N.O.V.A.

Navigational, Observational, Visual Aide for Astronauts

Collaborative Lab for Advancing Work in Space
C.L.A.W.S | University of Michigan

NASA SUITS Challenge 2023
September '22 - May '23

High Level Features Overview

01 UIA Egress

Preliminary actions before starting an EVA procedure

02 Vitals

Monitor O2 levels, Pressure values, and battery capacity

03 Navigation

To/from a custom location with trailing breadcrumbs

04 Geo Sampling

Add details on interesting rock formations with intuitive supporting notes

05 Rover

User controlled and commands set for rover

06 Messaging

Allows user to talk to other astronauts, MCC, etc.

Components

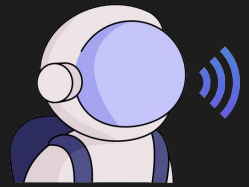
U.I.

HoloLens User Interface

General AR UI the user interacts with. Includes widgets, screens, pop-ups, alerts, etc.

V.E.G.A.

Voice Entity for Guiding Astronauts



AI Voice assistant that assists astronaut activities and performs basic requests

L.U.N.A.

Light Unit Navigation Aid

External light attached and display extension, to avoid AR screens from overwhelming the user

M.C.C.

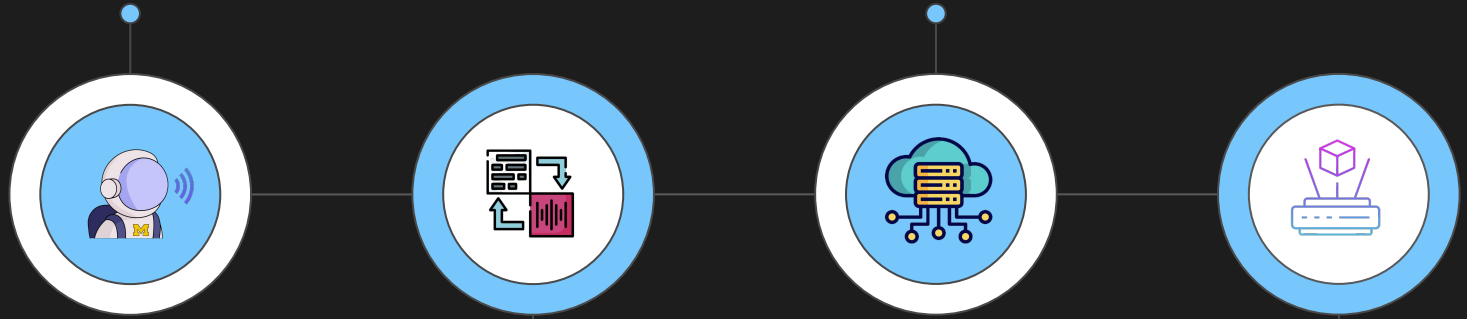
Mission Control Center

Web application used for supporting astronauts EVA activity, monitor vitals etc.

How Does VEGA Work?

AWS EC2 Server

An API call is then used to prompt the NLU processing on an AWS EC2 server instance. This keeps processing off of the HoloLens.



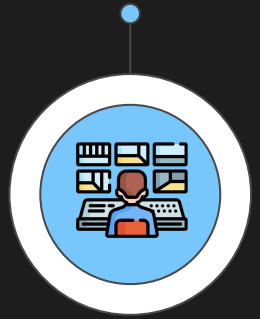
Azure Speech-to-Text

used to process the audio stream from an astronaut speaking

Rasa Intent Classification

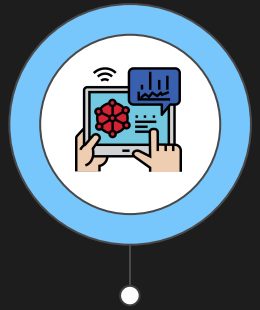
VEGA then utilizes open-source intent classifier & entity recognizer Rasa and returns the appropriate functionality for the HoloLens.

