Project

Selection of Project:

The chosen project will be the same as from Individual Assignment 1, namely my Fourth Year Design Project on automatic urban delivery.

Statement of Contributions:

Out of all my team members for the FYDP, none of them are in the SYDE 543 Winter 2021 class. This project is done individually.

PART A: Situation of Concern as a Sociotechnical System

1) The motivation of this project is that delivery companies now, more than ever, are looking for ways to save on costs, especially in the midst of this pandemic. One way they can save on costs is by automating the delivery process, as this can save the company money by not having to pay for the various expenses that pertain to normal delivery (ex. paying employees, having liabilities, etc.). Thus, we identified a need for the development of an automatic delivery system for companies to autonomously deliver their packages. Stakeholders for this project include companies who have services focused on the delivery of general payloads and packages such as Uber Eats, Amazon, and FedEx. Target users consist of the employees present at the source of the delivery site, as they are the ones who will prepare the payloads, such as food or mail, and then place them in the delivery system. As a result, this requires extensive training for the employees to ensure not only that the packages are situated properly, but also that the robot is setup to successfully deliver the packages and return safe and sound.

2) Many of the delivery systems in the works today are either wheeled robots such as cars and small automobiles, or tread-based robots such as tanks. However, our design is a new proposed solution in this space of autonomous delivery, which is that of a hexapod robot:
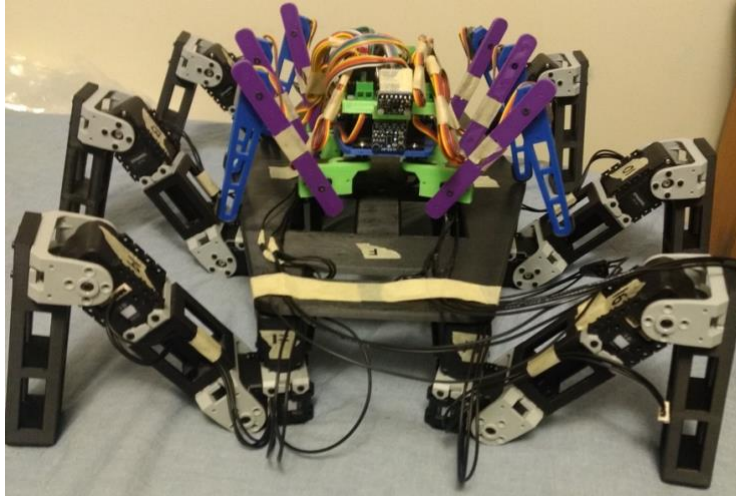
Project

Figure 1: Our FYDP of an urban delivery system carrying a sample payload.

We are at the point where we can control the robot and get it to traverse simple paths such as straight-line deliveries and small stairs. The strength of this design over wheeled and tread-based robots is that this one is capable of performing more complex movements which will allow it to avoid more obstacles that are typically present in dense urban environments (ex. people walking by, signs, curbs, etc.). Although hexapod-based robots already exist, they are typically only used for other applications such as for hobbyists, security, and the army. Thus, the design itself is an existing solution, however, the problem we are applying it to is brand new and turns into a proposed solution.

3) This solution should be considered a sociotechnical system, both in terms of how it interacts with the environment during its deliveries, as well as how it might impact the job market with respect to delivery. As it is intended to operate in dense urban environments, it is important that the robot be aware of its surroundings and avoid any contact or harm with other humans. Nonetheless, it would take a while for a city of humans to get used to seeing robots drive around on a daily basis, which may impact their general behaviour and how they view technology and automation. Some people may feel uncomfortable or even threatened being around these robots, even if they are designed to pose no harm to humans. With respect to the job market, people who work in the delivery sector may lose their jobs to such a system and fight back against it as a result. Overall, it would take a while for humans to assimilate themselves to living in a city full of delivery robots, and this may slow down further development and integration of such systems on a wider scale.

