JACKSON STATE UNIVERSITY

Department of Industrial Systems and Technology

Course Syllabus and Lesson Plans

Course Number and Title:	IT 311 – Sensors used in connected and automated vehicles
Credit hours:	3.00
Semester and Year:	Summer 2016
Instructor:	Dr. James A. Ejiwale
Office Location:	JYW Building, Room 209
Office Hours:	T, W (1:00 – 4:00 PM) or by appointment
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Telephone:	601-979-2471

Required Texts:

Siegwart, R., Nourbakhsh, I. R., Scaramuzza, D. (2011). Introduction to Autonomous Mobile Robots, 2/ed., MIT Press, ISBN: 978-0262015356 http://www.robotee.com/EBooks/Introduction_to_Autonomous_Mobile_Robots.pdf

Supplemental Readings/ Resources:

Anderson, J., Kalra, N., Stanley, k. Sorensen, P., Samaras, C. & Oluwatola, O. (2014). *Autonomous Vehicle Technology: A Guide for Policy Makers*. Santa Monica: RAND Corporation. file:///C:/Users/James/Downloads/RAND_RR443-2.pdf

Android Software Operation Tutorial. http://www.tutorialspoint.com/android/

Glancy, D. J. (2015). Autonomous and automated and connected cars----Oh My! First generation Autonomous cars in the legal ecosystem. Minn. J. L. Sci. & Tech., 16(2). http://conservancy.umn.edu/bitstream/handle/11299/174406/619%20Glancy.pdf?sequence=1

Glancy, D. J. (2015). Legal Outlook for Autonomous, Automated, and Connected Cars A Preview of First Generation Autonomous Cars. Federation of Defense & Corporate Counsel Annual Meeting Fairmont Banff Springs, July 25 to August 1, 2015. http://www.thefederation.org/documents/04.Glancy%20-%20AutonomousCars.pdf

Everett, H. R. (1995). Sensors used for mobile robots: Theory and application, AK Peters, Ltd. Natik, MA

Schipper, D. (2001). Mobile Autonomous Robot Twente: A Mechatronics Design Approach. http://doc.utwente.nl/36603/1/t000001e.pdf

Leitman, S. & Brant, B. (2009). Build your own electric vehicle. McGraw-Hill. New York: NY.

Ozguner, U., Acarman, T., & Redmill, K. (2011). Autonomous Ground Vehicles. Norwood, MA ISBN-13: 978-1608071920 ISBN-10: 1608071928 Ozkil, A. G. (2009).

Schwarz, C., G. Thomas, K. Nelson, M. McCrary, & N. Schlarmann. 2013. "Towards Autonomous Vehicles." *Final Reports and Technical Briefs,* Mid-America Transportation Center. Lincoln: University of Nebraska, Lincoln. http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1092&context=matcreports
Vehicle Sensors and Actuators: ISBN: 978-0-7680-2125-7; 2009
Varghese, J. Z. & Boone, R. G. (2015). Overview of autonomous vehicle sensors and systems. Proceedings of 2015.
Quadrennial Technology Review 2015: Advancing clean transportation and vehicle systems and technologies. http://energy.gov/sites/prod/files/2015/09/f26/QTR2015-08-Transportation.pdf

Course Description:

This course introduces students to principles of sensors (GPS, MEMS, LIDAR, Radar, Ultrasonic, Infrared) used in connected and automated vehicles, locomotion, kinematic models and constraints, maneuverability, workspace of autonomous mobile robots and vehicles.

Course Objectives:

Upon completion of this course students will be able to:

1. Explain the concept, history, and the importance of automated (autonomous) and connected vehicles.
2. Describe the automation levels, the associated technical, social and ethical issues of automated and connected vehicles.
3. Appraise locomotion methods of autonomous mobile robots.
4. Report on appropriate wheeled mobile robots and vehicles.
5. Build kinematic models and constraints and apply principles of mobile robot maneuverability.
6. Report on mobility design workspace.
7. Demonstrate the understanding of the material covered by the learning outcomes in Lessons 1–6.
8. Discus the variety of sensors used in mobile robots and the strategies for extracting information from the sensors.
9. Assess the pros and cons of different sensors and use them for different real world applications in mobile and vehicles.
10. Describe the performance characteristics of a sensor.
11. Discuss the strategies for using uncertain sensor input to guide the robot's behavior.
12. Apply Android Software Operation and sensors technology to create a software tool kit.

Course Content and Assignment Schedule

Weeks **Topics** **Assignments**

Part I. Fundamentals of connected (autonomous) and automated vehicles

1. Overview of the history of automated and connected vehicles
    a. Introduction to the history of automated and connected vehicles
    b. NHTSA Levels of vehicle automation
    c. Difference between automated and autonomous vehicles

Read Handout_6_b (p. 3 – 10)
Read Handout_9
Read Handout_10 (p. 1 – 13)
Read Handout_11 (p. 178 – 186)
LECTURE_1

Homework #1 assigned
Group assignment

Part II. Fundamentals of the locomotion of autonomous mobile robots and vehicles

2. Introduction to the locomotion of autonomous mobile robots and vehicles
    a. Introduction and Key issues for locomotion
    b. Legged mobile robots: Leg configurations and stability

Read: Chapters 1 & 2 (Siegwart, et al., p. 1 – 29)
LECTURE_2

3. Wheeled mobile robots locomotion: design space and case studies

Homework #1 due
Read: Chapters 2 (Siegwart, et al., p. 30 – 46)
LECTURE_3

Part III. Fundamentals of mobile robot kinematics

4. Overview of Robot Kinematic models and constraints
    a. Representing robot position

b. Kinematic models (fixed and steered standard wheels)
c. Robot kinematic constraints

Test #1
Read Handout_4
LECTURE_4
Read: Chapters 3 (Siegwart, et al., p. 47 – 66)

5. Mobile robot maneuverability
    a. Degree of mobility
    b. Degree of steerability
    c. Robot maneuverability

Homework #2 assigned
Read Handout_5
LECTURE_5
Read: Chapters 3 (Siegwart, et al., p. 67 – 73)

6. Mobile robot workspace
    a. Degree of freedom
    b. Holonomic robots
    c. Path and trajectory considerations
    d. Beyond basic kinematics
    e. Kinematic (motion) control:
        i. Open loop (trajectory-following) and
        ii. Feedback controls

Homework #2 due
Project assigned to groups
Read: Chapters 3 (Siegwart, et al., p. 74 – 88)
LECTURE_6

7. ***Review for Mid-term Exam #1***
    a. Review material from Lesson 1 – 6.

8. ***Mid-term Examination (#1)***
    a. Administer Mid-term examination on lesson 1 – 7.

