Integration of Augmented Reality and Neuromuscular Control Systems for Remote Vehicle Operations

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ABSTRACT

Traditional remotely operated vehicles (ROV's) require extensive setup and unnatural control systems. By integrating wearable devices as a control system, operators gain mobility and situational awareness. The analysis is conducted to understand if wearable devices connected through the Internet of Things (IoT) allow for a more responsive and natural human-in-the-loop control system for ROV's. The study also analyzes if a wearable heads-up-display (HUD), used in place of A heads-down-display (HDD) control system increases operator situational awareness and response time. A gesture recognition armband is worn around the operator's forearm and reads surface electromyography (sEMG) signals produced by their muscles. This turns hand signals into electrical signals. An augmented reality (AR) headset overlays supplemental information on the HUD without obscuring the users natural sight. The system is an IoT, enabling each component of the system to transmit and receive data over a secure network. The AR headset serves as the central processing unit (CPU), processing sEMG signals and transmitting respective commands to a ROV. The ROV acts on the received commands and transmits data describing its actions and environment to be displayed on the HUD. A library of signal patterns related to hand signals defined in US Army Publication TC3-21.60 is developed as a control set of commands. Signal processing and machine learning methods reduce cross-talk and interference of weak sEMG signals to increase gesture recognition accuracy. Analysis results provide insight into the effectiveness of neuromuscular control compared to human-to-human instruction, and how wearable control systems can increase operator situational awareness and emergency response time.

INTRODUCTION

sEMG sensors measure potential (voltage) difference between an array of electrodes on the surface of the skin. The measurement represents superficial muscle activity, assuming signal interference and sEMG cross-talk are mitigated. Benatti, developer of a wearable gesture recognition device, processed sEMG signals with a Support Vector Machine classifier with 90% accuracy [1]. Machine learning methods show promising results of gesture classification. Adding visual aides to a real world environment helps provide additional information without diminishing situational awareness. In 1992 Rosenberg reduced those ideas to practice by developing the first AR system, Virtual Fixtures, at the U.S. Air Force Armstrong Labs. His research concluded that "Fixtures composed of haptic and auditory perceptual overlays increased operator performance up to 70% [3]." In a Cisco whitepaper, Evens states that Cisco predicts that there will be 50 billion devices connected to the internet by 2020 [2]. IoT is popular because of how easy it is to access information. Each subset of this design is technology that is rapidly increasing in capability and will help ensure a successful future for this design.