Collaborating with MCC



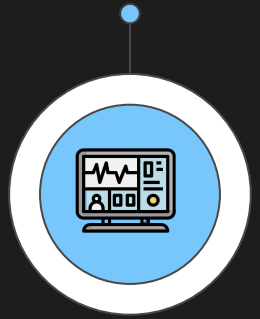
Information displayed on MCC panel

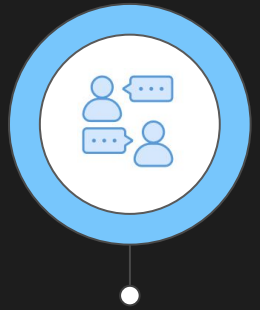
Navigation overview, Vitals, Messages, Geo Sampling Data



Updating States

Astronaut sends a POST request every second to MCC, with updated information on their vitals, UIA Egress completion status and so on.





Two Way communication

MCC can send the astronaut messages, locations and vitals of other astronauts, and waypoints

LINK

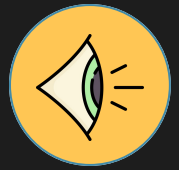
User Interview Key Takeaways: Less is More

Metrics

Deliver information in a way that the user can easily understand (i.e. by presenting battery percentage as remaining time).

Instructions

Provide the user with as concise instructions as possible, without them needing to think excessively.

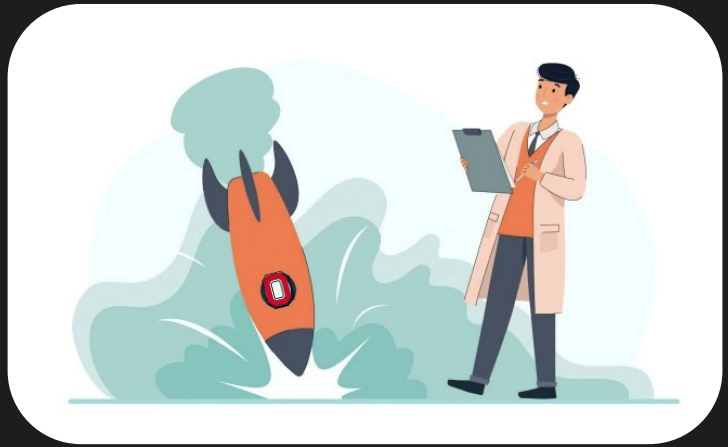


Touchless

Gloves are not very mobile— discourage tapping and encourage methods like eye gaze and voice commands.

User Testing Findings:
Pain Points

- **Eye-gaze** is not reliable
- Too many instances of **accidental selection**
- **Integration** of many different components
- Difficulty with **connectivity**



User Testing Findings: Successes

- ★ UI is **intuitive** and clean
- ★ High degree of **flexibility** with input methods
- ★ **Context-dependent** voice commands
- ★ **LUNA** lighting rig

Future Scope

- Improving **eye-gaze** usability
- Improve **field of vision** with LUNA IMU
- Integration with **MCC**
- Expand **VEGA's** corpus

Research

MANUSCRIPTS

1. **Illuminating the Augmented Reality Stage: Assessment of Complex Lighting Conditions for Space Exploration,** Human Factors and Ergonomics Society Journal, 2023. *Washington D.C.* (Accepted)

POSTERS

2. **Augmented Reality in Space and in Surgery**: An Assessment of HoloLens 2's Compatibility with Varied Lighting Conditions and Hand Coverings. Global Surgery Student Alliance National Conference, 2023. *Ann Arbor, Michigan.*
3. Innovation with Emerging Technologies: **Collaborative Lab for Advancing Work in Space**. NASA SUITS Challenge Research Symposium, 2023. *Houston, Texas.*
4. **Evaluation of Lighting on the HoloLens** Performance for Space Exploration. Extended Reality Summit, 2023. *Ann Arbor, Michigan*
5. **Emerging Technologies for Space Exploration**: Extended Reality Evaluation. College of Engineering Aerospace Day, 2023. *Ann Arbor, Michigan.*