Part IV. Fundamental of sensors for mobile robots and vehicles

9. Sensors for mobile robots and vehicles
    a. Overview of autonomous vehicle sensors and systems
    b. Sensor classifications
    c. Characterizing sensors performance

d. Safety administrations
e. Internal vehicle systems
f. External world sensing

Read: Chapters 4 (Siegwart, et al., p. 89 – 97)
Read Handout_3
Read Handout_5
Read Handout_4
Read Handout_6
Read Handout_11 (p. 178 – 186)
LECTURE_9

10. Sensors for mobile robots and vehicles
    a. Wheel/motor sensors
    b. Heading sensors

Read: Chapters 4 (Siegwart, et al., p. 97 – 101)
Read Handout_8
Read Handout_9
LECTURE_10

11. Sensors for mobile robots (continued)
    a. Ground-based beacons
    b. Active ranging
    c. Motion/speed sensors
    d. Vision-based sensors

Homework #3 assigned
Read: Chapters 4 (Siegwart, et al., p. 101 – 151)

Read Handout_4
Read Handout_5
Read Handout_10
LECTURE_11

12. Representing Uncertainty
    a. Statistical representation
    b. Error propagation: Combining uncertain measurements

Read: Chapters 4 (Siegwart, et al., p. 145 – 150)
LECTURE_12

13. Feature (Line) extraction
    a. Feature (Line) extraction based on range
    b. Visual appearance based on feature extraction

Test#2

Read: Chapters 4 (Siegwart, et al., p. 151 – 181)

LECTURE_13

14. Introduction to Android Software Operation
    a. Overview of Android Software Operation
    b. Android Line Following Algorithm
    c. Android GPS Navigation Algorithm
    d. Android GPS Navigation Algorithm Test.

Open Laboratory Session - Create your own data, design and presentation

Read Handout_1

Read Handout_2

Read Handout_4

LECTURE_14

: Android Software Operation Tutorial

Homework #3 due

15. Review for final examination and Project presentation
    a. Project presentation
    b. Review materials from 1 – 14

16. Final Examination (#2)
    a. Final review of materials with students
    b. Final examination

Instructional Strategies

The course content will be presented through a blend of instructional methods to include:

- Lecture - Face-to-face
- Discussion/Questioning
- Independent Learning/Self-Instruction
- Problem-Solving
- Multimedia presentations
- Guest Speaker (s)
- Library Referencing and Resources
- Computer and Internet Research

STUDENT ACTIVITIES:

- 16 class meetings - Class attendance and participation in class discussion

- 3 homework assignments – Read (study), complete and turn in assignments at the scheduled time (*usually* at the *beginning* of class periods on the due dates)
- 2 Tests
- Laboratory exercises/ Project – Complete a robotic building project during lab periods
- Mid-term Examination
- Final Examination

Class attendance and participation
There will be a total of 16 class meetings, including final examination day. During these meetings, class attendance and participation in class discussions are essential. Students should be prepared to discuss all required readings before each scheduled class.

Homework assignments
The assignments are designed primarily to increase your familiarity with sensors used in autonomous robots, automated and connected vehicles and make it easier for you to use it in our projects and research work. There will be 3 homework assignments and will generally be based on materials covered in the class. The remaining two parts will require a lot more effort and may require you to refer to material outside the lectures. Students should read (study), complete and turn in assignments at the scheduled time.

Quizzes and Tests
During the semester, all students are required to successfully pass two (2) tests and participate on at least 10 quizzes. These tests will come from your lectures, readings and writing assignments and will consist of multiple choices, fill in the blank, essays and true/false.

Examinations
During the semester, all students are required to successfully pass two (2) examinations (midterm and final). These examinations will come from your lectures, reading and writing assignments and will consist of multiple choices, fill in the blank, essays and true/false.

Laboratory Exercises/ Project
Laboratory exercises measure skills and abilities relating to knowledge learned in class. These laboratory exercises will aid the in the design, building and examination of the operation of different sensors used in robotics. It is anticipated that the laboratory exercises will result in the creation of a software tool kit that can allow for the immediate use of these sensors without the need for an in-depth knowledge of the physics behind the sensors as the final project.

Students are required to complete a project involving team collaboration. As such a complete involvement and contribution in all phases of the project is expected from each team member.

For the duration of the course, each team is expected to work together and produce a professional quality response to a problem in the form of a written report. In addition, each team will make a 10 – 15 minutes oral presentation. Final reports are due on the day of the presentation and each member of the team, regardless of input, will receive the same grade for the team project. The

projects will be judged by a panel consisting of the course faculty and external experts in automated and connected vehicle

Written Report (Format)

I. Executive Summary.
II. Table of Contents, List of Team members, and Specific Team Member Contribution.
III. Problem Statement, Design Objectives and Development of Requirement.
IV. Methods and Discussion Leading to Proposed Design.
V. Schedule.
VI. Results Including the Measures of Success (speed, range, conservation of energy).
VII. Equipment List for robotic project.
VIII. Lesson Learned.
IX. Power Point Presentation Slides.
X. References

Methods of Student Evaluation:

Grading will consist of the following criteria and percentages:

3 Homework assignments 15%
10 Quizzes ……...……. 05%
2 Tests ……10%
1 Mid-term Examination …… 20%
1 Final Examination ……. 20%
1 Laboratory exercises/ Project……. 20%
1 Presentation ……10%

Total 100

Grading Scale:

A	B	C	D	F
90-100	**80-89**	**70-79**	**60-69**	**< 60**

Methods of Course Evaluation

A. Jackson State University Student Instructional Rating System (SIRS)

Special Needs Learners:
"It is the University policy to provide on a flexible and individualized basis, reasonable accommodations to students who have disabilities that may affect their ability to practice in course activities or to meet course requirements. Students with disabilities are encouraged to contact their instructors to discuss their individual needs for accommodation." Contact Information:

ADA Coordinator, Disability Services & ADA Compliance
2100 Student Center, 2nd Floor, P.O. Box 17156, Jackson, MS 39217
Phone: (601.979.3704), Fax: (601.979.6918), TTY: (601.979.6919)
Website: http://www.jsums.edu/disability/

Diversity Statement:

Jackson State University is committed to creating a community that affirms and welcomes persons from diverse backgrounds and experiences and supports the realization of their human potential. We recognize that there are differences among groups of people and individuals based on ethnicity, race, socioeconomic status, gender, exceptionalities, language, religion, sexual orientation, and geographical area. All persons are encouraged to respect the individual differences of others.

Class Attendance Policy:

All students at Jackson State University must fully commit themselves to their program of study. One hundred percent (100%) punctual class attendance is expected of all students in all scheduled classes and activities. Instructors keep attendance records and any absence for which a student does not provide written official excuse is counted as an unexcused absence. Students must understand that even with an official excuse of absence, they (students) are responsible for the work required during their absence.

Students may be officially excused from class for attendance at University approved functions, provided the sponsor properly executes a Student Affairs Leave Form. Such excuses shall be accepted by the instructor. Students may also be officially excused by the Dean of their School or the Vice President for Academic Affairs for certain campus activities. Students must submit written documentation to Student Affairs to obtain official excuses for absences due to illness or other emergency situations.

Students who willfully miss class face serious consequences. After being absent three times in a 50-minute class, three hours in a class that meets longer than one hour, or one time immediately before or after a scheduled recess/holiday, the instructor shall report the next unexcused absence to the Dean of University College for freshman and sophomores and to the school dean and department chair for juniors and seniors. The dean/chair or designee will counsel with the student and in concert with the instructor, may require the student to complete complementary course assignments. If a student does not respond well to the counselor with the assignments, the instructor may impose a grade penalty on the student. Unexcused absences that exceed the equivalency of six 50-minute Sessions may lead to an "F" for the course. Students who do not maintain the minimum grade point average required for retention over two semesters are suspended from the University.

At the discretion of the school dean and with approval of the Office of Academic Affairs, there may be additional class attendance policies stipulated in school handbooks and other official school documents.

Academic Dishonesty Statement:

Academic dishonesty will be rewarded with a grade of zero for the assignment or exam and may possibly lead to failure of the course.

