Augmented Reality User Interface for NASA Spacesuits

University of Central Florida
Department of Electrical and Computer Engineering,
College of Optics and Photonics (CREOL)

Dr. Samuel Richie
Senior Design I

Group 6

David Brown	*Computer Engineering*
Yongsheng Xu	*Electrical Engineering*
Teodor Malendevych	*Photonic Science and Engineering*
Sammy Lee	*Photonic Science and Engineering*

I. Project Narrative

Ever since man dreamt of going to space, there was a suit design created. In the first human spaceflight program in the United States, Project Mercury, a suit was designed to be worn only inside the spacecraft.The requirements for such a suit were to allow the wearer to withstand low pressure environments. NASA's second mission included activities outside of the spacecraft. A new suit had to be designed to perform these extravehicular activities (EVA). The spacesuit requirements for Gemini included Protection during emergency ejections, intra vehicular activities (IVA), EVAs, and Comfort. These suits were connected to the spacecraft to supply oxygen through a hose.

The previous two projects were set up for Apollo. In the Apollo Program, astronauts would be walking on the moon untethered to the space craft. New boots had to be designed such that they could walk on the moon without discomfort. A life support system as added to the suit in order to remove the necessity of the hose.

As space missions continue, the design of the space suit is changed to fit that particular mission. Currently NASA is pursuing the Artemis missions in which the first woman and next man are planned to explore the moon by 2024. NASA has issued a challenge in which the visual display systems integrate with some modern technology. Teams are tasked with creating spacesuit information displays in an augmented reality (AR) environment.

The requirements for the displays are used to help astronauts complete EVAs. These tasks include Navigation, EVA Systems States, and Geology Sampling. For navigation, the device must accurately guide the user to multiple EVA assets and designated geology excavation sites in real time. The EVA system states require the AR device to interact with a suit port to execute airlock activities and interaction with the suit to display vitals. The AR device must also help in science sampling and geology field notes.

Other considerations will be that of user interface (UI). Included in this is low light conditions due to the nature of the lunar south pole. High contrast conditions also must be considered. Easy controls to allow the user to complete EVA tasks. A requirement of a system tutorial is added to help new users navigate through the UI efficiently and effectively.

We have decided to take on this challenge.

II. Requirement Specifications

General Requirements

- EVA task instructions shall be displayed
- The astronaut must be able to access the status of the spacesuit at anytime
- The astronaut shall be able to communicate with ground control at any time
- A caution and warning system must be implemented to inform the astronaut about spacesuit anomalies.
- In case of an interruption, the astronaut must be able to continue the task on hand seamlessly.
- The user interface shall not permanently impede the astronaut's ability to perform.
- All hand gestures must be operable with EVA gloved hands (like heavy ski gloves)
- The user interface shall take field notes for lunar sampling.
- The astronaut should know its location and how to navigate from one point to another at all times.

Peripheral Device Requirements

- Any external or additional device must be approved by NASA prior to the test week
- The device shall communicate with the Head Mounted Display
- Any removable components shall have a tether attachment point
- All Tools must be operable with EVA gloved hands (like heavy ski gloves)
- Devices must not have holes or openings which would allow/cause entrapment of fingers.
- There shall be no sharp edges on any tool
- Pinch points should be minimized and labeled.
- An optical heart rate monitor that is designed with a EVA gloved hand in mind.
- A pulse oximeter designed such that it is not an impedance in the suit.
- A sensor that interacts with vision filters to create a similar effect to night vision.

Possible Constraints

- **Cost:** We only have about $1000 in our budget. Nasa wants us to use a Hololens 2 or Magic Leap. Each one of these devices cost more than $1000. We also will have to create sensors or buy sensors in order to integrate them into the AR environment. We have applied for a hololens loan from NASA.
- **Time:** We only have until October 21st to submit a team proposal and the team selection is announced November 17th. So we would have to expedite the work to meet the deadline.
- **Selection:** The basis of continuing this project would be on the selection process by NASA. If we are not selected we would either have to pivot to a different AR device or project. The pivot that we would be attempting to simply create a head mounted display.

