Project #25-318 and Safe Human-Robot Collaboration through AI-embedded Smart Glove System

Project Proposal

Prepared for

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By

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10/11/24

Executive Summary

The executive summary highlights the key points of the document. While your advisor(s) and sponsor are expected to read the document in detail, others may only read the summary looking for a brief overview of the report. Casual readers may look at the summary to decide if they would like to continue reading. Some, more senior decision makers (e.g. executives), may read the summary to help make decisions regarding the future of the project (e.g. continuation, financing, resource allocation, etc.). It is important that all readers get a complete sense of the project, including purpose, primary objectives, design requirements, deliverables, work done to date, and timeline, among other required components provided in a table of contents. Summaries should be considered as "stand-alone" containing a complete account of the essential points of the document in chronological order of the document. Particular focus should be placed on the first sentence in order to draw readers in and should explicitly include the "who, what, and why" of the project. The executive summary is usually between half a page and a full page.

Note: The Executive Summary should be updated between major reports as more knowledge is acquired and understanding of the project expands. For example, when submitting Preliminary Design Report in December 2024, make sure you update this page to reflect the progress on the project since the submission of Project Proposal in early October 2024.

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Section A. Problem Statement

In industries like manufacturing and healthcare, robots are progressively working alongside humans to increase efficiency, reduce manual labor, and improve precision. However, as all these technologies advance and new tech demands need to be met, cost and safety propose new concerns, according to Ryan King's Article talking about the "7 Challenges in Industrial Robotics"[1]. Current systems use complex and costly technologies like computer vision, LIDAR, and motion capture to ensure safe human-robot interaction. Although these technologies are effective, they can become very costly and can bring up more concerns like difficulties in real-time responsiveness and privacy concerns.

This project falls under the general scope of computer science with a mix of artificial intelligence, human-technology interaction, and robotics. More precisely, the project includes the study of AI and cobots (collaborative robots), which are robots designed to 'collaborate' with humans in shared spaces. More research of the use of AI/machine learning for gesture recognition in robots has increased due to its potential to improve the safety and efficiency of human-robot collaboration in manufacturing, healthcare, and other industries. In this project, we are using AI to develop an algorithm that can recognize and deliver hand gestures from a smart glove to a cobot. A smart glove is a glove containing multiple sensors and produces data concerning the movement of the user's hands. The goal is to improve human-robot interaction by making the communication between humans and machines more simple to understand, making it more user-friendly and reducing the need for other sensors that can be expensive. By focusing on gesture recognition through a sensor-embedded glove, this project contributes to the broader goal of making robotic systems more accessible and user-friendly, especially in scenarios where close and safe interaction is required.

This is a faculty-sponsored project that is done in the Engineering East Hall Laboratory at VCU. In the lab, we will be using a CRB 15000 robot (collaborative robot hand grabber) to perform a simple task: picking-up 3D shaped blocks and placing them into their corresponding shaped holes. This task illustrates a real-world application of fine motor skills, which robots struggle with when relying solely on traditional automation techniques. It will present that it can be used to perform an object transfer task. We will use a Rokoko Smart Glove that has multiple sensors in each finger to train an AI model we implement to recognize various hand gestures, which will then control the robot's hand.

A similar project produced by 5 Montclair State University students on the "Development and Implementation of an AI-Embedded and ROS-Compatible Smart Glove System in Human-Robot Interaction" [2] presented an effective, low-cost solution. They integrated their own smart glove system and an Extreme Learning Machine (an AI model) to recognize gesture movements "relaxed", "fist", and "pinch". The "relaxed" state communicated to the robot to open its gripper. The "fist" gesture correlates to the robot closing its gripper. When users performed the "pinch" gesture, the system interpreted this to have the robot pick up an object. Findings show that while the system could recognize the "fist" and "pinch" hand movement very well, it had a hard time interpreting the "relaxed" hand gesture. Overall, the smart glove system successfully controlled the robotic arm in picking up and delivering objects in real-time. The implementation of their own smart gloves used force-sensitive resistors and flex sensors, which are simple sensors that are relatively inexpensive compared to more advanced technologies like LIDAR and motion capture systems.


