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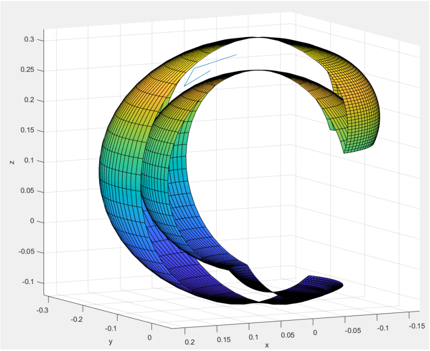
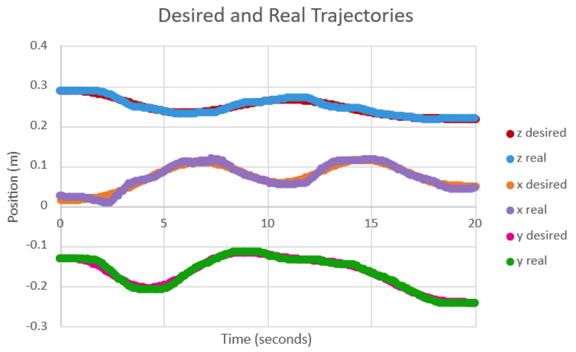
## NAO Robot Arm Trajectory Generation and Motion Control

*University of Waterloo - Robotics Dynamics and Control Course*

*NAO v6 robot*



*Limits of right hand end effector in 3D Cartesian space, and four points defining a tested trajectory*




*Desired vs real trajectories of robot arm in x, y, z*

**What:**

- Control the end-effector of a NAO V6 robotic arm to follow a complex trajectory accurately, with 3 degrees of freedom (DOF).

**How:**

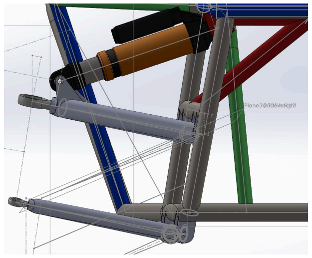
- End effector limits were identified with forward kinematics, and appropriate target points were selected. A minimum jerk trajectory was generated.
- First-pass joint torques were determined with an inverse dynamics control and an arm simulation. The gains were refined and the joint torques were optimized with the real robotic arm.

**Result:**

- Accuracy requirements were met, and the arm successfully followed the trajectory.

## Front Suspension Design for Off-Road Vehicle

*University of Waterloo - Baja SAE Team*



*Suspension, front view*


*Support structure*

**What:**

- Design front suspension of an all terrain vehicle to withstand an instantaneous force of 3200 N per wheel with a yield safety factor of 1.2.
- Numerous constraints - building on pre-existing structure, accommodating future parts, competition rules and more.

**How:**

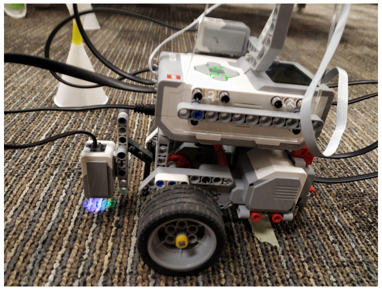
- Extremes of the possible suspension positions were identified to derive resultant design load cases.
- Used Solidworks FEA to simulate preliminary designs under design loading conditions.
- This led to the addition of support structure to prevent buckling and refinements to facilitate ease of manufacturing.

**Result:**

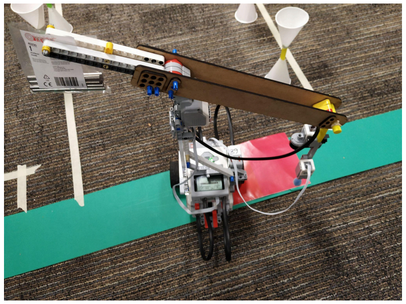
- Final design withstood loads while also satisfying all constraints.

## Flower Pollinator Robot Prototype

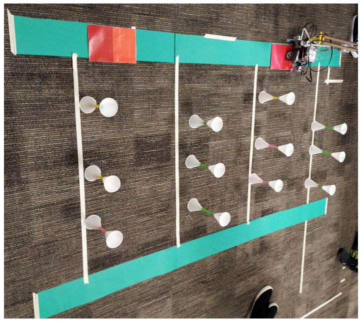
*University of Waterloo - Introduction to Mechanical Engineering Practice course*



*Pollinator robot, side/bottom*



*Pollinator robot, above/behind*



*Pollinator robot on a trial course flower bed, with fake flowers of varying heights*

**What:**

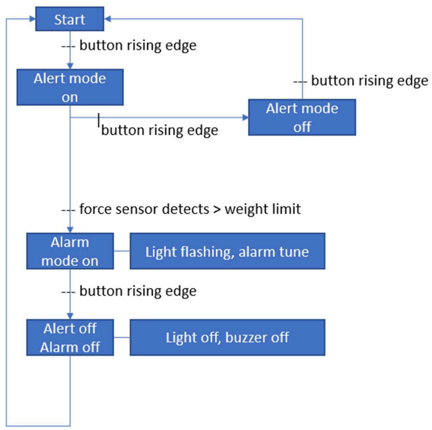
- Create a Lego Mindstorm EV3 robot to pollinate flowers.

