NRI: Co-Robots to Enhance Motivation and Self-efficacy in Formal STEM Education

PIs: Nina Mahmoudian [1], Mo Rastgaar [1], Nathan Mentzer [1], and Ryan Novitski [2];

[1] Purdue University and [2] ITEEA STEM Center for Teaching and Learning

NSF 2133028-IIS

Abstract

It is estimated that the aging population will double by 2050. However, with current technologies, there won't be enough health care professionals to meet these demands. In order to evolve health care technologies, we must engage young people in assistive and rehabilitation co-robotics learning experiences early in their education.

To meet this goal we propose implementing a neurally controlled human-like robotic arm project for grades 8-9. This project aims to increase STEM participation of underrepresented ethnical/racial minorities and female learners by increasing engineering self-efficacy, motivation and performance in the building of this robotic arm. The project was first implemented as summer camp in NSF-NRI 1426989 project, and is currently being piloted in a classroom setting by a teacher from East Tipp Middle School in Tippecanoe School Corporation, Lafayette, Indiana.

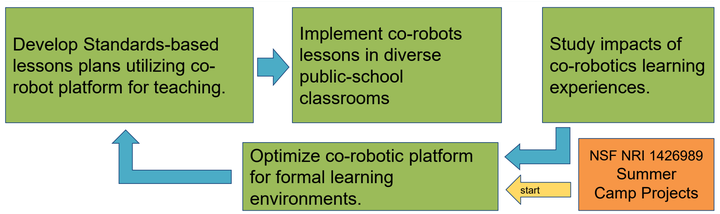
Introduction

The Neu-pulator (neural manipulator) is a robotic arm that measures muscle voltage signals to control movement of revolute servo joints. The muscle activity is measured safely from the surface of the skin, through a technique called electromyography (EMG). These technologies are widely used in medical devices, prosthesis and co-robots. Yet, we propose an accessible, simplified and affordable version of these technologies to a formal classroom environment.

Student uses muscle signals to control Neu-pulator

The **hypothesis** is that hands-on learning of assistive and rehabilitation robotics in meaningful contexts such as improving quality of life will broaden participation of underrepresented students including females and ethnic minorities.

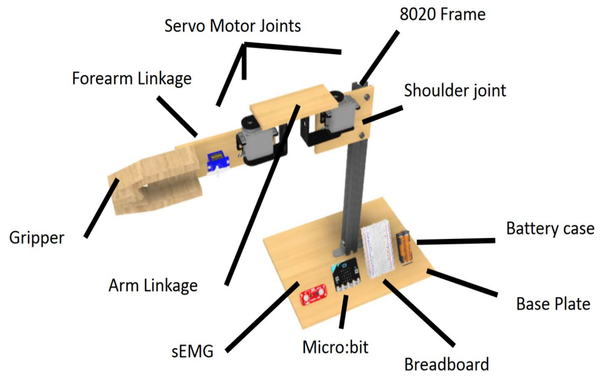
Objectives



Lesson Plans

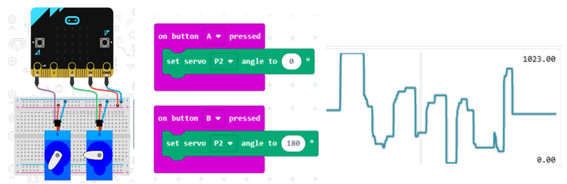
A storyline is used to keep students engaged. Six lesson plans are provided with the project for public middle school implementation. Lesson plans are flexible and can be edited as needed. Supplementary materials provided include a 36" x 48" vocabulary poster, an engineering design brief, activity handouts, and a formal assessment.

Project Design & Components



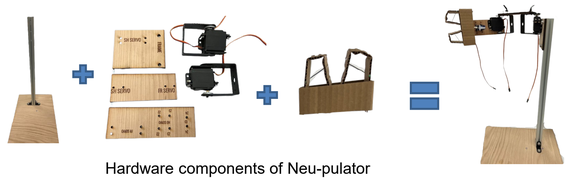
Assembled Neu-pulator with labeled components

The Neu-pulator resembles a human arm, actuated by servo motors at the shoulder, elbow and hand. Students will control each joint with a different type of sensor. An accelerometer for the shoulder, EMG for the elbow and push-buttons for the hand (gripper). Students will learn to code using an intuitive online-based block programming tool called "*Microsoft Makecode*".



Makecode programming environment

Students will assemble key mechanical and electrical components. The research team considered how to label components to reduce tedious and error prone assemblies. The total cost of these components is less than $100 per student pair, and cost of consumables doesn't exceed $4 per curriculum.



Hardware components of Neu-pulator

Materials

MG995 RC Servo x 2	AAA batteries x4	¼ Wood
Servo Set Mount Bracket 2 DOF for MG995 x2	SG90 Servo Motor	Cardboard
Vilros BBC Micro:bit V2 Project Starter Kit	Wires	L – Bracket x 2
4 Battery case	EMG electrodes x 12	sEMG Sensor
8020 Frame	8020 fasteners	

Teaching Standards

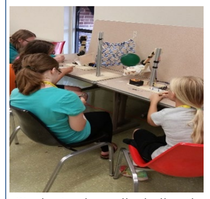
The project seeks for students to reach mastery of learning that is guided by the following national/international standards :

- Standards for Technological and Engineering Literacy (**STEL**) (**ITEEA**, 2020)
- Standards for the English Language Arts (**NCTE/IRA**, 1996)
- Principles and Standards for School Mathematics (**NCTM**, 2000)
- Next Generation Science Standards (**NGSS**, 2012)

Engagement & Feedback

The Neu-pulator was implemented in 2014-2016 for informal STEM Education over week-long summer camps. The project focused on middle school students. Survey results indicated the following: (1) increase in the students' level of interest in robotics, with a significant increase for girls, (2) young students can learn complex STEM-related topics, such as programming, sensors, actuators, and human biomechanics, through engaging hands-on activities, (3) students showed an increase in their confidence level as they learned new concepts and practiced their skills throughout the week, especially when they could see the Neu-pulator in action.

Students from Purdue Polytechnic Highschool (PPHS) participated in a STEM education-focused workshop during July 2021. Students went through the designed lesson plans over five days. The pinball-vs-pinball minigame is an example of gamified activities that students enjoy while building knowledge and skills for the final project.



Students play volleyball with their built Neu-pulator

PPHS students participate in pinball tournament

Students test functionality of their assembled Neu-pulator

Impact Evaluation

Evaluation of the impact of the final co-robotics lessons on student performance will be completed using student work. During Year 3, a team of researchers and teachers will assess the robotics design projects from all students in both control and treatment groups. All work will be de-identified, so evaluators are blind to the research condition. Student work will be evaluated using the Engineering for All (EfA) Design Journal Rubric.

Get Involved

We will soon have a website that contains all information about needed materials, lesson plans, and assembly videos. We hope to reach out to implement this project in diverse public-school classrooms.
To get involved please scan the following QR Code.

SCAN ME

2022 NRI & FRR Principal Investigators' Meeting
April 19-21, 2022

This work is supported by NSF Award # 2133028