Robotics Engineering

Project Presentation Day

April 19, 2019

Worcester Polytechnic Institute

Welcome!

To help us judge, please visit our online evaluation site:

https://wpi.qualtrics.com/jfe/form/
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Robotics Engineering Program MQP
Project Presentation Day
Foisie Innovation Studio, Second Floor

8:00 am
Welcoming Remarks
Prof. Jing Xiao, Robotics Engineering Program Director
Prof. Carlo Pinciroli, MQP Committee Chair

8:15 am — *MQP 1*
Engineered Skeletal Muscle
Michael Antonelli, Lyra Huynh, Deborah Kalambayi, Lara Schmoyer, Nicholas Seagrave
Advisors: Raymond Page, Marko Popovic

8:30 am — *MQP 2*
Wolfgang: An Autonomous Mobile Robot for Outdoor Navigation
Aidan Cookson, Mark Landergan, Sean O'Neil
Advisor: William Michalson; Co-Advisor: Xinming Huang

8:45 am — *MQP 3*
Modular Electric Skateboard (MESB)
Nicholas Fajardo, Phillip Konyeaso, Zane Weissman
Advisors: Craig Putnam, Susan Jarvis

9:00 am — *MQP 4*
Telenursing RoboPuppet
Zachary Caplin, Ryan Kennedy, Grant Zahorsky
Advisor: Zhi (Jane) Li

9:15 am — *MQP 5*
Sailbot 2018-2019
Sydney Fisher, Sierra Palmer, Kellen Randall
Advisors: Kenneth Stafford, William Michalson

9:30 am BREAK – Demonstrations and Poster Presentations, Foisie 2nd floor

9:45 am — *MQP 6*
Agriculture SWARM
Anqi Shen, John Stegeman
Advisor: Michael Ciaraldi; Co-Advisor: Nicholas Bertozzi

10:00 am — *MQP 7*
Soft Matter Manipulation
Mingqi Shuai, Michelle Zhang
Advisors: Marko Popovic, Zhi (Jane) Li

10:15 am — *MQP 8*
A.I. LEGO Sorter
Peter Donaldson, David Jin, Andrew Schueler
Advisors: Craig Putnam, Brad Miller

10:30 am — *MQP 9*
Lionfish Bot 2.0
Alex Antaya, Katharine Conroy, Eric Peterson, Thomas Ralph
Advisors: Susan Jarvis, Brad Miller, Craig Putnam
Sponsor: Robots in Service of the Environment (RSE)

10:45 am — *MQP 10*
Oddisy Drone Dispatch System
Noah Hillman, Nick Sorensen, Marek Travnikar, Steven Viola
Advisors: Nick Bertozzi, Reinhold Ludwig, Brad Miller, Carlo Pinciroli

11:00 am BREAK – Demonstrations and Poster Presentations, Foisie 2nd floor

11:15 am — *MQP 11*
Swarm Construction with Intelligent Scaffolding
Albert Enyedy, Felix Sanchez
Advisor: Carlo Pinciroli

11:30 am — *MQP 12*
Walking Quadruped
Nicole Franco, Nicoli Liedtke, Danny Lu
Advisors: Craig Putnam, William Michalson, Gregory Fischer

11:45 am — *MQP 13*
Autonomous Scale Car Using Computer Vision and Neural Networks
Mitchell Curbelo, Ryan Darnley, Ava Karet, Krishna Madhurkar, Dylan McKillip, Ethan Schutzman, Christian Scillitoe
Advisors: Pradeep Radhakrishnan, Kaveh Pahlavan

12:00 pm — *MQP 14*
Autonomous RC Car Platform
Jason Ashton, Sean Hunt, Myles Spencer
Advisor: Jie Fu; Co-Advisor: Michael Gennert

12:15 pm — *MQP 15*
SmallKat
Keion Bisland, Xavier Little, Alex Tacescu
Advisors: Nicholas Bertozzi, Loris Fichera, Gregory Fischer, Brad Miller

12:30 pm LUNCH – Foisie 2nd floor

1:00 pm — *MQP 16*
K.O.L.T.: Known Object Localization and Tracking
Nathan Rosenberg
Advisor: William Michalson

1:15 pm — *MQP 17*
Robot Tour Guide
Henry Dunphy, Zoraver Kang, William Mosby
Advisors: Jing Xiao, Gregory Fischer
Sponsor: AVA Robotics

1:30 pm — *MQP 18*
Object Manipulation and Control with Robotic Hand
Colin Buckley, Bhon Bunnag, Apiwat Ditthapron, Rebecca Miles
Advisors: Zhi (Jane) Li, Stephen Bitar, Loris Fichera

1:45 pm — *MQP 19*
Kinisi
Gabriel Entov, Lanhao Mao, Cassandra Pepicelli, Jonathan Tai, Samuel White, Cooper Wolanin
Advisors: Alexander Wyglinski, Hugh Lauer
Sponsors: SICK Sensor Intelligence, Pico Technology, Mitsubishi Electric Research Lab, WPI Society of Automotive Engineers

2:00 pm — *MQP 20*
Diagnosing Robotic Swarms (Dr. Swarm)
Josiah Boucher, Jerry Brown, Erika Snow, Alexandra Wheeler
Advisors: Carlo Pinciroli, Lane Harrison

2:15 pm BREAK – Demonstrations and Poster Presentations, Foisie 2nd floor

2:30 pm — *MQP 21*
Thermal Infrared Endoscope
Matthew Collins, James Kradjian, Ryan St. Hilaire, Chenggu Wang, Wentao Yuan
Advisor: Loris Fichera; Co-Advisor: Gregory Fischer

2:45 pm — *MQP 22*
Autonomous Landmine Detection Rover
Dillon Arnold, Nicholas Lanotte, Benjamin Wagner, Dan Wensley
Advisors: Craig Putnam, Susan Jarvis, Nick Bertozzi

