GroceryBee 🐝

Group T2323
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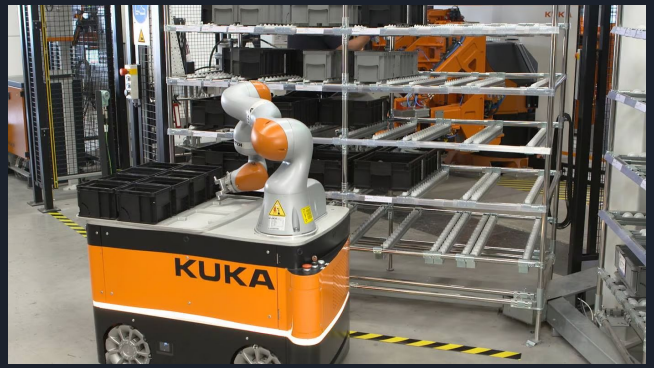
Background Information

- Surge in the number of online grocery orders
- Turkey’s online supermarket sales grew by 434% in 2020
- US: 70% of shoppers state they would buy groceries online by 2022
- GroceryBee: automate & expedite online shopping process
- Collect items from shelves

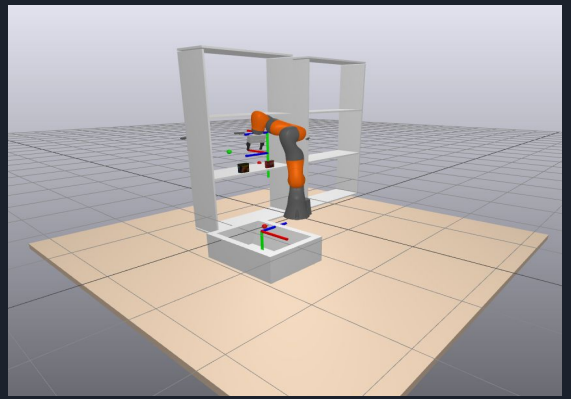
Background Information

- Improve current developments: sustained innovation
- Transformation of system (humans -> robots) to optimize gathering items
- Emphasize process type of innovation: aim to enhance inner processes of markets
- Assume an existing system receives and relays the order info to robot
- Delivery will be done by store employees
- Our project: focus on traversing store, collect items



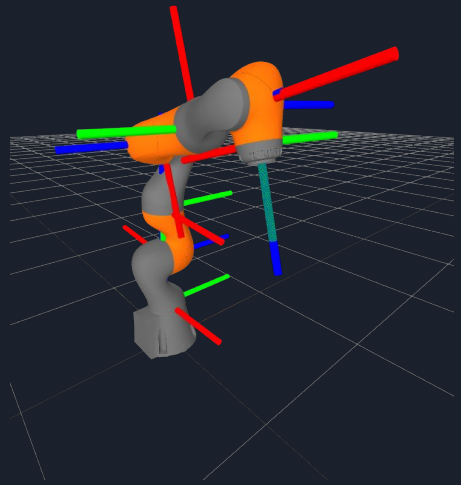
Project Plan

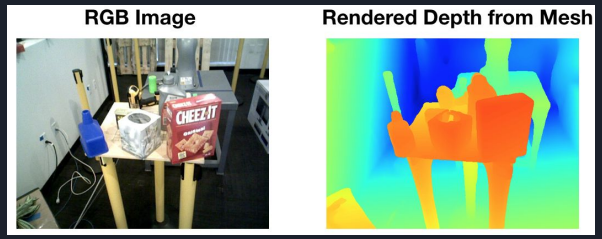
- Collect items for online orders
- Navigate the supermarket without crashing
- Detect object, pick object up with gripper, bring object back for delivery
- Calculate optimal path to collect orders



Proposed System

- Make sequential decisions in an uncertain environment
- Not possible to plan everything beforehand
- Perception and motion planning problems
- Estimate pose of objects
- Exploit real time information from RGBD cameras
- Differential inverse kinematics, ICP
- Deep learning - used to segment item from window of frames

