BUMPKIN

Final Update

Team 6A - MART

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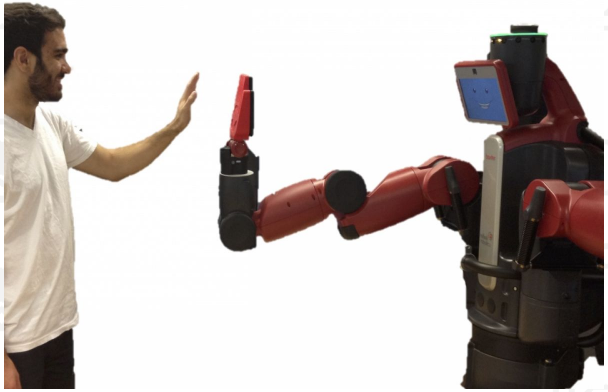
Motivation & Problem Statement

Make human-robot collaboration more natural and provide robots with characteristics that make them more sociable

Goal: Robot will detect a fist, track it in real time, and move to give it a fist bump with reasonable force

Problems addressed

- Detecting PoI (closest fist) in a cluttered environment
- Tracking PoI from one frame to the next
- Dynamic planning to ensure smooth motion to constantly changing setpoints
- Safe interaction with environment by limiting maximum force applied



Human Robot Interaction - UPenn GRASP Lab

Robot assisting in a Manufacturing Task - ResearchGate

Approach

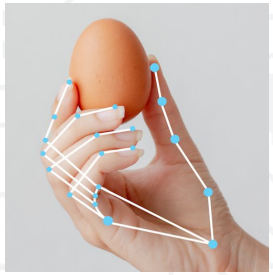
Perception Stack

Detect hands
Focuses on closest hand (PoI) to ego
Tracks PoI across frames

Transform fist PoI centroid in image coordinates (u, v) to 3D pose in world frame (origin at robot base)

Planning/Control Stack

State Machine
Continuously get new PoI pose
Dynamic execution
Impedance control to make contact



