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Cyber Empathic Design - Using Sensors to Analyze Anthropometric Orientation for Design Feedback in Office Chairs

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Abstact

In product design, it is important to understand how products are used by the consumers. A common method of obtaining this information is through observation or the use of surveys, but these methods have their drawbacks. One major problem with current methods is bias. The interpretation of the results by a designer is influenced by past experience or industry practice. An ideal design path for a product would remove this. Cyber-Empathic Design is the concept of using sensors to collect data on product usage and mapping these results into the design space to remove human bias. In this branch of the project, sensors were imbedded into an office chair and data was collected. The goal of this project is to create a model that can identify and track seating positions as it is being used without designer supervision.

Building the Chair

The chair, which was built for use in multiple projects, was imbedded with 28 force sensors. There are 13 sensors in the seat, 13 in the back, and 2 in the armrests. The final build of the chair can be seen in figure 2. Accelerometers are installed in the back and seats of the chair to monitor motion, as well as temperature sensors to track any changes in heat. All the sensors are connected to a circuit board on the back which runs into an Arduino microcontroller. The data is written to an SD card as the tests are performed at a rate of around 20 Hz. It is powered by four AA batteries and has about an eight hour battery life. Four chairs were built.

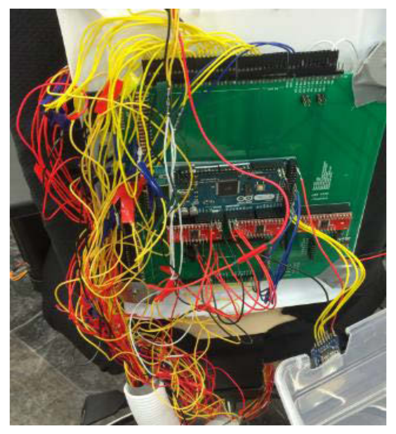

Figure 1: The chair circuit

Figure 2: The complete chair

Challenges

An obvious challenge with any human analysis is the immense variance among the human body [2]. In designing a model that analyses and makes conclusions about positioning, the vast variance in body types must be accounted for. For example, figure 3 shows a sample of the different shapes a body can take. There is also significant difference between the genders as it relates to weight distribution. For this model, research was done to try and "cast a broad net" and represent all body types using only weight and height as inputs. To do this, average anthropometric ratios will be used [1], as can be seen in figure 4 These will be best suited to fit all participants.

Figure 3: Various body sizes [1]

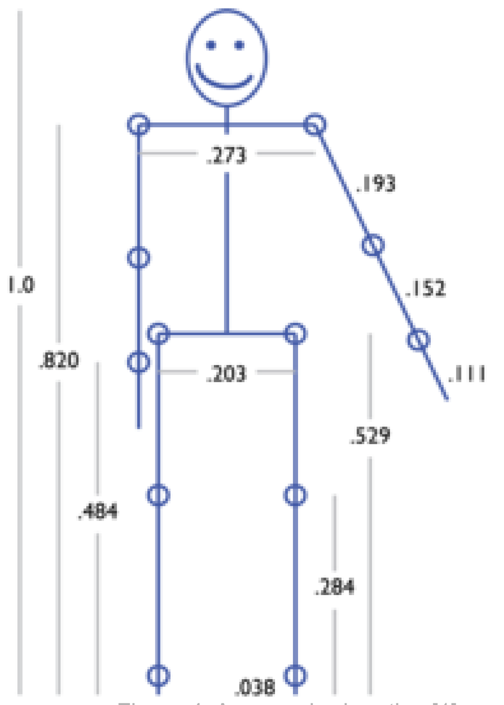

Figure 4: Average body ratios [1]

Testing

For simplicity, seating orientations were broken down into five main positions:

- Central/Balanced
- Leaning Forward
- Leaning Backwards
- Leaning Left
- Leaning Right

For the scope of this project, all seating orientations will be assumed to fit into one of these five categories. Twenty participants were instructed to sit in each position for one minute. The only other data gather for input into the model was the participant's height and weight.

