JC3504 Robot Technology

Lecture 1: Introduction

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Outline

- History of Robot
- Definition of Robot
- Course Arrangements

History of Robot

Leonardo’s Robot

Leonardo da Vinci's robot, conceptualised in the late 15th century, is considered one of the earliest attempts to create a mechanised human figure capable of movement. This visionary design, reflecting da Vinci's profound understanding of human anatomy and mechanics, showcases the remarkable foresight of automata's potential.

The Writer Automaton

Jaquet-Droz's "The Writer" is a remarkable example of 18th-century automaton craftsmanship, created by Pierre Jaquet-Droz, a Swiss watchmaker, and his son Henri-Louis. Completed around 1774, this automaton is one of the most famous and intricate mechanical devices of its time. "The Writer" is a mechanical boy seated at a desk, equipped with a quill pen that he dips into ink before writing any custom text up to 40 characters long on a piece of paper.

This feat is accomplished through a complex internal mechanism consisting of cams, levers, and gears, which can be programmed to follow specific patterns for each letter and number, allowing the automaton to write various phrases and messages. The device's ability to be programmed makes it a precursor to modern computers, showcasing the ingenuity and mechanical prowess of its creators.

The Writer Automaton

<video: 01 - The Writer.mp4>

Mechanical Turk

The Mechanical Turk, also known as the Automaton Chess Player, or simply The Turk, was a fraudulent chess-playing machine constructed in 1770, which appeared to be able to play a strong game of chess against a human opponent. For 84 years, it was exhibited on tours by various owners as an automaton. The machine survived and continued giving occasional exhibitions until 1854, when a fire swept through the museum where it was kept, destroying the machine.

Afterwards, articles were published by a son of the machine's owner revealing its secrets to the public: that it was an elaborate hoax, suspected by some, but never proven in public while it still existed.

Unimate

George Devol's Unimate, introduced in 1961, is heralded as the world's first industrial robot, revolutionising manufacturing with its automated capabilities. This groundbreaking innovation laid the foundation for modern robotics, transforming production lines with unprecedented efficiency and precision.

Unimate

<Video: 01 - First Industrial Robot Ever.mp4>

Shakey

Shakey the Robot (1969) was the first general-purpose **mobile** robot able to reason about its own actions. While other robots would have to be instructed on each individual step of completing a larger task, Shakey could analyse commands and break them down into basic chunks by itself.

Due to its nature, the project combined research in robotics, computer vision, and natural language processing. Because of this, it was the first project that melded logical reasoning and physical action. Shakey was developed at the Artificial Intelligence Center of Stanford Research Institute (now called SRI International).

Some of the most notable results of the project include the A* search algorithm, the Hough transform, and the visibility graph method.

Shakey

<Video: 01 - Shakey the Robot.mp4>

Da Vinci Surgical System

The Da Vinci Surgical System represents a pioneering advancement in the field of robotic-assisted surgery, allowing surgeons to perform complex procedures with enhanced precision, flexibility, and control. Utilising a 3D vision system and tiny wristed instruments that bend and rotate far beyond the capabilities of the human hand, this innovative system has revolutionised minimally invasive surgery since its introduction.

Through its design, the Da Vinci Surgical System facilitates highly delicate operations, improving patient outcomes by reducing recovery times, minimising scarring, and lowering the risk of complications.

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Amazon Warehouse Robots

The Amazon warehouse robots are an innovative automation system designed to enhance storage and sorting efficiency. These robots are engineered to navigate within the warehouse autonomously transporting goods based on order requirements. Equipped with advanced navigation technology and sensors, they can manoeuvre around obstacles and accurately locate the required items swiftly, Integrated with warehouse management systems, these robots provide real-time updates on the location of goods, making the entire storage process more efficient and intelligent.

Amazon Warehouse Robots

<Video: 01 - Inside the Amazon Robotic Sort Center in Tracy.mp4>

Boston Dynamics' Atlas and SpotMini

Boston Dynamics' Atlas and SpotMini are exemplary showcases of cutting-edge robotics technology, demonstrating great agility, mobility, and adaptability in robots. Atlas, often referred to as one of the world's most advanced humanoid robots, has been designed for a variety of search and rescue tasks. It exhibits remarkable human-like dexterity and mobility, capable of running, jumping over obstacles, and even performing backflips. On the other hand, SpotMini is a smaller, four-legged robot that resembles a dog. It's known for its ability to navigate complex environments, climb stairs, and handle objects with its mechanical arm. SpotMini's applications range from assisting in construction sites to performing tasks in offices and homes.

Boston Dynamics' SpotMini

<Video: 01 - Boston Dynamics takes on its door-opening SpotMini.mp4>

What Is A Robot?

Are Them Robots?

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What Is A Robot?

A robot is a machine designed to execute one or more tasks automatically with speed and precision. There are several essential characteristics that define a robot:

- Autonomy -- Robots can operate on their own, making decisions based on pre-programmed instructions or through artificial intelligence (AI) without human intervention. The level of autonomy can vary, from fully autonomous robots that can navigate and make decisions independently, to semi-autonomous robots that require some level of human input.

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- Sensory Perception -- Robots often have sensors to perceive their surroundings. These can include cameras, microphones, temperature sensors, and tactile sensors, among others. Sensory input allows a robot to gather information about its environment, which it can then process to make decisions or take actions.