III. Block Diagram

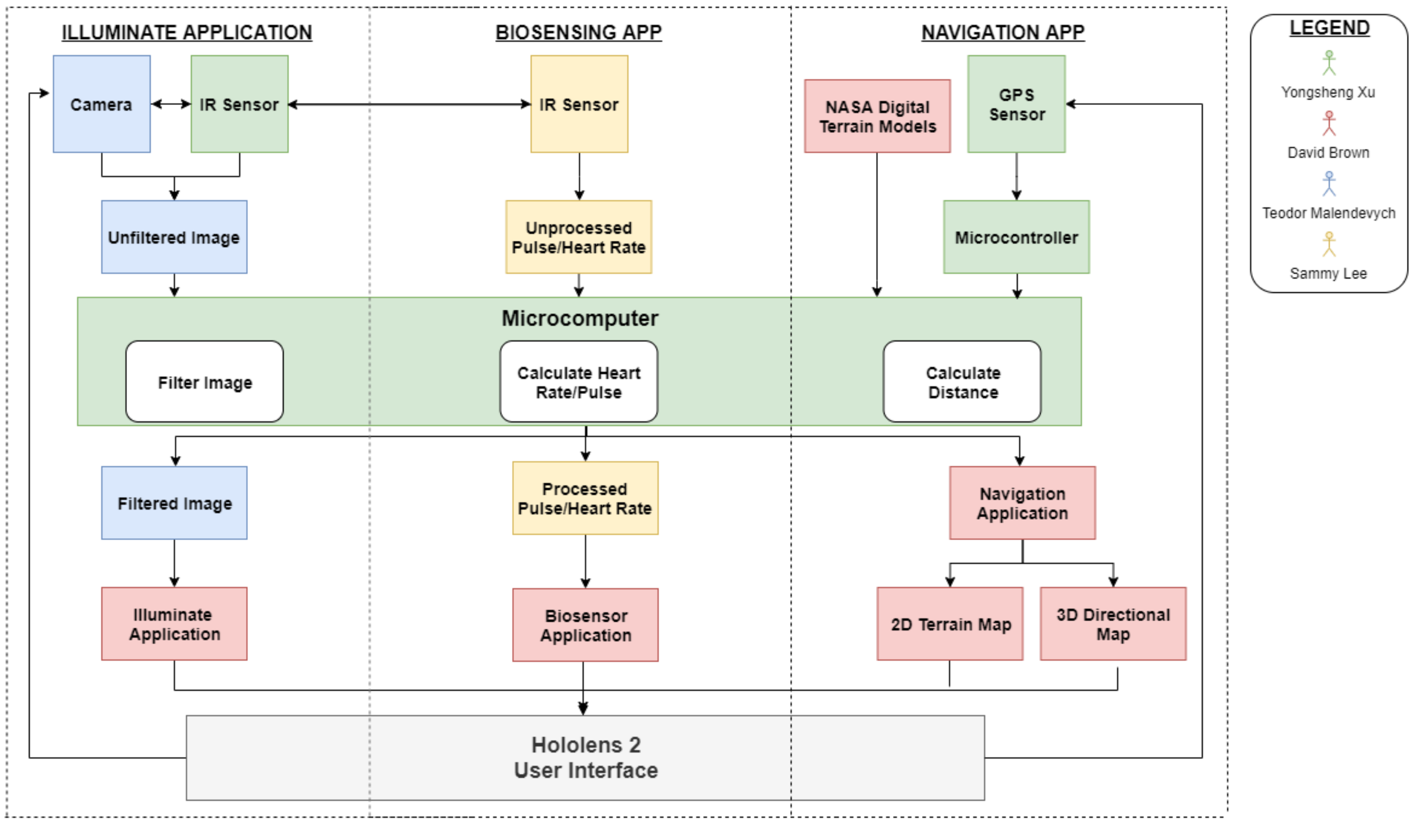

Figure 1: Design Block Diagram

Status of blocks as of 9/17/2020:

- All blocks are currently under research.
- None of the blocks have been purchased or acquired.
- All blocks in the design process.
- None of the blocks is currently being prototyped.
- None of the blocks are completed.

