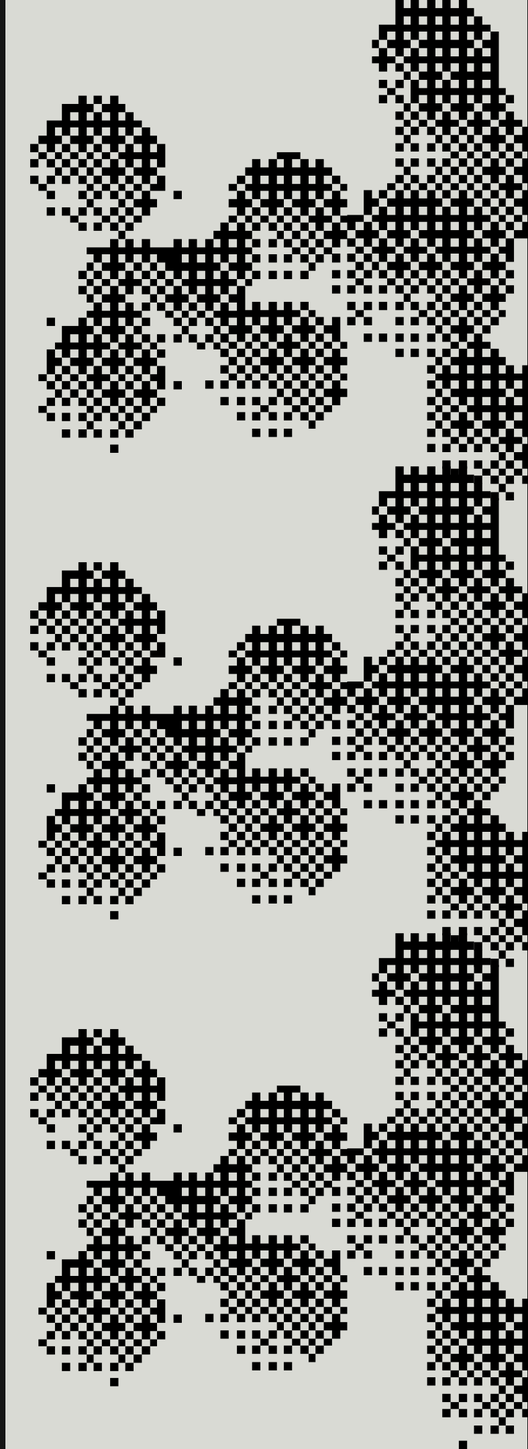
General Bionix

# Complete guide to Moveit!

Exploring the functionalities and limitations of MoveIt

**Annie Du**



# MoveIt Key Features

RobotModel:

- Customizable **Robot-Agnostic** Kinematic Modeling with your own URDF + SRDF, **No need to rewrite** motion planning logic for every new robot

RobotState:

- fine-grained control with **instant updating** of the robot’s configuration at runtime
- Can **directly query and manipulate** raw kinematic data (joint positions, FK, IK, collision checks, trajectories, velocity control & torque estimation) to achieve custom poses.
- Supports plug-in custom IK solvers, controllers, planning libraries

Planning Scene Monitor

- Live updates on the robot arm's internal state (joints, objects attached, sensor messages etc) and external environment (real-time collision, perception updates); **ideal** for synchronization between sensing, planning, and acting
- Modify and synchronize the simulated environment to match the real-world workspace and changes
- Supports interfacing with custom boards, biosensors
- Can precompute a set of valid robot poses that already meet the constraint, save and reuse them

# Core capabilities

# MoveIt grasps

Great for quick motion planning and IK-filtered pose generation

**Features + Dubs**

1. Responds quickly to varying object poses or workplace constraints
2. Pick and place simple objects
3. Reachability filtering & motion planning

Works with:

- Parallel finger grippers
- Suction grippers
- UR5, Jaco2, Baxter, REEM, Panda

**Cons**

1. Only supports basic shape objects (blocks/cylinders).
2. Cannot model complex physics IRL
3. Cannot execute the full logic & sequence

# MoveIt Task Constructor

ideal for complex pick-and-place tasks

**Features + Dubs**

1. **Automatic** Pipeline Assembly & Execution: connects valid paths between stages to form complete solution
2. Modular stages are reusable across different objects & tasks
3. **Auto-generate** grasps and **compute** inverse kinematics
4. **Automatic** Failure recovery: MTC tries alternatives automatically.

