dimensions of our finished glove.

Sign Language Teaching Glove[5] This project was done by students from University of Illinois Urbana-Champaign. This glove uses sensor-based detection, notably flex sensors for each finger, and gyroscopes and accelerometers at the end of each finger for angular motion and tilt sensing. Bluetooth transmitter was used to communicate sensor data to computer, which reduces the wires needed. Noise filter is applied to the data, which are then passed thru a perceptron algorithm for classification. Since extra sensors add more dimensionality to data that may increase accuracy, we considered this alternative. However, we found that the gyroscopes and accelerometers on the market are rather large and may be uncomfortable for the users and rejected this idea. We find it interesting that they chose to use the perceptron classifier despite having a rather low accuracy of 75%. We have decided to explore several different machine learning algorithms to find a model that's best fit for our type of data.

10 SUMMARY

Overall, we were able to achieve what we set out to do. We created a glove that uses sensor data and a machine learning model to recognize the letter being signed by the user and output it as audio on a computer's speaker. We were able to achieve a testing accuracy of 98.9% and real-time accuracy of 75.68% as well as using our 63.89 ms prediction time to allow users to sign at 0.862 s/gesture (this number could also be increased or decreased depending on the user).

The greatest challenge we came across was improving accuracy in our system: we made several iterations of the glove, which involved adjusting the existing sensors, adding more sensors for different purposes, and also tuning the hyperparameters of our machine learning model. Other challenges we faced were due to the reliability of our sensors. We found our selves replacing and fixing connections to the sensors quite often and were able to eventually secure the sensors onto the glove in a way that makes it less prone to breaking.

10.1 Future Work

We may continue our current work beyond this semester as this has been an interesting project so far. One area we can certainly improve on is the communications between the Arduino Nano and the computer. As of now, the glove uses a wired component for communications, which may not be ideal for users. We intended to change it into a wireless Bluetooth connection so that the users do not have to connect the glove to the computer to operate it, however we ran out of time.

Another area is certainly expanding the number of signs to recognize. This may prove to be a hard task as the physical components may need to be redesigned to include more sensors to detect a wider range of signs and to account for more complexity in signs.

It's also important to note that in its current form, the Gesture Glove could not practically be used by an ASL speaker to communicate with a non-ASL speaker. The ASL alphabet is only used for spelling out proper nouns. Furthermore, communicating in ASL involves more than just hand gestures – it involves facial expressions, body position, and movement. A wearable solution would probably involve more sensors in which case the appeal of portability and unobtrusiveness could disappear. It's possible that continuing to build off of our device may not be the best solution for our original use case.

However, this device could still have other applications. This glove could enable a different way to interact with computers. It could help monitor hand movements and track rehabilitation. It could also be used to get novice learners excited about learning ASL.

10.2 Lessons Learned

The general advice that we have is to start on tasks early and follow through the schedule. If there is any slack in the schedule, we suggest still try to work on tasks that are scheduled for the future. If possible, we highly suggest dividing tasks between team members based on their expertise.

Next, we recommend reaching out to your user to hear their feedback on your solution proposal. Although when generating our solution approach, we spent a lot of time trying to think from the point of view of the user, we found our hypothesis differed from the actual opinions of the user once we had a conversation with them. Verify hypothesis about the users as early as possible to help motivate a solution that works the best for the use case.

Another general advice to start early on contacting people for data collection. While we have planned enough time for data collection, we realized that it is something we could have started before the glove is built and doing it early could have saved us some time in the long run.

As for the technical side, one piece of advice we can give is to decide how the streams of data will be read in and if the user needs to signify pauses between signs using buttons or a pause sign. User experience and level of efforts needed will differ based on approach taken and that is something that needs to be balanced out in a time-constrained project.

We also learned that looking at the data from different aspects of our system's performance is extremely helpful. By making graphs of different variables, we understood better how different parts of our system interacted with each other and it also helped us identify better where the problems were.

Lastly, we suggest researching about different types of sensors. We had different type of sensors to use and different ideas of placement in mind. We believe that our current design will give the best accuracy for ASL letters while not sacrificing craftsmanship. However, there could be more optimal placements for other types of sign recognition and that is something worth of spending time to research about for future teams.