IT 311 – Sensors used in automated and connected vehicles
Course Safety Confirmation

This course is an introductory course in sensors used in automated and connected vehicles. Students will work in teams and apply Android Software Operation and sensors technology to create a software tool kit that can allow for the immediate use of these sensors without the need for an in-depth knowledge of the physics behind the sensors and overall robotic vehicle structure in a hands-on laboratory environment. Each student team will design and build an autonomous robot by selecting various components and system configurations, and integrating the systems for optimal vehicle performance.

SAFETY: ***This course may involve the use of laboratory and/or shop equipment, and no student is allowed to utilize methods/techniques without the supervision of course instructors. This safety requirement includes all aspects of the development, construction, assembly, transportation and operation of all components of the robot. As a rule, once the robot is capable of self-contained movement, the robot may not be powered if anyone is within 15 feet of its direction of movement (i.e. don't turn it on until there is no one standing in front of the vehicle). Any student who chooses to disregard ANY safety rules, or conducts himself/herself in a manner that places anyone in danger, will be dismissed from the course immediately, and the case will be turned over to the Dean of Students.***

The first imperative of the automated and connected Vehicle Systems course is personal and property safety. As a student in this course, I have read the course outline. I understand the course safety imperative and have asked all questions regarding safety and safety expectations. I will abide by all safety requirements placed upon us as part of the conduct of the course. Further, I will abide by safety practices common to laboratories as well as customary transportation safety.

I _____ (have/ do not have) a valid

operators license in _____ (state).

Signature: _____ Date: _____

Assignment #1

Write a research paper on sensors used in autonomous vehicles. Possible outlines include:

1. Types of sensors used in connected and automated vehicles.
2. Difference between automated and autonomous vehicles.
3. Classification of automated vehicles.
4. Challenges (communication, computation power, time constraints, sensor data, cost, etc.).

Discuss how some of these listed outlines may be applied towards your project.

You must include at least 4 references to refereed journal or conference papers.

Assignment #2

Write a paper on how you plan to use some of the sensors you surveyed in the previous assignment in your project.

You must include at least 4 references to refereed journal or conference papers.

Early Milestones

1. Assemble EV3 robot and test it.
2. Initial design intentions: central control, sensor subsystems, power, etc.
3. Initial test of control system. Use a control unit to have the robot go in a square
4. Down selection of sensors.
5. Sensor integration and testing.
6. Complete prototype testing and evaluation

Assignment #3

Write a paper on "Preparation for self driving cars in my city."

<u>Project Requirements and Design Specifications</u>

I. Total cost of final product must not exceed $500.00
II. Budget provided by the IS&T dept. is $400.00
III. Programmable EV3 Brick - serves as the control center and power station for your robot.

- 4 Input ports: 1, 2, 3, 4 (to connect sensors to EV3 Brick)
- 4 Output ports: A, B, C, D (to connect motors to EV3 Brick)
- 1 Mini USB PC port (to connect EV3 brick to computer)
- USB host port (to add Wi-Fi dongle and do "Daisy chaining")
- Micro SD Card port (to increase available memory for EV3 Brick)
- Built-in speaker

It 311 - Course Learning Objectives/ Outcomes

	Course Learning Objectives/Outcomes mapped to lessons	*LESSONS*														
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1	*Explain* the concept, history, and the importance of automated (autonomous) and connected vehicles.	X														
2	List different automation levels.	X														
3	*Explain* the concept and discuss the importance of automated, autonomous and connected vehicles	X														
4	Describe the history of autonomous mobile robotics and automated and connected vehicles.	X														
	Investigate the automation levels and the difference between automated and autonomous vehicles.	X														
6	*Explain* the associated technical, social and ethical issues.	X														
7	*Recognize* and *apply* laboratory safety procedures.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
8	*Appraise* locomotion methods of autonomous mobile robots.		X													
9	*Appraise* different locomotion methods in the context of example of applications in autonomous mobile robots and vehicles.		X													
10	*Demonstrate* the ability to use specialized and hand tools for troubleshooting in the lab.		X													
11	Report on appropriate wheeled mobile robots and vehicles.			X												
12	Report on appropriate wheel design for mobile robots and vehicles			X												
13	Appraise different locomotion methods in the context of example applications.			X												
14	Build kinematic models and constraints.				X											
15	Build kinematic models and constraints for mobile robots and vehicles.				X											
16	Appraise different locomotion methods in the context of example applications.				X											
17	Apply principles of mobile robot maneuverability.					X										
18	Appraise different locomotion methods in the context of example applications.					X										
19	Apply principles of maneuverability in the design of mobile robots and vehicles.					X										
20	Report on mobility design workspace.						X									
21	Report on appropriate mobility design workspace for an application in mobile robots and vehicles.						X									
22	Demonstrate the basic understanding of the material covered by the learning outcomes in Lessons 1–7.	X	X	X	X	X	X	X	X							
23	Discus the variety of sensors used in mobile robots and the strategies for extracting information from the sensors.									X						
24	List the characteristics of sensors that exist within autonomous vehicle systems.									X						
25	Discus the variety of sensors used in mobile robots and the strategies for extracting information from the sensors.									X						
26	Assess the classifications of different sensors used									X						

	for different real world applications in mobile and vehicles.															
27	Distinguish between systematic and random errors.									X						
28	Assess the pros and cons of different sensors and use them for different real world applications in mobile and vehicles.										X					
29	Describe and recognize the features of different sensors commonly used in autonomous mobile robot and vehicles.										X					
30	Analyze and assess critically the pros and cons of different sensors and use them for different real world applications in mobile and vehicles.										X					
31	Describe the ground-based beacons used in mobile robots and vehicles.										X					
32	Describe the performance characteristics of a sensor.											X				
33	Characterize the error of a sensor for any measurement in real world applications in mobile and vehicles.											X				
34	Discus error propagation											X				
35	Choose appropriate features for robot to use at the design stage.												X			
36	List four factors that are essential when designing a mobile robots												X			
37	Explain two key requirements that must be met for a vision-based feature extraction												X			
38	Apply Android Software Operation and sensors technology to create a software tool kit.													X		
39	Define Android Operation System													X		
40	Explain “Android Application Publishing” as a process															
41	Demonstrate the understanding of the material covered by the learning outcomes in Lessons 1–15.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

