Engineering Portfolio

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Social Force Model for Adaptive Cruise Control on 1/10 Scale Mobile Robot

Robotics Researcher

For my Applied Bachelor's Degree final project, I developed an Adaptive Cruise Control (ACC) system using a 1/10-scale Ackerman-steered mobile robot as the prototyping platform. The goal was to design an intelligent system capable of automatically adjusting vehicle speed to maintain a safe following distance in dynamic environments.

Technical Approach

- Social Force Model (SFM) was adapted from crowd simulation to estimate interaction forces between the robot and nearby objects, forming the basis for speed and direction adjustment.
- LiDAR and camera provided continuous distance sensing for real-time environment awareness.
- A Fuzzy Logic Controller dynamically tuned sensitivity based on environmental conditions.
- A PID controller regulated motor speed using PWM signals to track the target velocity generated by the SFM.
- The full system was implemented on ROS and deployed on an NVIDIA Jetson Nano for real-time computation.

Key Results

- Achieved 100% collision-free navigation across all test scenarios.
- Reached 62.7% performance in metrics such as ride smoothness and speed stability.
- Awarded 2nd Place in the 2025 PENS Final Project Competition.

Skills & Tools

Real-Time Control Systems · C++ · Python · ROS (Robot Operating System) · LiDAR–Camera Integration · Fuzzy Logic · PID Control · LaTeX · NVIDIA Jetson Nano

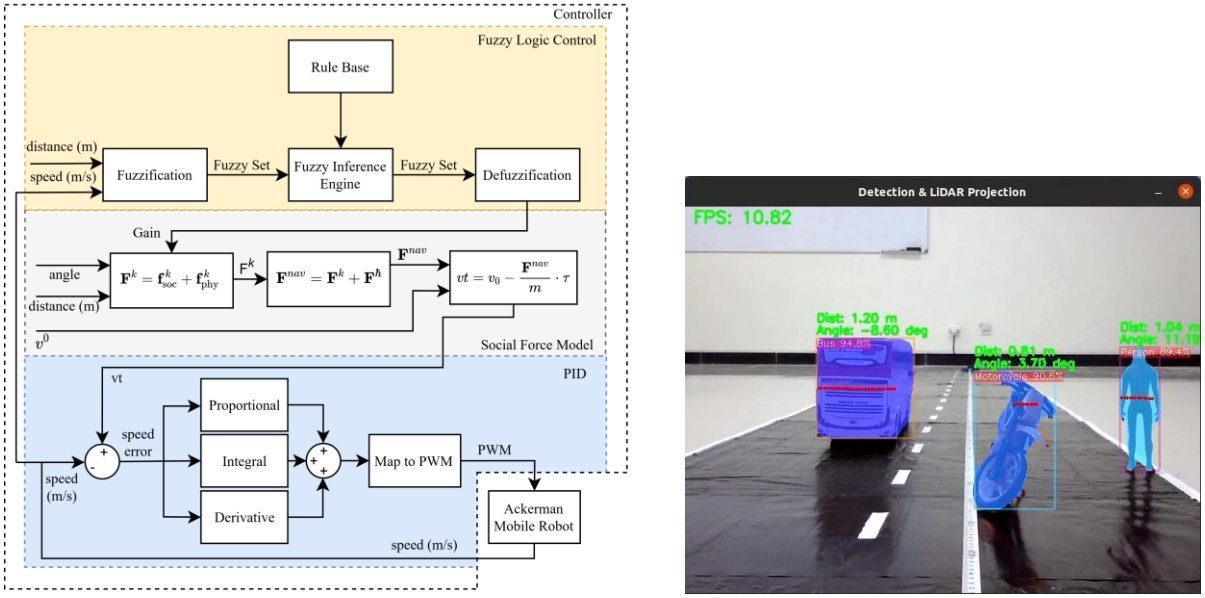

Figure 1 *Control Diagram and Object Detection*

Wearable Drone Control Interface & Semi-Autonomous Drone System V2

Technical Mentor

For our second year competing in the Singapore Amazing Flying Machine Competition, I served as the Technical Mentor, guiding the development of an upgraded wearable-based drone control system. The goal was to enhance control accuracy, responsiveness, and system reliability compared to the previous generation.

Technical Approach

- Provided hands-on mentoring in system design, hardware debugging, and software troubleshooting.
- Led the transition from a single-glove to a dual-glove control system, enabling more expressive and intuitive drone operation.
- Migrated the communication system from Wi-Fi to CRSF, significantly improving latency, signal stability, responsiveness, and overall user experience.