Figure 1. Top view of a Rokoko Smart Glove [3].

Figure 2. Bottom view of the smart gloves where sensors are placed [4].

In this project, we will be utilizing a Rokoko smart glove instead of implementing our own. These smart gloves have flex sensors placed along the length of each finger to measure the degree of bending at each joint, tracking finger movement. It also includes Force-Sensitive Resistors (FSRs) that measure where the hand applies pressure. They have built-in bluetooth components to transmit the captured data wirelessly to a computer/robotic system as stated on the Rokoko website[5]. This is a tool that combines advanced sensor technology with real-time processing that will greatly contribute to our research and overall build on top of Montclair State University's study.

Section B. Engineering Design Requirements

These requirements were decided upon our sponsor/advisors needs. It is also derived from potential design usability, like manufacturing and healthcare. It includes our goals that we wanted our design to achieve and certain goals and considerations from similar projects. Some measurable requirements come from measurements of similar project findings.

B.1 Project Goals (i.e. Client Needs)

- Create a cheaper and safer alternative for human-robot interaction
- To produce an improved model that will interpret hand gestures
- Successful smooth real-time connection between the smart glove and robot
- Validate the system in collaborative tasks

B.2 Design Objectives

- The design will include a created AI model to learn a list of hand gestures and accurately recognize the different hand movements.
- The design will relay the data from the Rokoko smart glove to the CRB 15000 robot.
- The robot will perform tasks from the given data of hand gestures derived from the smart glove.
- The robot will respond to human gestures instantaneously.

B.3 Design Specifications and Constraints

- Design must operate within Rokoko Studio Live, Robot Studio, an AI model, and must use a Rokoko Smart Glove.
- Design must capture real-time data from the smart glove until the program is terminated.
- Design must use an AI model to interpret hand gestures with at least a 90% accuracy, them being a fist, an open hand, and hand direction.
- Design must be able to operate for at least 20 minutes, the more the better.
- Design must be cheaper than current technologies being used in human-robot collaboration (LIDAR, motion capture, etc.) of less than $1000.
- Design must have the Rokoko smart glove operate with the CRB 15000 robot.
- Design must have the robot be able to carry an object that is at least a pound and not be well over 5 pounds to be able to deliver the toy to a specific location users choose to put the object.
- Design must be able to connect using hotspots.

B.4 Codes and Standards

Note: The codes and standards section is not required for the Project Proposal, but is required for all subsequent reports. This section should be comprehensive and thorough, requiring a significant research effort.

List all specific codes and standards that are relevant to the design providing specific details of each as they relate to the design. While the terms codes and standards are often used interchangeably, there are in fact important differences in their definitions that should be understood. **Standards** are documents that provide a set of technical definitions, instructions, rules, guidelines and/or characteristics of a product, process, or service meant to provide consistent and comparable results (e.g. performance requirements, dimensions, testing procedures, file formats etc.). They allow for interchangeability of components and system interoperability and are typically produced by industry or professional organizations such as ASME, ANSI, ASTM, IEEE, ISO, ACM, IAPP, AIS, etc. Standards are meant to help ensure quality, reliability, and safety.

Codes are laws or regulations that specify the methods, materials, components, etc. required for use in a certain product, process, or structure. Codes have been *codified* into a formal written policy or law and can be approved at the local (municipal), state, or federal level. While standards provide sets of guidelines, codes are constraints that *must* be met in accordance with the law. It is, however, common for codes to reference or require the use of one or more standards. Some common code producers include the EPA, OSHA, DOTs, and the NFPA. Codes help set minimum acceptable levels in order to protect public health, safety, welfare.

Codes and standards are often listed by their producer followed by an identifying numerical code. They often contain hyphens or periods which may help reference specific parts of a larger code/standard or provide the year of the latest revision. Some general examples in a list of codes and standards are as follows:

- ASME Standard No. xxx – design must consider some specific fatigue failure criteria
- IEEE Standard No. xxx – design components must not exceed some maximum current limit
- ISO Standard No. xxx – design components must adhere to some standard thread size
- OSHA Code No. xxx – operators of design must wear appropriate eye and face protection
- IRTF Standard No. xxx – design must consider internet communication protocols
- W3C Standard No. xxx – design must adhere to some HTML/CSS standards
- NIST Standard No. xxx – design must consider some specific data security standards

Note: Relevant codes and standards should be incorporated into the design specifications and constraints listed above.