IT 311 - Course Content and Assignment Schedule – Summer 2016			
Wk	**Topics/Readings/Study**	**Assignments**	**Due Date**
Part I. Fundamentals of automated (autonomous) and connected vehicles			
1 **7/13**	Overview of automated and connected vehicles - Introduction to the history of automated (autonomous) and connected vehicles - NHTSA Levels of vehicle automation - Differences between automated and autonomous vehicles	Read Handout_6_b (p. 3-10) Read Handout_9 Read Handout_10 (p. 1 – 13) Read Handout_11(p. 178-186) LECTURE_1 ***Homework #1 assigned*** ***Group assignment***	
Part II. Fundamentals of autonomous mobile robots and locomotion			
2 **7/14**	Overview of autonomous mobile robots - Introduction to locomotion - Key issues for locomotion - Legged mobile robots • Leg configurations and stability • Examples of legged robot locomotion	Read: Chapters 1& 2 (Siegwart, et al., p. 1 – 29) LECTURE_2 ***Homework #1 due***	
3 **7/15**	Wheeled mobile robots - Wheeled locomotion: design space and case studies	Read: Chapters 2 (Siegwart, et al., p. 30 – 46) LECTURE_3 ***Test#1***	
Part III. Fundamentals of mobile robot kinematics			
4 **7/18**	Overview of Kinematic models and constraints a. Representing robot position b. Forward kinematic models c. Wheel kinematic constraints d. Robot kinematic constraints	Read Handout_4 Read: Chapters 3 (Siegwart, et al., p. 47– 66) LECTURE_4 ***Homework #2 assigned***	
5 **7/19**	Mobile robot maneuverability - Degree of mobility - Degree of steerability - Robot maneuverability	Read Handout_5 Read: Chapters 3 (Siegwart, et al., p. 67 - 73) LECTURE_5 ***Homework #2 due***	
6 **7/20**	Mobile robot workspace - Degree of freedom - Holonomic robots - Path and trajectory considerations - Beyond basic kinematics - Kinematic (motion) control • Open loop control (trajectory-following) • Feedback control	Read: Chapters 3 (Siegwart, et al., p. 74 - 88) LECTURE_6 ***Project assigned to groups***	
7 **7/21**	**Review for Mid-Term Exam** Review material from lesson 1 - 6	Read assigned chapters (1-3) and handouts	
8 **7/22**	**Mid-Term Exam** Material from lesson 1 - 6	Read Chapters 1-3 and handouts	
Part IV. Fundamental of sensors for mobile robots			
9 **7/23**	Sensors for mobile robots - Sensor classifications	Read: Chapters 4 (Siegwart, et al., p. 89-101) Read Handout_3	

	- Characterizing sensors performance - Wheel/motor sensors - Heading sensors	Read Handout_4 Read Handout_5 Read Handout 6_b (p. 3-10) Read Handout_11(p. 178-186) LECTURE_9	
10 **7/25**	Sensors for mobile robots (continued) - Ground-based beacons - Active ranging - Motion/speed sensors - Vision-based sensors	Read: Chapters 4 (Siegwart, et al., p. 101 - 145) Read Handout_8 Read Handout_9 LECTURE_10 ***Homework #3 assigned***	
11 **7/26**	Representing Uncertainty - Statistical representation - Error propagation	Read: Chapters 4 (Siegwart, et al., p. 145 - 151) Read Handout_4 Read Handout_5 Read Handout_10 (p. 1 – 13) LECTURE_11	
12 **7/27**	Feature extraction - Based on range data - Based on visual appearance	Read: Chapters 4 (Siegwart, et al., p. 151 - 181) LECTURE_12 ***Test#2***	
13 **7/28-30**	Introduction to Android Software Operation - Overview of Android Software Operation - Android Line Following Algorithm - Android GPS Navigation Algorithm - Android GPS Navigation Algorithm Test.	Read Handout_1 Read Handout_2 Read Handout_4 LECTURE_13 **Homework #3 is due**	
14 **8/1-3**	Open Laboratory Session - Create your own data, design and presentation	Create your own data, design and presentation LECTURE_14	
15 **8/4-5**	Project presentation and Final Examination Review	***Written Report – due***	
16 **8/6**	***Final Examination***		

IT 311 – Sensors used in connected and automated vehicles

WEEKLY LESSON PLANS

Lesson Plan for week #1

Lesson 1: Introduction to automated and connected vehicles

Delivery Time: 180 minutes of lecture and 60 minutes lab

Course Objective

1. Explain the concept, history, and the importance of automated (autonomous) and connected vehicles.
2. Describe the automation levels, the associated technical, social and ethical issues of automated and connected vehicles.

Lesson Learning Outcomes

Following this lesson, the student will be able to:

3. Explain the concept and discuss the importance of automated, autonomous and connected vehicles
4. Describe the history of autonomous mobile robotics and automated and connected vehicles.
5. Investigate the automation levels and the difference between automated and autonomous vehicles.
6. Explain the associated technical, social and ethical issues.
7. Recognize and apply laboratory safety procedures.

Required Texts:

Siegwart, R., Nourbakhsh, I. R., Scaramuzza, D. (2011). Introduction to Autonomous Mobile Robots, 2/ed., MIT Press, ISBN: 978-0262015356
Handout: Schwarz, C., et al. (2013, p. 1 – 13).
Handout: Technology Assessments.
Handout: Eno Center for transportation (2013, p. 3 – 10).

Preparation and Setup

- Prepare a first day handout: course syllabus, Lab 1 – safety rules and regulations, Homework 1 – Lab handout and reading assignment.

- Prepare Lecture 1: Concept and history of automated (autonomous) and connected vehicles.
- This lecture includes: 1) instructor introduction and qualifications, 2) discussion of First Day Handout, including course content, schedule, and grading policies, 3) assign reading of chapter in textbook, and, 4) lecture on concept, history, importance and automation levels of automated and connected vehicles.
- Prepare Lesson 1 Quiz and a scoring rubric for the quiz. Alternatively, wait until the end of Lesson 2 and give a comprehensive quiz on Lessons 1 and 2.

Lesson Delivery

Topics Covered

1. Introduction to the course: Syllabus, structure, expectations, policies, and procedures
2. Overview of the concept and history of automated and connected vehicles
    a. Introduction to the concept and history of automated (autonomous) and connected vehicles
    b. Why autonomous vehicles?
    c. Classification of automated (autonomous) and connected vehicles
        i. NHTSA Levels of vehicle automation
        ii. Difference between automated and autonomous vehicles
    d. Associated technical, social and ethical issues
3. Lab 1 is on personal, property and safety practices common to laboratories as well as customary transportation safety.

Homework #1 assigned
Group assignment

Lecture/Discussion

- Introduce yourself and review your qualifications; encourage students to introduce themselves, take notes during lectures, and ask questions anytime.
- Provide an overview of the topics to be covered in the course, the textbook to be used, and any online resources associated with the textbook.
- Discuss the concept and history of automated (autonomous) and connected vehicles.
- Discuss the levels of automations
- Discuss associated technical, social and ethical issues
- Discuss Lab 1 on personal, property and safety practices common to laboratories as well as customary transportation safety.
- Define some basic terminologies needed in a discussion of automated and connected vehicles.

- Have students complete the Lab handout.
- Assign homework for Lesson 1. For this first week only, the homework is due at the end of the week. Alternatively, depending on the textbook, the student may be able to complete the homework online and email it to the instructor.
- Define any new terms.
- Answer student questions on lecture topics.

Handouts/References

- First day handout including syllabus, polices, procedures, and grading information.
- Homework from textbook for next week.
- Lab 1 on personal, property and safety practices common to laboratory.
- Lesson 1 Quiz.

Lab Activities

- Students gain experience on related laboratory safety procedure:
    - Lab 1 on personal, property and laboratory safety practices.
    - Students will learn to abide by safety practices common to laboratories as well as customary transportation safety.

Homework

Explain expectations and grading policy on the homework. Have the students complete the homework prior to the lecture, based on their reading of the textbook chapter and assigned handouts. This will reinforce the message in the chapter reading, prepare the students to better understand the lecture, and ask questions on things they did not understand.

Assign the following homework:
- Have students read chapter(s) and handouts on automated (autonomous) and connected vehicles.
- Lab 1 assignment is due at the end of Lesson 1.