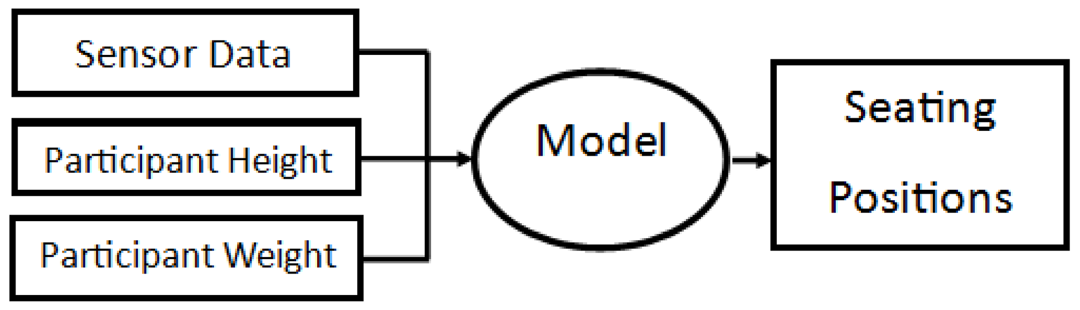

Figure 5: System flow diagram

Results

Although this research is still in progress, some data can be pulled from the sensor readings. The testing data was processed in the MATLAB software. For the majority of the tests, there is a distinct separation between the seating arrangements, which can be seen in figure 6.

