Course Number
ENGR 4291

Title
Autonomous Vehicle Systems Development – II (AVSD2)

Credits
2

Cross-Listed As
AE5291 - Advanced Studies in Aerospace Engineering (Dogan, Subbarao)
CSE5291 - Individual Study in Computer Science (Reyes)
IE5291 - Advanced Studies in Industrial Engineering (Huff)
ME5291 - Advanced Studies in Mechanical Engineering (Dogan, Subbarao)

Term
Spring Semester 2009

Days & Times
Tuesdays 1:00-2:50 PM

Location
Room 311 Woolf Hall

Course Description
AVSD2 is the second course in a two-semester introduction to autonomous vehicle systems (AVS). AVSD1 is broad, conceptual, & theoretical. AVSD2 (worth 2 credits) is focused, practical & applied.

The objective of this course is to provide students with the opportunity to learn about and work directly with the technologies needed to create an autonomous vehicle. The students will then work as a team to integrate these technologies (embodied as a set of sensor, actuator, and mobility platform sub-systems) into a functioning autonomous vehicle. This vehicle will be designed to compete in an AUVSI sponsored student competition or to support a specific mission or function defined by the AVL faculty. The targeted competition or mission for the AVSD2 class team will be selected during their previous AVSD1 class.

One or more students on the AVSD2 team will be assigned one or more system sub-components. For their assigned sub-component the student(s) will be required to do the following:
   a) Understand how the class of technology embodied in the system sub-component contributes to the field of autonomous systems.
   b) Learn how to operate the assigned sub-component in “stand-alone” mode.
c) Access the role the sub-component will play and evaluate its utility within the competition or mission selected by the team.
d) Design a procedure to evaluate the performance of the system sub-component as it relates to the service it is expected to provide to the overall system within the competition or mission.
e) Conduct the designed sub-system performance tests and compare your results with any available performance projections. Comment on the fitness for use of the component within the proposed overall system. Offer solutions or alternatives if a problem is found.
f) Write up a report presenting your findings and efforts associated with activities “a” thru “e” presented above.

A key aspect of this course is to provide the students with the experience of working with an interdisciplinary team. The students within AVSD2 will most likely come from multiple engineering backgrounds. In addition, it is possible that other students from outside the class will be contributing to the autonomous vehicle development effort. It will be up to the AVSD2 students, with the assistance of the AVL faculty, to manage this very fluid organizational structure. The AVSD2 team may not “own” the system development effort and may perhaps have to negotiate with other contributing team members from outside AVSD2 on the design and implementation of the overall system. Expect feelings to get hurt and toes to be stepped on. Get used to it, because it will be that way in industry. The key is learning how we can work together to reach our common objective of a competitive entry in our selected competition. Each AVSD2 student will take part in the following activities designed to foster the creation of an integrated multi-disciplinary team:

g) Identify and work with others required to utilize or integrate the student’s assigned sub-system.
h) Actively share the knowledge and findings accumulated during activities “a” thru “f” above with others requiring to integrate or utilize the sub-system.
i) Work with other team members to create a component level integration test plan to ensure that your assigned sub-system works within the larger integrated system and actually provides the performance determined in activity “e.”
j) Conduct the component level integration tests and identify and integration problems.
k) Work with team members to diagnose and fix integration issues. Activities “i,” “j,” and “k” might have to be performed iteratively until the component is successfully integrated into the larger system.
l) Develop a Component Level Integration Report that documents the activities and findings associated with tasks “i” thru “k.”

It is important that AVSD2 students never lose sight of the fact that they are developing a system to perform a mission. AVSD2 students are responsible, first individually and then collectively, for identifying the critical success factors for winning the competition or completing the system’s defined mission. The AVSD2 students will work with the extended team to identify Integrated System Level Tests to verify that the total system can meet these critical success factors. A series of tests will be needed to determine the capabilities and problems with the integrated system. These tests will first verify that the system can perform atomic actions and
behaviors. More complex tests will be designed and conducted until a simulation of the competition or final mission is completed. An iterative cycle that includes: Defining and developing tests, conducting tests, analyzing system performance results, identifying problems, designing and implementing solutions to those problems is anticipated. The AVSD2 students will be involved in the following activities:

m) Individually identify system performance critical success factors.

n) The entire autonomous vehicle development team will create a unified list of critical success factors.

o) Define Integrated System Tests designed to verify that these critical success factors can be met.

p) Design the Integrated System tests

q) Purchase or fabricate test props or targets

r) Conduct tests

s) Analyze test results

t) Identify problems

u) Design and implement solution to problems

Repeat “p” thru “u” as needed.

v) Write an Integrated System Level Test report documenting the activities “n” thru “u.”

