacies.

The Wireless 3D Scanning Device is designed to scan physical objects accurately and transfer the RGB and depth frame streams to a desktop interface for further processing. On the desktop interface, the frames will be processed into a 3D model and undergo post-processing via a machine learning model to properly eliminate noise within the image and background. This device comprises a cohesive system that provides efficient and accurate scanning capabilities through sensors, a microcontroller, and a user interface.

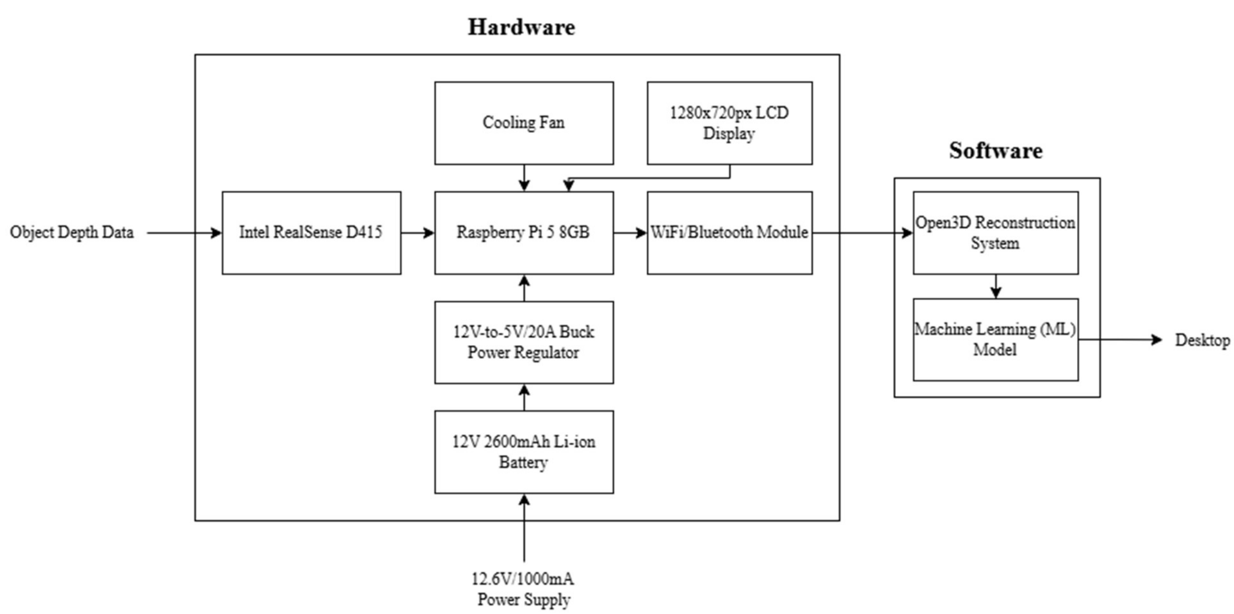


Fig. 23. Block Diagram of Wireless 3D Scanning Device, including Hardware and Software components

Figure 23 illustrates the internal architecture of the Wireless 3D Scanning Device and breaks it down through hardware and software components. In the hardware section, the Intel RealSense

D415 camera records frames from its stereo and RGB modules and outputs a .bag file, a zipped file that contains all the frame data. The user can access the live stream data from the LCD, rename the file, and playback the recording before sending it to the Raspberry Pi 5. The Raspberry Pi, powered by a lithium-ion battery, packages this data and communicates with the Azure cloud platform to send the data for processing. This is achieved through key verification to ensure that information can only be sent from a trusted source. The .bag file the camera generates on the cloud platform will be unzipped and processed via a Python script through Open3D's reconstruction system pipeline. Once the model is reconstructed, the machine learning model will clean up noise and unnecessary information. Then, the 3D model (currently in PLY format) will be ready for the user to access on their desktop and can be exported to other popular formats.OBJ and .STL.

Fig. 24. Back (left) and front (right) faces of the Wireless 3D Scanning Device.

The end product can be seen in its physical form in Figure 24. The robust housing and ventilation on the backplate allow the electronics to have proper airflow and house our battery and power converter. All scanning features, such as pre-processing optimization, firmware updates, and WiFi network connectivity, will be accessed by the user on the LCD screen. The green button cuts off power from the device since the Raspberry Pi is continuously connected to power; however, the user may shut down the device on the screen if they wish. Due to the wireless nature of the device, the user will be indicated when the power is low so that they may charge the device for use (currently runs for 2-3 hours).

B. ***Functions and Specifications***

To accurately represent the Wireless 3D Scanning Device, we will explain its operation through diagrams and describe each subsystem in detail. This will help us better understand how each subsystem works within itself to operate within the device and other subsystems.

1) Scanning Module

The scanning module comprises the Intel RealSense D415 camera, which enables capturing depth data from an object. This module uses stereo vision to produce depth maps by analyzing the disparity between the images from the two cameras. The device can be configured to stream at up to 90fps, 1280x720px (depth output), and 1920x1080px (RGB output). However, our 3D Wireless Scanning Device streams at 30fps and 1280x720px for the RGB output to optimize resolution and CPU utilization. The scanning module's primary function is to capture frames and depth data from an object in the real world and package the data to transfer to the processing unit. With a depth range from 0.5m to 3m and achieving ±2% accuracy at 1 meter, this camera is well equipped for high-level detail, especially for medium-sized objects.

2) Processing Unit (Raspberry Pi)

The processing unit comprises the Raspberry Pi 5, a WiFi/Bluetooth module, and an LCD. Acting as the "brains" of the device, it receives the stream data from the scanning module and packages it into a .bag file. This .bag file is sent via the WiFi/Bluetooth module to Azure, a cloud platform. The Raspberry Pi is also used to run the underlying Python and C++ scripts to ensure data capture, data transfer, and a user-friendly interface. The user's capacitive touch inputs on the LCD trigger specific events that the Raspberry Pi interprets. The main functionalities that the user can control via the LCD are starting a scan, editing the camera intrinsics, and connecting to WiFi.

3) LCD Display

The LCD Display was incorporated to make the device easy to operate. It provides an intuitive display that allows the user complete control over the scanning process. The interface lets users start and stop scans, adjust scanning settings (such as resolution or scan mode), and view real-time feedback. The primary function of the LCD Display is to provide users with a seamless experience, where they can monitor the scan's progress, receive status updates, and be alerted to any potential issues (e.g. if the object is not correctly aligned). The screen also provides an interface for users to interact with the system, making it straightforward to operate without complex configurations.

4) WiFi/Bluetooth Module

The WiFi/Bluetooth Module transmits the stereo stream to Azure for further analysis, storage, or use. By using both WiFi and Bluetooth, the module enables seamless data transmission without the need for physical connections. The primary function of this subsystem is to wirelessly send the stereo stream to a desktop or cloud-based system. This provides users with flexibility, allowing them to work with the scanned data on their preferred platform or share the data remotely. The communication module ensures fast and secure data transfer, enabling real-time updates and the ability to continue working on the models immediately after scanning.

5) Power Supply

The power supply is a critical subsystem that ensures the entire device remains operational. It comprises a lithium-ion battery, a buck regulator, a power supply, and a cooling fan. It converts wall output to 12V DC, which the buck converter regulates to a stable 5V DC and 20A. This power supply unit is designed to provide a consistent 5V, which is necessary for the Raspberry Pi to supply sufficient amperage to its USB connections (scanning module and LCD). The power supply unit is also equipped with overhead to ensure the device can perform optimally without risk of power loss during operation. Since the device is powered via a lithium-ion battery with 2600mAh, the device can only run for 2-3 hours wirelessly, which is sufficient for jobs off-site that necessitate our 3D scanning technology. The constant power output is also essential, as lowered voltages can cause more noisy scans on the scanning module. If the battery drops to roughly 4.63V, the user will be indicated as having lower power levels. However, this lowered voltage (compared to a typical 5V) is sufficient to provide optimal scans until a recharge with our 12.6V power supply wall connector.

6) Cloud Platform

The cloud platform Azure is paramount to the functionality of our device. It consists of Open3D's reconstruction system and a machine learning model for post-processing. Once the .bag file has been transferred to Azure, it begins to be processed using Open3D. The stereo frames are extracted and stitched into fragments, each containing 100 frames. These frames undergo point cloud generation and get converted into a 3D reconstruction. The algorithm uses the pose information from the scan to estimate where the frames exist in real space, creating an accurate 3D model. Finally, once the scene has been reconstructed, the model passes through a machine-learning algorithm to eliminate as much noise as possible. This cleaned-up model is then transferred to the user's desktop, where they can view it in popular file formats.STL, .OBJ, and .PLY.