Assessment

Learning Outcome 3

- **Outcome:** List different levels of automation.
- **Assessment:** Student demonstration of successful verification of safety practices in the laboratory.

- **Evaluation:** Verify that the student has read, understood and signed the course safety confirmation form.
- **Standard:** Successful signing the course safety confirmation form.

Learning Outcome 7

- **Outcome:** Recognize and apply laboratory safety procedures.
- **Assessment:** Lesson 1 Quiz.
- **Evaluation:** Score quiz using grading guidelines.
- **Standard:** Minimum score of 70%.

Lesson Plan for week #2

Lesson 2: Locomotion of autonomous mobile robots

Delivery Time: 160 minutes of lecture/ 80 minutes of lab

Course Objective

8. Appraise locomotion methods of autonomous mobile robots.

Lesson Learning Outcomes

Following this lesson, the student will be able to:

9. Appraise different locomotion methods in the context of example of applications in autonomous mobile robots and vehicles.

10. Demonstrate the ability to use specialized and hand tools for trouble shooting in the lab.

Required Texts:

Siegwart, R., Nourbakhsh, I. R., Scaramuzza, D. (2011). Introduction to Autonomous Mobile Robots, 2/ed., MIT Press, ISBN: 978-0262015356

Lesson Delivery

Topics Covered

1. Lesson 2 Quiz and Lab Activity review.
2. Overview of the locomotion of autonomous mobile robots and vehicles
    a. Introduction to locomotion
    b. Key issues for locomotion
    c. Legged mobile robots: Leg configurations and stability

Lecture/Discussion

- Introduction to a mobile robot Locomotion
- Review locomotion mechanisms
- Discuss the biped walking system
- Discuss the key issues for locomotion
- Assign homework for Lesson 2 and hand out hard copies to students.
- Define any new terms.
- Answer student questions on lecture topics.

Handouts/References

- Homework for Lesson 2.

Lab Activities

- Review laboratory safety rules, regulations and procedures.
- Assign students to teams.
- Students assign responsibilities among each other.

Homework

- Students read textbook chapter(s) on Lesson 3.
- Develop bill of materials for your project.

Assessment

Learning Question 1

- **Outcome:** List the three key issues for locomotion system?
- **Assessment:** Quiz.
- **Evaluation:** Score quiz using prepared answer key.

Learning Question 2

- **Outcome: D**iscuss the key advantages and disadvantages of legged robots
- **Assessment:** Quiz.
- **Evaluation:** Score quiz using prepared answer key.

Lesson Plan for week #3

Lesson 3: Wheeled mobile robots

Delivery Time: 240 minutes of lecture

Course Objective

11. Report on appropriate wheeled mobile robots and vehicles.

Lesson Learning Outcomes

Following this lesson, the student will be able to:

12. Report on appropriate wheel design for mobile robots and vehicles

13. Appraise different locomotion methods in the context of example applications.

Required Texts:

Siegwart, R., Nourbakhsh, I. R., Scaramuzza, D. (2011). Introduction to Autonomous Mobile Robots, 2/ed., MIT Press, ISBN: 978-0262015356

Lesson Delivery

Topics Covered

1. Lesson 3 Quiz and Lab Activity review.
2. Wheeled mobile robots locomotion
    a. design space
    b. case studies

Lecture/Discussion

- Review the wheeled mobile robots
- Discuss the four basic wheel types
- Discuss the wheel configurations for rolling vehicles
- Discuss the case studies
- Define any new terms.
- Give exam #1 on the materials in Lessons 1 and 2 at the end of Lesson 3.
- Answer student questions on lecture topics.

Handouts/References

- Read: Chapters 2 (Siegwart, et al., p. 30 – 46)
- Homework for Lesson 3.

Lab Activities
Group assignment.

Homework

- Students read textbook chapter(s) on Lesson 4.

Assessment

Learning Question 1

- **Outcome:** List and discuss the four basic wheel types
- **Assessment:** Quiz.
- **Evaluation:** Score quiz using prepared answer key.

Learning Question 2

- **Outcome:** List five types of robots
- **Assessment:** Quiz.
- **Evaluation:** Score quiz using prepared answer key.

Lesson Plan for week #4

Lesson 4: Kinematic models and constraints

Delivery Time: 120 minutes of lecture and 120 minutes of lab

Course Objective

14. Build kinematic models and constraints.

Lesson Learning Outcomes

Following this lesson, the student will be able to:

15. Build kinematic models and constraints for mobile robots and vehicles.

16. Appraise different locomotion methods in the context of example applications.

Required Texts:

Siegwart, R., Nourbakhsh, I. R., Scaramuzza, D. (2011). Introduction to Autonomous Mobile Robots, 2/ed., MIT Press, ISBN: 978-0262015356

Lesson Delivery

Topics Covered

1. Lesson 4 Quiz and Lab Activity review.
2. Kinematic models and constraints
    a. Representing robot position
    b. Forward kinematic models
    c. Wheel kinematic constraints
    d. Robot kinematic constraints

Lecture/Discussion

- Review the history of Mobile Robot Kinematics
- Discuss the kinematic models and constraints
- Discuss the representing robot position
- Discuss the forward kinematic models
- Define any new terms.
- Answer student questions on lecture topics.

Handouts/References

- Homework (#2) assigned for Lesson 4.
- Read Chapter 3 (Siegwart, et al., p. 47 – 66)

- Lesson 4 Quiz.

Lab Activities

- Students gain experience on building kinematic model and constraints:
- Lab 3 on building robotic models.

Homework

- Students read textbook chapter(s) on Lesson 5.
- Assign homework #2

Assessment

Learning Question 1

- **Outcome:** Kinematics is the study of how mechanical systems behave. Why is this important?
- **Assessment:** Quiz.
- **Evaluation:** Score quiz using prepared answer key.

Learning Question 2

- **Outcome:** Define the following:

    a. Fixed standard wheel
    b. Steered standard wheel
    c. Castor wheels
    d. Swedish wheel
    e. Spherical wheel

- **Assessment:** Quiz.
- **Evaluation:** Score quiz using prepared answer key.

Lesson Plan for week #5

Lesson 5: Mobile robot maneuverability

Delivery Time: 240 minutes of lecture

Course Objective

17. Apply principles of mobile robot maneuverability.

Lesson Learning Outcomes

Following this lesson, the student will be able to:

18. Appraise different locomotion methods in the context of example applications.
19. Apply principles of maneuverability in the design of mobile robots and vehicles.

Required Texts:

Siegwart, R., Nourbakhsh, I. R., Scaramuzza, D. (2011). Introduction to Autonomous Mobile Robots, 2/ed., MIT Press, ISBN: 978-0262015356

Lesson Delivery

Topics Covered

1. Lesson 5 Quiz and Lab Activity review.
2. Mobile robot maneuverability
    a. Degree of mobility
    b. Degree of steerability
    c. Robot maneuverability

Lecture/Discussion

- Introduction to Mobile robot maneuverability
- Discuss the four wheel Ackerman steering
- Discuss the differential drive robot
- Define any new terms.
- Answer student questions on lecture topics.

Handouts/References

- Homework for Lesson 5.
- Lesson 5 Quiz.
- Read: Chapters 3 (Siegwart, et al., p. 67 – 73)

Lab Activities
Team working on projects.

Homework
Students read textbook chapter(s) on Lesson 6.