3:00 pm — *MQP 23*
Firefighting Robot
Eva Barinelli, Jacob Berman-Jolton, Gavin MacNeal, Karina Naras, Yil Verdeja
Advisors: Carlo Pinciroli, Sarah Wodin-Schwartz, William Michalson

3:15 pm — *MQP 24*
Increasing the Throughput of 3D Printers with Automated Part Removal
Brian King, Chris Kirven, Hussain Muhammad, Brian Sayers, Benjamin Secino, Baron Strasburger
Advisors: Pradeep Radhakrishnan, Mehul Bhatia

3:30 pm — *MQP 25*
Super-elastic Continuum Robot for Endoscopic Articulation and Manipulation (SCREAM)
Zachary Boyer, Cory Brolliar, Benjamin Mart, Kevin O'Brien
Advisors: Loris Fichera, Gregory Fischer, Kenneth Stafford

3:45 pm BREAK – Demonstrations and Poster Presentations, Foisie 2nd floor

4:00 pm — *MQP 26*
Automatic Vehicle Recharging Station
Matthew Fortmeyer, Nikolas Gamarra, Ryan O'Brien, Jacob Remz
Advisors: Craig Putnam, Jie Fu

4:15 pm — *MQP 27*
Developing a Modular Control Moment Gyroscope for Planetary Rover Mobility
Aidan Brawley, Stephen Burke, Fang Han, Oliver Sanderson, Jeremy Wiles
Advisor: Pradeep Radhakrishnan

4:30 pm — *MQP 28*
Development of a Modular Animatronic Head
Matthew Dick, Owen France, Richard Hosea, Kevin Le, Rachel Lia, Patrick Meehan, Kyle Seymour
Advisor: Pradeep Radhakrishnan

4:45 pm — *MQP 29*
Rehabilitative Arm Exoskeleton
Eric Carkin, Parker Grant, Bryan Therrien
Advisors: Marko Popovic, Stephen Bitar, Joseph Stabile

5:00 pm — *MQP 30*
Investigation of UCL Tears in Baseball Pitchers
[Non-judging Presentation]
Maddie Brennan, Steven Gallagher, Ben Kurtze, Paula Sardi
Advisors: Marko Popovic, Selcuk Guceri

5:15 pm
Concluding Remarks
Prof. Marko Popovic, MQP Committee Member

MQP 1

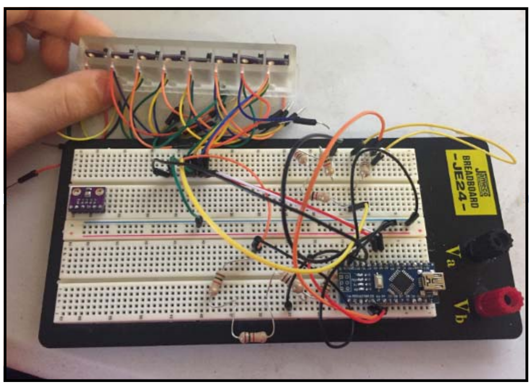
Engineered Skeletal Muscle

Michael Antonelli, Lyra Huynh, Deborah Kalambayi, Lara Schmoyer, Nicholas Seagrave

Advisors: Raymond Page, Marko Popovic

Abstract

Ninety percent of new investigational drugs fail phase 2 clinical trials due to a lack of accurate existing models for human skeletal tissue. Animal models are not representative of human tissues due to physiological differences between the animals and the human body. Additionally, 2D skeletal tissue models cannot accurately serve as drug testing models for the human body due to the structural difference between 2D and 3D muscle. This is a waste of investments of time and resources. The objective of this MQP is to provide a solution to this problem by creating a device in which 3D, fully differentiated and functional skeletal muscle can be easily grown in lab settings. The device is designed to mechanically stimulate the tissue using PDMS micropost deflection driven by air pressure. A correlation profile was drawn for the pressure and deflection angle to determine the amount of strain produced. Electrodes were used to produce additional tissue contraction in order to maximize tissue maturation.



Wolfgang: An Autonomous Mobile Robot for Outdoor Navigation

Aidan Cookson, Mark Landergan, Sean O'Neil

Advisor: William Michalson; Co-Advisor: Xinming Huang

Abstract

The goal of this project was to design and implement an autonomous robot capable of competing in the 2019 Intelligent Ground Vehicle Competition. The competition outlined several technical requirements including: lane detection and holding, obstacle avoidance, path planning, and GPS navigation. To achieve these tasks a Husky A100 platform was retrofitted with a more powerful computer and integrated with sensors such as a LIDAR, Camera, Satellite Compass, IMU, and GPS. A software architecture was developed based on Robot Operating System to reliably perceive the course lanes and obstacles, localize the robot through sensor fusion, and guide it through each waypoint.

MQP 3

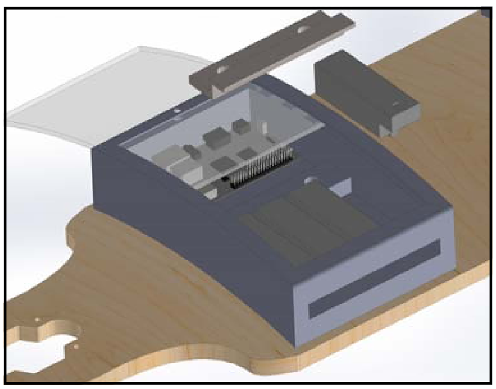
Modular Electric Skateboard (MESB)

Nicholas Fajardo, Phillip Konyeaso, Zane Weissman

Advisors: Craig Putnam, Susan Jarvis

Abstract

The Modular Electric Skateboard (MESB) allows the user to attach components tailored to specific demands. The MESB is equipped with two motors controlled by a handheld RC controller and is capable of achieving speeds as high as 20 mph. The deck can be disassembled and reassembled by hand to swap out major mechanical components of the board. The board's electrical system includes an apparatus for mounting hot-swappable accessories, which can communicate to a database. A front end application was implemented that reads and writes to the aforementioned database, allowing visualization of aggregate data.