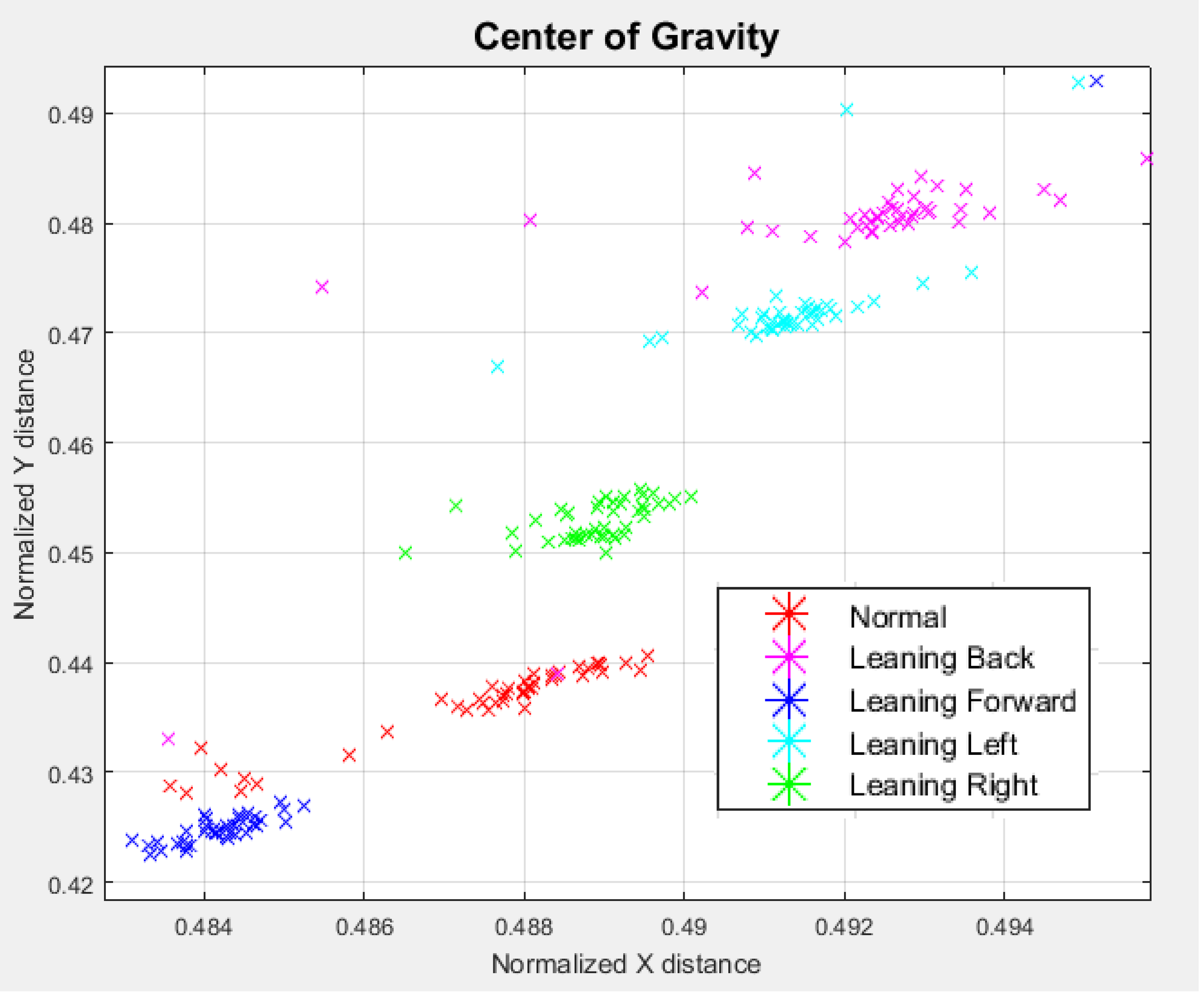

Figure 6: Center of gravity graph

This data is biased to the right. Even the balanced positions shows a center of gravity leaning to the right. It is unclear if this is user related or if the chair itself is biased. More data collection will resolve this. An ideal solution would be able to adjust to error like this through machine learning to accurately analyze seating positions.

