B.Sc. Projects Topics Spring '20
(MRS Research Group)

Overview, Descriptions, Expectations
And Overall Regulations

Projects under supervision of

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Prepared by

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B.Sc. Projects Topics Spring '20
(MRS Research Group)

This document presents an overview about the B.Sc. projects presented by the Multi-Robot Systems (MRS) Research Group for the Bachelor students in the Spring '20 semester.

MRS Research Group is one of the active research groups in the Mechatronics Department - Faculty of Engineering and Materials Science (EMS) - German University in Cairo (GUC). It is established since 2015 with a scope to extend the research and practical practices from working with single robotic units to Multiple cooperating entities. Through the cooperation of different robotic systems, we are able to harness capabilities that are far beyond the reach of a single unit alone in terms of capacity or even decision making.

In this document, the different topics presented under this scope from the MRS Research group is presented with basic description about each topic. Under each topic, brief description would be presented, the set of skills required to work in this project and the expected outcomes.

Overview:

Under the above mentioned scope of the MRS Research Group, this year we present **20** B.Sc. Topics addressing different fields of robotics applications. The topics addressed this year are:

- Intelligent Transportation Systems (ITS) City
- Advanced-Driver-Assistance-Systems (ADAS)
- Mobile Robotics
- Multi-Rotor Systems
- Soft Robotics / Elastic Manipulators
- Flexible Manufacturing Systems

In each of these topics, previous results have been achieved by previous undergrad and postgrad students and we want to further build upon these results.

General Regulations:

The following regulations apply to all accepted students:

- Attendance in lab 8hrs/day, 5 days/week throughout the B.Sc. project interval
- Thesis MUST be written in Latex (Not Microsoft Office Word)
- Bi-Weekly Presentations

IEEE Paper Outcome:

Each Student is required to submit a scientific publication in the IEEE paper format during (or by the end of) his/her B.Sc. project. If this paper is with high quality will be submitted to one of the IEEE International conferences after being reviewed from the supervisory team.

Supervisory Team

We work as a Research Group, and this by definition means that no single member is knowledgeable in all aspects. Thus through the B.Sc. thesis interval, you will be co-supervised by several members from the MRS Research group.

Each of the members is an expert in some specific field and would be able to support in some directions more than others, and so on.

The team members are:

- **Omar** M. Shehata,
- **Catherine** M. Elias,
- **Dalia** M. Mahfouz,
- **Omar** M. Khairy,
- **Sama'a** Khaled,
- **Ahmed** H. Fahmy,
- **Arsany** Youssef,
- **Mirna** Bassem,
- **Silvana** Guirguis,
- **Amr** Farag,
- **Mohamed** Manzour,
- **Mohamed** H. Badra,
- **Ahmad** Salah,
- **Andrew** Faried

As well as several other Alumni from the group on both national and international levels.

Spring '20 B.Sc. Project Topics

The List of Projects Presented for Spring '20 Semester are:

	ITS City
1	Analysis and Implementation of a Reconfigurable Navigation in Formation (NiF) Controller for Connected Vehicles
2	Development and Implementation of an integrated Architecture for miniature vehicle control
3	Development and Implementation of a Multi-Layer Trajectory Tracking Controller for a Platoon of Vehicles
4	Development and Implementation of Various Multi-Layer Intersection Management Controllers
5	Investigating an Optimal Intelligent Charging/Discharging Policy for EVs in Smart Grid Environment
6	Implementation and Validation of a Multi-Vehicle System for Capacitated Vehicle Routing Problem
7	Design and Implementation of an Intelligent Multi-Vehicle Cooperative Localization Algorithms
8	Development and Implementation of a ROS-based Hybrid Control for Multi AVs in Intersection Management Applications

	ADAS
9	Development and Implementation of an Active-Suspension Test-Rig for ADAS Applications
10	Development and Implementation of an Intention Prediction Algorithm for surrounding Traffic Participants
11	Design and Implementation of an Intelligent Real-time State Estimator for AVs in Highly Uncertain Environments
12	Design and Implementation of a Real-time Actuated Driver Seat based on Vehicle Simulator Behavior

	Mobile Robots
13	Development and Implementation of an Integrated Reliable Mobile Robot Platform for E-Lab Applications
14	Development and Implementation of an Omni-directional Mobile Robot Platform for E-Lab Applications

	Multi-Rotors
15	Modeling and Analysis of a ROS-Enabled Multi-Rotor Platform for Trajectory Tracking Applications
16	Design and Implementation of a ROS-enabled Multi-Rotor Platform for indoor applications

	Robotics
17	Design, Implementation and Control of a Miniature Soft Robotic Manipulator
18	Design, Implementation and control of Smart Elastically Actuated (SEA) Robotic Manipulator
19	Design, Implementation and Control of Universal Soft Robotic Gripper

	Flexible Manufacturing Systems
20	Development of a Robust Path Planning and Tracking Algorithm for Flexible Manufacturing Systems

In the upcoming Sections, we will discuss each of these projects in more detail.
The expected outcomes of each project is mentioned alongside as well.