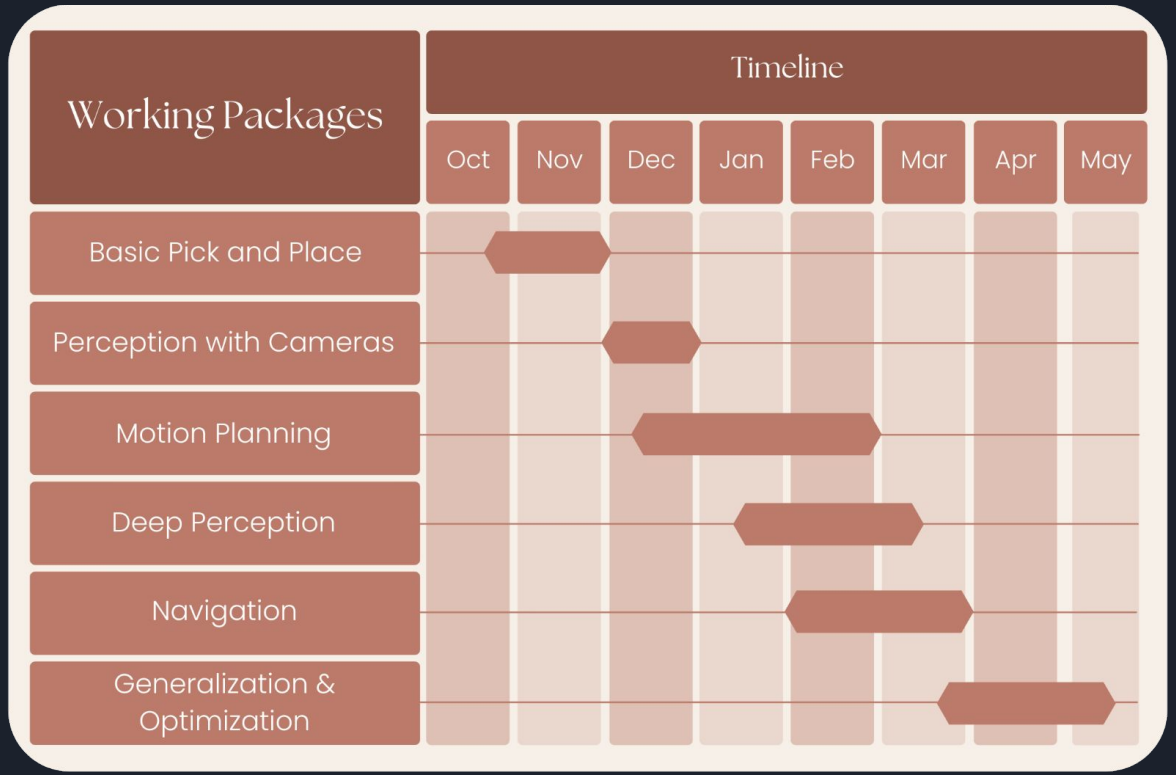




Used Technologies

- Drake—C++/Python toolbox for Robotics
- Allows users to create virtual simulations
- Includes a range of algorithms and functions
- Has tools for sensing and perception
- Extensive math packages
- Physics engine

Gantt Chart

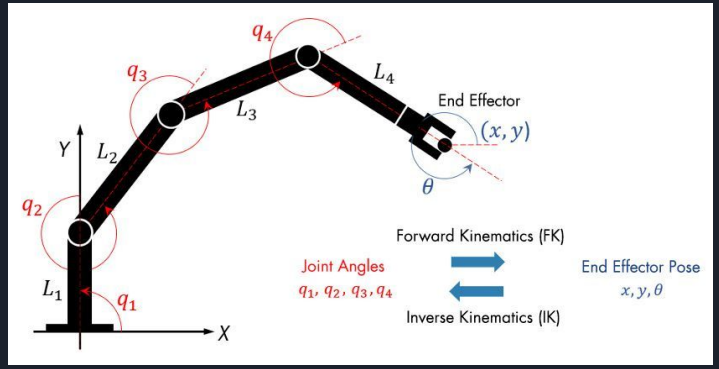

Working Packages
Timeline
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Basic Pick and Place
Perception with Cameras
Motion Planning
Deep Perception
Navigation
Generalization & Optimization

