Department of Mechanical Engineering
THE UNIVERSITY OF UTAH

LIFTING COACH-SMART INSOLE

ERGONOMICS & SAFETY
THE UNIVERSITY OF UTAH

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BACKGROUND

Work-related low back pain contributes to lost productivity, reduced quality of life and billions of dollars lost each year in the U.S. Much of this pain can be traced back to poor lifting technique, especially in the manual labor workforce. Ergonomics has shown that weight distribution and center of pressure in the feet during a lift is important in avoiding injury. If workers could be trained on the job and receive automated live feedback about their lifting technique, debilitating back injuries, lost wages, and workers compensation claims could all be decreased. The "Lifting Coach" smart insole is designed to be a solution to these problems by providing live lifting data to aid in injury prevention.

Lifting Coach – Smart Insole In Shoe

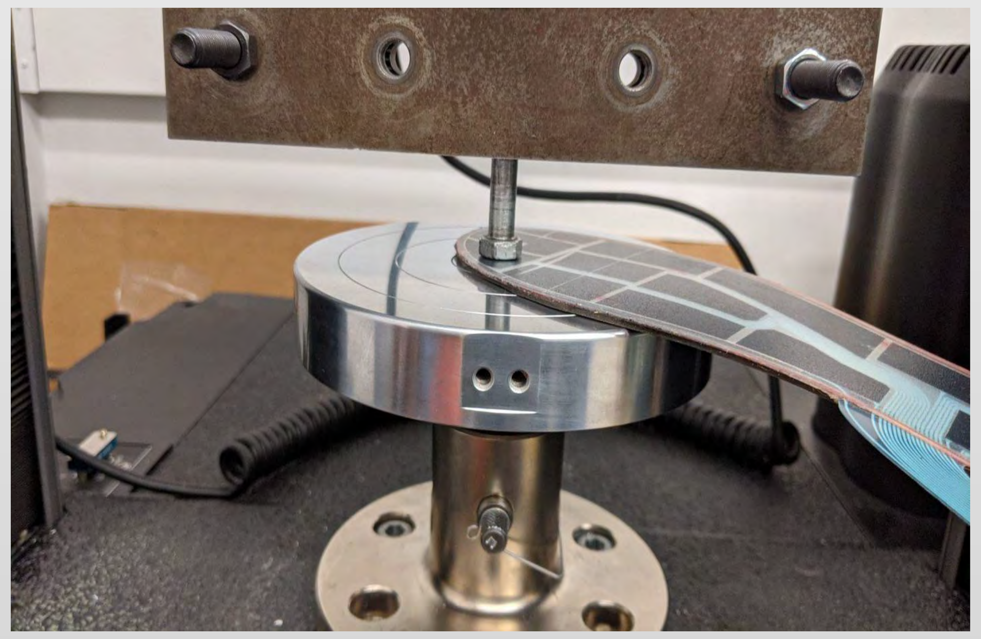
PROJECT SCOPE

- ❖ Design and build a smart insole system to monitor the user's weight distribution in real time, using force sensing resistors (FSR).
- ❖ Implement communication protocol between insole and the user's device.
- ❖ Provide information to the user → forces applied & center of pressure.

OBJECTIVE	METRIC	DESIGN SOLUTION
Monitor weight distribution of user	Applied pressure changes voltage by >100 mv	12 sensors are providing real time voltage differences that are used to calculate forces
Calculate center of pressure	Locate coordinate location of users center of pressure in centimeters	User can see center of pressure in real time from data received by sensors
Will work in typical work or sporting enviroments	Product must send data wirelessly	Bluetooth communication is set up between the insole and a computer
Cost effective	Unit will cost less than $5000 to manufacture	Current manufacturing cost per unit is $550
Real time data	Microcontroller does not drop more than 10% of data packets	Current coding has less than 10% of packets dropped
Battery life	Battery life lasts up to 4 hours	Battery life is 4+ hours

