Assignment 1

Part A. Answering a “Kind” Signal Detection Task

1. A signal is defined as information that is relevant and useful to the user, and in this case, the signals are the 50 audio clips that have the indicators. Conversely, noise is information that is irrelevant to the user’s current need, and in this case, the noises are the $600 - 50 = 550$ other audio clips that do not have the indicators.

2. A' is the measure of the area under the ROC curve that provides an alternative sensitivity. In particular, it represents the triangular area formed by connecting the lower left and upper right corners of the ROC space to the measured data point. Let H represent the number of hits and FA represent the number of false alarms. The equation is:

$$A' = 0.5 + \frac{\big(P(H) - P(FA)\big)\big(1 + P(H) - P(FA)\big)}{4P(H)\big(1 - P(FA)\big)}$$

For each co-op student, the following data is given:

Student	**Hits**	**Correct Rejections**
A	48	300
B	36	126
C	25	500

Since the number of clips with indicators is given (50), the number of misses (M) and false alarms (FA) can be obtained with the following equations:

$$M = 50 - H$$

$$FA = 550 - CR$$

Applying these equations, the misses and false alarms of each student are as follows:

Student	**Misses**	**False Alarms**
A	$50 - 48 = 2$	$550 - 300 = 250$
B	$50 - 36 = 14$	$550 - 126 = 424$
C	$50 - 25 = 25$	$550 - 500 = 50$

Paolo Torres

With this information, a probability table can be constructed for each student:

Student	**Hits**	**Misses**	**False Alarms**	**Correct Rejections**
A	$48\ (0.96)$	$2\ (0.04)$	$250\ (0.45)$	$300\ (0.55)$
B	$36\ (0.72)$	$14\ (0.28)$	$424\ (0.77)$	$126\ (0.23)$
C	$25\ (0.50)$	$25\ (0.50)$	$50\ (0.09)$	$500\ (0.91)$

Finally, these probabilities can be used to calculate the A' of each student as follows:

$$A'_A = 0.5 + \frac{(0.96 - 0.45)(1 + 0.96 - 0.45)}{4(0.96)(1 - 0.45)} = 0.86$$

$$A'_B = 0.5 + \frac{(0.72 - 0.77)(1 + 0.72 - 0.77)}{4(0.72)(1 - 0.77)} = 0.43$$

$$A'_C = 0.5 + \frac{(0.50 - 0.09)(1 + 0.50 - 0.09)}{4(0.50)(1 - 0.09)} = 0.82$$

Therefore, student A has an A' of 0.86, while student B is 0.43, and student C is 0.82.

3. Of the three co-op students, student B seems to have the most difficulty discriminating between targets and non-targets. This is because they have the lowest sensitivity at 0.43, which is much less than 0.86 and 0.82, of student A and student C, respectively. This is attributed to their high number of false alarms at 424, at a probability of 0.77, which negatively contributes to their A' calculation. In particular, they are the only student where the probability of their hits is less than the probability of their false alarms ($P(H) < P(FA) \rightarrow 0.72 < 0.77$).

Assignment 1

Part B. Drafting a "Wicked" Signal Detection Task

The project that will be chosen is my Fourth Year Design Project on automatic urban delivery. My team members are Danny Guo, Jeff Niu, Sherman Qiu, and Kevin Zhang, however none of them are in the SYDE 543 Winter 2021 class. This assignment is done individually.

4. **Situation of Concern**

a. The project for this assignment will be my Fourth Year Design Project on automatic urban delivery, where a solution is being developed for the autonomous delivery of packages in dense, urban environments. The idea is to create a system capable of transferring a package from point A to point B anywhere within a city, completely on its own. Example stakeholders include companies like Uber Eats, Amazon, and FedEx, where the robot would be able to deliver payloads like food, consumer products, and mail to customers [1]. The motivation behind this is that people are dependent on delivery of items now more than ever, considering COVID-19, and a system like this could help companies be more efficient and save money.

   The main concern that will be addressed is its ability to navigate its environment. The most difficult challenge with this project is being able to traverse dense and busy terrain, consisting of obstacles such as curbs, street signs, and humans, all while doing it fully autonomously. There is a need to be able to handle all of these obstacles effectively and safely, to ensure the packages get delivered on a timely manner and within all safety regulations. Thus, a high-level analysis will be given on the computer vision techniques needed and general navigation algorithms required to be able to achieve these goals.

