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**--TITLE Page--**

**TDPS Notebook by Team 07**

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*Ten members from three majors: four IE majors, four CE majors, and two ME majors.*

***Work distribution (Second week meeting) ………………………………………………………… 2, 3***

*Each person formed a group according to their own strengths and focused on the development of modules they were responsible for.*

***First group meeting and tasks achievement methods (Third week meeting) ………… 3, 4***

*Developed the rover's system. Team members work on their partially constructed modules and discussed coordination and communication difficulties.*

***Modules improvement (Third week day-to-day progress) ……………………………… 4, 5, 6***

*Primarily on adjusting the communication content of each module and the robot arm, improving the OpenMV pathfinding system, and writing the initial report.*

***Second group meeting and system integration (Fourth week meeting) …………… 6, 7***

*Submitted third-week progress and discussed methods to integrate the system and finish later modules.*

***Modules improvement (Fourth week day-to-day progress) ……………………… 7, 8, 9, 10***

*OpenMV camera , ultrasonic detector and chassis design were being implemented. PCB group designed the connection. Mid-term report and notebook might be finished.*

***Third week group meeting and midterm assessment (Fifth week meeting) ………… 10***

*Sensor, camera, and chassis integrated, together with communication and robotic arm modules were given to PCB team for assembly and field testing.* *To solve issues, PCB group should also ensure proper integration and group communication.*

***Mid-term progress assessment and online presentation(Fifth week presentation) 10, 11***

*Mid-term report and Mid-term notebook were completed. After presentation, our team was on track to meet TDPS each patio’ goals and deliver a functional rover system.*

***Fourth group meeting and system improvement (Sixth week meeting) ………… 11, 12***

*Reviewed our progress after last week’s online presentation and discuss plans for system improvement, including PCB assignments and the missing documents of the prior pre to submit to Teams.*

***Modules improvement (Sixth week day-to-day progress) ……………………………… 12, 13***

*PCB group started with modules integration, and the Gantt chart and budget chart was completed and submit to Teams.*

***Fifth group meeting and parts’ enhancement (Seventh week meeting) …………… 13, 14***

*PCB design was on progress, and OpenMV required future enhancement. Ultrasonic group still had issues. 3D model and CAD design were discussed to stabilize robotic arm.*

***Vacation on Tomb Sweeping Day (Eighth week day-to-day progress) ………… 14, 15, 16***

*OpenMV employed serial connectivity for chassis data and next arrow recognition. PCB pin headers and wiring were identified. Robotic arm was iterated for throwing precision.*

***Sixth group meeting and future enhancement (Ninth week meeting) ……………… 16, 17***

*After vacation,* *OpenMV team linked data with chassis, adopted arrow recognition framework. Robotic arm flow was revised, and chassis was interfaced with OpenMV camera. Patio2 Task3 data-sending communication started.*

***Modules improvement (Ninth week day-to-day progress) ………………………… 17, 18, 19***

*Arrows identification was completed, and PCB design was completed for applying the servo motor system. The wireless data transmission system successfully transmitted and displayed.*

***Seventh group meeting and mid-term exams (Tenth week meeting) ……………… 19, 20***

*All the rover related parts were on progress, including arrow detection algorithm, PCB design, wireless data transfer system, and 3D printing progress. Our team decided to halt rover improving to focus on studying for midterms.*

***Eighth group meeting and*** ***future field operation (Thirteenth week meeting) …… 20, 21***

*After mid-term exam, our team reviewed progress and planned for the upcoming field operation, with successful 3D-printing of rover components. Field testing and adjustments were prioritized for stability and compatibility.*

***Field operation and improvement (******Fourteenth week day-to-day progress)…21, 22, 23***

***Ninth group meeting and final demonstration (Fourteenth week meeting) ………23, 24***

***准备ppt/调参/Final report (Fifteenth week day-to-day progress) ………………………………***

***Final demonstration(Fifteenth week demonstration)…………………………………***

***Final team presentations(Sixteenth week presentation)…………………………………***

***Tenth group meeting and final report polishing(Sixteenth week meeting)………………***

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**First week meeting**

*Date:* Thursday, 23 February, 2023, 19:00–20:00 PM

*Title****:*** Identification of team members

*Purpose:*Identify group members.

*Procedures:*

1. During the first week of class, I sat in the Liren Building classroom and listened intently as the teacher outlined the guidelines for this group assignment.
2. Classmates and I spent an hour after class debating and adjusting the team members in each major (including IE, ME, and CE) to form a fair and cohesive team.

*Results:*We selected ten members from three majors: four IE majors, four CE majors, and two ME majors.

*Conclusion and suggestions for future enhancement:*After confirming the division of labor, our team members and I should carefully read the project's tasks and requirements for this semester and conduct work preparation.

*Recorded by:* Gu Xingci

**Second week meeting**

*Date:*Tuesday, 28 February 2023, 16: 15 PM-18: 00 PM

Title**:** Work distribution

*Purpose:* Determine team members' distribution of labor and position project

*Procedures:*

1. Firstly, our team members and I clarified the project's goals and timeline. Our aim was to program a robot to carry out a series of operations and complete two patios’ activities, each with three tasks.
2. We started with both Patio 1 and Patio 2’s tasks, deciding that our team needed to confirm the construction of our rover model system before moving on to the pathfinding process for the initial goal. At this point, everyone started introducing the parts they are good at; for example, Chen Xi said he is suitable for the control module based on the servo principle; Yang Chun said he can handle the OpenMV vision processing module; and Yuan Ye said he is good at building the system's framing.
3. After that, we confirmed the initial roles assigned to each member of the group: Sun Linhan, Guo Linhong, and Zou Hanlin were all working on PCB integration and document. As for me, I was responsible of notebook keeping and initial report. Chassis and tires were Sheng Dian's domain. Motor maintenance is within the purview of Chen Xi. Li Chenghao and Liu Cehan were in charge of the communication between modules and adjusting the clock frequency. The OpenMV module was developed by Yuan Ye and Yang Chun.
4. Finally, we identified the timing of the initial project report, notebook, and intermediate evaluation to ensure that the content of these sections was submitted on time.

*Results:* We confirmed the initial division of labor among the group members and verified that everyone had an appropriate division of labor and was capable of completing the mid-term progress assessment successfully.

*Conclusion and suggestions for future enhancement:* Following a week of clarifying roles and responsibilities, everyone began working on their assigned tasks this week, with a plan to report the progress and integrate partial the system at the same time next week.