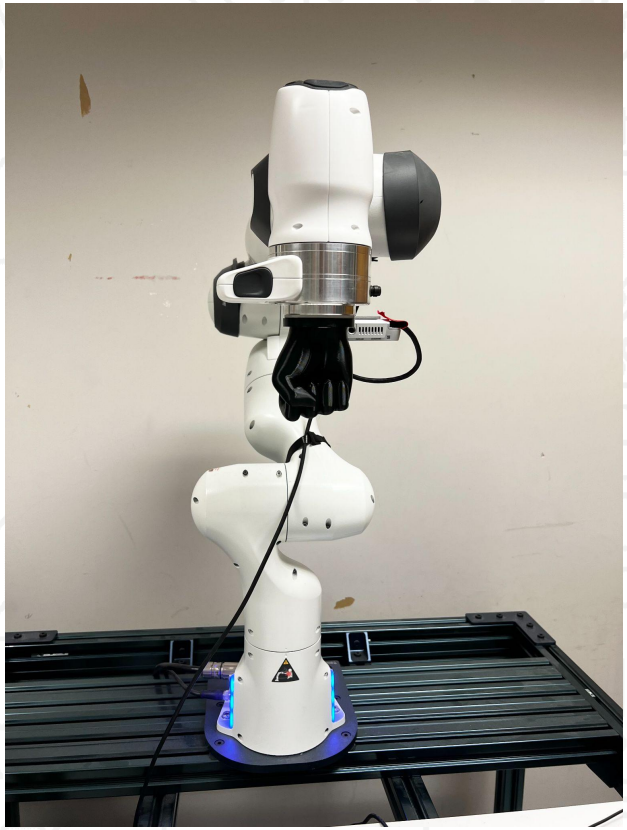
MediaPipe Studio

easy_handeye
ROS TF2
Camera intrinsics

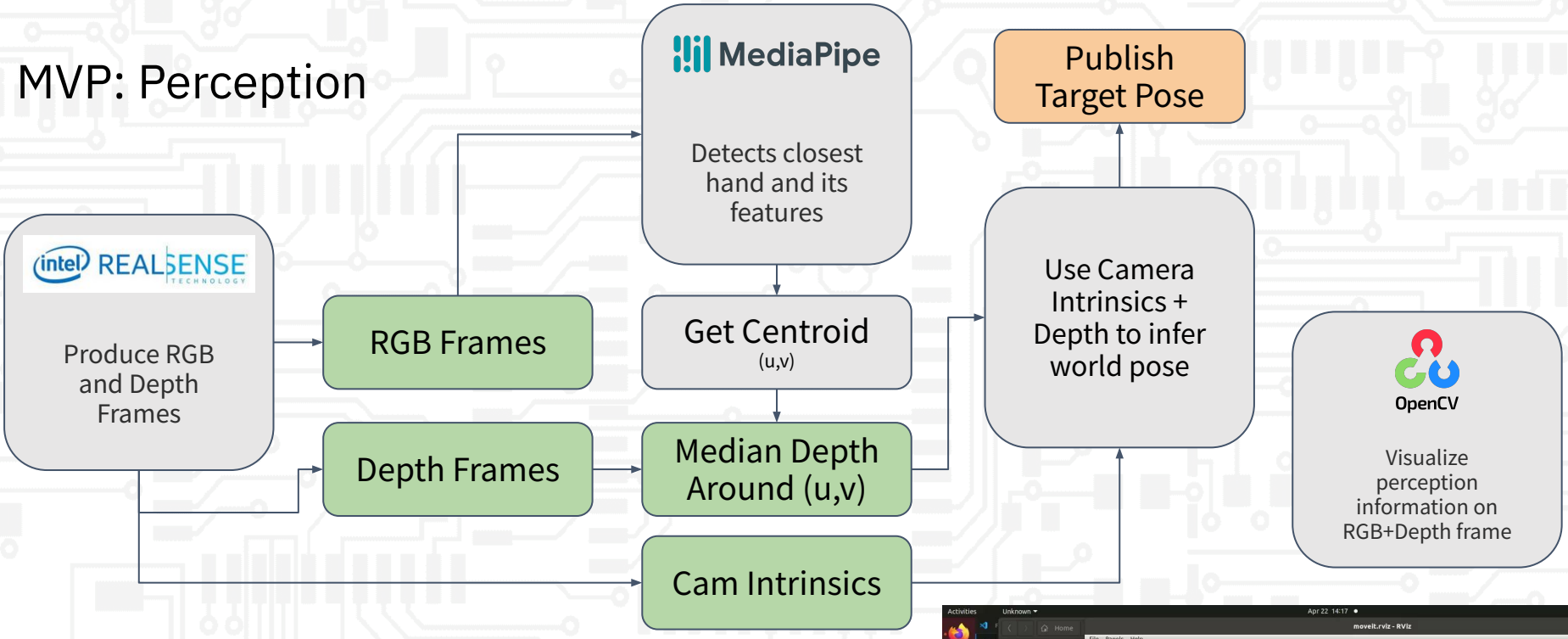
Frankapy

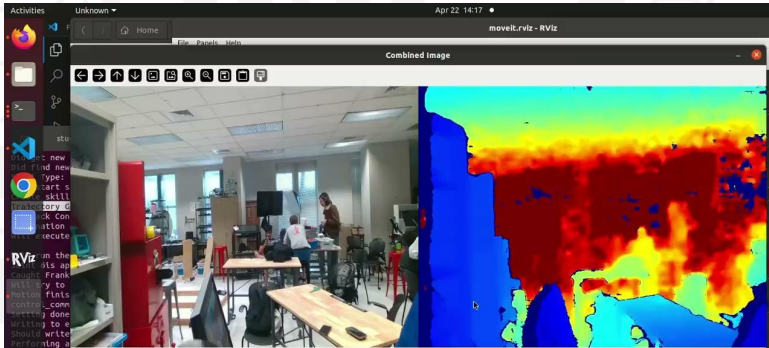
MVP: Hardware Setup

- Designed a mockup of a fist as an end-effector on the arm
- Configured arm to correctly account for changed end-effector weight/dynamics
- Printed fist is softer than PLA and more compliant to ensure safety while testing

