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EDUCATION

Instituto Tecnologico y de Estudios Superiores de Monterrey ITESM *August 2017 – June 2023* **Monterrey, NL**
Bachelor of Science in Digital Systems and Robotics Engineering (Research and Innovation Modality) ***Academic Excellence***

Space Robotics Summer Program *July 2019 – August 2019* **Berlin, DE**
Learned fundamental topics of robotics and ROS at TU Berlin Aeronautics and Aerospace Faculty.

WORK EXPERIENCE

ZF Group Intern (VantTec Self-Driving Car Project) *July 2022 – September 2023* **Monterrey, NL**

Steering and braking system development

- **Electronic design:**

Designed a steering and braking control boards for an electric golf cart shuttle using STM32L431RC microcontrollers on KiCAD. Both the steering and braking modules share the same hardware design. Each module is implemented on a standalone circuit board, capable of connecting to two stepper motor drivers. Additionally, each board incorporates a MAX33040EAKA+T CAN transceiver, which facilitates communication between the STM32 microcontroller and external CAN-bus lines. Furthermore, I integrated connectors to interface with two CAN encoders, specifically the IFM RM8004 (steering wheel) and Briter BRT38 (brake pedal) models.

- **Embedded development:**

Programmed FreeRTOS tasks to manage stepper motor control and CAN communications. Created short library to parse CAN frames from the encoders to obtain the current position angle of the steering wheel or brake pedal. A short library was created to actuate the steering wheel or pedal brake steppers with an Xbox controller or via a desired angle (float) up until a saturation angle measured by the encoders.

Longitudinal and Lateral control development

- **Vehicle dynamics (embedded and ROS2 development):**

Research-oriented development and characterization of vehicle dynamics based on a bicycle model for the electric car. Conducted comprehensive experiments in a parking lot to determine the rolling resistance and the propulsion forces of the car induced by a 255-step digital potentiometer embedded in a throttle PCB module connected to the vehicle motor controller. A VectorNav VN-300 was employed to measure vehicle speed and acceleration against different step inputs to the motor controller on straight-line tests until a constant speed was reached, then giving a zero-throttle command until the car stopped. The velocity and acceleration profiles were used in turn to determine a rolling resistance coefficient and a propulsion force profile for the car that could be used to design a velocity controller.

- **Control system:**

Created a ROS-agnostic C++ control library encompassing the bicycle dynamic model, featuring the incorporation of various control laws, including PID and SMC-based controllers, as auxiliary control signals for feedback linearization controllers. The library also offers definitions for Line-Of-Sight and Stanley guidance laws. The lateral control employs the Stanley guidance law, while longitudinal (velocity) control utilizes PID, ASMC, or AITSMC developed controllers. These controllers were initially developed in ROS2 simulations and later fine-tuned in real-world scenarios.

Navigation

- Performed waypoint navigation based on NED-reference frame goal positions obtained from processing VectorNav VN-300 INS measurements.
- Started integration with an AMCL-based localization system, for in-Campus navigation, as the standalone VectorNav VN-300 odometry is subject to drift in the presence of tall buildings or bushy trees. Ready, but further testing is required.

ROS instructor *March 2022 – July 2022* **Monterrey, NL**
ROS teaching assistant for 6th semester Robotics and Digital Systems undergraduate students.

Storyteller *August 2019 – June 2019* **Monterrey, NL**
Generated high-impact articles from Tec de Monterrey's community for the ITESM Communication Department Conecta.

RESEARCH EXPERIENCE

Undergraduate Robotics Researcher *January 2021 – September 2023* **Monterrey, NL**
Research assistant at Robotics Laboratory at Tecnologico de Monterrey with Dr. Herman Castañeda Cuevas (hermancc@tec.mx).

- Designed a custom 6-thruster configuration for a 6-DOF Unmanned Underwater Vehicle (UUV)
- ***Robust Control Design***: designed 6-DOF sliding-mode-based controllers for an Unmanned Underwater Vehicle (UUV) in Simulink and ROS. These controllers provide robustness against unmodeled system dynamics, insensitivity to parameter variations and external disturbance rejection. The control laws were used in turn as auxiliary controllers to develop model-based feedback linearization controllers for the UUV.
  Performed model characterization of the vehicle using CAD tools for final feedback linearization control design and implemented a second order ASMC and ANTSMC for an UUV and aided in the development of a first order AITSMC.

