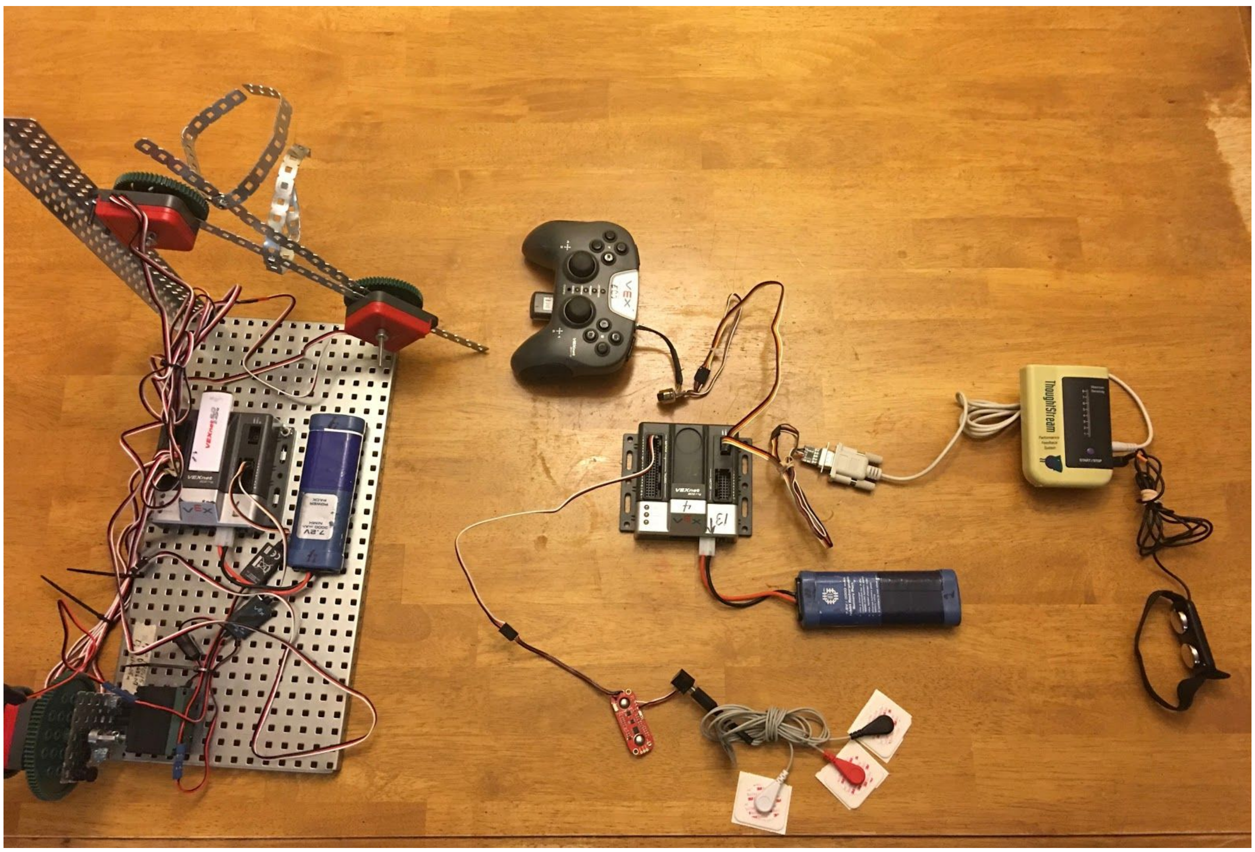
Emoto-bot Demonstration Control System

I am building a demonstration control system for VEX robotics that creates a human-machine interface for an assistive or companion robotic device. My control system uses direct instantaneous measurement of biological parameters of the user, including stress level, eye position, minute muscle motions, heart rate, and brain activity. All the sensor information is read, collected, and managed on a VEX Cortex. A program running on the Cortex organizes and maps the collected data onto joystick controls, simulating button presses, joystick movements, and accelerometer readings. The Cortex transmits this information over one of the UART channels to a primary joystick. The primary joystick then sends this information via VEXNet to the robot.



The purpose of this project is to show that with only standard vex components, you can implement futuristic sensing and control. These control systems will be able to sense emotional and physical state of the user, and the user's environment. This could be used as a seamless prosthetic that is responsive and predictive, which would improve the emotional state of its users.