Results

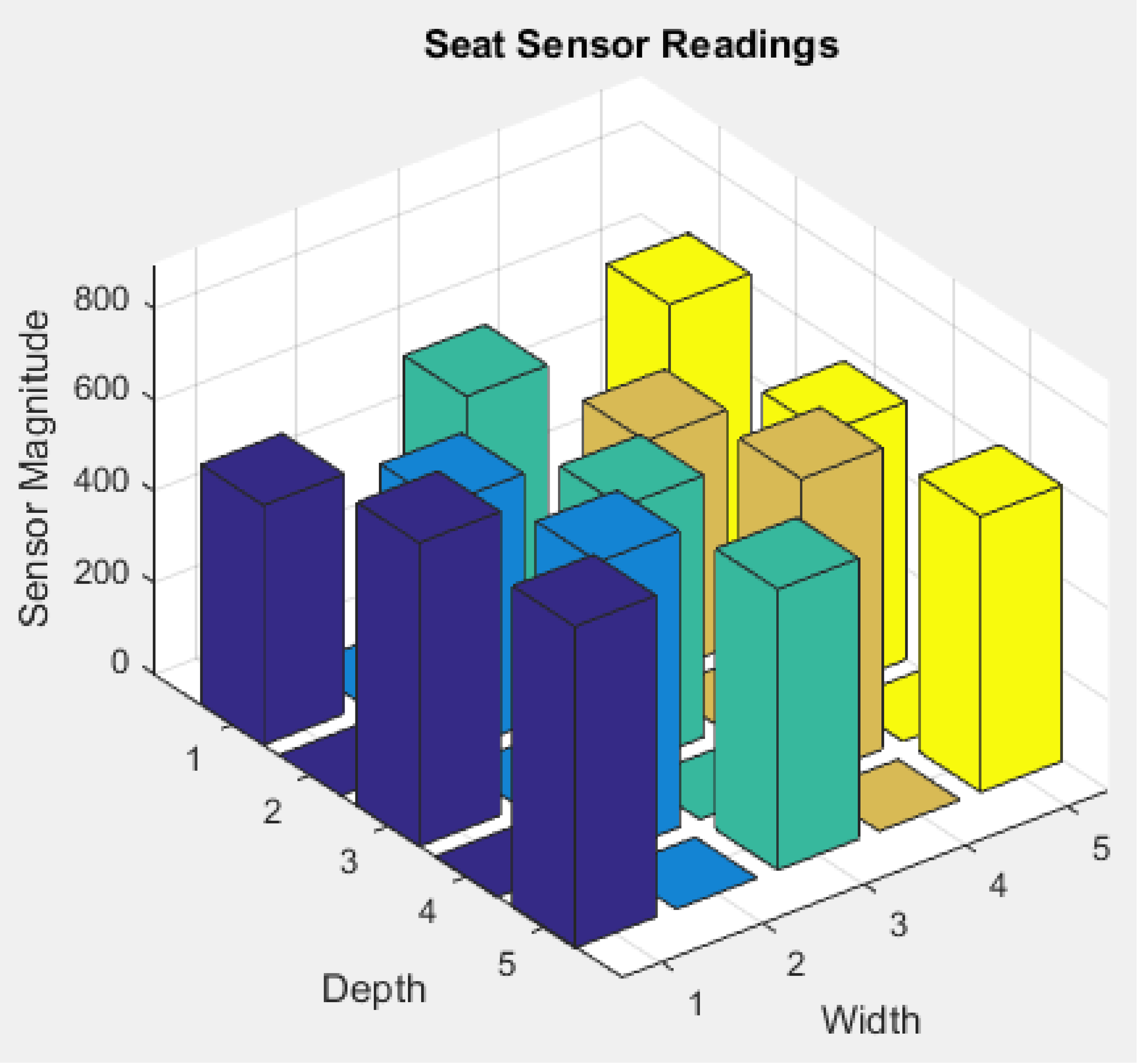

Figure 7: The sensor readings at a particular time

In figure 7, the 13 sensors can be seen. Their range is between 0 and 1023. The images below show the contrasting between seating positions. Figure 8a shows the user leaning to the right whereas figure 8b is a central position.

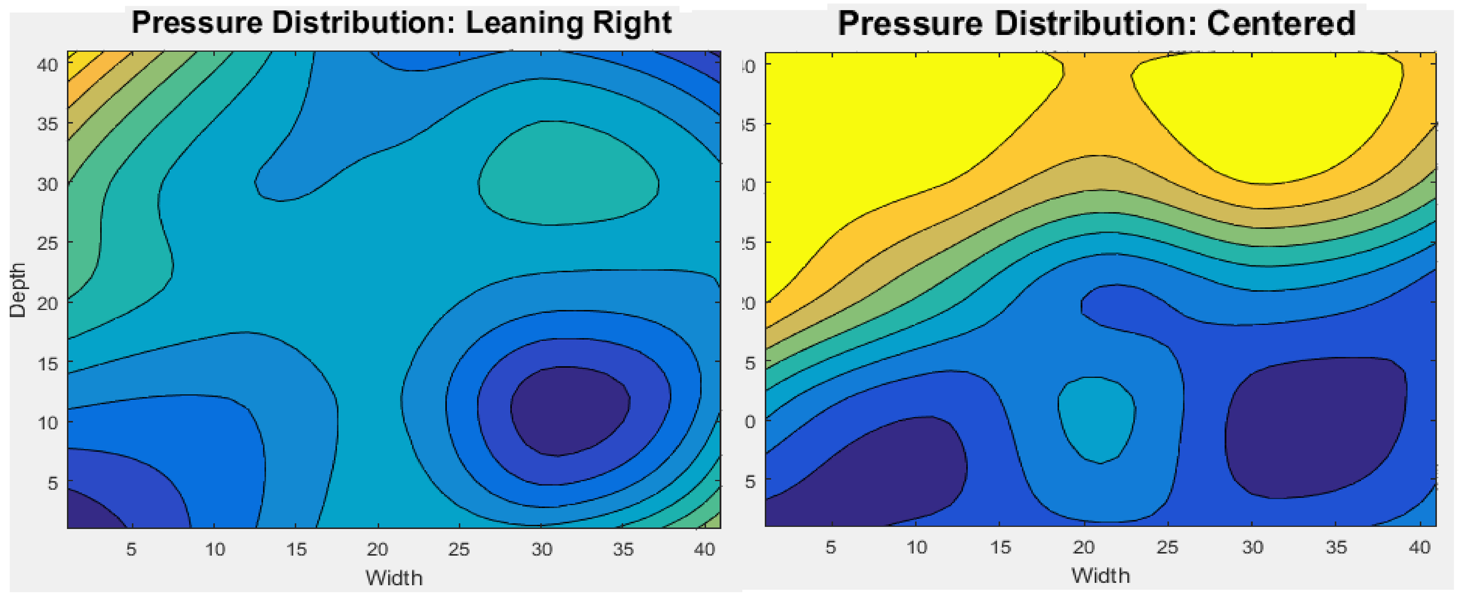

Figure 8: A comparison of pressure distribution between different seating positions

Future Work

Moving forward, the following design challenges will be solved:

- Refine model to analyze automatically
- Create visual representation of chair usage
- Provide live feedback as chair is being used
- Create user interface to communicate user habits
- Provide suggestions to improve sitting technique
- Implement machine learning for an adaptable model

References

1. Parkinson, Matt L. "ANTHROPOMETRIC DATA." *Matt Parkinson*. N.p., 1 May 2014. Web. 29 Mar. 2016.
2. Pheasant, Stephen, and C. M. Haslegrave. *Bodyspace: Anthropometry, Ergonomics, and the Design of Work*. Boca Raton: Taylor & Francis, 2006. Print.