Paolo Torres

Project
PART B: Literature Search on Cognitive Academic Disciplines

1) The cognitive capabilities of the robot are very important, as it needs to autonomously get from its source to its destination all on its own. The cognitive architecture of the robot must plan the most optimal path it needs to take, as well as effectively re-route and reconfigure itself if any issues arise. Therefore, the cognitive level of the robot in this case is its decision-making and execution of its task to achieve its goals. Based on the information gained from its various sensors and objectives, the cognition and control system decide how to act and what to do in specific situations. As a result, the robot needs a cognitive model to represent itself, the environment, and the interaction between them accordingly. Thus, much like the cognitive psychology and decision-making when it comes to human performed tasks, the robot needs to perform the same way, and make decisions and actions similar to what a human would do when making deliveries, i.e., avoiding collisions with other humans and objects, and following all city street and road regulations like stop signs and right-of-way [1].

   Human-computer interaction between the robot and people around it is important to consider and essential to keep in mind when developing the robot. Basic human actions such as listening, speaking, and reading should be taken into account for the interaction with the robot. More specifically, the robot should be equipped with alerts and warnings, both in text and in sound, to convey to humans when there are issues such as being too close to them. This takes into consideration anyone who may be blind or deaf and adds onto its accessibility functionality that could help it gain some trust within the community. The important idea here is that the robot builds trust with the people and changes their negative perceptions of any potential danger or trouble. Once it gains some traction and credibility, only then can it really take off and become a mainstream product and service in the future of delivery [2].

2) An important and highly applicable topic from Cognitive Ergonomics is the concept of a wicked environment, which is an environment where next steps and goals may not be clear, have rules that may change, and may or may not get feedback. For our robot, we are absolutely working in a wicked environment, as its surroundings is constantly changing as it moves towards its destination. Furthermore, external factors such as the

Paolo Torres

Project

weather can change at any time, from sunny to rainy to snowy, so the robot needs to account for that and be able to handle it. As a result, it is vital that the robot is properly protected and tested for these conditions. We added a protective casing to store all the electronics in, as well as a case for the packages, to protect it from the weather and other debris. Furthermore, we will test thoroughly under conditions such as harsh weather, as well as ensure it can handle the changing environment such as the movement of humans in its surroundings, with appropriate responses [3].

Paolo Torres

Project

PART C: Application of Signal Detection Theory

1) A relevant signal detection task within this problem space is the robot's ability to turn on the spot. This detection task is important to the performance of the overall system because it would most definitely need to perform turns to get to its destination, whether that be for following its route or avoiding an obstacle. Given an input, for example how much to turn at via a measurement of angle or position, the robot must react accordingly and actually turn that number of degrees. Furthermore, the time between the command being sent and actual movement of the robot needs to be minimized, in order to maximize its performance. As mentioned, this signal of turning would be detected in two ways: either from its GPS tracking and routing system, or because of an obstacle in its path. In addition, if events such as blocked sidewalks due to construction or special occasions occur, the GPS could trigger a re-route, resulting in another instance of turning. Before choosing a new decision-maker, first some context: due to the pandemic, we decided to first develop the robot being manually controlled via a game controller by humans. This was done to ensure we first had a working product before trying to implement autonomous control, which is especially difficult now considering we are effectively working on the project separately. With that being said, the decision-maker for this task will be the human controlling the robot through the game controller. The robot is currently programmed to accept controller-based input and react according to said inputs. Thus, it is now up to the human to perform the desired tasks and get the packages to their destinations. In addition, rather than autonomous navigation, it is the humans that have to avoid the obstacles and move at the appropriate speeds.