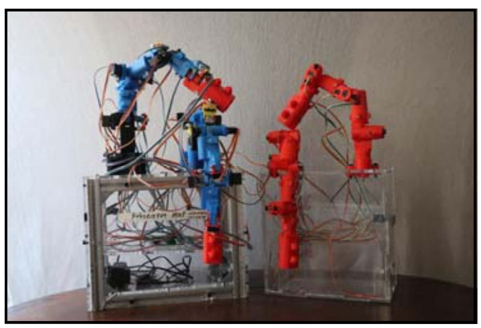
Telenursing RoboPuppet

Zachary Caplin, Ryan Kennedy, Grant Zahorsky

Advisors: Zhi (Jane) Li

Abstract

The Tele-Robotic Intelligence Nursing Assistant (TRINA) assists nurses working with infectious patients by performing highly repetitive tasks. The project focused on fabricating a new version of the 2017-2018 Telenursing RoboPuppet through the addition of motors and sensors that provide haptic feedback to the user while simultaneously resisting gravity when the user releases the device. The addition of a simulation environment to visualize the forward/inverse kinematics as well as fully functioning hand controls for TRINA allows for a more user friendly working system. This article discusses the process of the fabrication and implementation of the circuitry, hardware, and programming for the first iteration of the active version of the Telenursing RoboPuppet.



MQP 5

Sailbot 2018-2019

Sydney Fisher, Sierra Palmer, Kellen Randall

Advisors: Kenneth Stafford, William Michalson

Abstract

The goal of this MQP is to create an autonomous sailboat, known as "The Wide Awake", that builds upon lessons learned from the previous Sailbot projects. The team used the International Robotics Sailing Regatta (IRSR) rules to guide the creation of the boat for the 2019 competition. These guidelines included, but were not limited to, the following challenges: precision navigation, fleet race, and endurance. The final products of this MQP were a more mechanically and technically reliable boat, a better navigation system, and a user friendly guide on how to run and manage "The Wide Awake".

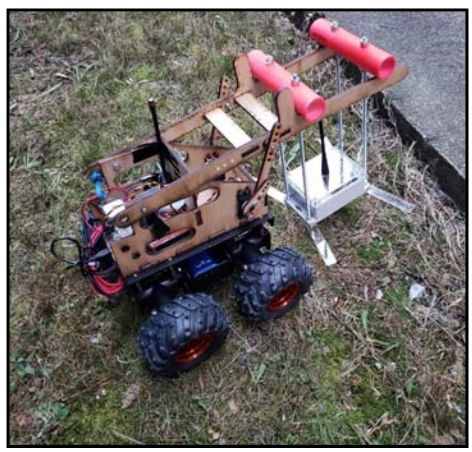
Agriculture SWARM

Anqi Shen, John Stegeman

Advisor: Michael Ciaraldi; Co-Advisor: Nicholas Bertozzi

Abstract

This project aimed to help farmers improve crop production, in order to feed the world with limited resources. With the surge of the Internet of Things devices and ever smaller, more power efficient, cheaper electronic components, farmers can accurately measure micro-climate conditions and thus manage their fields more effectively. Our project continued the work of a previous MQP team to develop an Internet of Things SWARM agriculture system that would allow farmers to monitor environmental conditions in their fields with sensor Nodes and manage and maintain the Nodes using autonomous Rovers. The battery-powered Nodes collect temperature, humidity, light levels, and air quality to give insights into the growing conditions in the fields. The Rovers pick up, carry, and place Nodes autonomously so that the farmer does not need to worry about placing and recovering the Nodes manually. With the developed system, farmers would be able to accurately assess conditions in their fields at a low cost.



MQP 7

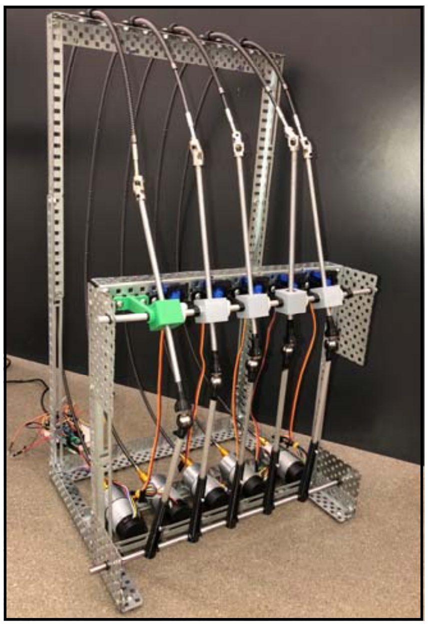
Soft Matter Manipulation

Mingqi Shuai, Michelle Zhang

Advisors: Marko Popovic, Zhi (Jane) Li

Abstract

While the automation of planar sewing is a rather mature technology, the automation of sewing in three-dimensional space is still a challenging task to accomplish and is mostly done by human workers in factories. Our project researches into automating the sewing process by designing a system for soft matter manipulation. We proposed a design that utilizes a symmetric pin system that consists of a set of motorized top pins and passive bottom counter-parts. The system has two degrees of freedom and is able to form complex curves in three-dimensional space. Our project is subject to future iterations to make it compatible with new technology used in factory processes.



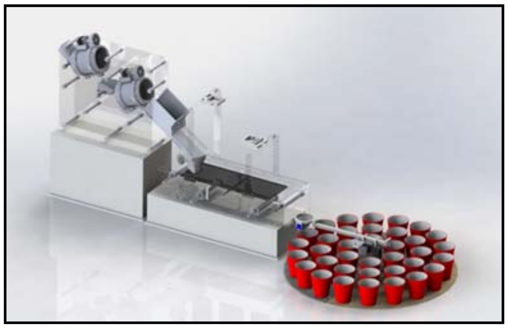
A.I. LEGO Sorter

Peter Donaldson, David Jin, Andrew Schueler

Advisors: Craig Putnam, Brad Miller

Abstract

The goal of this Major Qualifying Project is to develop a robotic system to autonomously separate, identify, and sort a multitude of LEGO pieces. The solution developed is a three-part sorting apparatus which utilizes complex mechanical design, computer vision (CV), and convolutional neural networks (CNNs) to serialize, classify, and distribute hundreds of unique part combinations. The completed mechanism is capable of processing a large input of unsorted components and fully sorting them by user-defined metrics.