**Cons**

Learning curve: lengthier setup

# MoveIt Deep Grasps

Integration inside MTC that uses AI to generate viable grasp poses from sensor data, ideal for unstructured environments or unknown objects.

**Features + Dubs**

1. **AI-based grasp generation** from point clouds (GPD) or RGB-D images (Dex-Net); Automatically detect viable grasps using deep learning, **adapt** to different object positions, shapes, and orientations
2. Modular task stages, reusable

1. Works with:

- simulated or physical depth cameras
- all types of robot arms with parallel-jaw grasps

**Cons**

- Slow interface times with large point clouds
- Only supports Parallel-Jaw Grasps
- Requires training; Have their own setup, models, and system requirements.

# MoveIt Servo

End-effector of the robot arm responds to incremental changes in pose

**Features + Dubs**

1. Can customize
- Individual joint velocities.
- Velocity of end effector.
- Pose of end effector.

1. Achieves real-time adjustment with velocity mapping via an inverse Jacobian that provides the relation between the joint velocities and the end effector velocities.
2. Environment-aware servo-ing, ensures collisions are prevented

MoveIt Servo tutorial

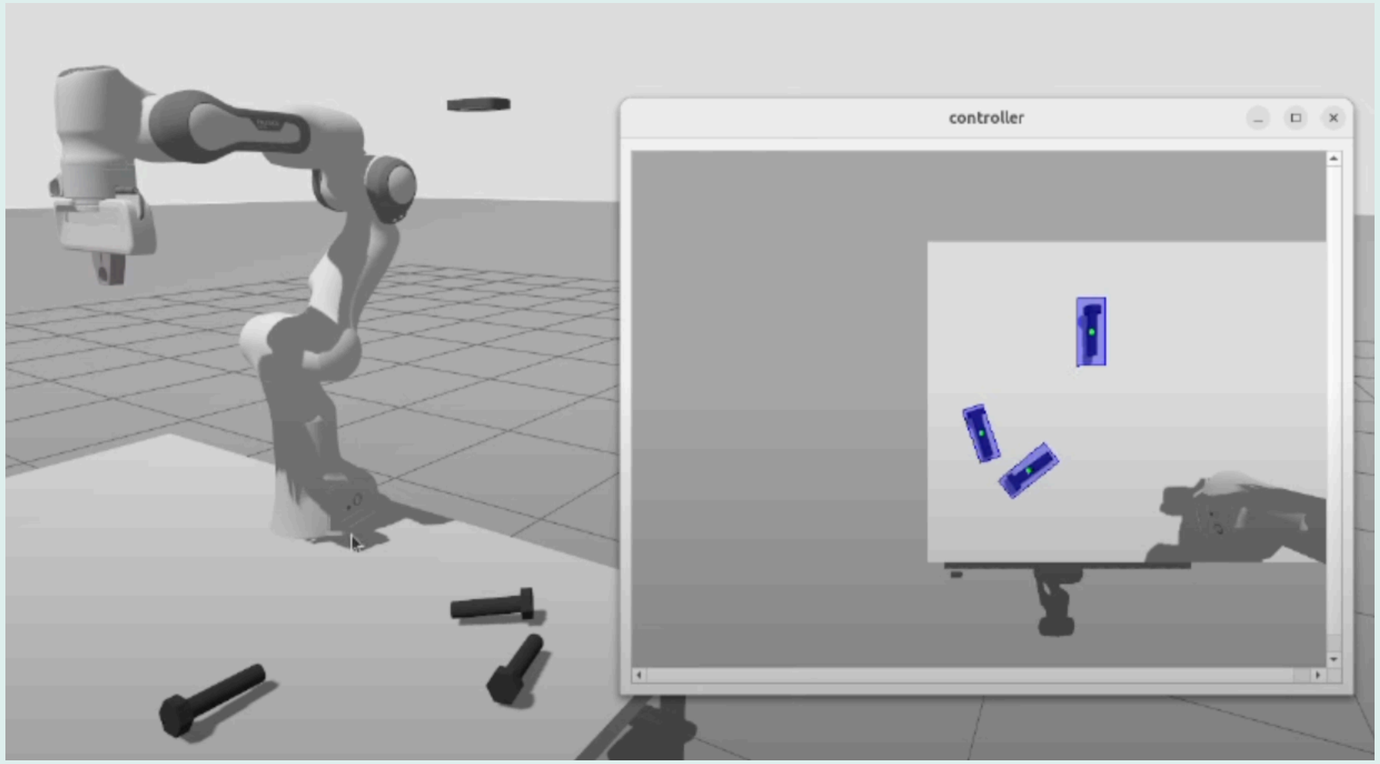
# Demo: picking and placing bolt

**Features + Dubs**

- YOLO: real-time object detection, divides the image into a grid & creates bounding box coordinates, confidence scores, object classification
- fast; can be trained with visual patterns to quickly and accurately classify object

