

Automation in Construction /Construction Automation and Robotics (Fall 2022)

UNIQUE NUMBER: CEE 4803C/8813L

INSTRUCTOR: Dr. Yong K. Cho

Mason 4140B

Phone: 404-385-2038

Email: yong.cho@ce.gatech.edu

Website: <http://rical.ce.gatech.edu> (Links to an external site.)

LECTURE ASSISTANT Seongyong Kim, Andrew Yarovoi, Yeseul Kim (PhD students)

Bunger-Henry #214

Office Hour: TR 12-3pm ((preferred with online meeting, e.g., Skype)

Email: skim3310@gatech.edu, ayarovoi3@gatech.edu, ykim858@gatech.edu

MEETINGS: MW 3:30-4:45 pm

LOCATION: Molecular Sciences and Engr 1222

OFFICE HOURS: T-TH, 4:45-6 PM, or by appointment (preferred with online meeting, e.g., Zoom)

PRE-REQUISITE CEE 3000 Civil Engineering Systems, Engineering Economics, or similar courses

CLASS WEBSITE Canvas

COURSE OBJECTIVES

This course covers recent developments in construction automation and robotics. The emphasis is on understanding the capabilities and methods that can be selected for a particular construction automation project. Lectures on Automation in Construction provide exposure to available state-of-the-art technologies. Lectures on needs assessment, AHP, and economic feasibility provide the means to evaluate the new technology. Case studies and hands-on activities provide more details on specific applications and address obstacles to implementing new automation technology in the construction industry.

GOALS FOR THE COURSE

From this course, the following outcomes can be obtained:

- 1) The student will understand industrial robotics that aids partial or full automation of construction processes.
- 2) The student will be able to systematically prioritize the need and feasibility of the construction technologies based on safety, productivity, quality, and economics.
- 3) The student will be able to design a conceptual automated construction system based on the criteria of need, economic feasibility, and technical feasibility.
- 4) The student will experience state-of-the-art construction technologies, including 3D reconstruction, virtual reality, augmented reality, aerial and ground robots, and global industry robotic applications.

HOMEWORK POLICY

Multiple assignments will be given throughout the semester and is an essential part of understanding the lecture materials. The homework should be submitted on the due day before the beginning of the class. Homework will be graded and returned. Students are responsible for assignments turned in on time; even for days, the student has an excused absence. Late homework will be graded for the benefit of the student, but no credit will be given. Assignments are intended for individual effort, so you are on the honor system. When working on homework, you may work with other students in the class. Should you collaborate with another student(s), the name(s) of everyone you collaborated with must be marked on the cover sheet. Each student is responsible for submitting her/his own homework. When group homework is given, only one group submission is permitted.

Submittals:

Electronic copies: After online submission, it is strongly recommended that you should save and store your homework in your local drive.

Hard copies: The submittals are to be identified on each page with names and other identification as directed by the person receiving the submittal. Each problem is to commence on a new page with multiple pages **stapled** once in the upper left corner relative to the "portrait" orientation. The pages are to be numbered and sequenced in a logical manner and neatly lettered and drawn with a straightedge and other appropriate drawing tools as required. All page contents will be free of colors in the "red" range of the spectrum, which is reserved for grading. Submittals will reproduce on a black/white copier. No pages torn from spiral or ring binders or with separate covers will be accepted. The instructor reserves the right to lower a submittal grade if it is not understandable in any way regarding legibility and/or organization.

EXAM POLICY

An exam and quizzes will cover material given in the lecture slides, notes, handouts, homework, movies, guest lectures, and/or projects. Unless stated otherwise, all quizzes, tests, and examinations will be a closed book exam without notes or any other mnemonic methods. Sufficient information will appear on these items to complete them. Students not taking the required quizzes, tests, and examinations will receive a grade of zero for them. The only university excused circumstances will be considered. A grade of zero will be assigned for missed exams. Exams will not be rescheduled to accommodate early trips home or any other trips of a personal nature. Bring only

the required resources (pen, pencil, ruler, calculator, etc.) to exams. Nothing else will be allowed; bags or cell phones are not allowed with the person or underneath the table. If necessary, the seating diagram needs to be followed during exams.