MQP 9

Lionfish Bot 2.0

Alexander Antaya, Katharine Conroy, Eric Peterson, Thomas Ralph

Advisors: Susan Jarvis, Brad Miller, Craig Putnam

Sponsor: Robots in Service of the Environment (RSE)

Abstract

The Lionfish MQP team has worked with Robots in Service of the Environment (RSE), a subsidiary of iRobot, in order to improve their existing computer vision, electrical panel and intake mechanism systems on their lionfish capturing robot. The team created an object detection model that can identify the location of lionfish within a video, keeping into consideration hardware limitations, the model was optimized for mobile computing. This model could eventually be used by the RSE team to automate the capturing of lionfish. Next, the RSE robot has two electrical panels which are used to stun the lionfish before it is captured. The team researched and tested different configurations of panels and through this, recommended a design that would increase the effectiveness of the electrical panel system. Finally, the team developed an alternative to the existing lionfish intake mechanism on the RSE robot. The mechanism utilizes two cleated conveyor belts that work in tandem to gently ingest lionfish into the robot. We believe this research can be applied to help eradicate the invasive lionfish population in the Atlantic Ocean.

Oddisy Drone Dispatch System

Noah Hillman, Nick Sorensen, Marek Travnikar, Steven Viola

Advisors: Nick Bertozzi, Reinhold Ludwig, Brad Miller, Carlo Pinciroli

Abstract

Commercial applications that require autonomous air platforms are becoming more prevalent, however there is a lack of commercially available ground stations that enable remote takeoff and landing. This project served to design and fabricate a ground station and a custom UAV interface to allow remote landing, storage, and takeoff of autonomous drones for commercial applications. This included hardware in the base station responsible for charging and protecting the drone with a weatherproof enclosure for storage. The drone is autonomously controlled using a high accuracy GPS combined with custom control software to follow flight paths and land within the ground station. The drone is extendable and can mount various standard sensor suites to serve a wide range of commercial applications.

MQP 11

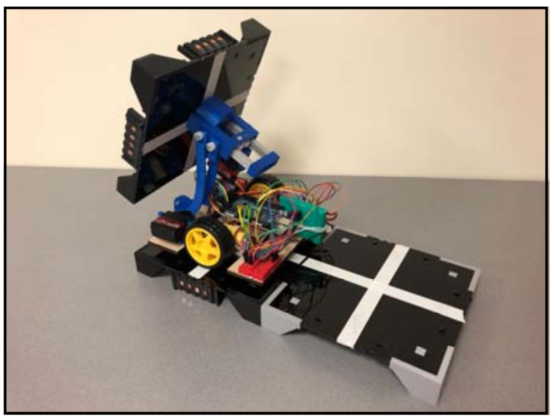
Swarm Construction with Intelligent Scaffolding

Albert Enyedy, Felix Sanchez

Advisor: Carlo Pinciroli

Abstract

Swarm robotics would aid construction by utilizing a distributed network of robotic workers cooperating to accomplish a larger task. Our system uses a network of intelligent scaffolding blocks to direct a simple manipulator robot to construct two dimensional structures from dedicated building blocks. This project incorporates a processing network, heterogeneous swarm intelligence, and magnetic block manipulation to accomplish this goal. Each intelligent scaffolding block supervises the robot within a radius in order to maintain a simple communication protocol throughout. The manipulator robot adheres to commands from the intelligent scaffolding blocks for path planning and block placement.



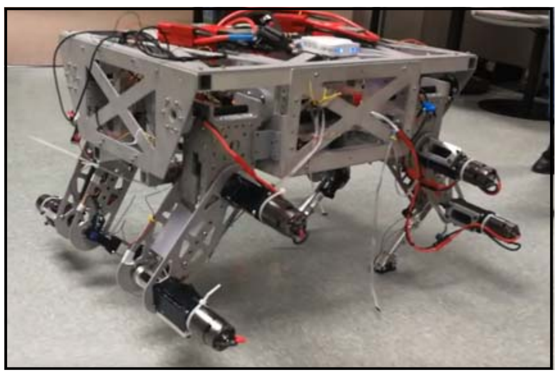
Walking Quadruped

Nicole Franco, Nicoli Liedtke, Danny Lu

Advisors: Craig Putnam, William Michalson, Gregory Fischer

Abstract

The goal of this project was to continue developing a functioning quadrupedal platform for the WPI robotics department. The quadruped is a forty-pound robot with four independently moving legs built by a previous MQP. This project consists of testing and implementing motion control systems. The primary goal of the project was to ensure that the robot quadrupedal chassis build by a previous MQP could move stability and intelligently so that it can be useful for future projects. Three main motion gaits were studied, a crawl gait, a walking gait, and a turning gait. The project implemented stable motion for the three gaits mentioned. In addition, the team also made significant system design improvements in the structure, electrical circuit, and code.



