Module Specification

Probabilistic Robotics

Version: 2021-22, v3.0, 26 Apr 2022

Contents

Part 1: Information

Module title: Probabilistic Robotics

Module code: UFMFNF-15-3

Level: Level 6

For implementation from: 2021-22

UWE credit rating: 15

ECTS credit rating: 7.5

Faculty: Faculty of Environment & Technology

Department: FET Dept of Engineering Design & Mathematics

Partner institutions: None

Delivery locations: Frenchay Campus

Field: Engineering, Design and Mathematics

Module type: Standard

Pre-requisites: None

Excluded combinations: None

Co-requisites: None

Continuing professional development: No

Professional, statutory or regulatory body requirements: None

Part 2: Description

Overview: All engineered systems are designed and built within specified tolerances beyond which the costs for physical improvement become prohibitively high. By applying a probabilistic framework tothe use of such systems we can improve their overall performance using computational resources rather than through physical engineering.

This module provides an applied introduction to the mathematics of probability and how it has been used to solve a number of real-world problems in robotics engineering.

Features: Not applicable

Educational aims: The module will also link the students to the broaderapplications of probability and inference, specifically how it has been incorporated into machine learning and computational neuroscience.

Outline syllabus: The syllabus includes:

Core teaching:

Probability basics; Random variables and distributions, Conditional probability, Recursive state estimation, Bayes theorem.
Probability applied; Bayesian filters, Hidden Markov Models, Kalman filter(linear, extended, unscented), Histogram and particle filters.
Probabilistic mobile robot localisation and mapping; Markov and Gaussian approaches, Grid and Monte Carlo approaches, Occupancy grid, Simultaneous Localisation and Mapping (SLAM).
Extended applications of probabilistic frameworks; Probabilistic neural models, Inference in machine learning, probabilistic decision making.

Practical teaching:
Robot simulation; Use of contemporary open source robotics simulation engines, Introduction to middleware and robot operating systems.
Probabilistic localisation; Implementation of Bayesian filter algorithms using C and object oriented languages.
Probabilistic mapping; Implementation of occupancy grid mapping in C, interface to simulated sensors and environment.
SLAM; simultaneous localisation and mapping of a simulated mobile robot using a particle filter, re-sampling strategies, noise modelling, loop-closure.

Part 3: Teaching and learning methods

Teaching and learning methods: Scheduled learning:

This module will use lectures and computer based laboratory tutorial sessions during which the theories and concepts taught in the lectures will be applied in solving a simulated robotic localisation and mapping problem. The work undertaken in the laboratory sessions will provide the practical skills necessary to undertake a small project which will be the subject of the written report assessed in component B.

Independent learning:

The students have an essential and suggested reading list that include a number of self-directed exercises. They will also be asked to prepare their assignment which will include additional computer based practical work (outside of tutorial time) and a wider literature survey to contextualise their work. Most lectures will also direct the students toward sources of additional interest (online video seminars, special interest web-sites and journals) which will be discussed in subsequent lectures.

Contact Hours:

Activity:
Contact: 36 hours (12x 1hour lectures, 12x 2hour tutorials)
Self-directed learning: 42 hours
Course work: 42 hours
Exam preparation: 30 hours
Total: 150 hours

Module Learning outcomes: On successful completion of this module students will achieve the following learning outcomes.

MO1 Demonstrate an understanding of the core concepts of probabilistic theory and how it has been applied to solve robotic engineering problems

MO2 Describe the broader use of inference algorithms outside of robotic engineering and demonstrate an awareness of the commercial and socio-economic benefits in adopting this approach to problem solving

MO3 Be able to apply a probabilistic framework toengineering problems toward finding optimal solutions to those problems

MO4 Compare and contrast the advantages and limitations of a variety of contemporary implementations of Bayesian filterswhen applied to different robotics problems

MO5 Implement a probabilistic solution to solve the localisation and mapping problem of a simulated mobile robot

MO6 Demonstrate aptitude in self-directed research through finding, analysing and assimilating current technical literature and other information sources

Hours to be allocated: 150

Contact hours:

Independent study/self-guided study = 114 hours

Face-to-face learning = 36 hours

Total = 150

Reading list: The reading list for this module can be accessed at readinglists.uwe.ac.uk via the following link https://uwe.rl.talis.com/modules/ufmfnf-15-3.html

Part 4: Assessment

Assessment strategy: The module employs 2 components of summative assessment:

Component A:
An examination at the end of the semester covering core concepts learnt in lectures and through self-directed reading.

Component B:
Submission of a 2500 word written report of applied knowledge developed during laboratory tutorials and directed self-study. The written report has been chosen as a

means for assessing the students' ability to apply the theories learnt from the lecture series and self-directed reading. The application of knowledge will be in the form of a computer simulation of robot localisation and mapping, whilst the assessment criteria for the report will be:

Level of technical competence
Ability to decompose a real problem and to relate to theory
Ability to critically analyse different solutions to problems
Clarity of presentation, including referencing
Level and adequacy of research

Assessment components:

Examination (Online) - Component A (First Sit)
Description: Online Examination (4 hours)
Weighting: 50 %
Final assessment: Yes
Group work: No
Learning outcomes tested: MO1, MO2, MO3, MO4

Report - Component A (First Sit)
Description: Written report
Weighting: 50 %
Final assessment: No
Group work: No
Learning outcomes tested: MO3, MO4, MO5, MO6

Examination (Online) - Component A (Resit)
Description: Online Examination (4 hours)
Weighting: 50 %
Final assessment: Yes
Group work: No
Learning outcomes tested:

Report - Component A (Resit)

Description: Written report

Weighting: 50 %

Final assessment: No

Group work: No

Learning outcomes tested:

Part 5: Contributes towards

This module contributes towards the following programmes of study:

Robotics [Sep][FT][Frenchay][3yrs] BEng (Hons) 2019-20

Automation and Robotics Engineering {Foundation} [Feb][FT][GCET][4yrs] BEng (Hons) 2018-19

Robotics {Foundation} [Sep][FT][Frenchay][4yrs] BEng (Hons) 2018-19

Robotics [Sep][SW][Frenchay][4yrs] BEng (Hons) 2018-19

Automation and Robotics Engineering {Foundation} [Oct][FT][GCET][4yrs] BEng (Hons) 2018-19