**Team Butterfly (ELEC330) – *Group 5 Logbook – Assignment 3***

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| Student Names  /Attendees: | 1. Mesa Giner, Alvaro | 2. Tladi, Gideon Omaatla Pako | 3. Wang, Yanzhang |
|  | 4. Wang, Yifan | 5. Wu, Zijin | 6. Xiao, Junyang |

**Week 1**

**Date:** Wednesday, 29th January 2025

**Notes:**

* We had a team meeting to review progress and create a project plan for Assignment 3.
* Tasks were distributed as follows:
  + Stabilising the butterfly’s orientation when stationary (W1 - 3) = Junyang, Yifan
  + Basic Butterfly Movement (W1 - 2) = Yanzhang, Zijin
    - Tele-op keyboard (manual operation)
  + Generate a map of the environment & saving it (W1 - 3) = Alvaro & Gideon
    - Use ROS to broadcast sensor data
  + Demonstrate Object Recognition (W3 - 5)
    - Interface with sensors (Semester 1)
    - Identify one target object
  + Autonomous navigation and flight (W4)
    - Movement
      * Drone-like or submarine-like movement (buoyancy plugins and such)
      * Butterfly flapping wings
    - Target object and safely land on it.
  + Project Plan Update = W4
  + Project Plan Update = W7
  + Fully Functional Robot Simulation (W10)
  + Bench Inspection (W12)
    - Practice (W11)
  + Report Writing and Submission (Easter - W12)
    - Prepare a Bill of Materials
    - GitHub documentation (ReadMe files, etc)
    - Upload report and all code and maps

**Week 2**

**Date:** Monday, 3rd February 2025

* Gideon & Alvaro
  + Worked together from 2 pm – 5 pm.
  + Slowly reviewed the env\_ws.sdf, butterfly.sdf, and butterfly.urdf files to identify bugs in the code to correct in future sessions.

**Date:** Tuesday, 4rd February 2025

* Yanzhang

Result:

* + Try to use the existing SLAM [**turtlebot3**](https://github.com/ROBOTIS-GIT/turtlebot3) library ([ROBOTIS-GIT/turtlebot3: ROS packages for Turtlebot3](https://github.com/ROBOTIS-GIT/turtlebot3)) in combination with our project.

Problem:

* + It was found that the traditional “gmapping” and “cartographer” packages are mainly designed for wheeled robots and are not suitable for flying bionic robots.
  + During the test of the SLAM Toolbox, it was discovered that the balance control of the butterfly was difficult, and the frequent changes in posture led to the failure of feature point matching.

Future work:

* + Take research on how to stabilize the flight posture of bionic butterflies and reduce the impact of vibrations on SLAM
  + Search for suitable SLAM algorithms for flying robots or modify existing algorithms to adapt to high dynamic environments

**Date:** Wednesday, 5th February 2025

* Gideon & Alvaro
  + Worked together from 9 am – 12 pm.
  + Tried adding a point cloud lidar function to our robot system.
  + Encountered errors while trying to develop a proper publisher-subscriber relationship.

**Week 3**

**Date:** Tuesday, 11th February 2025

* Yanzhang

Result:

* + Try to finish the integration of the existing IMU sensor with the butterfly model to get the attitude data.
  + A simple PID controller was designed to attempt to stabilize the flight posture of the butterfly.

Problem:

* + The IMU data noise exceeded expectations significantly, sometimes even causing instability in the control system.
  + The adjustment of PID parameters has been progressing slowly. After multiple attempts, an appropriate parameter combination could not be found.

Future work:

* + Consider redesigning the mechanical structure
  + Study more suitable attitude estimation methods for high dynamic environments

**Date:** Wednesday, 12th February 2025

* Gideon & Alvaro
  + Encountered a ROS2 Launch error: Missing Robot Tag. Worked on debugging the error during the lab session.

**Date: S**atursday, 15th February 2025

* Zijin
  + Studied flapping-wing aerodynamic models, explored the Gazebo Flapping-Wing plugin.
  + Researched both the official Velodyne plugin and the Ignition Sensors Hydra plugin, and attempted to use the latter to output PointCloud2 data in Gazebo.
* Junyang
  + Studied flapping-wing aerodynamic models, explored the Gazebo Flapping-Wing plugin.
  + Learn how to call and store 3D LiDAR point-cloud data with ROS 2 bags, and learn how to integrate it into the current butterflybot.

**Week 4**

**Date:** Monday, 17th February 2025 – Tuesday, 18th February

* Gideon & Alvaro
  + Worked individually at home, using Virtual Machines installed in USB drives.

**Date:** Wednesday, 19th February 2025

* Gideon & Alvaro
  + Experimented with adding an ultrasound sensor to our robot’s URDF instead of using LiDAR.

**Date:** Wednesday, 19th February 2025

* Junyang
  + Deepened understanding of ROS 2 launch mechanics: set environment variables so Gazebo loads model resources correctly, and configured ros\_gz\_bridge in the launch file to bridge
* Zijin
  + Studied and updated the simulation world file: switched the default physics engine to Bullet, added gravity settings, and consolidated the buoyancy plugin configuration with a unified fluid density and enabled target model.