Section C. Scope of Work

C.1 Deliverables

Academic:

- A team contract that specifies the roles and responsibilities for each team member.
- A project proposal.
- A preliminary design report detailing performance analysis of gesture recognition accuracy and efficiency on real-time human robot collaboration based on test scenarios.
- A fall poster and presentation displaying the process done so far.
- A final design report detailing the design process, implementation, analysis, and project outcomes.
- A capstone EXPO poster and presentation.

Design, Code, Software, and Testing:

- A list of gestures that will define the robot's performance.
- A system that captures and displays real-time motion sensor data during user use from the smart glove.
- A connection between a hotspot and the smart glove.
- An AI model code for gesture recognition.
- A functional prototype of the smart glove being used to relay gesture recognition data to the robot.
- Detailed comments and explanations within the AI model code and other code files to ensure clarity and update other team members.
- A test plan outlining the methods for evaluating the smart glove's performance
- Test results from experiments involving the robot and different gestures.

C.2 Milestones

All deliverables and milestones should be included in the project timeline found in Appendix 1.

Due Date	Description
Sep 30, 2024	Team contract, GIT repository, planned day to meet with team members and advisor/sponsor
Oct 31, 2024	Individual assignments, project proposal report, obtain Rokoko Studio Live Subscription & Robot Studio License, successful smart glove connection, detailed list of gestures, display data output from smart glove
Nov 15, 2024	Determine AI model, glove & robot research, fall design poster
Nov 24, 2024	Begin development of AI model, required code, and calculations
Nov 25 - Dec 1	**THANKSGIVING BREAK**
Dec 22, 2024	75% AI model code should be complete. (duration during finals week)
Dec 23 - Jan 12	**WINTER BREAK**
Feb 14, 2025	Connection between robot and smart glove achieved
Feb 28, 2025	AI model complete, instantaneous reaction of robot achieved
Mar 7, 2025	Testing procedure plan
Mar 9 - Mar 16	**SPRING BREAK**
Mar 28, 2025	Precision accuracy reached, collected all data needed for final project report
Apr 4, 2025	Final Project Analysis
May ??, 2025	Capstone EXPO poster and presentation

C.3 Resources

- Access to the East Engineering Laboratory
- Softwares: Rokoko Studio Live +, Robot Studio, IDEs (Colab)
- Rokoko Smart Gloves
- AI Models (ELM or LLM) and Machine Learning Libraries (scikit-learn, PyTorch)

Section D. Concept Generation

A number of methods can be used to help generate design concepts from simple reflection and brainstorming, to working the problem backwards, using reverse thinking techniques, and looking to nature for inspiration (i.e. biomimicry). Existing solutions, or components of existing solutions, can be substituted, combined, adapted, modified, put to other uses, eliminated, or rearranged to meet new design objectives and specifications. A minimum of 3 overall design concepts is required for this section although more are welcome. Provide a brief description of how each design concept addresses the design problem. Discuss the potential pros and cons, including and potential risks of failure, of each of these concepts.

It is likely that each design concept may consist of several components. In this case, one or more of these components may offer a sub-problem that can be further explored, modified, or otherwise improved upon. These sub-problems may lead to the addition of several additional design concepts and may require the inclusion of a design concept chart or matrix to organize all ideas and potential solutions.

Provide any initial design sketches, drawings, 3D renderings, or conceptual models such as dataflow diagrams, process flows, etc. developed during the concept ideation phase. All hand drawings should be drawn to scale using basic engineering drafting tools (i.e. ruler, protractor, and compass). Geometric stencils can also be used to help produce quality hand drawings. Drawings should be presented in a profession manner, preferably done on engineering graph paper and using a high-quality scan. All sketches should be labeled to identify major components and different drawing views or projections if applicable. Basic dimensions should be provided to give a general sense of scale. Label each sketch or drawing with the name of the team member responsible for the sketch, the date it was drawn, and the drawing scale.

