Course Description/ Overview:
This course will involve the introduction of autonomous vehicle technologies that serve as the foundation for development and operation. This will include the identification and development of autonomous system subsystems, simulation methods and incorporate topics on algorithms for localization, dead reckoning, sensor fusion, perception, deep learning, planning/control, and payload development.

Objectives:
- Identify and list the common subsystems and technologies deployed in autonomous vehicles.
- Use the Matlab/Simulink toolsets to model autonomous systems
- Discuss the various types of sensors used within autonomous systems and describe suitable sensor fusion methods
- Describe the common methods used autonomous systems to perform Guidance, Navigation, Obstacle Detection and Control functions

Primary Text
Introduction to Autonomous Mobile Robots (Intelligent Robotics and Autonomous Agents series)
Siegwart, Roland, ISBN-10: 0262015358

Additional References
Creating Autonomous Vehicle Systems (Synthesis Lectures on Computer Science), Shaoshan Liu (Author), Liyun Li (Author), Jie Tang (Author), ISBN-10: 1681730073


Tentative Syllabus Schedule
Lecture Topics (Tentative)

<table>
<thead>
<tr>
<th></th>
<th>Introduction to Autonomous Systems (1/2 week).</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>An introduction into system autonomy and mission configurations.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>System Architecture (1/2 week).</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Various autonomous vehicle control architectures will be presented and discussed.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Vehicle kinematics and Dynamic Modeling (2 weeks).</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Introduction to vehicle design, system dynamics, and vehicle structures.</td>
</tr>
<tr>
<td></td>
<td>Chapters 2 and 3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Sensors (2 weeks).</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Classes will introduce the classes of sensors typically found on autonomous vehicle systems. Sensors used for mobility platform control and those utilized within payloads will be discussed.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Sensor Fusion (2 weeks).</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Chapter 5</td>
</tr>
</tbody>
</table>
Techniques, like Kalman Filters, used to combine sensor inputs to create more robust estimates of environmental conditions and system states will be presented.

6. **Localization (2 weeks).**
   Methods used to determine the vehicle’s position within a given reference frame and techniques used to map the operational environment will be reviewed.

7. **Navigation/ Path Planning (2 weeks).**
   Topics relating to vehicle guidance and path planning, navigation, vehicle control, and mission planning will be presented.

8. **Obstacle Detection and Avoidance (2 weeks).**
   Topics related to the deployment of sensors used to detect a range of objects and their strengths and weaknesses will be presented.

9. **Human/Operator Interface (1 week).**
   Methods and technologies used to communicate the operator’s intent to the autonomous vehicle will be presented.

10. **Topical Items (1 week).**
    Will include expert systems and neural networks

**Labs**
1. Robot Operating System (ROS) introduction (1 wk)
2. ROS intro II with skid steer robot and control implementation (1 wk)
3. Obstacle avoidance and wall following using infrared sensor and collision sensor (2 wk)
4. Dead reckoning of the robot using motor encoders and IMU (2 wk)
5. Lane detection and following using Raspberry Pi 3 camera module (2 wk)
6. Simulate the control of Jackal and visualization of LiDAR in Gazebo simulator (1 wk)
7. Line following, dead reckoning, sensor fusion (IMU & GPS) and obstacle avoidance (LiDAR) using Jackal (4 wk), this includes:
   - Implementation/ simulation on Gazebo
   - Final demo on engineering quad's paved road utilizing all the features implemented.

The weeks allocated for each part of the lab may be subject to change.

**Expectations**
To succeed in this class, you will need to:
- Read the chapter before coming to class, and formulate questions
- Participate in the class
- Make sure you understand the homework problems and solutions
- Seek out help when you have trouble

Obtaining help: The main two ways to obtain help are online at Piazza or in person at office hours. You can also speak with your professor briefly after lecture. Please do not send email directly to TAs or professors for routine help or absences. In cases of emergencies related to exams (e.g., illness) you should email your professor at the earliest possible opportunity.

**Online Resources/ Forum**

*Email*
Email communication should be addressed to both the instructor and TA. All relevant email will start with the subject line: SE 498: [SUBJECT]. The TA will respond to emails as soon as possible and will check emails at least once per day.

*Compass*
We will use Illinois Compass as the central site for course resources. This includes announcements, online homework questions, a discussion board, and grades.
[https://compass2g.illinois.edu/](https://compass2g.illinois.edu/)
Piazza
This class uses Piazza for all communication between the instructor, TAs, and students. Please visit https://piazza.com/illinois/fall2018/se498 to register. The Piazza link will take you to the current class page at any time. Official class announcements will be sent via Piazza, so you must register with an email address that you regularly check. If you desire, you can post anonymously on Piazza or make a private post just to the instructors (this should be done rather than emailing the professor directly). TAs are scheduled to be checking Piazza three times per day during the week. Note that Piazza should be used to communicate with your instructors, rather than email.

Media Use in Class
Please turn off your phone-ringer before class.

Activities and Grading
There are two sections for this class. The 4-credit graduate students will be assigned extra problems/extra homework. 3-credit undergraduate students may attempt these problems for EXTRA CREDIT. The grade break-down:

- Participation 5 %
- Assignments 20 %
- Quizzes 10 %
- Lab Reports 30 %
- Mid-term Examination 15 %
- Final Examination 20 %

Participation
Participation in class and group work is essential to success in any project and in this class. The quality and quantity of contributions to the class activities and discussion will contribute 5% to each student's final grade.