Outreach

Exhibit

University of Michigan XR Summit

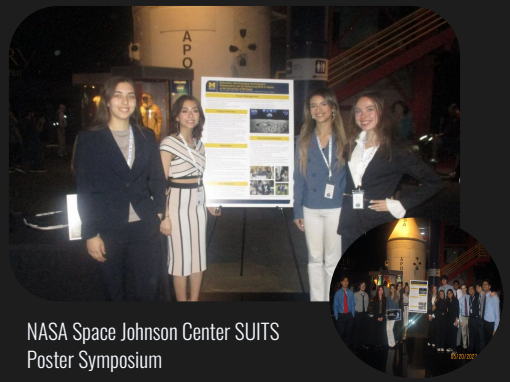
Poster

Global Surgery Student Alliance National Conference

Volunteer

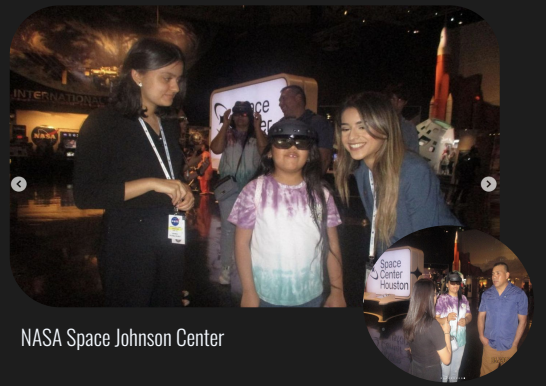
Local High School Aerospace Day

Poster



NASA Space Johnson Center SUITS Poster Symposium

Volunteer



NASA Space Johnson Center

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Interdisciplinary Team

CLAWS members come from multiple programs across University of Michigan:

- Computer Science
- UX Research and Design
- Robotics
- Aerospace Engineering
- Art and Design
- Neuroscience
- Computational Medicine & Bioinformatics
- Astronomy & Astrophysics
- Microbiology
- Biomedical Engineering
- And more!

Thank You!

A Quick Recap:

1. **VEGA**: A voice assistant that allows users to perform various actions.
2. **LUNA**: A display extension that allows the user to position displays outside their primary FOV.
3. We prioritized eye-gaze and voice commands to compensate for the lack of mobility with gloves on.
4. Primary displays are persistent as widgets in the user's secondary FOV, with supporting windows opening on peripheral LUNA displays.

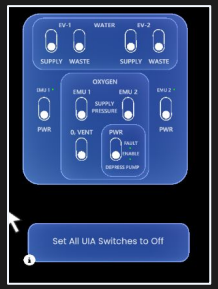
User Interview Findings

Participant	Key Observation 1	Key Observation 2	Key Observation 3
P1	Gloves are not very mobile	Astronauts are very persistent on what they want to see	Astronaut field of view is very limited
P2	Think about physical and human constraints	Wants to know context on Oxygen leaks and Co2 accumulation	Highlight the hardware that the user needs to find
P3	Minimize interaction with the interfaces	Users use a variety of hand-held instruments	Manual list or checklist for the astronaut
P4	Easier to keep instructions readable than being only read out	Data would be analysed both on the spot and later as time permits	MCC decides what's relevant, but reconsider the information stream.

