Validation of Fall Identification with FloorX

Anthony Washington, Florida State University and Pressley Perry, University of South Carolina
Mentor: Dr. Juan Caicedo
Department of Civil and Environmental Engineering

Motivation

- 50% of residents living in senior homes will experience a fall annually in which falls is the 7th leading cause of death in people that's older than 65
- "FloorX's patented sensor technology and world-class data analysis track presence information and behaviors of residents in real time. Embedded seamlessly in flooring from tile to carpeting, FloorX monitors movements and can alert staff to situations requiring attention. FloorX monitors, so staff can spend more time giving care."

Methods

Data Acquisition

- The mat used for experimentation in this research project was 10 meters long with a 4 in matrix resolution provided by SmartSense
- Two classifiers are used to determine if the data collected from the mat is from the following activities described in Table 1. The data used for classification were the standard deviation of the raw data in each of the mat axes
- A total of 248 experiments were completed in a low traffic hallway
- Participants were mostly between the ages of 20 and 26 and included both female and male
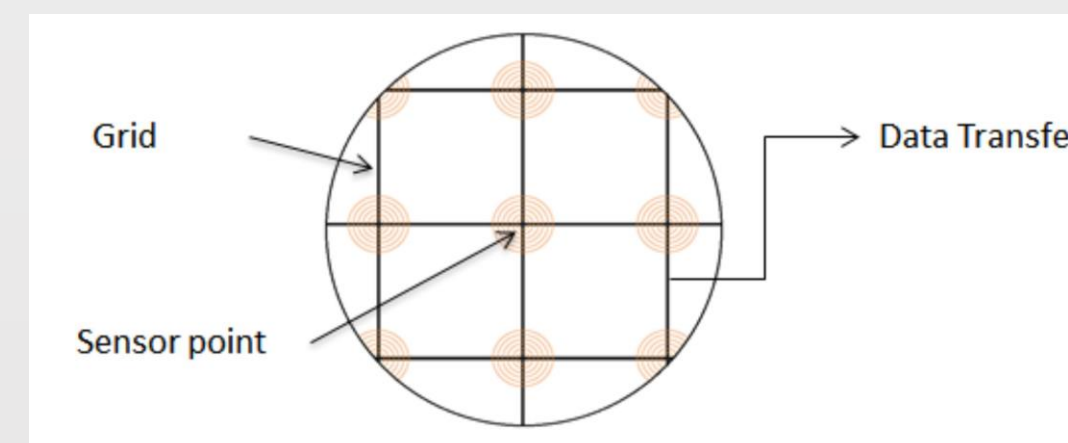
Activity	Description	Quantity of Initial Experiments
Walk	Participant walks from the start of the mat to the end of the mat	63
Sit	Participant walks to the middle of the mat, sits in a provided chair for 10 seconds, and finishes the walk across to the end of the mat	40
Fall	Participant walks to the middle of the mat, lays down for 10 seconds, and finishes the walk across to the end of the mat	40
Stand	Participant walks to the middle of the mat, stands for 10 seconds, and finishes the walk across to the end of the mat	22
Tragic	The participant starts off to the side at the middle of the mat, lays down onto the mat for 10 seconds, and gets back off the mat (no walking involved)	47
Standstill	The participant starts off to the side at the middle of the mat, stands onto the mat for 10 seconds, and steps back off the mat (no walking involved)	36

