we use signal processing and support vector machines to classify brain waves from a test subject and feed the result into the control for the robot arm. In this way, we demonstrate a method to perform basic tasks using brain-controlled robots and proof-of-concept for future applications of complex human-robot interaction.

2 Implementation

2.1 EEG Protocol

The first task depends on detection of alpha brain waves. These can be detected on EEG by asking the test subject to close their eyes and observing a peak in EEG signal in the 8-13Hz range [5]. In contrast, when the subject opens their eyes, there is a significant reduction in signal in this range.

EEG placement on the subject's head is optimized in order to precisely record the alpha wave signal and use it to control robot motion. A custom EEG cap is created from elastic material to ensure secure lead placement on the subject's head.

Classically, alpha wave signal can be most strongly detected in the occipital lobe of the brain. While the bulk of the signal comes from this region, finer alpha signal can also be obtained from other areas in the brain– namely, the parietal lobe and central lobe. Three elastic bands are placed over the central lobe, parietal lobe, and occipital lobe.

Lead placement is determined according to the international 10-20 system of electrode placement, as seen in Figure 1, in order to accurately detect signal from the three areas of interest mentioned above. A summary of lead positions can be found in Table 1. In summary, the electrodes are placed at 10 and 20 percent intervals of various perimeter measurements of the skull. The electrodes are secured using Ten20 conductive neurodiagnostic electrode paste. This paste serves a dual function of securing the electrodes and ensuring high levels of conductivity.

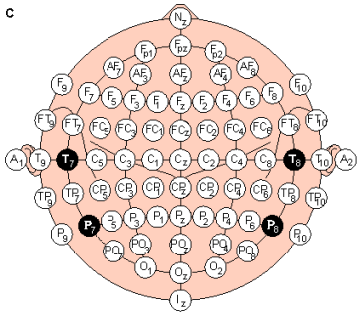

Figure 1: International 10-20 System of Electrode Placement for EEG [6]

2.2 End Effector Design

Since the WAM robot does not possess an inherent end-effector, we present several designs for potential end-effectors to attach to the last joint and demonstrate versatility of the system. The first design is a thumbs-up model, which simply moves up and down when the alpha-wave is detected by the OpenBCI sensor. This is