Home Screen

Geosample Screen with Description

Expanded Geosample Screen

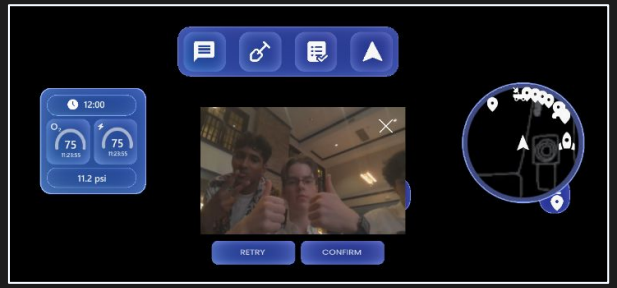


UIA Egress Display

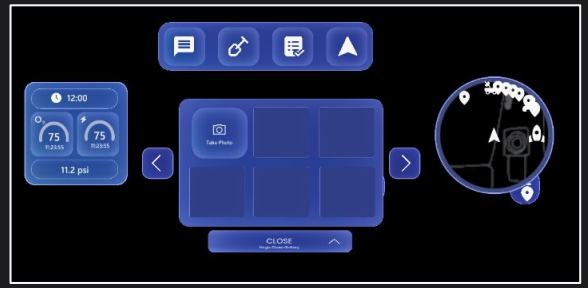
Messaging Screen

Geo sample Screen with Camera

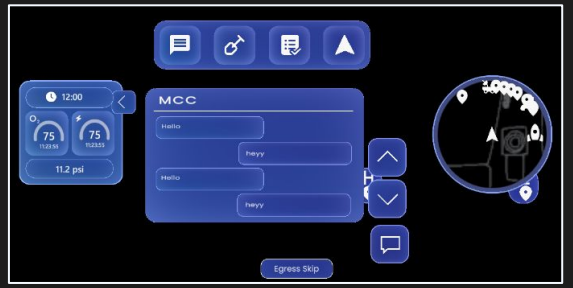
Geosample Screen



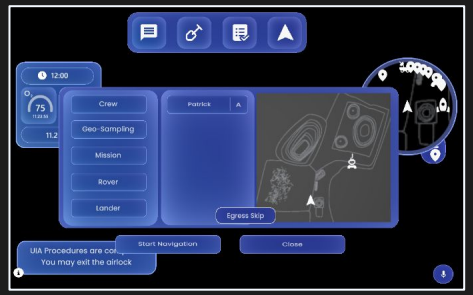
Geosample Screen with Confirmation Prompt



Geosample Screen with Gallery



Chat Screen



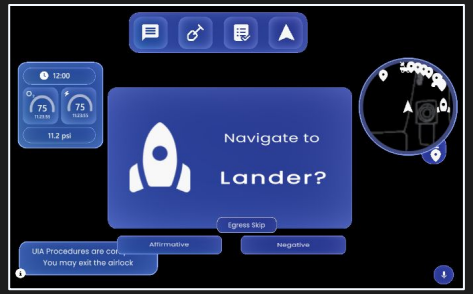
Navigation Crew Display

Geographical Navigation Display

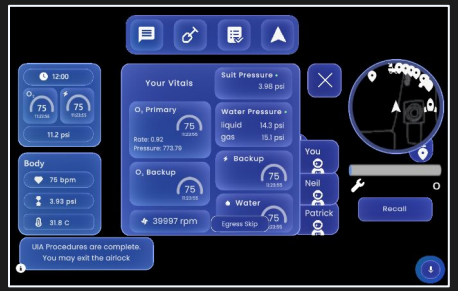
Navigation Mission

Current Task Display

Rover Navigation



Lander Navigation

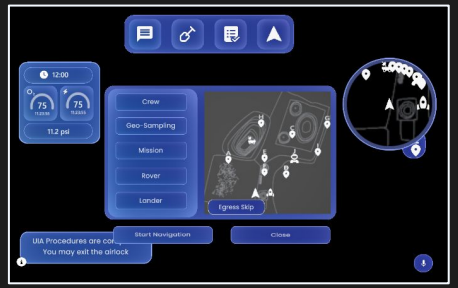


Vitals

Task List

Waypoint Navigation Confirm Display

Rover Navigation Confirm Display



Navigation DIsplay

A Touchless System

"**The biggest shortfall of the suit is the glove**. The gloves are the issue since late 1940s. Astronaut could hardly use their dexterity in the gloves because of the high pressure in the spacesuit"

— P2

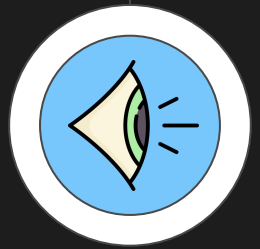
Our Goals with LUNA

Expand Field Of Vision

Used IMU heading to set location of screens to the orientation of users body, expanding field of vision

Eye Gaze

Used physical light to ensure proper conditions for eye gaze to work



LUNA Commands

“LUNA left,” “LUNA right,” and “LUNA center” cause display to focus on one of three screens