Assignment 1

5. Signal Detection Task and Decision Maker

a. A relevant signal detection task within this problem space is the robot's ability to stop when it detects an object in front of it. This detection task is important to the performance of the overall system because it keeps the packages protected and secure, prevents the robot from being damaged, and allows it to maneuver said obstacles. This is a simple requirement that is necessary of the robot, because if it cannot reliably avoid obstacles, then this product would be quickly rejected by any potential stakeholders. In addition, being unable to stop at objects would introduce danger to its surroundings, which is not a good look for any product trying to make it in the market.

b. The decision maker for this task is only the robot itself, as it is fully autonomous, so the developers of the product would not be a part of it. Certainly, the developers contribute to its ability to navigate in the first place, however when it is actually out there, it is all up to the robot to make the decisions. The developers implement its navigation techniques through software and computer vision algorithms, but the robot is expected to traverse its environment by itself.

Assignment 1

6. Signal vs. Noise

a. From the perspective of the robot itself, the signal will be any object directly in its field of view on its path of traversal that must be stopped at. The robot will be equipped with a camera for vision, and any obstacle it sees along its current path that must be stopped at are considered as signals. Conversely, the noise will be any objects in its field of view that do not need to be stopped at, which are objects not in its direct path of traversal. Although the signal and noise pertain to the same idea, namely the detection of objects, the distinguishing aspect that makes them either a signal or noise is whether or not they need to be stopped at, which is an important function in modern object detection [2].

b. It is first important to identify the four outcomes of the map for the signal detection. There are two actions, either to stop or to not stop, as well as two events, either there is an object that must be stopped at or there is not an object that must be stopped at. With this in mind, the outcome map can be constructed as follows:

	There is an object to stop at	There is no object to stop at
The robot stops	Hit	False alarm
The robot does not stop	Miss	Correct rejection

In words, when there is an object to stop at: a hit is when the robot successfully stops, while a miss is when it fails to stop even though there is an object in front of it. When there is no object to stop at: a false alarm is when it stops even though there is no object in front of it, while a correct rejection is when it successfully continues forward since there is no object in its way.

Assignment 1

7. Training Decision Makers on the Signal Detection Task

a. A significant part of object detection and navigation is training the algorithms with sample data, so that over time, it learns from this training and becomes more effective, a practice known as machine learning [3]. The developers first code the computer vision and navigation algorithms with tunable parameters, and this along with sample data and training, optimizes these parameters to maximize its performance. The stimuli that will be used in this case are the objects it sees in its field of view, more specifically, methods will be developed to clearly separate the objects directly in front of it from the objects on its sides. The system will consider aspects like its own size, the size of the objects in its field of view, and speed at which itself and the objects are going, when determining whether it needs to stop.

To objectively measure the signal to count events, as mentioned in the last paragraph, the robot will go through rigorous training to maximize its performance. Various training data, which will consist of a wide variety of scenarios, will be used, and each time, the number of objects it successfully detects versus does not successfully detect will be tracked. With this method, the team can track how many hits and correct rejections it achieves, versus misses and false alarms. This is the essence of the learning strategy, as each time a simulation is performed with certain tunable parameters, the results of each simulation (i.e., hits and correct rejections versus misses and false alarms) can be used to further tune the parameters to achieve optimal performance.

8. References

[1] D. Jennings and M. Figliozzi, "Study of Sidewalk Autonomous Delivery Robots and Their Potential Impacts on Freight Efficiency and Travel," SAGE Journals, 16 May 2019. [Online]. Available: https://journals.sagepub.com/doi/abs/10.1177/0361198119849398. [Accessed 31 January 2021].

[2] S. Prasad and S. Sinha, "Real-time object detection and tracking in an unknown environment," IEEE, 30 January 2012. [Online]. Available: https://ieeexplore.ieee.org/document/6141394. [Accessed 31 January 2021].

[3] X. Zhu, C. Vondrick, D. Ramanan and C. C. Fowlkes, "Do We Need More Training Data or Better Models for Object Detection?," CiteSeerX, 2012. [Online]. Available: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.259.7748&rep=rep1&type=pdf. [Accessed 31 January 2021].