

CS 5247 Motion Planning & Applications

Robots, Digital Actors, and Molecules

Instructor: David Hsu



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Overview

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Motivation



Mars Rover, NASA



Robotics Institute, CMU [Thrun et al., 2000]



Roomba, IRobot
(www.irobotstore.com)

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3

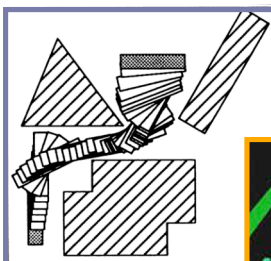
Goal of motion planning

- Compute **motion strategies**, e.g.,
 - Geometric paths
 - Time-parameterized trajectories
 - Sequence of sensor-based motion commands
- Achieve **high-level goals**, e.g.,
 - Go to the door and do not collide with obstacles
 - Assemble/disassemble the engine
 - Build a map of the hallway
 - Find and track the target (an intruder, a missing pet, etc.)

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4

Examples with rigid objects



Ladder problem

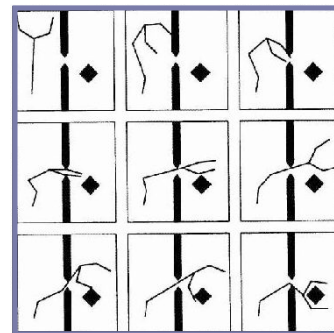
Piano mover's problem



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5

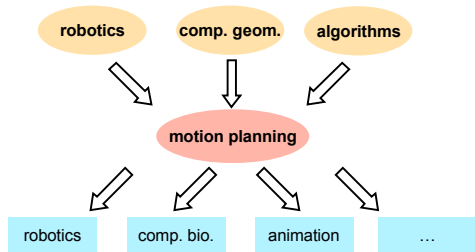
Examples with articulated objects



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6

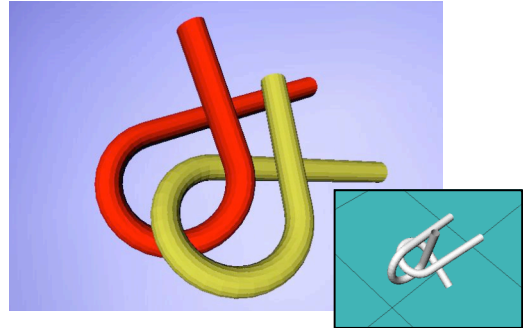
Relationships



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7

Is it easy?



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8

Hardness results

- Several variants of the path planning problem have been proven to be **PSPACE-hard**.
- A complete algorithm may take exponential time.
 - A complete algorithm finds a path if one exists and reports no path exists otherwise.
- Examples
 - Planar linkages [Hopcroft *et al.*, 1984]
 - Multiple rectangles [Hopcroft *et al.*, 1984]

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9

Course web site & schedule

<http://www.comp.nus.edu.sg/~cs5247>

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10

Shall I take the course?

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What background shall I have?

- Suitable for students in computer science, electrical engineering, mechanical engineering...
- Background knowledge
 - Data structures and algorithms
 - Substantial programming experiences in a modern programming language, e.g., C, C++, Java, ...
 - Probability theory
 - Linear algebra
 - Computational geometry
 - Computer graphics

Please come to talk to me if you have doubt!

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12

How do I know whether I have sufficient background?

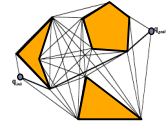
- Quick sort takes $O(n \log n)$. Bubble sort takes $O(n^2)$. So quick sort is much better.
- The lower bound for sorting is $O(n \log n)$. So I cannot expect to do much better than quick sort under normal conditions.
- Traveling salesman problem is NP-hard. So I won't try to solve it by buying a faster computer.
- If $P(A)=0.2$, $P(B)=0.1$, and A, B are independent events, then $P(A \text{ and } B) = 0.02$.
- An orthonormal matrix A with $\det(A) = 1$ represents a rotation.
- Take a look the papers on the course schedule

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13

Visibility graph method

- Represent the connectivity of the configuration space in the visibility graph
- Running time $O(n^3)$
 - Compute the visibility graph
 - Search the graph
 - An optimal $O(n^2)$ time algorithm exists.
- Space $O(n^2)$
- Can we do better?



Sample Slide

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14

What am I going to learn?

- Representations of 2-D and 3-D geometric structures: robots, animated human characters, molecules
- A coherent computational framework for representing and computing the motion of complex geometric objects

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17

How much work is it?

- No exams?
Yes! 😊
- Lots of work?
Yes! 😞

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18

Work to do

- Actively participate in classroom discussions
- Read 2-3 papers every week
- Hand in two paper-and-pencil homework assignments
- Give powerpoint presentations on one or two research papers selected from a list
- Complete a significant programming project with simple graphic interface



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20

Will I get a good grade?

- Yes, if you work hard.

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22

Between you and me...

Goal

- Research oriented
 - Learn about **current research efforts**
 - Learn **how to do research**

Course format

- Lectures (5 sessions); student presentations (8 sessions)
- I provide basic information; you study the topic in details.
- I cover classic results; you explore more recent and advanced findings.

Please don't ask...

- Is this equation important? Do I have to memorize it?
- Is this topic examinable?
- Can you post detailed solutions to Question 5 in Homework 1?

Please do ask...

- Why does the algorithm take this step? What if it doesn't?
- Is there a way to improve the efficiency of the algorithm?
- What are the advantages and disadvantages between these two algorithms