

## **Sensing Space**

### **Experimental System**

#### **Proprioceptive Sensing**

Sense the environment with internal sensors

#### **Pose Map**

Simple map, just sensor data and poses in the environment

## **Defining Position**

### **Defining Pose and Direction**

Orientation and coordinate frame on articulated robot

### **Motion Models**

Estimating travel of articulated robot

## **Environmental Landmarks**

### **Finding Landmarks**

Landmark features to track environment, difficult using only proprioceptive sensing

### **Corner Examples and Results**

Corner features extracted from posture image, much difficulties

### **Wall Detection**

Detect and measure the wall, time-consuming and sparse.

### **Pipe Shape, Macro Feature**

Use general shape of environment, can be approximated with sparse data

### **Macro Feature Extraction**

postureimage->alpha shape->medial axis

### **Different Macro Features**

1) anchor points spline, 2) polygon walls, 3) medial axis

## **Pose-Based Mapping**

### **Inter-Pose Correction**

Correct transform between poses by ICP on medial axis

### **Paired Pose Correction**

Same, ICP on medial axis between forward-backward probe pairs

### **Constraint Mapping**

Show map using simple pose constraints between poses. Unclear how to solve data association problem

## **Aggregate Pose Mapping**

### **Union of Posture Images**

Global medial axis from union of posture images

## **Mapping with Junctions**

### **Junctions**

Breaking off from main medial axis indicates junction. Junctions only partially observable.

### **Shoot Map Representation**

Each shoot is path graph, with two leaves. Except for root, all shoots have origin from a parent shoot at the branch point

### **Generating Shoots**

Basic algorithm to generate medial axis of each shoot set, and cut the medial axis to create the shoots.

### **Detecting branch**

Algorithm to detect a divergence of a pose from a shoot and deciding there is a branch.

### **Localizing on Shoot Map**

Splicing shoots together, performing ICP on splices. Take best guess.

## **Curve segment algorithms**

isOverlapped(), getOrientation(), getContiguity(), etc.

## **Probabilistic Mapping**

### **Space of Possibilities**

Poses, Branches, Branch Locations. Some decisions can lead to irrevocable consequences. Replicated shoots, circular cases.

### **Pose Particle Filter**

Population of pose hypotheses, localized, evaluated, resampled.

### **Pose+BranchLoc Particles**

Pose + Small grid of branch locations. Evaluated by overlapCost of full medial axis of child on parent.

### **Branch Decision**

Shoot map for each go/nogo branch decision. Eliminate options based on degenerate conditions.

## **Appendix: Control and Locomotion**

### **Control Methodology**

### **Behaviors**