CAPSTONE PROJECT 2

Activity Log

PRJ3213 CAPSTONE PROJECT 2

by

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BCs Computer Science

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School of Engineering and Technology

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4.1 Capstone 1 Gantt Chart

Activities/ Task	Duration	Week													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.Introduction															
- Crete a detailed project plan	Two Weeks														
- Define project Objective and Challenges.	Three Days														
- Engage with stake holders	Two Day														
2.Research															
- Literature Review	Five Weeks														
3.Methodology															
- Decide which tools to use and selection of software for system	Ten Days														
- Create a proposed framework	Ten Days														
4.Documentation															
- Modify the work plan and Gantt Chart	One Week														
5.Project Assessment															
- Determine the project risk and the project outcome	One Week														
Touch Up and Submit Planning Document															

★ This picture indicates milestone.

al preparations are addressed. For first task student involves creating a detailed project plan, task is expected to take two weeks to ensure thorough planning and scheduling. Next, the

project's objectives and challenges are defined within three days. The student must identify the project's scope and limitations, for example focusing on the challenges related to tracking a person throughout their time in the library. Student engagement is another crucial step, which takes two days to communicate with mentors and clarify the project's feasibility and scope.

The Research section is allocated the most time, lasting five weeks. During this period, students will conduct an extensive literature review on the topic of human following robots. By gathering a diverse range of research papers, students will gain a comprehensive understanding of the subject matter, ensuring that they explore various theories and concepts related to the project's objectives.

The Methodology section, taking three weeks, student would be involved in applying the knowledge gained from the research phase. Students will decide on the tools and software to be used in the project, choosing those that align with the objectives. Following the tool selection, a proposed framework will be developed which will illustrating how all the components will interact and work together to create the human following robot. This stage is crucial as it determines the architecture of the robot and how it will function in real-world scenarios.

In the Documentation section, students will modify the work plan and Gantt Chart to reflect any changes or adjustments made during the project. This step is important as it maintains a clear and updated overview of the project's progress for supervisor and student to refer at, ensuring that the student stays on track with the project timeline.

Finally, the Project Assessment section which last one week, involves student evaluating the project's risks and potential outcomes. They will assess the challenges faced, potential issues, and the overall feasibility of the robot's implementation. This assessment will help identify areas of improvement and ensure the project's success.

4.2 Capstone 2 Gantt chart

Activities/ Task	Duration	Week													
		15	16	17	18	19	20	21	22	23	24	25	26	27	28
1. Hardware and Software set up															
- Set up ROS on laptop and Reeman Big Dog Chassis	One Week														
- Assemble all the components on the Reeman robot	One Week														
- Set up, train data and test human detection SSD	One Week														
- Implement colour based identification HSV	One Week														
- Set up trajectory prediction algorithm	One Week														
- Implement SLAM navigation using LIDAR	One Week														
- Implement obstacle avoidance algorithm	One Week														
- Implement recovery module (Last Observed Position, Last Predicted Position, and Searching State)	One Week														
2. Testing and feedback															
- Testing the robot after all integrations	One Week														
- Fine tuning for performance optimization	One Week														
- Real world implementation and evaluation	One Week														

3. Documentation															
- Documentation and final report writing	One Week														
- Edit capstone 1 report	One Week														

 This picture indicates milestone.

The project will start with setting up the necessary hardware and software components which will take around one week. This includes configuring the Robot Operating System (ROS) on a laptop and integrating it with the Reeman Big Dog Chassis. All the robot's physical components, such as wheels, sensors, and cameras, will be assembled on the Reeman robot to create a functional platform.

The robot's core functionality will rely on human detection student would install Single Shot Multibox Detector (SSD) algorithm which takes up one week. Additionally, a colour-based identification system using HSV (Hue, Saturation, Value) will be implemented to further enhance the accuracy of target detection.

On the next week a trajectory prediction algorithm will be incorporated to ensure smooth and efficient tracking. This enables the robot to anticipate the human target's movements. The implementation of SLAM (Simultaneous Localization and Mapping) navigation using LIDAR (Light Detection and Ranging) will provide accurate localization and mapping of the environment.

Continuously for the next week student would also code the obstacle avoidance algorithm to safely navigate through dynamic and crowded environments while avoiding collisions. In order to combat missing target problem, a recovery module will be integrated which includes strategies such as Last Observed Position, Last Predicted Position, and Searching State, enabling the robot to find and re-identify the target in case of temporary disruptions or occlusions.