7) Open3D Reconstruction System

Open3D is a library for 3D data processing equipped with a reconstruction system pipeline for ROS data, which integrates with our scanning module. The main workflow of the Python scripts is to generate fragments of 100 frames each, create them into point clouds controlled by a configuration file, stitch together the scene, and integrate the RGB frames. The configuration file, *realsense.json*, has important parameters that can alter the quality of the reconstruction. Some parameters, such as *voxel_size* and *tsdf_size*, impact the volumetric region-of-interest (ROI) and point cloud accuracy, which can increase computational time. Other parameters, such as *preference_loop_closure_odometry* and *preference_loop_closure_registration*, can optimize the pose graph consistency during stitching, impacting how much adjacent and duplicate frames impact the final reconstruction.

8) Machine Learning (ML) Model

The machine learning model enhances the accuracy of 3D scan outputs by performing automated noise reduction on raw point clouds. It is implemented as a denoising autoencoder trained in Azure Machine Learning using PLY files captured from the RealSense D415 camera. The model receives the noisy input and learns to reconstruct a cleaner version by minimizing the point-wise difference between the noisy and clean data during training. This process improves point cloud fidelity without requiring manual filtering or mesh cleanup. Once trained, the model runs in the cloud and is triggered after each scan. Its output is stored in the Azure Blob container and can be converted into user-specified formats like STL, OBJ, or CAD for download. This subsystem improves the usability of 3D models in CAD software while preserving the lightweight, wireless nature of the device.

The Wireless 3D Scanning Device operates as a fully integrated system, with each subsystem playing a crucial role in achieving its primary function: capturing, processing, and transmitting 3D model data. Together, these functions enable users to quickly and easily scan objects, process the data, and use the results in various applications, from 3D printing to digital modeling.

TABLE XXII below shows the specifications for each of the significant components of the wireless 3D scanning device.

TABLE XXII. FUNCTIONS AND SPECIFICATIONS

Component	Input	Output	Functionality
Scanning Module	Object depth data	Stereo camera stream	Captures precise spatial data of the object using stereo vision sensors.
Processing Unit	Stereo camera stream, Power Supply	.bag file	Processing stereo stream to be wirelessly transmitted to a cloud platform
User Interface	User commands	Operational feedback	Allows users to interact with the system, control scanning settings, and view real-time progress.

Wireless Communication	.bag file	Transmitted data	Wirelessly transmits the stereo stream to external devices for further processing or storage.
Power Supply	12.6V DC input	Stable 5V DC power to all subsystems	Ensures consistent operation of the device. Optional battery backup provides portability and uninterrupted functionality.
Cloud Platform	.bag file	.PLY/.STL/.OBJ file	Reduces noise, calibrates measurements, and converts raw data into a usable 3D model. Supports advanced features like object recognition and background removal.

*C. **Other Deliverables***

In addition to the completed Wireless 3D Scanning Device, the following deliverables will be provided:

1) User Manual

A comprehensive user manual detailing the setup process, operation instructions, and user troubleshooting tips will be developed. It will also cover maintenance and safety information.

2) Prototype Demonstration Video

A video demonstration of the working prototype will be created to showcase the device's functionality, scanning process, and user interface.

3) Testing and Validation Report

A detailed report on system testing will be provided, outlining the functional, performance, and reliability tests conducted to validate the device's effectiveness.

The End Product Description and Other Deliverables section encapsulates the essence of the Wireless 3D Scanning Device, offering a clear vision of its capabilities, components, and functionality. Through detailed descriptions and visual representations, we have outlined how the device operates as a cohesive system to meet the diverse needs of users and clients. Each subsystem—from the Scanning Module to the Wireless Communication Module—is critical in delivering high-precision 3D models efficiently and effectively.

The accompanying deliverables, including the user manual, promotional materials, and validation reports, complement the device by ensuring ease of use, market readiness, and reliability. Together, these elements form a complete package that fulfills technical and user requirements and exemplifies innovation and practicality in 3D scanning technology. With this robust foundation, the Wireless 3D Scanning Device is positioned to deliver exceptional value and impact across various applications.

XIX. Plan of Action

Delegated tasks to optimize limited timeframes are essential to obtaining a deliverable product. Therefore, a plan of action was implemented to outline crucial milestones for the overarching project, assign responsibilities to each team member, and provide a breakdown of the work needed. This action plan was a living guide throughout the project, regularly adapted to reflect technical and logistical changes, ultimately leading to a completed and demonstrable product.

*A. **Statement of Work (SOW)***

A Statement of Work (SOW) defines the framework for the project. It detailed the scope, tasks, and necessary deliverables and defined deadlines to be met. Over time, modifications were made to the original plan, particularly regarding the scanning method and data processing techniques.

1) Scope of Work

Initially, the product was expected to use Structured Light Scanning (SLS) technology. However, after evaluating feasibility, the team used the Intel RealSense D415 depth camera to simplify design and improve reliability. The Raspberry Pi 5 was the central processing hub, capturing and uploading data to Azure for machine learning-based cleanup. The end goal remained: a wireless, portable device that delivers STL-ready files with minimal user intervention.

2) Location of Work

From November 2024 to December 2024, initial research and planning were conducted remotely. Subsequent phases, including hardware assembly and testing, were completed at Florida International University's Engineering Center. Software development and ML model training continued on campus and remotely, allowing flexible collaboration across team roles.

3) Period of Performance

The project ran from August 2024 to April 2025. The preliminary proposal was completed by December 6, 2024. Hardware integration and code development spanned from January to April 2025, with optimization and testing continuing through late April.

4) Deliverables Schedule

The crucial outputs and deadlines can be structured as follows:

- Final proposal (Senior I): December 6, 2024
- The final draft of schematics: January 6, 2024
- Integration of hardware and initial testing: January-February 2025
- Core software development and cloud setup: February-March 2025
- AI/ML model training and optimization: March-April 2025

5) Responsibilities

The team comprised multiple engineering disciplines, including electrical, computer, software, telecommunications, and power. Over the course of the project, specific responsibilities shifted slightly in response to design changes. The roles given to each team member are shown below:

- Team Leader: Oversaw task delegation and scheduling. Supported both hardware and software teams.

- Hardware Designers: Handled component selection, power regulation, wireless communication, and camera integration.
  - Power: Ensured that the device was adequately powered. The primary consideration was voltage regulation to ensure that each part of the circuit would be fed with its respective voltage rating.
  - Wireless: Ensured the device is correctly linked to an external PC for data transfer. The primary consideration was connecting via wireless protocol (WiFi).
  - Camera Integration/Scanning Technology: Ensured the camera was connected correctly and the scanning technology worked. The primary consideration was confirming that the microcontroller was capturing data.
- Software Designers: Developed Python scripts for data acquisition, managed PLY file generation, and created the ML pipeline in Azure.
  - AI/ML Model: Developed the AI/ML model using algorithms such as decision trees, DBSCAN, SVM, and Kalman filter. The primary consideration was ensuring that the ML model properly removed noise from the 3D scan and efficiently captured data points from the object.
  - 3D Modeling: The data acquisition and processing code was developed. Libraries like Open3D were used to work with 3D data and train ML models to remove noise. The librealsense library interfaced with the Intel RealSense depth camera, which was used for data capture.

*B. **Work Breakdown Structure (WBS)***

The Work Breakdown Structure (WBS) provided the team with an efficient hierarchical framework that laid out the project’s tasks, phases, and milestones. The team used deliverables-based WBS, highlighting the project's tangible outputs, such as hardware components and software milestones. The total percentage of all tasks at each phase is up to 100%. Although the significant phases remained consistent, specific tasks evolved throughout development.