Section E. Concept Evaluation and Selection

Using a systematic decision-making process, evaluate each of the design concepts and choose the one that is most likely to succeed in meeting the design objectives and constraints. A Decision Matrix, or Pugh Matrix, helps to analyze alternatives, eliminate biases, and make rational decisions through thought and structure. First, work to develop a set of selection criteria for which to evaluate the previously generated design concepts. Selection criteria often include concepts of performance, cost, safety, reliability, risk, etc. Note that the selection criteria developed here will likely be more general than the project design objectives. As with the design objectives, conversations with the client help define appropriate selection criteria.

In many cases, the client may value the selection criteria differently, preferring that more emphasis be placed on some than others. In this case, weighting factors may be used to place more or less importance on the various criteria in the decision making process. Again, conversations with the client can be used to define criteria weighting factors. Often times, these conversations must be analyzed and interpreted by the team to determine which criteria are more important to the client and by how much. Feel free to discuss the assigned weighting factors with the client to see if they seem accurate.

Next, define an associated metric to represent each criteria. Metrics should be specific and quantifiable, providing numerical values that quantify the often vague concepts of the selection criteria. Metrics can be obtained, generated, or estimated through a number of methods including simple background research, preliminary design calculations, or basic analyses. Note that these metrics do not need to specifically align with the design specifications although there may be some commonality between the two. Provide a brief discussion of the rationale for selecting each of the assigned metrics.

Using the defined metrics, evaluated each design concept against all selection criteria by filling out a Decision Matrix. Design concepts can be compared by using simple rank scoring, raw scoring, or weighted scoring techniques and design concept with which to move forward can be selected. This type of process provides a meaningful, unbiased means for choosing a preliminary design concept prior to moving forward with more comprehensive, detailed analyses as provided in the design methodology section below. The results of this process should be discussed with the project client prior to moving forward with the selected design. Table 1 provides an example of a simple decision matrix.

Table 1. Example of a Decision Matrix.

Note: Weights can be assigned to each criterion if desired.

Section F. Design Methodology

Provide a detailed explanation of the methods that will be used to help evaluate, improve, and evolve the design through the iterative engineering design process. Consider that ultimately, the final design must be verified and validated to ensure that it meets all of the previously developed and listed design objectives and specifications. Verification ensures that the design meets all specification, while validation confirms that the design functions as intended such to meet the client's needs. While it is common for initial design concepts to first be evaluated using simplified design criteria and metrics, the chosen design should be advanced, and later verified, using engineering calculations, computational models, experimental data, and/or testing procedures.

Use this section to describe any underlying physical principles and mathematical equations that govern the design. Provide details of any computer-aided modeling techniques used to evaluate the design including the software used, prescribed boundary conditions, and assumptions. Include a detailed description of any experimental testing methods including required testing equipment, test set-up layout, data acquisition and instrumentation, and testing procedures. If one or more prototypes is to be produced and tested, provide a detailed description of how each will be evaluated.

Note: The contents of this section are expected to vary from project to project. Subsections may be appropriate for providing details of analytical, computational, experimental, and/or testing methods. Some potential subsections that may be included in this section are provided. While critical design equations may be provided here, lengthy mathematical derivations may be included in an appendix. Validation procedures are critical and all projects should address such topic.

F.1 Computational Methods (e.g. FEA or CFD Modeling, example sub-section)

F.2 Experimental Methods (example subsection)

F.3 Architecture/High-level Design (example subsection)

F.5 Validation Procedure

Describe how the design team will validate that the final design meets the client's needs. This section should include a plan to meet with the client towards the end of the project to discuss final design details and demonstrate a prototype, experimental test, and/or simulation results. Provide a relative time frame for this validation to occur (e.g. "mid-March" or "early-April"). Include a brief discussion on how client feedback will be captured, such as a formal survey, interview, or observation notes of the client using the prototype. It may also include plans to solicit feedback from other stakeholders and/or potential users.