The sensors I am currently using are listed below.

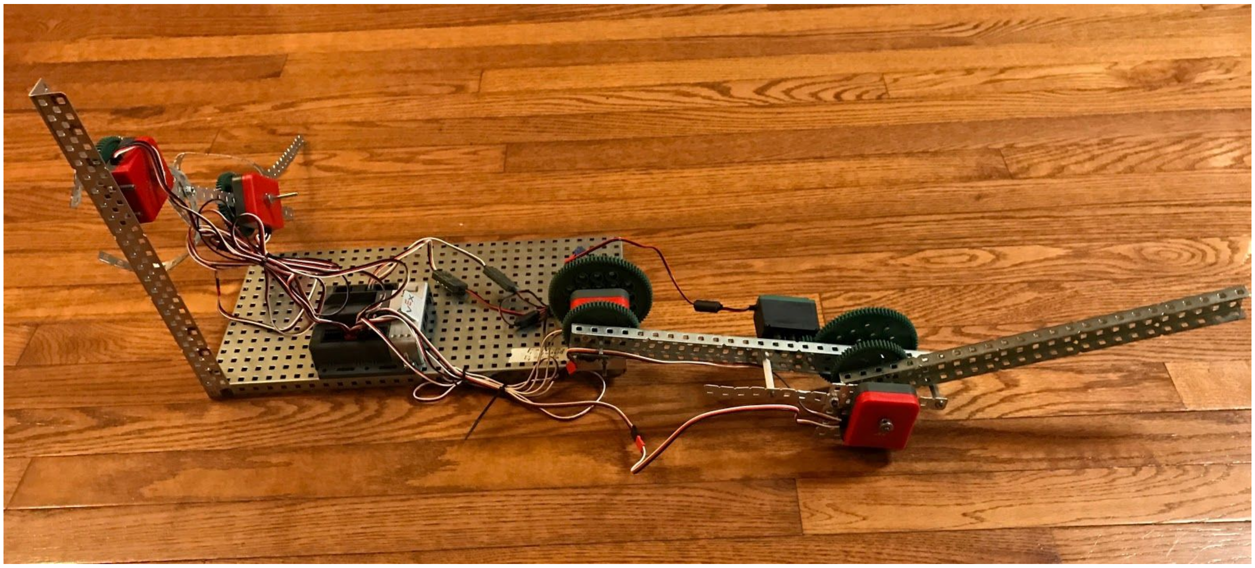
Sensor	**What it measures**	**Information Provided**
Mechanical Encoders	Rotary motion	Joint position
ThoughtStream Biofeedback System	Galvanic Skin Response (‘GSR’)	Stress/Relaxation level; excitement level
Electromyography	Muscle activation	arm/leg movement; hand/finger movement; facial micro expressions
Electrooculography	Electrical field of the eye	Eye position; gaze direction
Electrocardiography	Heart rate and rhythm	Excited vs calm
Electroencephalography	Brain wave activity	Sleep vs wake; attention

I am following a phased approach to this development work, with iterative cycles of brainstorm, research, prototype, refine. I am testing/prototyping each part individually before integrating it into the prototype system. The list below describes the general phases/steps I am following to develop and expand my robotic control system.

1. Robotic arm prototype using mechanical encoders.
2. Research the integration of ThoughtStream biofeedback to demonstrate acquisition of stress/relaxation level.
3. Develop and test the acquisition of arm muscle movements; demonstrate use of myoelectric signal capture to move the prototype mechanical arm.
4. Demonstrate remote control of a robot using some of the integrated signals described above; use Cortex to simulate partner joystick, sending control wirelessly over primary joystick controller.
5. Integrate robotic control by eye position using electrooculography.
6. Integrate measurement of heart rate and rhythm to assess excitation level.
7. Integrate measurement of brainwave activity to assess attention and sleep vs wakefulness.

As each new part is integrated into the system, it becomes more functional, with a richer set of controls available. In my current development plan, I intend to display my control system functioning up through phase 5 at the Kentucky State VEX Championship, and up through phase 7 at Worlds.

