**Nazwa przedmiotu:**

Navigation of Autonomous Vehicles

**Koordynator przedmiotu:**

Maciej Trojnacki, Ph.D., D.Sc.

**Status przedmiotu:**

Obowiązkowy

**Poziom kształcenia:**

Studia I stopnia

**Program:**

Electric and Hybrid Vehicles Engineering

**Grupa przedmiotów:**

Specjalnościowe

**Kod przedmiotu:**

354

**Semestr nominalny:**

6 / rok ak. 2022/2023

**Liczba punktów ECTS:**

4

**Liczba godzin pracy studenta związanych z osiągnięciem efektów uczenia się:**

1) Number of contact hours - 50, including:
a) lecture - 30 hours,
b) laboratory - 15 hours,
c) consultations - 3 hours,
d) exam - 2 hours,
2) Student's own work - 50 hours, including:
a) literature studies - 10 hours,
b) preparation for laboratories - 10 hours,
c) preparation of laboratory reports - 20 hours,
d) preparation for the test - 10 hours,
3) TOTAL - 100 hours.

**Liczba punktów ECTS na zajęciach wymagających bezpośredniego udziału nauczycieli akademickich:**

2 ECTS points - 50 hours, including:
a) lecture - 30 hours,
b) laboratory - 15 hours,
c) consultations - 3 hours,
d) examination - 2 hours.

**Język prowadzenia zajęć:**

angielski

**Liczba punktów ECTS, którą student uzyskuje w ramach zajęć o charakterze praktycznym:**

1 ECTS point - 25 hours, including:
a) realization of laboratory exercises - 15 hours,
b) preparation of laboratory reports - 10 hours.

**Formy zajęć i ich wymiar w semestrze:**

|  |  |
| --- | --- |
| Wykład:  | 30h |
| Ćwiczenia:  | 0h |
| Laboratorium:  | 15h |
| Projekt:  | 0h |
| Lekcje komputerowe:  | 0h |

**Wymagania wstępne:**

Basic knowledge in mechatronics, mechanics, programming, control and Matlab/Simulink package.

**Limit liczby studentów:**

zgodnie z zarządzeniem Rektora

**Cel przedmiotu:**

Introduction to issues related to navigation of autonomous vehicles, introduction to methods of localization, motion planning and autonomous realization of desired motion.
Within the lecture part of the course, the student gains knowledge in the field of navigation of autonomous vehicles.
Within the laboratory part of the course, the student gains practical skills in the field of navigation of autonomous vehicle and develops teamwork skills.

**Treści kształcenia:**

The course includes a lecture and a laboratory parts. The laboratory part is realized after discussion particular topics in the lecture part of the course.
The lecture part of the course (30 hours in total) includes:
1. Introduction to navigation of autonomous vehicles, description of kinematics of ground vehicles, generating desired motion trajectory.
2. Introduction to control of autonomous vehicles.
3. Introduction to measurement uncertainty. Introduction to inertial positioning systems.
4. Introduction to determination of orientation using magnetometers. Methodology of localization and determination of motion parameters of vehicle using IMUs and magnetometers.
5. Introduction to Global Navigation Satellite Systems.
6. Models of wheeled mobile robots for control applications.
7. Tracking control of wheeled mobile robots.
8. Modeling and control of cars.
9. Introduction to sensors and methods of environment mapping.
10. Simultaneous Localization and Mapping.
11. Machine vision in autonomous vehicles.
12. Introduction to probabilistic methods in vehicle navigation.
13. Deep learning in self-driving cars.
14. Local motion planning of vehicles.
15. Global motion planning of vehicles.
The laboratory part of the course (total 15 hours) includes:
1. Generating desired motion trajectory of a mobile robot.
2. Processing measurements from Inertial Measurements Units.
3. Processing measurements from lobal Navigation Satellite Systems.
4. Simulation of tracking control algorithm of mobile robot.
5. Simulation of selected automatic maneuvers of self-driving car.
6. Experimental investigations of surroundings sensors.

**Metody oceny:**

The ability of solving problems connected with navigation of autonomous vehicles and work in a group is verified on the basis of reports developed from individual topics within the laboratory part of the course.
The knowledge in field of naviagation of autonomous vehicle gained by students in the lecture part of the course is verified through a theoretical test during the exam.
The lecture grade is equal to the grade from theoretical test.
The laboratory grade is a weighted average of the grades from the reports.
The total grade is the weighted average of the grades from laboratory and lecture parts of the course.