IV. Software Flowchart

The following flowchart shows an order of how the software is going to decide what to do given some input. As per the specification, the tutorial is easily accessible for new users. The user interface will then decide based on two areas based on the user's discretion. In the illumination area the software is to decide upon cases of low light or high contrast and help increase visibility. The navigation will be a real time update based on gps to help the astronauts reach their goal.

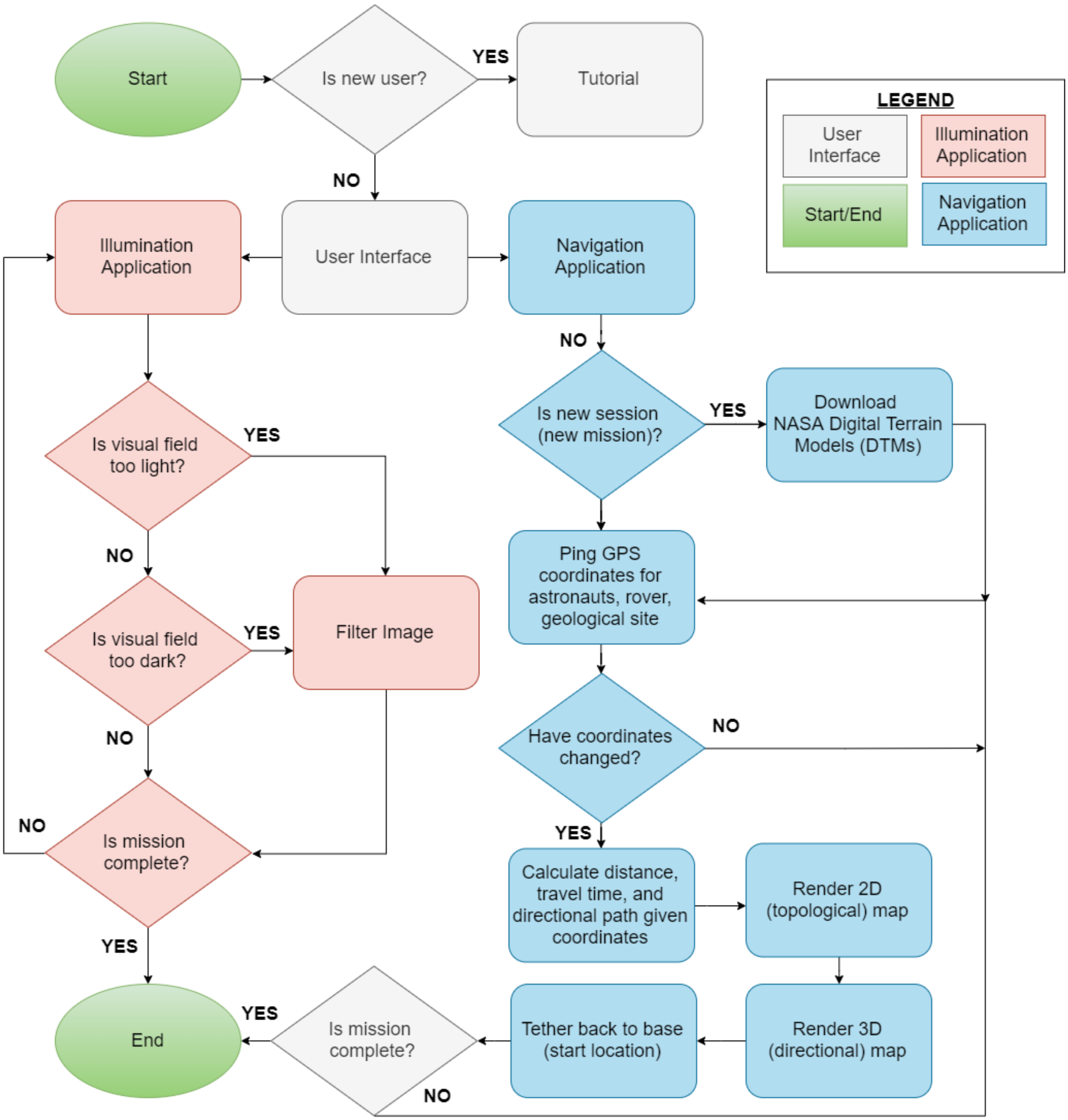

Figure 2: Software Design Diagram

V. House of Quality

The following figure details the tradeoff matrix where we identify the customer specifications and engineering constraints. This House of Quality helps the engineers in determining the main limitations with regards to certain aspects of the project. We evaluated how the needs of the project correlate with said limitations.

