Course ID and Title: CSCI 599, Introduction to Holodecks
Units: # 4
Term—Day—Time: Spring 2024 — Mon, Wed 5-6:50 pm

Location: TBD

Instructor: Shahram Ghandeharizadeh
Office: SAL 208
Office Hours: Mon, 12-1:30, Wed, 3:30-5 pm
Contact Info: shahram@usc.edu; 213-740-4781

Catalogue Description
None. This is a seminar on a new topic.

Course Description
A holodeck enables users to see virtual objects without glasses and to interact with them without wearing gloves or bodysuits. Holodecks may occupy physical volumes such as a tabletop cuboid or sphere, a telephone booth, a self-driving vehicle, a room, a concert hall, a stadium, or other well defined spaces. This course introduces students to Flying Light Specks (FLSs) as miniature drones with Red/Green/Blue (RGB) lights that fly as swarms to illuminate a virtual object. These illuminations provide true depth, enabling a user to perceive a scene more completely by analyzing its illumination from different angles. In addition, students are introduced to FLS-matter, a swarm of miniature drones to generate the tactile (simulating skin receptors only) and kinesthetic (muscle sense of pushing or lifting objects with mass) senses. These concepts enable immersive and interactive 3D displays depicted in science fiction shows, e.g., Star Trek's holodeck. A holodeck will revolutionize the future of human communication and perception, and how we interact with information and data.

Learning Objectives
This course introduces students to:
- Programmable matter such as Claytronics, BitDrones, Roboxels, and FLSs.
- Encounter-type haptic devices.
- Centralized and decentralized algorithms for group formation.
- Collision prevention and detection techniques.
- Localization techniques.
- Matlab and MathWorks for rapid prototyping and evaluation of algorithms.
- Physics engines such as Airsim and Gazebo to conduct simulation studies.
- Virtual Reality, Augmented Reality, and Mixed Reality.
- Holographs.

Prerequisite(s): Principles of Software Development (CSCI 201)
Co-Requisite(s): None
Concurrent Enrollment: None
Recommended Preparation: Operating Systems (CSCI 356), AI (CSCI 360), Data Management (CSCI 485), Robotics (CSCI 445L).
Course Notes
All lecture material will be posted on the USC blackboard system prior to lectures. We will use Piazza for class discussions.

Technological Proficiency and Hardware/Software Required
Students should be proficient in design and implementation of concepts in different programming languages.

Required Readings and Supplementary Materials
Required readings and supplementary materials are based on recently published papers. USC students may use their provided ACM/IEEE/Springer digital library membership to download these papers for free.

Optional Readings and Supplementary Materials
[Optional course materials that are not required but recommended.]

Description of Assignments and How They Will Be Assessed
The course includes a class project. Students are encouraged to conduct their project on the numerous research topics related to the Flying Light Specks, FLSs.

Participation [if applicable]
In-class participation counts towards 10% of grade. This may include a student presentation of a paper.

Grading Breakdown

<table>
<thead>
<tr>
<th>Assessment Tool (assignments)</th>
<th>% of Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class Participation</td>
<td>10%</td>
</tr>
<tr>
<td>Exam 1</td>
<td>30%</td>
</tr>
<tr>
<td>Project Description</td>
<td>30%</td>
</tr>
<tr>
<td>Final Project Report</td>
<td>30%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>100%</td>
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</table>

Grading Scale
The final letter grade is based on a curve.

Assignment Submission Policy
Exams will be graded promptly and returned in a week.
Project description and the final project report include an oral presentation.

Course-Specific Policies
In-class participation is a requirement.
No late reports are accepted. All deadlines are final.
Class participation may include students presenting technical papers.
Students who conduct original research are awarded with extra credit.