PARTICIPATION POLICY

Although class attendance is mandatory, up to **one absence** is allowed during the semester. All students are still expected to attend class regularly, as well as be punctual in every class session. Sleeping in class, being late, or leaving early without prior notice may result in an unexcused absence. Each student is responsible for all material and administrative instructions given during the lecture period. Instructions will not be repeated outside of class. Each unexcused absence will result in one percentage point deducted from your final grade up to a maximum of 10%. It is a student's own risk if a student misses homework deadlines, exams, or quizzes due to any absence. Also, each excused absence requires prior approval (before class begins), followed by proofing materials (e.g., interview invitation, other class field trips, institute athletic activities). Please see other absences related to personal emergencies in the next section. Also, using a cell phone, talking, or eating during the class is inappropriate, discourteous, and inexcusable and will negatively affect the participation grade.

Missing Classes for Personal Emergencies

Students may need to miss classes (especially exams or quizzes) due to personal emergencies such as being hospitalized, being in a car accident, or family issues. The Office of the Dean of Students can assist students with documented emergencies by contacting professors on behalf of the student. For more information, please call the Office of the Dean of Students at 404-894-6367, or complete the [Request Assistance Form](https://gatech-advocate.symplicity.com/care_report/). (https://gatech-advocate.symplicity.com/care_report/ (Links to an external site.)). The office may ask for a related document as well.

GRADING SCHEME

Percentage	Grade
90.00-100	A
80.00-89.99	B
70.00-79.99	C
60.00-69.99	D
59.99 or lower	F

GRADING CRITERIA

Participation (10%), Quizzes & Homework (30%)	40%
1 Test @ 30%	30%
Final Group Project @30%	30%

Required resources:

It is recommended for each student to bring a laptop computer (Windows OS) to class for hands-on activities for machine learning, image processing, and point cloud processing. Mac users can access the CEE virtual lab or use Windows with a dual booting setup (e.g., Boot Camp). The computer should be able to run software products efficiently. A laptop can be checked out from the library (4 hours per day) or the instructor's lab, if needed.

Academic Integrity:

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. For information on Georgia Tech's Academic Honor Code, please visit <http://www.catalog.gatech.edu/policies/honor-code/> (Links to an external site.) or <http://www.catalog.gatech.edu/rules/18/> (Links to an external site.).

Any student suspected of cheating or plagiarizing on a quiz, exam, or assignment will be reported to the Office of Student Integrity, which will investigate the incident and identify the appropriate penalty for violations.

Academic Accommodations for Students with Disabilities:

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services at (404)894-2563 or <http://disabilityservices.gatech.edu/> (Links to an external site.), as soon as possible to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also e-mail me as soon as possible in order to set up a time to discuss your learning needs.

Course Schedule:

Week	Topics	Remarks (Assignments release date)
1 (Aug 22, 24)	<ul style="list-style-type: none">Course IntroductionIntroduction to Construction Automation	
2 (Aug 29, 31)	<ul style="list-style-type: none">Automated Building Construction SystemsNeeds Assessment Process	

3 (Sept 5, 7)	<ul style="list-style-type: none"> Economic feasibility analysis <ul style="list-style-type: none"> - Part 1 	<ul style="list-style-type: none"> Labor day Assignment #1: AHP
4 (Sept 12, 14)	<ul style="list-style-type: none"> - Part 2 - Part 3 	<ul style="list-style-type: none"> Assignment #1: Sensitivity analysis
5 (Sept 19, 21)	<ul style="list-style-type: none"> Analytic Hierarchical Processes (AHP) 	<ul style="list-style-type: none"> Assignment #2: AHP
6 (Sept 26, 28)	<ul style="list-style-type: none"> Introduction to Robotics <ul style="list-style-type: none"> - Kinematics (part 1) - Kinematics (part 2) 	<ul style="list-style-type: none"> Assignment #3: Kinematics
7 (Oct 3, 5)	<ul style="list-style-type: none"> UAV (drones) for construction <ul style="list-style-type: none"> - Safety, FAA regulations, Operations - Applications 3D reconstruction <ul style="list-style-type: none"> - Photogrammetry - Structured light (RGB-D) 	<ul style="list-style-type: none"> Drone flying demo Assignments #4: Photogrammetry
8 (Oct 10, 12)	<ul style="list-style-type: none"> Laser scanning <ul style="list-style-type: none"> - Laser scanning using targets Introduction to Artificial Intelligence/ Machine Learning Part 1 	<ul style="list-style-type: none"> Group project intro. Hands-on practices Assignment #5: laser scans registration practice (Autodesk Recap 360)
9 (Oct 19)	<ul style="list-style-type: none"> Introduction to Artificial Intelligence/ Machine Learning Part 2 	<ul style="list-style-type: none"> Oct. 17: semester break
10 (Oct 24, 26)	<ul style="list-style-type: none"> Object detection (2D) / Teachable machine <ul style="list-style-type: none"> - Recall, Precision, F1 Exam Review/Group Discussion for proposal 	<ul style="list-style-type: none"> Assignment #6: Image Segmentation