Table 1: Descriptions of all 6 activities performed on FloorX mat

Fall Detection Classifiers

A. Classifier Method 1) K-Means
- K-means is an unsupervised learning algorithm to recognize groups within large sets of data and work iteratively to place future data points within one of these groups
- K-means was applied to the initial data set of experiments taken on the mat
- K-means did not recognize the Sit and Stand activities or the Tragic and Standstill activities as separate clusters
- The four clusters assigned were Walk, Sit/Stand, Fall, Tragic/Standstill as shown in Figure 1
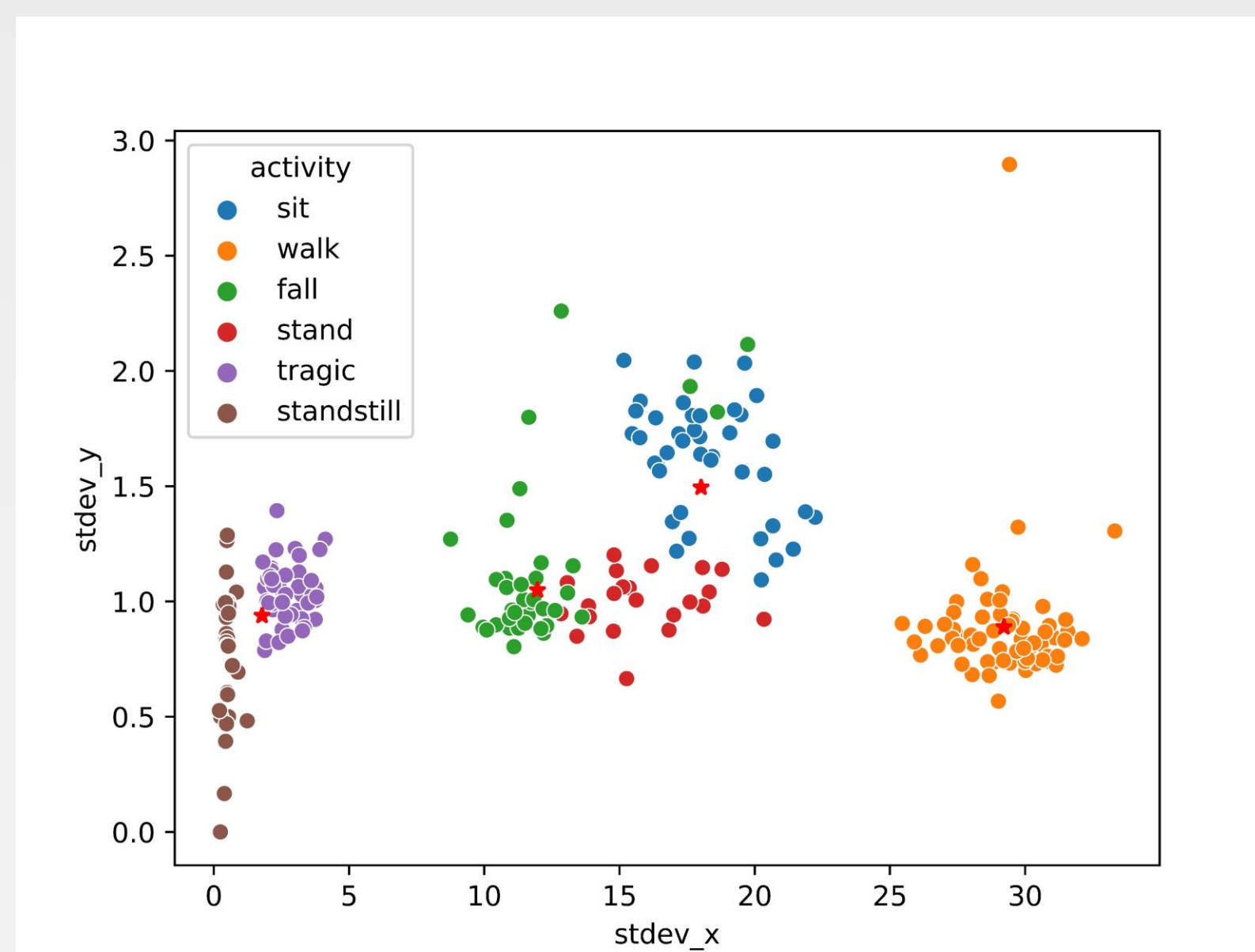

Figure 1: Scatterplot of K-Means Unsupervised learning algorithm classifying 4 cluster centers within initial data

