Research Experiences for Teachers

Perceptive Robots for Field-oriented Industry

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Introduction

1. Construction industry suffers from safety issues - High number of fatalities
2. Construction industry has productivity issues
3. Is facing labor challenges and aging workforce: Median age – 41

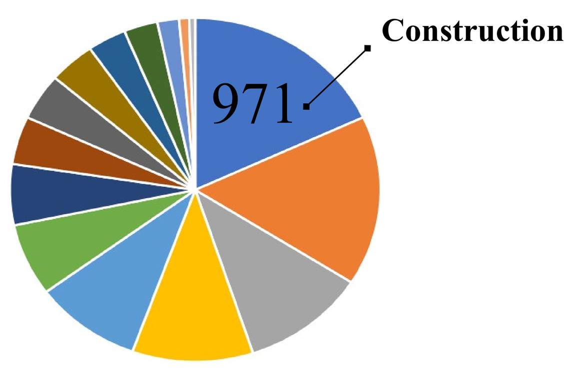

Figure 1: Number of fatal occupational injuries in industry sector (BLS 2017).

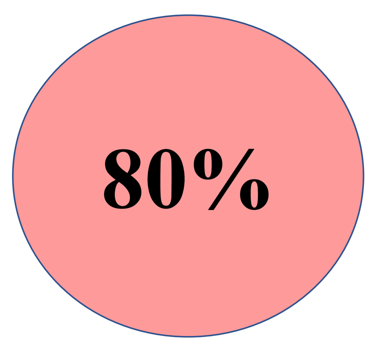

Figure 2: Percentage of companies are suffering from labor shortage.

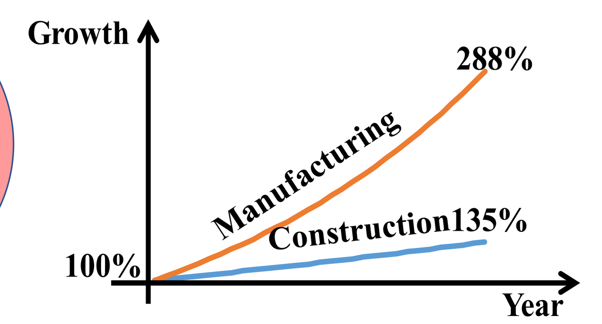

Figure 3: Labor-productivity growth in construction vs. manufacturing.

Robotics in Construction Sites

Figure 4: Construction Robots.

Challenges

1. Current construction robots may raise new safety challenges
2. Current construction robots may raise new productivity challenges

Primary Objectives

1. Develop a Brainwave-driven **Human-Robot Collaboration (HRC)** framework to create communication between workers and robots using **EEG signal** from real construction worker **in real time**.
2. Test the HRC framework by measuring worker's three different **mental states** (i.e., low, medium and high cognitive load).