Glossary of Acronyms

- ASL – American Sign Language
- IMU – Inertial Measurement Unit
- ML - Machine Learning
- KNN - K Nearest Neighbors
- SVM - Support Vector Machine

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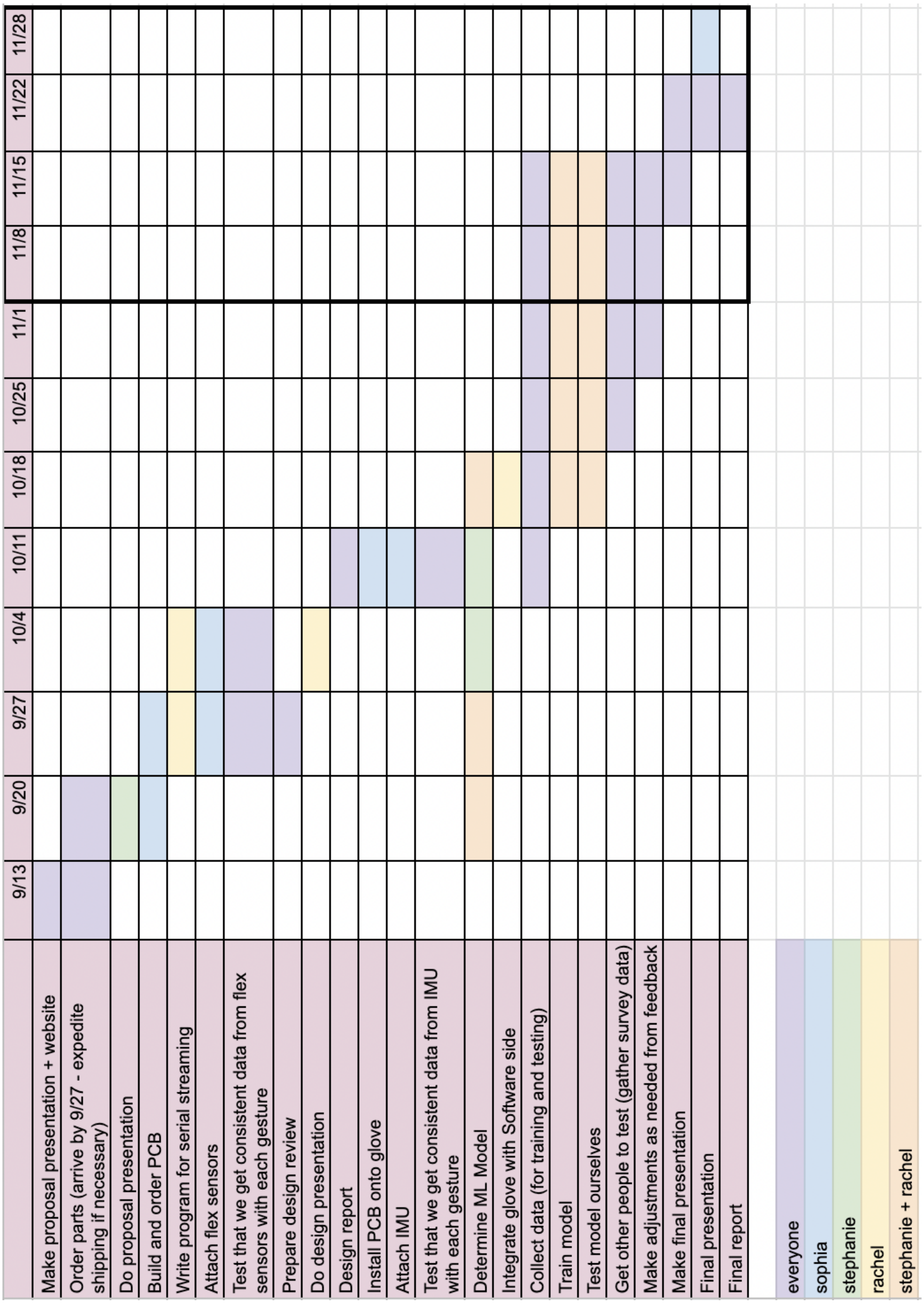

Figure 15: Gantt Chart