CS 758 – Computational Geometry

UNIVERSITY OF NEVADA LAS VEGAS
Department of Computer Science
Semester/Term:
Time:
Class Location: Remote Learning (Zoom Enabled)
Office Location:
Office Hours:
Phone:
Email:

Note: The instructor reserves the right to change the syllabus as it relates to how the course is administered.

Course Description

- **Elementary geometric methods**: points, lines and polygons. Line segments intersection. Simple closed path, inclusion in a polygon, inclusion in a convex polygon, range search, point location in planar subdivision and duality.
- **Convex hull**: Graham's scan, Jarvin's march, divide and conquer approach, on-line algorithms, approximate algorithms, convex hull of simple polygons, lower bound proofs and diameter of a point set.
- **Proximity**: Closest pair, triangulation, divide and conquer approach for closest pair, Voronoi diagram and their properties, dual of Voronoi diagram, construction of Voronoi diagram, Euclidean minimum spanning tree, gaps and covers.
- **Intersections**: convex polygons, polygons, star polygons, line segments, half planes and plane sweep paradigm.
- **Mesh generation algorithms**: Delaunay triangulation, quad-trees, and Quadrangulations.
- **Visibility and path planning**: visibility properties of polygons, visibility graphs, applications of computational geometry in robotics, shortest s-t path inside a simple polygon, shortest s-t path amidst polygons, introduction to path planning in 3-d, decomposition of polygons.

Text Books:

1. Computational Geometry: Algorithms and Applications by Marc van Kreveld, Mark Overmars, and Mark de Berg, Third Edition, Springer
2. Computational Geometry in C (Second Edition) by Joseph O'Rourke

Course Prerequisite(s):

CS 677/ CS 477 or consent of the Instructor

Course Rationale

This course gives advanced methods for understanding algorithms and data structures having geometric flavor. Students will learn new paradigm of algorithm development that include plane sweep paradigm and geometric reasoning.

Program Competencies

In-depth familiarity with areas of theoretical computer science.

Course Competencies

- Elementary geometric objects
- Visibility and Art Gallery Problems
- Triangulation of points and 2-d shapes
- Convex hull algorithms
- Intersection algorithms
- Voronoi Diagram and Delaunay Triangulations
- Doubly connected edge list data structures
- Geometric algorithms on planar straight line graph
- Plane sweep methods
- Path planning and robotics applications

Learning Outcomes (SLO) / Course Objectives

SLO 1: Exhibit a breadth of knowledge in the areas of algorithms, programming languages and compilers, theory, operating systems, and computer architecture.

SLO 2: Exhibit a depth of knowledge in at least one specialized area of computer science.

Topics relating to SLO 1 and 2: Problems having geometric flavor. Triangulation, visibility problems, convex hull, Voronoi diagram with applications, Fortune's algorithm, algorithmic motion planning, geometric algorithms for obstacle avoidance, paths with clearance from obstacles, robot motion planning.

Evaluation Methods

1. Assignments
    - Written homework assignments. (20%).
2. Examinations
    - Midterm (not cumulative, counts for 30% of the grade) Length 75 minutes
    - Final Exam (cumulative, covers all material, counts for 50% of the grade)

Academic Dishonesty

Details are in section "University Policies". Use of sites such as Chegg and Course Hero is considered academic misconduct.

Grading Scale

A	> 89
A-	85 – 89
B+	81 – 84
B	73 – 80
B-	70 – 72
C+	67 – 69
C	63 – 67
C-	60 – 62
D	50 – 59
D	64 – 66
D-	60 – 63
F	< 50

University Policies

Public Health Directives

Face coverings are currently mandatory for all faculty and students in the classroom. Students must follow all active UNLV public health directives while enrolled in this class. UNLV public health directives are found at Health Requirements for Returning to Campus, https://www.unlv.edu/coronavirus/health-requirements. Students who do not comply with these directives may be asked to leave the classroom. Refusal to follow the guidelines may result in further disciplinary action according to the UNLV Student Conduct Code, https://www.unlv.edu/sites/default/files/page_files/27/StudentConduct-Code.pdf, including being administratively withdrawn from the course.