The development of an autonomous system is a complex undertaking involving many people. To be successful, the activities of each individual on the team must be coordinated with the activities of her or his teammates. AVSD2 students will be required to:

w) Keep records of their project activities

x) Keep and monitor e-mails for team communications

y) Coordinate and attend team meetings

z) Establish dead-lines for your work and contribute to the development of a AVSD project plan

The most important requirement of this course is that its participants obtain hands-on experience and knowledge in the development of autonomous vehicles, they have the opportunity to take part in a multi-disciplinary system development effort, and they have fun in the process.

Prerequisites
Completion or concurrent enrollment in AVSD1

Instructors:
Dr. Atilla Dogan
MAE Dept.
dogan@uta.edu
(817) 272-3744
Objectives

- Introduce students to the emerging field of autonomous vehicle systems (AVS).
- Allow students to obtain hands-on experience with various classes of AVS technologies.
- Challenge students to develop system designs for autonomous vehicles, based upon realistic mission scenarios, that are intended to compete in International Collegiate AVS Competitions.
- Utilize autonomous vehicle system architectures and enabling technologies for the development of an autonomous vehicle.
- Build a functional autonomous vehicle to perform a specific mission.
- Provide students with the opportunity to work in multi-disciplinary teams, i.e., make it obvious to each student where their major’s disciplines fit into the development of large, complex system.
- Demonstrate the infrastructure required to coordinate development of a complex system featuring aspects that cross several engineering disciplines.
- Introduce the concept of specifying physical & functional interface requirements that must be satisfied across all disciplines during design refinement.
- Introduce test planning & execution for all levels of the system hierarchy.

Outcomes

A. Ability to apply knowledge of mathematics, science and engineering

This will be covered in lectures on mathematical models describing constraints on AVS movement, performance, weight, energy capacity, propulsion & power consumption, sensor capabilities, data links & human factors.

B. Ability to design and conduct experiments, analyze and interpret data
Design & conduct of experiments will be covered in the lectures on test planning & execution. Analytical models describing fundamental constrains on AVS will be graphed, analyzed, & interpreted. Performance data of real AVS and components will be analyzed for trends & interpreted for applicability, feasibility, & tradeoffs.

C. Ability to design a system, component, or process to meet desired needs

The rules of the intended competition will provide the “desired needs”. The team project assesses the ability to design systems, components, & processes.

D. Ability to function on multi-disciplinary teams

Students majoring in AE, CS, CSE, SE, ME, IE, EE or other academic discipline can come together in this course in inter-disciplinary teams. Together they can develop a shared understanding of high-level requirements, system-wide scope, and functional & physical interfaces from an inter-disciplinary perspective.

E. Ability to identify, formulate, and solve engineering problems

Introductory or overview lectures will cover how to identify AVS engineering problems. Lectures on mathematical models of AVS constraints will cover how to formulate AVS engineering problems. Lectures on solving the mathematical models of AVS constraints & performance data for actual systems & components will cover how to solve AVS engineering problems.

F. Understanding of professional and ethical responsibility

What kind of AVS sensor & resolution is required to distinguish a combatant from a non-combatant? If an AVS has or can deploy sensors that can eavesdrop on a conversation, how do we ensure that privacy laws are not broken? What is the maximum AVS tread pressure that can be applied to permafrost without causing damage to the delicate ecosystem? What is the price/performance threshold at which a humanitarian organization will purchase an AVS for landmine remediation? How do you reduce the likelihood of data link exploitation by an adversary? Is an AVS covered by the Geneva Convention? These are relevant questions to address during lectures.

G. Ability to communicate effectively

Students will need to work in a multi-disciplinary team. Students/Teams will have to write/present project proposals and reports.

H. Broad education necessary to understand the impact of engineering solutions in a global and societal context
Students will learn about AVS flight operations conducted in public airspace under the auspices of the Federal Aviation Administration (FAA) & the Federal Communications Commission (FCC).