METHOD

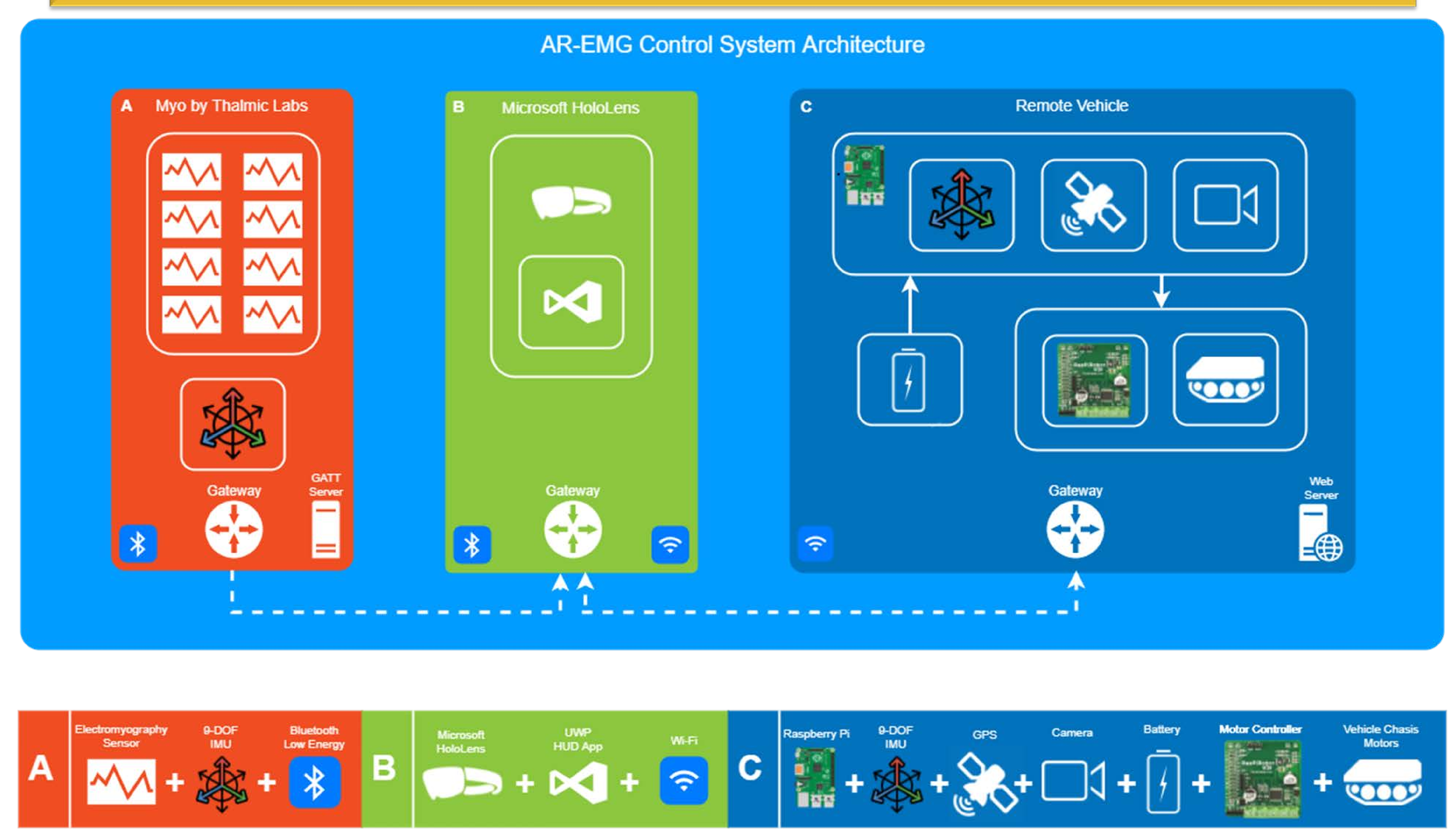

Figure 1: System Architecture

Gesture Recognition Device: Myo Armband by Thalmic Labs
- GATT Server
  - Transmits sEMG and IMU Data

Augmented Reality Headset (CPU): Microsoft HoloLens
- GATT Client
- HTTP Web Client
- HUD UWP application
  - Gesture classification library
  - HUD

Remotely Operated Vehicle: Custom Built
- HTTP Web Server: Raspberry Pi Micro Computer
- Sensor Suite: Video, Audio, IMU, GPS

Off-Board Pre-Processing
- kNN and SVM machine learning algorithms
- Training and generation of gesture libraries

Figure 2: HUD

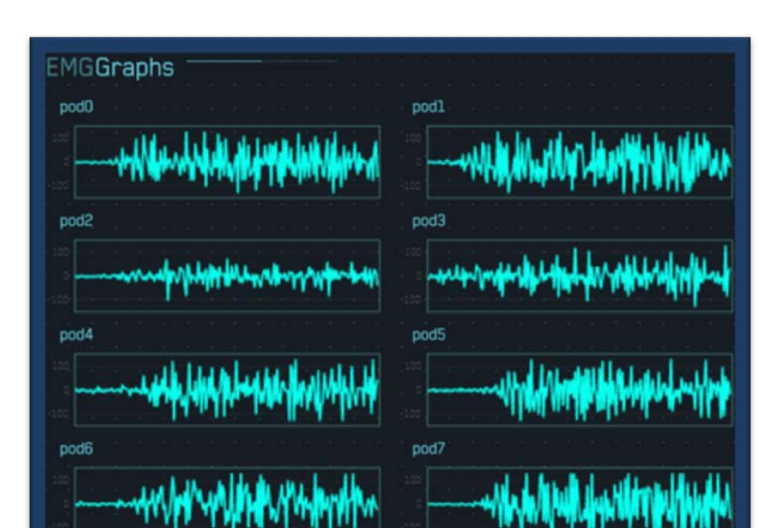

Figure 3: Filtered EMG Data (Fist Hand Gesture)

