MAQUETTE FISE 3A

				%	H	C	TD	TP	Projet
SEMESTRE 9	Sciences économiques, humaines et sociales, langues 5 (6 ECTS)	Langues - LV1 + LV2 au choix		50%	36		36		
		Innovation et législation		50%	30	10	20		
	Sciences de spécialité 7 (9 ECTS)	Systèmes robotiques		40%					
			Perception 3D	25%	27	10	8	9	
			Coopération multi-robots + architecture	15%	16	6	4	6	
		Filtrage particulaire et SLAM		20%	20	6	6	8	
		Intégration de systèmes robotiques		40%					
			Projet intégration sous ROS	25%	25	3	2	20	
			Motion planning et robotique humanoïde	15%	18	6	4	8	
	Sciences de spécialité 8 (6 ECTS)	Mineure Interaction (choix)		60%					
			Agents conversationnels	25%	16	3	5	8	
			Intégration IA et Interaction	35%	20	6	8	6	
		Mineure Robotique (choix)		60%					
			Systèmes robotiques complexes	20%	12	4	4	4	
			Optimisation de trajectoires et commande ref vision	40%	24	8	8	8	
		Multithreading/Safety		40%	30	10	8	12	
	Sciences de spécialité 9 (9 ECTS)	Gestion de projet, Coaching PGE, Agilité, Logistique		40%	42	10	8	24	40
		Systèmes interactifs		60%					
			Vision et IA	20%	36	10	10	16	
			IA appliquée à l'interaction	10%	14	2	2	10	
			IHM multimodale	10%	18	4	2	12	
			IA et Dialogue oral	10%	18	4	4	10	
			Interactions distribuées	10%	14	4	2	8	
		Total des heures S9			**380**	94	129	157	**40**

			%	H	C	TD	TP	Projet
SEMESTRE 10	Sciences économiques, humaines et sociales, langues 6 (3 ECTS)	RE&D2	100%	20	20			
	Sciences de spécialité 10 (6 ECTS)	Professionnalisation et Qualification	100%					60
	STAGE (21 ECTS)	Stage	100%					
		Total des heures S10		**20**	20	0	0	**60**
		3A : total des heures étudiant		**400**				**100**

UE	*SCIENCES DE SPECIALITE 7*	*9* ECTS	1er semestre
Matière	*Perception 3D* **3D Perception**	Organisation	Présentiel : 10 h C, 8 h TD, 9 h TP

Learning outcomes and skills - Objectifs d'apprentissages et compétences

Master the 3D perception techniques of camera self-calibration, 3D structure from motion, 3D localization and recognition from exteroceptive sensors.

Pedagogical methodology and specific aspects of teaching - Méthodologie pédagogique et particularités de l'enseignement

Classical pedagogy: courses, TD and TP.

Summary description of the lessons - Description synthétique des enseignements

3D perception functions given exteroceptive sensors of robotics:

- Camera self-calibration
- Structure from motion
- Incremental modelling of 3D scene
- 3D localization and recognition
- Applications by examples

Prerequisites - Pré-requis

UE Image processing (S8), UE 3D Perception (S8).

Bibliographical references - Références bibliographiques

[1] M. Dhome. Perception visuelle par imagerie vidéo. Hermès et Lavoisier, 2003.

[2] F. Goulette. Modélisation 3D automatique, outils de géométrie différentielle. Presses des Mines, 1999.

[3] O. Faugeras. Three Dimensional Computer Vision. A Geometric Viewpoint. MIT Press, 1993.

Keywords - Mots clés

Camera self-calibration, structure from motion, 3D modelling, 3D recognition.

UE	*SCIENCES DE SPECIALITE 7*	*9* ECTS	1er semestre
Matière	*Supervision et Coopération multi-robots* **Multi-robot supervision and cooperation**	Organisation	Présentiel : 6 h C, 4 h TD, 6 h TP

Learning outcomes and skills - Objectifs d'apprentissages et compétences

Apply advanced software techniques for autonomous systems. Master robotic integration.