Note:
In each project, the underlined name of the co-supervisors is the primary responsible member of the team for this project, and the one with the most expertise in the project topic.

Project No. (01)

Analysis and Implementation of a Reconfigurable Navigation in Formation (NiF) Controller for Connected Vehicles

Main Supervisor	Dr. Eng. Omar M. Shehata
Co-Supervisors	Prof. ElSayed Imam Morgan and M.Sc. Catherine M. Elias

Project Description	The world is currently moving rapidly achieving the autonomy of vehicles seeking a well-structured Intelligent Transportation System (ITS). Accordingly, several laboratories started to direct their research towards exploring the Cooperative Autonomous Vehicles (CAV) behaviour. In this context, the aim of this thesis is formulating what is called a Flexible Reconfigurable Navigation in Formation (FR-NiF) between the autonomy-driven vehicles. The main target of the CAV formation problem or multi-platoon of vehicles on highways is: 1. Controlling the relative dynamic distance between the vehicles in both lateral and longitudinal directions; 2. moving along a planned trajectory; 3. avoiding obstacles; and 4. re-configuring the formation pattern based on the observed surrounding environment optimizing the overall CAVs performance.
Expected Outcomes	In this project, students are expected to work on the following tasks: -- Develop models to describe the behavior of the vehicle dynamics. -- Validate the developed models. -- Developing the general formation control architecture. -- Formulating low level controller on both longitudinal and lateral vehicle dynamics. -- Develop top-level control layer to achieve the Formation task. -- Validate the multi-layer control architecture on a group of homogeneous vehicles. --Insertion of the Navigation subsystem formulating pattern reconfiguration criteria. --Integration and validation of the overall subsystems.
Essential Skills Required	-Mathematical Analysis Skills; -System Modelling using state space and Control approaches; -Programming Skills (Matlab is a Preferable/ C,C++,Python are edges); -Robot-Operating System (ROS) is an edge; -Others ...
Useful Links (if any)	The following links are useful: https://ieeexplore.ieee.org/document/8430659 https://ieeexplore.ieee.org/document/6906280
Further comments	N/A

Project No. (02)

Development and Implementation of an integrated Architecture for miniature vehicle control

Main Supervisor	Prof. ElSayed Imam Morgan
Co-Supervisors	Dr. Eng. Omar M. Shehata, M.Sc. Catherine M. Elias, Eng. Dalia M. Mahfouz, Eng. Mohamed H. Badra and Eng. Ahmad Salah Salem

Project Description	Autonomous Driving is one of the most trending fields in research and industry in the last decade, and now the wave is up to Cooperative Driving where vehicles communicate with each other to perform some of cooperative driving behavior as avoiding an obstacle or drive in a swarm harmonically. Artificial Intelligence will be the science by which Autonomous Driving will be fetched, and also perform some sort of cooperative driving behavior. In this context, this project shall have an influence on Cooperative Intelligent Transportation System (C-ITS) and Smart Mobility in general, where roads have fleet of autonomous vehicles cooperate with each other and also with the environment to enhance two of the most important targets in autonomous driving which are Safe Driving and reducing Traffic Congestion.
Expected Outcomes	In this project, students are expected to work on the following tasks: -- Develop dynamical model for the vehicle. -- Develop controller for trajectory tracking. -- Test the controller on Udacity/Carla self-driving cars simulators. -- Develop top-level control algorithm to perform Cooperative driving. -- Test the proposed controller on a miniature vehicle experimentally. -- Test the top-level control algorithm for Cooperative driving on fleet of miniature vehicles experimentally.
Essential Skills Required	-- Programming Skills (Python) -- System Modelling using state space and Control approaches
Useful Links (if any)	The following links are useful: -https://www.semanticscholar.org/paper/A-Fleet-of-Miniature-Cars-for-Experiments-in-Hyldmar-He/a130b1fd02fcfb03dd756f4cb305e2de2d079afb -http://carla.org/ -https://github.com/udacity/self-driving-car-sim
Further comments	N/A

Project No. (03)

Development and Implementation of a Multi-Layer Trajectory Tracking Controller for a Platoon of Vehicles