TESTING & RESULTS

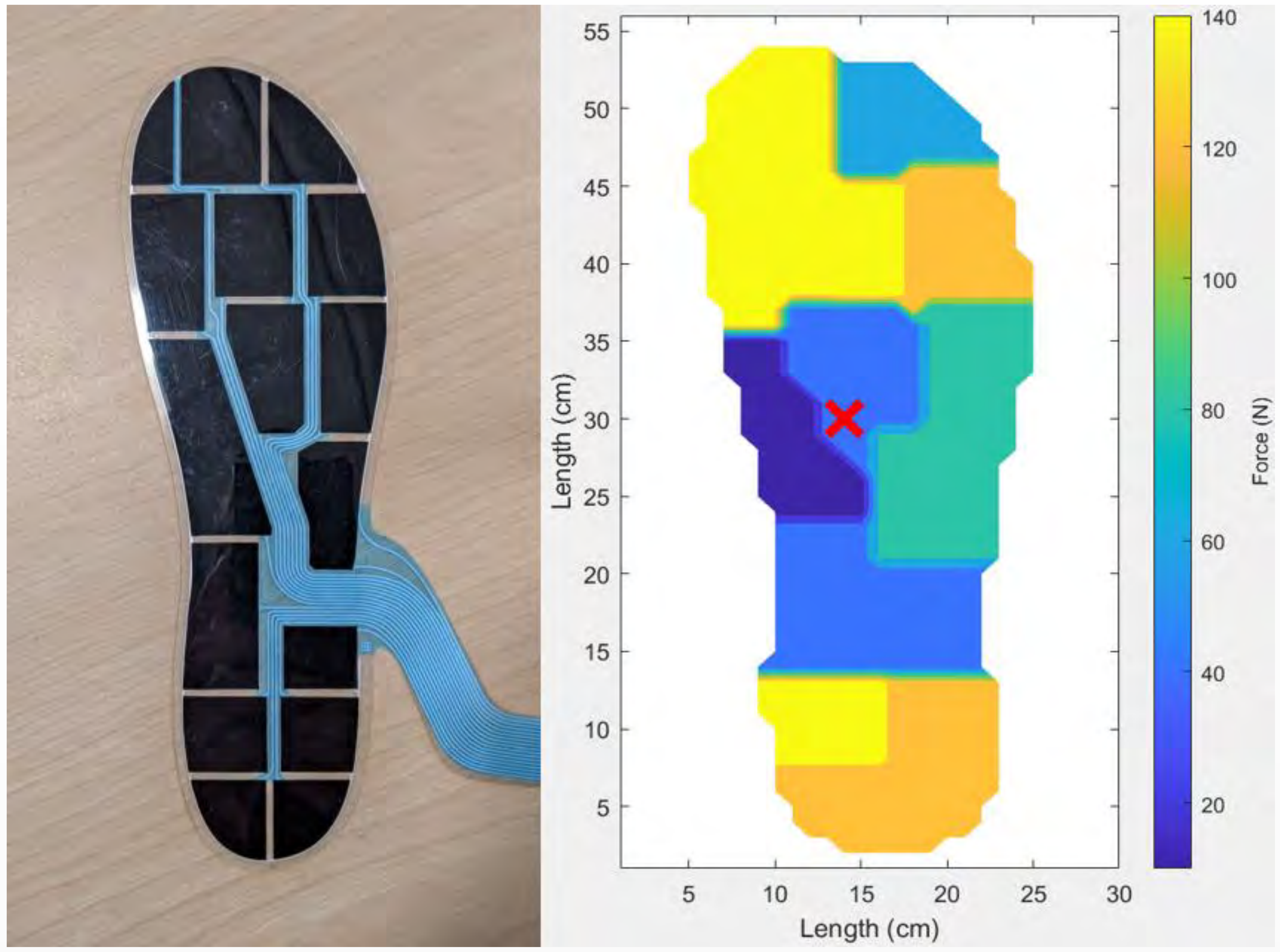
- ❖ Compression tests were performed with an Instron 5969.
- ❖ 3 replicates of the test were run with each sensor (12), for 36 data sets.
- ❖ Predictive equations were implemented to relate Force (N) to Arduino digital outputs (0-1023).



Instron Testing Machine.