Pedagogical methodology and specific aspects of teaching - Méthodologie pédagogique et particularités de l'enseignement

Classical pedagogy: courses, TD, TP

Summary description of the lessons - Description synthétique des enseignements

Robot software integration and architecture

- MiddleWare (ROS, ROS2, PocoLibs)
- Emphasis on ROS/ROS2 MW and Tools (BE)
- GenoM (BE)

Validation and Verification of robotic systems

- V&V of functional components/layer (BE)
- Deployment of verification on the two running examples (BE

Multi-robot Cooperation : Architectures and Paradigms

Prerequisites - Pré-requis

Software, Objet programming

Bibliographical references - Références bibliographiques

[1] M. Ghallab, D. Nau, and P. Traverso. Automated planning and acting. Cambridge University Press, 2016

[2] F. Ingrand Verification of Autonomous Robots: A Roboticist's Bottom-Up Approach. Software engineering for robotics, Springer, pp.219-248, 2021,

UE	*SCIENCES DE SPECIALITE 7*	*9* ECTS	1er semestre
Matière	*Filtrage particulaire et SLAM* **Particle filtering and SLAM**	Organisation	Présentiel : 6 h C, 6 h TD, 8 h TP

Learning outcomes and skills - Objectifs d'apprentissages et compétences

- Master prominent particle filtering techniques
- Know the main properties and solutions to the Simultaneous Localization and Mapping (SLAM) problem in Robotics

Pedagogical methodology and specific aspects of teaching - Méthodologie pédagogique et particularités de l'enseignement

Classical pedagogy: lectures, seminars, labs – Polls using clickers – Flipped classroom

Summary description of the lessons - Description synthétique des enseignements

- Recursive exact equations of Bayesian filtering
- Approximate solution based on particle filters: sequential importance sampling, sequential importance resampling, Rao-Blackwellized filter
- Mathematical statement and properties of Simultaneous Localization and Mapping (SLAM)
- SLAM solutions based on Extended Kalman filtering and Rao-Blackwellized particle filtering
- Factor graph approach to SLAM and its solution based on sparse quadratic nonlinear optimization

Prerequisites - Pré-requis

Good knowledge on stochastic estimation and Kalman filtering

Bibliographical references - Références bibliographiques

[1] DOUCET A., DE FREITAS N., GORDON N., "Sequential Monte Carlo Methods in Practice", Springer, 2001.

[2] THRUN S., BURGARD W., FOX D., "Probabilistic Robotics", MIT Press, 2005.

Keywords - Mots clés

Sequential Monte Carlo methods – Probabilistic SLAM – Graph SLAM

UE	*SCIENCES DE SPECIALITE 7*	*9* ECTS	1er semestre
Matière	*Projet intégratif sous ROS* **ROS Integrative project**	Organisation	Présentiel : 3 h C, 2 h TD, 20 h TP

Learning outcomes and skills - Objectifs d'apprentissages et compétences

Apply ROS basics concepts to a real use case (robot, sensor, decision)

Pedagogical methodology and specific aspects of teaching - Méthodologie pédagogique et particularités de l'enseignement

Practical sessions / use case study

Summary description of the lessons - Description synthétique des enseignements

Presentation of the objectives
Basic functionalities (motion planning, sensor acquisition)
Identification of the expected contribution
Node development and integration
Test in simulation (Yaskawa & motorman)
Test in real conditions

Prerequisites - Pré-requis

Introduction au middleware robotique ROS

Bibliographical references - Références bibliographiques

[1] https://www.motoman.com/en-us/about/y-blog/ros-enabled-ready-to-go
[2] http://wiki.ros.org/motoman

Keywords - Mots clés

ROS/ROS-industrial, robotic integration

UE	*SCIENCES DE SPECIALITE 7*	*9* ECTS	1er semestre
Matière	*Motion planning et robotique humanoïde* **Motion planning and humanoid robotics**	Organisation	Présentiel : 6 h C, 4 h TD, 8 h TP

Learning outcomes and skills - Objectifs d'apprentissages et compétences

Master the motion planning problem
Understand humanoid robotic

Summary description of the lessons - Description synthétique des enseignements

Motion planning

- Limitation of deterministic methods
- Probabilistic methods and algorithms
- Industrial applications within and outside robotics

Humanoid robotics

- Modeling
- Control
- Planning

Practical lesson : planning legged robotics

Prerequisites - Pré-requis

Modélisation robotique 1 et 2

Bibliographical references - Références bibliographiques

[1] S. Lavalle. Planning Algorithms. Cambridge Univ. Press, 2006.

[2] S. Kajita, S. Sakka, H. Hirukawa, K. Harada, K. Yokoi. Introduction à la commande des robots humanoïdes : De la modélisation à la génération du mouvement. Springer 2005.

