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Survey on Robonaut2

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Abstract:

Crew time is precious in space NASA and General Motors have developed the second generation Robonaut, Robonaut 2 or R2. Robonauts are complex but useful. R2 is upgrade of R1. Upgrades include: increased force sensing, greater range of motion, higher bandwidth and improved dexterity.In this paper we discuss about R2's composition, its motion and various constraints.

Keywords : Robonaut2, CTB, MoveIt

1. Introduction

Robonaut 2 (R2) is a complex humanoid robot. R2 is designed to be an assistant to the crew currently stationed on-board the ISS.
It consist of all the parts which any human have.
It is composed of an anthropomorphic upper body and two legs with each having seven degrees-of-freedom. It has a total of 34 degrees-of-freedom in the main body. It has twelve degree-of-freedom in its hands.

Figure 1: Multiple Size Of Arm Spring

Figure 2: R2 lifting weight

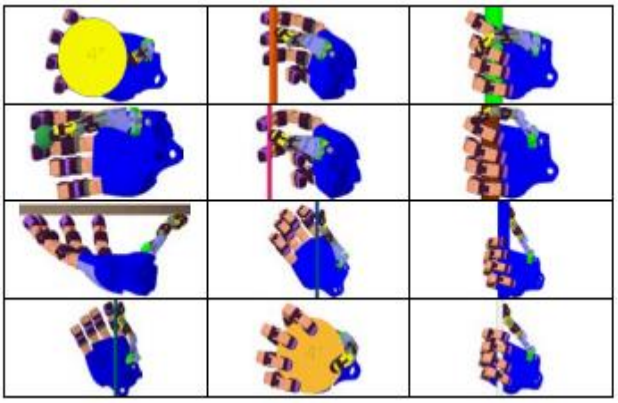

Figure 3: Cutkosky's Grasp Taxonomy

2. Cargo Transfer Bag

Today, cargo is stored within a general purpose container called a Cargo Transfer Bag. R2 is used to retrieve and manipulate a desired CTB from a logistics module to another desired location. Operations are distinct from tasks as the operator plans the sequence of subtasks.

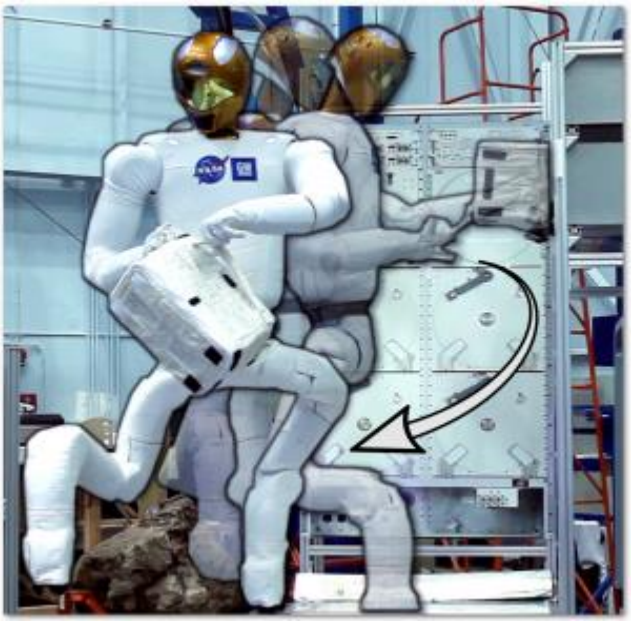

Figure 4: R2 Retrieving CTB

R2 executing the CTB retrieval scenario. R2 has to respect different constraints when planning motions. When holding the CTB with both hands,

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there is a constraint imposed on the hands as to not drop the CTB . These are the few of the constraints that R2 has to take care of.
CTB removal operation would be defined as:
• The left leg end-effector is fixed.
• The goal constraint of the torso is such that the object's grasping points are reachable using the upper body's end-effectors.
• The right leg is positioned such that an automated handrail rendezvous procedure can be used to affix the end-effector to the handrail.

The Advanced Exploration Systems (AES) Logistics Reduction (LR) Project has been finding ways to use these bags for crew outfitting. Multipurpose Cargo Transfer Bags (MCTBs) have been designed such that they are the same size and can serve the same purpose as a Cargo Transfer Bag (CTB). CTBs are available in a range of set sizes. A single CTB has dimensions of 50 cm long x 42 cm wide x 25 cm high. They are also available in half, double, and triple sizes.

3. Challenges

There are many challenges to consider when designing a system to command a robot like R2.
Many of which are related to mobile manipulation, constrained motion planning, and dexterous manipulation. . These problems range over the entire operation, starting with approaching the CTB, grasping it, and continuing through the following manipulation subtasks. Locating the pose of the CTB relative to the robot and grasping it is another set of problems; sensors must detect the CTB, and the dexterous hands of R2 must grasp the CTB's pliant canvas straps.

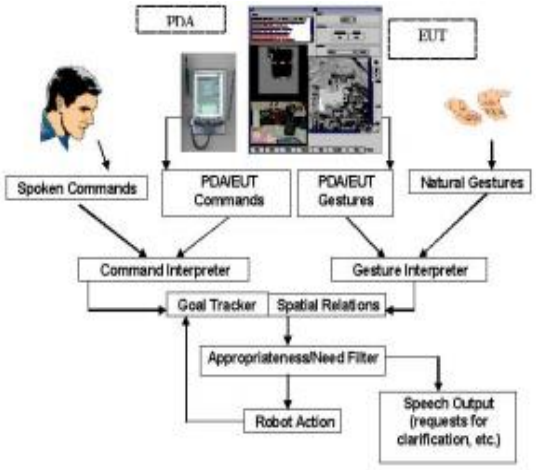

Figure 5: Human Interaction

4. MoveIt

Complex operations like CTB retrieval can be simplified into a sequence of subtasks, in which the operator specifies a set of goal constraints on a set of frames, and a set of constraints that apply through the entire subtask.

