Design and Validation of Control Interfaces for Anna

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ABSTRACT

This project improves the control mechanisms for a semi-autonomous wheelchair with an assistive robotic arm system, also known as Anna. The system is aimed at increasing the self-sufficiency of individuals with Locked-In Syndrome (LIS). The objectives of this project include the validation of the existing control interfaces, as well as the integration and design of new systems. The wireless brain-computer headset, used to implement the control system for wheelchair navigation, is validated through several user studies. An Electromyography (EMG) sensor system serves as an alternative control module for wheelchair navigation. To increase physical interaction with the environment through object manipulation, a 6 degree-of-freedom robotic arm system is integrated with Anna. The arm system includes a RGB-D camera for object detection and localization, enabling autonomous object retrieval to enable self-feeding. The project outcomes include a demonstration of Anna in various conditions performing navigation and manipulation tasks.

EPOC EMOTIV HEADSET

- EPOC Emotiv Headset measures and classifies electrical muscle activity caused by different facial expressions using Electromyography
- Data from 30 human trials used to determine optimal facial expressions for system control
- Switches between wheelchair navigation, arm system control, and passive modes
- Identified commands to control 5 degrees of freedom in each mode
- Command detection accuracy of 85% and 4% false command detection

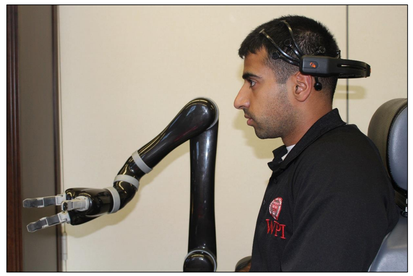

Figure 1: Wireless Brain-Computer Headset

ANNA

Figure 2: Anna and Control Interfaces

ROBOTIC ARM SYSTEM

- 6 degree-of-freedom Kinova Robotics Jaco arm
- Manual and autonomous end effector control
- 0.90m workspace, 2kg weight limit
- Calculates a kinematic chain using the KDL plug-in
- Capable of static path-planning
- Using x,y,z point and orientation input from camera, calculates a goal angle for each joint
- Plans a series of trajectories to the goal, simplifies the plan, and executes trajectory
- Image segmentation with ASUS XTION Pro Live
- RGB-D camera, 0.8m to 3.5m range
- Extracts object point cloud for objects on horizontal surfaces (e.g. table or counter top)
- Calculates approximate centroid of each object
- Determines pose of object wrt wheelchair base

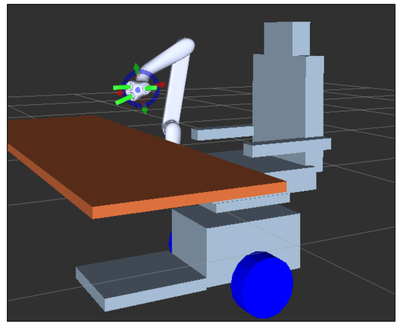

Figure 3: Jaco Arm Trajectory Planning

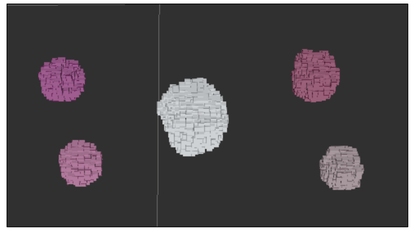

Figure 4: Segmented Objects Point Cloud

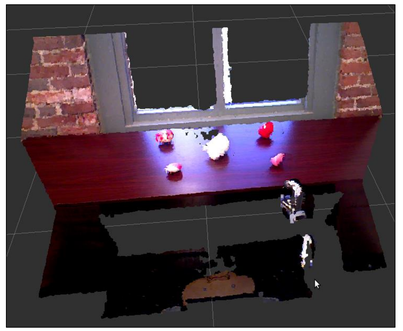

Figure 5: RGB-D Image Point Cloud

SYSTEM CONTROL ARCHITECTURE

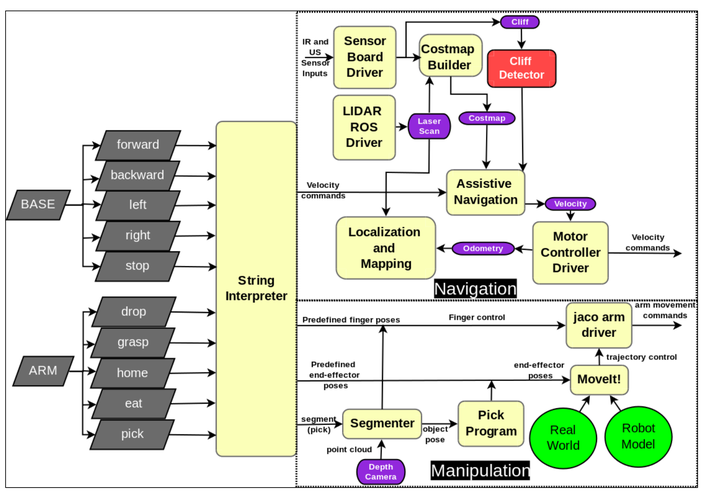

Figure 6: Full System Diagram

OUTCOMES

Emotiv Headset

Created a multi-modular system with 5 degrees of freedom and an 85% command accuracy

EMG Module

Converted muscle signals to logic high pulses for wheelchair navigation

Robotic Arm

Preformed object retrieval with the use of static path-planning and object avoidance

Vision System

Performed image segmentation to extract object centroid and pose

ELECTROMYOGRAPHY (EMG) MODULE

- EMG module measures electrical neck or arm muscle activity
- Module converts muscle signal to a logic high pulse
- Two stage amplifier circuit amplifies electrical activity
- Module can detect finger movement dependent upon forearm location

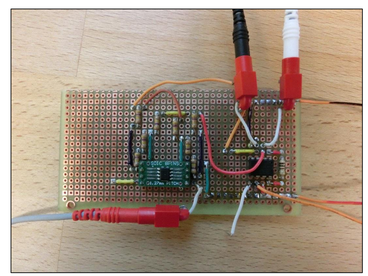

Figure 7: Final EMG Module Board

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