UE	*SCIENCES DE SPECIALITE 8*	*6* ECTS	1er semestre
Matière	*Agents conversationnels* **Conversational Agents**	Organisation	Présentiel : 3 h C, 5 h TD, 8 h TP

Learning outcomes and skills - Objectifs d'apprentissages et compétences

- Master new technologies (methods, concepts, tools) for developing conversational agents (chatbot/voicebot)
- Understand and apply advanced speech understanding principles based on word embeddings to interpret user's utterances
- Understand and apply advanced dialog management methods based on machine learning and deep learning to predict the next action of the system
- Train and test the chatbot components to evaluate their performances
- Design interactive applications for people with special needs considering human factors or accessibility

Pedagogical methodology and specific aspects of teaching - Méthodologie pédagogique et particularités de l'enseignement

Case studies

Summary description of the lessons - Description synthétique des enseignements

- Chatbot/Voicebot Architecture
- Speaker's intent detection
- History and Dialog state tracking
- Current approaches for conversational dialogue management.
- Metrics and Evaluation methods of interactive systems

Prerequisites - Pré-requis

Python programming (S5, S7) – AI: Machine learning and deep learning (S8) - Introduction to Speech and Language Processing (S8) – AI: Decision Method under Uncertainty (S9) AI: Spoken Dialog system (S9)

Bibliographical references - Références bibliographiques

[1] D. Jurafsky, J.H. Martin. Speech and Language Processing: an Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition. Edition Pearson International (3ème édition – draft 2021) https://web.stanford.edu/~jurafsky/slp3/

[2] Kat Holmes, Mitmatch – How inclusion Shapes Design, MIT Press, ISBN 978-0-262-03888-1

Keywords - Mots clés

Chatbot/Voicebot, conversational applications, vocal interaction.

UE	*SCIENCES ET TECHNIQUES 8*	*6* ECTS	1er semestre
Matière	*Intégration IA et Interaction* **AI and interaction: integration project**	Organisation	Présentiel : 6 h C, 8 h TD, 6 h TP

Learning outcomes and skills - Objectifs d'apprentissages et compétences

- Collaborative work in a project group, choice of the application framework (target audiences, communication modalities, accessibility constraints, communication with existing web services or databases through corresponding API).
- Specification, design and development of the conversational agent (voicebot).
- Adaptation of the different models based on artificial Intelligence method (machine learning, deep learning) to the conversational context (intentions, named entities, actions).
- Integration and performance evaluation of the different components.

Pedagogical methodology and specific aspects of teaching - Méthodologie pédagogique et particularités de l'enseignement

Pedagogy based on project

Summary description of the lessons - Description synthétique des enseignements

- Large-scale implementation
- Mobilization of transversal (project management, collaborative work) and specialized skills (multimodal interaction, oral dialogue, conversational agents, distributed computing, …)
- Confrontation with integration issues…

Prerequisites - Pré-requis

Spoken dialogue Systems (S9), Multimodal Interaction (S9), Distributed computing (S9), Artificial Intelligence (S8 & S9), Conversational agents (S9), Project Management (S7,S9).

UE	*SCIENCES DE SPECIALITE 8*	*6* ECTS	1er semestre
Matière	*Systèmes robotiques complexes* **Complex robotic systems**	Organisation	Présentiel : 4 h C, 4 h TD, 4 h TP

Learning outcomes and skills - Objectifs d'apprentissages et compétences

Understand and solve the redundancy robot's problem

Understand the principle of modern algorithms toolbox

Know closed-chain problem

Identification robots' problem

Pedagogical methodology and specific aspects of teaching - Méthodologie pédagogique et particularités de l'enseignement

Classical pedagogy: courses, TD and TP.

Summary description of the lessons - Description synthétique des enseignements

Redundancy robots (jacobian null space, stack of tasks...)

Algorithms for dynamic robot modelling (RNEA…)

Closed-chain robots

Identification concepts

Prerequisites - Pré-requis

Modélisation robotique 1 et 2

Bibliographical references - Références bibliographiques

[1] R. Featherstone, Rigid Body Dynamics Algorithms. Springer, 2008.

[2] Y. Nakamura. Advanced robotics : redundancy and optimization. Addison-Wesley, 1991.

[3] K. Lynch, F. Parck. Modern robotics : mechanics, planning and control. Cambridge University Press, 2017.

