UCF Senior Design I

Motion Capturing Glove with Haptic Feedback From a 3D Environment

Department of Electrical Engineering and Computer Science

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Initial Project Document and Group Identification

Divide and Conquer

Group 2

David Simoneau	Computer Engineering
Chris Britt	Electrical Engineering
Hunter Hinnant	Computer Engineering
Francisco Tirado Perez	Computer Engineering

Project Narrative

Our product will be a glove controller that has the capabilities of interacting with a virtual 3D object. The design will be focused on taking position inputs from the glove, transmitting data through a processor, and then sending that data through our interface to the computer running the simulation. The project is designed in such a way to allow us to gain experience in PCB design as well as data communication, ARM development, and 3D modeling software API.

The glove will capture motion using multiple accelerometer PCBs located on the center points of each finger bone and one on the back of the hand. Each accelerometer will communicate with the processor board using I2C at a sufficiently high rate to ensure smooth operation. The processor will calculate the relative position of the fingers and hands relative to the ‘0’ accelerometer located on the back of the hand. This will require a reset button to calibrate the system. Once calculated the processor will interpret these positions as commands and then to a Bluetooth module which will send the commands via UART to a receiver which will communicate those commands to the computer and to a 3D modeling software such as Blender. The program will communicate back data that will allow the glove to give sensational feedback to the user. To do this the glove will incorporate Peltier devices for heating and cooling and small vibrational motors for touch feedback. Since the glove will be wireless we will be creating a rechargeable battery board. The choice for a rechargeable board was made because of the need for high quality low weight batteries to supply the high current requirements of the Peltier devices. This provides our project with two main facets. The construction of the glove and the computer Bluetooth interface is the hardware facet, while the incorporation of the 3D modeling software is another facet.

Through this project, we will add to the open-sourced community. The open-sourced community is filled with hobbyists that are always hungry for new challenges and fun project ideas. We look to supply this community with a comprehensive design that people can make use of for their own projects and applications. Specifically, we feel that the ability for hobbyists to interact with their own virtual 3D environments may drive innovation in the field of virtual and augmented reality.

Virtual and augment reality is and has been a hot new topic in technology development for quite some time. With the advent of the HTC Vive, immersive virtual reality gaming became an actual reality. However, a major drawback of current virtual reality is its lack of haptic feedback. When I touch something in the real world I can feel its heat and the pressure of my hand on it. Our project seeks to bridge that gap in current technology by allowing a control sensitive enough to accurately capture hand motions, while allowing for immersive feedback from the virtual world.

Our goals are to work on a fun, technically challenging project that will allow us to learn about real-world circuit design by implementing the knowledge gained from our education thus far. We also seek eye-opening conversations with professional industry workers, such as our professors, about industry standards, project design, and engineering concepts. We are hoping to advance our careers and industry visibility by contributing to an open source community. From this design, we will have gained industry-level experience to add to our resumes and gain necessary skills required by the field of computer/electrical engineering. The key feature we aim for with our glove input design is for it to have a high frequency rate to get a quick and accurate response rate of our input. We will implement sensors on the glove that will be able to track the motion of the hand and fingers with a high degree of accuracy and communicate that to 3D modeling software. The software will communicate back to the glove which of the feedback devices should activate and by what degree based on the current position of the virtual hand. We would also like to establish a base design that future hobbyist might be able to expand from. Since many hobbyist struggle with the more technical aspects of electronic and computer engineering, it is our hope that by designing the more technically challenging aspects of this project we will establish a hardware and code base that can be expanded from easily in the future.