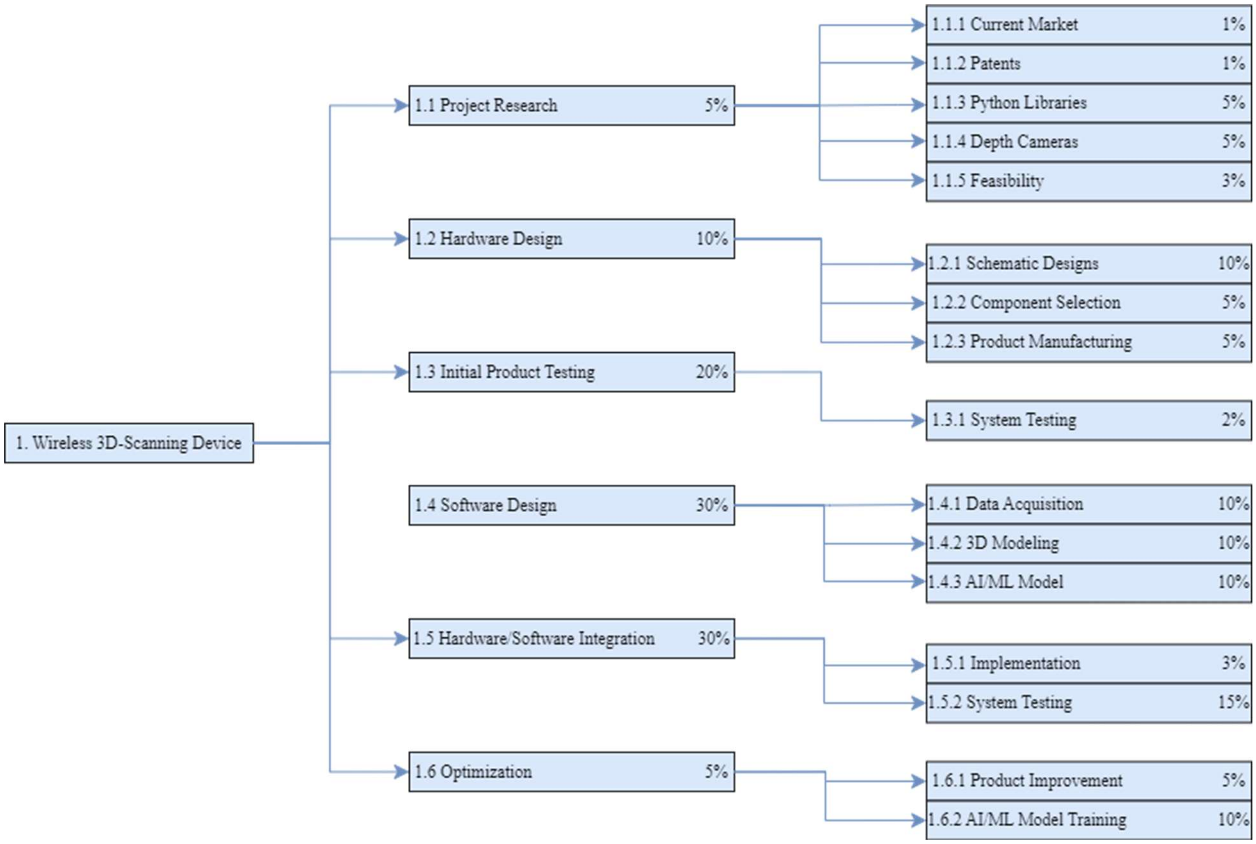


Fig. 25. Workbench Breakdown Structure (WBS)

1) Phase 1.1: Project Research

- Objective: Assess feasibility and gather required background information
- Approach: To ensure the project can be completed, we will research what significant components we need (i.e., microcontrollers, camera, power supply). Additionally, we will ensure that our project does not infringe on existing patents and follows an ethical code of conduct.
- Adjustments: The research confirms that our design does not infringe on existing patents and is a feasible project.

2) Phase 1.2: Hardware Design

- Objective: Design schematic diagrams for different hardware sections (power, wireless, peripheral integrations).
- Approach: The power schematic will be dedicated to the power specifications of the microcontroller (RPi) and the camera (Intel RealSense). The wireless schematic will utilize the WiFi/Bluetooth capabilities of the RPi. The peripheral integrations can be found via the many inputs on the RPi.

- Adjustments: Additional casing modifications were made mid-project to accommodate an added hardware switch.

3) *Phase 1.3: Initial Product Testing*

- Objective: Test the hardware section of the product to ensure that each component is adequately supplied with sufficient power and that the camera is capturing data.
- Approach: We will use a digital multimeter to ensure proper voltage regulation from our power supply. Then, we will program a simple Python script that raises a flag whenever an object is in front of the camera. The script will also create a matrix of data points so the user can ensure the camera works correctly.
- Adjustments: Continued into mid-March, later than expected, due to issues with PLY file size and scan generation time.

4) *Phase 1.4: Software Design*

- Objective: Develop two Python scripts on the RPi and external PC. The RPi will be equipped with data acquisition tools and an AI/ML model to eliminate noise in the scan. The computer will be equipped with 3D modeling tools that interpret data from the device.
- Approach: The librealsense/pyrealsense2 libraries will be used as they offer functionality for the Intel RealSense cameras and data acquisition tools. For 3D processing, the Open 3D library provides seamless integration with RealSense-generated point clouds. For the AI/ML model, we will use PyTorch and TensorFlow to eliminate noise reduction.
- Adjustments: AI/ML implementation transitioned from local execution to Azure cloud for better performance and scalability.

5) *Phase 1.5: Hardware/Software Integration*

- Objective: Integrate the hardware and software components of the device and ensure that everything works properly.
- Approach: We will download the Python scripts into their designated areas and do a handful of scans to ensure our device outputs 3D models.
- Adjustments: Integration occurred in stages, with real-time testing of file transmission and cloud processing.

6) *Phase 1.6: Optimization*

- Objective: Optimize the AI/ML model to ensure it develops and efficiently eliminates noise, leading to higher-quality scans.
- Approach: We will employ Point Cloud Networks and Convolutional Neural Networks to improve noise reduction and Object Detection Models to efficiently improve the scan's range of interest (ROI).

  Adjustments: Focus was placed on speeding up scan-to-cloud-to-desktop processing and improving ML model accuracy.

The WBS efficiently divides the project into six structured phases, each with clearly defined and manageable tasks. Throughout development, the WBS was used to organize the workflow and adapt to evolving project needs, such as the shift to cloud-based ML processing and changes in hardware integration. By leveraging the WBS, the team could track milestone progress, allocate resources effectively, and identify high-priority tasks, ensuring steady progress toward a complete and functional prototype.

*C. **Project Milestones***

Despite a few timeline shifts, all project milestones were successfully met:

- Research Phase: Completed 12/7/2024
- Hardware and Software Design: Completed 04/6/2025
- Prototype: Completed 4/14/2025

The research phase encompassed the background information required to determine the materials needed. Adjustments were made along the way to allow time for additional software testing and cloud pipeline tuning, but these were offset by early completion of the hardware phases. These milestones remained essential reference points for gauging progress.

*D. **Gantt Charts***

Gantt charts are similar to the WBS in dividing labor into manageable sections. However, Gantt charts illustrate project scheduling, where tasks are listed versus a time frame, and the width of the task is correlated to the estimated time that task takes to complete. The Gantt chart also highlights dependencies between functions, and the project time will be optimized so that dependent tasks succeed each other immediately and no resources overlap. Fig. 26 illustrates the Gantt Chart representative of this project using ProjectLibre software.

The Gantt chart was regularly updated to reflect fundamental project dynamics. Tasks were restructured to better align with actual development timelines. Notable updates include:

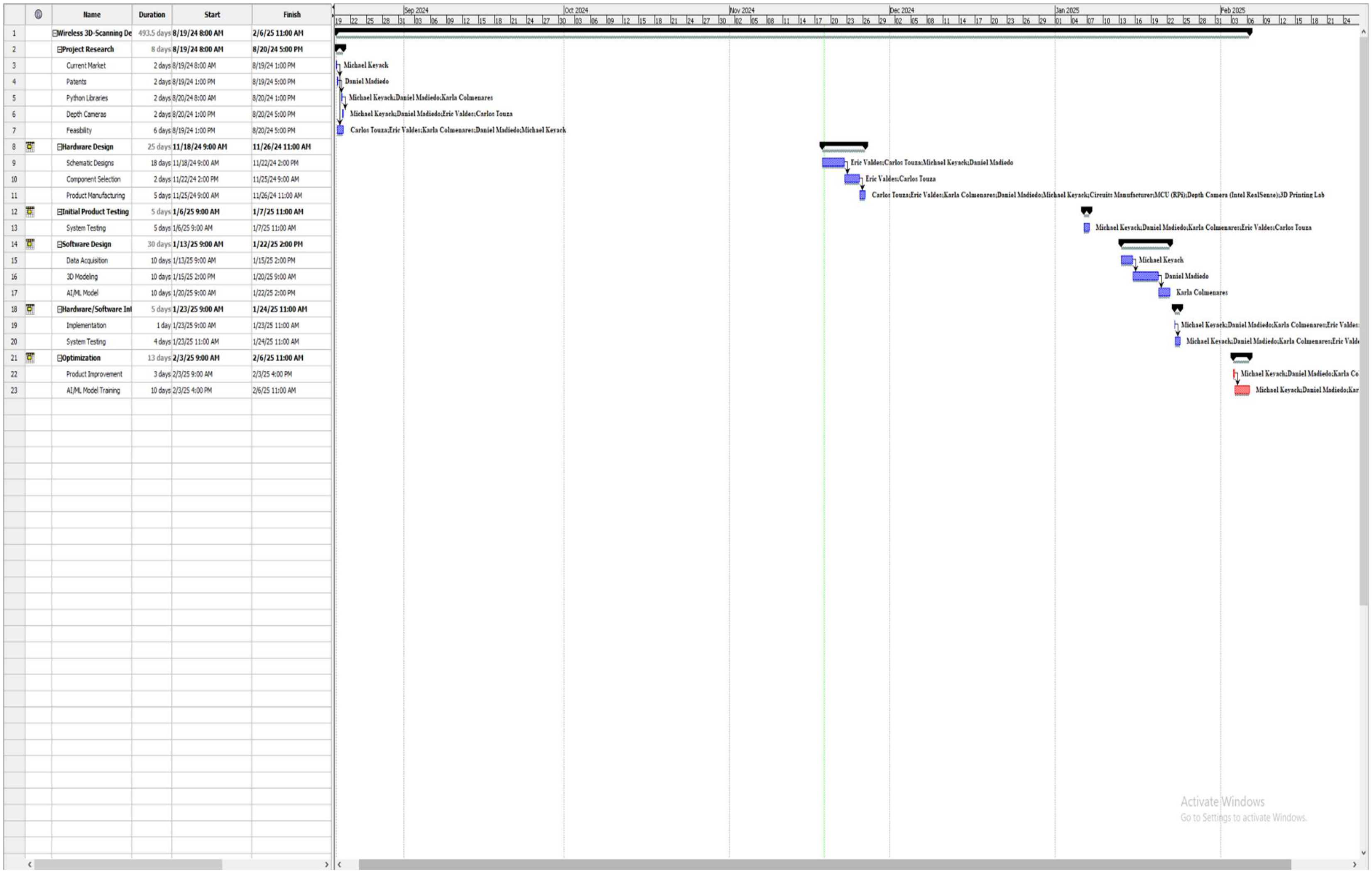
- AI/ML training and testing moved to March–April 2025.
- System testing extended through mid-March to address cloud sync and latency issues.

1) PERT Chart

PERT (Program Evaluation and Review Technique) charts are a visual tool that defines project activities and their dependencies within timelines. They borrow visual queues from the Gantt chart for entertainment activities. The team will utilize a PERT chart to identify the critical path, the longest chain of dependent tasks. In doing so, the team can manage the critical path, which is crucial in the timeliness of the project completion. Fig. 27 illustrates the PERT chart representative of this project and highlights the critical path using ProjectLibre software.

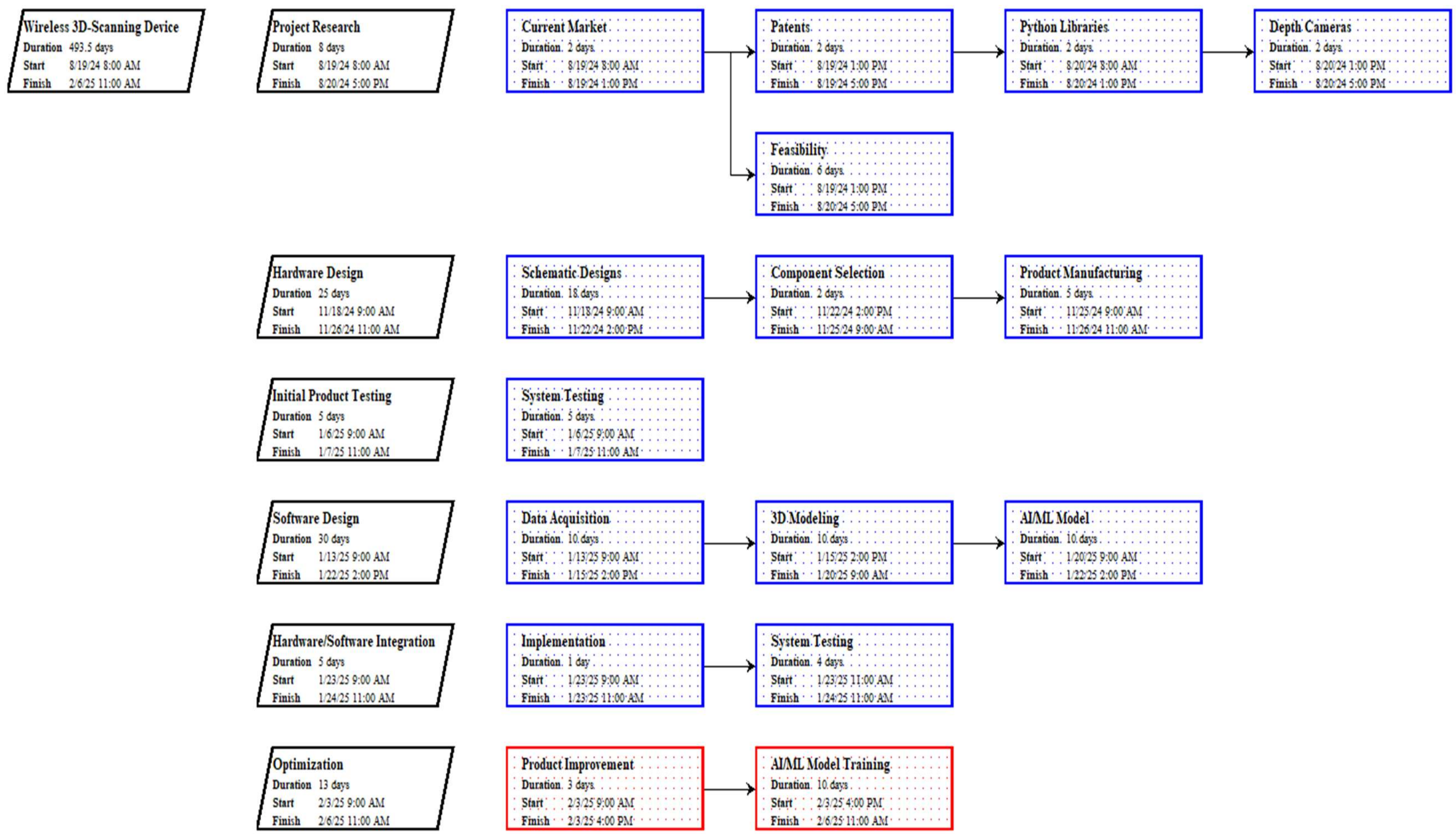
The Plan of Action effectively guided the team from concept to execution. Adjustments made throughout the project reflect responsive planning and a strong understanding of technical limitations. With every phase completed and milestones met, the planning tools proved instrumental in delivering the Synapse3D Wireless 3D Scanning Device.

Fig. 26. Gantt Chart



	Name	Duration	Start	Finish
1	Wireless 3D-Scanning De	493.5 days	8/19/24 8:00 AM	2/6/25 11:00 AM
2	Project Research	8 days	8/19/24 8:00 AM	8/20/24 5:00 PM
3	Current Market	2 days	8/19/24 8:00 AM	8/19/24 1:00 PM
4	Patents	2 days	8/19/24 1:00 PM	8/19/24 5:00 PM
5	Python Libraries	2 days	8/20/24 8:00 AM	8/20/24 1:00 PM
6	Depth Cameras	2 days	8/20/24 1:00 PM	8/20/24 5:00 PM
7	Feasibility	6 days	8/19/24 1:00 PM	8/20/24 5:00 PM
8	Hardware Design	25 days	11/18/24 9:00 AM	11/26/24 11:00 AM
9	Schematic Designs	18 days	11/18/24 9:00 AM	11/22/24 2:00 PM
10	Component Selection	2 days	11/22/24 2:00 PM	11/25/24 9:00 AM
11	Product Manufacturing	5 days	11/25/24 9:00 AM	11/26/24 11:00 AM
12	Initial Product Testing	5 days	1/6/25 9:00 AM	1/7/25 11:00 AM
13	System Testing	5 days	1/6/25 9:00 AM	1/7/25 11:00 AM
14	Software Design	30 days	1/13/25 9:00 AM	1/22/25 2:00 PM
15	Data Acquisition	10 days	1/13/25 9:00 AM	1/15/25 2:00 PM
16	3D Modeling	10 days	1/15/25 2:00 PM	1/20/25 9:00 AM
17	AI/ML Model	10 days	1/20/25 9:00 AM	1/22/25 2:00 PM
18	Hardware/Software Int	5 days	1/23/25 9:00 AM	1/24/25 11:00 AM
19	Implementation	1 day	1/23/25 9:00 AM	1/23/25 11:00 AM
20	System Testing	4 days	1/23/25 11:00 AM	1/24/25 11:00 AM
21	Optimization	13 days	2/3/25 9:00 AM	2/6/25 11:00 AM
22	Product Improvement	3 days	2/3/25 9:00 AM	2/3/25 4:00 PM
23	AI/ML Model Training	10 days	2/3/25 4:00 PM	2/6/25 11:00 AM