Objective

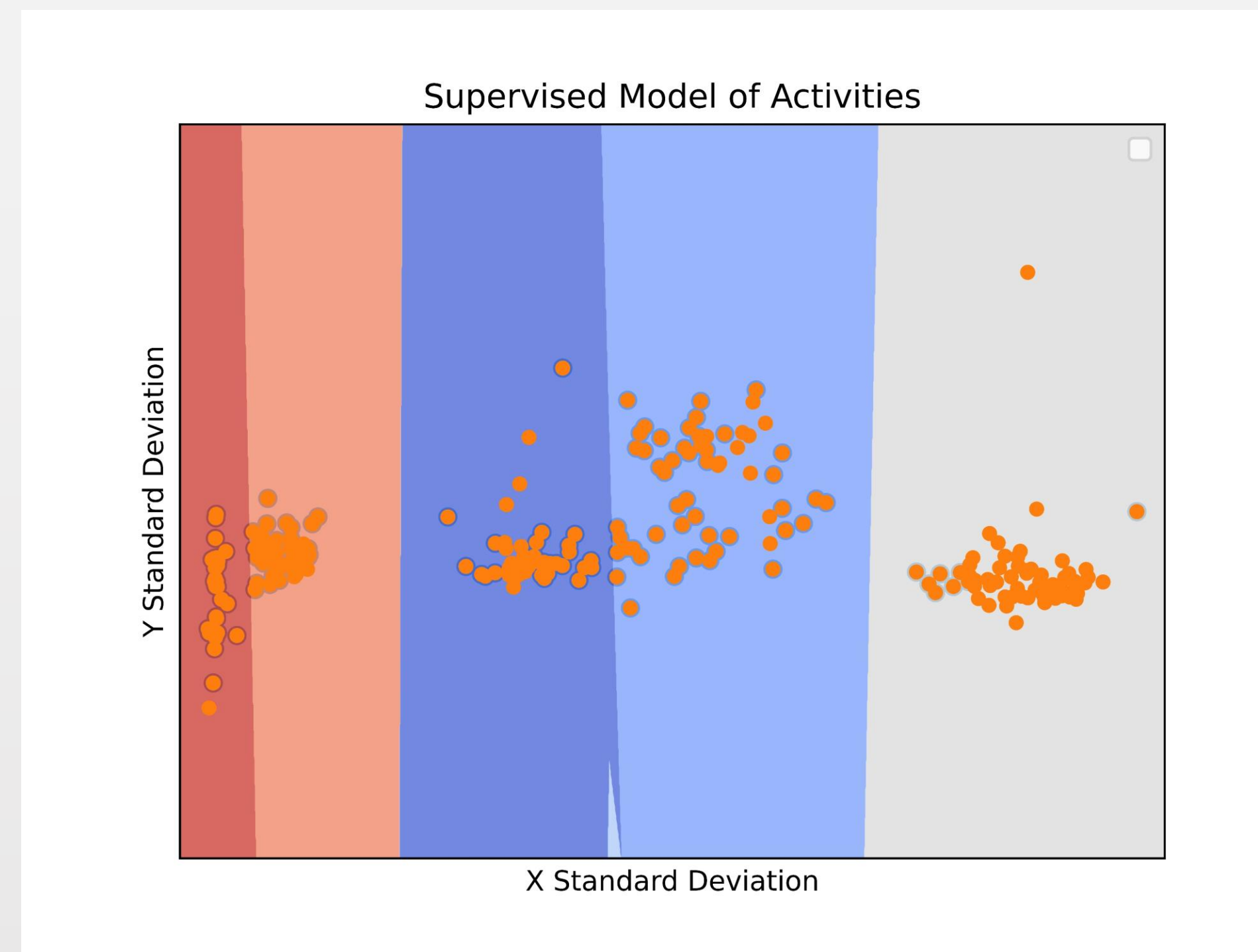### 1. Validate the FloorX mat ability to identify a fall

Figure 2: Scatterplot of SVM linear separation of initial data into 5 regions

B. Classifier Method 2) Support Vector Machine
- A Support Vector Machine uses an algorithm that is able to categorize new data after being trained by data that is labeled
- Linearly separate the data into regions as shown in Figure 2
- Not successful in differentiating between a stand and a sit, these two activities differ slightly only in the y standard deviations and are represented in the light blue region