Current Motion Planning

- Forward kinematics: calculating gripper pose from joint angles
- Inverse kinematics: calculating the joint angles to achieve a desired gripper pose
- Differential inverse kinematics (DiffIK)
- Constrained optimization

$$V^G = J^G(q)v.$$

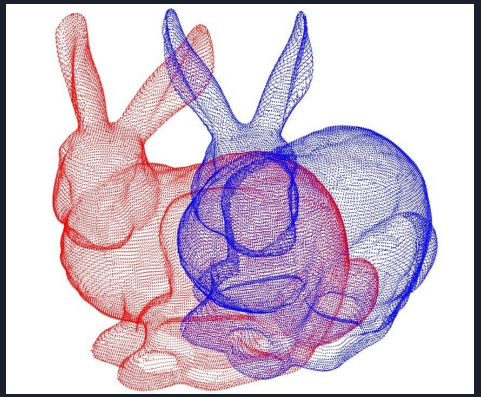
$$\begin{aligned} \min_{v_n} \quad & \left\| J^G(q)v_n - V^{G_d} \right\|_2^2, \\ \text{subject to} \quad & v_{min} \le v_n \le v_{max}, \\ & q_{min} \le q + hv_n \le q_{max}, \\ & \dot{v}_{min} \le \frac{v_n - v}{h} \le \dot{v}_{max}. \end{aligned}$$



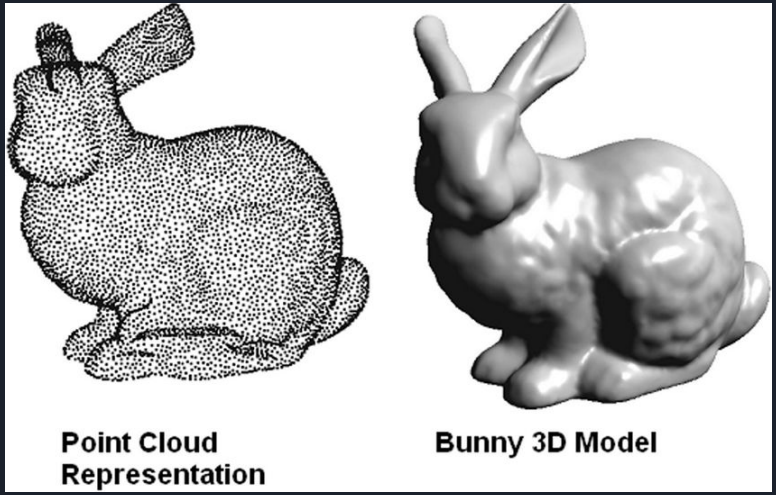
Current Perception

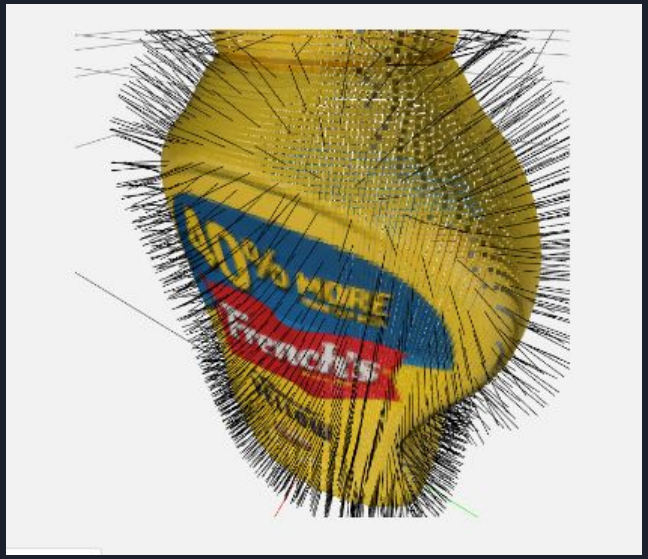
- Firstly: picking up objects with known positions
- Now: Use information received from RGB-D cameras
- Calculate point-clouds, use ICP (iterative closest point) to match objects with perceived objects
- Find gripping points
- Pick up object and place object in bin

$$\forall i, \hat{c}_i = \operatorname{argmin}_{j \in N_m} \| \hat{X}^O \, {}^O p^{m_j} - p^{s_i} \|^2.$$