*Recorded by:* Gu Xingci

**First group meeting**

*Date:*Wednesday, 8 March, 2023, 13:00 PM–16:15 PM

*Title***:** Tasks achievement methods and strategies

*Purpose:* Organize first week’s progress reports and system integration

*Procedures:*

1. Chen Xi: I give a detailed briefing on motors, and I have purchased a motor and tweaked its module to better regulate the robotic arm's motion. I also recommend that, once everyone had finished their individual reports, the team’s group members should go on to complete their group reports.
2. Sun Linhan Guo Linhong, Zou Hanlin: For the PCB integration team, we would try to convert the Arduino code to STM32 to meet the course requirement. As the two chips' designs and programming languages are different, we need to make some adjustments to guarantee the code's correctness and stability.
3. Li Chenghao and Liu Cehan: we are in charge of communication and two key parts of our current effort are fixing RTCs and transferring data via HC12. Among these is real-time clock debugging, in which we are trying to utilize a Nucleo-L432KC chip to retrieve the time over the I2C protocol.
4. Yuan Ye and Yang Chun: we are in charge of the OpenMV module, we conduct a field trip to the pavement conditions of our school's East Lake,
5. Sheng Dian: I went to confirm the terrain conditions to ensure that the chassis and wheels of the rover I designed could maintain a smooth progress on gravel ground and flat stone pavement.
6. After all group members were debriefed, everyone focused on the problem of how to identify road signs in Task 2.1. There are currently two schemes to achieve the recognition of arrows. One is through machine learning algorithms; the other is to directly identify triangles and rectangles. The final decision of the discussion was the former. It was decided to ensure the basic functions of the rover to complete the task of midterm display. Secondly, every team member was concerned with finishing Task 2.2, which entailed throwing small balls, using the motor to operate the robotic arm, and also had a requirement for the 3D printer arm. The current discussion was led by Chen Xi to finish the content of the servo, while Sun Cehan and others were responsible for assisting with the modeling and finishing the task of 3D printing the robotic arm. Finally, I wrote everyone's report in detail on the electronic notebook in order to find everyone's corresponding progress and make timely adjustments.

*Results:* Modules have been developed for the project, and our team has discussed system integration. Everyone on the team knew what he needed to do to move his part of the project forward.

*Conclusion and suggestions for future enhancement:* The robot's system was taking shape. This week, team members should continue developing the partially assembled modules they were accountable for and communicate with each other about the coordination and communication issues that have arisen between the modules.

*Recorded by:* Gu Xingci, and others

**Third week day-to-day progress：**

*Purpose:* Modules improvement

*Date*: Friday, 10 March 2023.

*Title***:** communication technique and principle

*Purpose:* Adjust the communication content of each module by communication team members, including Li Chenghao and Liu Cehan.

*Procedures:*

1. To lessen the burden on the main control's memory and boost the stability of time communication, we’ve settled on a communication system with a different design in which the main control and communication module were split.
2. In the end, we settled on the DS3231 as our RTC after considering other options. By using an external crystal oscillator, Beijing time can be pre-programmed into the system. The module then functions as an independent clock, enabling time processing even during a blackout.
3. We decided to jump into the coding. Our proposed starting procedure framework is as follows: The HC12 receives an enable signal from the main control STM32 (H7 series) when the tram reaches the predetermined location. The signal is received by the HC12, and then the L432kc receives data via the UART protocol from the stm32L432kc linked to the HC12. The L432kc then uses the time read from the RTC's (DS3231) crystal oscillator module as a buffer after receiving the command. After that, the PC receives the group's name and time through USB and displays them.

*Results:* The planning of the communication system has already taken shape, and on top of this, it was ensured that the programming of the communication module was partially completed before the next group meeting.

*Recorded by:* Gu Xingci, Li Chenghao, and Liu Cehan

*Date:*Saturday, 11 March 2023.

*Title****:*** Road surface patrol by OpenMV

*Purpose:* Improve the OpenMV pathfinding system by OpenMV programming team members, including Yuan Ye and Yang Chun.

*Procedures:*

1. Based on observations made during field trips, Our subteam established that the

OpenMV camera might perform the duty of road surface patrol: the surface used for the patrol line with a sparse gravel pavement, while the surrounding pavement with a flat stone pavement. And the camera was required to send a signal to the rover, which might determine the direction of the current small car based on the signal's intensity.

2. We chose to use the CANNY operator for edge detection of the pavement. While

the edge of the standard pavement was sparse, and the edge of the patrol line surface was thick and complex. The next step involved detecting as many edges as possible. Hence, a higher resolution was needed.

1. After a heated discussion, we finally chose to use the mean operator to lighten the

load on the subsequent computations, involving adaptive binary and image filtering. The next step was to apply mean pooling to grayscale photos to identify pavement in areas where there were many edges.

*Results:* OpenMV Camera's path detection has been provisionally implemented. Thus, the team moved on to discussing how to establish communication with Sheng Dian's Rover chassis in preparation for their next group meeting.

*Recorded by:* Gu Xingci, Yuan Ye and Yang Chun

*Date:*Sunday, 12 March 2023.

*Title****:*** Robotic arm structure controlled by servo

*Purpose:* Adjust servo and robotic arm modules by Chen Xi

*Procedures:*

1. After a heated discussion at the third-week group meeting with team members, I carefully evaluated the design of the robotic arm and the selection of servos.
2. The original concept for the control module I was tasked with was as follows: when the rover was in front of the trash can, the master (STM32) sent a PWM signal to the robotic arm, which then rotated 180 degrees and dropped the ball into the opening at the bottom of the frame. For the ball to be successfully deposited into the frame, the trolley's servo and robotic arm would be elevated above the frame via a platform.
3. There were three reasons that I settled on this basic structure. One, it was easy to build (requiring only a single servo), and two, it was lightweight and took up little room. Inherent in its bridge-type construction, the PLC material was surprisingly lightweight. Using this layout, you could save some space. The third was personalization. We were able to adjust the drive rod's length, thickness, and interface type thanks to the 3D model. Also, you can alter the appearance of several objects, including the tennis ball used in the mission.

*Results:* I had a rough plan for his robotic arm's control system and hoped to have some of the programming parts and some of the parts 3D-modeled and printed by the time of the next group meeting next week.

*Recorded by:* Gu Xingci, and Chen Xi

*Date:*Sunday, 12 March 2023.

*Title***:** Initial report preparation

*Purpose:* Write an initial report based on the progress they reported to me.

*Procedures:*

1. I listened to some of the group's day-to-day development and wrote down my

observations in the digital version of the notebook.

1. Then I drafted the initial report's abstract, introduction, and task content introduction.

based on the partially formed system framework.

*Results:* The notebook was half filled with entries by the due date. and a draft of the initial

report has been created.

*Recorded by:* myself

*Conclusion and suggestions for future enhancement:* The focus was mainly on adjusting the communication content of each module and the robot arm, improving the OpenMV pathfinding system, and writing the initial report. It was also intended to report the progress and handover of modules in the next group meeting.