Key Results

The upgraded system delivered higher control precision, smoother operation, and increased robustness, contributing to the team's achievement of 2nd Place in the 2025 competition.

Skills & Tools

C Programming · Digital Electronics · Communication Protocols · Troubleshooting · Real-Time Operating Systems (RTOS)

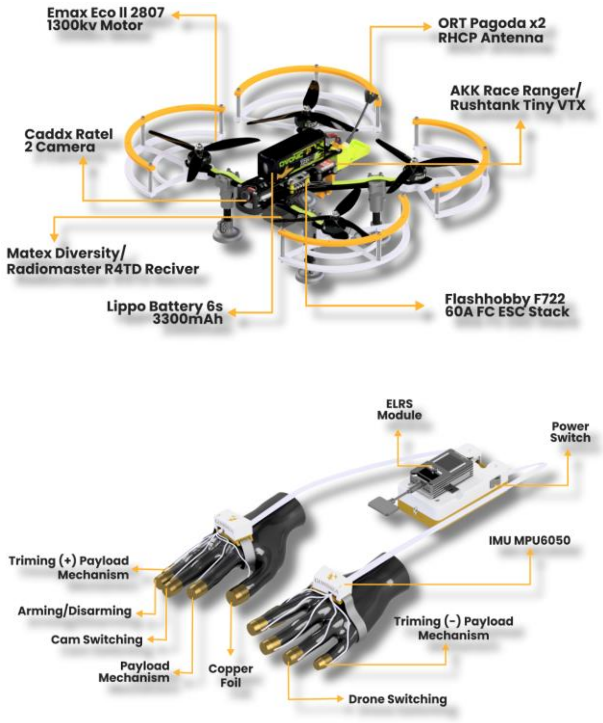

Figure 2 *Drone System and Wearable Device*

Wearable Drone Control Interface & Semi-Autonomous Drone System V1

Embedded System Engineer

For our first year participating in the Singapore Amazing Flying Machine Competition (SAFMC), I led the development of a glove-based drone control system designed to enable intuitive, gesture-based piloting. The goal was to explore creative human–drone interaction techniques through wearable technology.

Technical Approach

- Designed and developed a gesture-control glove powered by an ESP32 running FreeRTOS, enabling deterministic real-time task handling.
- Integrated IMU sensors to capture hand orientation and motion with high responsiveness.
- Implemented UDP communication over 2.4 GHz Wi-Fi for transmitting gesture data with minimal latency.
- Built a custom receiver module on the drone to decode control signals in real time, enabling direct mapping from hand movements to drone behavior.
- Engineered a fully functional semi-autonomous flight system combining embedded systems, wireless communication, and real-time processing.

Key Results

The wearable interface allowed the drone to be controlled through natural hand gestures and earned the team a Top 8 finish in the semifinal round, an exceptional result for our first year in the competition.

Skills & Tools

C Programming · Embedded Systems · Digital Electronics · Real-Time Operating Systems (RTOS) · Troubleshooting · Wireless Communication