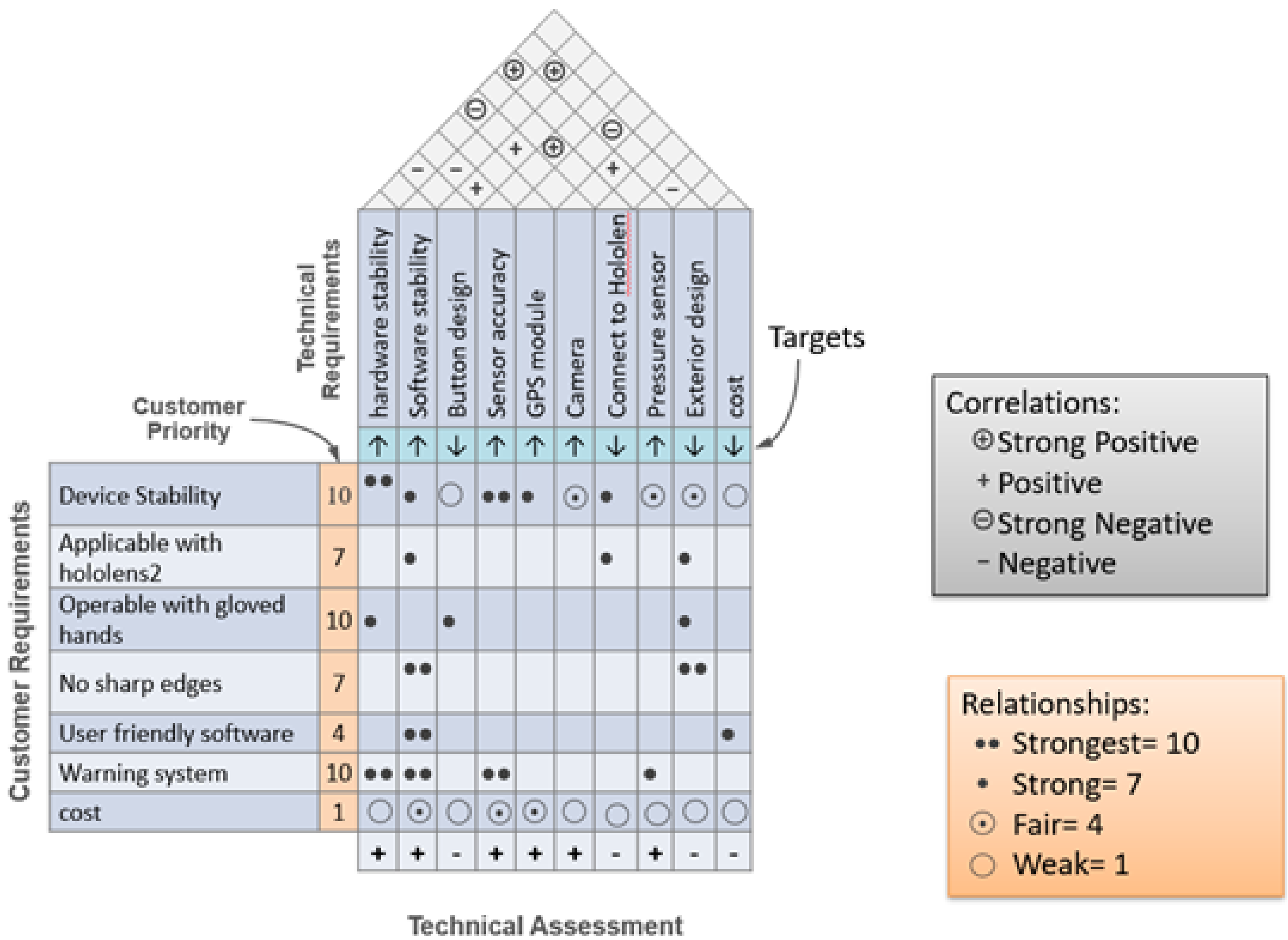

Figure 3: House of Quality

VI. Budget and Funding

Our project will be self-funded, our max limited to $1,000. The table below is based on estimates. Parts used may change in the future. For the HoloLens 2, there is a program called university loan program that allows teams to borrow a HoloLens 2 from NASA to use during the challenge. We are also looking into external funding from companies and the NASA Consortium Grant. (In this project, we are gonna use GPS used on earth, on the moon, there is special device used to navigate)

Item	Quantity	Price($)
Microsoft Hololens 2 (Rent)	1	0
PCB Board	5	100
Photosensor	1	10
Microcontroller	1	30
Camera Interface	1	50
GPS Module	1	12
Temperature Sensor	1	11
Push Button	10	12
Wireless Communication Module	1	9
Pressure Sensor	1	9
Night Vision (self-made)	1	30
Eye Tracing (self-made)	1	30
Pulse Oximeter (self-made)	1	100
Optical Heart Rate Monitor (self-made)	1	100
Total (Estimated Range)	N/A	<600

Table 1: Estimated Budget

VII. Milestones

This section details our schedule and deadlines through the duration of the project for both Senior Design I and Senior Design II. Each of these milestones is vital in the completion of our design and project. As we get more information regarding Senior Design II, the table will be updated.

Number	Task	Start Date	End Date	Status
Senior Design I				
1	Project Selection	Aug 20th	Sept 9th	Completed
2	Divide and Conquer Documentation	Sept 8th	Sept 19th	Completed
3	NASA SUITS Letter of Intent	Sept 8th	Sept 30th	Completed
4	Divide and Conquer Documentation Update	Sept 20th	Oct 2nd	Completed
5	NASA SUITS Proposal	Oct 1st	Oct 20th	In Progress
6	Parts List	Sept 8th	Oct 20th	In Progress
7	Draft Document	Oct 3rd	Nov 13th	Not Started
8	Final Document	Nov 14th	Nov 27th	Not Started
Senior Design II				
1	Prototype Completion	TBD	-	-
2	Peer Review	TBD	-	-
3	Mid-Term Demo	TBD	-	-
4	Project Completion	TBD	-	-
5	Final Presentation	TBD	-	-