**Second group meeting**

*Date:*Tuesday, 8 March, 2023, 14:00 PM-16: 05 PM

*Title***:** Progress report on separate parts

*Purpose:* Second week’s progress reports and system integration

*Procedures:*

1. Sheng Dian (Chassis): I carefully reported the chassis I was now correcting. After receiving the progress of the OpenMV camera under the charge of Yang Chun and Yuan Ye. I was picking modules, first deciding that the chassis wheels should utilize the Mecanum wheel, which allowed wheels to synthesize force in any direction. Then it was determined that the main control OpenMV and the chassis motor to carry out UART communication. Through the calculation, the motor gets the corresponding speed assigned to each Mecanum wheel.
2. After the basic work on Sheng Dian's chassis was finished, the following groups with

day-to-day weekly progress last week was reported separately.

Yang Chun and Yuan Ye (OpenMV): we reported last week on the rover's basic pathfinding, progress and discussed the code operation. We would next finish Patio 2's machine learning-based OpenMV camera to identify garbage can and recognize an arrow icon.

1. Chen Xi: As the robotic arm's in-charge designer, I displayed his 3D-modeled portion of the arm. pointing out that the component frame can reserve a 3mm border for the pitch to prevent the ball from getting stuck in the custom 3D printing. But that the original model is simple and needs to be iterated and raised to achieve the process of throwing into the trash.
2. Li Chenghao and Liu Cehan (communication team): We should accelerate the programming part of the communication module content. As elapsed time was pre-injected via the external crystal oscillator module, we used the DS3231 as RTC. Nucleo-L432KC used the time read from the DS3231 crystal oscillator. module after receiving the signal to perform buffering. The time and the group's name were then sent to the computer via USB and shown there."
3. I reported that I had completed the first half of the notebook content, and also indicated that I would continue to draft the report's initial version.
4. Yang Chun and Yuan Ye gave chassis designer Sheng Dian OpenMV's orders and signals during module handover. Chen Xi, who is in charge of the robotic arm exports the 3D modeling diagram to the students in charge of the document for writing report part, and Li Chenghao and Liu Cehan also hand over their communication module to Sun Linhan. Guo Linhong. and Zou Hanlin, who were all working on PCBs and document integration, let their group be responsible for drawing the schematic and system-design writing.
5. The students who were in charge of the prior phase would make enhancements to the system next week. while the students who would be in charge of the phase after that would create the matching modules in the fourth week following the handover of the prior phase, I meticulously recorded everyone's reports in the digital notebook so that could track down their individual improvements and make necessary adjustments.

*Results:* After submitting third-week progress, our team discussed how to integrate the system and finish later modules.

*Conclusion and suggestions for future enhancement:* The students who promoted the early project continue to build and improve the module. The students in charge of the handover must complete the communication interaction with the early progress and develop their later modules.

*Recorded by:* Gu Xingci and others

**Fourth week day-to-day progress：**

*Purpose:* Improve some group's modules

*Date:*Friday, 17 March 2023.

*Title***:** Pathfinding and arrow recognition by Ultrasonic sensors and OpenMV image recognition

*Purpose:* Improve the OpenMV recognition system by OpenMV programming team members, including Yuan Ye and Yang Chun.

*Procedures:*

1. To achieve the unity of accuracy and robustness, we planned to use that one ultrasonic detector was placed at the front of the rover and two ultrasonic detectors were placed on the right side, allowing them to realize the second stage of pathfinding and arrow signpost recognition using OpenMV's artificial intelligence image recognition function.
2. In the early stages, we discussed numerous strategies to recognize arrows. But conventional algorithms had trouble recognizing the arrow itself from a great distance. Then our team started using a machine learning approach. In order to determine the orientation of the arrows, we wanted to take photographs of acrylic and black standing plates.
3. As the ground's pebbled texture makes stable extraction difficult, we planned to utilize numerous ultrasonic sensors to help the rover navigate safely along the edge of the railing as it searched for trash cans.

*Results:* The framework for the OpenMV camera's path-finding and icon recognition tasks was taking shape, and the camera would be fully programmed before the next group meeting.

*Recorded by:* Gu Xingci, Yuan Ye and Yang Chun.

*Date:*Friday, 17 March 2023,

*Title***:** Top level system integration by PCB

*Purpose:* Begin working on the PCB design and the top-level system integration by PCB and document integration team members including Sun Linhan, Guo Linhong, and Zou Hanlin.

*Procedures:*

1. We decided in the beginning. The PCB acts as a reliable connector between components of the system, such as the microcontroller, servo, motor drivers, and communication module. Other components of the system include the battery. They said that We had brought the initial components and designed the preliminary PCB board. After the system had been put through its paces in terms of testing, the precise design of the PCB would be completed.
2. We also incorporated the communication team's module into the previously discussed system solution, drew and described the high-level design of our initial report in detail, and broke the process down into detection phases in which the sensors are in charge of gathering data, and the STM32 MCU is in charge of processing and analyzing that data. Once the draught report section was complete, it was sent to the execution section, where the robot arm and Chassis' motor controlled the movement. And these were delivered to me to complete the draft initial report part.

*Results:* The preliminary materials and design of the PCB board had prepared, and they had made a simple layout of the main control part and the integration of other parts, which was used to designed the top-level system design and included it in the writing portion of the initial report.

*Recorded by:* Gu Xingci, Sun Linhan, Guo Linhong, and Zou Hanlin

*Date:*Saturday, 18 March 2023,

*Title***:** Chassis driven by PID algorithm

*Purpose:* Design and Adjust rover’s chassis modules by Sheng Dian

*Procedures:*

1. After determining the choice of Mecanum wheels, I finally settled on the PID algorithm, a linear controller with a simple concept, strong robustness, and a broad practical range that guaranteed the real speed of the wheel was identical to the desired speed and considerably improves the precision with wheels moving. My programming part started by measuring the wheels' real and rotational speeds with the use of a rising-edge interruption, then work to bring the two speeds closer together until they are equal.
2. Specifically, I decided to use a PWM output to regulate the motor's speed and direction by adjusting the duty cycle, and a pair of digital pins to alter the output's potential level.
3. Finally, with regards to communication, I chose to use UART serial communication. Once OpenMV published information with front and rear speed and its direction, left and right speed and its direction, these information would go through calculation to obtain the corresponding speed assigned to chassis motor then to each wheel, resulting in matching the control of the speed and direction of the four wheels.

*Results:* Sheng Dian's modified PID algorithm moved wheels perfectly. PWM output, digital pins, and UART connection enhanced chassis motor and wheel precision to complete rover chassis components.