Fig. 27. PERT Chart



XVIII. Multidisciplinary Aspects

To accomplish our set goals, we must collaborate and work with our fellow students to complete our senior design project. It is essential to know how each team member can contribute to the competition of our project. A team with a diverse skill set is better disposed to complete the project than a team without various skills. Each team member's strengths contribute to the ultimate project completion by aiding in each area where they excel. Our project requires a team with a wide array of skills to collaborate and work together to see its completion, as it requires knowledge in multiple disciplines and fields.

Our team consists of five members in the Electrical and Computer Engineering fields, each with their area of expertise and focus. Our team consists of four electrical engineers and one computer engineer. Michael Keyack is an electrical engineer focused on the wireless and software aspects of the project. Daniel Madiedo is an electrical engineer focused. Eric Valdes is an electrical engineer who will address the project's power and battery aspects. Karla Colmenares is a computer engineer who will be working on the project's machine learning angle. Carlos Touza is an electrical engineer who will be focusing on the power aspect of the project.

Here is a structured and organized list of our team members, highlighting their roles in the project and how we work together to complement one another.

- Michael Keyack is an honors student pursuing a Bachelor of Science in Electrical Engineering at Florida International University and is expected to graduate in May 2025. With a solid academic foundation, Michael has focused his studies on RF Circuit Design, Communication Systems, Solid-State Devices, and Programming Embedded Systems. Michael has extensive hands-on experience through research roles and internships. As an undergraduate research assistant at NASA CRE2DO, he operated advanced PCB printers, managed multi-material 3D electronics printing, and applied ECAD software to construct intricate circuits. During his internship at Nano Dimension, he worked on cutting-edge projects involving ultra-thin flex sensors and robotic circuitry, developing innovative designs and automating testing processes with Python. His technical acumen extends to tools like Ansys HFSS, KiCad, and 3D printing, along with proficiency in programming languages like C++ and Java.
- Daniel Madiedo is a senior Electrical Engineering student at Florida International University, expected to graduate in May 2025. He is an accomplished engineer proficient in programming languages such as C, Java, and Python. He is complemented by extensive experience with electronic simulation tools, including Multisim, LT SPICE, EAGLE, MATLAB, and Wolfram Mathematica. Daniel has practical experience designing efficient and responsive systems through his involvement with Panther Robotics, where he worked on the electronics for a prosthetic hand. He contributed to developing a compact and reliable circuit design, optimizing battery usage to enhance the device's usability and integration with the prosthetic structure. Additionally, he collaborated on a personal audio system project, where he utilized LT SPICE and EAGLE to simulate and design circuits before implementing them on a breadboard. With a robust simulation and circuit development foundation, Daniel is passionate about creating innovative and efficient electrical systems. His technical skills and hands-on project experience make him a strong candidate for advanced circuit design and system development roles.

- Eric Valdes is a senior Electrical Engineering student at Florida International University, expected to graduate in May 2025. Dedicated to continuous learning, Eric has developed strong proficiency in tools such as Multisim, AutoCAD, and MATLAB, with a foundational understanding of electrical and power electronics principles. Eric has gained valuable experience through his internship with the Miami-Dade County Department of Solid Waste Management, where he worked under the Engineering division. Additionally, as a Junior Electrical Technician at VA-Electrical Motors, he honed his technical skills and contributed to practical engineering solutions. Eric's project work showcases his ability to apply theoretical knowledge to real-world challenges. He designed and built a two-phase AC generator capable of powering a light bulb, overcoming design challenges with critical thinking and problem-solving. In another project, he modeled and simulated a grid-connected residential photovoltaic system in MATLAB/Simulink, optimizing energy yield and cost performance. With a focus on power systems, critical thinking, and teamwork, Eric is eager to contribute to renewable energy and sustainable design projects.
- Karla Colmenares is a senior Computer Engineering student at Florida International University, expected to graduate in May 2025. She is a versatile engineer proficient in multiple programming languages, including C, C++, Python, Java, JavaScript, HTML, and CSS. Karla has experience with version control systems like Git, various IDEs such as Visual Studio, and a broad range of debugging tools. Karla has undertaken projects that highlight her expertise in machine learning and cybersecurity. She developed a machine learning model to detect diabetic retinopathy from retinal images, leveraging tools like Scikit-learn, OpenCV, and Python libraries to achieve notable accuracy and precision. In cybersecurity, she researched penetration testing using tools such as Kali Linux, Metasploit, and Wireshark, enhancing her skills in identifying vulnerabilities and improving system security. In addition to her technical acumen, Karla has hands-on experience in circuit design software, hardware description languages, and microcontroller-based systems. Her interest lies in bridging the gap between machine learning, IoT applications, and cybersecurity.
- Carlos Touza is a senior electrical engineering student at Florida International University, expected to graduate with a Bachelor of Science in Electrical Engineering in May 2025. He has taken concentrations focused on Power / Energy, Integrated Nano-technology, and Networking and security. He is proficient in Java, HTML, CSS, Python, and C programming languages. He is primarily focused on power/energy concentration and the networking and security aspect of his degree, and he wishes to work either in the IoT or power generation sectors. He also has technical skills in using the Ubuntu Linux system, PyCharm, NetBeans, and Eclipse IDEs. I also have technical skills using Wolfram Mathematica, Multisim, SAM, and PowerWorld.

In conclusion, effective collaboration with our fellow team members is essential to achieving our goals and completing our senior design project. Understanding how each member contributes to the project is crucial for its success. A diverse skill set within our team dramatically enhances our ability to tackle challenges. Each member's unique strengths are vital in advancing the project, allowing us to excel in various areas. By working effectively with one another, we can better reach the final project goal and complete our goals promptly. Given the interdisciplinary nature of our project, a team with a broad range of skills working together is critical to its successful completion.

XIX. Personnel

Daniel Madiedo

Contact Information

- Phone: (786) 747-1002
- Email: dmadi008@fiu.edu

Summary

Engineer with a focus on Electrical engineering. Proficient in C, Java, and Python. Experienced with simulation systems (e.g., Multisim, LT SPICE, EAGLE, MATLAB, Wolfram Mathematica, HFSS).

Education

- Florida International University, Miami, FL
    - Bachelor of Science in Electrical Engineering
    - Expected graduation date: May 2025

Experience

- Panther Robotics
    - Developed prosthetic hand group electronics section. Worked on the electronics for the prosthetic hand, focusing on making it responsive and efficient. Designed the circuit to use battery power efficiently and ensured everything was compact and reliable. My goal was to create a system that is easy to use and fits nicely into the prosthetic design.

Projects

- Personal audio system circuit development (Spring 2023- Now): used LT SPICE and EAGLE to develop and simulate circuits. We used a breadboard to actualize the circuits.

Skills

- Electronic Simulation: Multisim, LT SPICE, EAGLE, Wolfram Mathematica, HFSS, MATLAB.
- Web Development: C, Java, and Python.
- Programming Languages: C, Java, and Python.
- Operating Systems: Proficient with Windows and MAC

Eric Valdes

Contact Information

- Phone: (786) 525-2266
- Email: evald098@fiu.edu

Summary

A senior electrical engineer continually strives to learn new things in all aspects of life. Proficient in Multisim and AutoCAD, and understanding basic electrical and power electronics.

Education

- Florida International University, Miami, FL
    - Bachelor of Science in Electrical Engineering
    - Expected graduation date: May 2025

Experience

- Miami Dade County Mayors Internship
    - In the department of Solid Waste Management under the department of Engineering.VA-Electrical Motors
- VA-Electrical Motors
    - Junior Electrical Technician

Projects

- Two-phase AC Generator – Designed and created a two-phase AC generator capable of producing up to two volts and lighting a light bulb. This allowed me to apply what I had learned to a real-world application. I also had to use critical thinking to fix a major flaw we had in the design to make the generator function properly.
- Photovoltaic Cost Simulation -- This project entails modeling and simulating the design process for a grid-connected residential PV system to maximize energy yield and cost performance. The project was conducted on MATLAB (Simulink).