Attendance
This course is based on either recently introduced technical manuscripts or an adaptation of novel concepts for the exciting topic of holodecks. Some of these manuscripts are difficult to read. In-class attendance and participation is a requirement.
**Academic Integrity**

Unless otherwise noted, this course will follow the expectations for academic integrity as stated in the [USC Student Handbook](#). The general USC guidelines on Academic Integrity and Course Content Distribution are provided in the subsequent “Statement on Academic Conduct and Support Systems” section.

[Include information regarding grade outcomes a student may expect if found in violation, such as: If found responsible for an academic violation, students may be assigned university outcomes, such as suspension or expulsion from the university, and grade penalties, such as an “F” grade on the assignment, exam, and/or in the course.]

Please ask the instructor [and/or TA(s)] if you are unsure about what constitutes unauthorized assistance on an exam or assignment, or what information requires citation and/or attribution.

You may not record this class without the express permission of the instructor and all other students in the class. Distribution of any notes, recordings, exams, or other materials from a university class or lectures — other than for individual or class group study — is prohibited without the express permission of the instructor.

**Use of Generative AI in this Course**

Students may use generative AI to improve the written English of their report. With advanced courses, Generative AI makes a lot of mistakes. It is the responsibility of the student to read the technical manuscripts and verify technical correctness of their reports.

Solutions to assignments and projects that are technically flawed will get a score of zero.
Course Evaluations
Course evaluation occurs at the end of the semester university-wide. It is an important review of students’ experience in the class. The process and intent of the end-of-semester evaluation should be provided. In addition, a mid-semester evaluation is recommended practice for early course correction.

Course Schedule: A Weekly Breakdown

Week 1: FLS Displays & Claytronics


Dig Deeper (Optional Reading):

Week 2: FLS Illuminations & Group Construction (Matching Problem)


Dig Deeper:

Week 3: Encounter-Type Haptics (Guest Lecturer Heather Culbertson)


Dig Deeper:

Week 4: Sensors for Localization


Dig Deeper:


**Dig Deeper:**


**Week 6: Quadcopters in Action**


**Dig Deeper:**


**Week 7: Collision Avoidance, Detection, Planning, Prevention**


**Dig Deeper:**

- B. Han, T. Qu, X. Tong, J. Jiang, S. Zlatanova, H. Wang, C. Cheng, Grid-optimized UAV indoor path planning algorithms in a complex environment, International Journal of
Week 8: Review for Midterm and Exam

Week 9: Matlab

Week 10: Spring Break

Week 11: Manufacturing


Week 12: Localization/Positioning System


Dig Deeper:

- Hari Balakrishnan, Roshan Baliga, Dorothy Curtis, Michel Goraczko, Allen Miu, Nissanka B. Priyantha, Adam Smith, Ken Steele, Seth Teller, Kevin Wang, Lessons from Developing and Deploying the Cricket Indoor Location System, November 2003. (Preprint.)
- This paper describes the lessons learned from Cricket v1 and how Cricket v2's design builds on these lessons.