*Recorded by:* Gu Xingci and Sheng Dian

*Date:*Saturday, 18 March 2023,

*Title***:** Ultrasonic sensors development

*Purpose:* Design and Adjust ultrasonic detectors modules by Sun Linhan

*Procedures:*

1. Yang Chun and Yuan Ye: after our group meeting, we decided to assign ultrasonic detectors module to Li Chenghao, who was in charge of communications and the ultrasonic module needs to cooperate with the person in charge of the main control. He accepted, and expected the rover's three ultrasonic sensors' data transmission capability to be activated by the main control board when the vehicle neared the site's edge.
2. Sun Linhan: I planned to design two of the three ultrasonic sensors installed 10 cm apart, parallel to the right side of the rover, at the height level of the railing column. The rover could go to the field's edge, made turns, and performed other movements by programming its two ultrasonic sensors to keep a distance of roughly 10 centimeters from the right railing column. And he promised that the programming part would have done before the next group meeting.
3. At last, I proposed that the garbage can symbol in front of the rover would be recognized by the ultrasonic sensors put there. In order to make it possible for the rover to automatically alter the rate of each wheel based on the received data, I decided to build PID regulation specific to the ultrasonic sensor data format.

*Results:* Sun Linhan promised to finish the programming before the next group meeting and proposed to build a PID regulation specific to the ultrasonic sensor data format for automatic wheel rate adjustment.

*Recorded by:* Gu Xingci, Yang Chun, Yuan Ye and Sun Linhan

*Date:*Sunday, 19 March 2023.

Title: Completion of Initial report

*Purpose:* Write digital notebook and almost finished initial report based on the progress they reported to me.

*Procedures:*

1. I hosted some of the group's day-to-day progress online meeting rooms and made notes in the electronic version of the notebook on what I heard.

2. After receiving the top-level design flowchart and each team member described his work part. I wrote the rest of our initial report.

*Results:* By the due date, the notebook was nearly full of entries. Also, the first report draft might be completed before the next scheduled group meeting.

*Recorded by:* Gu Xingci

*Conclusion and suggestions for future enhancement:* The OpenMV camera's pathfinding and identification detection functions were operational, and the ultrasonic detector module was being improved for cooperating with the camera. Chassis design and rover communication are also at the implementation stage. The PCB group had designed the main connection method and top-level system flowchart. I got more information, and a comprehensive mid-term notebook and initial report were able to be submitted before the deadline.

**Third group meeting**

*Date:*Wednesday, 23 March 2023, 15:00 PM-18: 05 PM

*Title***:** Progress report of camera, robotic arm and communication module

*Purpose:* Third week progress reports and midterm assessments

*Procedures:*

1. Yang Chun and Yuan Ye (OpenMV camera) : we had completed our report this week, detailing how we’ve begun to implement the project's goals of path-finding and arrow and trash can identification.
2. Sheng Dian and Li Chenghao (members in charge of the senor module and chassis that interacted with the camera): we had begun to run the wheels in accordance with the data sent by OpenMV, with adjustments made by ultrasonic detector. After integrating these components, rover proved capable of implementing the Patio1 tasks, which completed initial part of the mid-term assessment. We had uploaded the code and its explanation together with description on GitHub for other members to view and understand their modules.
3. Chen Xi: I confirmed the ball-throwing robot arm by continuously modifying it.
4. Li Chenghao and Liu Cehan: we added the communication module to the running state of the rover for testing and field investigation and demonstration to ensure that the tasks of Patio2 could be completed on the basis. However, the module was not installed on the trolley, so we decided to hand over our module to the group in charge of PCB for final assembly and testing.
5. Finally, we talked about the writing of the initial report. I used the version of Word to typeset and record the text content. But in order to facilitate the modification of the format, we settled on using LaTeX so that everyone on the team could view and edit it; and we agreed that the final report would also be typeset in LaTeX so that everyone could easily make changes to the format and share it with one another.

*Results:* The sensor, camera, and chassis parts had been integrated and installed, and the team in charge of communication, the robot arm, and my notebook and initial report were handed over to the PCB team for assembly and field testing.

*Conclusion and suggestions for future enhancement:* The PCB group should continue to test and integrate all modules to ensure they worked well together. Regular communication and progress updated between groups might help maintain consistency and solve problems.

*Recorded by:* Gu Xingci and others

**Fifth week online presentation**

*Date:*Wednesday, 26 March 2023, 20:00 PM-21: 05 PM

*Title***:** Mid-term progress assessment and online presentation

*Purpose:* To present the rover system design made before mid-term and to be assessed our team's performance at the halfway point of the TDPS project.

*Procedures:*

1. The team introduced themselves and provided an overview of the project, first Sun Linhan presented top-level system design, including the sensor design, control design, and integration design.
2. Then Yang Chun and Yuan Ye introduced the OpenMV camera programming design, including the software used to program the camera and the design of the ultrasonic detectors.
3. Following that, Sheng Dian presented the chassis design and Chen Xi presented robotic arm design, including the materials used to build the chassis and the type of servos used in the robotic arm.
4. Sun Linhan, Guo Linhong and Liu Cehan discussed the communication approach used to integrate the different components of the system, including how sensor data was transmitted to the main controller and how the PCB main controller controled.
5. I and Chen Xi presented their mid-term report and mid-term notebook, which outlined the progress made so far and the plan for the remaining weeks.
6. Then Li Chenhao discussed future enhancements to the project, including finishing building the system and starting testing and creating a PCB for a stable connection between the components.

*Results:* The mid-term report and Mid-term notebook were completed and handled to the professor. After presentation, our team was on track to meet TDPS each patio’ goals and deliver a functional rover system.

*Conclusion and suggestions for future enhancement:* Overall, our team concluded the presentation by summarizing their progress and suggesting future experiments, including testing the system in different environments and conditions to ensure its accuracy and reliability. Also, future enhancements should also included finishing building the system and starting testing and creating a PCB for a stable connection between the components.

*Recorded by:* Gu Xingci and others

**Fourth group meeting**

*Date:*Wednesday, 29 March 2023, 15:00 PM-16: 05 PM

*Title***:** Review our progress over the past week and discuss plans for system improvement.

*Purpose:* Discussed the next phase of improvement, and handed over the PCB assignments to the PCB group and determined the missing documents of the prior pre to submit to Teams.

*Procedures:*

1. The meeting began with a review of progress made during the last week, including improvements to the OpenMV camera, ultrasonic detector, and chassis design, as well as progress on the mid-term report and notebook.
2. The team then discussed plans for the next phase of improvement, focusing on the integration and testing of the various modules.
3. PCB assignments were handed over to the relevant team, with an emphasis on ensuring proper integration and group communication.
4. The team identified missing documents from the previous phase that needed to be submitted to Teams, and assigned tasks to address these issues.

*Results:* PCB assignments were successfully handed over to the relevant team, with clear instructions on integration and communication. Missing documents from the previous phase were identified and assigned for completion.

*Conclusion and suggestions for future enhancement:* The team concluded the meeting by emphasizing the importance of proper documentation and communication throughout the project. Suggestions were made for future experiments, including testing and optimizing the various modules to ensure maximum performance.