Table 2: Schedule and Deadlines

VIII. Decision Matrix

In the following table, we describe different project ideas we came up with and the considerations that led to us to choose the NASA SUITS project.

Idea	Description	Requirements	Constraints
NASA SUITS Project	Using Hololens II and external sensors to aid astronauts on the Moon in guidance and task management.	- Microsoft Hololens II - UI Software - Sensors (Solar Radiation, IR, Temperature)	- Sponsorship of the Hololens II
Augmented reality Microscope	A microscope utilizing AI to detect cancer cells and displaying the outline of said cells (AR) in real-time for the viewer.	- Optics for the Microscope - AI Software - AR Software - GPU for analyzing images	- Cost - Would require a significant amount of programming
Augmented reality Board Game	A player plays with his phone, which takes video real time and displays 3D models of characters and events on an interactive board game.	- Phone app - Board Game Set (including moving parts, lights, etc.)	- Coding for phone apps might be tricky - Heavy computing tasked on phone
Robot Turret	Utilizes a camera to scan the room for certain players. Proceeds to shoot said players with nerf darts.	- High-speed camera - Color/Face recognition software - Laser sights	- Applications are limited to entertainment
UV Mask Sterilization	Only one air route for the mask with UV light to sterilize the air. Integrated circuit in the mask.	- Integrated Circuit - UV laser - Mask	- Not sure on effectiveness of UV lasers on air - The size of the device could be large
Keyboard Eye-tracking	Eye-tracking technology would determine where the user is looking at the screen. A keyboard will be displayed so the user can articulate a message without any touching or speaking needed.	- Camera - Eye-tracking software	- Application-wise, there are possibly more effective methods of communication for those who are mute/paralyzed

Table 3: Decision Matrix