**Week 13: 3D Acoustics**


**Dig Deeper:**

**Week 14: Noise Reduction**


**Dig Deeper:**
https://doi.org/10.2514/6.2006-2720

Week 15: Project Presentations

Course Schedule
<table>
<thead>
<tr>
<th>Week</th>
<th>Topics/Daily Activities</th>
<th>Readings/Preparation</th>
<th>Deliverables</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Week 1</strong>&lt;br&gt;Jan 8</td>
<td>FLS displays, Claytronics &amp; Catoms,</td>
<td>Ghandeharizadeh FLS displays, Sutherland Ultimate Display, Goldstein Catoms</td>
<td>3D Illuminations Matter for the Holodeck</td>
</tr>
<tr>
<td><strong>Week 2</strong>&lt;br&gt;Jan 15</td>
<td>Group Construction, Matching Problem</td>
<td>Preis centralized algorithm, Chmielowiec decentralized algorithm</td>
<td>Centralized and decentralized algorithms to form groups</td>
</tr>
<tr>
<td><strong>Week 3</strong>&lt;br&gt;Jan 22</td>
<td>Encounter-Type Haptics (Guest Lecturer Heather Culbertson)</td>
<td>Rodrigo Haptics-On-Demand, Abdullah HapticDrone</td>
<td>Encounter-Type Haptics</td>
</tr>
<tr>
<td><strong>Week 4</strong>&lt;br&gt;Jan 29</td>
<td>Sensor for Localization</td>
<td>Phan et. al. Three Distance Measurement Sensors.</td>
<td>Localization of FLSs.</td>
</tr>
<tr>
<td><strong>Week 5</strong>&lt;br&gt;Feb 5</td>
<td>User Safety (Guest Lecturer Luis Garcia)</td>
<td>Ghandeharizadeh &amp; Garcia Safety in Holodeck App</td>
<td>User Safety</td>
</tr>
<tr>
<td><strong>Week 6</strong>&lt;br&gt;Feb 12</td>
<td>Project Reports due 2/28 &amp; Quadcopters</td>
<td>Auda Flyables, Abtahi Beyond the Force,</td>
<td>Class Projects Quadcopters in different applications</td>
</tr>
<tr>
<td><strong>Week 7</strong>&lt;br&gt;Feb 19</td>
<td>Collision Detection &amp; Avoidance</td>
<td>Sun APF Path Planning, Jyoti Rogue Agent, Sun APF Collision Avoidance</td>
<td>Artificial Potential Field (APF) Algorithm</td>
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<tr>
<td><strong>Week 8</strong>&lt;br&gt;Feb 26</td>
<td>Review for Exam 1 Exam 1 is on 3/4</td>
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<tr>
<td><strong>Week 9</strong>&lt;br&gt;Mar 4</td>
<td>Introduction to Matlab &amp; Mathworks</td>
<td>Motion illumination using FLS</td>
<td>Abstractions &amp; modeling</td>
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<tr>
<td><strong>Week 10</strong>&lt;br&gt;Mar 11</td>
<td>Spring Recess</td>
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<tr>
<td><strong>Week 11</strong>&lt;br&gt;Mar 18</td>
<td>Manufacturing</td>
<td>Fang et. al. AR in Manufacturing</td>
<td>Industry 4.0 and 5.0, AR and MR</td>
</tr>
<tr>
<td><strong>Week 12</strong>&lt;br&gt;Mar 25</td>
<td>Indoor Positioning System</td>
<td>Smith Cricket</td>
<td>Device tracking techniques</td>
</tr>
<tr>
<td><strong>Week 13</strong>&lt;br&gt;Apr 1</td>
<td>3D Acoustics</td>
<td>Mehra Wave-Based Sound Propagation</td>
<td>Sound in games</td>
</tr>
<tr>
<td><strong>Week 14</strong>&lt;br&gt;Apr 8</td>
<td>Noise Reduction</td>
<td>Herkes Quiet Technology</td>
<td>Suppress drone noise</td>
</tr>
<tr>
<td><strong>Week 15 &amp; 16</strong>&lt;br&gt;Apr 15 &amp; 22</td>
<td>Project Presentations</td>
<td>Project Presentations</td>
<td>Project Presentations</td>
</tr>
<tr>
<td><strong>FINAL</strong></td>
<td></td>
<td></td>
<td>Refer to the final exam schedule in the USC Schedule of Classes at classes.usc.edu.</td>
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</tbody>
</table>
Time Permitting

**Holograms**


**Physics Engines Airsim and Gazebo**


**Self-Assembly**


**Immersive Human Computer Interaction System**

Dig Deeper:

**Data Physicalization**

Swarms


Roboxels & Bit-Drones


Dig Deeper:
Statement on Academic Conduct and Support Systems

Academic Integrity:
The University of Southern California is a learning community committed to developing successful scholars and researchers dedicated to the pursuit of knowledge and the dissemination of ideas. Academic misconduct, which includes any act of dishonesty in the production or submission of academic work, comprises the integrity of the person who commits the act and can impugn the perceived integrity of the entire university community. It stands in opposition to the university’s mission to research, educate, and contribute productively to our community and the world.