**How:**

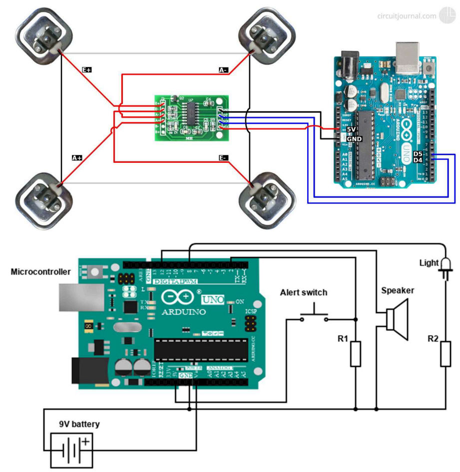
- The robot is moved forward with two motors until an ultrasonic sensor detects a flower.
- The robot arm lowers the pollen attachment until a touch sensor contacts the flower. A color sensor was used to detect the bounds of the flower bed.

# Kelp Harvester Alert System Prototype

*University of Waterloo - Capstone Project*




*Simplified state diagram*




*Load cell setup (top), circuit exclusive of load cells (bottom)*

*Harvester prototype*

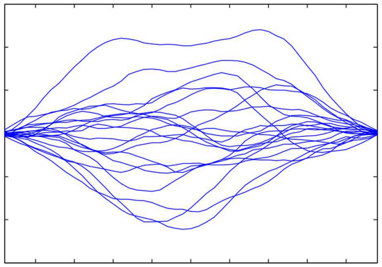
## What:

- Created a kelp harvesting system designed for installation on boats, with an alert system for kelp bin fullness.

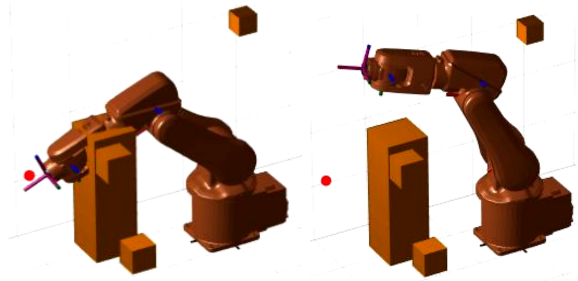
## How:

- An Arduino UNO microcontroller was programmed in C++ to process sensor data and provide control signals.
- Four load cells detect bin weight. They were wired, then soldered to a voltage signal amplifier. Pins were soldered to the amplifier to enable breadboard prototyping.
- LEDs and buzzers connected to the system indicate “ready” and “ threshold weight detected” states.

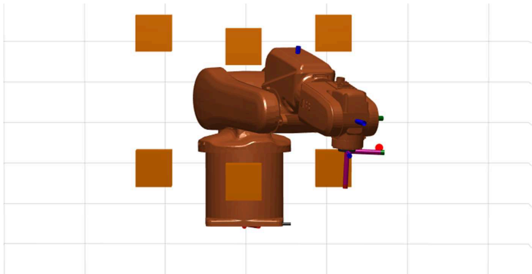
## Implementing STOMP Algorithm for Robot Arm Obstacle Avoidance
*National University of Singapore - Human Robot Interaction Course*



*Variance of a joint path in STOMP algorithm*



*Arm on partially optimized trajectory colliding with object (left), fully optimized trajectory (right)*



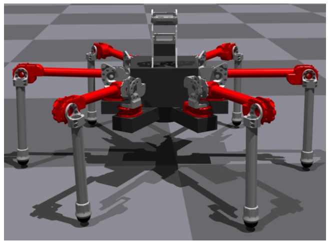
*Robot arm completing second obstacle scenario*

**What:**
- Move the end effector of an ABB IRB 6 DOF MATLAB robot model between positions while avoiding collisions with obstacles

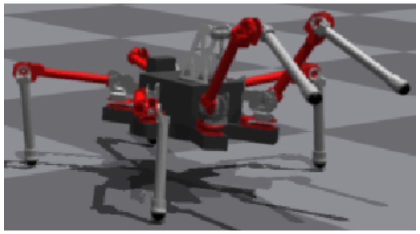
**How:**
- Achieved by implementing STOMP (Stochastic trajectory optimization for motion planning) algorithm to find optimized trajectories.

**Result:**
- The arm successfully completed two obstacle avoidance scenarios, which included additional constraints on EE position and orientation

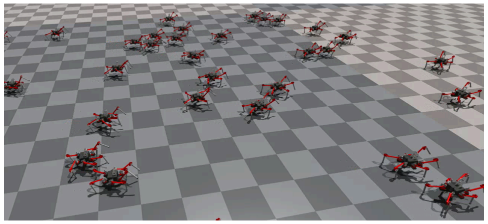
## Training Hexapod Robot with Machine Learning
*National University of Singapore - Machine Learning in Robotics Course*



*Hexapod robot standing in Isaac Gym physics simulation*



*Hexapod robot ready to push an object*



*Multiple hexapod robots training in parallel*

**What:**
- Train a six-legged robot to walk on four legs, with two legs positioned to push an object in an Isaac Gym physics simulation.

**How:**
- This was accomplished via reinforcement learning, programmed with Python and run on a Linux OS.
- After testing, four layer structures were used for the actor and critic neural networks.

**Result:**
- The robot was able to walk to the goal positions with its two pushing limbs posed correctly.