Main Supervisor	Dr. Eng. Omar M. Shehata
Co-Supervisors	Prof. ElSayed Imam Morgan and Eng. Dalia M. Mahfouz

Project Description	Intelligent Transportation System (ITS) has become a topic of considerable interest for the development of a safer and more efficient means of transportation. Despite of the standalone applications presented as ITS, nowadays, the world mentality is shifting towards Cooperative-ITS (C-ITS) that can cooperatively exchange information to make a better action, as well as collaboratively execute tasks in complicated applications that can't be achieved using only a single system. One of the most important applications in the field of C-ITS is vehicle platooning. This thesis addresses the control problem of platoon vehicles to track a desired planned trajectory while maintaining a certain formation geometry. This type of problems is challenging as it tackles different perspectives including trajectory generation, model development, control algorithm design and implementation for multi-vehicles.
Expected Outcomes	In this project, students are expected to work on the following tasks: -- Develop a dynamic model to describe the behavior of each single vehicle. -- Validate the developed model. -- Generate different trajectories for the overall system. -- Develop a top-level controller to achieve the trajectory tracking task for each vehicle. -- Develop a low-level controller to control the system dynamics of each vehicle. -- Validate the proposed controller on a group of homogeneous vehicles. -- Test and validate the overall system experimentally.
Essential Skills Required	-- Programming Skills -- Robot-Operating System (ROS) is an edge -- System Modelling using state space and Control approaches
Useful Links (if any)	The following links are useful: -https://ieeexplore.ieee.org/document/8917439
Further comments	N/A

Project No. (04)

Development and Implementation of Various Multi-Layer Intersection Management Controllers

Main Supervisor	Prof. ElSayed Imam Morgan
Co-Supervisors	Dr. Eng. Omar M. Shehata and Eng. Sama'a Khalid

Project Description	Nowadays, Intersection safety with autonomous vehicles has received growing research attention. The traffic conditions is heavily affected by the performance of the control systems, therefore, several intersection management techniques should be implemented and validated. The objective of this thesis is to develop an intersection control algorithm that optimizes the system performance and the trajectory of each single in order to avoid collisions and reach the destination in minimum time.
Expected Outcomes	In this project, students are expected to work on the following tasks: -- Develop models to describe the behavior of each vehicle. -- Validate the developed models. -- Develop different intersection management control techniques. -- Develop top-level controller to achieve safe intersection. -- Test and validate the proposed control techniques experimentally.
Essential Skills Required	-Programming Skills -Robot-Operating System (ROS) is an edge -System Modelling using state space and Control approaches
Useful Links (if any)	The following links are useful: -https://ieeexplore.ieee.org/abstract/document/7016754?section=abstract
Further comments	N/A

Project No. (05)

Investigating an Optimal Intelligent Charging/Discharging Policy for EVs in Smart Grid Environment

Main Supervisor	Prof. ElSayed Imam Morgan
Co-Supervisors	Dr. Eng. Omar M. Shehata and Eng. Silvana Guirguis

Project Description	The world is shifting to the mentality of Multi-vehicle Systems that are connected in smart grid environment; where they can cooperatively exchange information to better make action, as well as collaboratively execute tasks in complicated applications that can't be achieved using a single robot only. One of the main important aspects is shifting from fuel vehicles to Electric vehicles which majorly helps in the automation process of vehicles and their connection through the smart grid. This field accordingly addresses the problem of how to optimally charge electric vehicles in order to minimize the cost needed for the vehicles to operate. In addition to that the optimality of battery discharging in electric vehicles according to the battery levels can highly affect the overall cost over time. This type of problems is challenging as the optimization of charging and discharging of different battery types and different operational vehicles such that the overall cost for the grid is minimized.
Expected Outcomes	In this project, students are expected to work on the following tasks: -- Develop models to describe the behavior of each type of robot. -- Validate the developed models. -- Develop single robot Control algorithm for trajectory tracking -- Test the controller experimentally. -- Develop top-level controller to achieve the MRS task. -- Validate the proposed controller on a group of heterogeneous robots. -- Test the top-level controller experimentally.
Essential Skills Required	-Programming Skills -Robot-Operating System (ROS) is an edge -System Modelling using state space and Control approaches
Useful Links (if any)	The following links are useful: N/A
Further comments	N/A

Project No. (06)

Implementation and Validation of a Multi-Vehicle System for Capacitated Vehicle Routing Problem

Main Supervisor	Prof. ElSayed Imam Morgan
Co-Supervisors	Dr. Eng. Omar M. Shehata and Eng. Omar M. Khairy