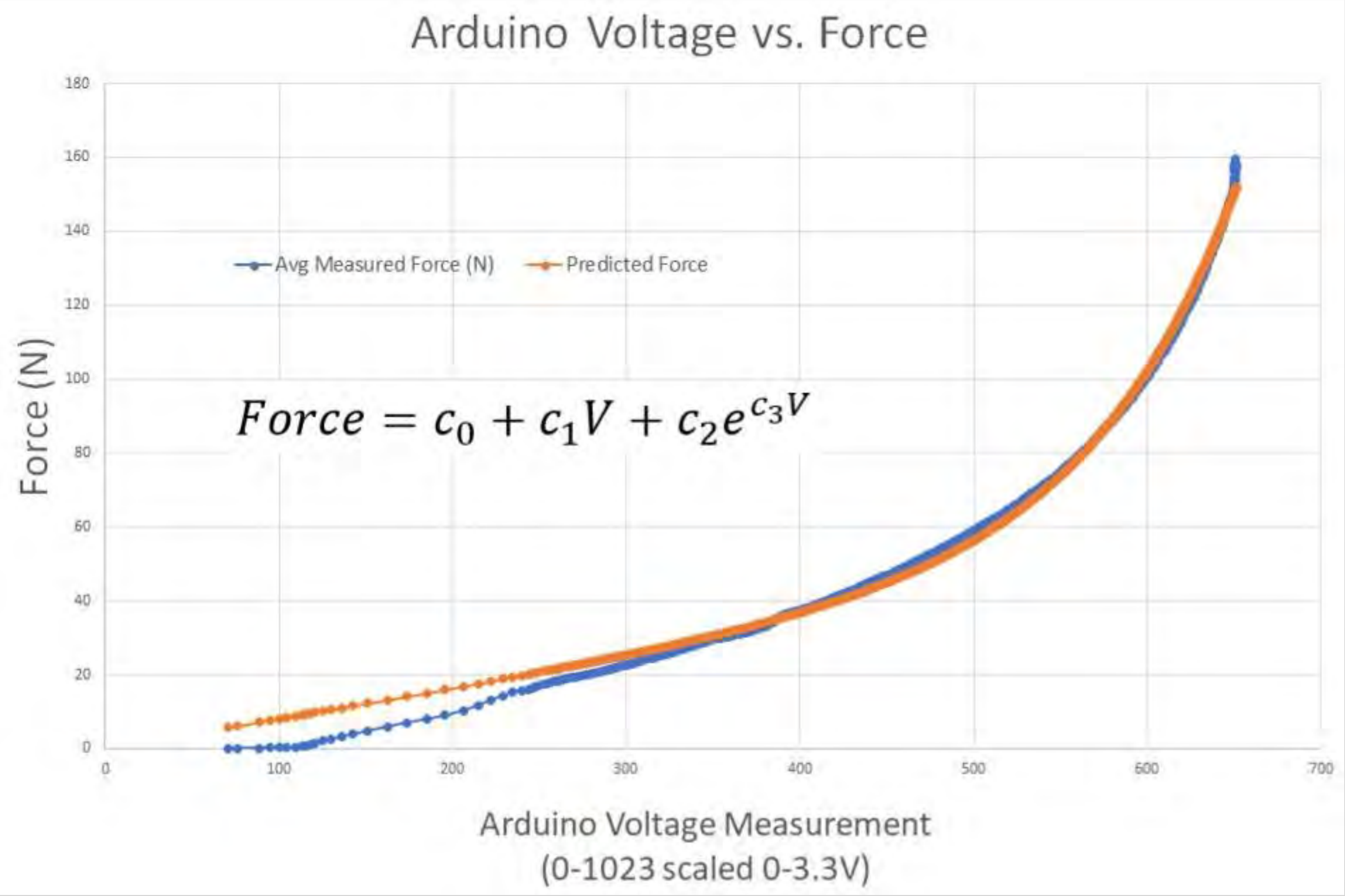
- ❖ This equation was fit to the sensors, each having a unique set of coefficients.
- ❖ Compression tests were performed again to determine the error.
- ❖ The design goal was to measure within +/- 5 Newtons.