Results/Validation

Validation of Fall Identification

- A total of 331 validation experiments were executed in the same environment with the same pool of participants as used to train the classifiers
- Classifications made based on the trained SVM algorithm from method B
- A confusion matrix was built to compare identified activities to the true activities and evaluate the mat's ability to identify a fall
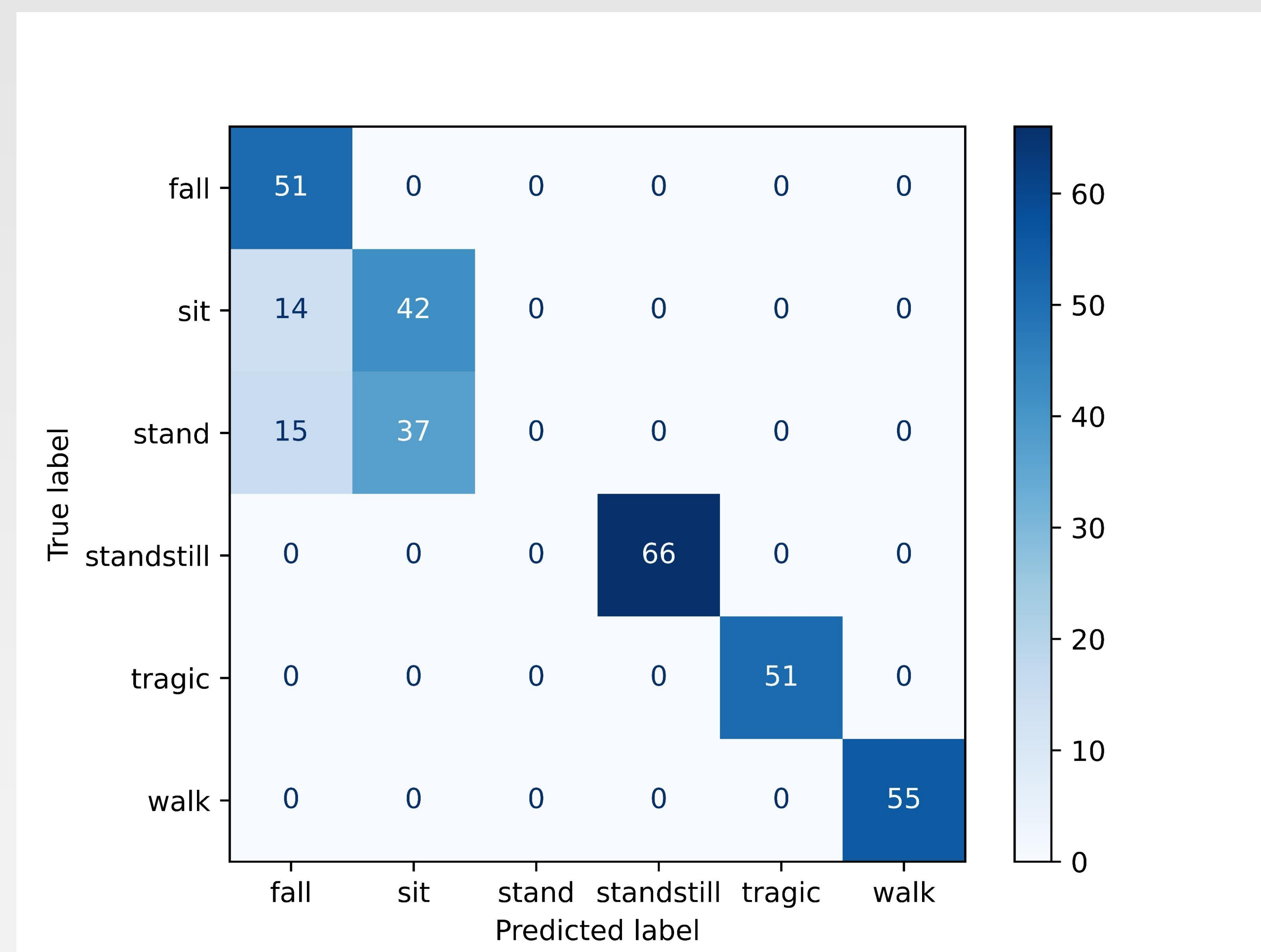