- ***Controller Library:*** developed a C++ controller library designed for use in various vehicles. Employs the Eigen library to perform linear algebra computation. This library offers a range of control laws (PID and SMC-based controllers), which can be used independently or as supplementary control signals for both first and second-order feedback linearization controllers. It also includes base class definitions for marine (both surface and underwater) and car-like (bicycle model) vehicles that serve to create specific controller definitions for real-world vehicles. Additionally, the library provides definitions for Line-Of-Sight and Stanley controllers, employed as guidance laws. This library has undergone real-world testing in a car and in simulation for a boat and submarine.
- ***Trajectory Generation*:** developed a simple C++ motion planning library with RRT* sample-based planner (from OMPL) used for trajectory generation based on sigmoid-curve jerk profiles to obtain smooth references for an UUV (tested in simulations) on 2D maps.
- Characterized dynamics and designed robust controller for an autonomous car.

Conference Publications

Adaptive Non-Singular Terminal Sliding Mode Tracking Control of an UUV Against Disturbances
2022 – IFAC Conference on Control Applications in Marine Systems, Robotics and Vehicles – V. Sebastian Martinez-Perez – Andres E. Sanchez-Calvo – Alejandro Gonzalez-Garcia – Herman Castañeda
Adaptive Integral Terminal Sliding Mode Guidance and Control for an UUV Under Perturbations
2022 – AMCA Congreso Nacional de Control Automatico – Andres E. Sanchez-Calvo – V. Sebastian Martinez-Perez – Alejandro Gonzalez-Garcia – Herman Castañeda

LEADERSHIP AND PROJECTS

VantTec: *Student group from ITESM focused on research and development of Autonomous Vehicles.* **Monterrey, NL**

Self-Driving Car Project Leader *May 2022 – September 2023*

Led a 25-person team in equipping an electric golf cart shuttle for Tec de Monterrey's 80th anniversary with autonomous features, including control, localization on-campus, and collaborated with ZF Group. Managed mechanics, electronics/embedded, and localization teams.

Research Mentor *August 2022 – June 2023*
Vicepresident *August 2021 – July 2022*
President *August 2020 – July 2021*
Software developer *January 2020 – September 2023*

- ***3D Object Position Estimation using LiDAR + ZED for a Boat***: employed a previously developed buoy detection method based on the Velodyne VLP-16 LiDAR. This method classifies buoys based on their physical dimensions (width, height, and depth), but it often failed in real-life scenarios due to noise. Since it relied on physical shapes, any object with similar dimensions to a buoy would be misclassified as one. To enhance accuracy, a 3D object detection using the ZED camera and YoloV3 was developed. A pre-trained YoloV3 object detection network was used through a ROS package with GPU support. This package provided distance estimation using the ZED's depth map, and trigonometric calculations were applied to estimate the 3D position of each detected object. To validate the presence of objects detected by the LiDAR method, the Yolo-ZED detection was utilized for verification. Although results were obtained, they were not entirely satisfactory.
- ***Collision Avoidance for a Boat*:** developed collision avoidance method for a boat based on Velocity Obstacles in simulations with RViz and ROS for RoboBoat 2021. The Velocity Obstacle method considers an agent's current velocity and heading and calculates a set of velocities that the agent can safely choose to avoid collisions with nearby obstacles. This set of safe velocities is represented as a geometric shape known as the "Velocity Obstacle." The Velocity Obstacle is defined in the agent's velocity space, and it encodes the possible velocities that would result in a collision with obstacles if chosen by the agent. By avoiding velocities inside the Velocity Obstacle, the agent can guarantee collision avoidance. The Computational Geometry Algorithms Library (CGAL) was used to create geometric representations and operations of polygons used in this method, which was also useful for visualization in Rviz.
- ***Simulation Environment for RoboSub and RoboBoat competitions*:** developed Gazebo simulator environment for online RoboNation competitions during the pandemic, serving to validate challenge solutions and ease future development when physical testing isn't feasible. The simulator utilizes dynamic models for USV (used in real life to design controllers) and UUV to simulate their state (pose and velocity), features 3D models for both vehicles, includes a simulated sensor suite (LiDAR and stereo camera for the boat, two cameras for the submarine), provides a basic lake scenario, and incorporates custom props for each competition.
- ***Sensor simulation for Collision Avoidance for a Boat***: as part of a project focused on training a reinforcement learning agent for collision avoidance, a 2D LiDAR sensor simulation was developed. This simulation configured sensor parameters (based on a real VLP-16 LiDAR), created an algorithm for laser scan distance calculation, and implemented sector-based data reduction methods (min pooling, max pooling, and feasible pooling) for obstacle detection. Collision detection was achieved by assessing distances to obstacles and identifying collisions when distances fell below a predefined safety threshold, accounting for boat and obstacle sizes.
- Leader of software development for the RoboSub 2021 competition. Integrated and tested challenge solutions in simulations using Gazebo and ROS, involving control, guidance, and perception systems.