Project Description	The world mentality is shifting from single vehicle to Multi-Vehicle Systems applications that can cooperatively exchange information to better make action, as well as collaboratively execute tasks in complicated applications that can't be achieved using a single vehicle only. One of the most important applications of multi-autonomous vehicles is Vehicle Routing. This field addresses the problem of how to utilize a group of vehicles to do tasks that exceed their number. This type of problems is challenging, as a decision has to be made about which vehicle should handle which task, such that the overall cost for the team is minimized. Cost could include travelled distance, execution time, battery levels or otherwise.
Expected Outcomes	In this project, students are expected to work on the following tasks: -- Study the Vehicle Routing Problem, its variations and methods to solve it. -- Develop algorithms to solve the Vehicle Routing Problem on homogeneous vehicles.. -- Validate the developed algorithms. -- Test the algorithms experimentally.
Essential Skills Required	-Programming Skills (Matlab is a Preferable). -Knowledge of basics of Optimization is a plus. -Robot-Operating System (ROS) is an edge.
Useful Links (if any)	N/A
Further comments	N/A

Project No. (07)

Design and Implementation of an Intelligent Multi-Vehicle Cooperative Localization Algorithms

Main Supervisor	Prof. ElSayed Imam Morgan
Co-Supervisors	Dr. Eng. Omar M. Shehata and Eng. Amr Farag

Project Description	The world mentality is shifting from single robot applications to the mentality of Multi-Robot Systems (MRS) that can cooperatively exchange information to better make action, as well as collaboratively execute tasks in complicated applications that can't be achieved using a single robot only. One of the main important applications in MRS applications is the field of Multi-Robot Task Allocation (MRTA). This field addresses the problem of how to utilize a group of heterogeneous robots to do tasks that exceed their number. One of these tasks is the localization task, in which every robot can, by using multiple sensors, know their location. However, due to the heterogeneity of the robots, they may vary in the sensors' setup. Therefore, robots may share their information together to obtain a better localization with a better covariance.
Expected Outcomes	In this project, students are expected to work on the following tasks: -- Develop and validate models to describe the behavior of each type of robot. -- Develop single robot Control algorithm for trajectory tracking -- Test the controller experimentally. -- Develop top-level controller to achieve the MRS task. -- Validate the proposed controller on a group of heterogeneous robots. -- Implement and validate multiple-filters for sensor fusion of a single robot. -- Build a high-level localization model to extend the sensor fusion techniques of single robots. -- Validate the high-level localization model on a hardware, if possible.
Essential Skills Required	-Programming Skills -Robot-Operating System (ROS) is an edge -System Modelling using state space and Control approaches -Sensor fusion techniques is a plus
Useful Links (if any)	N/A
Further comments	N/A

Project No. (08)

Development and Implementation of a ROS-based Hybrid Control for Multi AVs in Intersection Management Applications

Main Supervisor	Dr. Eng. Omar M. Shehata
Co-Supervisors	Prof. ElSayed Imam Morgan and Eng. Dalia M. Mahfouz

Project Description	Intersections and their management represents one of the most challenging problems in the control of transportation networks due to the various interacting entities (vehicles, pedestrians, etc). For an environment filled with Autonomous Vehicles it is really challenging how to develop such a system and control it in a reliable manner. ROS enables several researchers as well as industrial parties to implement their work in a seamless manner, with high accuracy and precision. Using ROS communication, it becomes possible to implement several hybrid controllers that combine the powers of conventional control approaches and intelligent controllers to be implemented on the target application platform. In this project, the student is required to work on developing a ROS environment that enables him/her to apply several controllers in controlling multiple AVs in the environment of an intersection. The work is expected to be implemented using one of the advanced simulators (CARLA).
Expected Outcomes	In this project, students are expected to work on the following tasks: -- Develop models to describe the behavior of the vehicle. -- Develop a model for the interaction of vehicles in the intersection -- Develop a testing environment in the simulator (CARLA for example) -- Develop a ROS based model for the control of the vehicles. -- Implement a basic control approach to control the vehicles in the simulator. -- Implement a hybrid controller to do the task. -- Assess the performance of the proposed controller and its modifications.
Essential Skills Required	-Programming Skills -Robot-Operating System (ROS) is an edge -System Modelling using state space and Control approaches -CARLA simulator is an edge.
Useful Links (if any)	The following links are useful: N/A
Further comments	N/A

Project No. (09)

Development and Implementation of an Active-Suspension Test-Rig for ADAS Applications

Main Supervisor	Dr. Eng. Omar M. Shehata
Co-Supervisors	Prof. ElSayed Imam Morgan, M.Sc. Catherine M. Elias and Eng. Dalia M. Mahfouz