**Cons**

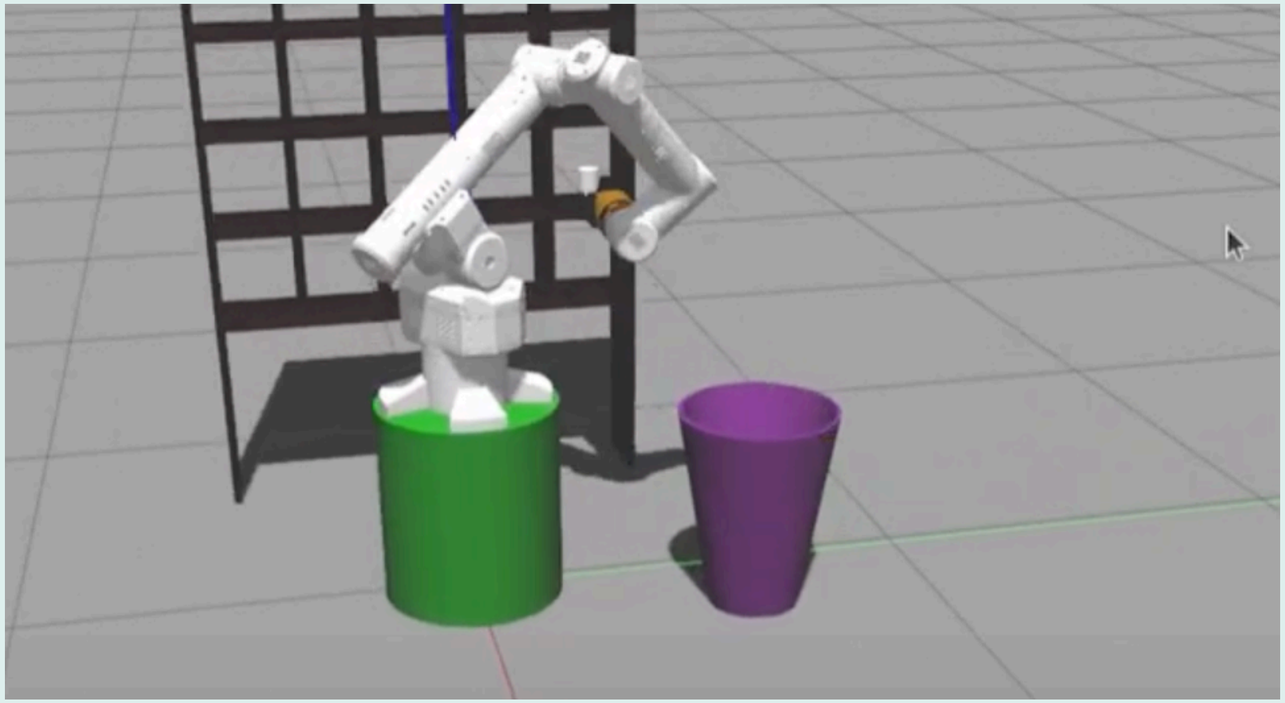
- YOLO detection affected by shadows
- Requires manual projection perspective transformation of 2D to 3D robot coordinates [requires us to know camera intrinsics (fx, fy, cx, cy), camera depth, position relative to robot]



# Currently working on:

**Advanced usages:**

- Picking up the bolt from the shelf, dropping into a vase (constrained space)



# Plug insertion with MoveIt

Useful Features for General Bionix

- MTC: Modular, ideal for complex tasks
- **MoveIt Servo:** Real-time visual servoing, enables fine alignment and adjustment
- Cartesian & constraint-based path planning
- Connected with external sensors for force feedback and verify successful connection

# Conclusion

### Main incentives

- **Robot-Agnostic**: Works with any ROS-supported robot using URDF/SRDF; supports plugin-based planners, controllers, and IK solvers.
- **High-Level Motion Planning**: MTC for complex workflows, vision integration (GPD, Dex-Net).
- **Real-Time** adjustments

### Cons

- Learning curve
- Requires integration with ros2control for real hardware control
- Simplifying assumptions: basic pick-and-place **assumes** simple geometry; advanced grasping works best with 2-finger grippers

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# Thank you!

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