Smart Insole



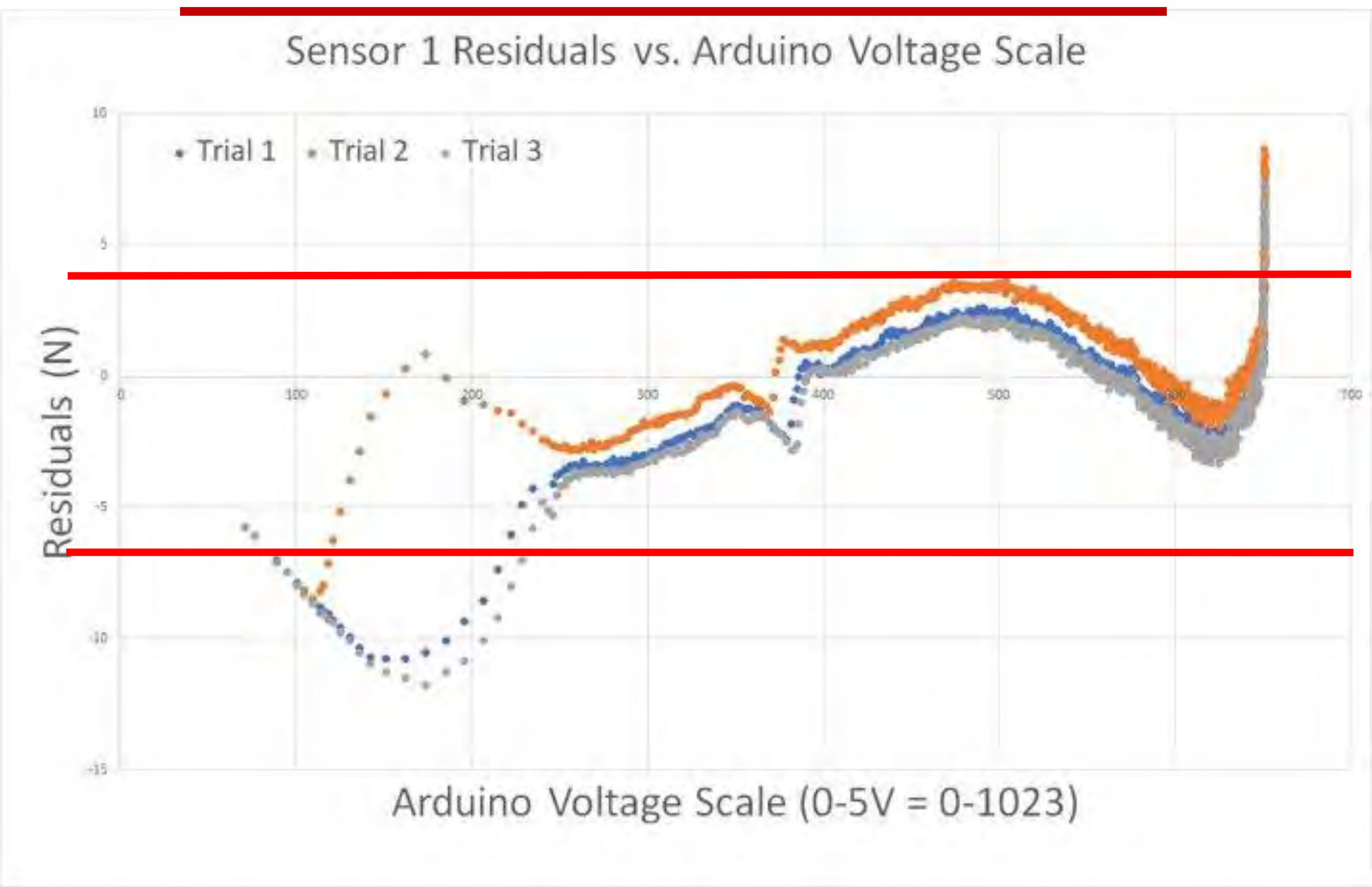
Smart Insole Sensing Circuit (left) Pressure measurement display (right)

- ❖ Pressure sensors imbedded into a comfortable shoe insole. Microcontroller and components are attached to user's ankle.
- ❖ Forces and Center of Pressure (COP) calculated from voltage resistances and visually displayed to the user in real time.
- ❖ Information can be sent via Bluetooth up to 10.6 meters away.
- ❖ Component cost per unit is $450.00