Project Description	The world is racing towards the development of different autonomous vehicles that are expected to enhance the level of quality of life of the users. Yet one of the most important factors in this transportation system is the driver himself and his comfort. One of the factors affecting the comfort of the user is the motion transmitted through the suspension system of the vehicle. One of the most advanced approaches in suspension is the active-suspension, in which through the addition of an extra actuator in parallel with the conventional shock absorber, it becomes possible to actuate the sprung mass (vehicle body) in order to keep the user's level steady against different road disturbances. In this project, the student will build a model for the quarter car model of active suspension system, and will study the effect of different controllers on the performance of the moving mass, and investigate how to improve it through various controllers.
Expected Outcomes	In this project, students are expected to work on the following tasks: -- Develop models to describe the behavior of the suspension system. -- Develop a model for the behavior of the active suspension system. -- Design and implement a hardware test rig for the quarter car model. -- Develop a real-time control system -- Conduct several experiments to validate the presented controllers. -- Assess the performance of the tested controllers.
Essential Skills Required	-Programming Skills -Robot-Operating System (ROS) is an edge -System Modelling using state space and Control approaches -CAD and electronics circuits design.
Useful Links (if any)	The following links are useful: -Active Suspension (https://www.youtube.com/watch?v=AgUn3d486cU)
Further comments	N/A

Project No. (10)

Development and Implementation of an Intention Prediction Algorithm for surrounding Traffic Participants

Main Supervisor	Prof. ElSayed Imam Morgan
Co-Supervisors	Dr. Eng. Omar M. Shehata and Eng. Mohamed Manzour

Project Description	One of the main barriers against the full deployment of autonomous vehicles in traffic environments is the understanding of the intentions and behaviours of any traffic participant (e.g. vehicle, pedestrians...) around them. The aim of this thesis is to apply computer vision algorithms on different methodologies to make intention prediction for traffic participants in different situations (e.g. lane changing, crossing street...).
Expected Outcomes	In this project, students are expected to work on the following tasks: -- to be able to make autonomous vehicles able to perceive the environment around them using computer vision. -- Analysing the collected visual data and use an appropriate method in order to make intention prediction . -- Formation of a new dataset of different traffic situations (e.g. pedestrian crossing, lane changing...) in Egypt.
Essential Skills Required	- Programming Skills: Python (is a must), C (is a plus). - Background knowledge about Machine and Deep Learning (is a plus).
Useful Links (if any)	The following links might be useful: https://drive.google.com/open?id=1Opm4dbe_7m_D_Sm1n9DsYsAh6FSOFk1X
Further comments	N/A

Project No. (11)

Design and Implementation of an Intelligent Real-time State Estimator for AVs in Highly Uncertain Environments

Main Supervisor	Dr. Eng. Omar M. Shehata
Co-Supervisors	Prof. ElSayed Imam Morgan and M.Sc. Catherine M. Elias

Project Description	The study of system dynamical model is one of the main key aspects in autonomous and control engineering field. It is observed that the system behavior can significantly change by making any small perturbation in the system, especially when we are talking about complicated, multi-physics systems such as large trucks or vehicle driving on high speed. Therefore, it really matters to study and take all the forces applied on the vehicle into consideration to obtain an accurate model. However, formulating such a model is almost impossible in reality Moreover, the vehicle behavior can vary in different situations depending on the status of the surrounding environment including the road infrastructure. This can be seen if we compared the cars' statuses in Egypt where we can rarely find structured roads with almost no infrastructure and the cars in Germany. Such unstructured environment can enormously affect the car performance on the long term leading to change in the car's affecting factors and parameters. Therefore, the main aim of this thesis is to build a real-time state estimator with the use of intelligent algorithms (Machine Learning) to estimate the uncertainties in the system subjected to environmental disturbances. The estimator can be designed to estimate parameters in the vehicle, or even can be extended to estimate a degree of freedom.
Expected Outcomes	In this project, students are expected to work on the following tasks: -- Studying the different degrees of freedom of the vehicle and the affecting environmental parameters. -- Studying different approaches of ML and determining the most suitable technique for the thesis purposes. -- Collecting any necessary data experimentally for training the model. -- Extract
Essential Skills Required	-Mathematical Analysis Skills; -System Modelling using state space and Control approaches; -Programming Skills (Matlab is a Preferable/ C,C++,Python are edges); -Robot-Operating System (ROS) is an edge; -Machine Learning (ML) basics; -Others ...
Useful Links (if any)	The following links are useful: https://ieeexplore.ieee.org/document/8917106 https://ieeexplore.ieee.org/document/8916954
Further comments	N/A