MQP 13

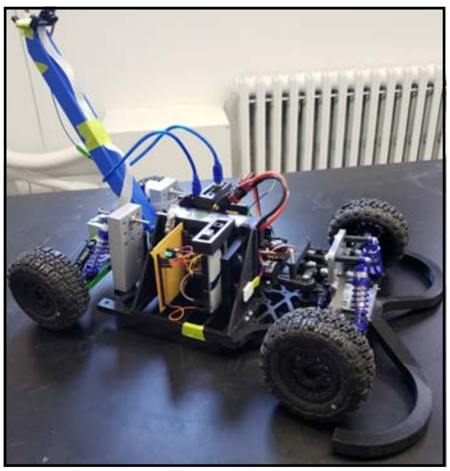
Autonomous Scale Car Using Computer Vision and Neural Networks

Mitchell Curbelo, Ryan Darnley, Ava Karet, Krishna Madhurkar, Dylan McKillip, Ethan Schutzman, Christian Scillitoe

Advisors: Pradeep Radhakrishnan, Kaveh Pahlavan

Abstract

This project explores the feasibility of creating an autonomous 1:10 scale car capable of racing against RC cars on any indoor track. Prior to conducting autonomous testing, a custom made scale car was designed and manufactured. Comprised mainly of 3D printed parts, the car had rear-wheel drive with passive independent front and rear suspensions. To enhance the car design, tachometers, strain gages, temperature sensors, and an inertial measurement unit were integrated to monitor vehicle performance. The obtained data from all sensors were displayed in real time on a webpage. For autonomous navigation, the car leveraged Artificial Neural Networks to produce optimal driving outputs. Taking grayscale pixel input from a single, front-facing camera, the car down-sampled and masked the input data to locate brown walls. Without relying on mapping or localization, the car collected high quantities of training data to navigate variable track conditions. Ultimately, the training produced a car that could perform partial laps under its own control.



Autonomous RC Car Platform

Jason Ashton, Sean Hunt, Myles Spencer

Advisor: Jie Fu; Co-Advisor: Michael Gennert

Abstract

This project explores building an autonomous research robot on a 1/10 scale RC car platform. The goals of the project were to build an easy to use system that allowed for the exploration of techniques such as localization, object detection, mapping, and more. The completed robot consists of a self-contained RC car, running on battery power, that uses a camera, lidar, inertial measurement unit, and other sensors to observe the environment. Completed research explored pose estimation based on combining dead reckoning, inertial measurement unit readings, and visual odometry in an Extended Kalman Filter. The result of this project included the RC car and a build guide on replicating the process for future students.

MQP 15

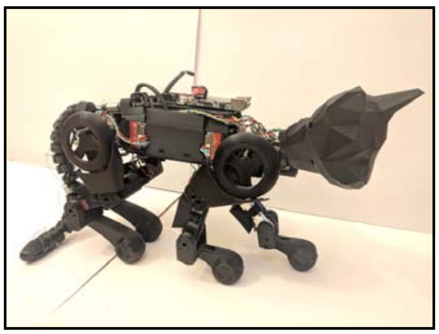
SmallKat

Keion Bisland, Xavier Little, Alex Tacescu

Advisors: Nicholas Bertozzi, Loris Fichera, Gregory Fischer, Brad Miller

Abstract

SmallKat MQP will develop a small robotic quadruped for research and development purposes. It will be designed with 4 degree-of-freedom (DoF) legs, a continuum tail, and 3D printed body and construction. This will all be powered by custom servo motor controllers and 9DoF IMU sensors, all connected to a custom embedded SPI daisy chain protocol running on a custom microprocessor. The higher level controller will be running on a single-board computer for added performance when running kinematics and dynamics algorithms. To prove its capability, a basic walking gait will be developed. Eventually, SmallKat will be used by academic institutions, corporations, or hobbyists that are interested in further developing multipedal robotics platforms. Since SmallKat will be open sourced, anyone will be able to modify both the software and hardware to their need. This opens up possible future research opportunities, including but not limited to new gaits for quadrupedal platforms, continuum spines and necks for more mobility, and psychological research in the effect of robotic pets for mentally disabled citizens. An inexpensive quadrupedal platform will decrease the barrier of entry in robotics and allow for more innovation in the field.



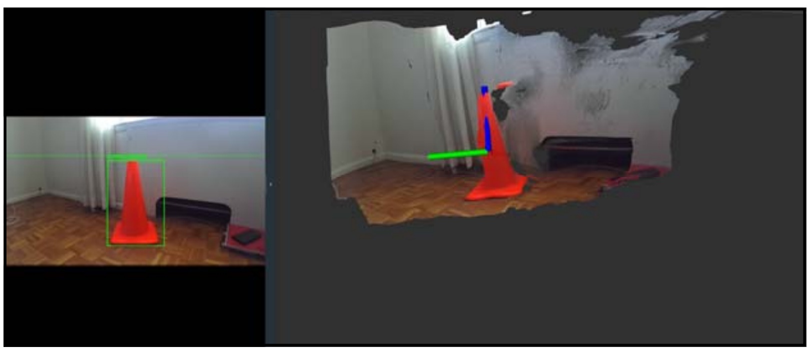
K.O.L.T.: Known Object Localization and Tracking

Nathan Rosenberg

Advisor: William Michalson

Abstract

An important task performed by many robots is detecting, localizing, and tracking objects in the environment. All sorts of robots—from humanoid robots to autonomous cars and drones—need to be able to find objects around them and track their location. KOLT delivers a drop-in solution to this problem. A software package build for ROS, KOLT consists of a deep neural network for object detection in RGBD images coupled with a Kalman filter for tracking and filtering of detecting objects. The ultimate goal is to develop a drop-in solution for most vision tasks that roboticists encounter.



MQP 17

Robot Tour Guide

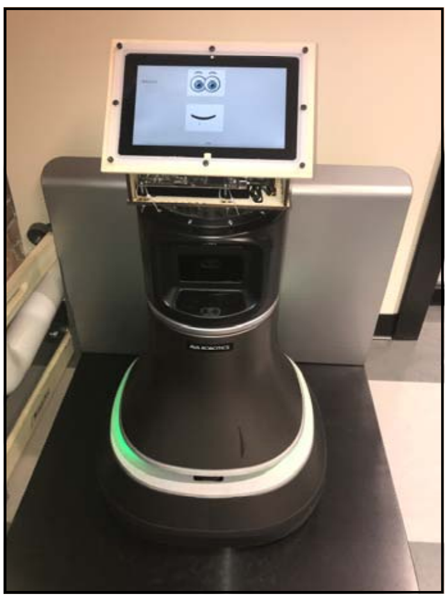
Henry Dunphy, Zoraver Kang, William Mosby

Advisors: Jing Xiao, Gregory Fischer

Sponsor: AVA Robotics

Abstract

Our goal was to create a friendly robot that could safely guide a user through a building. On our way towards creating an end product we explored a number of fields including human robot interaction and robot navigation. Thanks to Ava Robotics, we used one of their first generation drive bases as the core of our robot, PAT. We mounted a "head," which contains a Jetson TX2 Module, a camera, and a touch screen for user interaction. PAT can take users through a set of destinations efficiently either from voice commands or its graphical interface. If PAT is stuck, it can detect obstacles and ask for help to remove an obstacle in order to continue guiding the user. We have accomplished a basic tour guide using Ava Robotics' base model, which created a stepping stone for future development.