Section G. Results and Design Details

Use this section to highlight the major results of the design methodology described above including important analytical, computational, experimental, modeling, assembly, and testing results. This section should be one of the most substantial sections of the report showcasing all of the hard work and effort that went into the completion of the final design and delivery of the project deliverables. Show how the identified problem was solved.

Highlight the prominent features of the final design through analysis results, modeling, drawings, renderings, circuit schematics, instrumentation diagrams, flow and piping diagrams, etc. to show that the design functions as intended and meets all design objectives and constraints. Overview designs such as dataflow diagrams, process flow, swim lane diagrams, as well as presentation-layer designs (e.g. storyboards for front-ends) should be included here. Detailed designs such as database designs, software designs, procedure flowcharts, or pseudocode should be included here. Support computational and experimental results with key plots and figures. All supporting figures should be clearly labeled and annotated to highlight the most important points of the figure (i.e. explicitly point out what the reader should focus on or understand about the image).

Note that while all results should be used to help inform design decisions, not all results may be necessary to include in the main body of the report. Extraneous supporting results (e.g. graphs, data, design renderings, drawings, etc.) that are not necessary for presenting the fundamental findings can be placed in one or more appendices. Detailed documentation of each program module can be provided as appendix.

G.1 Modeling Results (example subsection)

G.2 Experimental Results (example subsection)

G.3 Prototyping and Testing Results (example subsection)

G.4. Final Design Details/Specifications (example subsection)

Note that while the design constraints and specifications may have provided minimum or maximum values, or ranges or values, that the design needed to meet, the final design specifications should be listed here showing that the required design values were met. A list of final design details can also be included demonstrate fulfillment of the design objectives.

Note: Preliminary results should be included in the Preliminary Design Report to show the progress made of the selected design concept to-date. This section should be updated for the Final Design Report to include documentation of all of the work that was completed on the project throughout the entirety of the academic year.

Section H. Societal Impacts of Design

In addition to technical design considerations, contemporary engineers must consider the broader impacts that their design choices have on the world around them. These impacts include the consideration of public health, safety, and welfare as well as the potential societal, political/regulatory, economic, environmental, global, and ethical impacts of the design. As appropriate for the project design, discuss how each of these considerations influenced design choices in separate subsections. How will the design change the way people interact with each other? What are the political implications of the design? Does the technology have the potential to impact or shift markets? Does the design have any positive or negative effects on the environment? Don’t forget to consider unintended consequences such as process or manufacturing byproducts. What impacts might the design have on global markets and trade? Are there any ethical questions related to the design?

While it is hard to forecast the various impacts of a technology, it is important to consider these potential impacts throughout the engineering design process. When considered during the early stages of the design phase, consideration of these impacts can help determine design objectives, constraints, and specifications and help drive design choices that may mitigate any potential negative impacts or unintended consequences.

***Note*:** A minimum of 4 of these design considerations, including the consideration of public health, safety, and welfare, are required for the Preliminary Design Report while a section for all considerations must be included in the final design report.

H.1 Public Health, Safety, and Welfare

Provide a list of all design safety features and provide a brief description of each. Discuss the potential effects the design may have on public health, safety, and welfare. References to the codes and standards previous provided and the organizations that produced them may be summarized or referenced here.

H.2 Societal Impacts

H.3 Political/Regulatory Impacts

H.4. Economic Impacts

H.5 Environmental Impacts

H.6 Global Impacts

H.7. Ethical Considerations

Section I. Cost Analysis

Provide a simple cost analysis of the project that includes a list of all expenditures related to the project. If an experimental test set-up or prototype was developed, provide a Bill of Materials that includes part numbers, vendor names, unit costs, quantity, total costs, delivery times, dates received, etc. Do not forget to include all manufacturing costs incurred throughout the completion of the project. If the design is expected to become a commercial product, provide a production cost estimate including fixed capital, raw materials, manufacturing (including tooling and/or casting), and labor costs to produce and package the device. Note that this type of detailed cost analysis may be listed as a project deliverable.