Project No. (12)

Design and Implementation of a Real-time Actuated Driver Seat based on Vehicle Simulator Behavior

Main Supervisor	Dr. Eng. Omar M. Shehata
Co-Supervisors	Prof. ElSayed Imam Morgan, Eng. Mohamed H. Badra and Eng. Ahmad Salah

Project Description	Several applications worldwide are developed to improve the performance of the vehicles on the road. Yet one of the most important factors is the driver in the vehicle itself. The comfort of the driver is one of the most critical factors that should be considered. The effect of different motion profiles (acceleration, deceleration and maneuvering) must be checked with their effects on the driver. In this project, a real-time actuated driver seat is to be designed and implemented which will reflect how the driver would feel if the vehicle is behaving in a specific manner. The vehicle behavior is to be reflected from the simulator which will be tested in different driving scenarios. The inputs to the simulator will be from a real driving wheel and pedals system.
Expected Outcomes	In this project, students are expected to work on the following tasks: -- Develop model for the vehicle behavior. -- Develop a simulation environment with different scenarios. -- Acquire inputs from the driving wheel and pedals. -- Design and Implement a real-scale actuated driver seat. -- Develop a real-time output from the simulation to the actuators. -- Conduct several tests to validate the proposed system. -- Assess the performance of the system and its recommendations.
Essential Skills Required	-Programming Skills -Robot-Operating System (ROS) is an edge -System Modelling using state space and Control approaches -CAD and electronic circuits design.
Useful Links (if any)	The following links are useful: -Vehicle Simulator (https://www.youtube.com/watch?v=V9s75MtnUxA&t=211s)
Further comments	N/A

Project No. (13)

Development and Implementation of an Integrated Reliable Mobile Robot Platform for E-Lab Applications

Main Supervisor	Dr. Eng. Omar M. Shehata
Co-Supervisors	Prof. ElSayed Imam Morgan and M.Sc. Catherine M. Elias

Project Description	Robotics applications are growing worldwide, and they are being used in almost every application. One of these main applications is learning processes. The usage of robots in teaching and learning allows the students to get hands-on experience with how it would feel to model and control their systems, instead of only relying on the simulations available. Yet, one of the main limitations to this is the availability of a suitable reliable platform for testing and demonstrating. Thus, one of the solutions to this problem is the usage of remote e-labs, in which the hardware available physically in one lab could be accessed and controlled remotely. Using this approach the user does not have to be physically there in the lab. In this project, the student will work on developing a reliable mobile platform that can be used in e-lab applications.
Expected Outcomes	In this project, students are expected to work on the following tasks: -- Develop models to describe the behavior of each type of robot. -- Validate the developed models. -- Develop single robot hardware and architecture -- Build and validate architecture for the e-lab -- Conduct several experiments to test the proposed system and assess its performance as well.
Essential Skills Required	-Programming Skills -Robot-Operating System (ROS) is an edge -System Modelling using state space and Control approaches -CAD and electronics boards design.
Useful Links (if any)	The following links are useful: N/A
Further comments	N/A

Project No. (14)

Development and Implementation of an Omni-directional Mobile Robot Platform for E-Lab Applications

Main Supervisor	Prof. ElSayed Imam Morgan
Co-Supervisors	Dr. Eng. Omar M. Shehata and Eng. Arsany Youssef

Project Description	The uses of mobile robots are continuously increasing in non-industrial applications such as military and security settings, inspection of power lines in smart grids, crop-inspection in smart agriculture.... Mobile robots can be classified accordingly to the motion system or by the type of mobility. The motion system can be based on wheels, tracks, ball-shaped wheels or legs. The type of mobility can be classified as omnidirectional (or holonomic) or non-omnidirectional. The holonomic mobile robots have the advantage that they can change the direction of motion without having to perform intermediate rotation steps and they are able to move in all directions from a given starting point while simultaneously rotating.
Expected Outcomes	In this project, students are expected to work on the following tasks: -- Design, hardware implementation of the three-wheel omnidirectional robot. -- Validate the developed models. -- Mechanical design and electronic control. -- Develop single robot Control algorithm for trajectory tracking -- Analyzing the kinematics of the motion system and validating the estimation of the trajectory comparing various techniques. -- Simulating the robot on a 3D simulator ex: Gazebo. -- Test the controller experimentally. -- Develop top-level controller to achieve the MRS task. -- Test the top-level controller experimentally.
Essential Skills Required	-Programming Skills -Robot-Operating System (ROS) is an edge -System Modelling using state space and Control approaches
Useful Links (if any)	The following links are useful: https://www.mdpi.com › pdf https://www.youtube.com/watch?v=Q4cmc4eKXr0 https://www.youtube.com/watch?v=iFEJDe21j9Q https://www.youtube.com/watch?v=eNfRvT9SuLI&t=72s https://www.youtube.com/watch?v=J_HTEfHBbfE
Further comments	N/A