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- Actuation -- Robots react to their environment through actuators, which are the mechanisms that allow the robot to move or manipulate objects. This can include motors that drive wheels or legs for movement, arms for picking up or manipulating objects, or other tools specific to the robot's designed tasks.

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- Programmability -- Robots are programmable, meaning they can be coded to perform a wide variety of tasks. This programming can be fixed and unchangeable or adaptable, allowing the robot to learn from its environment and experiences to improve its performance over time.

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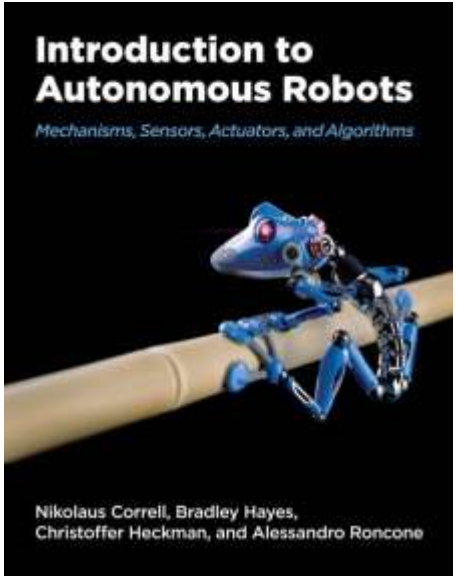
- Integration -- Robots can integrate the data received from their sensors to plan and execute tasks, navigate, or perform complex operations. This integration is often facilitated by sophisticated software that processes inputs and directs the robot's actions accordingly.

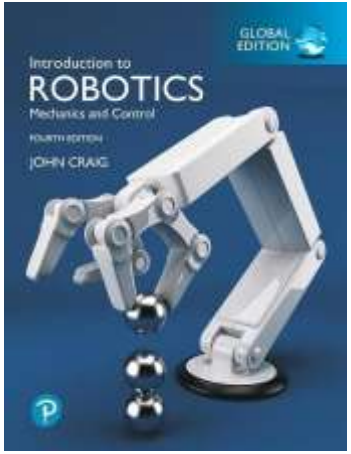
About Our Course

Syllabus

- The Robot Operating System (ROS)
- Kinematic constraints on robot motion
- Overview of different sensing modalities
- Computer vision and image processing
- Localisation
- Planning and search
- Robot architectures

Textbook


Introduction to
Autonomous Robots
Mechanisms, Sensors, Actuators, and Algorithms
Nikolaus Correll, Bradley Hayes,
Christoffer Heckman, and Alessandro Roncone


GLOBAL EDITION
Introduction to
ROBOTICS
Mechanics and Control
FOURTH EDITION
JOHN CRAIG


HUMBLE
HAWKSBILL


ARTICLE
Mastering the game of Go without human knowledge

Teaching Arrangements

Teaching Arrangements:

- 32 theory sessions (across 16 weeks)
- 32 practical sessions (across 16 weeks)

Assessment:

- Group programming assignment (50%) x 2

Theory Session Arrangements

1. Introduction
2. The Robot Operating System (ROS)
3. Mechanical Manipulator Introduction
4. Kinematics (1)
5. Kinematics (2)
6. Sensing and Actuation
7. Computer Vision (1)
8. Computer Vision (2)
9. Computer Vision (3)
10. Plan and Search
11. Localisation
12. Simultaneous Localisation and Mapping
13. Reinforcement Learning (1)
14. Reinforcement Learning (2)
15. Autopilot (invited talk)
16. Review

Practical Session Arrangements

For our practical sessions, we will dedicate our efforts entirely to learning ROS. Tomorrow's lecture will provide a basic introduction to ROS, then, subsequent practical sessions will be geared towards self-guided learning of ROS. We will provide a series of practical guides to step-by-step familiarise you with ROS.

The content of the lectures may not align with ROS, as some topics covered in the lectures can be challenging to implement directly with ROS. Thus, you are encouraged to tailor your practical sessions according to your personal preferences and pace.

By the end of this four-week course, we hope you will have acquired a fundamental proficiency in using ROS.

You are encouraged to utilise the practical sessions to complete your project assignments.

Assessment 1 -- Catch Turtle All

- In this project, you are required to develop and implement an interactive simulation in the Turtlesim environment using ROS2.
- Your main objective is to program a master turtle to "catch" other turtles that appear randomly within the environment.

See: Catch Turtle All.pdf

Assessment 1 -- Catch Turtle All

Group Project:

- 3-5 people/group

Deadline:

- 25 May 2025

Submission:

- Code
- Video Evidence !
- Project Report
- Group workload profile

See: Catch Turtle All.pdf

Assessment 2 – Robert Development Proposal

- Complete a proposal for a robot project design. The proposal requirements are given in '**RobertDesignProposal.docx**'.
- You need to fill in the questions in '**RobertDesignProposal.docx**' according to the requirements to complete the proposal.

Group Project:

- 3-5 people/group

Deadline:

- 1 June 2025

Submission:

- Completed RobertDesignProposal.docx

Ask Questions

We encourage students to ask questions at any time during working hours.

- Just Ask: feel free to interrupt the me with your questions without the need to raise your hand, as we promote discussion in the classroom.
- You can also make use of the time during lab sessions or breaks to ask questions.
- Additionally, you are welcome to send emails with your queries, or pose them during the Office Hour on Thursday afternoons (it would be prudent to check the lecturer availability in advance due to the limited office space).

No Code Show Policy: We will NOT look at students' code during as students are expected to know how to debug issues with their own code.