Assessment

Learning Question 1

- **Outcome:** Discuss mobile robot maneuverability
- **Assessment:** Quiz.
- **Evaluation:** Score quiz using prepared answer key.

Learning Question 2

- **Outcome:** Explain the degree of mobility
- **Assessment:** Quiz.
- **Evaluation:** Score quiz using prepared answer key.

Learning Question 3

- **Outcome:** What is the overall degree of freedom that a robot can manipulate called?
- **Assessment:** Quiz.
- **Evaluation:** Score quiz using prepared answer key.

Lesson Plan for week #6

Lesson 6: Mobile robot workspace/ Review for Midterm Examination

Delivery Time: 180 minutes of lecture and 60 minutes of lab

Course Objective

20. Report on mobility design workspace.

Lesson Learning Outcomes

Following this lesson, the student will be able to:

21. Report on appropriate mobility design workspace for an application in mobile robots and vehicles.

Required Texts:

Siegwart, R., Nourbakhsh, I. R., Scaramuzza, D. (2011). Introduction to Autonomous Mobile Robots, 2/ed., MIT Press, ISBN: 978-0262015356

Preparation and Setup

- Deliver lecture
- Review Lab Activities and Homework.
- Prepare Handouts/References.

Lesson Delivery

Topics Covered

1. Lesson 6 Quiz and Lab Activity.
2. Mobile robot workspace
    a. Degree of freedom
    b. Holonomic robots
    c. Path and trajectory considerations
    d. Beyond basic kinematics
    e. Kinematic (motion) control: Open loop control (trajectory-following) & Feedback control.

Lecture/Discussion

- Introduction to Mobile Robot Workspace
- Discuss degrees of freedom
- Discuss Holonomic robots
- Discuss Path and Trajectory Considerations
- Discuss beyond basic kinematics
- Discuss lab report writing
- Define any new terms.
- Answer student questions on lecture topics.

Handouts/References

- Homework for Lesson 7.
- Lesson 6 Quiz.
- Read: Chapters 3 (Siegwart, et al., p. 74 – 88)

Lab Activities

Students work as team members on projects assigned to each group.

Homework

- Students read textbook chapter(s) on Lesson 1 – 7 and complete lab assignments.

Assessment

Learning Question 1

- **Outcome:** What should be examined when defining Mobile Robot Workspace?
- **Assessment:** Quiz.
- **Evaluation:** Score quiz using prepared answer key.

Learning Question 2

- **Outcome:** What are the several mathematical areas that holonomy is applicable?
- **Assessment:** Quiz.
- **Evaluation:** Score quiz using prepared answer key.

Lesson Plan for week #7

Lesson 7: Review for Midterm Examination

Delivery Time: 240 minutes of lecture

Course Objective

22. Demonstrate the basic understanding of the material covered by the learning outcomes in Lessons 1 – 6.

Lesson Learning Outcomes

Following this lesson, the student will be able to:

1. Demonstrate the basic understanding of the material covered by the learning outcomes in Lessons 1 through 6.

Required Texts:

Siegwart, R., Nourbakhsh, I. R., Scaramuzza, D. (2011). Introduction to Autonomous Mobile Robots, 2/ed., MIT Press, ISBN: 978-0262015356

Preparation and Setup

- Prepare a summary of the first seven Lessons
- Return all graded homework, lab activities, and quizzes.
- Prepare a comprehensive mid-term exam covering the first seven lessons.
- Prepare Handouts/References.

Lesson Delivery

Topics Covered

1. Review Lesson 1 - 6 Quiz and Lab Activity.
2. Review for midterm examination.

Lecture/Discussion

- Review for midterm examination.
- Encouraged to ask questions on the review, and students should organize all returned materials and any handouts in preparation for the mid-term exam.

- Answer student questions on lecture topics.

Handouts/References

- Lesson 1 – 6 Quiz.
- Read: Chapters 1- 3 (Siegwart, et al.,)

Lab Activities

Students continue to work on group projects

Homework

- Students read textbook chapter(s) on Lesson 1 – 7 and complete lab assignments.

Assessment

Learning Outcome 22

- **Outcome:** Demonstrate basic understanding of material covered in lessons 1 – 6.
- **Assessment:** Mid-term Exam.
- **Evaluation:** Score quiz using prepared answer key.
- **Standard: M**inimum score of 70%

Lesson Plan for week #8

Lesson 8: Midterm Examination

Delivery Time: 240 minutes of lecture

Course Objective

Following successful completion of this course, the student will be able to:

22. Demonstrate understanding of the material covered by the learning outcomes in Lessons 1 through 7 on a mid-term exam.

Lesson Learning Outcomes

Following this lesson, the student will be able to:

22. Demonstrate understanding of the material covered by the learning outcomes in Lessons 1 through 7 on a mid-term exam.

Instructional Resources

Recommended Textbook(s)

Siegwart, R., Nourbakhsh, I. R., Scaramuzza, D. (2011). Introduction to Autonomous Mobile Robots, 2/ed., MIT Press, ISBN: 978-0262015356

Preparation and Setup

23. Prepare a summary of the first seven Lessons
24. Prepare a comprehensive mid-term exam covering the first seven lessons.
25. Administer mid-term examination.

Lesson Delivery

Topics Covered

Lesson 1 – 7 Review
Midterm exam

Lecture/Discussion

- Review the major topics in the first seven Lessons

- Encouraged to ask questions on the review, and students should organize all returned materials and any handouts in preparation for the mid-term exam.
- Administer the midterm exam.

Handouts/References

26. Homework for Lesson 9.
27. Midterm exam.

Lab Activities

None.

Online Component

28. Post the summary review and midterm handout for Lesson 7 prior to class so the students can preview it.
29. Post grades for homework, lab activities, and quizzes on the Blackboard.

Homework

- Students read textbook chapter(s) and handouts on Lesson 9 topics.

Assessment

Learning Outcome 22

- **Outcome:** Demonstrate basic understanding of the material covered in lessons 1 – 7.
- **Assessment:** Midterm exam.
- **Evaluation:** Score exam using prepared answer key.
- **Standard:** Minimum score of 70%.

Lesson Plan for week #9

Lesson 9: Sensors for mobile robots and vehicles

Delivery Time: 240 minutes of lecture

Course Objective

Following successful completion of this course, the student will be able to:

23. Discus the variety of sensors used in mobile robots and the strategies for extracting information from the sensors.

Lesson Learning Outcomes

Following this lesson, the student will be able to:

24. List the characteristics of sensors that exist within autonomous vehicle systems.
25. Discus the variety of sensors used in mobile robots and the strategies for extracting information from the sensors.
26. Assess the classifications of different sensors used for different real world applications in mobile and vehicles.
27. Distinguish between systematic and random errors.

Required Texts:

Siegwart, R., Nourbakhsh, I. R., Scaramuzza, D. (2011). Introduction to Autonomous Mobile Robots, 2/ed., MIT Press, ISBN: 978-0262015356

Lesson Delivery

Topics Covered

1. Lesson 9 Quiz and Lab Activity review.
2. Sensors for mobile robots
    a. Sensor classifications
    b. Characterizing sensors performance
    c. Wheel/motor sensors
    d. Heading sensors

Lecture/Discussion

- Introduction to Sensors for Mobile Robots

- Review Sensor Classification
- Discuss Characterizing sensor performance
- Discuss wheel/motor heading sensors
- Define any new terms.
- Answer student questions on lecture topics.