Academic Misconduct

Academic integrity is a legitimate concern for every member of the University community. We all share in upholding the fundamental values of honesty, trust, respect, fairness, responsibility, and professionalism. By choosing to join the UNLV community, students accept the expectations of the Student Academic Misconduct Policy, and are encouraged to always take the ethical path whenever faced with choices. Students enrolling at UNLV assume the obligation to conduct themselves in a manner compatible with UNLV's educational mission. An example of academic misconduct is plagiarism. Plagiarism is using the words or ideas of another person, from the Internet or any other source without proper citation of the source(s). See the Student Conduct Code, https://www.unlv.edu/studentconduct/student-conduct.

Auditing a Course

Auditing a course allows a student to continue attending the lectures and/or laboratories and discussion sessions associated with the course, but the student will not earn a grade for any component of the course. Students who audit a course receive the same educational experience

as students taking the course for a grade, but will be excused from exams, assessments, and other evaluative measures that serve the primary purpose of assigning a grade.

Classroom Conduct

Students have a responsibility to conduct themselves in class and in the libraries in ways that do not interfere with the rights of other students to learn, or of instructors to teach. Use of devices such as cellular phones and pagers, or other potentially disruptive activities are only permitted with the prior explicit consent of the instructor. Students are specifically prohibited to record classes without instructor authorization, including online/remote classes (either audio only, or video and audio). The instructor may rescind permission at any time during the class. If a student does not comply with established requirements or obstructs the functioning of the class, the instructor may initiate an administrative withdrawal of the student from the course.

Since the COVID-19 pandemic forced some instruction to be delivered remotely starting in Spring 2020, numerous students have asked instructors to record their synchronous classes, so that they can access them at their convenience. Instructors who agree to record their classes (audio only, or video and audio) should inform students in advance. Recorded lectures may not be broadly released to anyone, but made available exclusively to those students enrolled in the class during the particular academic term. Recorded lectures must be stored securely, and are subject to the Nevada System of Higher Education's Records Retention Policy, meaning that the recordings can only be deleted 120 days after the end of class (i.e., after grades are posted). Once this requirement is met, the recordings should be deleted. Class recordings are protected from disclosure, as they are deemed part of an educational record under the Family Educational Rights and Privacy Act (FERPA).

Copyright

The University requires all members of the University Community to familiarize themselves with, and to follow copyright and fair use requirements. You are individually and solely responsible for violations of copyright and fair use laws. The University will neither protect nor defend you, nor assume any responsibility for student or employee violations of fair use laws. Violations of copyright laws could subject you to federal and state civil penalties and criminal liability, as well as disciplinary action under University policies. Additional copyright policy information is available at https://www.unlv.edu/provost/copyright.

Disability Resource Center (DRC)

The UNLV Disability Resource Center (Student Services Complex, SSC-A, Room 143, https://www.unlv.edu/drc, telephone 702-895-0866) provides resources for students with disabilities. Students who believe that they may need academic accommodations due to a permanent disability, temporary or permanent medical need, or academic support due to pregnancy are encouraged to contact the DRC as early as possible in the academic term. A Disabilities Specialist will discuss what options may be available to you. Students who are already registered with the DRC should request their accommodations online each semester, and make an appointment to discuss their accommodations with their instructors.

Final Examinations

The University requires that final exams given at the end of a course occur on the date and at the time specified in the Final Exam schedule. The Final Exam schedule is typically available at the start of the semester, and the classroom locations are available approximately one month before the end of the semester. See the Final Exam Schedule, https://www.unlv.edu/registrar/calendars.

Identity Verification in Online Courses

All UNLV students must use their Campus-issued ACE ID and password to log in to WebCampus-Canvas.

UNLV students enrolled in online or hybrid courses are expected to read and adhere to the Student Academic Misconduct Policy, https://www.unlv.edu/studentconduct/misconduct/policy, which states that "acting or attempting to act as a substitute for another, or using or attempting to use a substitute, in any academic evaluation or assignment" is a form of academic misconduct. Intentionally sharing ACE login credentials with another person may be considered an attempt to use a substitute, and could result in investigation and sanctions, as outlined in the Student Academic Misconduct Policy.

UNLV students enrolled in online courses are also expected to read and adhere to the Acceptable Use of Computing and Information Technology Resources Policy, https://www.it.unlv.edu/policies/acceptable-use-computing-and-information-technology-resources-policy, which prohibits sharing university accounts with other persons without authorization.