Skills

- Electronic Simulation: Multisim, PowerWorld Simulator, MATLAB.
- Web Development: C.
- Programming Languages: C
- Operating Systems: Proficient with Windows and MAC
- Technical skills: AutoCAD

Karla Colmenares

Contact Information

- Phone: (754) 260-4325
- Email: karlacolmenares14@gmail.com

Summary

Engineer with a focus on computer engineering. Proficient in C, C++, HTML, CSS, Python, Java and JavaScript. Experience with version control systems (e.g., Git), IDEs (e.g., Visual Studio), and debugging tools.

Education

- Florida International University, Miami, FL
- Bachelor of Science in Computer Engineering
- Expected graduation date: May 2025

Experience

- Machine Learning Research
    - Developed a machine learning model to automate the detection of diabetic retinopathy from retinal images, aiming to improve early diagnosis and intervention. Technologies Used: Python, Scikit-learn, Random Forest, Support Vector Machine (SVM), OpenCV, Pandas, NumPy.

Projects

- IOT Applied Machine Learning Project - Diabetic Retinopathy Debrecen Model Lead Developer - Developed a machine learning model to automate the detection of diabetic retinopathy from retinal images, aiming to improve early diagnosis and intervention. Implemented and compared two machine learning classifiers, Random Forest and Support Vector Machine (SVM), to detect diabetic retinopathy from retinal images. The SVM classifier achieved superior performance with an accuracy of 74.86% and a precision of 84.67%, slightly outperforming the Random Forest classifier.
- C Program Development – FIU Online Banking Program Software Developer and Team Lead - Developed a comprehensive online banking program for FIU, demonstrating the implementation of various banking functions using C programming. Delivered a working prototype of the online banking system that incorporated all fundamental C programming techniques covered in the coursework. Cybersecurity Research Project

Skills

- Programming Languages: Proficient in C, C++, HTML, CSS, Python, Java, and JavaScript.
- Software Development: Experience with version control systems (e.g., Git), IDEs (e.g., Visual Studio) and debugging tools.
- Hardware Design: Familiarity with circuit design software (e.g., Altium Designer, KiCad) and hardware description languages (e.g., VHDL)
- Web Development: Proficient with HTML, CSS, and JavaScript.
- Operating Systems: Proficient in Windows and MAC.
- Electronics: Knowledge of analog and digital circuits, microcontrollers (e.g., Arduino, PIC)
- Machine Learning: Familiar with basic concepts and libraries (e.g., sci-kit-learn, jupyter)

Michael Keyack

Contact Information

- Phone: (786)-759-5582
- Email: michaelkeyack@gmail.com

Summary

Engineer focusing on Electrical engineering: Fields and Waves, RF Circuit Design, Communication Systems, Filter Design, Solid State Devices, Programming Embedded Systems, Engineering Economy, HFSS).

Education

- Florida International University, Miami, FL
- Bachelor of Science in Electrical Engineering
- Expected graduation date: May 2025

Experience

- NASA CRE2DO at FIU - Undergraduate Research Assistant
    - Operated a desktop PCB printer (Voltera V-One) to print high-resolution patch antennas on an FR1 substrate using commercial conductive silver ink.
    - Managed a multi-material electronics printer (A2200) using uniquely formulated Copper and Germanium inks to print electronic circuits.
    - Applied vital ECAD software and 3D-printing skills in constructing multiple circuits, from simple resistor circuits to RFID tags.
    - Organized 500+ chemicals to mitigate lab hazards and streamline the 3D printing process.
- NANO Dimension - Research Intern
    - Skillfully operated the cutting-edge DragonFly IV multi-material, multi-layer 3D printer to produce ultra-thin flex sensors measuring 300 microns in thickness, achieving a remarkable resistance of 20 ohms.
    - Collaborated amongst a team of application engineers to innovate circuitry design for a robotic hand, leveraging advanced printed flex sensors to engineer precise analog input control that interfaced seamlessly with a microcontroller.
    - Implemented a Python script to control a stepper motor precisely, enabling automated bending of flex sensors within a range of -90 to +90 degrees according to user-defined durations, as well as including data logging functionalities to capture resistance profiles of flex sensors using a digital multimeter.

Projects

- Personal audio system circuit development (Spring 2023- Now) - used LT SPICE and EAGLE to develop and simulate circuits. Used a breadboard to actualize the circuits.

Skills

- Technical Skills: Ansys HFSS, KiCad, Multisim, Autodesk Fusion 360, SolidWorks, 3D Printing, Soldering
- Programming Languages: C++, Java.
- Certifications: BLS Provider (provided by American Heart Association)

Carlos Touza

Contact Information

- Phone: (305) 606-4779
- Email: carlstouza1@gmail.com

Summary

Engineer with a focus on Electrical engineering. Proficient in C, HTML, CSS, Python, and Java. Experienced with PowerWorld Simulator, Eclipse IDE, Ubuntu, MATLAB, Multisim, and Netbeans.

Education

- Florida International University, Miami, FL
- Bachelor of Science in Electrical Engineering
- Expected graduation date: May 2025

Experience

- Power Systems I
    - As a group member, it was contributed to developing a power generator that converted mechanical energy into electrical energy. The generator consisted of a rotor and a stator, where the rotor's spinning created a changing magnetic field that induced an electric current in the stator's coils. The generator exceeded the minimum voltage requirements and successfully powered a small LED light.
- Power System I LAB
    - As a group member, Carlos was in charge of designing a solar power generation system that would be a positive investment. The solar power generation system would have to bring in profit within its 25-year lifecycle. SAM simulation software was used, and local weather data was imported. The system had a payback period of 15 years.

Projects

- Power Systems I Project - As a group member, I helped develop and create a Power Generator that converted mechanical power into electrical power. The generator comprised a rotor and a stator. As the rotor spins, it makes a changing magnetic field that induces an electric current in the stator's coils—creating dozens of thin copper (enameled wire) coils used for electronic applications. The small generator surpassed the minimum voltage readings and lit a small LED light.
- Power Systems I LAB - As a group member, I was charged with designing a solar power generation system that would be a positive investment. The solar power generation system would have to bring in profit within its 20-year lifecycle. SAM simulation software was used, and local weather data was imported. The system had a payback period of 15 years and installation costs of $23,000. Trina Solar TSM-245PA05.18 modules were used with SMA America: SB7.0-1TP-US-40 inverters. The project had a life of 25 years with no salvage value.

Skills

- Technical Skills: Multisim, MATLAB, Wolfram Mathematica, SAM, PowerWorld Simulation, Wireshark.
- Web Development: C, Java, Python, HTML, CSS.
- Operating Systems: Proficient with Windows and MAC.

XX. Budget

It is essential to have an efficacious budgeting strategy when attempting to complete a project or create a product. A well-designed budget plays a crucial role in various aspects of the project completion, such as resource allocation, financial planning, and assessing the project's feasibility. For our Wireless 3D-Scanning Device for STL Creation project, various materials and components are required, with their costs. A budget will help ensure that all necessary items are considered and permit the team to procure them quickly without exhausting financial resources. Proper budgeting is crucial in monitoring project progress and preventing delays from shortages.

The tables below illustrate different budgeted parts of our project that are considered for successful completion. Our sponsor, Dr. Cheng Yu Lai, will contribute $800 to our budget. In this project, we have hypothetically placed our hourly earnings based on $15.00 per hour for all team members, With an average of 10 hours per week for each team member, totaling around 120 hours in the entire semester. The price for the labor cost is theoretical, and in actuality, each team member will not be compensated for their labor. Other costs were considered, such as shipping and utilization of labs or services.

