Implementation of ROS and MoveIt with a Light Weight Manipulator System

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Introduction

Objective

The research objective for this project was to investigate the implementation of ROS (Robotic Operating System) and MoveIt software for real-time control of LWMS (Light-Weight Manipulator System).

Background – the LWMS

- Part of a larger project by Dr. Nokleby's Mechatronics and Robotic Systems Laboratory on developing an UAV system with a manipulator
- Intended to be used for repair works on high-voltage lines, oil and gas pipelines, and other field applications where dangerous conditions or poor accessibility would pose great risk for workers.
- Designed by a group of upper-year undergraduate students for 2015-2016 Capstone Design Project.
- A 6-DOF (degree-of-freedom) robotic arm with three types of Dynamixel servos in series, custom-made carbon fiber brackets and a two-gear reduction system to increase torque and payload-carrying capabilities.

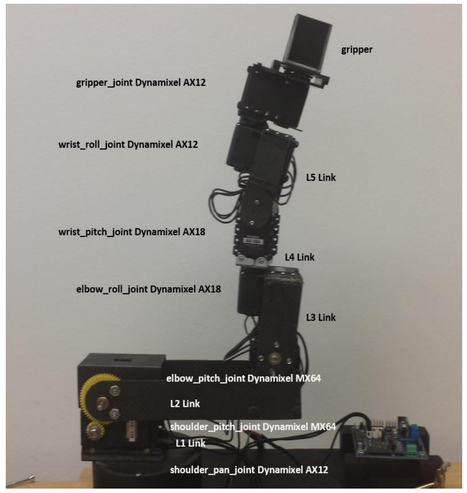

Figure 1. The Light Weight Robotic Manipulator

Methods

This project relied on:

- Official ROS, MoveIt and Gazebo documentation and tutorials
- Discussions of the robotic community members on official ROS.org Answers forum, Google forum, GitHub Issues for relevant repositories, and Trossen Robotics forum.

All implemented features were tested for performance and stability on Linux Ubuntu 14.04 using ROS Indigo, and current stable versions of MoveIt, Gazebo, and Rviz.

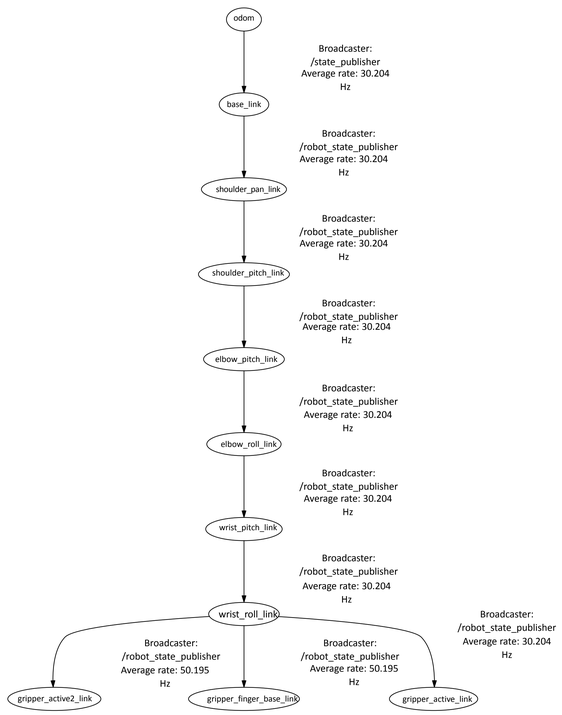

Figure 2. Robot_state_publisher tf graph.

Results

Real-time ROS control of the LWMS

Several approaches were researched and tested for implementing real-time control with ROS:

1. ROS-ArbotiX Control Package
   Outcome: Implemented as robot_arbotix_control
2. Custom Controllers Based on Dynamixel Interface Library
   Outcome: Library not maintained
3. ROS Dynamixel Control and Rosserial Stacks
   Outcome: Servos not recognized
4. ROS Dynamixel Controllers Stack
   Outcome: Servos not recognized
5. ROS Control Boilerplate
   Outcome: Future Direction

Universal Robot Description File

- Simulation in Rviz, Gazebo, and MoveIt required URDF (Universal Robot Description File)
- URDF describes the structure and functionality of the robot to Rviz, Gazebo and MoveIt in a language that these software tools understand.
- URDF for the LWMS was written based on the information provided on ROS.org and URDFs of similar manipulators available in open source.
- URDF was used to create the basic ROS package robot_description. This package is non-executable but necessary for development of:
- robot_moveit_config executable package for visualization and motion planning of the LWMS in MoveIt
- robot_state_publisher executable package for transformations of the simulation, visualized in Rviz.

Conclusions

In summary, four functional ROS packages were created for the LWMS in the course of this project:

1. robot_description package that contains URDF, XACRO, and DAE files describing the configuration and physical metrics of the manipulator.
2. robot_moveit_config package for simulated motion planning with MoveIt!
3. robot_state_publisher package that uses URDF to publish the state of the robot to tf.
4. robot_arbotix_control package – uses ArbotiX control stack and an edited yaml file specific for the manipulator to provide low-level control of the arm via ArbotiX GUI.

Future Directions

- robot_arbotix_control package offers control of each joint via graphical interface
- LWMS-specific controllers based on ROS Control boilerplate will provide a more applicable, stable, and flexible interface
- Custom controllers in combination with MoveIt, kinematics plugins, and URDF will provide framework necessary for real-time remote control of LWMS with motion planning and inverse kinematics.

Sources:

[1] http://www.ros.org/

[2] http://moveit.ros.org/

[3] http://gazebosim.org/

[4] http://www.trossenrobotics.com/

[5] Martinez, A., Fernandez, E. *Learning ROS for Robotics Programming*. Packt Publishing, 2013.

[6] https://github.com/davetcoleman/clam