11 (Oct 31, Nov 2)	<ul style="list-style-type: none"> Object detection (3D) / Software Exam (Nov. 2) 	<ul style="list-style-type: none"> Group project proposal abstract due (Nov 1) Assignment #7: point cloud-based object recognition
12 (Nov 7, 9)	<ul style="list-style-type: none"> Scan to BIM <i>Simultaneous localization and mapping (SLAM)</i> 	
13 (Nov 14, 16)	<ul style="list-style-type: none"> AR/VR Digital Twin/Metaverse 	
14 (Nov 21)	<ul style="list-style-type: none"> IoT and wireless sensing for worker safety and productivity 	Nov 23-25, Thanksgiving Recess
15 (Nov 28, 30)	<ul style="list-style-type: none"> Mobile robots and quadruped robots RICAL Lab Tour and demos 	<ul style="list-style-type: none"> Technology and robots demos
16 (Dec 5)	<ul style="list-style-type: none"> Group project presentations 	<ul style="list-style-type: none"> Final Project Proposal Report due (by noon)

Important Days (Fall 2022):

- Sept.5: Labor day
- Oct. 17-18: No classes, Fall break
- Oct. 29: Withdrawal Deadline
- Nov. 23-25: Thanksgiving recess
- Dec. 5: Final Instruction Class Day

*The outline contents are subject to change at the discretion of the instructor.

** Exam date can be rescheduled based on the class progress, guest speakers, field trip, and discussion in class.

Final Group Project

Automation Opportunity Analysis and Conceptual Design (Tentative topic)

The main purpose of the final group project is to identify candidate construction activities for automation by evaluating the top tasks based on cost and concern needs analysis. Then, the group

will finally propose the automation solution that will most benefit the construction project from safety, quality, productivity, feasibility, and economic viewpoints.

- Team formation: Students need to make a group with a max. of three team members.
- Learning objectives: From this project, students will better understand the construction process and state-of-the-art construction technologies and be able to identify the tasks for automation potential and estimate the economic benefits of the automation solution using engineering economics techniques. Also, students will be able to systematically identify research needs for automation, design conceptual automated solutions, and apply evaluation techniques to justify the solutions' feasibility.
- Tasks:
 - Choose an industry sector, such as roads, bridges, apartment complexes, warehouses, offices towers, homes, refineries, etc. Explain the background and motivation for your choice. The topics can be from an on-going project or future project.
 - Conduct a Need Analysis for a minimum array of five tasks associated with that type of construction, based on crude estimates and your collective experience and judgment.
 - Briefly describe how you would have collected data if this had been requested.
 - Suggest an automation solution for each task using one paragraph and a single illustration description.
 - Conduct AHP analysis on your solution with the criteria of safety, quality, productivity, and/or cost-saving
 - Assess the opportunity associated with each solution by considering technical, economic, and financial feasibility.
 - Develop a conceptual design
 - Describe impediments to implementation
 - Make conclusions and recommendations.
- Submittals to Canvas:
 1. 10-page report (MS word file): **Due on Dec 5, 2022, noon**
 2. Presentation slides for 12-15 minutes (PPT file): **Due on Dec 5, 2022, noon**

*Only one representative per team submits files to Canvas.