I. Recognition of the need for, and the ability to engage in life-long learning

This course will introduce a number of disciplines that are outside each student’s major. It should be obvious to each student that if they wish to be employed in the AVS industry, they will need to acquire more detailed knowledge & skills in specific areas.

J. Knowledge of contemporary engineering issues

The “Build versus Buy” Issue: Because capable & relatively inexpensive commercial hardware & software components are available for many parts an AVS, e.g., base vehicle, automatic control components, imaging, image processing, etc., this course will discuss and expose students to the pros and cons of both sides of the “Build versus Buy” dilemma.

K. Ability to use techniques, skills, and modern engineering tools necessary for engineering practice

Students will work with the MATLAB/SIMULINK by Mathworks Inc. to develop analytical models of AVS, develop and implement embedded guidance and control algorithms. Students will also have the opportunity to work with sensors, microcontrollers and interface software suitable for use with AVS.

Textbook

There is no assigned text for AVSD2. If there is already a book written about the autonomous system you are planning build, then you probably should be considering a more innovative design!

Required Software

MATLAB/SIMULINK Student Edition with Control and system ID toolboxes by Mathworks Inc.

Other Material

The instructors will provide handouts on topics not covered in the textbook, such as issues specific to UGVs, USVs, & UUVs.

Course Website

There will be a WebCT website created.
Assessments & Weights

Project Proposal: [10%]
Each student is required to write a project proposal describing (i) what he/she will produce in the course, (ii) how he/she will produce it, (iii) what resources he/she will need to have to be able produce it, and (iv) what schedule he/she will follow. The proposal may be about a collaborative effort with other classmates, however the roles, responsibilities and objectives within the collaborative effort should be clearly defined. Each student needs to present his/her proposal to the faculty and the classmates in class and revise his/her proposal based on the feedback given by the faculty and the other students.

Midterm Progress Report: [30%]
Each student is required to write/present a progress report around mid semester. The report should summarize how he/she has carried out the project proposed in the project proposal up to that point. This will also be an opportunity for revising the project proposal. The report should explain what, if any, revision is needed to the project plan with justifications why the revisions are needed.

Final Report: [40%]
Each student is required to write/present his/her project at the end of the semester. The written report should describe some or all of the following components: complete technical description, requirements, functionality, usability, reliability, performance, serviceability, high-level design, unit or component level design, candidate designs considered, evaluation methods, hardware development accomplished. The presentation should include selected components from the written report as well as hardware or software demonstration, if applicable.

Teammate Evaluation: [10%]
An evaluation form will be provided by the end of the semester. Each student is required to provide his/her evaluation of each teammate. Your evaluation will affect your teammates' grade he/she will get from the project according to the policy provided in the evaluation form.

Attendance: [10%]
Attendance in the classes and any other project meetings is required
Grading

Final letter grades will be assigned according to the following scale.
A: 85 <= Grade 
B: 70 <= Grade < 85 
C: 55 <= Grade < 70 
D: 40 <= Grade < 55 
F: Grade < 40 

We will record numeric grades to the nearest 1/100 of a percentage point. I.e., if your final, numeric grade is 84.99%, your final letter grade is B.

Tentative Course Schedule

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<thead>
<tr>
<th>Dates</th>
<th>Deliverable</th>
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<tbody>
<tr>
<td>Tuesday, January 20, 2009</td>
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<tr>
<td>Tuesday, January 27, 2009</td>
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<tr>
<td>Tuesday, February 03, 2009</td>
<td>Proposal Deadline</td>
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<tr>
<td>Tuesday, February 10, 2009</td>
<td>CENSUS DAY is feb 4</td>
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<td>Tuesday, February 17, 2009</td>
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<td>Tuesday, March 03, 2009</td>
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<tr>
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<td>Midterm Report Status</td>
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<td>Tuesday, March 24, 2009</td>
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<td>Tuesday, March 31, 2009</td>
<td>Last day to drop is April 3</td>
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<td>Tuesday, April 07, 2009</td>
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<td>Tuesday, April 28, 2009</td>
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<td>Tuesday, May 05, 2009</td>
<td>Last day of classes is May 8</td>
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<tr>
<td>Tuesday, May 12, 2009</td>
<td>Final Report &amp; Presentation</td>
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