**Week 5**

**Date:** Tuesday, 25th February 2025

* Yanzhang

Result:

* + Try to implement the Extended Kalman Filter (EKF) for processing IMU data
  + Using camera to attempt visual positioning assistance

Problem:

* + The EKF completely fails during rapid attitude changes, and the state estimation does not converge.
  + The computational load exceeds expectations, resulting in increased control delay and further deteriorating flight stability.

Future work:

* + Consider redesigning the mechanical structure

**Date:** Wednesday, 26th February 2025

* Gideon, Alvaro
  + Updated the links, joints and plugins for the lidar, camera and IMU sensor. Aimed to implement full sensor integration, and achieved better lidar functionality with fewer errors, though some persistent bugs still remained.
  + Teleoperation for basic movement was still challenging, so we reassessed the group’s week 1 plan for autonomous navigation.

**Week 6**

**Date:** Wednesday, 5th March 2025

* Gideon, Alvaro, Yifan
  + The lab instructors (C. Taqizade and A. Al-Irhayim) suggested our team could use propellors in our design. So we relayed the message to the rest of the team, then the three of us discussed in the lab and conducted basic research to get inspiration for crafting a new design.

**Date:** Sunday, 9th March 2025

* Yifan
  + Designed the new robot drone.
  + Uploaded all associated STL files to the group’s OneDrive.
* Junyang，Zijin
  + The team decided to abandon the flapping‐wing approach and switch directly to a quadrotor architecture, defining propeller placement and overall dimensions.

**Week 7**

**Date:** Wednesday, 12th March 2025

* Zijin, Junyang, Yanzhang
  + Exported the new butterfly CAD model from Solidworks to a URDF.
  + Studied and updated the simulation world file: added gravity settings, and consolidated the buoyancy plugin configuration with a unified fluid density and enabled target model.
* Gideon
  + My USB-based VirtualMachine kept crashing, so I installed Linux on my laptop (dualboot), with assistance from the instructor (C. Taqizade) during the lab session.

**Week 8**

**Date:** Wednesday, 19th March 2025

* Gideon
  + Encountered multiple bugs and errors whilst trying to use the new URDF file.

**Date:** Wednesday, 20th March 2025

* Zijin, Junyang
  + Modefied the launch.py file. Integrates the nodes for the sensor's connection and loading the environment file.
  + Resolved compilation errors caused by package name conflicts and missing paths when configuring gazebo\_ros\_pkgs dependencies, mastering colcon workspace debugging techniques.

**Week 9**

**Date:** Tuesday 25th March 2025

* Yanzhang

Result:

* + Finish the basic code of object recognition
  + Create the GitHub repository and invite other team members.
    - Uploaded the work of object recognition

Problems

* + Due to there is no camera sensor in the new model in the gazebo, my work cannot test on the gazebo to work with other tasks.

Future work

* + Integrating object recognition into the robot, the final output of rviz shows the recognition results.

**Date:** Wednesday, 26th March 2025

* Gideon
  + Updated the plugins in the env\_ws.sdf file.

**Date:** Tuesday 27th March 2025

* Zijin, Junyang
  + Integrated LiDAR and IMU sensors in the SDF file: defined sensor frames, positions, and update rates, mastering <sensor> plugin syntax and coordinate mapping.
  + Studied and attempted to integrate a 3D LiDAR (Velodyne) plugin, configured point-cloud topics and debugged the pipeline, but ultimately could not load the 3D LiDAR due to driver compatibility issues.

**Week 10**

**Date:** Wednesday, 2nd April 2025

* Bench Inspection Time – No Lab Session.

**Easter Break**

**Date:** Friday, 25th April 2025

* Gideon
  + Created a plan and WhatsApp poll to help distribute tasks among group members, with consideration of Bench Inspection in 2 weeks’ time.
    - Junyang and Zijin selected: Update sensor integration.
    - Gideon selected: Mapping
    - Yanzhang selected: Object recognition
    - Yifan and Alvaro selected: (Basic) Autonomous navigation

**Week 11**

**Date:** Wednesday 30th April 2025 (Morning)

* Gideon, Zijin, Junyang
  + Worked together to add sensors in new butterfly.sdf
  + We modified the path to open the STL file of the butterflybot and environment models.
  + The sensors include Lidar, IMU, and camera
  + Create and debug the launch file for the new model.
  + Now the launch.py could work.

**Problems encountered**

* + The interaction between the sensors and the Rviz still have some problems
  + The image from the camera and the result from the Lidar cannot be observed in Rviz

**Date:** Wednesday 30th April 2025 (Afternoon)

* Gideon
  + Organized the GitHub repository.
    - Uploaded the most up-to-date version of our code from today’s morning session.
  + Created a bash script (butterflybot.sh) to help save time when building and launching the simulation.