MoveIt! is a popular, state-of-the-art framework that ties together robot kinematics, motion planning algorithms, and environment monitoring for manipulation and motion planning.

MoveIt is Mobile manipulation software in ROS.

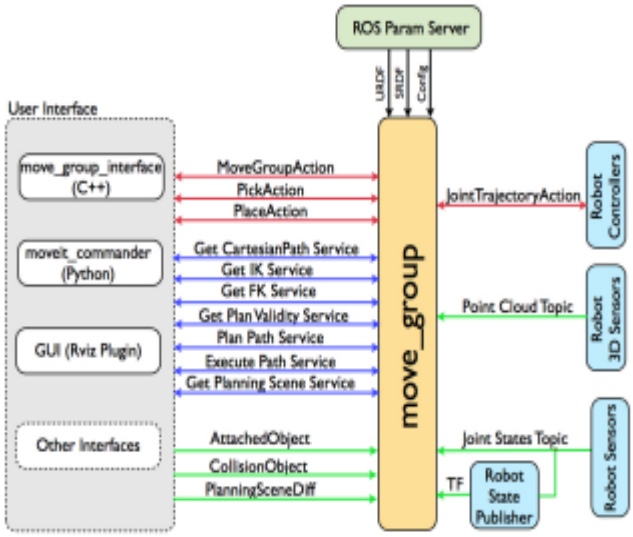

Figure 6: MoveIt System Architecture

ROS: Robotic Framework

- Hardware abstraction for robots
- Inter-process communication
- Package management system
- Development and deployment ease

ROS Features:

- Multi-language (C++, Python)
- Modular and re-usable Peer-to-peer communication Open-source

MoveIt! configuration requires a URDF file of the robot to generate a semantic robot description format file used for planning.

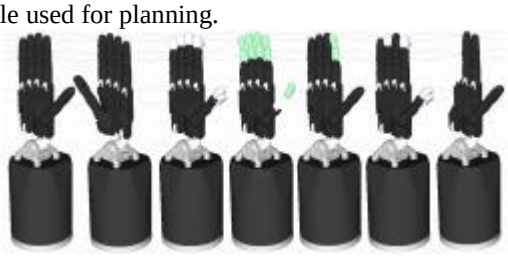

Figure 7: Robot Hand for various versions

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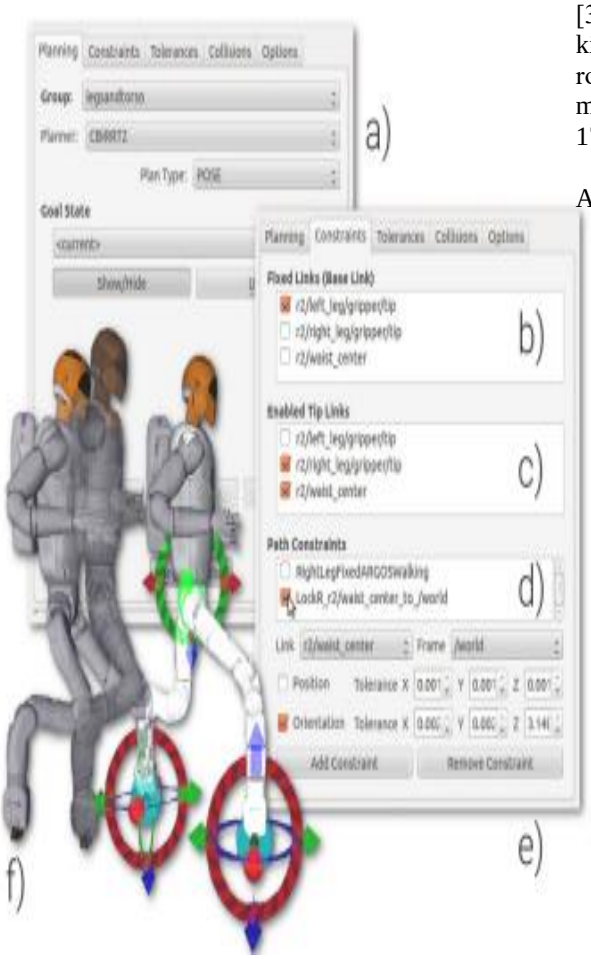
5. Solving Constraints

When specifying a subtask in an operation for a complex system like R2, constraints naturally arise from high-level requirements and low-level physical limits. Both requirements and limits are represented in a unified constraint framework that translates constraints into geometric limits on the robot.

CTB creates a constraint between the palms of R2's hands, as they must maintain a fixed relative pose with respect to each other to continue to grip the bag. These constraints can be broken up into two broad categories: global coordinate frame constraints and relative coordinate frame constraints.

By defining a constraint of one frame on the robot to another, an implicit linkage is defined that binds the movement of the frames together. Relative constraints are a harder problem to solve, but some tasks are impossible to specify using only global frame constraints. There is no distinction between the two types of constraints in the interface as they are defined by the same set of parameters; methods that manipulate constraints have no notion of whether the constraints are relative or global.



6. Conclusions

Humanoid robots such as Robonaut offer many opportunities for advancing the use of robots in complex environments such as space, and for development of more effective interfaces for humans to interact with robots.

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