Project No. (15)

Modeling and Analysis of a ROS-Enabled Multi-Rotor Platform for Trajectory Tracking Applications

Main Supervisor	Dr. Eng. Omar M. Shehata
Co-Supervisors	Prof. ElSayed Imam Morgan, M.Sc. Catherine M. Elias and Eng. Mirna Bassem

Project Description	The world mentality is shifting from single robot applications to the mentality of Multi-Robot Systems (MRS) that can cooperatively exchange information to better make action, as well as collaboratively execute tasks in complicated applications that can't be achieved using a single robot only. One of the main important applications in MRS applications is the field of Multi-Robot Task Allocation (MRTA). This field addresses the problem of how to utilize a group of heterogeneous robots to do tasks that exceed their number. This type of problems is challenging as a decision has to be made about which robot should handle which task, such that the overall cost for the team is minimized. Cost could include travelled distance, execution time, battery levels or otherwise.
Expected Outcomes	In this project, students are expected to work on the following tasks: -- Develop models to describe the behavior of each type of robot. -- Validate the developed models. -- Develop single robot Control algorithm for trajectory tracking -- Test the controller experimentally. -- Develop top-level controller to achieve the MRS task. -- Validate the proposed controller on a group of heterogeneous robots. -- Test the top-level controller experimentally.
Essential Skills Required	-Programming Skills -Robot-Operating System (ROS) is an edge -System Modelling using state space and Control approaches
Useful Links (if any)	The following links are useful: N/A
Further comments	N/A

Project No. (16)

Design and Implementation of a ROS-enabled Multi-Rotor Platform for indoor applications

Main Supervisor	Prof. ElSayed Imam Morgan
Co-Supervisors	Dr. Eng. Omar M. Shehata, Eng. Mirna Bassem, Eng. Mohamed Hadi Badra and Eng. Ahmad Salah

Project Description	Multi-Rotors have an important role these days in many fields (Maintenance, Search and Rescue, Military, and many others). Also, how these Rotors being built make a huge difference in performance as there are many variables that manipulate it; such as from hardware perspective (weight, propellers, battey, sensors,motors,and many more) and also from software perspective (programing language,communication protocol,software architecture design, and many more) Using a platform to implement these controllers make it easier and one of the most powerful platforms is Robot Operating System (ROS) as it is able to apply sensor filters, controllers and simulation on Gazebo (simulation platform) out of the box.
Expected Outcomes	In this project, students are expected to work on the following tasks: -- Develop models to describe the behavior of Multi-Rotor -- Develop or use simple Multi-Rotor Control algorithm for trajectory tracking. -- Validate the developed model and the controller in a simulation tool (i.e Gazebo). --Design and implementation a Multi-Rotor hardware --Design and implementation a Multi-Rotor software interface
Essential Skills Required	-Programming Skills -Robot-Operating System (ROS) is an edge -System Modelling using state space and Control approaches
Useful Links (if any)	The following links are useful: N/A
Further comments	N/A

Project No. (17)

Design, Implementation and Control of a Miniature Soft Robotic Manipulator

Main Supervisor	Prof. ElSayed Imam Morgan
Co-Supervisors	Dr. Eng. Omar M. Shehata and Eng. Ahmed H. Fahmy

Project Description	Robotic manipulators have an important role in many fields including industrial, medical fields among others. A paradigm shift in the robotics field in the previous few decades is the use of soft continuum robotic manipulators, robots that can bend continuously through their body having theoretically infinite degrees of freedom in motion. For highly constrained unstructured environments the use of soft robots is required due to their high flexibility in motion. The field of soft robotics is a growing field facing many challenges. One of the main challenges is developing a model that can accurately predict the behavior of these robotic manipulators to be able to control their motion.
Expected Outcomes	In this project, students are expected to work on the following tasks: -- Develop models to describe the behavior of a soft continuum robot. -- Validate the developed models. -- Develop single robot Control algorithm for trajectory tracking -- Develop a simulation environment for the robot to test the controller -- Test the controller experimentally.
Essential Skills Required	-Programming Skills -System Modelling using state space and Control approaches
Useful Links (if any)	The following links are useful: N/A
Further comments	N/A

Project No. (18)

Design, Implementation and control of Smart Elastically Actuated (SEA) Robotic Manipulator