Handouts/References

- Homework for Lesson 9.
- Lesson 9 Quiz.
- Read: Chapters 4 (Siegwart, et al., p. 89 – 101).
- Varghese, et al., (2015), p. 178 – 186).

Lab Activities

Coding/ programming of robots.

Homework

- Students read textbook chapter(s) on Lesson 10.

Assessment

Learning Outcome 24

- **Outcome:** List the characteristics of sensors that exist within autonomous vehicle systems?
- **Assessment:** Quiz.
- **Evaluation:** Score quiz using prepared answer key.

Learning Question 1

- **Outcome:** For external world sensing, what are the sensors applicable?
- **Assessment:** Quiz.
- **Evaluation:** Score quiz using prepared answer key.

Lesson Plan for week #10

Lesson 10: Sensors for mobile robots and vehicles

Delivery Time: 240 minutes of lecture

Course Objective

Following successful completion of this course, the student will be able to:

28. Assess the pros and cons of different sensors and use them for different real world applications in mobile and vehicles.

Lesson Learning Outcomes

Following this lesson, the student will be able to:

29. Describe and recognize the features of different sensors commonly used in autonomous mobile robot and vehicles.
30. Analyze and assess critically the pros and cons of different sensors and use them for different real world applications in mobile and vehicles.
31. Describe the ground-based beacons used in mobile robots and vehicles.

Required Texts:
Siegwart, R., Nourbakhsh, I. R., Scaramuzza, D. (2011). Introduction to Autonomous Mobile Robots, 2/ed., MIT Press, ISBN: 978-0262015356

Lesson Delivery

Topics Covered

1. Lesson 10 Quiz and Lab Activity review.
2. Sensors for mobile robots (continued)
    a. Ground-based beacons
    b. Active ranging
    c. Motion/speed sensors
    d. Vision-based sensors

Lecture/Discussion

- Review ground-based beacons
- Review the calculation of position and heading based on the GPS
- Discuss time-of- flight active ranging
- Introduce the two sensors motion and vision
- Define any new terms.
- Answer student questions on lecture topics.

Handouts/References

- Homework for Lesson 10.
- Lesson 10 Quiz.
- Read Chapters 4 (Siegwart, et al., p. 101 – 151)

Lab Activities

Test different sensors' applications.

Homework

- Students read textbook chapter(s) on Lesson 11.
- Homework #3 assigned

Assessment

Learning Outcome 31

- **Outcome:** Describe the ground-based beacons used in mobile robots and vehicles.
- **Assessment:** Quiz .
- **Evaluation:** Score quiz using prepared answer key.

Learning Outcome 1

- **Outcome:** Explain the two time flight range
- **Assessment:** Quiz .
- **Evaluation:** Score quiz using prepared answer key.

Learning Outcome 2

- **Outcome:** Discuss motion/speed sensors
- **Assessment:** Quiz .
- **Evaluation:** Score quiz using prepared answer key.

Learning Outcome 3

- **Outcome:** Understand the importance of range visual based sensors
- **Assessment:** Quiz .
- **Evaluation:** Score quiz using prepared answer key.

Lesson Plan for week #11

Lesson 11: Representing uncertainty

Delivery Time: 240 minutes of lecture

Course Objective

Following successful completion of this course, the student will be able to:

32. Describe the performance characteristics of a sensor.

Lesson Learning Outcomes

Following this lesson, the student will be able to:

33. Characterize the error of a sensor for any measurement in real world applications in mobile and vehicles.
34. Discus error propagation.

Required Texts:

Siegwart, R., Nourbakhsh, I. R., Scaramuzza, D. (2011). Introduction to Autonomous Mobile Robots, 2/ed., MIT Press, ISBN: 978-0262015356

Borensten, J., Everett, H. R. & Feng, L. (1996). The University of Michigan "Where am I?" Sensors and methods for mobile positioning.

Lesson Delivery

Topics Covered

1. Lesson 11 Quiz and Lab Activity review.
2. Representing Uncertainty
    a. Statistical representation
    b. Error propagation
        i. Combining uncertain measurements

Lecture/Discussion

- Introduce representing uncertainty
- Discuss statistical representation
- Discuss the different formulas
- Discuss Error Propagation
- Define any new terms.
- Answer student questions on lecture topics.

Handouts/References

- Lesson 11 Quiz.
- Read chapter 4 (Siegwart, et al., p. 145 – 151).
- Borensten, J., Everett, H. R. & Feng, L. (1996). Navigation Mobile robots: Sensors and techniques for mobile positioning.

Lab Activities

Sensor applications to real world situations.

Homework

- Students read textbook chapter(s) on Lesson 12.

Assessment

Learning Question 1

- **Outcome:** Describe representing uncertainty
- **Assessment:** Quiz.
- **Evaluation:** Score quiz using prepared answer key.

Learning Question 2

- **Outcome:** Explain statistical representation.
- **Assessment:** Quiz .
- **Evaluation:** Score quiz using prepared answer key.

Learning Question 3

- **Outcome:** Understand the different formulas and what they are used for
- **Assessment:** Quiz.
- **Evaluation:** Score quiz using prepared answer key.

Learning Outcome 34

- **Outcome:** Discuss error propagation
- **Assessment:** Quiz .
- **Evaluation:** Score quiz using prepared answer key.

Lesson Plan for week #12

Lesson 12: Feature extraction

Delivery Time: 240 minutes of lecture

Course Objective

Following successful completion of this course, the student will be able to:

35. Choose appropriate features for robot to use at the design stage.

Lesson Learning Outcomes

Following this lesson, the student will be able to:

36. List four factors that are essential when designing a mobile robots
37. Explain two key requirements that must be met for a vision-based feature extraction.

Required Texts:

Siegwart, R., Nourbakhsh, I. R., Scaramuzza, D. (2011). Introduction to Autonomous Mobile Robots, 2/ed., MIT Press, ISBN: 978-0262015356

Lesson Delivery

Topics Covered

Lesson 12 Quiz and Lab Activity review.

Feature extraction

- Feature extraction based on range data
- Visual appearance based on feature extraction

Lecture/Discussion

- Introduce feature extraction
- Discuss feature definition
- Discuss the environment representation and modeling
- Review visual appearance
- Give Test#2 on the materials in Lessons 9 – 11 at the end of Lesson 12.
- Define any new terms.
- Answer student questions on lecture topics.

Handouts/References

- Homework for Lesson 12.

- Lesson 12 Quiz/ ***Test #2***
- Read: Chapters 4 (Siegwart, et al., p. 151 – 181).

Lab Activities

Coding and programming of robots.

Homework

- Students read textbook chapter(s) on Lesson 13.

Assessment

Learning Outcome 36

- **Outcome:** List four factors that are essential when designing a mobile robots.
- **Assessment:** Quiz.
- **Evaluation:** Score quiz using prepared answer key.

Learning Outcome 37

- **Outcome:** Explain two key requirements that must be met for a vision-based feature extraction.
- **Assessment:** Quiz.
- **Evaluation:** Score quiz using prepared answer key.

Learning Question 1

- **Outcome:** Discuss visual appearance based on feature extraction
- **Assessment:** Quiz.
- **Evaluation:** Score quiz using prepared answer key.

