## Team Member Qualifications

<table>
<thead>
<tr>
<th>Name</th>
<th>Qualifications</th>
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<tbody>
<tr>
<td>Thomas Hansel Knapp-Ramos</td>
<td>Thomas is a 4th year electrical engineering student. He has taken courses in topics including power systems, printed circuit board design, and digital signal processing. Thomas has had internships in both java application development and instrumentation development. He has also done research with the University of Hawaii, Particle Physics Instrumentation and Development Lab.</td>
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<tr>
<td>Greg Ryan Jorgensen</td>
<td>Greg is a 4th year electrical engineering major. His academic interests include sensors, mixed signal circuit design, nanotechnology, and optics. Greg is an undergraduate researcher at The Applied Optics Group specializing in optofluidics and nanofabrication.</td>
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<tr>
<td>Elai Dankner-Dvash</td>
<td>Elai is a 5th year electrical engineering major. His academic interests are in circuit design, building mechanical systems, and interfacing with sensors. He has taken courses that included mechatronics, PCB layout, and material properties. Elai has interned in the UCSC bionics lab developing piezoelectric sensor gloves for stroke patience, and has worked in the UCSC physics demonstration laboratory.</td>
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<tr>
<td>Nicholas Scott Chase</td>
<td>Nicholas is a 4th year computer engineering student with systems programming focus. He has finished classes in such topics as Microprocessor System Design and CS Algorithms and Abstract Data Types. In industry, Nicholas has had two website development internships for startup companies where he coded primarily in JavaScript, HTML, and CSS.</td>
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1. Abstract

A “Smart Sole” is, an ultra-thin flexible insole that can be inserted into a shoe. The insole will wirelessly connect to a computer or smartphone and display a real-time 2-dimensional pressure map of the human foot. Pressure map data will be stored for further analysis.

3. Motivation

The motivation for this project involves a wide variety of applications, including the following:

• Athletic training
• Diagnosis of plantar pressure problems
• Physical therapy
• Gaming

4. Objective

The goal of this project is to create a flexible sensor grid that can be inserted into a shoe as a shoe insole. The sensor grid will be configured in a crossbar architecture so that raw data from individual regions of the sensor can be sampled via analog multiplexer. The raw data from each region will then be processed through precision electronics, converted to a digital signal, and transmitted wirelessly via Bluetooth to a computer or smartphone to provide user feedback. A microcontroller will be responsible for control of the analog multiplexing, decoding sensor data into corresponding pressure values, sensor calibration, and controlling the Bluetooth communication module.

5. Approach

![Figure 1: System Block Diagram](image-url)
Sensor

The first possibility is to use capacitive Pressure sensors using micro-structured elastomer as a dielectric. When pressure is applied, the elastomer compresses, shortening the distance between electrodes, leading to higher capacitance. To fabricate an array we will use 2 flexible substrates with conductors arranged in a crossbar architecture (Figure 2). This allows us to sample individual capacitors and decode pressure.

Decoder

To measure capacitance we can multiplex through the array of capacitors by applying a square wave. An analog comparator compares the voltage resulting from an RC time constant with a well-defined reference voltage. The Output will be a square wave with a pulse width proportional to capacitance.

A second possibility is to use a metalized piezoelectric film and etch a crossbar architecture onto each side. When the piezoelectric film deforms it creates a voltage that can be measured. We can measure the piezoelectric pressure sensors by multiplexing through each piezoelectric device and measuring the output voltage. We believe a capacitive pressure sensors will be more sensitive.
Software
The pressure readings will be sent to a computer or Smartphone through a Bluetooth module, and will be received using an open-source Bluetooth API. Once received, the pressure distribution can be viewed as a heat map on the screen. The heat map will be generated using an open-source Python API, and then stored either locally or remotely in a database. This data can then be viewed by medical specialists for gait analysis. We will also implement a step counter, with a steps being calculated by analyzing the pressure with respect to time. A step will be registered at the moment when there is no pressure on one foot followed by pressure applied to the other foot.

The GUI will be divided into three tabs or sections. The first section will display the live heat map as well as the step count. The second section will allow the user to access previous heat maps and step counts based on date and time. The third and final section will be a user profile allowing for a picture and “About Me” section, as well as displaying general data about their smart sole usage.

Conclusion
Our goal is to generate a heat map of the pressure distribution of the human foot. We will use a sensor grid to obtain the pressure data and transmit it wirelessly to a computer or smartphone for viewing or analysis. This product has applications in medical diagnostics, recreational sports, and physical therapy.