**Date**: Thursday 1st May 2025 (Afternoon)

* Yanzhang

Result:

* + Find and solve a few problems from Wednesday’s work. The reason is that the path of the sensor is wrong; it uses version 1’s path.

Problems:

* + The fixed frame of lidar is not right, it needs to be changed to fix it with version’2 robot.

**Date**: Friday 2nd May 2025 (Afternoon)

* Yanzhang

Result:

* + Finish the object recognition in the gazebo.

Problem:

* + Object recognition requires a stable camera perspective, but the jitter caused by the butterfly's flight results in blurry images and a sharp decline in recognition rate.
  + The model's inference speed is slow (about 0.5 fps), seriously affecting real-time performance.

Future work:

* + Try to use lightweight models (such as YOLOv8-nano) to improve the inference speed
* Alvaro:
* Solved some problem with the environment and robot density causing unprevented movement on the drone when spawned

**Date:** Saturday 3rd May 2025 (Morning/afternoon)

* Alvaro:
* Installation of ardupilot
* Correctly connection between ardupilot console and simplified gazebo environment and simplified drone (drone respond to the ardupilot commands but no visual connection with gazebo yet)
* Visual connection of gazebo and ardupilot established, simplified version of the drone plus hardware limitations results in a discard of this option (lack of time too).

**Date:** Sunday 3rd May 2025 (Morning/afternoon)

* Alvaro:
* Simplified autonomous movement idea: utilization of thrusters to produce drone movement. Despite the attempts, the implementation could not be fully completed do some need of extra polishing on the drone sdf that caused problems during the simulation.

**Week 12**

**Date:** Monday, 5th May 2025

* Gideon
  + Created a Linktree to enable easy access of our GitHub repo and other files we will need for bench inspection day.

**Date:** Tuesday, 6th May 2025

* Gideon
  + Created an outline and plan for how the team will present tomorrow during the bench inspection.
  + Created a good publisher-subscriber relationship for the lidar and camera on my backup copy. (No error messages being displayed.) However, the camera and lidar data still had some issues with showing clearly on RViz.
* Alvaro:
* Different autonomous fly attempts code scripts uploaded to GitHub.

**Date:** Wednesday, 7th May 2025

[Bench Inspection Day]

**Date:** Thursday, 8th May 2025

* Gideon
  + I copied the group’s PC workspace onto my SSD to make a backup of the groups work and to be able to work from home using the latest version of the code.

**Week 13 (Submission Week)**

**Date:** Tuesday, 13th May 2025

* Zijin, Junyang
  + Modified the angle of the camera and the Lidar to provide a more clearly image. The body of the butterflybot will not affect the image.
  + Try to figure out the errors on the Lidar. There still some errors in the connection between the Lidar and the Rviz. The scanning result could see from the gazebo but could not see from the rviz.
* Gideon
  + I created a template for the Assignment 3 report on behalf of the group and uploaded it to the group’s OneDrive.

**Date:** Wednesday, 14th May 2025

* Gideon
  + I thoroughly cleaned up and commented the code, taking extra care to substitute the full file paths for dynamic ones (e.g., replacing “home/butterfly/butterflybot/src/butterflybot/meshes/base\_link.stl” with the shorter “package://butterflybot/meshes/base\_link.stl”. This change ensured the file paths of the STL files referenced within the .sdf and .urdf files can be loaded up properly when launching the program.
  + I edited existing thruster topics in the .sdf file to match the topics included in the ros\_gz\_bridge arguments in the launch file. This served as a foundation for enabling basic propeller thrusting capabilities.
  + I updated the transform\_broadcaster.py file to include the correct versions of the transforms for the camera link, lidar link, and imu link.
  + After updating the transforms, I successfully visualised the Robot Model in RViz and Joint\_State\_Publisher\_GUI alongside. This was achieved by adding a joint\_state\_publisher\_gui node in the launch file and then adding the RViz display for RobotModel, ensuring that the /robot\_description topic is utilised to visualise the robot.
  + I added a TF display to Rviz and then saved the final configuration as butterflybot.rviz, for future work.

**Date:** Thursday, 15th May 2025

* Gideon
  + I successfully visualised the /lidar\_scan data in RViz.
  + Shortly after, I achieved the breakthrough of getting the mapping working by integrating the cartographer\_ros package. I created a butterflybot\_2d.lua file and added a cartographer\_ros node in the launch.py file to enable mapping. I also used a static lidar transform and static imu transform to assist with the visualisation process.

**Date:** Saturday, 17th May 2025

* Gideon
  + I ran basic mapping tests with a dynamic and static robot setup. I continued to log the work using screenshots and screencasts, as I had done in previous times throughout the project.
  + I created a basic template for the Executive Summary.

**Date:** Sunday, 18th May 2025

* Gideon
  + I sent out a reminder to the group to ensure everyone checks their work and adds any missing information before the work is submitted.
  + I updated any relevant files from the group’s OneDrive and Backup Folders to the GitHub repository for submission purposes.