Assignments
Assignments will be given during this course for completion individually. These assignments will apply lecture and reading material and require specific skills and knowledge. There will be 5 assignments that will be posted on the course website. They are on due dates that will be shown in Compass. Homework must be turned physically in class AND electronically to Compass.

IMPORTANT: Students are responsible for ensuring that their work is correctly and successfully submitted electronically and should notify the instructor of any problems in this matter at least 30 minutes before the homework deadline. Students are encouraged to submit their homework assignments at least 40 minutes before the deadline.

Random Quizzes
The 20-minute quizzes will consist of questions designed to test your comprehension of the concepts we will cover during the lecture. They will be randomly given on the last day of class on weeks where there is no exam. The lowest quiz grade will be dropped at the end of the semester.

Lab Reports
All lab reports are to be turned in at the beginning of the lab period designated by your TA as the due date, using the time between labs to organize and formalize your lab reports. The lab report (except for the data pages completed in the lab) must be typed and printed. You must leave the lab room with your own data in ink and with your TA's initials on the data sheets. Lab reports turned in after the beginning of lab when they are due will be considered late. Lab reports more than one week late are not accepted.

- Quality of presentation and format 15 %
- Experimental data 40 %
- Analysis simulations and discussion 30 %
The grades of individual students in the same team may be different, based on their attendance and participation in the laboratory. The TA may modify the above as he or she sees fit.

**Examination and Cumulative Final**

There is one in-class exam and a cumulative final. If you are unable to sit for the exam for legitimate reasons (e.g., family emergencies, serious illness, attending a conference, etc.), please let the instructor and TA know in advance so that we can accommodate you. Not showing up w/o prior notice will result in 0 (zero) grade for the exam in question.

**Final Grade**

The final grade will be related to the total number of grade points you have earned during the course. Grades will be posted in Illinois Compass so that you can monitor your progress. Attendance of lectures and active participation are a plus. A total points-to-grade scale will be based on gaps in the total final score of the class students.

<table>
<thead>
<tr>
<th>Grade Ranges</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>98 + – A+</td>
<td>77-78 -- C+</td>
</tr>
<tr>
<td>92-97 -- A</td>
<td>72-76 -- C</td>
</tr>
<tr>
<td>89-91 -- A-</td>
<td>69-71 -- C-</td>
</tr>
<tr>
<td>87-88 -- B+</td>
<td>61-68 -- D</td>
</tr>
<tr>
<td>82-86 -- B</td>
<td>60- -- F</td>
</tr>
<tr>
<td>79-81 – B</td>
<td></td>
</tr>
</tbody>
</table>

**Course Policies**

Read and abide by the Code of Policies and Regulations Applying to All Students at [http://www.admin.uiuc.edu/policy/code/index.html](http://www.admin.uiuc.edu/policy/code/index.html). Please be aware that this syllabus may change during the semester. Changes to the syllabus will be announced in class and on Compass.

**Academic Integrity**

The University of Illinois at Urbana-Champaign Student Code should also be considered as a part of this syllabus. Students should pay particular attention to Article 1, Part 4: Academic Integrity. Read the Code at the following URL: [http://studentcode.illinois.edu/](http://studentcode.illinois.edu/).

Academic dishonesty may result in a failing grade. Every student is expected to review and abide by the Academic Integrity Policy: [http://studentcode.illinois.edu/](http://studentcode.illinois.edu/). Ignorance is not an excuse for any academic dishonesty. It is your responsibility to read this policy to avoid any misunderstanding. Do not hesitate to ask the instructor(s) if you are ever in doubt about what constitutes plagiarism, cheating, or any other breach of academic integrity.

**Students with Disabilities**

To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact the course instructor and the DRES as soon as possible. To ensure that disability-related concerns are properly addressed from the beginning, students with disabilities who require assistance to participate in this class should contact Disability Resources and Educational Services (DRES) and see the instructor as soon as possible. If you need accommodations for any sort of disability, please speak to me after class, or make an appointment to see me, or see me during my office hours. DRES provides students with academic accommodations, access, and support services. To contact DRES you may visit 1207 S. Oak St., Champaign, call 333-4603 (V/TDD), or email a message to disability@uiuc.edu. [http://www.disability.illinois.edu/](http://www.disability.illinois.edu/).

**Emergency Response Recommendations**

Emergency response recommendations can be found at the following website: [http://police.illinois.edu/emergency-preparedness/](http://police.illinois.edu/emergency-preparedness/). I encourage you to review this website and the
campus building floor plans website within the first 10 days of class.  http://police.illinois.edu/emergency-preparedness/building-emergency-action-plans/.

Diversity Statement
UIUC is committed to equal opportunity for all persons, regardless of race, ethnicity, religion, sex, gender identity or expression, creed, age, ancestry, national origin, handicap, sexual orientation, political affiliation, marital status, developmental disability, or arrest or conviction record. We value diversity in all of its definitions, including who we are, how we think, and what we do. We cultivate an accessible, inclusive, and equitable culture where everyone can pursue their passions and reach their potential in an intellectually stimulating and respectful environment. We will continue to create an inclusive campus culture where different perspectives are respected, and individuals feel valued.