Primary Case Study

Figure 5: Layouts of the Two Tasks

Primary Results

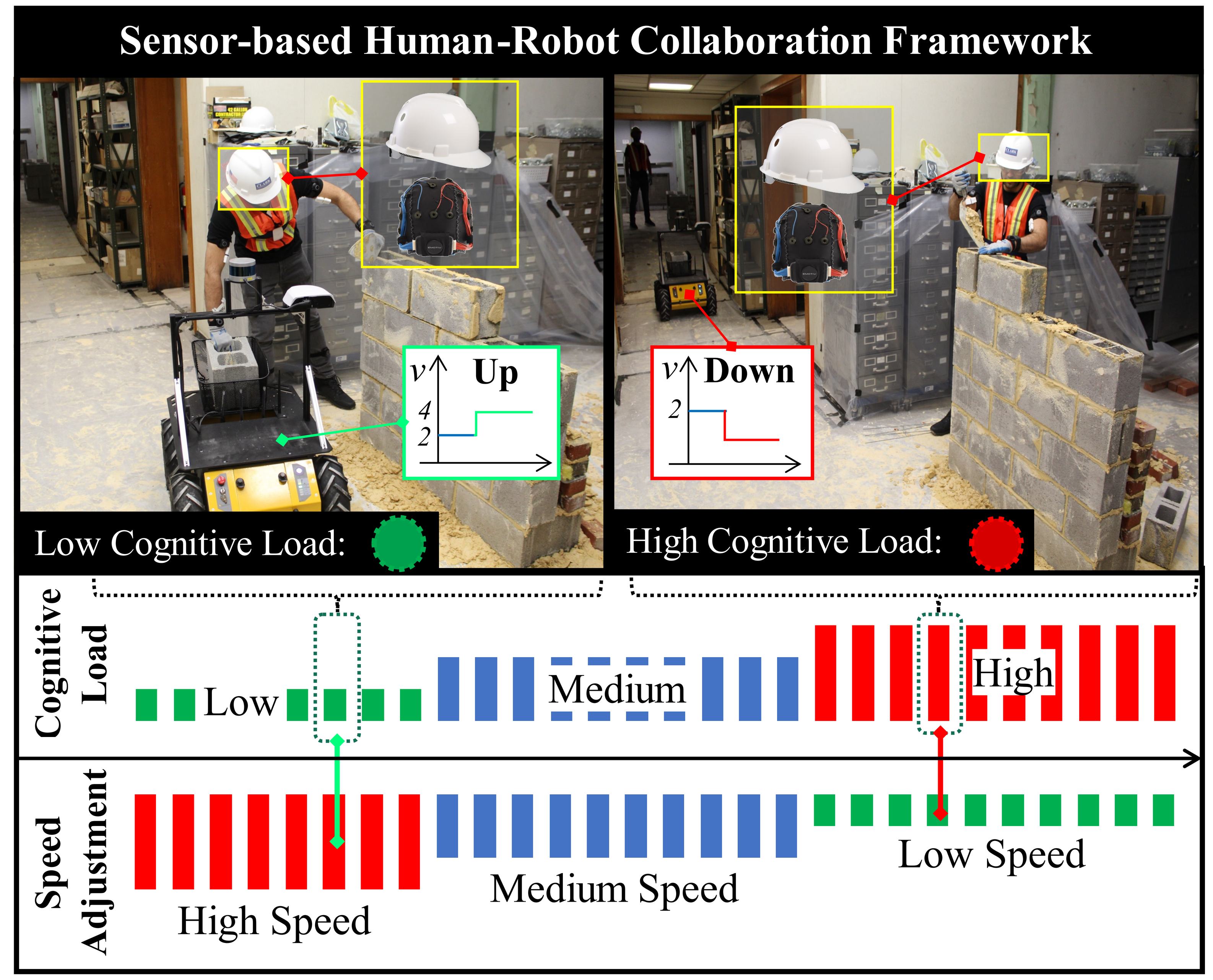

Figure 6: Performance of the proposed perceptive robot in material delivering task

1. Five workers wore helmets with 32 sensors to record EEG (brainwaves).
2. They completed a basic construction task (laying bricks) with no additional requirements (low cognitive), then with minimal requirements (med cognitive), and finally with difficult added requirements (high cognitive).
3. The data from the sensors was uploaded, analyzed, the "noise" data was filtered. Data collected contained "noise" from movement, EEG electrode, and construction equipment noise.
4. Data was filtered by removing signals outside of 0.5 to 45 HZ and adaptive filtering was used based on a reference point (baseline without noise - controlled environment)
5. The data was converted and processed using a "prediction equation".
6. The robot received the transmission and sped up or slowed down based on the filtered data.

