Introduction to Course Project

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Quiz (10 pts)

• (5 pts) What is the difference between motion planning and obstacle avoidance?

• (5 pts) Please describe the basic problem statement of motion planning – you can draw a graph to illustrate.
More than Obstacle Avoidance

• Path planning
  • Low-frequency, time-intensive search method for global finding of a (optimal) path to a goal

• Obstacle avoidance (aka “local navigation”)
  • Fast, reactive method with local time and space horizon

• Distinction: Global vs. local reasoning
Basic Problem Statement

- Robot and Obstacle Geometry
- Robot Kinematic and Dynamics
- Start and Goal

Planning Algorithm

A path from start to goal
Overview

- Platform
- Course projects
Tele-nursing robotic intelligent nursing assistant (TRINA)

- Major components
  - Baxter robot
  - Mobile base
  - Compliant grippers
  - 3D cameras
Operator Console

• Simulation mode
• Physical mode
• GUI
  • Various input devices
  • Multi-perspective camera views
Motion capture system

• Hardware
  • 10 cameras – Vero 2.2
  • Max frame rate = 330 Hz
  • Resolution 2048 x 1088 = 2.2 MP
  • Covered space = 17 ft X 21 ft
  • 8 on railing + 2 on ground (for closer view)

• Software
  • Nexus – human motion capture and analysis
  • Tracker – moving object tracking
Teleoperation of TRINA from Mocap System

VR Display

View of Robot Head Camera

Robot can teleoperated by human via Vicon Mocap system
Course Project
Overview

• Collaborative projects (5-6 students)
  • Mentored by me, TA and experienced students
  • Under-going Human-inspired robotics (HIRo) lab projects

• Small projects (1-2 students)
  • On the motion planning of surgical robots and swarm robots
  • In case you prefer working with fewer people
Successful projects need... 

- Functional robot platform
  - Debugging hardware is a pain!
  - May be stuck by technical details of a software

- Experienced members in the team
  - Starting from sketch takes much longer time

- Commitment of every team members
  - Your project grade may be ruined if the team fall apart

- Healthy team dynamics
  - Your leader is knowledgeable, reasonable, and helpful
  - Your partners are trustworthy
How important your team can be

- A good project team means
  - Successful project outcome (30% of course grade)
  - High-quality group literature review (10% of course grade, as part of the assignment)
  - Help you study the course material and prepare for quiz
Make a wise decision when you start

• Find the team right for you
  • Project survey form allow you to fill in preferred teammates
  • Talk to project contact to see whether you like and project and have the right skill set
  • Talk to your classmates and find the ones you like to work with

• It may be a good idea to choose a small project
  • You have full control of the project progress
  • You can work at your comfortable pace
Project category

• Standard projects
  • Physical Human-robot interaction
  • Manipulation
  • Navigation
  • Motion coordination

• Small projects
Physical human-robot interaction (pHRI)
Human intent and object affordance

- Human intent
  - Gaze, body posture, motion, verbal communication

- Object affordance
Not a trivial problem

• Goal
  • **Fluent** and **natural** human-robot object handing-over

• Human-robot object handing-over is not a trivial problem
  • Infer human intent
  • Identify object affordance
  • Planning feasible and natural motion
  • Handle exception
Example

- Robot observing human manipulation
Example

- Communicate Intent
Example

- Identifying and tracking object
Example

• Planning reaching and grasping
Example

- Trajectory control
Example
What if motion planning is too hard?

Basic Motion Planning Problems
Combining motion planning with robot learning
Project 1 – Coordinated motion of mobile manipulator nursing robot

• Project status
  • TRINA software allows direct teleoperation of mobile base

• Need to do
  • Safe navigation of omni-directional mobile base using LIDAR sensor
  • Combining learning and motion planning to determine when and how to move mobile base, to facilitate the manipulation task being performed
  • Teleoperate mobile base motion using mocap system (optional)
Coordinate manipulation end-effector with mobile manipulator
Project 1 – Coordinated motion of mobile manipulator nursing robot

- Search for related work on
  - Mobile manipulator motion planning
  - Micro- and macro-structure coordination

- Project Contact
  - Sihui Li <sli16@wpi.edu>
Project 2 – Dexterous arm-hand and bimanual coordination

• Project status
  • TRINA software allows direct teleoperation of baxter robot arms and Reflex SF hand

• Need to do
  • Acquire object affordance by object identification and classification
  • Learning object affordance by observing human manipulation
  • Planning grasping motion based on object affordance
Project 2 – Dexterous arm-hand and bimanual coordination
Project 2 – Dexterous arm-hand and bimanual coordination
Project 2 – Dexterous arm-hand and bimanual coordination

• Search for related work on
  • Image processing for feature identification and object classification
  • Learning affordance from demonstration
  • Grasping planning for compliant gripper