Testing and feedback will play a critical role in the development process which takes around three weeks. The robot will undergo rigorous testing after all integrations to verify its performance. Fine-tuning will be carried out to optimize the robot's behaviour and response in various scenarios. Real-world implementation and evaluation will be conducted to assess the robot's capabilities in practical environments.

Throughout the project from week 5 to week 14, documentation will be maintained by the student. Which will including progress reports, technical details, and results. A final report will be prepared, summarizing the project's development process, challenges faced, and solutions implemented. By the end of the

project, a fully functional Ground Human Following Robot will be showcased, capable of autonomously tracking and following designated human targets in real-world environments.

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DEPARTMENT OF COMPUTING AND INFORMATION SYSTEMS

SUPERVISION MEETING RECORD

Date: 11/9/2023 (week 1)

Time: 10:00 – 11:00 a.m.

Student: Adam Lo Jen Khai

Supervisor: Chew Zhe Zi

Items discussed this meeting:

Student starting to plan about what to start in the project and what to do with current robot. Student consulted supervisor to ask for advice. Mentor advised that use computer to download ubuntu. We also plan on thinking about which computer to use such as do we need raspberry pie?

Work for the coming meeting:

- Research on ubuntu and computer capability

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SUPERVISION MEETING RECORD

Date: 18/9/2023 (week 2)

Time: 10:00 – 1:00 p.m.

Student: Adam Lo Jen Khai

Supervisor: Chew Zhe Zi

Updates from the previous meeting:

- Researched on what hardware to use.

Items discussed this meeting:

Student initially planed to use the Nvidia jetson nano stream, but the lab was unable to provide because it has already been used up by other project. The only way of conducting this project is to use my own laptop. This week mentor also taught me to use Ros documentation, he told me to run through all the tutorials to understand Ros in order to code it. By this week student have to complete all the exercises and also learn about Reeman robot how to gather and use the topics.

Work for the coming meeting:

- Learn to use ROS
- Understand how Reeman robot works.
- Lean to use hardware such as batteries and volt meter.

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SUPERVISION MEETING RECORD

Date: 25/9/2023 (week 3)

Time: 10:00 – 11:00 a.m.

Student: Adam Lo Jen Khai

Supervisor: Chew Zhe Zi

Updates from the previous meeting:

- Finished Ros tutorials.
- Learn to startup the Reeman robot and control it.

Items discussed this meeting:

For the third meeting with my mentor, he explained installing Ubuntu and configuring the Intel RealSense camera posed initial challenges, particularly with copy-paste commands. Faced with persistent issues, a strategic decision was made to reinstall Ubuntu to ensure a clean slate. The supervisor played a pivotal role in imparting troubleshooting skills, emphasizing effective Google searches. The resolution of the copy-paste issue was meticulously documented in a personal notebook, creating a valuable reference for future problem-solving challenges.

Work for the coming meeting:

- Set up Ubuntu 16.04.
- Set up intel RealSense camera.

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SUPERVISION MEETING RECORD

Date: 2/10/2023 (week 4)
Time: 9:00 – 10:00 a.m.
Student: Adam Lo Jen Khai
Supervisor: Chew Zhe Zi

Updates from the previous meeting:

- Completed set up Ubuntu 16.04.
- Completed set up intel RealSense camera.
- Successfully troubleshoot the copy and paste issue.
- Able to take in camera frame and show output.

Items discussed this meeting:

The fourth week meeting involved the exploration of SSD setup and considerations about integrating Spencer. After insightful consultation with the mentor, a decision was made to opt for a conventional approach which is SSD V2 for human detection. The crucial question of using existing GitHub code or developing a solution from scratch was deliberated, and a purpose-driven decision to code from scratch was made after consulting mentor. Implementing camera input with human detection from SSD marked a key milestone. Leveraging SSD code from GitHub not only simplify the steps by showing step by step of implementing the function but also eliminated the need for extensive data training to recognize humans.

Work for the coming meeting:

- Implementing object detection SSD V2.

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SUPERVISION MEETING RECORD

Date: 9/10/2023 (week 5)

Time: 9:00 – 9:30 a.m.

Student: Adam Lo Jen Khai

Supervisor: Chew Zhe Zi

Updates from the previous meeting:

- implemented human detection algorithm SSD.
- manage to all detect objects in the camera frame.

Items discussed this meeting:

Week five focused on refining the SSD setup to achieve accurate human recognition. After consultation and enquiry mentor about what to do next. Successfully recognizing humans set the stage for the next challenge by identifying the correct target. The code's adaptation to single out the main target amid multiple individuals ensures precision and efficiency. This phase underscored the importance of improving human detection to enhance accuracy and reliability in target identification, setting the foundation for more advanced functionalities.