Requirement Specifications

Integrated Specifications

- The integrated package must be able to support 30 frames of data per second
    - Each frame will consist of 16 individual I2C reads, a processing step, and communication to the drone controller
    - The total time required for all steps in a frame must be less than 33 milliseconds
- The complete system will consist of:
    - A custom-built motion capture glove
    - A custom-built processor module
    - A custom-built computer-Bluetooth interface
    - A custom-built software package for the processor
    - Use of Open source 3D modeling software
    - A custom-built software package to interface with the 3D modeling software
    - A custom-built battery board
    - A store-bought Bluetooth communication pair

Glove Specifications

- Must use accelerometer chips to measure relative acceleration of each PCB
- Must not exceed 2 kilograms in total weight
- Accelerometers must be able to function at the ±2 G range
- Accelerometers must have at least 10 bits of resolution
- Accelerometers must be I2C compatible
- Must contain at least 6 vibrational motors
- Must contain at least 6 Peltier devices
- Must be able to run off rechargeable batteries
- Must be Bluetooth compatible
- Must contain current limiting devices as a safety measure for the Peltier devices
- Accelerometer PCBs should be approximately 1.5 cm^2

Processor Module Specifications

- The processor module will use an ARM architecture chip
- The processor module will not consume such a large amount of power that thermal considerations must be considered
- The processor chip must have at least 1 dedicated I2C line
- The processor chip must have a clock rate sufficient to support the 30-frame requirement
- The processor module must have a reset option to calibrate the system
- The processor module must have a power switch

Processor Software Specifications

- The software must be well documented as per ANSI/ANS 10.3-1995
- The software must be written in C or C++
- The software must be reliable, making all functions of the glove possible with little to no bugs or crashes

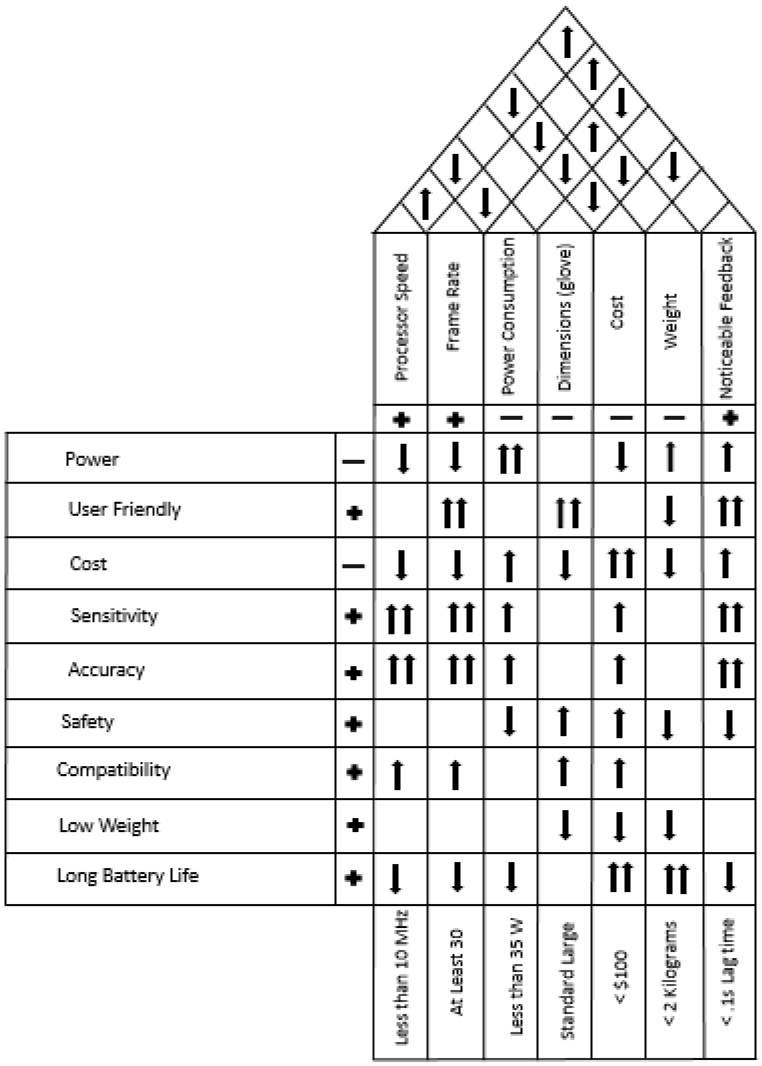
3D Modeling Software Interface Specifications