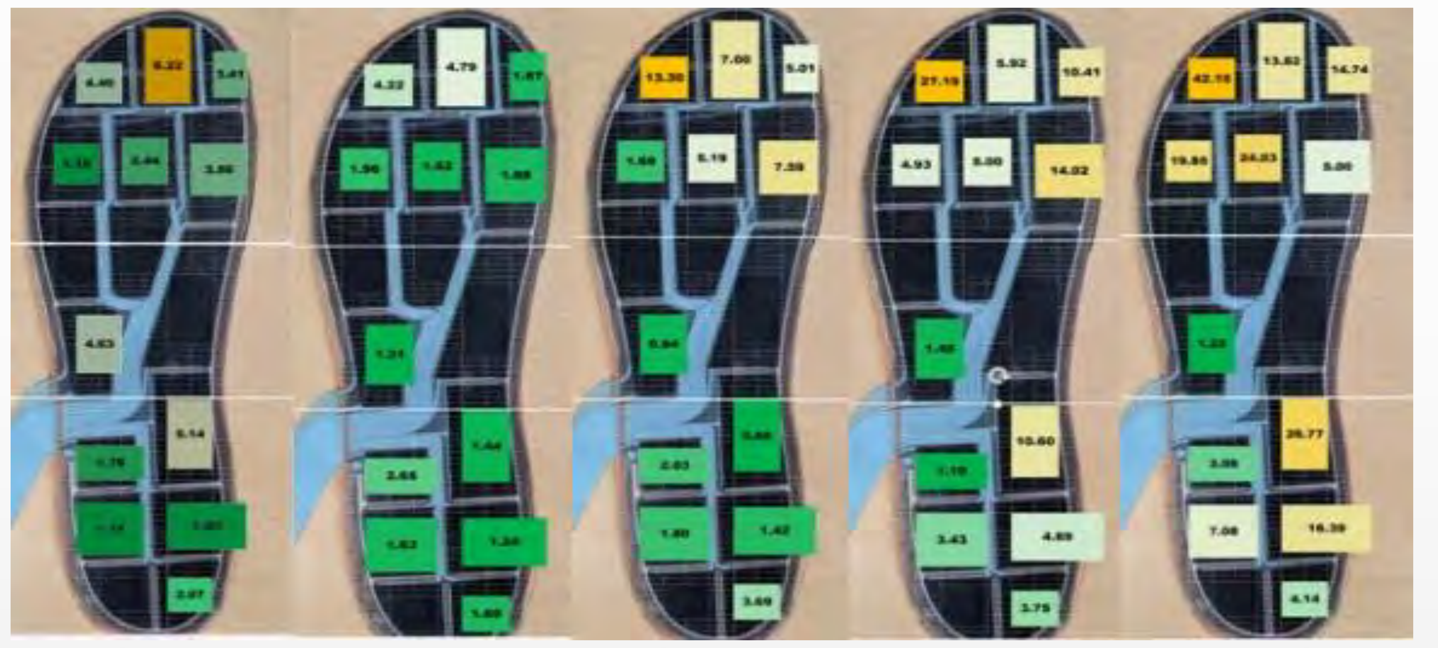


Final force calculation for sensor 1 from characterization testing.

VALIDATION OF DESIGN

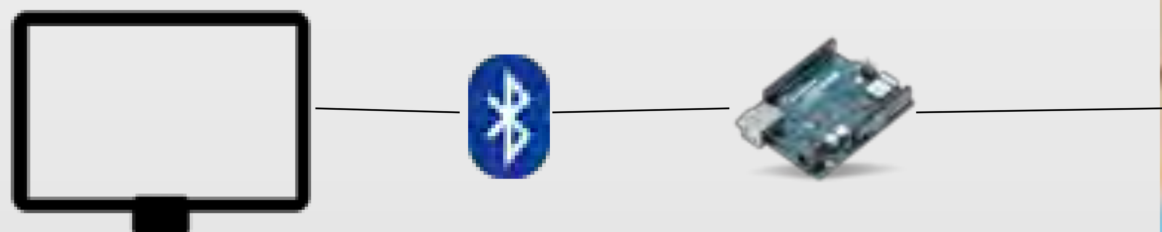


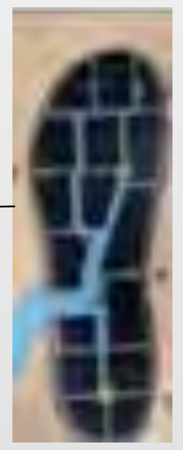
The figure above plots the residual errors between the predicted force and the applied force. The red bars represent our target of +/- 5 Newtons which is an important design metric.



The figure above is a summary of the average residual error value for all the working sensors. Applied force increased from left to right.

ACCOMPLISHMENTS & FUTURE WORK





Bluetooth communication system setup.

- ✓ Met Design Metrics.
- ✓ Established Bluetooth communication.
- ✓ Characterized equations to calculate forces at each sensor.
- ✓ Forces and Center of Pressure visually represented to user.

Future Work:

- ❖ Using digital potentiometers to automatically adjust sensing range
- ❖ Phone app user interface

ACKNOWLEDGMENTS

Special thanks to the following persons and organizations
- Dr. Andrew Merryweather
- Alex Orange
- University of Utah Materials Characterization Lab