Lesson Plan for week #13

Lesson 13: Introduction to Android operation

Delivery Time: 240 minutes of lecture

Course Objective

Following successful completion of this course, the student will be able to:

38. Apply Android Software Operation and sensors technology to create a software tool kit.

Lesson Learning Outcomes

Following this lesson, the student will be able to:

39. Apply Android Software Operation and sensors technology to create a software tool kit that can allow for the immediate use of these sensors without the need for an in-depth knowledge of the physics behind the sensors.
40. Explain "Android Application Publishing" as a process.

Required Texts:

Android Software Operation Tutorial.

Siegwart, R., Nourbakhsh, I. R., Scaramuzza, D. (2011). Introduction to Autonomous Mobile Robots, 2/ed., MIT Press, ISBN: 978-0262015356

McComb, G. (2013). Arduino Robot Bonanza Paperback. McGraw Hill Education, NY: New York. ISBN-13: 978-0071782777; ISBN-10: 007178277X Edition: 1st

Lesson Delivery

Topics Covered

Lesson 13 Quiz and Lab Activity review.
Introduction to Android Software Operation

a. Overview of Android Software Operation
b. Android Line Following Algorithm
c. Android GPS Navigation Algorithm
d. Android GPS Navigation Algorithm Test.

Lecture/Discussion

- Introduce Android Software Operation

- Explain Android Line Following Algorithm
- Discuss GPS navigation algorithm
- Demonstrate GPS navigation algorithm test
- Define any new terms.
- Answer student questions on lecture topics.

Handouts/References

- Homework for Lesson 13.
- Lesson 13 Quiz.
- Read Handout: Android Software Operation Tutorial

Lab Activities

Programming of robots.

Homework

- Students read textbook chapter(s) on Lesson 14.
- Homework #3 is due.

Assessment

Learning Question 1

- **Outcome:** Describe Android Software Operation.
- **Assessment:** Quiz.
- **Evaluation:** Score quiz using prepared answer key.

Learning Question 2

- **Outcome:** Explain Android Line Following Algorithm.
- **Assessment:** Quiz.
- **Evaluation:** Score quiz using prepared answer key.

Learning Question 3

- **Outcome:** Explain GPS navigation algorithm and Test
- **Assessment:** Quiz.
- **Evaluation:** Score quiz using prepared answer key.

Lesson Plan for week #14

Lesson 14: Project Presentation/ Open laboratory period

Delivery Time: 240 minutes of lecture

Course Learning Outcomes:
Following successful completion of this course, students will be able to:

41. Demonstrate the basic understanding of the materials covered by the learning outcomes in Lessons 1–15.

Lesson Learning Outcomes

Following this lesson, the student will be able to:

38. Apply Android Software Operation and sensors technology to create a software tool kit.
41. Demonstrate basic understanding of the materials covered in the course by the learning outcomes in Lessons 1–15.

Instructional Resources

Recommended Textbook(s):

Siegwart, R., Nourbakhsh, I. R., Scaramuzza, D. (2011). Introduction to Autonomous Mobile Robots, 2/ed., MIT Press, ISBN: 978-0262015356

Lesson Delivery

Preparation and Setup

- Prepare robot for demonstration
- Prepare the projector for PowerPoint presentation.
- Dry run your slides to ensure functionality.
- Prepare Assessment tools, such as grading rubrics, and related scoring guide.
- Review project reports.
- Designate presenters with assignments/handouts/references.

Lecture/Discussion

- Final project presentation.
- Students should be encouraged to ask questions on the each team's project during presentation.

Handouts/References

- PowerPoint presentation handout.

Lab Activities

Robotic demonstration.

Online Component

- Post presentation PowerPoint and final project report prior to presentation.

Homework

- Study for the comprehensive final exam.

Assessment

Learning Outcome 41

- **Outcome:** Demonstrate understanding of course learning outcomes on a project report and PowerPoint presentation.
- **Assessment:** Final report documentation, PowerPoint presentation, and attendance to other team's presentation sessions.
- **Evaluation:** Answer questions and assess project's report and presentation.
- **Standard:** Students receive 100% for documentation and presentation of report and attending other team's presentation.

Lesson Plan for week #15

Lesson 15: Review for the final Exam

Delivery Time: 240 minutes of lecture

Course Objective
Following successful completion of this course, the student will be able to:

41. Demonstrate the basic understanding of the materials covered in the course by the learning outcomes in Lessons 1–15.

Course Learning Outcomes:
Following successful completion of this course, students will be able to:

41. Demonstrate the basic understanding of the materials covered by the learning outcomes in Lessons 1–15.

Lesson Learning Outcomes

Following this lesson, the student will be able to:

41. Demonstrate the basic understanding of the materials covered in the course.

Instructional Resources

Recommended Textbook(s):

Android Software Operation Tutorial.
Siegwart, R., Nourbakhsh, I. R., Scaramuzza, D. (2011). Introduction to Autonomous Mobile Robots, 2/ed., MIT Press, ISBN: 978-0262015356

Preparation and Setup

1. Prepare to review material from previous lessons.
2. Identify topics that may have confused students.
3. Prepare Assessment tools, such as tests and related scoring guide.
4. Review Lab Activities, Homework, and projects.
5. Prepare Handouts/References.

Lesson Delivery

Topics Covered

1. Review of the Sensors used in connected and automated vehicles course material for final exam.

Lecture/Discussion

- Briefly review the material covered in the previous Lessons.
- Focus on topics that have confused students throughout the course.
- Students should be encouraged to ask questions on the topics covered in the course.

Handouts/References

- Course review handout.

Lab Activities

None.

Online Component

- Post the review handout prior to Lesson 15 prior.

Homework

- Study for the comprehensive final exam.

Assessment

Learning Outcome 41

- **Outcome:** Demonstrate the understanding of course learning outcomes on a comprehensive final exam.
- **Assessment:** Attendance at course review session.
- **Evaluation:** Answer questions and assess discussions about the course material.
- **Standard:** Students receive 100% for attending the review.

Lesson Plan for week #16

Lesson 16: Final Exam

Delivery Time: 240 minutes of lecture

Course Objectives
Following successful completion of this course, the student will be able to:

41. Demonstrate the understanding of the material covered by the learning outcomes in Lessons 1–15.

Course Learning Outcomes:
Following successful completion of this course, students will be able to:

41. Demonstrate the understanding of the material covered by the learning outcomes in Lessons 1–15.

Lesson Learning Outcomes

Following this lesson, the student will be able to:

1. Demonstrate basic understanding of the material covered in the course.

Instructional Resources

Recommended Textbook(s):

Siegwart, R., Nourbakhsh, I. R., Scaramuzza, D. (2011). Introduction to Autonomous Mobile Robots, 2/ed., MIT Press, ISBN: 978-0262015356
http://www.robotee.com/EBooks/Introduction_to_Autonomous_Mobile_Robots.pdf

Preparation and Setup

1. Prepare Final Exam and related scoring guide.
2. Review Lab Activities and Homework.
3. Prepare Handouts/References.

Lesson Delivery

Topics Covered

1. Final exam.

Lecture/Discussion

- Administer final exam.

Lab Activities

None.

Online Component

- Post the first and second-half handouts Online, along with all of the lectures
- Instructor should post grades for final exam on the Blackboard.

Homework

None.

Assessment

Learning Outcome 41

- **Outcome:** Demonstrate basic understanding of the material covered in the course.
- **Assessment:** Final exam.
- **Evaluation:** Score exam using prepared answer key.
- **Standard:** Minimum score of 70%.