To the greatest extent possible, all graded assignments and assessments in UNLV online courses should be hosted in WebCampus-Canvas or another UNLV-managed platform that requires ACE login credentials for access.

Incomplete Grades

The grade of "I" (Incomplete) may be granted when a student has satisfactorily completed three-fourths of course work for that semester/session, but cannot complete the last part of the course for reason(s) beyond the student's control and acceptable to the instructor, and the instructor believes that the student can finish the course without repeating it. For undergraduate courses, the incomplete work must be made up before the end of the following regular semester. Graduate students receiving "I" grades in 500-, 600-, or 700-level courses have up to one calendar year to complete the work, at the discretion of the instructor. If course requirements are not completed within the period indicated, a grade of "F" will be recorded, and the student's GPA will be adjusted accordingly. Students who are fulfilling an Incomplete grade do not register for the course, but make individual arrangements with the instructor who assigned the "I" grade.

Library Resources

Librarians are available to consult with students on research needs, including developing research topics, finding information, and evaluating sources. To make an appointment with a

subject expert for this class, please visit the Libraries' Research Consultation website, https://guides.library.unlv.edu/appointments/librarian. You can also ask the library staff questions via chat and text message at https://ask.library.unlv.edu/.

Missed Classwork

Any student missing class, quizzes, examinations, or any other class or laboratory work because of observance of religious holidays will be given an opportunity during that semester to make up the missed work. The make-up opportunity will apply to the religious holiday absence only. It is the responsibility of the student to notify the instructor within the first 14 calendar days of the course for Fall and Spring courses (except for modular courses), or within the first 7 calendar days of the course for Summer and modular courses, of their intention to participate in religious holidays which do not fall on state holidays or periods of class recess. For additional information, please visit the Missed Classwork policy, under Registration Policies, on the Academic Policies webpage, https://catalog.unlv.edu/content.php?catoid=32&navoid=8271&hl=.

In accordance with the policy approved by the Faculty Senate regarding missed class time and assignments, students who represent UNLV in any official extracurricular activity will also have the opportunity to make up assignments, provided that the student submits official written notification to the instructor no less than one week prior to the missed class(es).

The spirit and intent of the policy for missed classwork is to offer fair and equitable assessment opportunities to all students, including those representing the University in extracurricular activities. Instructors should consider, for example, that in courses which offer a "Drop one" option for the lowest assignment, quiz, or exam, assigning the student a grade of zero for an excused absence for extracurricular activity is both contrary to the intent of the Faculty Senate's policy, and an infringement on the student's right to complete all work for the course.

This policy will not apply in the event that completing the assignment or administering the examination at an alternate time would impose an undue hardship on the instructor or the University that could be reasonably avoided. There should be a good faith effort by both the instructor and the student to agree to a reasonable resolution. When disagreements regarding this policy arise, decisions can be appealed to the Department Chair/School Director, College/School Dean, and/or the Faculty Senate Academic Standards Committee.

For purposes of definition, extracurricular activities may include, but are not limited to academic recruitment activities, competitive intercollegiate athletics, fine arts activities, liberal arts competitions, science and engineering competitions, and any other event or activity sanctioned by a College/School Dean, and/or by the Executive Vice President and Provost.

Rebelmail

Rebelmail is UNLV's official email system for students and by University policy, instructors and staff should only send emails to students' Rebelmail accounts. Rebelmail is one of the primary ways in which students receive official University communications, information about deadlines, major Campus events, and announcements. All UNLV students receive a Rebelmail account

after they have been admitted to the University. Sending emails within WebCampus-Canvas is also acceptable.

Tutoring and Coaching

The Academic Success Center (ASC), at the Claude I. Howard Building, provides tutoring, academic success coaching, and other academic assistance for all UNLV undergraduate students. For information regarding tutoring subjects, tutoring times, and other ASC programs and services, please visit the ASC website, https://www.unlv.edu/asc, or call 702-895-3177. The ASC is located across from the Student Services Complex (SSC). Academic success coaching is located on the second floor of SSC A, Room 254. Drop-in tutoring is located on the second floor of the Lied Library, and on the second floor of the College of Engineering building (TBE A 207).