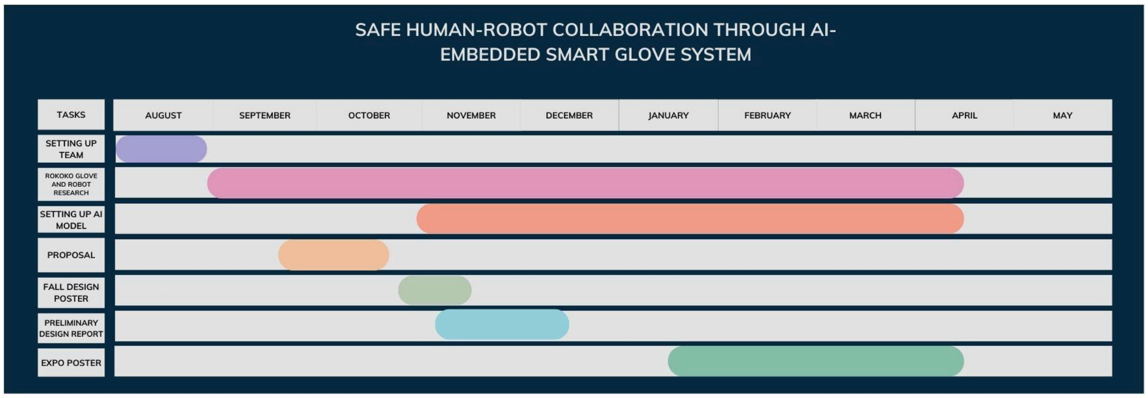
Note**:** The Preliminary Design Report should include all costs incurred to date. It is expected that this section will be expanded and updated between the preliminary and final design reports.

Section J. Conclusions and Recommendations

Use this section to summarize the story of how the design team arrived at the final design. Focus on the evolution of the design through the use of the engineering design process including lessons learned, obstacles overcome, and triumphs of the final design. Revisit the primary project goals and objectives. Provide a brief summary of the final design details and features paramount to the function of the design in meeting these goals and objectives.

A discussion may be included to discuss how the design could be further advanced or improved in the future. If applicable, summarize any questions or curiosities that the final results/design of this effort bring to mind or leave unanswered. If this project might continue on as a future (continuation) senior design project, detail the major milestones that have been completed to date and include any suggested testing plans, relevant machine drawings, electrical schematics, developed computer code, etc. All relevant information should be included in this section such that future researchers could pick up the project and advance the work in as seamless a manner as possible. Documents such as drawings, schematics, and codes could be referenced here and included in one or more appendix. If digital files are critical for future work, they should be saved on a thumb drive, external hard drive, cloud, etc. and left in the hands of the project advisor and/or client.

Appendix 1: Project Timeline



Appendix 2: Team Contract (i.e. Team Organization)

Step 1: Get to Know One Another. Gather Basic Information.

Task: This initial time together is important to form a strong team dynamic and get to know each other more as people outside of class time. Consider ways to develop positive working relationships with others, while remaining open and personal. Learn each other's strengths and discuss good/bad team experiences. This is also a good opportunity to start to better understand each other's communication and working styles.

Team Member Name	***Strengths each member bring to the group***	***Other Info***	***Contact Info***
Caitlin Ngo	Collaborator, problem-solver, Organized, Creative	I enjoy being a part of a team and meeting new people.	ngoca@vcu.edu 703-400-2786
Sienna Sterling	Works well under pressure, problem solver, determined, good presenter.	Normally I will complete things when I say I will. I'm really deadline oriented.	sterlingsr@vcu.edu 804-895-3042

Chris Hoang	Organization, Punctual, Easygoing, Fast typer, Work well under pressure.	I'm good at coming up with solutions. Good at public speaking.	hoangc3@vcu.edu 703-732-1494
Erin Anderson	Structured, Organized, problem-solver, accountable	I am good at designing.	andersones3@vcu.edu 202-300-4485

Other Stakeholders	***Notes***	***Contact Info***
Example: Faculty Advisor	Also our sponsor	*ebulut@vcu.edu*
Sponsor, Mentor, etc. (Add rows if necessary)		

Step 2: Team Culture. Clarify the Group's Purpose and Culture Goals.