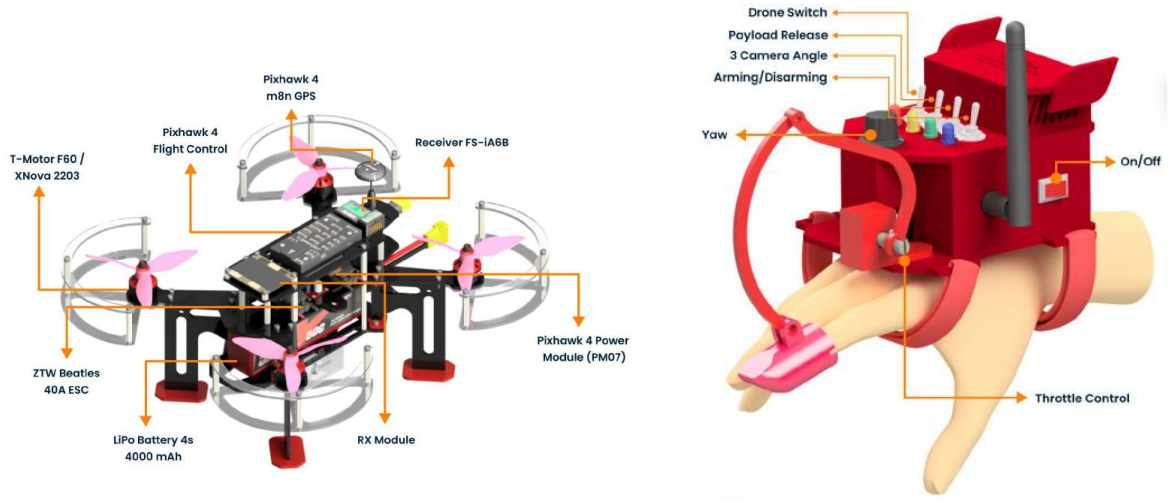

Figure 3 *Drone System and Wearable Device*

Factory Area Mapping & Topographical Survey

Photogrammetrist

As part of a freelance project with fellow researchers, our team conducted a high-precision topographical survey of a 7-hectare site using drone-based aerial mapping. I processed the aerial data in Agisoft Metashape to produce accurate terrain and elevation models. The goal was to provide PT VKTR with reliable geospatial insights for evaluating the site's suitability for future factory construction.

Technical Approach

- Executed autonomous drone flights to capture high-resolution aerial imagery across the entire survey area.
- Applied photogrammetry techniques to process imagery into a detailed 3D terrain model, including elevation contours, and surface characteristics.
- Performed terrain assessment to evaluate suitability for large-scale industrial construction.
- Delivered a comprehensive mapping report that highlighted major elevation inconsistencies and uneven terrain.

Key Results

The analysis revealed significant elevation challenges, leading PT VKTR to make an informed decision not to proceed with purchasing the land, preventing costly future construction issues.

Skills & Tools

Photogrammetry · Agisoft Metashape · Aerial Mapping · Terrain Analysis · Autonomous Drone Flight

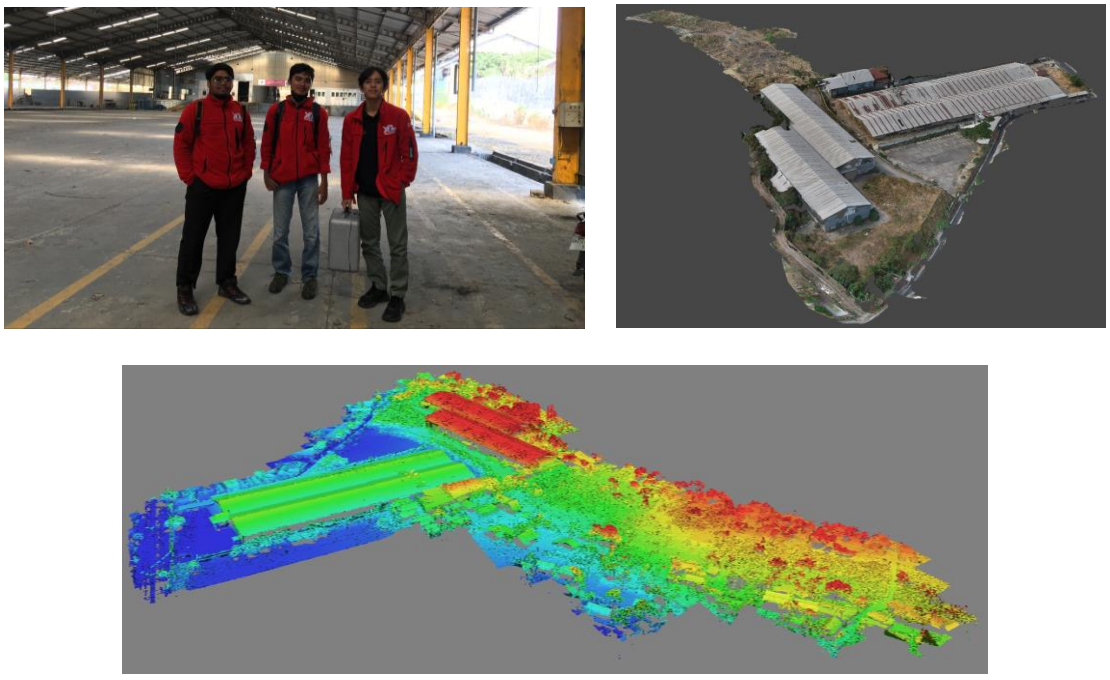

Figure 4 *Team Photo, 3D Map and, 3D Contours*

Autonomous Underwater Vehicle (AUV) for Underwater Cable Observation

Computer Vision Engineer

For the 2023 Kontes Robot Indonesia (KRI), which was the first time the underwater division was held, I developed an Autonomous Underwater Vehicle designed to detect and follow submerged cables using real time vision. The goal was to enable accurate underwater cable observation and following within a constrained and low visibility environment.