Main Supervisor	Dr. Eng. Omar M. Shehata
Co-Supervisors	Prof. ElSayed Imam Morgan and Eng. Andrew Faried

Project Description	Industrial requirements for automation of small parts assembly operations are driving technology into the direction of scalable robotic automation, suitable for operation in shared environments with human workers and exhibiting highest flexibility and ease of use. And to achieve this goal, safety factors for workers should be taken as a priority. Series elastic actuators (SEAs) are powerful devices in the area of human-robot collaboration, because of their mechanical and force sensing properties. Design, implementation and control of an industrial collaborative robotic arm with SEA approach is a complete process of producing an ideal mechatronic system.
Expected Outcomes	In this project, students are expected to work on the following tasks: -- Design the mechanical system of the manipulator. -- Implement the mechanical components of the manipulator. -- Assembly of the mechanical system, and system verification. -- Develop the control algorithm for the system. -- Test the system controller exprementally.
Essential Skills Required	-Programming Skills -Mechanical design using CAD software (Solidworks) -System Modelling using state space and Control approaches
Useful Links (if any)	The following links are useful: a- https://www.youtube.com/watch?v=Sb6JjH3Kn34 (this one to clarify the idea of industrial collaborative robot) b- https://www.youtube.com/watch?v=RVSFMvdkv80&t=43s (this one to clarify the idea of Series Elastic Actuator robot) c- https://www.youtube.com/watch?v=gZLO2Am0Zk8 (this one to clarify the idea of Series Elastic Actuator in general)
Further comments	N/A

Project No. (19)

Design, Implementation and Control of Universal Soft Robotic Gripper

Main Supervisor	Prof. ElSayed Imam Morgan
Co-Supervisors	Dr. Eng. Omar M. Shehata and Eng. Andrew Faried

Project Description	In the present state of industrial robot technology, any significant advancement with regard to versatility will result from an improvement of its gripping mechanisms. If the hand could manipulate hard, fragile or soft objects of various shapes, the industrial robot could be utilized in wider fields. Such devices require a more complex control and planning of the grasping action than intrinsically compliant structures which passively adapt to complex shapes objects. Design, implementation and control of this universal soft robotic gripper is headway into the scientific research in the field of compliant actuators' design in particular, and robotics in general.
Expected Outcomes	In this project, students are expected to work on the following tasks: -- Design the mechanical system of the gripper. -- Implement the mechanical components of the gripper. -- Assembly of the mechanical system, and system verification. -- Develop the control algorithm for the system. -- Test the system controller exprementally.
Essential Skills Required	-Programming Skills -Mechanical design using CAD software (Solidworks) -System Modelling using state space and Control approaches
Useful Links (if any)	The following links are useful: a- https://www.youtube.com/watch?v=gI0tzsO8xwc (this one to clarify the idea of soft gripper)
Further comments	N/A

Project No. (20)

Development of a Robust Path Planning and Tracking Algorithm for Flexible Manufacturing Systems

Main Supervisor	Dr. Eng. Omar M. Shehata
Co-Supervisors	Prof. ElSayed Imam Morgan, Prof. Lamia Shihata and Eng. Arsany Youssef

Project Description	The new challenging demands of the current market must be satisfied by modern material flow systems, with higher levels of flexibility and reliability. However, the current material flow systems are not capable to fully fulfill these new requirements and therefore, new approaches must be explored, focusing on mechanical modularization, interface standardization and decentralized control. New algorithms are proposed for a decentralized omnidirectional route planning and reservation for small-scaled material flow systems to facilitate the profitable realization of highly flexible material flow systems required by new market demands, by increasing flexibility, robustness as well as the range of achievable logistic tasks. One of the new conveyors is the omnidirectional conveyor….
Expected Outcomes	In this project, students are expected to work on the following tasks: -- Validate the developed conveyor model. -- Implement an algorithm for a decentralized omnidirectional route planning technique. -- Implement an algorithm for a reservation for small-scaled material flow systems. -- This algorithm should consider any change of the layout or form of the transported object dynamically. -- Provides the shortest route from source to destination along the available small-scaled modules. -- Robust tracking applied with camera and real hardware. -- Develop top-level controller to achieve the MRS task. -- Validate the proposed controller on a group of heterogeneous robots. -- Test the top-level controller experimentally.
Essential Skills Required	-Programming Skills -Robot-Operating System (ROS) is an edge -System Modelling using state space and Control approaches
Useful Links (if any)	The following links are useful: https://ieeexplore.ieee.org/document/8502655/ https://www.youtube.com/watch?v=fzN8LDL9a5E https://www.youtube.com/watch?v=mBCccgt8bZs
Further comments	N/A