Keywords - Mots clés

Redundancy, dynamic robot, complex robot

UE	*SCIENCES DE SPECIALITE 8*	*6* ECTS	1^{er} semestre
Matière	*Optimisation de trajectoires et commande référencée vision* **Trajectory optimization and vision-based control**	Organisation	Présentiel : 8 h C, 8 h TD, 8 h TP

Learning outcomes and skills - Objectifs d'apprentissages et compétences

- Understand the principles of vision-based control
- Synthesize a vision-based control

Summary description of the lessons - Description synthétique des enseignements

Visual servoing

- Position-based and image-based visual servoing
- Basic tools & notions for visual servoing
- Design of a vision-based controller using the inverse Jacobian matrix
- Redundancy in vision-based control
- Labs: design of a vision-based positioning task

Optimization and Control

- Trajectory optimization by numerical methods of open-loop optimal control
- Introduction to Model Predictive Control

Prerequisites - Pré-requis

Modélisation robotique 1 et 2, Modélisation des systèmes complexes

Bibliographical references - Références bibliographiques

[1] F. Chaumette, S. Hutchinson, «Visual servo control. I. Basic approaches », IEEE Robotics & Automation Magazine 13(4): 82–90, January 2007.

[2] Rossiter, J.A., « Model-based Predictive Control – A Practical Approach », CRC Press LLC, 2004.

Keywords - Mots clés

Vision-based control, position-based visual servoing, image-based visual servoing.

UE	*SCIENCES DE SPECIALITE 8*	*6* ECTS	1er semestre
Matière	**Multithreading/Safety**	Organisation	Présentiel : 10 h C, 8 h TD, 12 h TP

Learning outcomes and skills - Objectifs d'apprentissages et compétences

Develop safe multithreaded application based on POSIX standard
Understand the means of dependability dedicated to critical systems based on generic concepts of fault tolerance mechanisms
Implement fault tolerance mechanisms based on parallel programming concepts such as multithreading

Pedagogical methodology and specific aspects of teaching - Méthodologie pédagogique et particularités de l'enseignement

Classical pedagogy: courses and labs
Pedagogy by projects to improve the student's skills in the context of robotic integration project.

Summary description of the lessons - Description synthétique des enseignements

- Operational safety: failure, error, faults.
- Means for Operational Safety: forecasting, prevention, elimination.
- Fault tolerance: error detection, error recovery.
- POSIX threads: life cycle management, mutexes, conditional variables

Prerequisites - Pré-requis

Dependability, C language + UNIX, parallel programming

Bibliographical references - Références bibliographiques

[1] Algirdas Avizienis, Fellow, IEEE, Jean-Claude Laprie, Brian Randell, and Carl Landweh. Basic Concepts and Taxonomy of Dependable and Secure Computing. IEEE TRANSACTIONS ON DEPENDABLE AND SECURE COMPUTING, VOL. 1, NO. 1, JANUARY-MARCH 2004.
[2] Michael Kerrisk. The Linux Programming Interface: A Linux and UNIX System Programming Handbook. No Starch Press; 1st edition (October 28, 2010).

Keywords - Mots clés

Critical systems, dependability, parallel programming, fault tolerance, integration project.

UE	*SCIENCES DE SPECIALITE 9*	*9* ECTS	1er semestre
Matière	*Vision et IA* **Vision and AI**	Organisation	Présentiel : 10 h C, 10 h TD, 16 h TP

Learning outcomes and skills - Objectifs d'apprentissages et compétences

Know how to extract the different characteristics of an image and apply the most appropriate recognition method

Master the architecture of image analysis systems based on deep neural networks

Pedagogical methodology and specific aspects of teaching - Méthodologie pédagogique et particularités de l'enseignement

Classical pedagogy in courses and TD

Summary description of the lessons - Description synthétique des enseignements

- Image characterization (texture, shape, color, local singularities)
- Image and features regularization before recognition
- Recognition methods
  - based on mathematical transforms
  - based on discriminant analysis
  - based on decision trees
  - based Deep learning

Prerequisites - Pré-requis

Introduction to SRI (S6) Machine learning (S7) Image processing (S8).

Bibliographical references - Références bibliographiques

[1] Convolutional Neural Networks in Visual Computing: A Concise Guide, R. Venkatesan, B. Li, CRC Press, 2017

[2] Computer Vision: Algorithms and Applications, R. Szelinski, Springer, 2022

Keywords - Mots clés

Pattern recognition, image understanding

UE	*SCIENCES DE SPECIALITE 9*	*9* ECTS	1er semestre
Matière	IA appliquée à l'interaction **AI: Decision Method under Uncertainty**	Organisation	Présentiel : 2 h C, 2 h TD, 10 h TP

Learning outcomes and skills - Objectifs d'apprentissages et compétences

Address a reasoning/decision problem under uncertain knowledge:

- Identify the appropriate formal framework,
- Modeling,
- Select the relevant tools, implement and test the solution

Pedagogical methodology and specific aspects of teaching - Méthodologie pédagogique et particularités de l'enseignement

The basics of the studied models will be briefly presented in the course / TD, and developed and put into practice more deeply on case studies, during practical sessions.