Primary Data Analysis

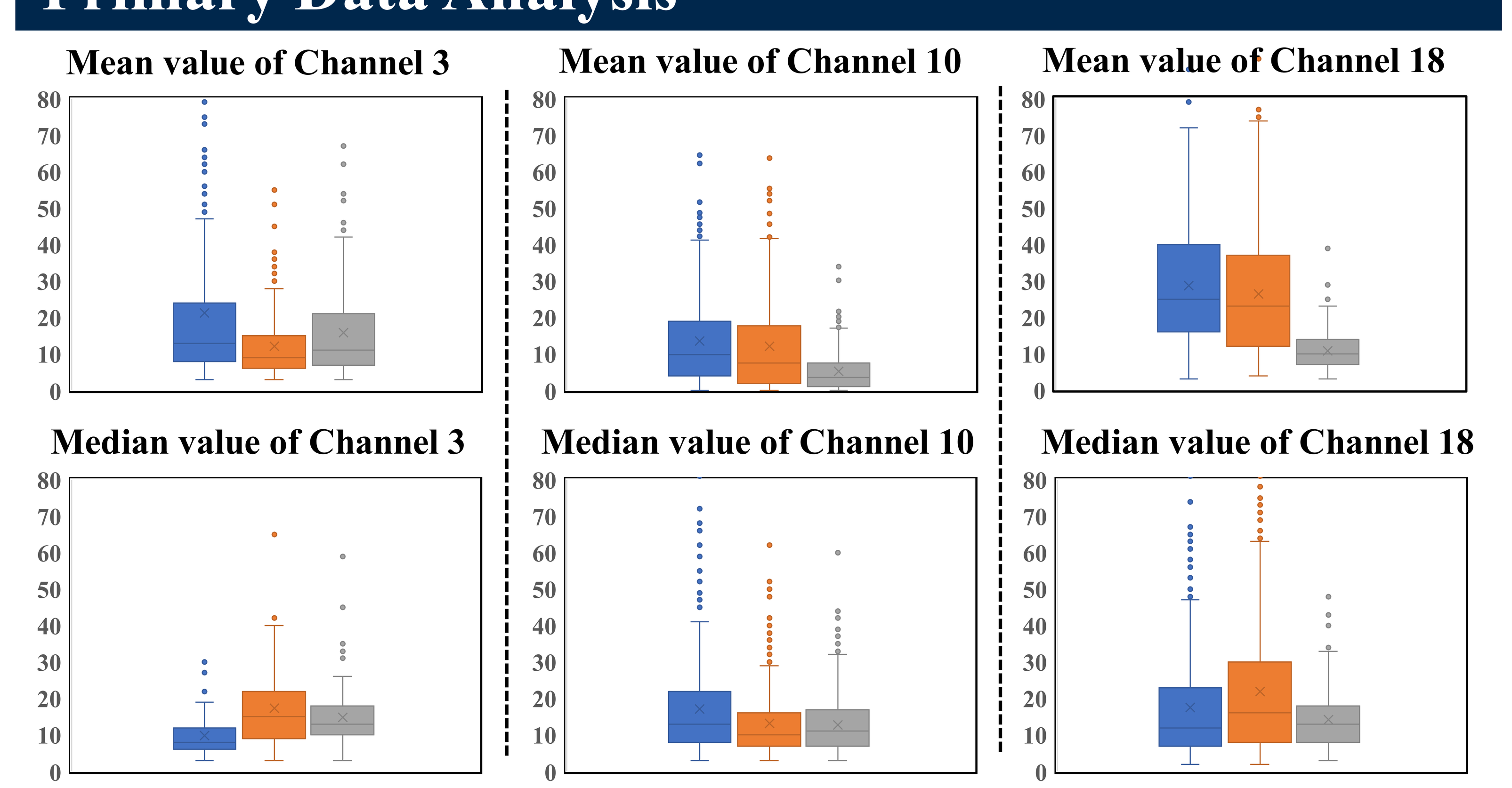

Figure 7: Comparisons of the Extracted Metrics (EEG) for Helmet Channels 3, 10, and 18 (Blue = Low Cognitive, Orange = Medium Cognitive, Grey = High Cognitive)

Secondary Objectives

1. Develop communication between workers and robots using **vital signs** from real subjects **in real time**.
2. Test by measuring worker's vital signs including heart rate, respiration, and blood pressure and passing this information through robotics sensors.

Secondary Case Study

1. Used Vernier DataQuest with available sensors to read biological vital signs in real time. Sensors and vital signs included Blood Pressure, Heart Rate, EKG, Oxygen, and CO_2

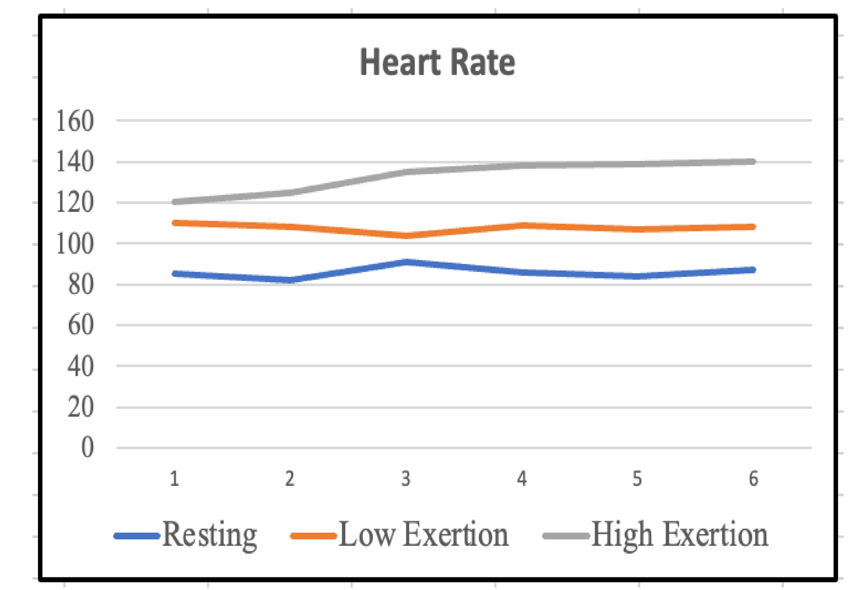

Figure 8: Heart Rate Data Collected

Figure 9: Vernier DataQuest and Heart Rate Sensor

2. Used Lego light and color sensors to detect change in vital signs.
3. Test subject was outfitted with each sensor and resting rates were recorded. The subject was then asked to run in place slowly in order to increase vital signs. Next the test subject was asked to run in place as fast as he could. Using this data, low, medium, and high ranges were recorded.
4. A Lego robot conveyor belt with light sensor was programmed as follows:
   a. Speed up and make alert sound if reading hits the "low range".
   b. Slow down and make alert sound if reading hits the "high range".
   c. Remain at same speed if reading is at "medium range"