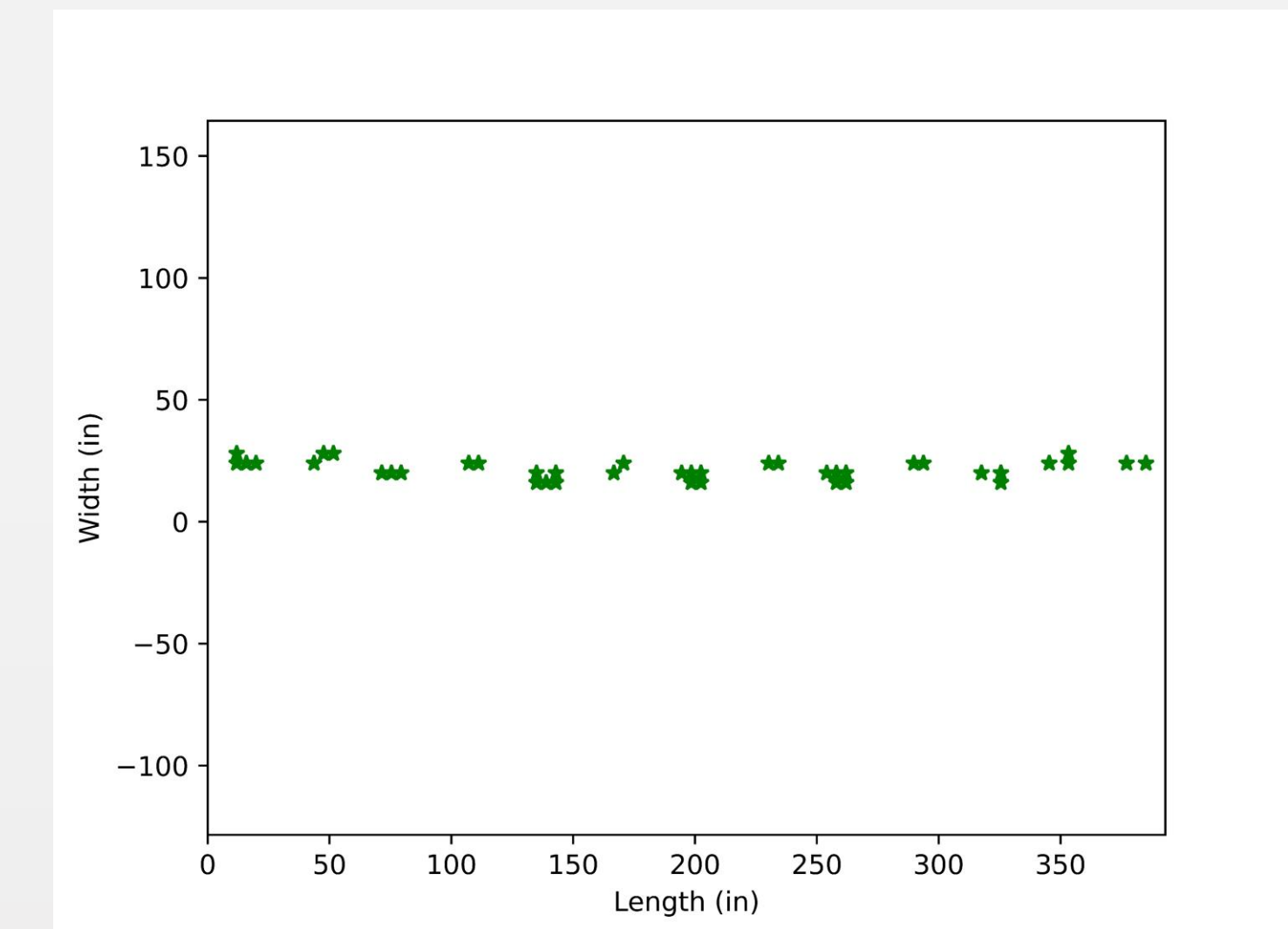Figure 3: Confusion Matrix of Validation Experiments
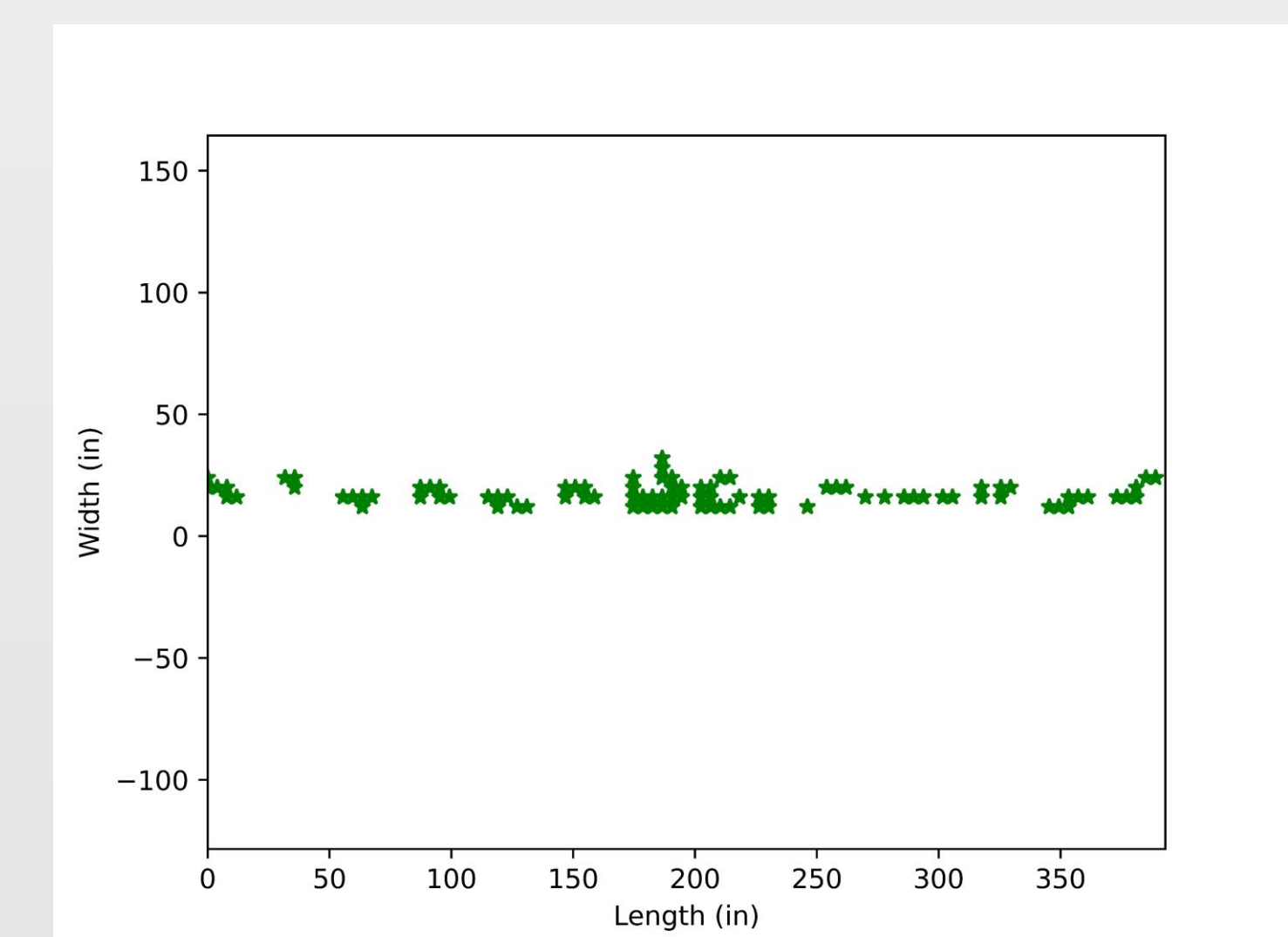

Figure 4: Plot of 'Walk' activity across the mat

Figure 5: Plot of 'Fall' activity across the mat

Conclusion

- The K-means unsupervised learning algorithm failed to recognize the 6 individual activities in the initial data as different clusters
- The Support Vector Method separated the initial data into 5 regions
- These linear separations were made only in the x-axis and was unable to differentiate stand and sit activities
- SVM successful in correctly classifying all fall activities and walk activities
- The FloorX mat can identify a fall with the current classifier method

Limitations
- All activities were only able to be executed in one direction on the mat
- The mat has a 4-inch matrix resolution
- Size of the mat

Future Work
- Expand the scope of research to identifying a fall on a whole floor
- Use a probabilistic method to determine the probability that someone has fallen based on data received

References

Rubenstein, Laurence Z. Falls in Older People. University of Oklahoma College of Medicine , 2021.

"Smart Senior Living." FloorX, floorx.com/index.php/applications/smart-senior-living/.