Carlo **Karam**

Control Systems Engineer

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Education

Politecnico di Torino (PoliTo)

Turin, Italy

MSc. in Mechatronic Engineering with a focus on Software Technologies for Automation

Sep. 2020 - Oct. 2022

Courses in Control Systems (nonlinear control, digital control, automatic control), Filtering and System Identification, Linear and Combinatorial Optimization, Machine Learning and Optimization, Embedded and Real Time Systems, and Modeling and Simulation of Mechatronic Systems.

Grade: 110/110

American University of Beirut (AUB)

Beirut, Lebanon

B.Eng. in Mechanical Engineering with a focus on Robotics and Control

Aug. 2016 - Jun. 2020

Courses in Control Systems (classical control, linear control, adaptive control), Optimization (convex optimization, optimal design of systems), Dynamics, Numerical Computing, Instrumentation, and Mechanical Design.

Experience

Dumarey Softronix - General Motors Contractor

Turin, Italy

Junior Control Systems Engineer - Selective Catalytic Reduction

Nov. 2022 - PRESENT

- Developed and implemented Model Predictive Control strategies and algorithms in the context of engine architecture upgrades.
- Improved the mathematical modelling of the SCR system to account for new phenomena.
- Performed the requirements specification for various software components of the SCR system.
- Maintained and updated legacy C code implementing various core MPC functions.
- Developed in-house tools to automate both engineering (e.g. MPC weights tuning) and non-engineering (e.g. documentatiom update) tasks.
- Calibrated and refined MPC controller weights for a new engine architecture via simulation and hardware tests.
- Maintained and upgraded the simulation environment to accommodate changes in software and engine architecture.

PUNCH Softronix

Turin, Italy

Control Systems Engineer - Thesis Student

Jan. 2022 - Oct. 2022

- Developed a Python MPC "toolbox", capable of finding the optimal control law for a given model, particularly in the context of power supervisory control in a Fuel Cell Hybrid Electric Vehicle.
- Developed a Global Optimization-based approach for the automatic tuning of MPC weights using Particle Swarm Optimization.
- Developed a machine learning algorithm which mimics the designed MPC controller for improved efficiency and eventual integration in more complex models.
- Publication (as a third author) based on a continuation of this thesis work.

Team DIANA (PoliTo)

Turin, Italy

Robotic Arm Controller Developer

Oct. 2020 - Apr. 2022

- Developed an inverse kinematics and inverse Jacobian controller for a 6DoF robotic arm mounted on a rover in MATLAB/Simulink.
- Implemented the controller on a NUCLEO-H7 board after code generation in C.
- Developed a simulation model of the arm on CoppeliaSim (formerly V-REP) with a C++ interface for communication via MQTT.
- Assisted in writing the manipulator's stepper motor drivers and their subsequent testing.
- Development done with conformity to the rules, regulations, and goals defined by the European Rover Challenge (ERC) committee.

Projects

Kinematic Control of a Robotic Arm

Italy

Coursework (PoliTo)

Mar. 2021 - Jun. 2021

Developed a full kinematic controller for a custom 3D printed and self-assembled 5DoF robotic arm using ROS and MoveIt! The packages and configurations provided a gazebo simulation and real-time virtualization of the arm, a keyboard tele-operation mode (direct kinematics), and an inverse kinematics mode through the MoveIt! GUI and a solver developed using OpenRave. Using Husarnet and the ROS networking capabilities, a ROS Master (Turin) successfully controlled the physical arm connected to a ROS slave (Sicily) with little delay. The servo motor control was implemented through an Arduino board communicating with ROS via the *rosserial* package.

Adaptive Control of a Nonholonomic Mobile Robot

Lebanon

Coursework (AUB) *Feb. 2020 - May 2020*

Designed a kinematic controller using Gain Scheduling, and a dynamic controller consisting of a full state feedback MRAC algorithm for a Kobuki mobile robot, in order to achieve perfect tracking of a circular trajectory under dynamical parametric uncertainty. The controller was developed in MATLAB and Simulink, and validated via simulations. Due to COVID-19 restrictions, no actual testing (and subsequent tuning and improvements) was possible.

Domestic Service Robot

Lebanon

Final Year Project (AUB) *Sep. 2019 - Jun. 2020*

Designed a domestic service robot capable of serving drinks to household members and their guests. The robot runs three control algorithms, the first of which tracks and follows the user from a starting point (i.e. kitchen) to a secondary area. The second algorithm is a path planner and tracker which generates an optimal path between the different users or guests, and accurately tracks and follows the generated trajectory. Liquid sloshing and subsequent spilling are limited by a vibration-reduction, input shaping algorithm. Implementation is done through ROS (both Python and C++ based) and MATLAB.

2-DOF Helicopter Attitude Control

Lebanon

Coursework (AUB) *Oct. 2019 - Dec. 2019*

Designed both an optimal (LQG) and a Feedforward - Feedback PI (using pole placement) controllers to control the yaw and pitch angles of a 2-DOF helicopter (Quanser Aero) platform. The controllers were then validated (through Simulink simulations), tested, and compared on the basis of speed, robustness and disturbance rejection.

Racing Track Generation via Convex Optimization

Lebanon

Coursework (AUB) *Oct. 2019 - Dec. 2019*

Developed an iterative algorithm which, given an initial path through a race track, runs a forward-backward integration scheme in order to determine the minimum-time longitudinal speed profile, subject to tire friction constraints. The algorithm then updates the vehicle's path based on that speed profile by solving a convex optimization problem that minimizes the path curvature while staying within the track's boundaries, and respecting affine, time-varying vehicle dynamics constraints. The results are validated using a MATLAB simulation on a real-life racetrack. The method and results were reproduced from a Stanford paper by Kapania et al.

Technical Skills

Programming	MATLAB/Simulink, C++, Python, C, Bash, LaTeX
Envrionments	ROS/ROS2, CoppeliaSim, Docker, Gazebo, LabVIEW, OpenCV
Platforms	Arduino, Raspberry Pi, Nucleo, NVIDIA Jetson
Operating Systems	GNU/Linux, Windows, Trampoline RTOS
CAD Packages	SolidWorks, AutoCAD, Fusion 360, Creo Parametric, ANSYS

Languages

Arabic	Native language
French	C2 Level (bilingual proficiency, French baccalaureate)
English	C2 Level, TOEFL: 118/120 (JAN 2020), higher education entirely in English
Italian	A2/B1 Level (informal rating)