

# CS4297: CLOUD ROBOTICS AND AUTOMATION

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## Effective Term

Semester A 2022/23

## Part I Course Overview

### Course Title

Cloud Robotics and Automation

### Subject Code

CS - Computer Science

### Course Number

4297

### Academic Unit

Computer Science (CS)

### College/School

College of Engineering (EG)

### Course Duration

One Semester

### Credit Units

3

### Level

B1, B2, B3, B4 - Bachelor's Degree

### Medium of Instruction

English

### Medium of Assessment

English

### Prerequisites

CS2310 Computer Programming

AND

(CS3103 Operating Systems or

CS4480 Data-Intensive Computing or

CS4487 Machine Learning)

### Precursors

Nil

### Equivalent Courses

Nil

### Exclusive Courses

Nil

## Part II Course Details

### Abstract

This course aims at studying robotics and automation from the perspective of cloud computing and computer science. The topics are grouped into three main areas: the basics of programmable robots for automated tasks, principles of cloud computing technologies and robotics-related software paradigm such as the Robotics Operating System (ROS). The traditional communication and networking technologies that enable the cloud computing technologies and their adoption in industry will be introduced by studying several case studies such as Google's autonomous car driving, consumer appliances robotics such as iRobot's Roomba cleaners, Amazon's automating of mobile platforms to move goods in a warehouse using indoor positioning and navigation. We will focus on how cloud computing techniques can automate manufacturing tasks using algorithms designed based on machine learning and big data analytics.

### Course Intended Learning Outcomes (CILOs)

CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Identify the basic problems, limitations, strengths and current trends of programmable robotics and automation.	x		
2	Explain the current cloud computing technologies and computing mechanisms for robotics such as ROS.		x	
3	Create novel mechanisms and systems for supporting cloud robotics and automation by examining emerging technologies such as iRobot' s consumer appliance and Google' s driverless car	x	x	
4	Analyse and critique the performance of robotics algorithms and data analytics algorithms for cloud robotics.	x	x	
5	Develop the attitude to use software programming and cloud computing solutions to create cloud robotics prototype.	x	x	

#### A1: Attitude

Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

#### A2: Ability

Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

#### A3: Accomplishments

Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

**Teaching and Learning Activities (TLAs)**

TLAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lecture	The lectures will present selected cloud robotics and automation technologies such as the Robot Operating Systems (ROS) programming paradigm, cloud computing automation, iRobot' s consumer appliance, and the theory and algorithms behind them. The algorithms will be illustrated with real-world examples to motivate the students' understanding. Implementation details will also be discussed.	1, 2, 3, 4, 5 3 hours/week
2	Tutorials	The students will work on problem sets during the tutorial sessions to gain better understanding of the lecture material.	1, 2, 3, 4, 5 8 hours/semester
3	Assignments	Students will implement selected cloud computing and robotics software programming, apply them to small robotics problems, and interpret the results. Students can then observe the effectiveness of the cloud robotics algorithm, and evaluate the differences between various algorithms.	1, 2, 3, 4, 5 2 hours/week

**Assessment Tasks / Activities (ATs)**

ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Homework Assignments	1, 2, 3, 4, 5	10
2	Midterm exam	1, 2, 3, 4, 5	10
3	Project	1, 2, 3, 4, 5	30

**Continuous Assessment (%)**

50

**Examination (%)**

50

**Examination Duration (Hours)**

2

**Additional Information for ATs**

For a student to pass the course, at least 30% of the maximum mark for the examination must be obtained.

**Assessment Rubrics (AR)**

**Assessment Task**

Tutorial

**Criterion**

Assignment may include short factual questions and design exercises regarding the various principles of cloud robotics and cloud computing. Assignment may include simple project / exercises. There would also be hands-on exercises.

**Excellent (A+, A, A-)**

High

**Good (B+, B, B-)**

Significant

**Fair (C+, C, C-)**

Moderate

**Marginal (D)**

Basic

**Failure (F)**

Not even reaching marginal levels

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**Assessment Task**

Midterm Exam

**Criterion**

The mid-term quiz will include questions assessing the students' understanding cloud robotics and cloud computing automation.

**Excellent (A+, A, A-)**

High

**Good (B+, B, B-)**

Significant

**Fair (C+, C, C-)**

Moderate

**Marginal (D)**

Basic

**Failure (F)**

Not even reaching marginal levels

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**Assessment Task**

Project

**Criterion**

There would be hands-on and case study on cloud robotics design in the project. Tasks may include software programming project.

**Excellent (A+, A, A-)**

High

**Good (B+, B, B-)**

Significant

**Fair (C+, C, C-)**

Moderate

**Marginal (D)**

Basic

**Failure (F)**

Not even reaching marginal levels

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**Assessment Task**

Final Exam

**Criterion**

The final exam and mid-term quiz will include questions assessing the students' understanding on cloud robotics.

**Excellent (A+, A, A-)**

High

**Good (B+, B, B-)**

Significant

**Fair (C+, C, C-)**

Moderate

**Marginal (D)**

Basic

**Failure (F)**

Not even reaching marginal levels

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## Part III Other Information

**Keyword Syllabus**

Programmable Robotics. Cloud computing. Robotics algorithms such as SLAM and navigation planning. Statistical Optimization. Robot Operating Systems (ROS) and architectures. Data analytics. Emerging networked robotics such as driverless cars and consumer robotics. Internet-of-Things Networks.

Syllabus

- Basic issues in cloud robotics and automation: Supports for cloud computing. Limitations and characteristics of programmable robots. Development tools and software. Robot operating systems and software services. Latest development and current trends of cloud robotics computing.
- Programmable robots: Microprocessors such as Arduino/Raspberry Pi with consumer robotic appliances. Robotics design. Navigation planning. Simultaneous Localisation and Mapping algorithm. Robot operating systems and its architecture.
- Cloud computing and networking: Cloud computing systems. Client-server programming and programming API in the cloud. Software programming and API services to integrate ROS and the Cloud.
- Cloud robotics and automation architectures: robotics and human automation by cloud computing, current trends of networked robotics using Internet and the Cloud. System components and architectures of the Internet of Things. Optimisation and Data analytics algorithms.

## Reading List

### Compulsory Readings

	Title
1	Robot Operating System (ROS), Open Source Robotics Foundations, <a href="http://www.ros.org">www.ros.org</a>
2	A Survey of Research on Cloud Robotics and Automation. Ben Kehoe, Sachin Patil, Pieter Abbeel, Ken Goldberg. IEEE Transactions on Automation Science and Engineering (T-ASE): Special Issue on Cloud Robotics and Automation. Vol. 12, no. 2
3	Mobile Robots: Mathematics, Models and Methods, Alonzo Kelly, Cambridge University Press, 1st Edition, 2013
4	Introduction to Autonomous Mobile Robots, Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzza, The MIT Press; 2nd Edition, 2011.
5	Programming Robots with ROS: A Practical Introduction to the Robot Operating System, Morgan Quigley, Brian Gerkey and William Smart. O' Reilly Media, 1st Edition, 2015.
6	Learning Robotics using Python, Lentin Joseph, Packt Publishing, 1st Edition, 2015.
7	A Gentle Introduction to ROS, Jason M. O' Kane, CreateSpace Independent Publisher; 1st Edition, 2013.

### Additional Readings

	Title
1	Nil