*Recorded by:* Gu Xingci and others

**Sixth week day-to-day progress：**

*Purpose:* Modules integration, and completed missing charts

*Date:*Friday, 31 March 2023.

*Title****:*** Modules Integration and main design for PCB controller

*Purpose:* To integrate the modules and develop the main design for the PCB controller.

*Procedures:*

1. They reviewed the modules to be integrated and identified any potential issues or challenges that may arise, and the main challenges lied in developing a main design for the PCB controller based on project requirements and using the main design to allocate specific tasks to team members.
2. They told me their first part of integration process, that they had designed the following components but still required to be taken into considerations:

STM32 G4 board – includes two rows of 2\*19 headers

STM32 H7 Core – contains two rows of 2\*22 pins

Distance detection\_Ultrasonic sensors - contains 3 1\*4 pins as the connection of three ultrasonic modules

ATK\_MS901M —- Includes 1 x 1\*6 pins

*Results:* Upon completion of the first integration process, they told me they needed to verify that all connections are accurate and functional. Any identified issues or challenges required be addressed promptly to ensure that the main design for the PCB controller was optimized for project requirements.

*Recorded by:* Gu Xingci, Sun Linhan and Guo Linhong

*Date:*Saturday, 1 Apill 2023.

*Title****:*** Completion of any missing charts for mid-term assessment

*Purpose:* To use design software to complete the Gantt chart and budget chart for the project.

*Procedures:*

1. I and Sun Linhan identified any missing charts required for the mid-term assessment, and discussed using which design software to create the missing Gantt chart and budget chart. Finally we choose to apply excel.
2. After collected each team members’ components price and their time table, the charts were created and we also verified the charts for accuracy and completeness.

*Results:* Missing charts were completed, verified for accuracy and submitted on Teams channel.

*Recorded by:* Gu Xingci and Sun Linhan.

*Conclusion and suggestions for future enhancement:* Progress was made on the PCB modules, with a focus on integration and communication and the missing charts were also handed out. Issues that arose during the implementation of the PCB connections were identified and required to be future addressed.

**Fifth group meeting**

*Date:*Friday, 8 Apill 2023, 16: 00 PM-17: 05 PM

*Title***:** Fifth group meeting and each parts’ enhancement

*Purpose:* Discussed the PCB design progress, and OpenMv required future enhancement. Ultrasonic sensors still had issues, and 3D model was discussed to stabilize robotic arm.

*Procedures:*

1. The meeting began with a review of progress made during the last week, Sun Linhan and Guo Linhong (the PCB team) said that they focused on integrating modules and developing the main design for the PCB controller based on project requirements, identifying potential issues and challenges along the way. Also, Sun Linhan and I (the graphing team) said that completed missing charts for the mid-term assessment, by using Excel to create the Gantt chart and budget chart, upon collection of team members' components prices and timetables.
2. Yang Chun and Yuan Ye, the OpenMv group members, reported that they would be responsible for completing Task 3 for Patio 1, which involves implementing the rover's turning function. Meanwhile, Chen Xi, who was in charge of the ultrasonic detection design discussed the ongoing issues with the ultrasonic sensors and his plans to focus on distance measurement Navigation and aligning to the fence.
3. To enhance the stability and efficiency of the robotic arm, Sheng Dian, responsible for the chassis, and Chen Xi, responsible for the robotic arm and ultrasonic sensor fixation, provided a 3D model and CAD schematic for the fixation. This model is expected to address the issues faced by the team with regards to the robotic arm's stability and efficiency.

*Results:* Our team discussed the progress made in each area and identified areas requiring further attention.

*Conclusion and suggestions for future enhancement:* In conclusion, it was recommended that the team continues to focus on resolving issues with the ultrasonic sensors and improving the stability and efficiency of the robotic arm. Effective communication and collaboration among team members required to be prioritized to ensure that all tasks were completed on time and to the highest possible standard, Additionally, I also suggested that the team conducted regular progress reviews to identify any potential issues early on and addressed them promptly.

*Recorded by:* Gu Xingci and others

**Eighth week day-to-day progress：**

*Purpose:* Modules integration and improvement

*Date:*Tuesday, 11 Apill 2023.

*Title****:*** Arrow recognition implement based on OpenMv camera

*Purpose:* To test the OpenMv's ability to recognize arrows based on machine learning algorithm.

1. To perform the test, Yang Chun and Yuan Ye from the OpenMV team first used serial communication to link the data with the chassis. After the chassis completed the turning task in Patio 1's Task 3, the OpenMV camera on the car was used to perform the Patio 2’s Task 1 for arrow recognition.
2. As for recognition, Yang Chun decided to use the FOMO machine learning algorithm for this task due to its lightweight nature, which was a machine learning algorithm that can be used for image classification and is particularly well-suited for embedded systems due to its low memory requirements.

*Results:* The results of the arrow recognition implement were not completed, and it was unclear how well the OpenMV platform performed. However, this test was likely an important step in the development of the OpenMV platform, as it would have provided valuable data on the algorithm's performance in a real-world scenario.

*Recorded by:* Gu Xingci, Yang Chun and Yuan Ye

*Date:*Wednesday, 12 Apill 2023.

*Title****:*** PCB design progress update

*Purpose:* To provide an update on the progress of the PCB design team and their work on determining the necessary pin headers and wiring for other modules.

*Procedures:*

1. Sun Linhan and Guo Linhong from the PCB design team continued to make progress on their work. They said that they were able to determine the necessary pin headers and wiring for other modules.
2. They told me their second part of integration process, which they had designed the following components:

Road recognition: This module included a 6-pin push button switch that serves as the reset button for both the STM32 G4 board and the STM32 H7 Core. When the switch was pressed, it was connected to ground and triggers a reset. It also included a 1x4 pin header for connecting to the OpenMV module.

Controlling: This module included three 1x3 pin headers.

Motor driver: This module included two 1x14 pin headers.

Connection parts: This module included a 2-layer USB port for power input and a 2-pin terminal block for connecting to the battery power supply.

Communication: This module included a 1x5 pin header.

*Results:* The progress made by Sun Linhan and Guo Linhong on determining the necessary pin headers and wiring for other modules was a significant step forward in the development of the PCB design, which would be crucial in ensuring that the different modules was able to communicate effectively with each other and function as a cohesive system.

*Recorded by:* Gu Xingci, Sun Linhan and Guo Linhong.

*Date:*Thursday, 13 Apill 2023.

*Title****:*** Robotic arm iteration

*Purpose:* To provide an update on the second iteration of the robotic arm, which had been modified to address issues identified in the initial version.