Work for the coming meeting:

- Able to identify the human inside the camera frame.

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SUPERVISION MEETING RECORD

Date: 16/10/2023 (week 6)
Time: 10:00 – 10:30 a.m.
Student: Adam Lo Jen Khai
Supervisor: Chew Zhe Zi

Updates from the previous meeting:

- Manage to detect all humans in the camera frame.

Items discussed this meeting:

Consultation with the supervisor emphasized the most effective colour detection, leading to a preference for HSV over RGB. This week focuses on implementation human identification using HSV (Hue, Saturation, Value). Recognizing the limitations of previous approaches, the student purposely divided the body into two sections to enhance detection rates. After implementation student found the detection is not accurate and cannot hard to detect bright colour as shadow makes it negative target. Threshold adjustment is implemented but there is no difference. Mentor suggest me to move to next objective instead of pondering this issue as it takes up time.

Work for the coming meeting:

- Make algorithm to detect one main target.
- Create a purple colour bounding boxes for all humans.
- Create a yellow colour bounding box for main target.

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SUPERVISION MEETING RECORD

Date: 23/10/2023 (week 7)

Time: 10:00 – 10:30 a.m.

Student: Adam Lo Jen Khai

Supervisor: Chew Zhe Zi

Updates from the previous meeting:

- Manage to make algorithm to detect one main target.
- Manage to create a purple colour bounding boxes for all humans.
- Manage to create a yellow colour bounding box for main target.

Items discussed this meeting:

For Week seven was dedicated to mastering the intricacies of publish-subscribe mechanisms. Mentor taught how to implement robot to the movement API, mentor suggest splitting the interface into two sides positive and negative based on the positive and negative frame calculate how much distant from the centre. Therefore, creating a distant from centre for rotation the robot. Despite encountering challenges in the publishing process, the student gained insights into message reception through the rostopic echo command. This week underscored the importance of effective communication between different components in a complex system, a fundamental skill for building robust robotic systems.

Work for the coming meeting:

- publish the depth information and distance form centre information.
- subscriber receive the published depth and distance from venter information.

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SUPERVISION MEETING RECORD

Date: 30/10/2023 (week 8)
Time: 9:00 – 10:00 a.m.
Student: Adam Lo Jen Khai
Supervisor: Chew Zhe Zi

Updates from the previous meeting:

- Successfully implemented publish and subscribe for another file.

Items discussed this meeting:

This week mentor taught student to identifying topics from the robot and implementing APIs for movement. The mentor's guidance was crucial in understanding topics, such as cmd/speed for robot movement control. A pivotal decision emerged to utilize depth information for predicting distance rather than relying solely on vision data. The creation of a region of interest based on human detection, combined with HSV, showcased a nuanced approach to refining target identification. To identify the main target we use confidence score to determine best scoring main target which would have a yellow bounding box, the rest of the box in purple would be human with lower confidence score citing false targets.

Work for the coming meeting:

- Making the robot rotate according to human movement.
- Make sure that there is distance judgment mechanism to tell the distance from the CenterPoint to direct the rotation of the robot.
- Able to make the robot rotate from left to right.
- Able to make the robot follow the human main target inside the frame.

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SUPERVISION MEETING RECORD

Date: 6/11/2023 (week 9)
Time: 9:00 – 10:00 a.m.
Student: Adam Lo Jen Khai
Supervisor: Chew Zhe Zi

Updates from the previous meeting:

- Successfully retrieved topics and implemented APIs.
- Robot demonstrated the ability to navigate based on a region of interest defined by the main target's centre point.
- Effective integration of sensor data and decision-making processes, enabling the robot to dynamically respond to its environment.

Items discussed this meeting:

Upon achieving reliable movement through API commands, the supervisor played a crucial role in guiding the student on incorporating coordinate APIs. This strategic decision streamlined the navigation process, eliminating the need for an intricate custom navigation system. Instead, the focus shifted to providing precise coordinates, empowering the robot to autonomously traverse towards the specified target location. This transition marked a notable advancement, simplifying the control mechanism and enhancing the system's overall efficiency.

Work for the coming meeting:

- The human always out of field of view of robot after each rotation.
- Unable to slow down the robot rotation API.

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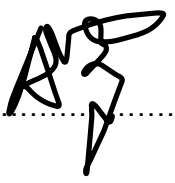

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SUPERVISION MEETING RECORD

Date: 8/11/2023 (week 9)
Time: 7:00 – 10:00 p.m.
Student: Adam Lo Jen Khai
Supervisor: Chew Zhe Zi

Updates from the previous meeting:

- Incorporating coordinate system API.
- Incorporating movement system API.
- Incorporating movement command using cmd_vel.