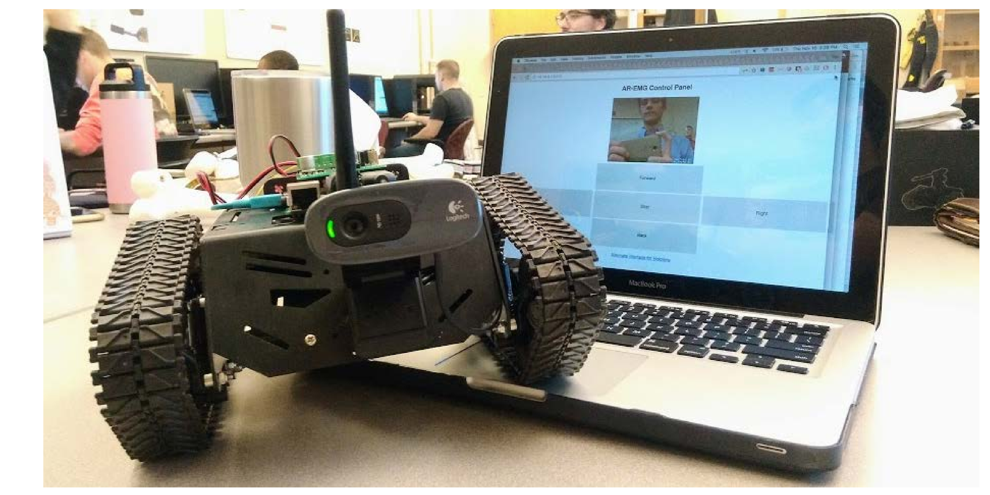

Figure 4: Remote Vehicle

RESULTS

Ten commands are given to both human and vehicle plants in ten separate trials of each variation. Variations include three ranges, three visibility environments, and three multi-task scenarios. The percent accuracy of executing the intended command is recorded and analyzed for each trial. To analyze how the control system affects user situational awareness, the user is required to perform three multi-task scenarios. Each scenario analyzes reaction time and percentage of task completion for both HUD and HDD control methods.

CONCLUSION

Analysis results provide insight into the effectiveness of neuromuscular control compared to human-to-human instruction, and how wearable control systems can increase operator situational awareness. Future work will further develop the system to allow operators to change ROV platform with out additional training, such as ground vehicle to aerial vehicle, and research how this control system can reduce cross platform training time.

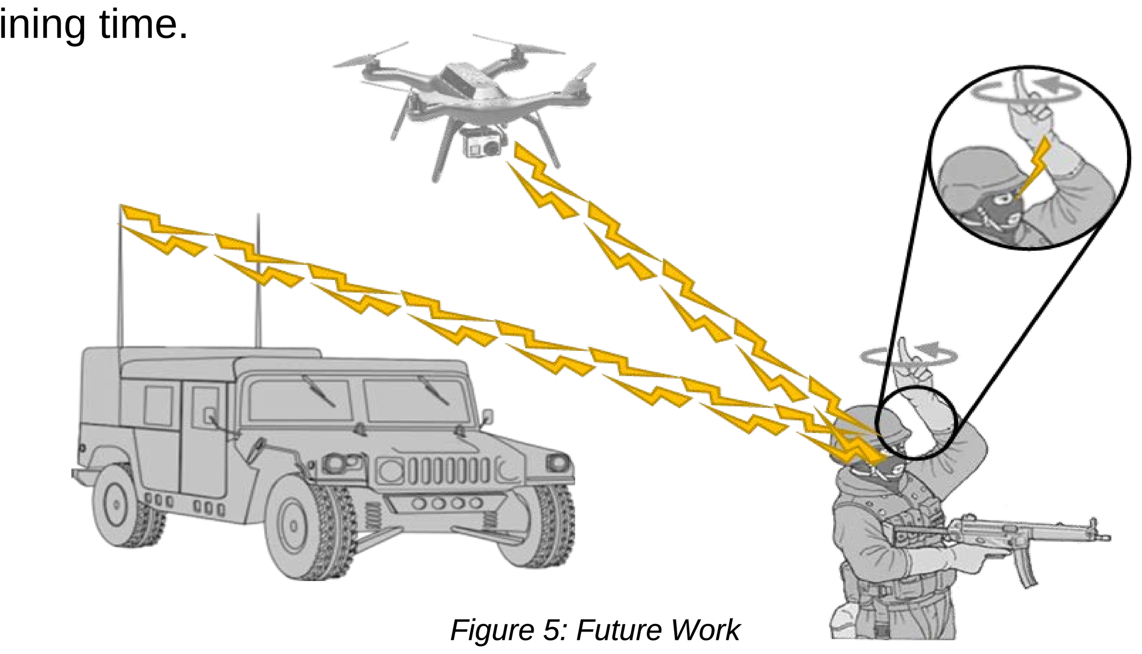

Figure 5: Future Work

SCIENTIFIC MERIT

Current methods of piloting remote vehicles require complex understanding of the vehicle, training in controlling it, and a dedicated driver. The fusion of ease of use of the MYO Gesture Control Armand and the real-time feedback of the HoloLens provides a user simplified solution to guiding a remote vehicle without requiring the user's full time and attention. This allows the pilot and vehicle to operate in tandem or independently.

REFERENCES

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ACKNOWLEDGMENTS

Dr. Eduardo Divo, Interim Chair of Department of Mechanical Engineering, ERAU

Dr. Victor Huayamave, Assistant Professor of Mechanical Engineering, ERAU