*Procedures:*

1. Chen Xi was responsible for the second iteration of the robotic arm, which was intended to be modified to address the issues identified during the mid-term assessment.
2. The new framework for the robotic arm he told me was as follows, when the car arrived in front of the garbage can, the main controller (STM32) would enable the arm with a PWM signal, causing it to rotate 180 degrees from its initial position. This allowed the ball to be dropped vertically into the box directly below the opening. The servo and arm on the car would be raised on a platform to ensure that their height is higher than the box, ensuring that the ball will definitely fall into the box.

*Results:* The modifications made to the robotic arm by Chen Xi represented an improvement over the initial version. By addressing the issues identified during the mid-term assessment, a more effective and reliable system was needed for collecting garbage. The use of a platform to raise the height of the servo and arm ensured that the ball will always fall into the box, improving the accuracy and efficiency of the system.

*Recorded by:* Gu Xingci and Chen Xi

*Conclusion and suggestions for future enhancement:* The progress made by the OpenMV, PCB design, and robotic arm teams was promising, with each group still in progress in completing their assigned tasks. The use of a lightweight machine learning FOMO algorithm for preliminary arrow recognition and the revisions made to the robotic arm framework were positive steps forward in the development of the project. However, to ensure effective integration of all modules, the teams would improve communication and carry out regular testing and debugging sessions.

**Sixth group meeting**

*Date:*Tuesday, 18 Apill 2023, 11: 00 AM-12: 05 AM

*Title***:** Sixth group meeting and each parts’ enhancement

*Purpose:* To discuss the progress of each group and identify areas for improvement in the project.

*Procedures:*

1. After the Tomb Sweeping Day, the meeting began with a review of progress made during the last week. The OpenMV team, led by Yang Chun and Yuan Ye, reported that they had successfully used serial port communication to link data with the chassis for patio1 task3. They had also decided to use a lightweight machine learning FOMO algorithm for preliminary arrow recognition.
2. Following that, the PCB design team, led by Sun Linhan and Guo Linhong, reported that they had identified the pin headers and wiring methods needed for other modules.
3. Then Chen Xi, who was in charge of the second iteration of the robotic arm, reported that he had revised the general flow of the arm and adopted a new framework. The arm would now rotated 180 degrees from its initial position when the rover arrived in front of the trash can. The servo and robotic arm on the rover would be raised on a platform to ensure that the ball would always fall into the frame directly.
4. Sheng Dian, who was responsible for chassis, also reported the interfacing part with Yang Chun and Yuan Ye's OpenMV camera, which used serial communication. And our chassis applied UART communication, to receive the information sent by the host computer, consisting of 10 bits, segmented by 3,3,4, where the first bit of each segment was the sign bit, 1 for reverse, 2 for forward represents the forward direction.
5. Liu Cehan was in charge of the time and communication part, which also showed that he was now completing the last part of the communication, when the cart reached the designated position, it would transmit the data through HC-12 to the outside via radio waves, and when another HC-12 connected to the computer received the data, it would display that data through the computer screen.

*Results:* The OpenMV team successfully linked data with the chassis for patio1 task3 using serial port communication and adopted a framework for preliminary arrow recognition. The PCB design team identified the pin headers and wiring methods for other modules. Chen Xi revised the flow of the robotic arm, and Sheng Dian reported the interfacing with the OpenMV camera team's camera. Li ChenHao was intended to complete the last part of communication.

*Conclusion and suggestions for future enhancement:* Our team's progress is commendable, collaborating and communicating effectively is a positive development towards completing the project successfully and within the stipulated time frame. However, implementing automated testing and debugging procedures were still required. Using machine learning algorithms to do sensors for arrow identified also were required to be improve. And the communication parts were required to be final improved.

*Recorded by:* Gu Xingci and others

**Ninth week day-to-day progress：**

*Purpose:* Modules integration and improvement

*Date:*Friday, 21 Apill 2023.

*Title:* Arrow identification using FOMO algorithm

*Purpose:* To identify arrows using the FOMO algorithm and evaluate its performance

*Procedures:*

1. To begin, they told me that the MobileNetV2 architecture was used as a base network for the FOMO algorithm. The FOMO algorithm then truncated the MobileNetV2 architecture to obtain an 8x8 feature map with c channels representing each classification.
2. And the next steps they told me that the feature map was traversed to identify coordinates with a confidence above the set threshold. These coordinates were then mapped back to the original image using the same scaling factor. Since the truncated feature map could not accurately reflect the bounding box coordinates, FOMO only outputted the geometric center of the key feature map to achieve simple object detection.
3. However, to balance target resolution and frame rate over long distances, we chose to use a resolution of 128x128 and int8 quantization to reduce the model's memory usage.

*Results:* The FOMO algorithm achieved 92.7% F1 score and 100% precision on the test set, indicating that it is an effective algorithm for arrow identification.

*Recorded by:* Gu Xingci, Yang Chun and Yuan Ye

*Date:*Saturday, 22 Apill 2023.

*Title****:*** Completed PCB design for a system with servo motors

*Purpose:* To complete the task of designing a PCB using Altium Designer (21.0.9) for a system with servo motors.

*Procedures:*

1. To begin, they told me that the PCB was designed using Altium Designer (21.0.9) and divided into multiple areas. The connection method between different modules in different areas was placed on the GitHub PCB section.
2. Then the functioning part included that power input was set to +5V, and the module GND was used as the ground. The signal lines on the PCB were 10mil wide, power lines were 30mil wide, and ground lines were 20mil wide. The power line was able to handle up to 2A of current, according to the relationship between the line width and current, and was chosen to be 30mil wide. However, the ground line was not directly connected but is covered by the copper on the PCB.
3. The completed PCB had a top and bottom layer, connected by vias. The board layout was planned with a mechanical layer, and the silk layer provided information text on the PCB surface. The PCB had many through-holes to fix the board, with a diameter of 24mil and a hole size of 12mil. The board also had four large through-holes, 10cm apart, to fix mechanical parts to the rover, with a diameter of 4mm and a hole size of 3mm.

*Results:* The PCB was successfully designed and underwent DRC (Design Rule Check) before being produced.

*Recorded by:* Gu Xingci, Sun Linhan and Guo Linhong.

*Date:*Sunday, 23 Apill 2023.

*Title:* Wireless Data Transmission with HC-12 and DS3231

*Purpose:* To transmit data wirelessly using the HC-12 module and DS3231 real-time clock and display it on a computer screen.

*Procedures:*

1. He first said to me that the whole system would start functioninf when the OpenMV camera detects a specific location, it sent a request to the main controller to transmit data. The main controller interrupted the program and read the time information from the DS3231 real-time clock module's register through the I2C protocol and put it in a buffer. Then, the data was communicated with the HC-12 module using UART.
2. The sending step included that OpenMV sent request to main controller, which readed time info from DS3231 and communicates with HC-12. HC-12 on rover receives data and sends out at 433MHz.
3. Then he told me the receiving part would end with when paired HC-12 on computer read and output to screen via serial port. In his design, DS3231 provided accuracy and low power consumption, and HC-12 ensured reliable communication.