- The software must be able to interface with the 3D modeling software to send and receive date

Operational Specifications

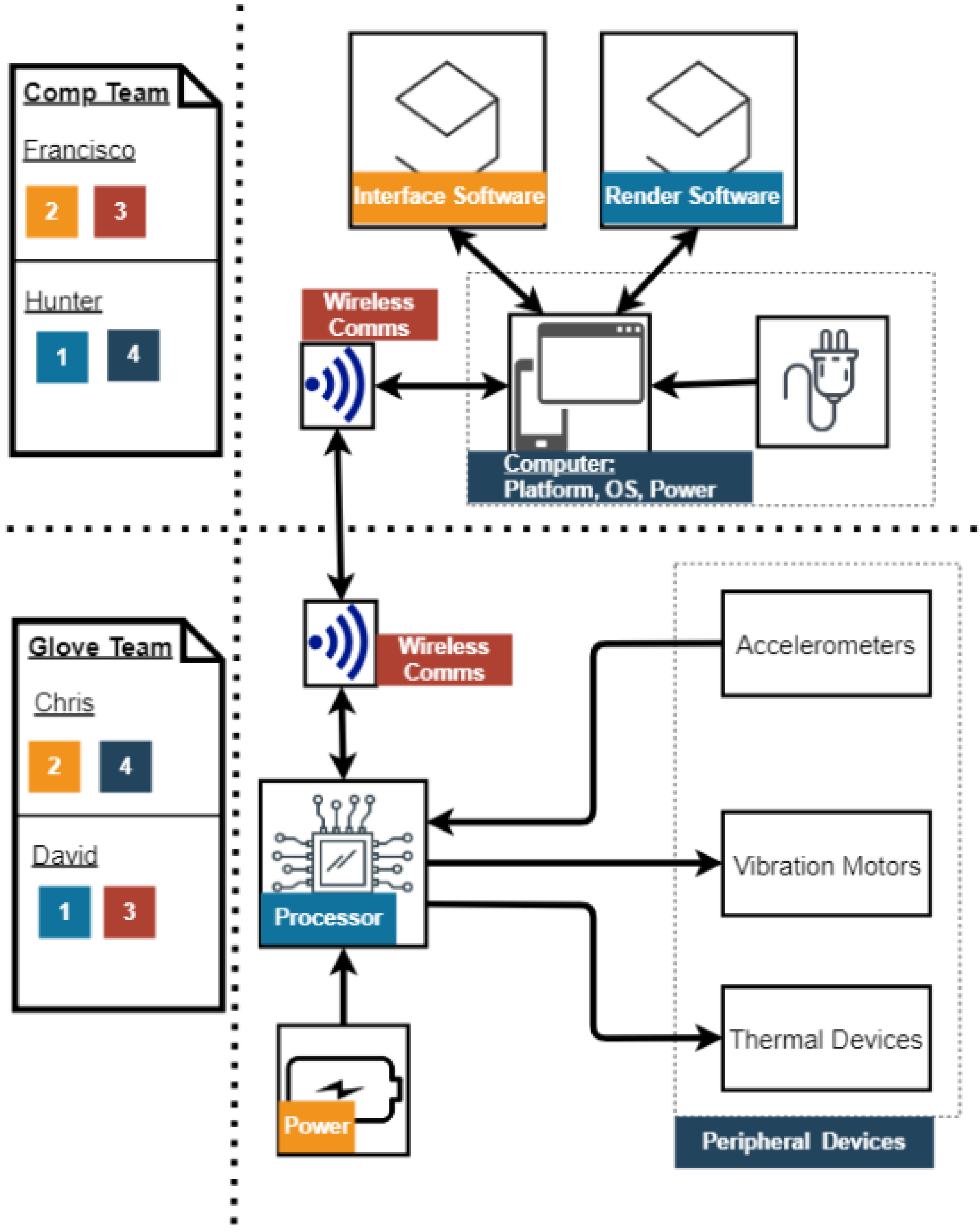
- The package must be operable for a minimum of 30 minutes from a full charge with standard use