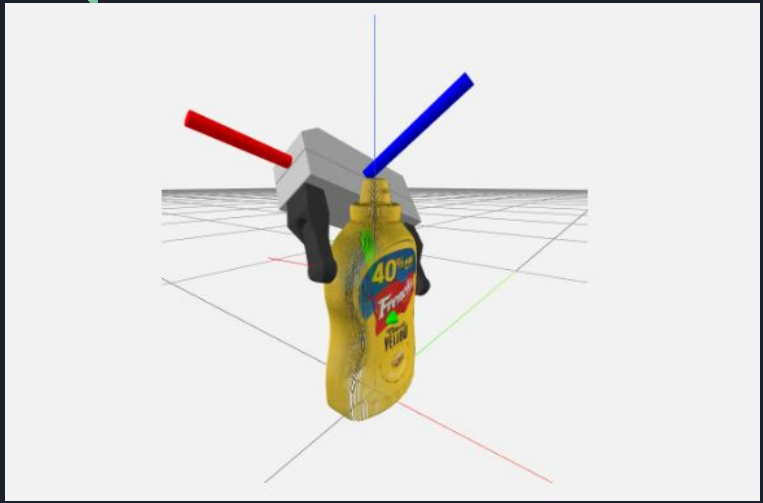
Current Perception

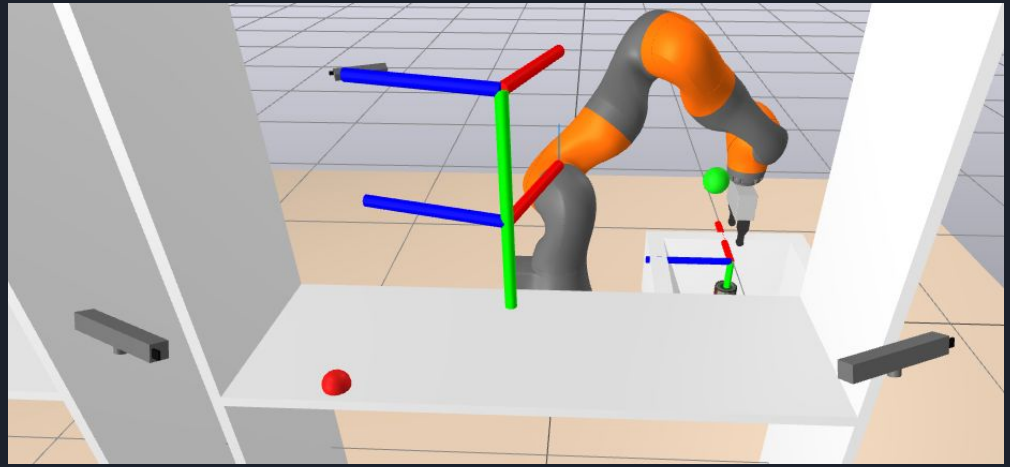




Normal vectors of a sample object for surface curvatures

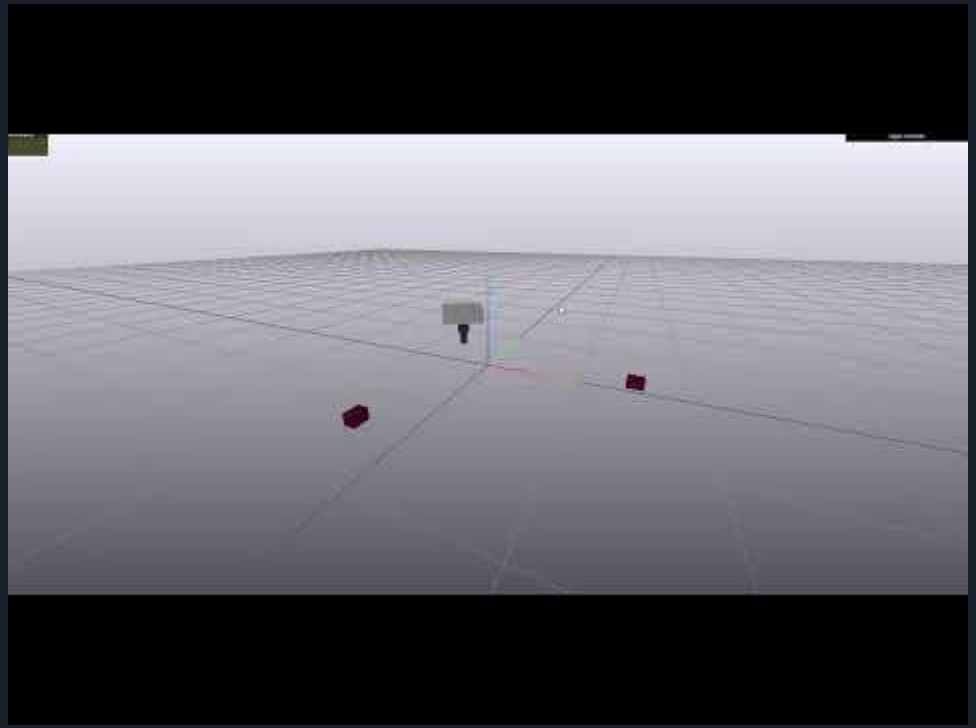
Current Perception

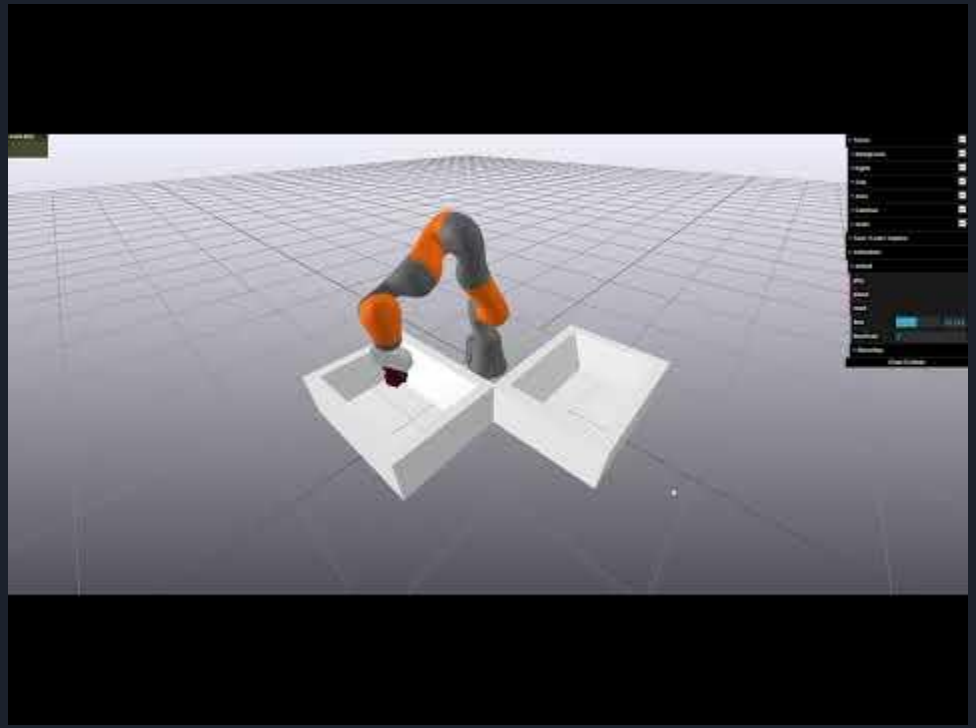


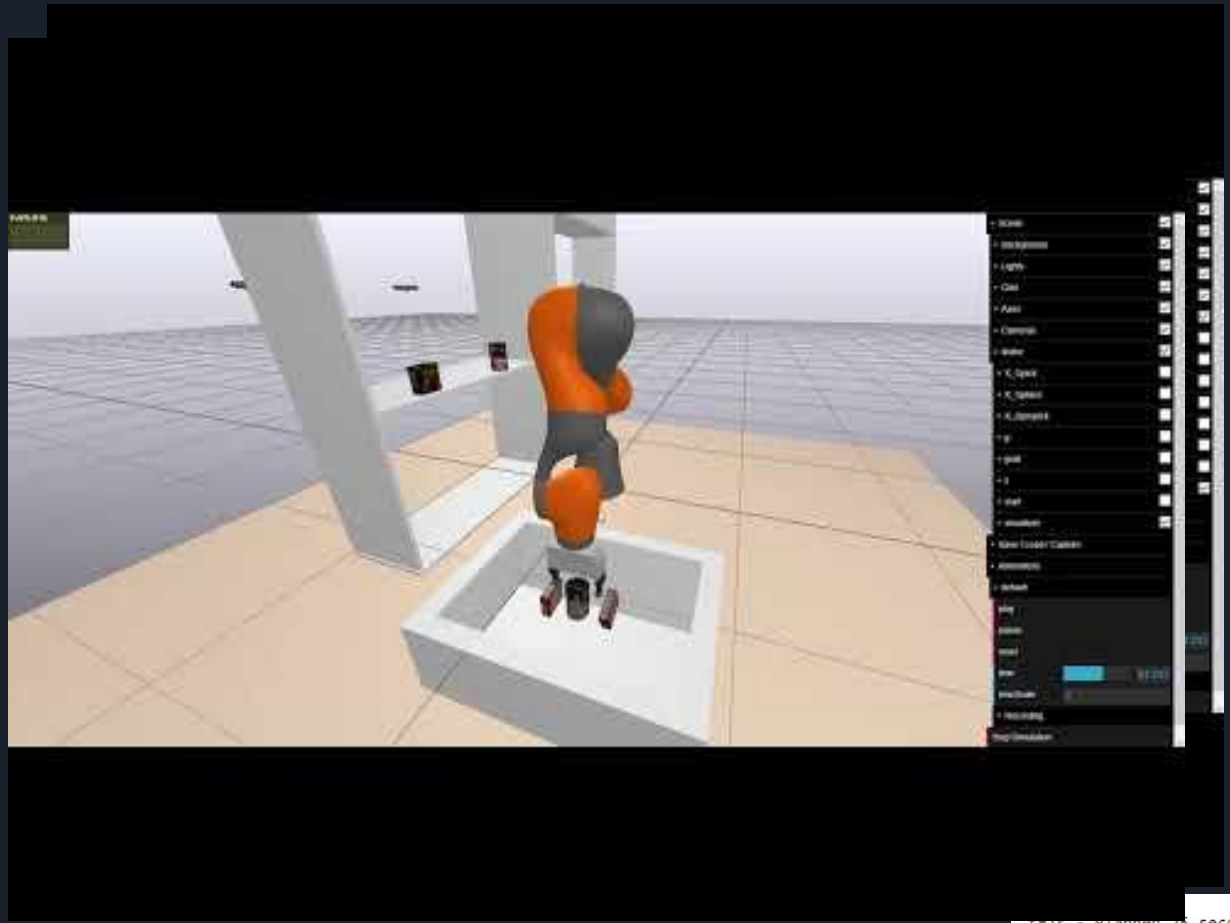


Select random points from point cloud for gripping

DEMO







t=1s - Planned 25 seconds trajectory for picking from the shelf.
t=27s - Planned 31 seconds trajectory for picking from the shelf.
t=58s - Planned 32 seconds trajectory for picking from the shelf.
t=91s - Planned 33 seconds trajectory for picking from the shelf.
Could not find a valid grasp in either bin after 5 attempts

Next steps

- Creating a supermarket environment
- Making the robot mobile
- Navigation and decision making algorithms
- Deep learning for object detection

Thank you for listening