Items discussed this meeting:

The initial week of the project involved a series of crucial troubleshooting steps and a strategic decision to upgrade the Robot Operating System (ROS) version. Student encountered challenges related to the Intel RealSense import library, specifically concerning compatibility issues with Python versions. Upon attempting to upgrade from Python 1 to Python 2, the student faced roadblocks as the Ubuntu system continued to label the Python version as outdated, hindering the download of essential components like realsense2. Mentor recommend a more drastic solution, the decision was made to undertake a ROS upgrade from kinetic kame to melodic. This deliberate shift presented an opportunity to align the system with more recent standards, potentially resolving the compatibility issues.

Work for the coming meeting:

- Finish up main target human identification.
- Fix the human following movement command for robot.
- Plan on what algorithm to integrate for tracking.

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SUPERVISION MEETING RECORD

Date: 13/11/2023 (week 10)
Time: 10:00 – 10:30 a.m.
Student: Adam Lo Jen Khai
Supervisor: Dr Steven

Updates from the previous meeting:

- Finished human identification of main target and non-main targets.
- Robot able to follow human around able to move forward and rotate.
- The distance from centre algorithm works and able to rotate according to centre distance difference.

Items discussed this meeting:

During our weekly progress meeting, Dr Steven and student discussed the advancements in the human detection algorithm, particularly the successful incorporation of movement commands. We explored strategies to enhance the quality of Chapters 1 to 3 in the final report. Dr. Steven emphasized the significance of Chapter 4, highlighting the need for a robust testing phase with a minimum of four well-designed experiments. He clarified that the evaluation would heavily weigh on the experimentation rather than the code itself. The report needs to look into what technique used then do an experiment, design the experiment and then collect the data to explain the output. The meeting concluded with a focus on refining the testing methodology and preparing for the upcoming experiments, aligning our project with academic objectives.

Work for the coming meeting:

- Start planning experiment for chapter 4

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SUPERVISION MEETING RECORD

Date: 15/11/2023 (week 10)

Time: 9:00 – 10:00 a.m.

Student: Adam Lo Jen Khai

Supervisor: Chew Zhe Zi

Updates from the previous meeting:

- Completed human identification.
- Completed human following function.
- Face issue with tracking human after each rotation.

Items discussed this meeting:

During the recent refinement of the human following algorithm, a notable challenge arose in the form of excessive robot overturning during rotation. For this week a meeting is one with mentor to troubleshoot the rotation speed. What we did was reducing the rotation magnitude API from 0.1 to 0.0000001. Despite attempts to mitigate this by reducing rotation speed, the impact was minimal, prompting mentor intervention. The mentor suggested shifting from the API to the cmd_vel command for controlling robot movement. This adjustment proved transformative, resulting in a smoother robot operation and an improved ability to keep the main target within the robot's field of view.

Work for the coming meeting:

- Think of a way to maintain tracking with the main target.
- Find a way to continuously track the target after rotation occlusion.

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SUPERVISION MEETING RECORD

Date: 20/11/2023 (week 11)
Time: 3:00 – 4:00 p.m.
Student: Adam Lo Jen Khai
Supervisor: Dr Richard

Updates from the previous meeting:

- Research done for vision tracking algorithm.
- Manage to make the robot rotate smoothly.

Items discussed this meeting:

This week student embarking on the development of the prediction trajectory algorithm marked a significant phase in the project. To implement this, extensive online research led to the exploration of Kalman filter and linear regression codes. The approach involved designating the centre point as a marker and subsequently tabulating the preceding 10 steps. While considering the incorporation of timing, challenges surfaced, prompting careful consideration. Early attempts with the linear regression algorithm yielded perplexing results, after consultation with Dr Rishard, an Artificial Intelligence lecturer student manage to gather valuable insights on how to us the algorithm. The algorithm would be two repetitive linear regression y= m x + c which y represents current axis and x is the array of past data of current axis. This makes the x axis not to be affected by y axis instead both axis should be affected by their own data.

Work for the coming meeting:

- Implement the code out of two tracking algorithms.
- Think of a way to successfully use the algorithm towards vision tracking.
- Think of a way to implement find back lost target algorithm.

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SUPERVISION MEETING RECORD

Date: 27/11/2023 (week 12)
Time: 9:00 – 10:00
Student: Adam Lo Jen Khai
Supervisor: Chew Zhe Zi

Updates from the previous meeting:

- Successfully implemented vision tracking algorithm.
- Give a few suggestions to mentor on how to find back lost target.