TABLE XXIII. Workload Hours and Pay

Team 7	**Hours**	**Wage/hr**	
Michael Keyack	136	$15.00	$2040
Daniel Madiedo	136	$15.00	$2040
Eric Valdes	112	$15.00	$1680
Karla Colmenares	92	$15.00	$1380
Carlos Touza	112	$15.00	$1680
SUM			$8820

TABLE XXIV. SOFTWARE COST

Item	**Hours**	**Total Cost**
Software Design	0	0
Python Application	0	$0
Software validation	10	$150
Analysis	10	$150

Michael Keyack	136 hours		
Data Acquisition	*20 hours*	*Flat*	*0 days*
Implementation	*2 hours*	*Flat*	*0 days*
Current Market	*4 hours*	*Flat*	*0 days*
Depth Cameras	*4 hours*	*Flat*	*0 days*
AI/ML Model Training	*20 hours*	*Flat*	*0 days*
Python Libraries	*4 hours*	*Flat*	*0 days*
Product Manufacturing	*10 hours*	*Flat*	*0 days*
System Testing	*10 hours*	*Flat*	*0 days*
Schematic Designs	*36 hours*	*Flat*	*0 days*
Feasibility	*12 hours*	*Flat*	*0 days*
System Testing	*8 hours*	*Flat*	*0 days*
Product Improvement	*6 hours*	*Flat*	*0 days*
Daniel Madiedo	136 hours		
Depth Cameras	*4 hours*	*Flat*	*0 days*
Python Libraries	*4 hours*	*Flat*	*0 days*
AI/ML Model Training	*20 hours*	*Flat*	*0 days*
Feasibility	*12 hours*	*Flat*	*0 days*
Implementation	*2 hours*	*Flat*	*0 days*
Product Manufacturing	*10 hours*	*Flat*	*0 days*
Patents	*4 hours*	*Flat*	*0 days*
System Testing	*8 hours*	*Flat*	*0 days*
3D Modeling	*20 hours*	*Flat*	*0 days*
Product Improvement	*6 hours*	*Flat*	*0 days*
Schematic Designs	*36 hours*	*Flat*	*0 days*
System Testing	*10 hours*	*Flat*	*0 days*
Eric Valdes	112 hours		
System Testing	*10 hours*	*Flat*	*0 days*
Implementation	*2 hours*	*Flat*	*0 days*
System Testing	*8 hours*	*Flat*	*0 days*
Product Manufacturing	*10 hours*	*Flat*	*0 days*
Feasibility	*12 hours*	*Flat*	*0 days*
Schematic Designs	*36 hours*	*Flat*	*0 days*
Component Selection	*4 hours*	*Flat*	*0 days*
Depth Cameras	*4 hours*	*Flat*	*0 days*
Product Improvement	*6 hours*	*Flat*	*0 days*
AI/ML Model Training	*20 hours*	*Flat*	*0 days*
Karla Colmenares	92 hours		
AI/ML Mode	*20 hours*	*Flat*	*0 days*
Feasibility	*12 hours*	*Flat*	*0 days*
Product Improvement	*6 hours*	*Flat*	*0 days*
Implementation	*2 hours*	*Flat*	*0 days*
AI/ML Model Training	*20 hours*	*Flat*	*0 days*
System Testing	*10 hours*	*Flat*	*0 days*
System Testing	*8 hours*	*Flat*	*0 days*
Python Libraries	*4 hours*	*Flat*	*0 days*
Product Manufacturing	*10 hours*	*Flat*	*0 days*
Carlos Touza	112 hours		
Depth Cameras	*4 hours*	*Flat*	*0 days*
Component Selection	*4 hours*	*Flat*	*0 days*
System Testing	*10 hours*	*Flat*	*0 days*
Implementation	*2 hours*	*Flat*	*0 days*
Feasibility	*12 hours*	*Flat*	*0 days*
Product Manufacturing	*10 hours*	*Flat*	*0 days*
System Testing	*8 hours*	*Flat*	*0 days*
Schematic Designs	*36 hours*	*Flat*	*0 days*
Product Improvement	*6 hours*	*Flat*	*0 days*
AI/ML Model Training	*20 hours*	*Flat*	*0 days*

Fig. 28. Resources and their cost organized with ProjectLibre.

TABLE XXV. ITEMS COST

Item Cost	Total Cost
Raspberry Pi	$80
LCD Screen	$80
Depth Camera (Intel RealSense D415)	$300
Circuits Manufacturer $50/hr	$100.00
3D Printing Lab $20/hr Project Total	$40.00 $9560

In short, having a well-organized budgeting strategy is crucial for completing any product development or project. A thoughtful budget facilitates essential tasks like allocating resources, financial planning, and determining the feasibility of a project. For our Wireless 3D-Scanning Device for STL Creation project, the total cost is $14,600. Budgeting will ensure that all required components, services, materials, and their specific costs are accounted for. This permits the team to secure the necessary resources within our financial limits.

XXI. Results Evaluation

This section evaluates the project's technical outcomes by comparing the proposed goals to the final deliverables and identifying accomplishments and areas that fell short. These evaluations are based on the project's original objectives, constraints, compliance with standards, implementation of concepts, adherence to design specifications, and the quality of deliverables.

1) *Project Objectives and Constraints*

The project goal involved creating a wireless portable 3D scanner to produce STL files through depth sensor cameras and machine learning algorithms for data improvement. The project needed a user-friendly operation, precise measurements, immediate performance feedback, and sustainable environmental practices. The team achieved multiple targets outlined in their objectives. The final prototype consisted of a handheld device with an Intel RealSense D415 depth sensor for precise scanning and a Raspberry Pi 5 for data handling. The system transmitted captured data wirelessly to the cloud for processing. Real-time STL file generation on the device remained partially unattainable because the onboard hardware lacked sufficient computational power and memory capacity. The STL generation process moved to Microsoft Azure because the machine learning model needed to process and refine data in that environment. The trade-off between latency duration and battery life made delivering real-time feedback to users through the device difficult.

2) *Standards Compliance*

Initially, the team followed IEEE safety guidelines and was compliant with RoHS (Restriction of Hazardous Substances). The component selection and design process included selecting recyclable materials and low-toxicity electronic parts per RoHS principles. The design choices do not reflect a pursuit of formal certification due to budget and time limitations, but they do reflect an awareness of and commitment to applicable industry standards. This aspect of the project will be necessary for future iterations if the device is moved toward commercialization or expanded user testing.

3) *Conceptual Implementation*

A central technical concept proposed was the use of machine learning to clean point cloud data and separate scanned objects from background noise, such as tabletops or other environmental clutter. This concept was successfully implemented using a cloud-based ML model deployed on Azure. The system could accurately identify object boundaries and generate refined STL files for modeling and 3D printing. However, running this machine learning algorithm locally on the Raspberry Pi was too resource-intensive. This limitation highlighted a key area for future work: optimizing the algorithm for edge devices or upgrading to a more powerful embedded platform.

4) *Specifications*

The proposed specifications included a physical footprint of no more than 12x12x5 inches, an onboard LCD for user feedback, a reliable power source, and wireless communication via Bluetooth or Wi-Fi. The final prototype met all dimensional requirements, was lightweight and compact, and included a functional LCD screen that provided system status and connectivity updates. Wireless data transmission to a paired computer was also implemented successfully. The real-time feedback system during scanning is one element that remains underdeveloped. The LCD can show static updates, but continuous visual tracking or object mapping during scan time is not fully supported due to software limitations and display constraints. This is another potential improvement area for future revisions of the project.

5) Deliverables

The proposal included the following deliverables: A fully functional prototype, machine learning integration for STL processing, a software package, user documentation, and a demonstration video. The team delivered the core functionality, including STL generation, through the integrated system and software developed in Python. A user manual and technical documentation were also produced. The demonstration video was planned but was delayed due to scheduling conflicts and team availability and is currently in post-production. However, most of the deliverables were on time and met expectations regarding quality and utility.

6) Globalization Retrospective

Our knowledge about global applicability and cross-border innovation challenges has evolved substantially as we finish developing the Wireless 3D-scanning Device for STL Creation. Our initial project focused on domestic markets, where we aimed to serve engineers, designers, and hobbyists as our primary user group. The project revealed that accessible portable 3D scanning technology has worldwide market potential during its development process. Our understanding of the project evolved from a regional focus to a global-scale innovation because we recognized the need to adapt our design and source components and standardize user interfaces for various international markets.

The modifications we made to the project directly affected our capability to reduce barriers to international trade. The implementation of Microsoft Azure cloud-based processing allowed remote device management and access, which made the system scalable across different hardware environments. The system design with standard hardware interfaces (USB-C, Wi-Fi, Bluetooth) allows users worldwide to use the product through their current equipment without needing proprietary technology or infrastructure modifications. The technical decisions lowered worldwide adoption barriers while enabling potential foreign market partnerships and distribution. The product gained easier international market access by complying with RoHS and IEEE standards, simplifying certification procedures for foreign markets.