2) From the perspective of the human robot operator now being the decision-maker, the signal (or targets) will consist of two things: the signal from the GPS and routing system to re-route its path, and the signal from the decision-makers controller to perform the appropriate turn(s). Now that it is manually controlled by a human, it is up to them to carefully observe the state and view of the robot, via its various sensors and cameras on board. Once the human detects an obstacle such as a street sign, or sees a required re-route, then they would send the turning signal through the controller to the robot. Conversely, the noise (or non-targets) the human must consider are similarly two things,

Paolo Torres

which are opposing the signals: either false/incorrect GPS re-routing detected by its positioning system, or mistakes made by the human to turn when not necessary. The objective of the routing system is to determine the shortest path to its destination in order to minimize cost, time, and usage. When a re-route is detected, it is up to the human to ensure this was intended before correcting its path. Along with that, there is also room for error on the human detection side, where they could mistake harmless obstacles as ones that they should avoid, even though they did not need to.

Using the signal detection paradigm, an outcome map for this case is as follows:

	Yes re-route or yes obstacle	No re-route or no obstacle
The human turns	Hit	False alarm
The human does not turn	Miss	Correct rejection

3) Response bias β, also known as the decision criteria, is the degree to which the perceiver is biased to detect or not detect. In this case of the human robot operator, more often than not, they would lean towards being more liberal, i.e., small β with maximal detection, as it is better to turn by accident and just correct yourself than it is to miss a turn and potentially crash into a human or other obstacles. Sensitivity d', more specifically perceptual sensitivity, is how different the signal is from the noise. In this case, the signal and noise are actually the same, i.e., a human or a wall; therefore, it is more dependent on the actual position of said obstacles, resulting in a smaller d', meaning the signal is less distinguishable from the noise. Lastly, sensitivity A', is a measure of the area under the ROC curve that provides an alternative sensitivity, i.e., the level of overlap between the signals. In this case, the A' would be relatively low, as it might be difficult at times to distinguish when and where to exactly turn, as it is solely dependent on the human's ability to identify when the turns are necessary, resulting in more hits and false alarms, which in turns results in a lower A' calculation.

Paolo Torres

Project

PART D: Application of Decision-Making

1) As mentioned in previous sections, the scope of this system is that the project aims to tackle the issue of autonomous delivery in dense urban environments. However, due to the pandemic, the group had to scale back our deliverables in order to still deliver a reasonable project and finish on time. As such, we had to set aside the autonomous navigation and substitute it with human controlled navigation via a game controller. This results in a change of decision-making, namely, from the robot making the decisions to the human operator making the decisions. Studying decision-making is important in this case because it is important that the system understands who is in control and who to listen to. This will allow it to function appropriately and be successful in the marketplace, that is, the focus is now on properly trained human operators for navigation.

2) The selected bias for the human robot operator from the Hindsight card deck is loss aversion, which is a term that implies people are more motivated by potential losses than by potential gains. With respect to general navigation and the act of turning and avoiding obstacles, the operators are much more inclined to avoid accidents if it means spending more money or time. For example, if there is a lot of debris up ahead, the operators have two choices: either continue through the debris and save time at the cost of potential collisions, or re-route and navigate around the debris, preventing potential collisions at the cost of time. For most people, the loss due to accidents is much worse than the loss due to time or late arrivals, therefore, loss aversion explains why they are most likely to decide to avoid the debris. From another perspective, the potential gain of saving that bit of extra time is outweighed by the potential gain of not getting into an accident by avoiding the debris in the first place. This is not all the time though, since some people may see the time save as more beneficial, therefore, the solution to this problem is proper and extensive training to ensure the operators make the best possible decisions.