Items discussed this meeting:

During this week, my focus shifted towards the implementation of the corner lost target prediction algorithm. The problem arises when algorithm would be activated once the target can't be seen in the field of view of the camera, it didn't manage to trigger the lost detection algorithm. Following guidance from my mentor, student incorporated a Boolean checker and flag mechanism to determine the optimal trigger position for activating corner detection. Once the initial issue with identifying the main target trigger was resolved, student encountered difficulties in introducing a 5-second delay before corner detection could be initiated. Addressing the timing delay became a focal point, requiring meticulous adjustments within the complex code structure. The process involved substantial effort and time in pinpointing the most effective location to insert the time counter, given the intricacies of the existing code. Despite these challenges, student manage to ensure the target was out of view and after 5 seconds the corner detection algorithm would be activated.

Work for the coming meeting:

- Get the lost detection command working and make sure when human lost for 5 seconds lost detection code would activated by publishing the last known position location.

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SUPERVISION MEETING RECORD

Date: 29/11/2023 (week 12)
Time: 9:00 – 9:30 a.m.
Student: Adam Lo Jen Khai
Supervisor: Chew Zhe Zi

Updates from the previous meeting:

- The corner detection algorithm gets triggered in time.
- The triangle method manage to find back the target.

Items discussed this meeting:

In this week consultation with my mentor, the question arose about whether to implement vision and coordinate system prediction alongside the current focus on the triangle method for lost target detection. The supervisor wisely advised me to prioritize the triangle method, considering its simplicity and the limited time available for implementing new algorithms. Despite this guidance, I was motivated to explore further possibilities and decided to implement two types of algorithms for lost target detection: the established triangle method and an additional approach involving linear regression. This decision was driven by a curiosity to understand the nuances and differences in the performance of both algorithms, even in the face of acknowledged challenges. The aim is to conduct thorough testing to gain insights into their respective strengths and limitations in the context of our project.

Work for the coming meeting:

- Try to implement the linear regression algorithm for coordinate system.
- Start testing the human detection and tracking algorithm for report.

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SUPERVISION MEETING RECORD

Date: 4/12/2023 (week 13)

Time: 9:00 – 10:00 a.m.

Student: Adam Lo Jen Khai

Supervisor: Chew Zhe Zi

Updates from the previous meeting:

- Still working on linear regression algorithm on coordinate system.
- Completed the triangle method to predict target lost at corners.
- Writing report on the experiments.

Items discussed this meeting:

During the implementation phase involving both the triangle method and linear regression for lost target detection, I encountered a significant hurdle related to connection issues. My supervisor aptly identified this challenge as a connection bug. The dynamic nature of my laptop's IP address, which tended to change each time I switched Wi-Fi connections. This inconsistency led to disruptions in the publish and subscribe functionalities crucial for the project. Addressing this, I spent considerable time troubleshooting the connection problem. I resorted to manually checking and updating the IP address in the ~/.bashrc file using the nano text editor. To ensure the changes took effect, I used the source command. Additionally, I went through a sequence of steps involving opening and closing the Ubuntu Wi-Fi connection and verifying the Wi-Fi settings to confirm the correctness of the IP address. Successfully resolving this connection bug was pivotal, as it reinstated the normal functioning of publish and subscribe mechanisms, allowing my robot to resume its intended movements. For this week I did not manage to do any testing because the robot cannot move at all.

Work for the coming meeting:

- Fix the connection issue.
- Continue with testing.

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SUPERVISION MEETING RECORD

Date: 6/12/2023 (week 13)

Time: 10:00 – 10:30 a.m.

Student: Adam Lo Jen Khai

Supervisor: Chew Zhe Zi

Updates from the previous meeting:

- Finishing up the all the code.
- Writing the testing for each algorithm.

Items discussed this meeting:

As the project progressed, student transitioned into the testing phase, dedicating significant time to delineate the testing procedures and articulate a comprehensive set of experiments. This involved meticulous planning to ensure a thorough examination of the system's functionalities, accompanied by an in-depth exploration of potential areas for improvement. Concurrently, student continued the coding efforts for the linear regression algorithm by using the robots coordinate. Balancing coding tasks with the formulation of testing methodologies, student strived to create a detailed and insightful report on the system's performance. This dual focus encapsulated both the developmental and evaluative aspects of the project, underscoring the commitment to a robust and well-documented outcome.

Work for the coming meeting:

- Finish up the final report.
- Finish up the coding for the human following robot.

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