Task: Discuss how each team member wants to be treated to encourage them to make valuable contributions to the group and how each team member would like to feel recognized for their efforts. Discuss how the team will foster an environment where each team member feels they are accountable for their actions and the way they contribute to the project. These are your Culture Goals (left column). How do the students demonstrate these culture goals? These are your Actions (middle column). Finally, how do students deviate from the team's culture goals? What are ways that other team members can notice when that culture goal is no longer being honored in team dynamics? These are your Warning Signs (right column).

Resources: More information and an example Team Culture can be found in the Biodesign Student Guide "Intentional Teamwork" page (webpage | PDF)

Culture Goals	***Actions***	***Warning Signs***

Being on time to every meeting	• *Set up meetings in shared calendar* • *Send reminder email in day before meeting* • *If you are going to be late beyond your control just let us know.*	• *Student misses first meeting, warning is granted* • *Student misses meetings afterwards – issue is brought up with faculty advisor*
Informing the group of any delays in completing assignments	• *Stay up to date with each other's project responsibilities* • *Set reasonable deadlines and note when an extension is needed* • *Inform team members if you're unsure of something*	• *Student shows up for weekly meeting with no considerable work done*
Take notes each meeting.	Document every meeting, including Google Drive and deadlines.	

Step 3: Time Commitments, Meeting Structure, and Communication

Task: Discuss the anticipated time commitments for the group project. Consider the following questions (don't answer these questions in the box below):

- What are reasonable time commitments for everyone to invest in this project?
- What other activities and commitments do group members have in their lives?
- How will we communicate with each other?
- When will we meet as a team? Where will we meet? How Often?

- Who will run the meetings? Will there be an assigned team leader or scribe? Does that position rotate or will same person take on that role for the duration of the project?

Required: How often you will meet with your faculty advisor advisor, where you will meet, and how the meetings will be conducted. Who arranges these meetings?
See examples below.

Meeting Participants	***Frequency Dates and Times / Locations***	***Meeting Goals Responsible Party***
Students Only	*As Needed, On Discord Voice Channel or Facetime.*	*Update group on day-to-day challenges and accomplishments (Avery will record these for the weekly progress reports and meetings with advisor)*
Students Only	*Fridayay*	*Actively work on project (Sienna will document these meetings by taking photos of whiteboards, physical prototypes, etc, then post on Discord and update Capstone Report)*
Students + Faculty advisor	*Every Wednesday at 1 pm in TBD*	*Update faculty advisor and get answers to our questions (Chris will scribe; Erin will create meeting agenda and lead meeting)*

Step 4: Determine Individual Roles and Responsibilities

Task: As part of the Capstone Team experience, each member will take on a leadership role, ***in addition to*** contributing to the overall weekly action items for the project. Some common leadership roles for Capstone projects are listed below. Other roles may be assigned with approval of your faculty advisor as deemed fit for the project. For the entirety of the project, you should communicate progress to your advisor specifically with regard to your role.

- **Before meeting with your team**, take some time to ask yourself: what is my "natural" role in this group (strengths)? How can I use this experience to help me grow and develop more?
- **As a group,** discuss the various tasks needed for the project and role preferences. Then assign roles in the table on the next page. Try to create a team dynamic that is fair and equitable, while promoting the strengths of each member.

Communication Leaders

Suggested: Assign a team member to be the primary contact for the client/sponsor. This person will schedule meetings, send updates, and ensure deliverables are met.

Suggested: Assign a team member to be the primary contact for faculty advisor. This person will schedule meetings, send updates, and ensure deliverables are met.