House of Quality

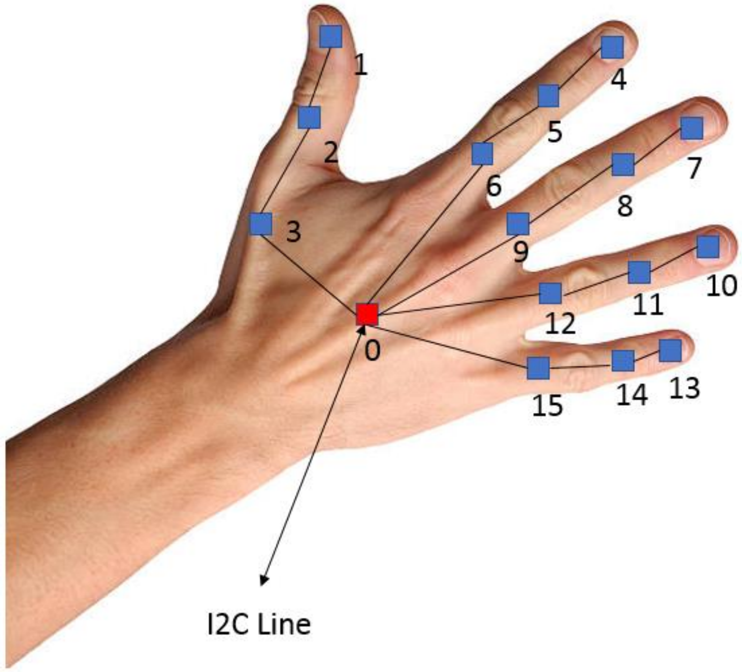


Block Diagram 1: House of Quality

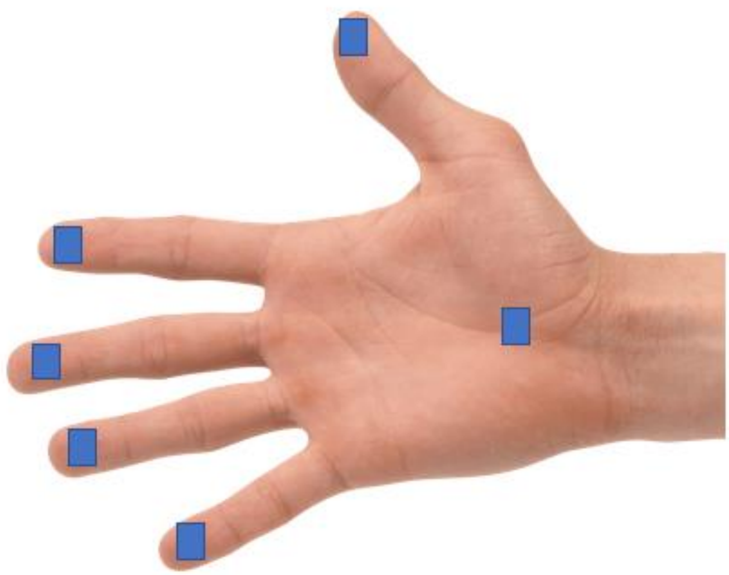
Block Diagrams



Block Diagram 2: Diagram of Modules and Responsibilities



Block Diagram 3: Diagram of Accelerometer Placements



Block Diagram 4: Diagram of Placement of Peltier Devices and Vibrational motors

Milestones

#	Senior Design I ~ Tasks	Due By	Admin	Pages Done
1	Have divide and conquer with rough outline of what needs to be researched	June 8th	Group 2	10
2	Have complete standards and have picked out all components for glove	June 15th	Chris	10
3	Have complete standards and components picked out for processor interfacing with glove	June 22nd	David	35
4	Have full understanding how data will be entering/exiting processor and have pseudocode for 5 necessary functions	June 29th	Group 2	60
5	Have power figured out and full understanding of how we will interface with 3D software	July 6th	Francisco	78
6	Order components. Research more into how to code ARM processor and interface with components. Build a breadboard or microcontroller interfacing with controller to ensure data will transmit correctly from outside input.	July 13th	Group 2 Hunter	98
7	Have photo of all components. Start making 3D components in Blender and have more understanding of how interacting with them will work. Then start constructing/designing glove for rough component placement.	July 20th	Group 2	115
8	Have report finished. Finalize any details. Proofread. Add/Subtract necessary information. Ensure citations present. Proofread again.	July 27th	Group 2	120+
9	Full Report Due ~ if time, make prototype and reorder and broken parts	July 30th	Group 2	120+

#	Senior Design II ~ Tasks	Due By	Admin
10	Prototype glove	Aug 24th	Group 2
11	Prototype processor, redesign glove, and start fully coding	Aug 31st	Group 2
12	Prototype interface with 3D software and redesign processor	Sept 7th	Group 2
13	Get accurate input into Blender and some type of output from Blender.	Sept 14th	Group 2
14	More implementing of all three components (glove, 3D software, haptic feedback)	Sept 21st	Group 2
15	More implementing of all three components	Sept 28th	Group 2
16	Troubleshooting / Redesign	Oct 5th	Group 2
17	Troubleshooting / Redesign	Oct 12th	Group 2
18	Fix individual issues with any of the three main components	Oct 19th	Group 2