Summary description of the lessons - Description synthétique des enseignements

Representation of uncertainty:

- Bayesian and non-Bayesian probabilistic models,
- Belief functions,
- Possibility theory.

Decision under uncertainty:

- Expected utility,
- Choquet integral,
- Non-expected utility and credal models,
- Qualitative pessimistic utility

Sequential decision under uncertainty:

- Decision trees,
- Markov Decision Processes.

Prerequisites - Pré-requis

Probability theory, Constraint programming and/or mixed integer linear programming

Bibliographical references - Références bibliographiques

Denis Bouyssou, Didier Dubois, Henri Prade, Pirlot (Edts) Decision Making Processes ; Wisley. 2009.

Keywords - Mots clés

Probability Theory, Imprecise Probabilities, Decision Theory, Decision under Uncertainty, Expected Utility, Multi Prior Model, Non-Expected Utility, Markov Decision Processes.

UE	*SCIENCES DE SPECIALITE 9*	*9* ECTS	1er semestre
Matière	*IHM multimodale* **Multimodal interaction**	Organisation	Présentiel : 4 h C, 2 h TD, 12 h TP

Learning outcomes and skills - Objectifs d'apprentissages et compétences

- Understand and experiment with the advantages and limitations of voice and gesture interaction modalities
- Know how to design and implement a multimodal fusion engine
- Know how to design and implement a multimodal fission engine

Pedagogical methodology and specific aspects of teaching - Méthodologie pédagogique et particularités de l'enseignement

Study program, practical work

Summary description of the lessons - Description synthétique des enseignements

Multimodal HMI

- Interactive System Engineering
- vocal and gestural interaction.
- Design of multimodal systems

Prerequisites - Pré-requis

Introduction to SRI (S6)

Bibliographical references - Références bibliographiques

R. Bolt, "Put-That-There": Voice and Gesture at the Graphics Interface, SIGGRAPH 1980
Sh. Oviatt, Ten Myths on Multimodal Interaction, Communication of the ACM, volume 42, Issue 11, November 1999

Keywords - Mots clés

Multimodal system

UE	*SCIENCES ET TECHNIQUES 9*	*9* ECTS	1er semestre
Matière	*IA et dialogue oral* **AI and spoken dialogue systems**	Organisation	Présentiel : 4 h C, 4 h TD, 10 h TP

Learning outcomes and skills - Objectifs d'apprentissages et compétences

- Understand the architecture of a task-driven spoken dialogue system to develop simple human robot interaction applications
- Use basic approaches to implement a frame-based speech understanding component
- Use basic approaches to implement a dialog management component
- Chose the appropriate interaction strategy to guide the flow of the dialogue depending on the user profile

Pedagogical methodology and specific aspects of teaching - Méthodologie pédagogique et particularités de l'enseignement

Case study

Summary description of the lessons - Description synthétique des enseignements

- Spoken dialog system architecture and components
- Concepts and Models dedicated to speech understanding and dialogue management
- Concepts related to user profiles and interaction strategy (directive or flexible)

Prerequisites - Pré-requis

Advanced Programming (S7) – Introduction to Speech and Language Processing (S8)

Bibliographical references - Références bibliographiques

[1] D. Jurafsky, J.H. Martin. Speech and Language Processing: an Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition. Edition Pearson International (3ème édition – draft 2021)
https://web.stanford.edu/~jurafsky/slp3/

Keywords - Mots clés

Spoken dialog system, Human-Machine Interaction, task-oriented systems.

UE	*SCIENCES DE SPECIALITE 9*	*9* ECTS	1er semestre
Matière	*Interaction distribuée* **Distributed Interaction**	Organisation	Présentiel : 4 h C, 2 h TD, 8 h TP

Learning outcomes and skills - Objectifs d'apprentissages et compétences

- know different programming approaches using communication networks
- be able to design, organize and implement systems composed of several sensors displayed into networks, make them interact, merge and visualize information

Pedagogical methodology and specific aspects of teaching - Méthodologie pédagogique et particularités de l'enseignement

Pedagogy by project dedicated to the integration of different sensors providing information through different protocols in the context of interactive system projects.

Summary description of the lessons - Description synthétique des enseignements

- sockets programming
- remote object programming
- event-driven bus programming
- API REST programming
- non-IP protocols

Prerequisites - Pré-requis

Be familiar with basic network concepts

Keywords - Mots clés

Networks, high-level protocols