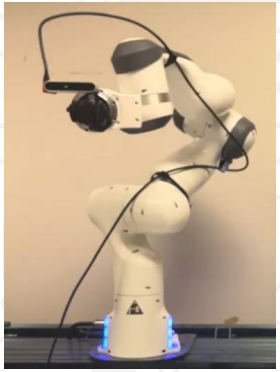


MVP: Perception





MVP: Motion Planning



Move to initial pose

Subscribe to Target Pose

Update goal_state if valid pose

Continuously: Publish goal_state to Frankapy's internal sensor topic

DEFAULT_SENSOR _PUBLISHER_TOPIC

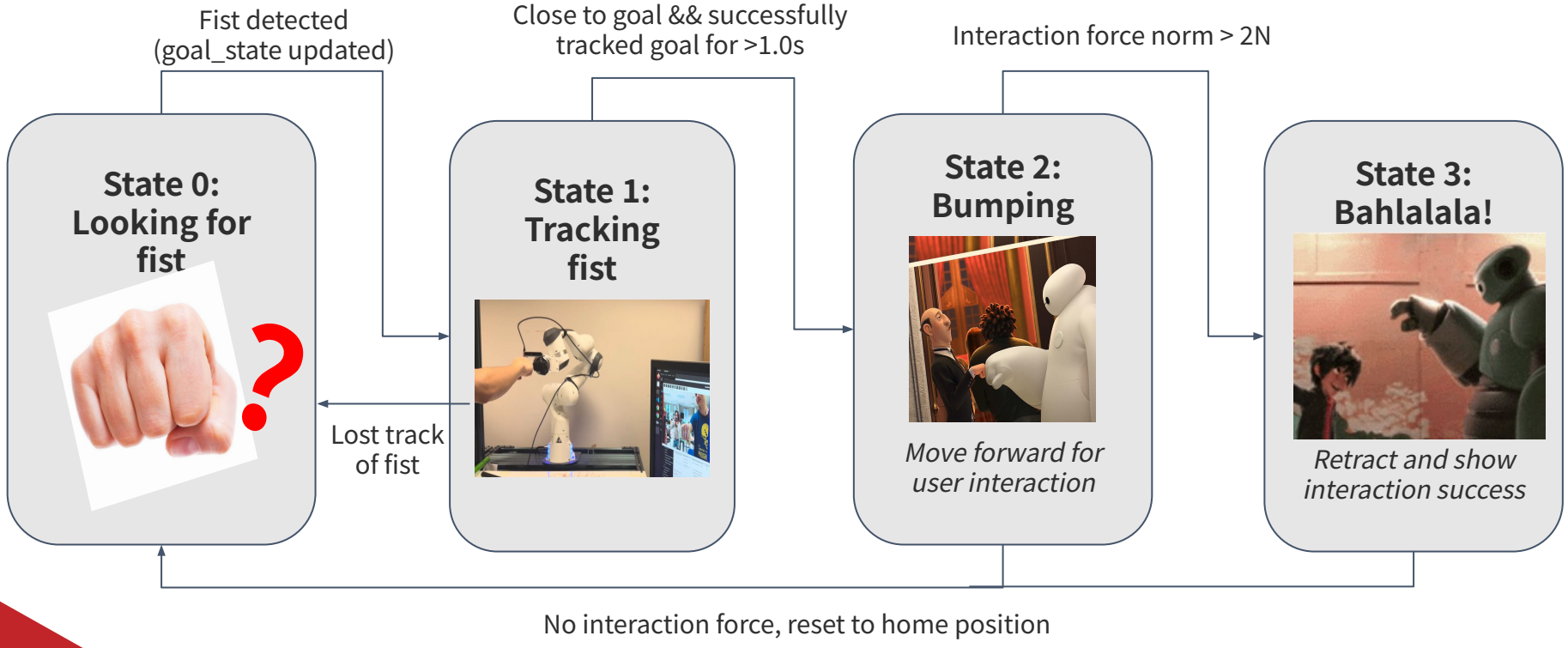
Frankapy allows for dynamic trajectory execution

- Continuous trajectory updates rather than discrete steps
- Takes small steps towards continuously updated goal (internal sensor topic)
- Limit magnitude of steps to control approach speed

MVP: State Machine

(this was updated for report) - Tom

- Designed to handle fault tolerance and recovery between perception and motion tracking interface



MVP: Demo video

- End effector tracks and matches fist location until distance threshold
- Moves in to fist bump, retracts to home pose
- Repeat forever

* Robot does not recognize out of bounds targets for safety, so need to “guide” it into desired position in some of these trials

Blockers

- Virtual wall limits arm motion and reachable space
- Movement sometimes causes joint limit/self-collision errors
- Unable to get force/torque sensor data from frankapy
  - Returning all zeros when contact obviously made

Plan for Stretch Goals

- Sense force/torque on the end effector and retract after meeting some threshold
- Ba-la-la-la retract fist in a wave motion to initial pose after making contact with user
    - Rotate end effector joint to add pizzazz

THANKS

Q&A Time