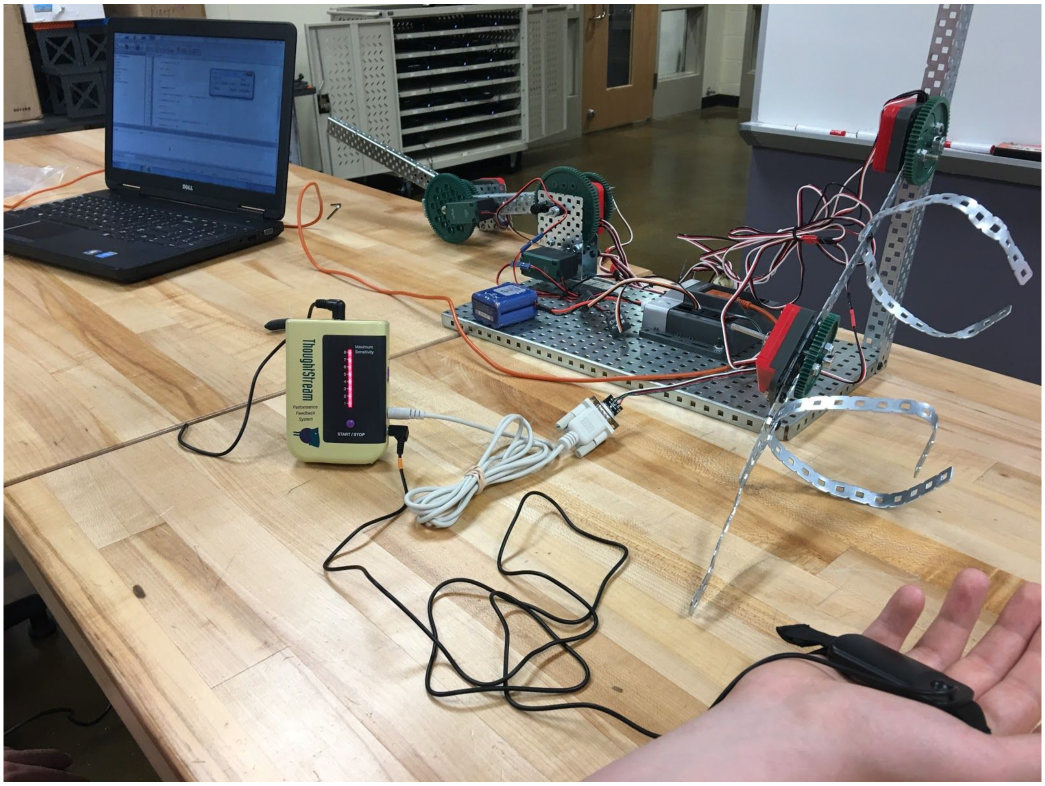
This is my initial design. As is depicted, you place your arm in the metal sleeve on the left and rotate your shoulder and elbow joints up and down.



The encoders on the sleeve record these movements as a measure of degrees, and then the encoders on the robotic arm read the position of the arm and determine whether the specific joint they were on was less or above the sleeve encoders value. The cortex then sends a signal for the motors to turn, depending on the encoders value.

The point of this design was to prove that you could, using only vex parts, build a mechanical arm to assist the weak and disabled, allowing them to interact with their environment in similar ways as they could before an accident or disease reduced their limb function. This design could be improved so that it would be wireless, and small movements could be signals for the arm to pick up or grab something, further increasing the user's independence and quality of life.