*Results:* Wireless data transmission with HC-12 and DS3231 was successful, demonstrating feasibility of using these modules.

*Recorded by:* Gu Xingci and Liu Cehan

*Conclusion and suggestions for future enhancement:* The FOMO algorithm successfully identified arrows with high accuracy, using MobileNetV2 architecture, int8 quantization, and a resolution of 128x128. The PCB design was completed for a system with servo motors used Altium Designer (21.0.9) and careful consideration of line widths, power, and ground lines. The wireless data transmission system using HC-12 and DS3231 successfully transmitted data wirelessly and displayed it on a computer screen. Future work could involve optimizing the threshold for confidence levels to improve the FOMO algorithm's accuracy. In the PCB design, additional components could be added to improve the system's performance.

**Seventh group meeting**

*Date:*Friday, 28 Apill 2023, 13: 00 PM-14: 15 PM

*Title***:** Seventh group meeting and mid-term exams.

*Purpose:* To present each group’s updates on their recent project work and discuss the plan for future work, considering the midterm exams.

*Procedures:*

1. First, Yang Chun and Yuan Ye, who were in OpenMV team, said that they had developed an algorithm using the FOMO algorithm to identify arrows with high accuracy, and they chose a resolution of 128x128 and int8 quantization to balance target arrows identification’s resolution and frame rate over long distances.
2. Then the PCB team, including Sun Linhan and Guo Linhong, said that the PCB was divided into multiple areas with the connection method between different modules in different areas placed on the GitHub PCB section. The signal lines on the PCB were 10mil wide, power lines were 30mil wide, and ground lines were 20mil wide. The completed PCB underwent DRC (Design Rule Check) before being produced.
3. Liu Cehan told us that he developed a wireless data transmission system using the HC-12 module and DS3231 real-time clock, which successfully transmitted data wirelessly and displayed it on a computer screen.
4. Then Chen Xi and Sun Linhan said that they were in progress to 3D-print the components for each part of the rover to be assemble as a functional rover and packaged all single part to the whole rover.
5. Finally, our team reviewed the progress made so far and decided to halt rover-related reports due to the midterm exam. And we scheduled the next group meeting and field operation after the mid-term exam and agreed that each member would improve their respective parts during this time.

*Results:* Our team all agreed to focus on studying for the mid-term exam and temporarily halt rover-related reports. During the group meeting, our team members presented updates on their recent project work, including an algorithm developed by the camera team using the FOMO algorithm to identify arrows with high accuracy, a completed PCB design for a system with servo motors, a wireless data transmission system using the HC-12 module and DS3231 real-time clock, and the whole system assembling.

*Conclusion and suggestions for future enhancement:* Our team prioritized studying for the midterm exam and decided to resume rover-related work after the exam. At the same time, all the team members agreed to use the time before the next meeting and field operation to improve their respective parts. In the future, our team could consider setting up a study schedule to balance academic work and project work. They could also discuss the possibility of incorporating the algorithm, PCB, and wireless data transmission system into the rover assembly part and plan for field testing.

*Recorded by:* Gu Xingci and others

**Eighth group meeting**

*Date:*Thursday, 18 May 2023, 16: 00 PM-18: 15 PM

*Title***:** Eighth group meeting and future field operation.

*Purpose:* To continue the team's progress after the midterm exam and plan for the upcoming field operation.

*Procedures:*

1. Our team reviewed the progress made since the last meeting and discussed the next steps towards completing the rover project. We also planned for the upcoming field operation, which involved assigning roles and responsibilities for each team member. The team members discussed the tasks that needed to be completed before the field operation, such as finalizing the rover's design, ensuring that all components were working correctly, and making any necessary adjustments.
2. Chen Xi and Sun Linhan reported that they had successfully 3D-printed various components for the rover, including the ultrasonic sensors module and OpenMV camera mount, as well as the servo motor brackets for the robotic arm. However, they noted that these were still initial versions and would require further testing during the next field operation.
3. Our team discussed the importance of testing the assembled components to ensure they were sturdy and compatible with other parts of the rover. Sun Linhan also discussed the potential for making further improvements and adjustments to the 3D-printed components based on the results of the field operation. After the field operation, each part of the rover should have the improvement to ensure the stability, also the next work about presentation and final report should also start after testing over.

*Results:* During the meeting, our team reviewed progress and planned for the upcoming field operation. Chen Xi and Sun Linhan reported successful 3D-printing of various rover components, but noted that these were still initial versions and would require further testing during the field operation. The team discussed the importance of testing and making necessary adjustments to ensure the components were sturdy and compatible.

*Conclusion and suggestions for future enhancement:* Our team prioritized testing and making necessary adjustments to the rover components. We should also consider potential areas for improvement based on the results of the field operation. The team members should continue to communicate effectively and future meetings should focus on progress updates, task assignments, and planning for more field operations to ensure the timely completion of the rover project.

*Recorded by:* Gu Xingci and others

**Fourteenth week day-to-day progress：**

*Purpose:* Field operations and modules improvement

*Date:*Monday, 22 May 2023.

*Title:* Testing 3D-printed outer shell for rover

*Purpose:* To verify the stability of the ultrasonic fixing module and the fixed stability of the OpenMV camera.

*Procedures:*

1. Sun Linhan and Chen Xi began by verifying the stability of the ultrasonic sensor’s fixing module on both sides of the rover. The module was responsible for aligning the car with the side, and needed two parallel ultrasonic module fixings to ensure accurate alignment. They found that the ultrasonic sensors module still needed to be secured to prevent it from popping out. To address this issue, They said they would added and 3D-printed additional support to the module and retest its stability.
2. Next, Sun Linhan and Chen Xi verified the fixed stability of the OpenMV camera, which was used to identify the road surface and patrol the line in front of the car. To control its angle, they added a hanging plate on the third layer of the rover. However, during previous tests, we found that the plate was not fixed securely enough, causing the camera to move and affecting its accuracy. To address this issue, they would reprint the plate and make any necessary adjustments to ensure the camera is fixed securely.

*Results:* They assessed the quality of the 3D printing and identified defects and irregularities that had affected the performance of the outer shell, including adding 3D-printed additional support to the ultrasonic sensor and fixing the stability of the camera module. They aimed to reprint the and performance of the rover's outer shell and improve its capabilities for future missions.

*Recorded by:* Gu Xingci, Sun Linhan and Chen Xi

*Date:*Tuesday, 23 May 2023.

*Title:* Testing Rover's Performance on Gravel Road

*Purpose:* To access the wheels' ability to navigate the gravel road and the camera's ability to detect the road surface and identify the forward way.