During the final stage of the project, we engaged with international contacts who provided critical feedback about features that would enhance adoption beyond the United States. We documented multilingual support for the LCD interface and user manual as a future implementation recommendation. The importance of cloud infrastructure access in low-bandwidth regions was confirmed through our discussions, which supported our decision to separate device processing from STL generation and use Azure's worldwide data center network. The current version of our project stands as a technically solid product with fundamental globalization design elements. Our experience demonstrates that achieving success in global markets requires more than innovation because it requires foresight, accessibility, and adaptability.

The project's technical goals were largely accomplished, with key innovations such as wireless 3D scanning and cloud-based STL generation successfully demonstrated. Some objectives, including complete on-device processing and advanced real-time feedback, were limited by hardware constraints, but suitable workarounds were implemented. The results validate the project's feasibility and offer a strong foundation for further development and commercialization.

XXII. Life-Long Learning

Developing and implementing a 3D scanner for 3D printing is a great project with excellent prospects. However, this is where the question arises: how can we ensure long-term success for our project? The answer to this question will show how successful we are in maintaining a long-term project and who remains willing to strive to learn with the current developments in their field.

First, we actively sought advancements and innovations in 3D scanning, 3D printing, and additive manufacturing. Thus, we frequently attended industry conferences, webinars, and workshops to be informed. Reading Additive Manufacturing Magazine and the 3D Printing Industry helped us discover the latest technological advancements, materials, and applications. Also, by subscribing to scientific journals and newsletters, one was constantly updated with current research findings.

To maintain the viability of the 3D scanner in the market, one has to ensure that the product is constantly being developed. This entails soliciting customers' feedback, assessing the market demand, and seeking improvement opportunities. Maintenance of the product would entail frequently updating the software and the scanner's hardware to meet the customers' needs, such as improving the resolution or making it compatible with other 3D printers. Also, improving our machine learning scanning algorithm or integrating the cloud-based storage services can position the product in the market.

Another critical factor is joining technical societies. IEEE is an organization that provides resources and platforms for meeting people and organizing events targeted at the scanner's electrical and software aspects. This membership is very cheap for a student and includes benefits such as access to research papers and training. Moreover, attending IEEE events and joining special interest groups could help the researcher interact with professionals who can help them with their work.

Apart from IEEE, involving local maker spaces and 3D printing communities to share experiences, get inspiration, and test the product in real life is also essential. This ensures the project is relevant and feasible in the community and the real world.

Thus, the concept of lifelong learning is crucial to the success of this 3D scanner project. Therefore, by following the trends, maintaining the product, and communicating with technical people, we can provide the market with an innovative and relevant scanner.

XXIII. Conclusion

The idea for the 3D scanner for 3D printing was gotten from the increasing need for efficient and easily accessible tools in the additive manufacturing industry. This idea was first generated through ideation sessions, and the team identified the need for low-cost, high-accuracy scanning solutions for enthusiasts and small enterprises. Market research in the form of user interviews at maker spaces and surveys to understand customer needs was used to make the idea more specific and well-defined in terms of features and requirements.

The following were the primary goals of this project: to design a simple, compact, and precise 3D scanner that can work with various 3D printers. These objectives evolved as feedback was collected, and the emphasis was made on creating software that makes scanning to printing more straightforward and accurate. The proposal activities included the research activity, conceptual design development, prototype modeling, and discussions with stakeholders to develop the implementation plan.

The results evaluation procedure included checking the scanner prototype's accuracy, resolution, and compatibility. This ensured that the device met the needs of the users and would be able to thrive in the market. It also showed that there is still room for improvement, such as in the calibration process and the time it takes to scan.

This project, in turn, benefits society by making advanced 3D scanning equipment more accessible to small businesses, educators, and hobbyists, thus enabling them to be more creative. Their low prices and simple operation make additive manufacturing technology applicable to various sectors, including education and individual product creation.

This project has also helped develop the individuals involved and the learning experience. It enhanced our knowledge of engineering principles, improved our problem-solving skills, and underlined the need for teamwork and flexibility. Thus, interacting with the technologies of interest and technical associations, we have some beneficial knowledge and a base for further professional development in this fast-developing field.

XXIV. References

[1] “Revopoint pop: Precise 3D scanner for 3D printing ...,” Kickstarter. Available: https://www.kickstarter.com/projects/revopoint-inspire/revopoint-pop-high-precision-3d-scanner-for-3d-printing.

[2] “Einscan-S: Fast, accurate, safe 3D scanner for 3D printing by Shining 3D — Kickstarter,” Kickstarter. Available: https://www.kickstarter.com/projects/681809941/einscan-s-fast-accurate-safe-3d-scanner-for-3d-pri.

[3] M. Edl, S. Mizerak, and J. Trojan, “Modern Approaches for 3D Scanning,” Acta Simulatio, vol. IV, no. 1, pp. 1–9, 2018. Available: https://www.actasimulatio.eu/issues/2018/IV_2018_01_Edl_Mizerak_Trojan.pdf.

[4] “Brand Story,” Einstar. Available: https://www.einstar.com/pages/brand-story.

[5] J. Smith, D. Johnson, and A. Lee, “Micromachining Applications of 3D Scanning,” Micromachines, vol. 11, no. 5, p. 456, 2020. Available: https://www.mdpi.com/2072-666X/11/5/456.

[6] “Vertical-cavity surface-emitting laser,” Wikipedia. Available: https://en.wikipedia.org/wiki/Vertical-cavity_surface-emitting_laser.

[7] “Artec Eva: Portable 3D Scanners,” Artec 3D. Available: https://www.artec3d.com/portable-3d-scanners/artec-eva.

[8] “Structured Light 3D Scanning,” Artec 3D Learning Center. Available: https://www.artec3d.com/learning-center/structured-light-3d-scanning.

[9] “Shining 3D: Company Information,” Einscan. Available: https://www.einscan.com/shining3d-company/.

[10] “US Patent No. 11112503B2,” Google Patents. Available: https://patents.google.com/patent/US11112503B2/en?oq=%23US11112503B2.

[11] “US Patent No. 20210158556A1,” Google Patents. Available: https://patents.google.com/patent/US20210158556A1/en?oq=%23US20210158556A1.

[12] “US Patent No. 11194171B2,” Google Patents. Available: https://patents.google.com/patent/US11194171B2/en?oq=US11194171B2.

[13] Coombs, Clyde F., Jr., ed. 2000. Electronic Instrument Handbook. 3rd ed. New York: McGraw-Hill. https://www.accessengineeringlibrary.com/content/book/9780070126183

[14] Jayamaha, Lal. 2016. Energy-Efficient Industrial Systems: Evaluation and Implementation. 1st ed. New York: McGraw-Hill Education. https://www.accessengineeringlibrary.com/content/book/9781259589782

[15] De Feo, Joseph A., ed. 2017. Juran's Quality Handbook: The Complete Guide to Performance Excellence. 7th ed. New York: McGraw-Hill Education. https://www.accessengineeringlibrary.com/content/book/9781259643613

[16] Franchetti, Matthew J. 2009. Solid Waste Analysis and Minimization: A Systems Approach. 1st ed. New York: McGraw-Hill. https://www.accessengineeringlibrary.com/content/book/9780071605243

XXV. APPENDICES

A. ***Team Contract***

B. ***Intellectual Property Contract***

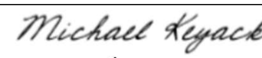
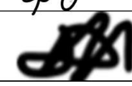
XXVI. SIGNATURES PAGE

Course Number: EEL 4921 Semester: Spring Year: 2025

Mentor Name: Dr. Armando Barreto

Senior II Instructor's Name: Dr. Wilmer Arellano

Name	PID	E-mail Address	Phone Number
Michael Keyack	6295349	mkeya002@fiu.edu	786-759-5582
Karla Colmenares	6361705	kcolm006@fiu.edu	754-260-4325
Daniel Madiedo	6302933	dmadi008@fiu.edu	786-747-1002
Eric Valdes	6178092	evald098@fiu.edu	786-525-2266
Carlos Touza	6185853	ctouz001@fiu.edu	305-606-4779

	PRINT	SIGNATURE	DATE
Michael Keyack	Michael Keyack		04/13/2025
Karla Colmenares	Karla Colmenares		04/13/2025
Daniel Madiedo	Daniel Madiedo		4/13/2025
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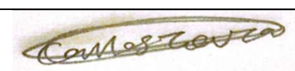
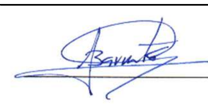
Carlos Touza	Carlos Touza		4/13/2025
Dr. Armando Barreto	Armando Barreto		4/14/2025