Technical Approach

- Implemented cable detection and tracking using OpenCV in C++, enabling real-time interpretation of underwater video feeds.
- Integrated system components using ROS for modular processing, communication, and control flow.
- Established MAVLink communication with a Pixhawk controller to execute autonomous navigation commands.
- Tuned vision and movement parameters through iterative pool testing, achieving stable autonomous behavior within two weeks.

Key Results

The AUV demonstrated reliable autonomous cable tracking and earned 2nd Place at the Regional level and 3rd Place at the National level in the 2023 KRI competition.

Skills & Tools

OpenCV · Image Processing · Computer Vision · C++ · Python · ROS · MAVLink

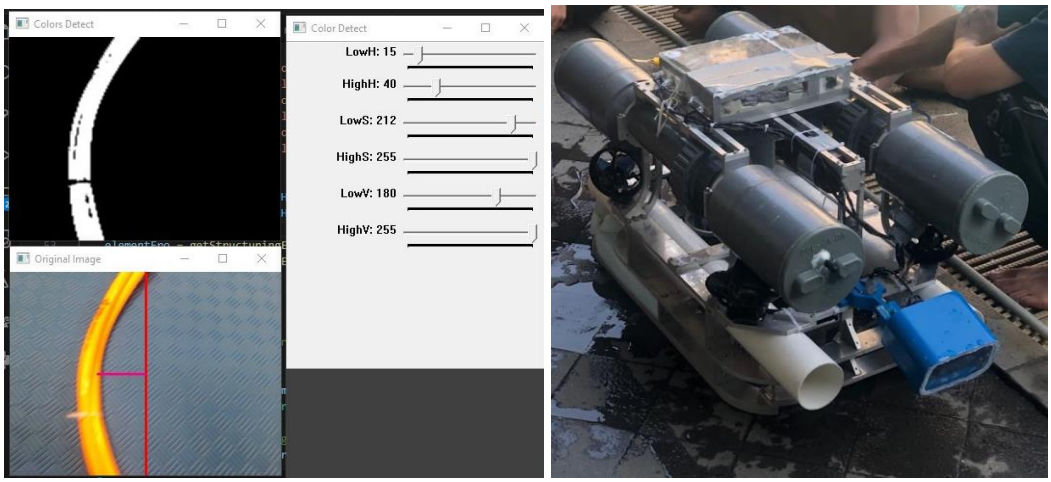

Figure 5 *Cable Detection Example and Underwater Robot*

PENSWae-V2 PM-2: Sporty Long-Range Electric Motorcycle for Delivery and Mobility

Fabrication and Assembly Support

For the PENSWae V2 PM 2 electric motorcycle project, I supported the manufacturing and assembly process to help my fellow researcher complete the prototype on time for an expo. The PM 2 is a mid drive electric motorcycle powered by a 2 kW BLDC motor and dual 60 volt LiFePO4 battery packs, delivering a top speed of 95 km per hour and a range of 150 km. The goal was to prepare a fully functional prototype that could be showcased as a long range electric mobility solution.

Technical Approach

- Assisted the manufacturing workflow, including material preparation and component pre-assembly
- Supported the mechanical team in positioning, aligning, and installing major parts
- Helped perform fit checks and basic functional verification during assembly

Key Results

The motorcycle was completed and prepared on time for exhibition. The PM 2 achieved twice the range of the PM 1 and demonstrated significant improvements in torque and design.

Skills and Tools

Manufacturing · Mechanical Assembly · Material Preparation · Team Coordination

Figure 6 *Manufacturing Process and Motorcycle Result*

Autonomous Fixed Wing UAV for Aerial Recovery System

Computer Vision Engineer

For our first year competing in TEKNOFEST, I contributed to the development of an autonomous fixed wing UAV designed for aerial recovery missions. The objective was to build a fully autonomous platform capable of detecting targets in real time and navigating the mission without manual intervention.

Technical Approach

- Developed the computer vision module using OpenCV in C++ on a Raspberry Pi 4
- Implemented real time object detection and tracking for in flight target identification
- Integrated the onboard computer with the flight controller using the MAVLink protocol
- Enabled autonomous navigation and mission logic through combined vision and flight control data

Key Results

The system successfully demonstrated autonomous aerial recovery behavior. Our proposal and mission video ranked 22nd globally, earning us a place as finalists in TEKNOFEST 2023.