*Procedures:*

1. Chen Xi began by testing the accuracy of the OpenMv Camera and wheels on the gravel road. He discovered that while completing the task of Patio1 Task2, the McNum wheels were prone to slip when the camera sent data to the wheels. Changing the wheel speed did not solve the problem, and he suspected that the McNum wheels algorithm had a problem on the oblique plane and gravel road.
2. When Sheng Dian came over, he also found that the McNum wheels were more suitable for smoothing the road, and there was no problem with active alignment on flat ground. But the rover would get stuck on the gravel road, and this was important to transmit back the road surface edge detection data identified by the camera, and the wayfinding on the gravel road accounts for a large part. After discussion, finally, Sheng Dian decided to replace the chassis module drive wheels with tracked types and make certain modifications to its PID algorithm.

*Results:* We found that the McNum wheels were not suitable for navigating the gravel road and often slipped, making it difficult for the camera to accurately detect the road surface and identify the way forward. Sheng Dian is responsible for replacing the Chassis module drive wheels with tracked ones and making modifications to the PID algorithm.

*Recorded by:* Gu Xingci, Chen Xi and Sheng Dian.

*Date:*Wednesday, 24 Apill 2023.

*Title:* Upgrading Rover's Wheels to Tracked Type

*Purpose:* To improve the stability and maneuverability of the rover on rough terrain by replacing the McNum wheels with tracked ones.

*Procedures:*

1. In the previous field test, our group discovered that the line patrol part was mainly caused by wheel's type, to solve the problem of Rover's stable operation on gravel road, Sheng Dian made timely adjustments to the receiving signal logic processing of wheels and chassis
2. He told me that the advantages of choosing the tracked type were mainly due to high stability, and the track chassis provides excellent stability, especially in the presence of uneven terrain or slopes.
3. Also, the tracked chassis was adept at navigating difficult terrain, including rough, uneven or slippery surfaces. The crawler system distributed the ᯿ᰁ of the vehicle over a larger contact surface, providing better traction and reducing the likelihood of being trapped
4. Then he said to me that he had improved the main technical part, the basic motor control was to adjust the duty cycle by a PWM output, so as to adjust the output size to control the motor speed. Besides, he adjusted the potential level of the two digital pins to control the direction of rotation of the motor.
5. Secondly, the other technical parts were that the UART serial port communication was carried out from the main control (G474) through its own protocol, and the speed and direction of the track were controlled by the received information (G474 publishes the actual speed of the left and right motors).

*Results:* After finding that the upgraded tracked wheels significantly improved the stability and maneuverability of the rover on rough terrain, Sheng Dian made modification to the receiving signal logic processing of the wheels and chassis to perform effectively in ensuring smooth and accurate communication between the components. Then the rover was able to navigate difficult terrain with greater ease and accuracy.

*Recorded by:* Gu Xingci and Sheng Dian

*Date:*Thursday, 25 Apill 2023.

*Title:* Addressing New Issues with Upgraded Tracked Rover

*Purpose:*

*Procedures:*

1. Sun Linhan first used the upgraded tracked rover, which was modified by Sheng Dian in the previous experiment, to carry out three tasks in Patio1 and Patio2. During the edge traversal, he found that the sensor readings were abnormal when the sensor was too close to the railing. Sun Linhan plans to set a program to maintain a safe distance from the railing. Additionally, during Patio1 Task2, he found that the rover was tipping when entering a downhill slope and proposed a solution of adding additional weight to the rover.
2. Sheng Dian then conducted tests on the rover's tracking system and found that the linear mapping was not functioning correctly. To address this issue, he opened a new PID process, but further optimization and adjustments are required. The same issue of instability was also observed in certain areas where the rover was unable to recognize its surroundings.
3. Finally, Liu Cehan, who is in charge of the ultrasonic sensor module, also noticed that the module was producing strange interference data. He plans to address this issue by modifying the algorithm in the evening.

*Results:* The results of this experiment were recorded by Gu Xingci, Sun Linhan, Liu Cehan, and Sheng Dian. We found several issues with the upgraded tracked rover, including abnormal sensor readings, instability, and ultrasonic sensor module interference. Proposed solutions include setting a program to maintain a safe distance from the railing, adding additional weight to the rover, optimizing the linear mapping of the tracking system, and modifying the algorithm of the ultrasonic sensor module. These findings will inform future modifications to the rover's design to enhance its capabilities for future missions.

*Recorded by:* Gu Xingci, Sun Linhan Liu Cehan and Sheng Dian

*Conclusion and suggestions for future enhancement:* Through a series of experiments, we have identified several issues with the rover's design and performance on different terrains. We have made several modifications and upgrades to the design, including 3D-printed additional support for the ultrasonic sensor, fixing the stability of the camera module, replacing the McNum wheels with tracked ones, and making modifications to the receiving signal logic processing of the wheels and chassis. While some issues have been resolved, others require further optimization and adjustments. Future enhancements to the rover's design should focus on improving its stability and maneuverability on rough terrain, as well as addressing issues with sensor readings and data interference. Upgrades could include the use of more advanced sensors and algorithms to improve the rover's ability to recognize its surroundings and navigate challenging terrain. Additionally, further testing and optimization of the rover's components and systems should be conducted to ensure optimal performance. Overall, continued research and development will be necessary to improve the capabilities of the rover for future missions.

**Ninth group meeting**

*Date:*Sunday, 28 May 2023, 14: 00 PM-16: 15 PM

*Title***:** Ninth group meeting and preparation for final demonstration

*Purpose:* To address new issues that arose after the upgrade to the tracked rover and make necessary modifications and adjustments.

*Procedures:*

1. un Linhan tested the upgraded tracked rover and found abnormal sensor readings when the sensor was too close to the railing during edge traversal. He suggested setting a program to maintain a safe distance from the railing. He also found that the rover was tipping when entering a downhill slope during Patio1 Task2 and proposed adding additional weight to the rover.
2. Sheng Dian conducted tests on the rover's tracking system and found that the linear mapping was not functioning correctly. He opened a new PID process to address the issue, but further optimization and adjustments are required. He also observed instability in certain areas where the rover was unable to recognize its surroundings.
3. Liu Cehan noticed that the ultrasonic sensor module was producing strange interference data. He planned to address this issue by modifying the algorithm in the evening.

*Results:* The team identified new issues with the upgraded tracked rover, including abnormal sensor readings and instability in certain areas. They proposed solutions such as adding weight to the rover and modifying the algorithm for the ultrasonic sensor module. Further optimization and adjustments are necessary to ensure optimal performance.

*Conclusion and suggestions for future enhancement:* The team identified several issues with the upgraded tracked rover and proposed solutions to address them. Future enhancements could focus on improving the rover's ability to recognize its surroundings and navigate challenging terrain, as well as addressing issues with sensor readings and data interference. Continued research and development will be necessary to improve the capabilities of the rover for future missions.

*Recorded by:* Gu Xingci and others