Common Leadership Roles for Capstone

1. **Project Manager:** Manages all tasks; develops overall schedule for project; writes agendas and runs meetings; reviews and monitors individual action items; creates an environment where team members are respected, take risks and feel safe expressing their ideas.
   Required: On Edusourced, under the Team tab, make sure that this student is assigned the Project Manager role. This is required so that Capstone program staff can easily identify a single contact person, especially for items like Purchasing and Receiving project supplies.
2. **Logistics Manager:** coordinates all internal and external interactions; lead in establishing contact within and outside of organization, following up on communication of commitments, obtaining information for the team; documents meeting minutes; manages facility and resource usage.
3. **Financial Manager:** researches/benchmarks technical purchases and acquisitions; conducts pricing analysis and budget justifications on proposed purchases; carries out team purchase requests; monitors team budget.
4. **Systems Engineer:** analyzes Client initial design specification and leads establishment of product specifications; monitors, coordinates and manages integration of sub-systems in the prototype; develops and recommends system architecture and manages product interfaces.
5. **Test Engineer:** oversees experimental design, test plan, procedures and data analysis; acquires data acquisition equipment and any necessary software; establishes test protocols and schedules; oversees statistical analysis of results; leads presentation of experimental finding and resulting recommendations.

6. **Manufacturing Engineer:** coordinates all fabrication required to meet final prototype requirements; oversees that all engineering drawings meet the requirements of machine shop or vendor; reviews designs to ensure design for manufacturing; determines realistic timing for fabrication and quality; develops schedule for all manufacturing.

Team Member	***Role(s)***	***Responsibilities***
Chris Hoang	*Scriber, Logistics Manager.*	● *Keep a detailed record of meeting notes and share with group* ● *Manages facility and resource usage.* ● *Lead external and internal interactions.*
Caitlin Ngo	Financial Manager, Test Engineer	● researches/benchmarks technical purchases and acquisitions; conducts pricing analysis and budget justifications on proposed purchases; carries out team purchase requests; monitors team budget. ● oversees experimental design, test plan, procedures, and data analysis; acquires data acquisition equipment and any necessary software; establishes test protocols and schedules; oversees statistical analysis of results; leads presentation of experimental findings and resulting recommendations.
Erin Anderson	Project Manager	● develops overall schedule for project ● writes agendas and runs meetings ● reviews and monitors individual action items ● creates an environment where team members are respected ● take risks and feel safe expressing their ideas.
Sienna Sterling	Systems Engineer, Historian	● Analyzes Client initial design specification and leads establishment of product specifications ● Monitor, coordinate and manage integration of subsystems in the prototype ● Develops and recommends system architecture and manages product interfaces. ● Take pictures of our team to document our progress.

Step 5: Agree to the above team contract

Team Member: Chris Hoang *Signature: __Chris Hoang_______________*

Team Member: Sienna Sterling *Signature: ________Sienna Sterling__________*

Team Member: Caitlin Ngo *Signature: ___Caitlin Ngo___*

Team Member: Erin Anderson *Signature: ____Erin Anderson______*

Appendix 3: [Insert Appendix Title]

Note that additional appendices may be added as needed. Appendices are used for supplementary material considered or used in the design process but not necessary for understanding the fundamental design or results. Lengthy mathematical derivations, ancillary results (e.g. data sets, plots), and detailed mechanical drawings are examples of items that might be placed in an appendix. Multiple appendices may be used to delineate topics and can be labeled using letters or numbers. Each appendix should start on a new page. Reference each appendix and the information it contains in the main text of the report where appropriate.

Note: Delete this page if no additional appendices are included.

References

Provide a numbered list of all references in order of appearance using APA citation format. The reference page should begin on a new page as shown here.

[1] VCU Writing Center. (2021, September 8). *APA Citation: A guide to formatting in APA style.* Retrieved September 2, 2024. https://writing.vcu.edu/student-resources/apa-citations/

[2] Teach Engineering. *Engineering Design Process*. TeachEngineering.org. Retreived September 2, 2024. https://www.teachengineering.org/populartopics/designprocess

[3] top view of glove (thanks for citing all this chris :p)

[4] bottom view of glove

[2] Development and Implementation of an AI-Embedded and ROS-Compatible Smart Glove System in Human-Robot Interaction (this is a paper in the related papers folder in our capstone folder)

[1] https://www.rowse.co.uk/blog/post/7-challenges-in-industrial-robotics

[5]https://support.rokoko.com/hc/en-us/articles/4410471103249-Getting-Started-with-your-Smartgloves