CSCI 599 - Introduction to Holodecks
Units: 4
Fall 2022 - Mondays and Wednesdays 2-3:50 pm

Instructor: Shahram Ghandeharizadeh
Office: SAL 208
Office Hours: Mon 12:30-1:30 pm, Wed 4-5:30 pm
Contact Info: shahram@usc.edu, 213-740-4781.

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.

Students will have the opportunity to conduct novel research and publish their work.

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

Prerequisite(s): Principles of Software Development (CSCI 201)
Recommended Preparation: Operating Systems (CSCI 356), AI (CSCI 360), Data Management (CSCI 485)

Course Notes: All lecture material will be posted on the USC blackboard system prior to lectures.

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.

Description and Assessment of Assignments
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.

**Grading Breakdown**
The class project is an important component of student grades. Projects may be done either individually or in teams.

<table>
<thead>
<tr>
<th>Assessment Tool (assignments)</th>
<th>Points</th>
<th>% of Grade</th>
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<tbody>
<tr>
<td>Class Participation</td>
<td>100</td>
<td>10%</td>
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<tr>
<td>Exam 1 (10/12/2022)</td>
<td>100</td>
<td>30%</td>
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<tr>
<td>Project Description</td>
<td>100</td>
<td>30%</td>
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<tr>
<td>Final Project Report</td>
<td>100</td>
<td>30%</td>
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<td><strong>TOTAL</strong></td>
<td><strong>100%</strong></td>
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**Assignment Submission Policy**
All project reports must be submitted using the USC blackboard system.

**Grading Timeline**
Exams will be graded promptly and returned in a week.
Project description and the final project report include an oral presentation.

**Additional Policies**
No late reports are accepted. All deadlines are final.
Class participation may include students presenting technical papers.
Students are rewarded with extra credit for conducting original research.
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: Roboxels & Bit-Drones**


**Dig Deeper:**
Week 5: User Safety (Guest Lecturer, Luis Garcia)


Dig Deeper:


Week 6: Quadcopters in Action


Dig Deeper:


**Week 7: Collision Prevention & Avoidance**


**Dig Deeper:**


**Week 8: Review for Midterm and Midterm**

**Week 9: Matlab**

**Week 10: Holograms**


**Week 11: Physics Engines Airsim and Gazebo**


**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.
- C. Watson. Permanent Magnet-Based Localization for Growing Robots in Medical Applications, Dissertation.

**Week 13: 3D Acoustics**

23. Mehra, Ravish and Raghuvanshi, Nikunj and Antani, Lakulish and Chandak, Anish and Curtis, Sean and Manocha, Dinesh. 2013. Wave-Based Sound Propagation in Large Open Scenes Using an

Dig Deeper:


Week 14: Noise Reduction


Dig Deeper:


Week 15: Project Presentations

<table>
<thead>
<tr>
<th>Week 1</th>
<th>Topics/Daily Activities</th>
<th>Readings/Preparation</th>
<th>Deliverables</th>
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<tbody>
<tr>
<td>8/22&amp;24</td>
<td>FLS displays, Claytronics &amp; Catoms, Ghandeharizadeh FLS displays, Sutherland Ultimate Display, Goldstein Catoms</td>
<td>3D Illuminations Matter for the Holodeck</td>
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<td>Week 2</td>
<td>Group Construction, Matching Problem, Preis centralized algorithm, Chmielowiec decentralized algorithm</td>
<td>Centralized and decentralized algorithms to form groups</td>
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<tr>
<td>8/29&amp;31</td>
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<tr>
<td>Week 3</td>
<td>Encounter-Type Haptics (Guest Lecturer Heather Culbertson) Rodrigo Haptics-On-Demand, Abdullah HapticDrone</td>
<td>Encounter-Type Haptics</td>
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<td>Labor day &amp; 9/7</td>
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<td>Week 4</td>
<td>Roboxels, Bit-Drones, Fast 3D printing McNeely Roboxels, Gomez Bit-Drones</td>
<td>Matter for the Holodeck Walking in a Holodeck</td>
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<td>9/12&amp;14</td>
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<td>Week 5</td>
<td>9/19&amp;21</td>
<td>User Safety (Guest Lecturer Luis Garcia)</td>
<td>Ghandeharizadeh &amp; Garcia Safety in Holodeck App</td>
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<td>Week 6</td>
<td>9/26&amp;28</td>
<td>Project Reports due 9/28 &amp; Quadcopters</td>
<td>Auda Flyables, Abtahi Beyond the Force, Quadcopters</td>
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<td>Week 7</td>
<td>10/3&amp;5</td>
<td>Collision Detection &amp; Avoidance</td>
<td>Sun APF Path Planning, Jyoti Rogue Agent, Sun APF Collision Avoidance</td>
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<td>Week 8</td>
<td>10/10&amp;12</td>
<td>Review for Exam 1 Exam 1 is on 10/12</td>
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<td>Week 9</td>
<td>10/17&amp;19</td>
<td>Introduction to Matlab &amp; Mathworks</td>
<td>Motion illumination using FLS</td>
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<td>Week 10</td>
<td>10/24&amp;26</td>
<td>Holograms</td>
<td>Chang Review, Xiang Future</td>
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<td>Week 11</td>
<td>10/31&amp;11/2</td>
<td>Physics Engines</td>
<td>Airsim &amp; Gozebo</td>
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<td>Week 12</td>
<td>11/7&amp;9</td>
<td>Indoor Positioning System</td>
<td>Smith Cricket</td>
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<td>Week 13</td>
<td>11/14&amp;16</td>
<td>3D Acoustics</td>
<td>Mehra Wave-Based Sound Propagation</td>
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<tr>
<td>Week 14</td>
<td>11/21&amp;23</td>
<td>Noise Reduction</td>
<td>Herkes Quiet Technology</td>
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<tr>
<td>Week 15</td>
<td>11/28&amp;30</td>
<td>Project Presentations</td>
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<td>FINAL</td>
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<td>Final Project Reports</td>
<td>Refer to the final exam schedule in the USC Schedule of Classes at classes.usc.edu.</td>
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**Time Permitting**

**Self-Assembly**


**Immersive Human Computer Interaction System**
Dig Deeper:


**Data Physicalization**


**Swarms**


**Statement on Academic Conduct and Support Systems**

**Academic Conduct:**

Plagiarism – presenting someone else’s ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, “Behavior Violating University Standards” policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on Research and Scholarship Misconduct.

**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
studenthealth.usc.edu/counseling
Free and confidential mental health treatment for students, including short-term psychotherapy, group
counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call
suicidepreventionlifeline.org
Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a
day, 7 days a week.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-9355(WELL), press “0” after
hours – 24/7 on call
studenthealth.usc.edu/sexual-assault
Free and confidential therapy services, workshops, and training for situations related to gender-based
harm.

Office for Equity, Equal Opportunity, and Title IX (EEO-TIX) - (213) 740-5086
eetoix.usc.edu
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
usc-advocate.symplicity.com/care_report
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.usc.edu
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) 821-4710
campussupport.usc.edu
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
diversity.usc.edu
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
dps.usc.edu, emergency.usc.edu
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) 442-120 – 24/7 on call
dps.usc.edu
Non-emergency assistance or information.

Office of the Ombuds - (213) 821-9556 (UPC) / (323-442-0382 (HSC)
ombuds.usc.edu
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) 442-3340 or oftp@med.usc.edu
chan.usc.edu/otfp
Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.