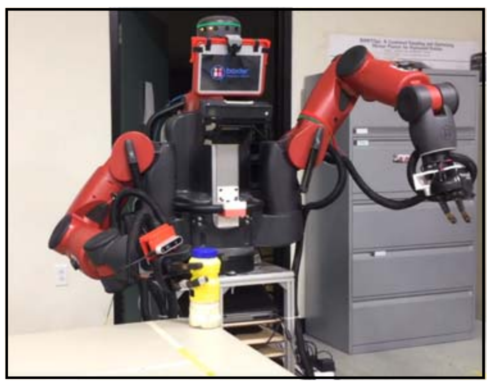
Object Manipulation and Control with Robotic Hand

Colin Buckley, Bhon Bunnag, Apiwat Ditthapron, Rebecca Miles

Advisors: Zhi (Jane) Li, Stephen Bitar, Loris Fichera

Abstract

From industrial robots to nursing robots, object manipulation has become a growing area of robotics research. This Major Qualifying Project explores methods of teleoperation through the use of a wireless data glove able to detect multiple degrees of freedom. Our project also explored methods for autonomous control, we developed a computer vision model by integrating two state-of-the-art Mask Region Convolutional Neural Networks (Mask-RCNN) models to create a final model for determining both object location and grasp angle. This allows the Baxter Robot to autonomously detect and reach towards the object. Using learning by demonstration, the robot can learn how to grasp and manipulate said objects.



MQP 19

Kinisi

Gabriel Entov, Lanhao Mao, Cassandra Pepicelli, Jonathan Tai, Samuel White, Cooper Wolanin

Advisors: Alexander Wyglinski, Hugh Lauer

Sponsors: SICK Sensor Intelligence, Pico Technology, Mitsubishi Electric Research Lab, WPI Society of Automotive Engineers

Abstract

This project proposed a modular system that would autonomize off-road vehicles while retaining full manual operability. This MQP team designed and developed a Level 3 autonomous vehicle prototype using an SAE baja vehicle outfitted with actuators and exteroceptive sensors. At the end of the team's work, the vehicle had a drive-by-wire system, could localize itself using sensors, generate a map of its surroundings, and plan a path to follow a desired trajectory. Given a map, the vehicle could traverse a series of obstacles in an enclosed environment. The long-term goal is to alter the software system to make it modular and operate in real-time, and so that the vehicle can autonomously navigate off-road terrain in order to rescue and provide aid to a distressed individual.

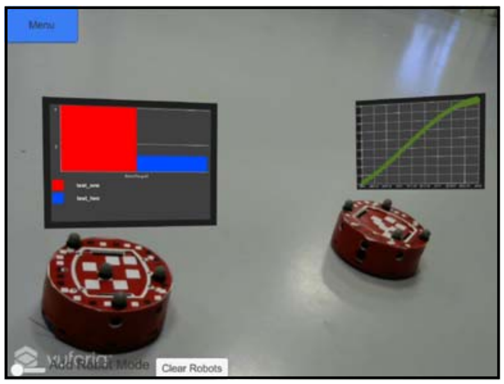
Diagnosing Robotic Swarms (Dr. Swarm)

Josiah Boucher, Jerry Brown, Erika Snow, Alexandra Wheeler

Advisors: Carlo Pinciroli, Lane Harrison

Abstract

Troubleshooting a robotic swarm can be a daunting task due to large quantities of information to sift through and many potential sources of problems. Currently there are no widely adopted swarm diagnostic systems. We developed Dr. Swarm, a mobile application which combines state of the art AR technology and existing visualization techniques to create a new kind of diagnostic tool for swarm robotics. Dr. Swarm enables developers to expose the behavior of swarm systems through intuitive visualizations and assists with troubleshooting swarm applications.



MQP 21

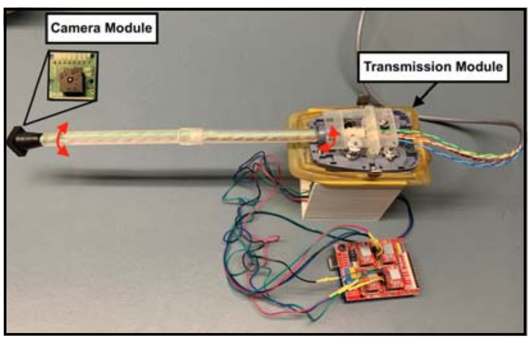
Thermal Infrared Endoscope

Matthew Collins, James Kradjian, Ryan St. Hilaire, Chenggu Wang, Wentao Yuan

Advisor: Loris Fichera; Co-Advisor: Gregory Fischer

Abstract

According to Intuitive Surgical's annual report of 2017, the da Vinci Surgical System was used in approximately 877,000 surgeries, and the number has been growing steadily over the years. During these surgical procedures, energy-based tools are frequently used to perform tasks such as cauterization, which means heating up tissue to coagulate blood vessels. However, use of these instruments poses a risk of spreading thermal energy to surrounding tissues and causing accidental damage to vital anatomy. To help mitigate this hazard, here we propose an infrared-based, minimally invasive thermal camera endoscope that can be attached to the existing instrument arms of da Vinci Research Kit (dVRK). This device will enable surgeons to monitor heat levels of surrounding tissue to reduce trauma secondary to heat. Our thermal endoscope consists of a set of modular tubes and independent transmission, allowing the camera to have a 180-degree view. Additionally, we incorporated real-time image processing of the camera stream through Raspberry Pi to provide thermal data to the surgeon in the form of a live hotspot and a display of the thermal image layer.