All students are expected to submit assignments that represent their own original work, and that have been prepared specifically for the course or section for which they have been submitted. You may not submit work written by others or “recycle” work prepared for other courses without obtaining written permission from the instructor(s).

Other violations of academic integrity include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), collusion, knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

The impact of academic dishonesty is far-reaching and is considered a serious offense against the university. All incidences of academic misconduct will be reported to the Office of Academic Integrity and could result in outcomes such as failure on the assignment, failure in the course, suspension, or even expulsion from the university.

For more information about academic integrity see the student handbook or the Office of Academic Integrity’s website, and university policies on Research and Scholarship Misconduct.

Please ask your instructor if you are unsure what constitutes unauthorized assistance on an exam or assignment, or what information requires citation and/or attribution.

Course Content Distribution and Synchronous Session Recordings Policies
USC has policies that prohibit recording and distribution of any synchronous and asynchronous course content outside of the learning environment.

Recording a university class without the express permission of the instructor and announcement to the class, or unless conducted pursuant to an Office of Student Accessibility Services (OSAS) accommodation. Recording can inhibit free discussion in the future, and thus infringe on the academic freedom of other students as well as the instructor. (Living our Unifying Values: The USC Student Handbook, page 13).

Distribution or use of notes, recordings, exams, or other intellectual property, based on university classes or lectures without the express permission of the instructor for purposes other than individual or group study. This includes but is not limited to providing materials for distribution by services publishing course materials. This restriction on unauthorized use also applies to all information, which had been distributed to students or in any way had been displayed for use in relationship to the class, whether obtained in class, via email, on the internet, or via any other media. (Living our Unifying Values: The USC Student Handbook, page 13).

Students and Disability Accommodations:
USC welcomes students with disabilities into all of the University’s educational programs. The Office of Student Accessibility Services (OSAS) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each
course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at osas.usc.edu. You may contact OSAS at (213) 740-0776 or via email at osasfrontdesk@usc.edu.

Support Systems:

**Counseling and Mental Health** - (213) 740-9355 – 24/7 on call
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

**988 Suicide and Crisis Lifeline** - 988 for both calls and text messages – 24/7 on call
The 988 Suicide and Crisis Lifeline (formerly known as the National Suicide Prevention Lifeline) provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week, across the United States. The Lifeline is comprised of a national network of over 200 local crisis centers, combining custom local care and resources with national standards and best practices. The new, shorter phone number makes it easier for people to remember and access mental health crisis services (though the previous 1 (800) 273-8255 number will continue to function indefinitely) and represents a continued commitment to those in crisis.

**Relationship and Sexual Violence Prevention Services (RSVP)** - (213) 740-9355(WELL) – 24/7 on call
Free and confidential therapy services, workshops, and training for situations related to gender- and power-based harm (including sexual assault, intimate partner violence, and stalking).

**Office for Equity, Equal Opportunity, and Title IX (EEO-TIX)** - (213) 740-5086
Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

**Reporting Incidents of Bias or Harassment** - (213) 740-5086 or (213) 821-8298
Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures, and response.

**The Office of Student Accessibility Services (OSAS)** - (213) 740-0776
OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

**USC Campus Support and Intervention** - (213) 740-0411
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

**Diversity, Equity and Inclusion** - (213) 740-2101
Information on events, programs and training, the Provost’s Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

**USC Emergency** - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call
Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

**USC Department of Public Safety** - UPC: (213) 740-6000, HSC: (323) 442-1200 – 24/7 on call
Non-emergency assistance or information.

**Office of the Ombuds** - (213) 821-9556 (UPC) / (323-442-0382 (HSC)
A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

**Occupational Therapy Faculty Practice** - (323) 442-2850 or otfp@med.usc.edu
Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.