• Project Contact
  • Yudong Yu <yyu6@wpi.edu> for using motion capture system
  • Sihui Li <sli16@wpi.edu> for setting up teleoperation of TRINA from mocap to perform bimanual reaching motion
Project 3 – Dexterous manipulation of multi-fingered robot hands
Project 3 – Dexterous manipulation of multi-fingered robot hands
Project 3 – Dexterous arm-hand and bimanual coordination

• Project status
  • TRINA software allows direct teleoperation of Baxter robot and Reflex SF hand

• Need to do
  • Plan coordinated reaching and grasping motion
  • Combine motion planning with learning reach-to-grasp motion from teleoperation
Project 3 – Dexterous arm-hand and bimanual coordination

• Search for related work on
  • Coordination of grasping with reaching
  • Grasping planning and learning for compliant gripper

• Project Contact
  • Duong Nguyen <dnguyen2@wpi.edu> - for ReFlex SF hand motion control and CaptoGlove
Project status

- Setting up teleoperation of Baxter robot and Reflex SF hand
- Preliminary work on
  - Phase estimation of physical human-robot interaction
  - Using Kinect for human skeleton and object tracking

Need to do

- Inference of human intent from gaze, body posture and etc.
- Learning task and object affordance
Project 4 – pHRI based human intent prediction and object affordance

- Search for related work on
  - Human intent detection and inference
  - Human-robot handing over

- Project contact
  - Gunnar Horve (TA) <gchorve@wpi.edu>
  - Heramb Nemlekar <hsnemlekar@wpi.edu>
  - Max Merlin <mtmerlin@wpi.edu>
Project 5 – High-level motion planning in physical human-robot interaction

• Project status
  • Setting up teleoperation of Baxter robot and Reflex SF hand
  • Preliminary work on algorithms on learning motion primitives

• Need to do
  • Learning low level motion primitives from demonstration
  • High-level modeling and planning of human-robot handing-over
Project 5 – High-level motion planning in physical human-robot interaction

• Search for related work on
  • Learning dynamic movement primitives
  • Learning motion plan

• Project contact
  • Gunnar Horve (TA) <gchorve@wpi.edu>
  • Heramb Nemlekar <hsnemlekar@wpi.edu>
  • Max Merlin <mtmerlin@wpi.edu>
Project 6 – Online motion planning in dynamic virtual environment

Bilateral

Multi-robot
Background – Robot-assisted stroke rehabilitation
• Inter-arm coupling due to cross-hemisphere talk
Background – Upper limb Rehabilitation Robots
Integrated Rehabilitation System
Development of highly-adaptive, low-cost home-based stroke rehabilitation system
Preliminary work
Project 6 – Online motion planning in dynamic virtual environment

Video Game

Motion planning/learning AI

Haptic Device
Project 6 – Online motion planning in dynamic virtual environment

• Project status
  • Build a pair of 3-DOF haptic devices
  • Interface with Pong game for bilateral rehabilitation

• Need to do
  • Develop AI for motion planning
  • Use motion learned from healthy arm to evaluate planned motion
  • Generate assistive force to guide the stroke arm
Planning motion in multi-agent, highly-dynamic virtual environment
Interesting questions

• How to create an AI that can play interactive video game?
• Can the AI-planned motion match natural human behavior?
• Can stroke patients recover faster by playing these games?
Project 6 – Online motion planning in dynamic virtual environment

• Project Contact
  • Nathaniel Goldfarb < nagoldfarb@wpi.edu >
  • Alexandra Valiton < arvaliton@wpi.edu >
  • Rishi Khajuriwala < rdkhajuriwala@wpi.edu >

• Project presentation
  • Speaker: Nathaniel Goldfarb (PhD)
  • Jan 18, at Gatepark 1002
Small projects
Coordinated swarm robot navigation (Small)

• Project description
  • Plan the coordinated motion of swarm robots that collaboratively move an object

• Question
  • How to coordinate swarm robots to follow a trajectory?
  • Can robot join and leave?
  • What if the object is deformable?

• Mentor
  • Prof Carlo Pincirolli < cpincirolli@wpi.edu >
Path planning for a continuum surgical robot (Small)

Continuum robotic probe inserted into an ear model

Planning the insertion into the ear cavity
Path planning for a continuum surgical robot (Small)

• Goals
  • Implement sampling-based path planning (RRT)
  • Implement obstacle detection to avoid collision with anatomical structures
  • Estimate the robot’s reachable workspace by generating a high number of motions

• Required skills
  • Strong Matlab programming skills
  • Familiarity with robot kinematics and frame transformations

• Mentor
  • Prof Loris Fichera < lfichera@wpi.edu >
Important

- Project workshop held in lab today during office hour
  - 2-3 pm Today, CIBR lab at 85 Prescott
  - Talk to me, TA, and project contacts to get more information

- File your project selection form by Friday (Jan 19) noon
  - Talk to your classmates to find good teammates
  - You can always update your form before submission deadline
End
A hard problem

Basic Motion Planning Problems