- Lead developer of the Gazebo simulation environment for the RoboBoat 2021 and RoboSub 2021 competitions.
- Assisted in the development of a reinforcement learning agent for collision avoidance for a boat.
- Developed a data augmentation library with OpenCV to train a YOLO v3 model for the RoboSub 2020 competition.
- ROS developer for the RoboBoat 2020 competition. In charge of boat-ground station communications.

RoboSub co-captain *August 2020 – July 2021*

ROS trainer *January 2020 – Present*

- Trained new team members in ROS and programming basics.

Web Development Course: ROS web dashboard May 2022 **Monterrey, NL**

Developed a ROS-based web dashboard to visualize and monitor sensors data from a simulated autonomous boat. The boat position change could be visualized in a map using the OpenStreetMap API. Information of sensors such as video camera and vehicle velocity, orientation and acceleration could also be visualized.

Languages & Compilers Course: Programming Language Interpreter *January 2021* **Monterrey, NL**

Developed a programming language syntax and interpreter focused on numerical calculations using Python Lex-Yacc library

Computer Vision Systems Course: Sentiment Analysis *January 2020* **Monterrey, NL**

Developed an NLP system capable of categorizing comments made in social media as positive or negative.

Escuderia Laguna *January 2018 – May 2018* **Torreon, Coahuila**

Student group focused on the construction of a non-motor cart for gravity-based competitions. Helped on building the chasis of the vehicle.

TECHNICAL SKILLS

Software	*C++, Python, Matlab/Simulink, ROS, ROS2, Git, Gazebo, Ubuntu, FreeRTOS, STM32 HAL, CUDA, OpenMP, OpenCV, SolidWorks, KiCad, Natural Language Toolkit, Docker.*
Sensors/hardware	*VectorNav VN-300, LiDAR Puck (VLP 16), ZED stereo camera, NVIDIA Jetson TX2/Xavier, STM32-based embedded design.*
Languages	*Spanish, English (ITP 637), French (DELF B1)*
Relevant Courses	*Kinematics: Describing the Motions of Spacecraft (Coursera)*
Leadership	*Acquired valuable leadership skills during presidency and vice-presidency of VantTec; managing four vehicle projects, 70 members, research programs, and RoboBoat and RoboSub competitions.*
Industry contact	*Stablished solid contacts with industries for fund raising and collaborations.*

AWARDS AND HONORS

Academic Excellence	*For students with final grades greater than 95/100 and within the top 5% of their career.*	*June 2023*
Gala Borrego 2021	*Best student among Academic Leadership Teams*	*September 2021*
RoboBoat 2021	*International autonomous surface boats competition: 6 awards granted*	*July 2021*
Premio Romulo Garza 2020	*National award for the best undergraduate research project at Tecnologico de Monterrey between 2018-2020.*	
RoboBoat 2020	*First place overall*	*July 2020*
RoboSub 2020	*International autonomous underwater vehicles competition: Third place overall*	*August 2020*
Conexion Tec	*First Place. Engineering fair.*	*December 2020*
	Project: Collision avoidance for autonomous surface vehicles using deep reinforcement learning	
Academic Talent Scholarship	*70% academic excellence tuition scholarship at Tecnologico de Monterrey*	*2017*