UNLV Writing Center

One-on-one or small group assistance with writing is available free of charge to UNLV students at the Writing Center, https://writingcenter.unlv.edu/, located in the Central Desert Complex, Building 3, Room 301 (CDC 3–301). Walk-in consultations are sometimes available, but students with appointments receive priority assistance. Students may make appointments in person or by calling the Center, telephone 702-895-3908. Students are requested to bring to their appointments their Rebel ID Card, a copy of the instructions for their assignment, and two copies of any writing they have completed on their assignment.

Diversity Statement

As an institution of higher learning, UNLV represents a rich diversity of human beings among its faculty, staff, and students, and is committed to aspiring to maintain a Campus environment that values that diversity. Accordingly, the University supports understanding and appreciation of all members of its community, regardless of race, sex, age, color, national origin, ethnicity, creed, religion, disability, sexual orientation, gender, gender identity, marital status, pregnancy, genetic information, veteran status, or political affiliation. Please see University Statements and Compliance, https://www.unlv.edu/about/statements-compliance.

A successful learning experience requires mutual respect and trust between the students and the instructor. Accordingly, the instructor asks that students be willing to listen to one another's points of view, acknowledging that there may be disagreements, keep discussion and comments on topic, and use first person, positive language when expressing their perspectives.

UNLV Land Acknowledgement

UNLV is situated on the traditional homelands of Indigenous groups, including the Nuwu or Nuwuvi, Southern Paiute People, descendants of the Tudinu, or Desert People. We honor and offer gratitude for those who have stewarded the land; for the land itself; and for the opportunity to cultivate a thriving, diverse, inclusive, and just scholarly community here today that works for a better tomorrow for all.

Course Agenda/Schedule

Tentative Schedule. This is for simple planning. Actual lecture topics and delivery dates may change.

Week	Date	Lecture#: Topics	Materials
Week 1	1/18/2021	**Martin Luther King Jr. Day recess**	
	1/20	L1: Elementary Geometric Objects and operations	Chapter 1
Week 2	1/25	L2: Visibility inside/outside polygons: Art Gallery Problem	Chapter 1
	1/27	L3: Triangulated polygons: 3 coloring	Chapter 1
Week 3	2/1	L4: Triangulation by ear removal	Chapter 1
	2/3	L5: Triangulating monotone polygons: top-down scan	Handouts
Week 4	2/8	L6: Convex decomposition – KM Algorithm	Chapter 2
	2/10	L7: Partitioning a polygon into trapezoids	Chapter 2
Week 5	2/15	**President Day Recess**	
	2/17	L9: Point inclusion in simple polygons	Chapter 7
Week 6	2/22	L10: Intersection between several line segments (plane sweep)	Chapter 7
	2/24	L11: Convex Hull - Introduction	Chapter 3
Week 7	3/1	L12: Jarvin's March Algorithm	Chapter 3
	3/3	L13: Quick hull and divide and conquer	Chapter 3
Week 8	3/8	L14: More on Convex Hull Algorithm	Chapter 3
	3/10	**Mid Semester Exam**	
Week 9	3/15	Spring Break Recess	
	3/17	Spring Break Recess	
Week 10	3/22	L15: Voronoi Diagram - Introduction	Chapter 5
	3/24	L16: Properties of Voronoi Diagram	Chapter 5
Week 11	3/29	L17: Delaunay triangulation	Chapter 5
	3/31	L18: Fortunes sweep-line algorithm for Voronoi Diagram	Handouts
Week 12	4/5	L19: Minimum spanning tree and Delaunay Triangulation	Chapter 5
	4/7	L20: Apprx Algorithm for Travelling Sales Person Problem	Chapter 5
Week 13	4/12	L21: Data Structure for Planar Straight Graphs	Chapter 4 and Handouts
	4/14	L22: Data Structure for Planar Straight Graphs … cntd	Chapter 4 and Handouts
Week 14	4/19	L23: Face routing algorithm	Handouts
	4/21	L24: 2D Path Planning – Visibility Graph	Chapter 8
Week 15	4/26	L25: More on 2D Path Planning	Chapter 8
	4/28	L26: Voronoi Diagram and Path Planning	Chapter 8 and Handouts
Week 16	5/3	**Study Week**	
	5/5	**Study Week**	
	5/12	**Final Exam (3:10 pm – 5:10 pm)**	