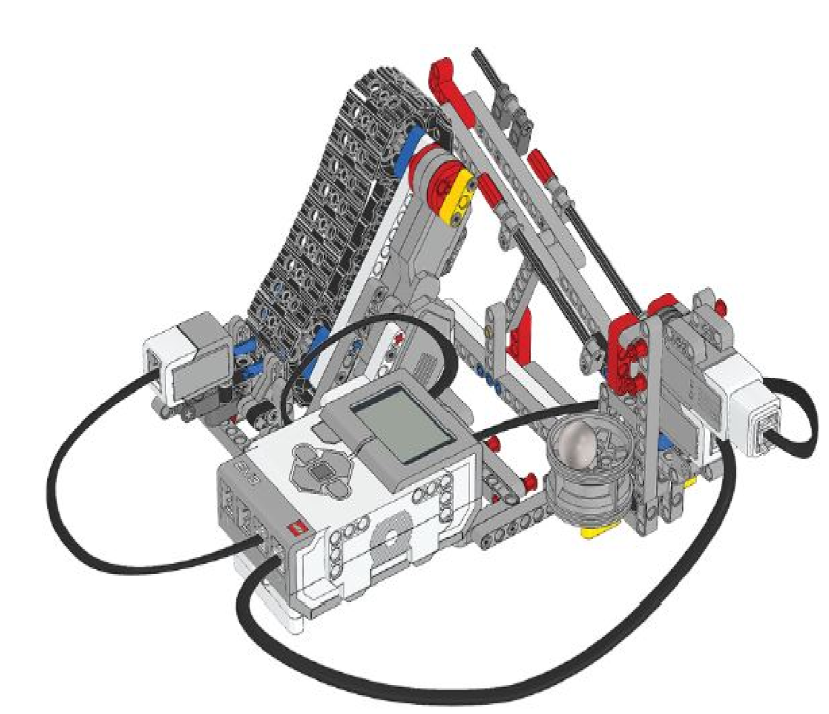

Figure 10: Lego Conveyor Belt with Color Sensor

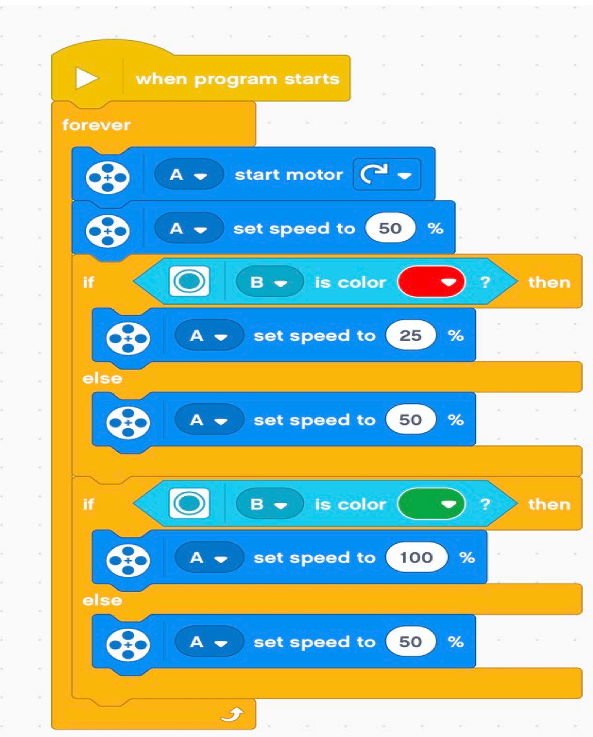

Figure 11: Lego program to control robot

Conclusion/Results

1. Vernier sensors are able to record and report biological vital signs including heart rate, EKG (electrical signal), and blood pressure.
2. The Vernier DataQuest displays results in real-time as a graph, chart, or number.
3. The Lego color sensor detects up to 8 different colors. The light sensor detects various shades of light.
4. The Lego sensors detect the change in data being displayed on the Vernier DataQuest and with programming, the attached Lego robot changed speed.

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