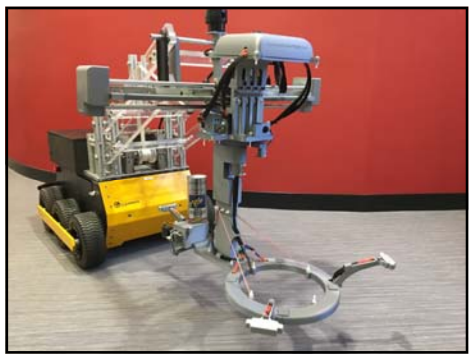
Autonomous Landmine Detection Rover

Dillon Arnold, Nicholas Lanotte, Benjamin Wagner, Dan Wensley

Advisors: Craig Putnam, Susan Jarvis, Nick Bertozzi

Abstract

Major engagements throughout modern history have left unexploded and unmarked anti-personnel landmines, which result in thousands of casualties each year. Current demining detection methods use sensors such as metal detectors or trained animals such as rats. This project will mitigate the threat to human life by substituting human operators with a robotic system. Building upon prior work, a rover and an octocopter drone will work in tandem to locate, mark and eliminate anti-personnel landmines in a user-defined location.



MQP 23

Firefighting Robot

Eva Barinelli, Jacob Berman-Jolton, Gavin MacNeal, Karina Naras, Yil Verdeja

Advisors: Carlo Pinciroli, Sarah Wodin-Schwartz, William Michalson

Abstract

Fire environments are dangerous and constantly changing. The goal of this project was to design and build a robot to provide firefighters with additional information about a fire environment to help them make more informed decisions when fighting a fire. We have built a prototype robot that is compact and quick to deploy, with a heat, water, and impact-resistant chassis designed to function in unpredictable firegrounds. The remote-controlled robot returns a real-time video feed and a heat map of a designated area in a building.

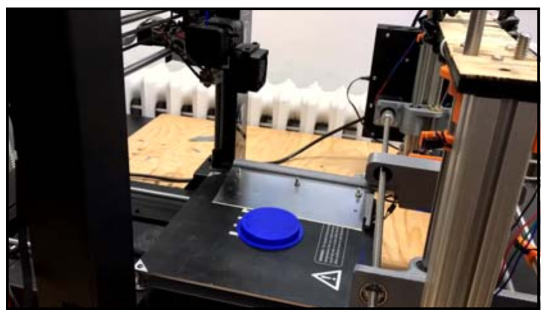
Increasing the Throughput of 3D Printers with Automated Part Removal

Brian King, Chris Kirven, Hussain Muhammad, Brian Sayers, Benjamin Secino, Baron Strasburger

Advisors: Pradeep Radhakrishnan, Mehul Bhatia

Abstract

Rapid prototyping is widely used due to the availability of high-quality low-cost 3D printers. To initiate the production process, the user uploads the G-code of the part to the machine. Upon completion, the user returns to the printer and manually removes the part. If the part removal is delayed, then the non-value-added time of the machine increases. This project proposes a new add-on system to automatically remove a part from the print bed thereby eliminating any idle time. This allows for subsequent parts to be printed without waiting for the user to return to the 3D printer. The design utilizes vertical and horizontal actuators working in tandem to place a scraper tool on the bed, scrape off the part, and home the tool out of the printer's workspace. Actuator motion is controlled with limit switches and a quadrature encoder. The machine is modular and able to fit several models of open-air 3D printers. Several parts have been successfully removed using this add-on system.



MQP 25

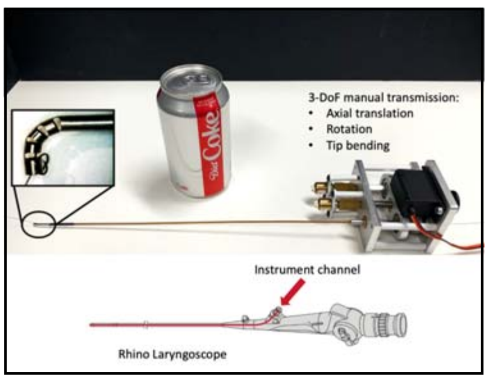
Super-elastic Continuum Robot for Endoscopic Articulation and Manipulation (SCREAM)

Zachary Boyer, Cory Brolliar, Benjamin Mart, Kevin O'Brien

Advisors: Loris Fichera, Gregory Fischer, Kenneth Stafford

Abstract

Office-based endoscopic procedures are an increasingly attractive option for the treatment of laryngeal tumors, but their effectiveness is limited by the restricted range of motions attainable by state-of-the-art surgical instruments. In this project, we propose a new ultra-thin dexterous manipulator made of super-elastic Nitinol intended to amplify a surgeon's manipulation capability during endoscopic procedures. Included with our tool is a graphical feedback system that offers intuitive visualization of the manipulator's configuration in real-time. The overarching goal of this research is to lay the groundwork for the creation of a new class of FDA-approved miniature steerable instruments for in-office laryngeal treatment.



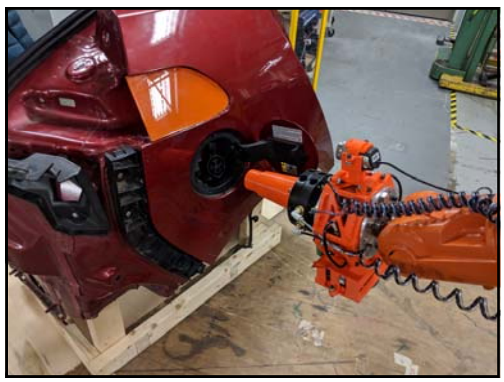
Automatic Vehicle Recharging Station

Matthew Fortmeyer, Nikolas Gamarra, Ryan O'Brien, Jacob Remz

Advisors: Craig Putnam, Jie Fu

Abstract

The goal of this project is to recharge autonomous electric vehicles by plugging them in to a charger, thus automating one of the last steps preventing a level 5 autonomous vehicle from being completely independent from human assistance. For this project we are using an ABB-IRB 1600 industrial robotic arm with a custom end effector. Our custom tooling has integrated force sensing and a tool change, allowing for switching between the tool capable of opening and closing the charging port and the tools for each of the two charging port standards (Tesla and J1772). To help us achieve this goal we implemented custom computer vision, point cloud processing software. These are all tied together into our system through the use of ROS and the ABB arm is controlled via ROS-Industrial. Ultimately, we were able to plug in our test vehicle using the ABB arm, there were issues with latency as well as with the reliability of the real time path planning features of ROS-Industrial.