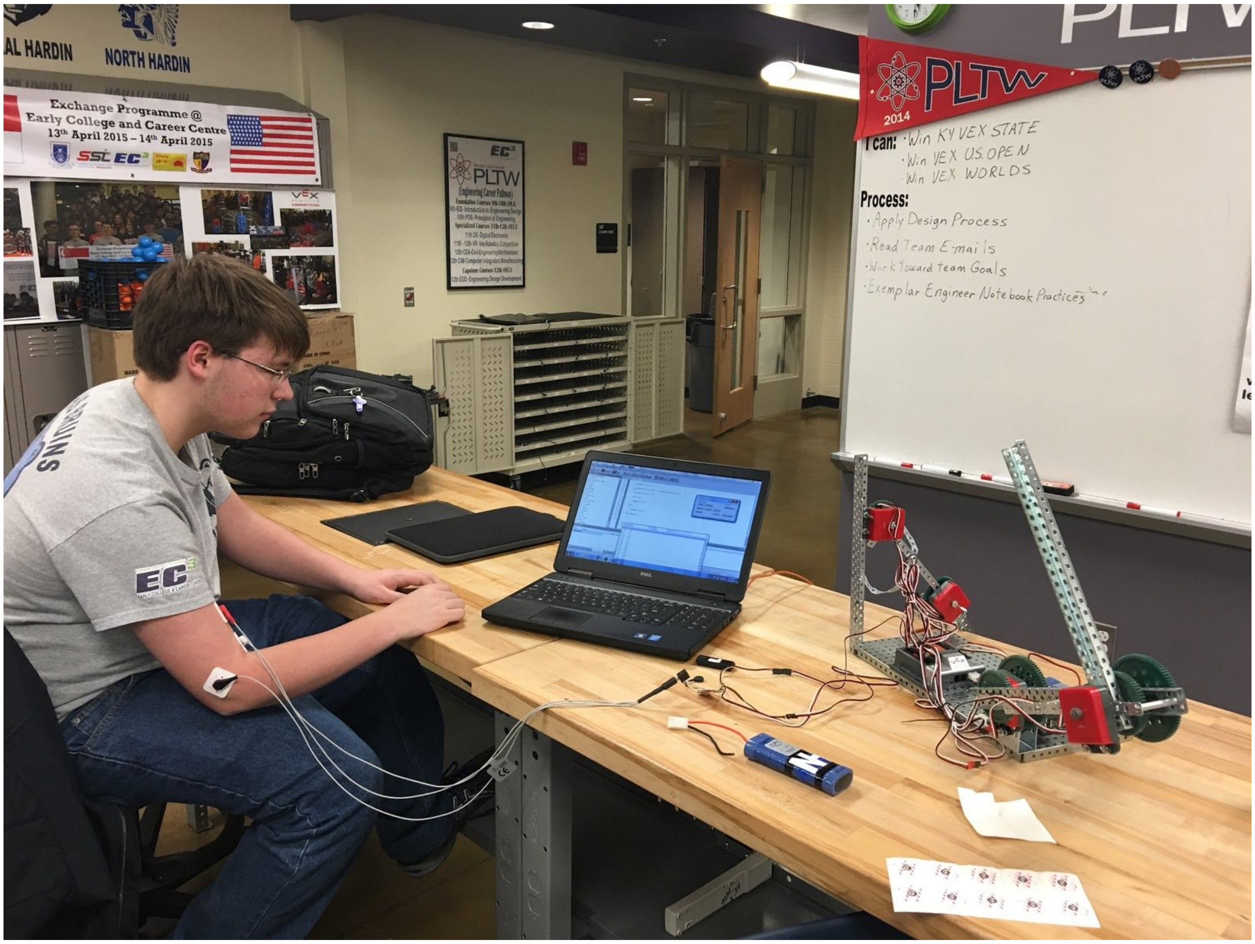
I began experimenting with other control schemes that required less effort on the part of the user. One of these was the ThoughtStream, a device that measures GSR or 'Galvanic Skin Response.' Typically, this is a measurement of stress or your current emotional state, and the machine is sensitive and adjustable enough for the user to manipulate the machine's response through thought alone. The sensor's readings are quantified, and thus can be read and fed into the arm, which can then move according to that data.



In other words, the arm can sense your current emotional state, and move according to it. This could be incredibly useful in emergency situations and monitoring those of poor health that are at risk in stressful situations. With practice, users can learn to control the readings, and thus the arm, making for an even more seamless and unobtrusive design to assist the weak and disabled. At this point in the engineering process, I began calling this project the emoto-bot.

As another control input, I measure nerve impulses sent to activate muscles. This works either for healthy and intact muscle, or on an amputated limb. These signals can be processed by the Cortex and used to actuate assistive devices.

In the photo below, I am running the debugger to display the muscle activation signal in the debugStream window. Every time I flex my bicep, the value read from the Cortex analog port increases from below 400 to above 3000. The response read from the port is proportional to the flex strength. This is the signal I use to position the elbow joint on the remote arm.



Another alternative control system I looked into was an electrocardiogram heart monitor, which also measure your emotional state, but this time through the beating of you heart. It is even less obtrusive as it requires much less hardware for use, although all of the control systems mentioned are light enough to be worn.

One additional interesting input is measurement of eye position using electrooculography. This information can be used by a quadriplegic user to simulate a button press on the VEX partner joystick, and thereby activate a control operation on the assistive robot.

Note that for ease of testing, we’ve used some larger devices. In practice, we would use smaller sensors.