**Egzamin:**

tak

**Literatura:**

Selected bibliography in English
1. Bishop R., Intelligent vehicle technology and trends, Artech House, 2005.
2. Bonnick A., Automotive computer controlled systems, Routledge, 2007.
3. Borenstein J., Everett H.R., Feng L., Where am I? Sensors and methods for mobile robot positioning, University of Michigan, 119(120), 27, 1996.
4. Craig J.J., Introduction to Robotics: Mechanics and Control (3rd Edition), Pearson, 2004.
5. Choset H.M., at al., Principles of robot motion: theory, algorithms and implementation, MIT press, 2005.
6. Corke P., Robotics, vision and control: fundamental algorithms in MATLAB. Vol. 73. Springer, 2011.
7. Fahimi F.. Autonomous robots: modeling, path planning, and control, Vol. 107, Springer Science & Business Media, 2008.
8. Jazar R.N., Vehicle dynamics: theory and application, Springer Science & Business Media, 2013.
9. Pacejka H., Tire and vehicle dynamics, Elsevier, 2005.
10. Quigley M., Gerkey B., Smart, W.D., Programming Robots with ROS: A Practical Introduction to the Robot Operating System, O'Reilly Media Inc., 2015.
11. Rajamani R., Vehicle dynamics and control, Springer Science & Business Media, 2012.
12. Siegwart R., Nourbakhsh I.R., Scaramuzza D., Introduction to autonomous mobile robots, MIT press, 2011.
13. Spong M.W., Vidyasagar M., Robot Dynamics And Control, Wiley, 2008.
14. Thrun S., Burgard W., Fox D., Probabilistic robotics, MIT press, 2005.
15. Wong J.Y., Theory of ground vehicles, John Wiley & Sons, 2001.

Selected bibliography in Polish
1. Giergiel M., Hendzel Z., Żylski, W., Modelowanie i sterowanie mobilnych robotów kołowych, Wydawnictwo Naukowe PWN, 2013.
2. Kozłowski K., Dutkiewicz P., Wróblewski W., Modelowanie i sterowanie robotów, Wyd. Naukowe PWN, Warszawa 2003.
3. Morecki A., Knapczyk J., Podstawy robotyki. Teoria i elementy manipulatorów i robotów, WNT, Warszawa 1999.
4. Tchoń K., et al., Manipulatory i roboty mobilne, AOWPLJ, Warszawa 2000.
5. Trojnacki M., Modelowanie dynamiki mobilnych robotów kołowych, Przemysłowy Instytut Automatyki i Pomiarów PIAP, 2013.
6. Żylski W., Kinematyka i dynamika mobilnych robotów kołowych, Oficyna Wydawnicza PRz, Rzeszów 1996.

**Witryna www przedmiotu:**

http://www.mechatronika.simr.pw.edu.pl/ Materiały dostępne w intranecie po zalogowaniu

**Uwagi:**

Brak

## Efekty przedmiotowe

### Profil ogólnoakademicki - wiedza

**Efekt 1150-00000-PE-0354\_W1:**

has knowledge in the area of mathematics and physics, and can use it to solve problems of modeling and motion planning of autonomous vehicles

Weryfikacja:

Exam, reports from laboratories

**Powiązane efekty kierunkowe:** K\_W01

**Powiązane efekty obszarowe:** T1A\_W01, T1A\_W07

**Efekt 1150-00000-PE-0354\_W2:**

has ordered knowledge in motion planning and control of autonomous vehicle, is aware of the limitations of that methods, can use the engineering tools

Weryfikacja:

Exam, reports from laboratories

**Powiązane efekty kierunkowe:** K\_W13

**Powiązane efekty obszarowe:** T1A\_W03

**Efekt 1150-00000-PE-0354\_W3:**

has ordered knowledge in the field of location and mapping of surroundings autonomous vehicle using various sensors, taking into account uncertainty of measurement

Weryfikacja:

Exam, reports from laboratories

**Powiązane efekty kierunkowe:** K\_W15

**Powiązane efekty obszarowe:** T1A\_W03, T1A\_W04, T1A\_W07

**Efekt 1150-00000-PE-0354\_W4:**

is aware of the current state of the art in motion planning and control of autonomous vehicles, sensors and engineering tools

Weryfikacja:

Exam, reports from laboratories

**Powiązane efekty kierunkowe:** K\_W19

**Powiązane efekty obszarowe:** T1A\_W05

### Profil ogólnoakademicki - umiejętności

**Efekt 1150-00000-PE-0354\_U1:**

can perform simulatios connected with generating of desired motion as well as motion planning and control of autonomous vehicle;
is able to determine the time histories of motion parameters of the vehicles based on recorded data from localization sensorsl
can create map of surroundings based on data from surroundings sensors

Weryfikacja:

Exam, reports from laboratories

**Powiązane efekty kierunkowe:** K\_U12

**Powiązane efekty obszarowe:** T1A\_U07, T1A\_U08

**Efekt 1150-00000-PE-0354\_U2:**

can select the basic sensors to enable its localization of autonomous vehicle and recognize the surroundings

Weryfikacja:

Exam, reports from laboratories

**Powiązane efekty kierunkowe:** K\_U17

**Powiązane efekty obszarowe:** T1A\_U01, T1A\_U16