Skills and Tools

Computer Vision · OpenCV · C++ · Python · Embedded Systems · MAVLink

Figure 7 *Team Photo at Airstrip and UAV System*

Electric Speed Controller (ESC) for Drones

Embedded System Engineer

This project began as an entry for a drone engineering competition, where I set out to design a high current ESC for custom UAV applications. When the competition was cancelled for the year, the work continued as a research project focused on improving reliability, real time motor response, and overall system robustness. The goal was to develop an ESC platform capable of delivering stable and efficient control for three phase BLDC motors.

Technical Approach

- Designed and implemented the ESC around the STM32F303 microcontroller, selected for its high speed ADC, and built in comparators
- Implemented motor commutation and control algorithms to ensure smooth torque output and rapid response to throttle changes
- Conducted testing and refinement to validate motor performance and system stability across a wide range of operating conditions

Key Results

The result was a functional ESC prototype capable of driving high current BLDC motors with precise real time throttle control. Although the original competition was cancelled, continuing the work allowed the system to mature into a reliable research platform for custom UAV propulsion.

Skills and Tools

Embedded Systems · C Programming · Motor Control · STM32 Microcontrollers · Power Electronics · Real Time Processing

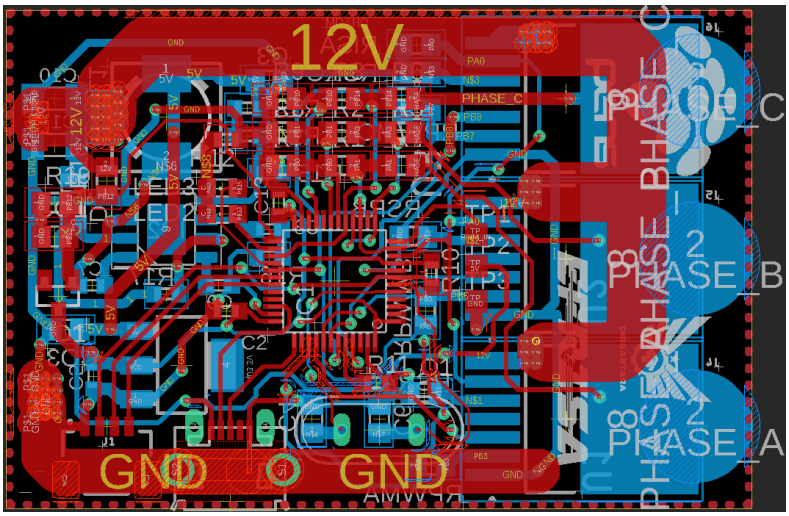

Figure 8 *ESC Board Wiring Design*

Attachments

Detailed documentation and extra projects can be accessed through these links:

Electric Speed Controller (ESC) for Drones

- https://drive.google.com/drive/folders/1CeyxUOB11F2GUsszi AnAMKKN41vSvy_k

Autonomous Fixed-Wing Unmanned Aerial Vehicle (UAV) for Aerial Recovery System

- https://drive.google.com/drive/folders/1e0Mt_0Tc8m4ebpO68XHEWResSZQr0_H9?usp=sharing
- https://youtu.be/sRoj_Ojju5A?si=E8w2d3Iy6WeQFTmp

Autonomous Underwater Vehicle (AUV) for Underwater Cable Observation

- https://drive.google.com/drive/folders/1egP3XHa4A7tuGCsW4NbjT9nP2zojleYM?usp=sharing

Autonomous Fixed-Wing Unmanned Aerial Vehicle (UAV) for Agriculture

- https://drive.google.com/drive/folders/1iWQoH_QWyVHmEnONGgTw0UZKeJcWx2IS?usp=sharing

Factory Area Mapping

- https://drive.google.com/drive/folders/1-tHYQLlDL0wtM6HIJ33oHoi9-5k1pGLa?usp=sharing

Wearable Device for Drone Control Interface & Semi-Autonomous Drone System V1 & V2

- https://drive.google.com/drive/folders/1KpLEQrpSvaeqcZ979_z0OIjf_rI4_0VG?usp=sharing

Adaptive Cruise Control System Based on Social Force Model

- https://drive.google.com/drive/folders/19H5bnIP1X17nwm1e5FTeIoksaILLXIeC?usp=sharing