3) Skill-based decision-making describes decisions made that are not only inherited, but also conditioned through experience and automated routines requiring little conscious attention. In this case, this would relate to the operator's level of experience, as the more they perform the tasks and operate the robots, the better they will get at making correct and effective decisions. Rule-based decision-making describes decisions made that are

Paolo Torres

Project

conditioned and codified by experience in the brain or in external references. In this case, this would be decisions made based on a documentation or guide towards certain scenarios; for example, whether or not to turn can be stated in supporting documentation by looking at specific parts of the user interface that display informational alerts or warnings. Knowledge-based decision-making describes decisions made with respect to the still mysterious process inherent in creative decisions and acts, where there is improvisation in unfamiliar environments, and no routines or rules available. In this case, this would be decisions made when unforeseen or unprecedented events occur; for example, if a big snowstorm or strong winds suddenly appear during the delivery, then the operator would have to adjust their decision-making accordingly to account for this change in the environment, perhaps by being extra cautious when navigating.

Paolo Torres

Project

PART E: Application of Mental Workload and Situation Awareness

1) As with the previous section, the decision-maker is the human operator who controls the robot through a game controller.

2) The first S, to switch attention between tasks, greatly influences mental workload in this case because the operator having to switch between navigating straight and avoiding obstacles is stressful, especially considering the environment is wicked, so they do not know when to switch until moments before. Next, to seek information minimally impacts mental workload because most of the important information is already there present in the user interface, so it does not take much effort to understand if there are any issues or alerts to be seen. Then, to study material moderately affects mental workload because there is a fair amount of knowledge and training to go through such as learning the basic operation and functionality of the robot before being able to navigate. Lastly, to safely behave greatly influences mental workload because it is of utmost importance that the operator performs the navigation carefully to avoid any accidents or harm to the robot. Therefore, for this project area of controlling an urban delivery system, the switching of tasks and safely behaving are the most mentally stressful, followed by studying material, and then seeking information. Switching tasks and safely behaving are the most important, and consequently the most stressful, because these are fundamental to the success of the product: switching tasks allow proper navigation of the robot to its destination, and safely behaving ensures protection of itself and others as well as gains the trust of the community members of the city.

3) The three levels of situation awareness (SA) are perception, comprehension, and projection. Perception is the first level of SA and is the awareness and recognition of relevant information from the environment, and in the case of the operator, this means being able to identify the obstacles that are present in the field of view of the robot. Comprehension is the second level and is perception but also demands that people understand the meaning and significance of what they have perceived; in this case, this means the operator not only identifies the obstacles, but understands what they have to do, namely whether or not to stop and avoid them or keep going because they mean no harm. Lastly, projection is the third level and is comprehension but also with the ability

Paolo Torres

Project

to forecast future situation events and dynamics; in this case, this means the operator adjusting their behaviour over time to account for similar obstacles and learn from these situations to make better navigation techniques in the future. For this case, it is best if the operators have a projection level of situation awareness, as this would allow them to perform better over time and learn from their mistakes and not repeat them again. For example, if they were going too fast before a stop and learned to slow down earlier, then every subsequent time this happens, they would have gained the experience and knowledge of stopping more effectively over time.

Project

PART F: Application of Expertise and Training

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Paolo Torres

Project

PART G: Application of Automation

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Project

PART H: Recommendations for Future Cognitive Ergonomics

TBD

Paolo Torres

Project

PART I: References

[1]   F. Rubio, F. Valero and C. Llopis-Albert, "A review of mobile robots: Concepts, methods, theoretical framework, and applications," International Journal of Advanced Robotic Systems, 16 April 2019. [Online]. Available: https://journals.sagepub.com/doi/full/10.1177/1729881419839596. [Accessed 17 March 2021].

[2]   F. Ren and Y. Bao, "A Review on Human-Computer Interaction and Intelligent Robots," World Scientific, 17 February 2020. [Online]. Available: https://www.worldscientific.com/doi/epdf/10.1142/S0219622019300052. [Accessed 17 March 2021].

[3]   S. Huntington, "How Are Robots Tested for Harsh Conditions?," Robotics Tomorrow, 11 December 2019. [Online]. Available: https://www.roboticstomorrow.com/story/2019/12/how-are-robots-tested-for-harsh-conditions/14538/. [Accessed 17 March 2021].

Paolo Torres