19	Fixes to individual issues with any of the three main components	Oct 26th	Group 2
20	Put all together. Try to have all coding functionality complete.	Nov 2nd	Group 2
21	More testing.	Nov 9th	Group 2

22	Troubleshooting. Have design/prototype complete if possible	Nov 16th	Group 2
	Thanksgiving 21st-26th		
23	Long weekend. Probably away for family. Ordered extra necessary components in case of hot fixes or things break. Test boundaries. Ensure standards and requirements are met.	Nov 23rd	Group 2
24	Hopefully an extra processor and glove made that both work. Hours of more testing needs to be done. Test boundaries more. Overheat, Cool, Drop, Vibration, Drastic hand movements	Nov 30th	Group 2
25	Present and get A.	Dec ?	Group 2

Cost

We are not trying to set a record for low-cost, but would like to implement a design that's cost-effective for potential hobbyists or enthusiasts to utilize or build our design. The total price we are looking to spend for all used, wasted, or extra components and items is $1000, but having a total build cost of under $100 for a "packaged" PCB design, enclosure, power adapter(s), 3D software interface with transmitter/receiver PCB, and glove. The purpose of having such a high price range for this design is to have the freedom to try out different components, fail a couple of times, learn from our mistakes, and not worry about trying to keep to a specific budget.

The project will most likely not have any funding due to lack of need in the market. However, when we seek funding, we will request from companies in the fields of gaming, for VR or AR needs, and of the movie industry for animation.

Item	Quantity	Price (rough estimate)
Glove	2	$20
PCB Design ~ Processor Board	4	$150
PCB Design ~ Glove	4	$150
Electrical Components on PCBs	?	$200

Bluetooth modules	2	$40
Peltier Devices	10	$50
Power Supply	2	$20
Vibrational Motors	10	$50
Gyroscope Sensor	2	$50
Room for Error	?	$270

Conclusion

Interacting with a virtual environment is both an academically interesting and technically challenging task that could produce dividends for the gaming and hobbyist communities. The addition of both haptic and temperature feedback could greatly expand the immersions of virtual worlds. By adding this design to the open source community, we expect to advance our careers and highlight our technical skills to prospective employers.