MQP 27

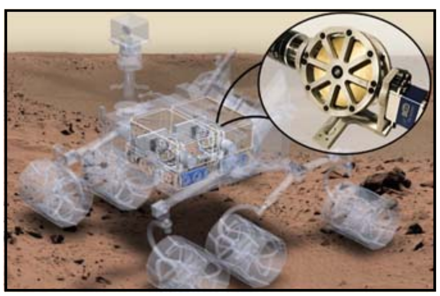
Developing a Modular Control Moment Gyroscope for Planetary Rover Mobility

Aidan Brawley, Stephen Burke, Fang Han, Oliver Sanderson, Jeremy Wiles

Advisor: Pradeep Radhakrishnan

Abstract

A control moment gyroscope (CMG) is a torque actuator typically used for spacecraft attitude control, but other applications of CMGs are seldom seen in practice. The goals of this project were to design, manufacture, and analyze a modular CMG for use in any application. The developed prototype consisted of a turned brass flywheel suspended in a servo-powered, aluminum gimbal structure; it was able to produce a nominal output torque of up to 6 Nm. A microcontroller was used to simulate CMG dynamics, control the motors, and calculate performance metrics. Quantitative analyses were conducted for the behaviors of the motors, dynamic disturbances in the system, and stresses in the structure. To further validate the design, its output torque performance was evaluated against a theoretical CMG model developed in Simulink. Subsequently, to exemplify the prototype's modularity, its use on planetary rovers for rollover prevention and recovery was substantiated through computer simulations; rollover recovery was also physically demonstrated. These applications aimed to address NASA's Space Technology Grand Challenge of "All Access Mobility", which identifies the need for next-generation rovers to safely traverse any terrain type.



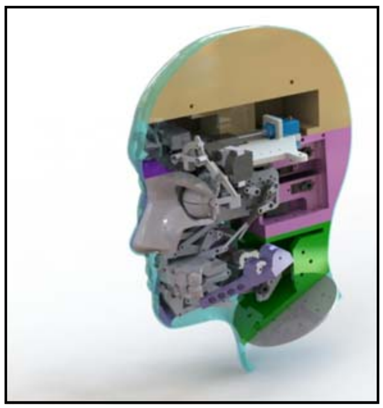
Development of a Modular Animatronic Head

Matthew Dick, Owen France, Richard Hosea, Kevin Le, Rachel Lia, Patrick Meehan, Kyle Seymour

Advisor: Pradeep Radhakrishnan

Abstract

Innovation in the field of animatronics has been driven primarily by the entertainment industry designing highly specialized and expensive systems. To make animatronics more commonly used and low cost, multi-use and cost-effective animatronics must be developed. Through this project, a modular animatronic head has been developed that can be configured for various applications ranging from entertainment to medical training. The head uses linkage-based mechanisms, designed in 3D modeling software, prototyped using 3D printing, and driven by micro-servo motors. Motions of features of a human head, such as the eyes, eyebrows, and mouth have been replicated. Additionally, a silicone skin with connection nodes to interface with the linkages was cast from a mold of the head. These mechanisms have been designed to scale to different sizes and to accommodate variations in spacing of the human features that have been replicated. The structural integrity of the linkages were tested using finite element modeling. Motion capture data from a human was compared with the simulation and prototype to verify replicated movements. Different expressions have been programmed to replicate facial gestures. Details of design, prototyping, and analysis will be discussed in depth in the report.



MQP 29

Rehabilitative Arm Exoskeleton

Eric Carkin, Parker Grant, Bryan Therrien

Advisors: Marko Popovic, Stephen Bitar, Joseph Stabile

Abstract

The Rehabilitative Arm Exoskeleton project aims to assist those in need of support when trying to perform daily tasks. Specifically, the group chose to target those afflicted by Muscular Dystrophy, and to address the need for independence during the act of eating. In order to accomplish this, a motorized linkage system capable of supporting a person's arm proof of concept was developed. In implementation, the device would be attached to the user's battery powered wheelchair, and be available to them whenever needed. The system uses a collection of force sensing devices (collectively dubbed the "NUB") in order to detect user intent. With the information gathered by this sensor interface, the system can position the five degree of freedom linkage, and subsequently the user's arm, anywhere within the work space, thus enabling the user to have independent control of their arm once again.

Investigation of UCL Tears in Baseball Pitchers

[Non-judging Presentation]

Maddie Brennan, Steven Gallagher, Ben Kurtze, Paula Sardi

Advisors: Marko Popovic, Selcuk Guceri

Abstract

Tearing of the ulnar collateral ligament (UCL) is one of the most common injuries for baseball pitchers. During a pitch, the UCL experiences high levels of stress between the cocking and acceleration phase due to a valgus moment. Because this stress cannot be directly measured in vivo, a pitching robot with numerous biomimetic features was created to gain a better understanding of these forces during a fastball pitch. This robotic research platform was then used to design a brace that reduces the amount of stress the ligament undergoes, prolonging the play time for athletes. The robotic arm in the form of a human skeletal replica features seven independently pneumatically actuated Hydro Muscles and a biomimetic UCL. The effectiveness of the brace was validated by interfacing it with the robotic arm and measuring the forces on the artificial UCL throughout the pitching phases.

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