Internship positions for 2024

1. Visual SLAM (Simultaneous Localization and Mapping)

Simultaneous Localization and Mapping (SLAM) is a fundamental technology with several applications in augmented reality and robotics. SLAM is a computational approach that enables a robot or a device to map its surroundings while simultaneously determining its own position within that environment. Visual SLAM, a specialized variant of SLAM, refers to the use of an RGB camera as the primary sensor for SLAM computation. To make a SLAM system truly useful for real-world applications, the following properties are essential. First, we want the SLAM system to be real-time, ensuring that it can process sensor data and update its estimates on the fly. Next, the system should have the ability to make reasonable predictions for regions without observations, allowing it to maintain accuracy in partially observed or occluded environments. Moreover, the system should be able to scale up to large scenes, ensuring it can handle the growing complexity of extensive environments. Finally, it is crucial to be robust to noisy or missing observations, as this guarantees the system reliability under challenging real-world conditions. In this internship, we will focus on addressing and advancing these critical challenges within the field of SLAM, contributing to its ongoing development and real-world application in visual navigation.

Keywords: computer vision, robotics, visual navigation.

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2. Breast Cancer Detection from Multi-view Mammography Images

This internship is dedicated to advancing breast cancer detection through the application of artificial intelligence in the field of medical imaging. The primary focus is on the development and optimization of recent deep learning models for the analysis of medical images. By exploiting the power of AI, the goal is to significantly enhance the accuracy and efficiency of early breast cancer screening. Key tasks for the intern include creating and training deep learning models, investigating image preprocessing techniques, feature extraction, and data augmentation methods. Furthermore, the development of explainable AI approaches will be explored to improve transparency and trust in the diagnostic process. The intern will contribute to evaluating these models using clinical datasets and play a key role in the advancement of AI-assisted breast cancer screening tools.

Keywords: computer vision, image processing, breast cancer, healthcare.

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3. Generative AI for 3D Modeling

There is an increasing demand for automated and efficient methods of generating 3D models. Manual 3D model creation is a time-consuming process that often requires expertise in 3D design and modeling software (e.g., Maya, Blender). By leveraging natural language descriptions, we can bridge the gap between textual information and 3D models, enabling faster and more accessible model generation. This internship aims to explore the potential of text-to-3D techniques to revolutionize the way 3D models are created, opening new possibilities for industries such as virtual reality, gaming, architecture, etc. A possible solution for doing this is by performing text-to-image in a first step, and image to 3D in a second one. The intern will have the opportunity to work on cutting-edge technologies related to computer vision such as generative AI, monocular depth estimation, semantic segmentation, Neural Radiance Fields (NeRF), etc.

Keywords: computer vision, image processing, generative AI, 3D models.

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4. Combining Augmented Reality and Medical Imaging for Surgical Procedures:

This internship focuses on the development and assessment of an augmented reality (AR) system that leverages medical imaging data for use in minimally invasive surgical procedures. Minimally invasive surgery (MIS) relies on real-time visualization and precise instrument control. By integrating AR with medical imaging, this project aims to enhance the accuracy and efficiency of MIS while improving patient outcomes. The internship involves a three-part focus: Firstly, conducting an extensive literature review on augmented reality (AR) applications in surgery, various medical imaging modalities, and minimally invasive surgical techniques. Secondly, an AR system based on Microsoft HoloLens capable of overlaying critical medical imaging data, such as 3D reconstructions, tumor locations, X-ray images, directly onto a surgeon's visual field during surgical procedures. Finally, the intern will explore how the AR system can be integrated with surgical equipment, such as laparoscopic or robotic surgery instruments.

Keywords: Minimally Invasive Surgery, Augmented Reality, Medical Imaging.

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5. Multi-agent Deep Reinforcement Learning for Drone Charging Scheduling

Benefiting from their flexibility, global spatial reach, and lower costs, Unmanned Aerial Vehicles (UAVs) gained significant popularity in recent years. As their use in various missions expands, limited battery life remains the primary constraint for sustaining extended mission durations. In practice, the scheduling of energy replenishment operations emerges as a promising solution to extend the battery life of UAVs. However, this approach increases the problem's complexity, especially in a centralized setting where the scheduler becomes a bottleneck with a higher number of UAVs. The distributed approach results in better scalability, robustness, and ease of deployment compared to the centralized setting. Moreover, this scenario presents a sequential decision-making problem that aligns well with the reinforcement learning framework. In this project, we propose a Multi-Agent reinforcement learning (MARL) approach, where agents act cooperatively or competitively to optimize their cumulative reward signal, to solve the charging scheduling of multiple UAVs in various missions.

Keywords: UAV scheduling, Distributed decision-making, Multi-agent reinforcement learning

Contact: Dr. Btissam El Khamlichi (btissam.elkhamlichi@um6p.ma)

6. Deep-RL for Collaborative Target Acquisition and Coverage Optimization Applied to a Satellite Constellation

The advent of Earth Observation Satellites has had a transformative impact on data collection for weather forecasting, environmental monitoring, and cartography. However, optimizing the efficiency of satellite constellations remains a significant challenge. This highlights the need for advanced methodologies such as Multi-Agent Deep Reinforcement Learning. This unique internship focuses on comprehending the dynamics of EOS and their optimization challenges, with particular attention on the principles of MADRL and its efficacy in improving satellite constellation's operational efficiency. Additionally, it aims to investigate the effect of diverse reward functions and agent behaviors on system performance, which can offer insights into the optimization of agent policies. Given the framework of this proposal, an in-depth understanding of the environment's features, including the presence of static and dynamic factors and team scalability, is expected. Performance and efficiency metrics such as redundancy and task execution are critical in assessing the training progression and convergence of the system within the MADRL context. This in-depth comprehension creates the foundation for developing robust, adaptable, and efficiently converging MADRL systems, furthering efficiency in satellite coordination scenarios.

Keywords: Earth Observation Satellites, satellite constellations, Multi-Agent Deep Reinforcement Learning, collaborative capabilities, incentive mechanisms

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7. Optimization of drone area mapping in GNSS-Denied environment via bio-inspired empowered Reinforcement Learning

A GNSS-denied environment is any environment where the Global Navigation Satellite System (GNSS) is not available or unreliable (e.g. buildings, mountains, and intentional interference). Area mapping with Unmanned Area Vehicles (UAVs) is the process of creating a map of a physical environment through the use of its embedded sensors such as cameras, LiDAR and radars. Area mapping is important in a GNSS denied setting since without it, vehicles and robots cannot determine their location or orientation in the environment. The subsequent generated maps can be then used to navigate without GNSS: by comparing the current environment to the map, a vehicle or robot can determine its location and orientation. Area mapping is a complex task where the bigger the area is, the longer will the mapping take for an UAV. Using UAV swarms is an intuitive idea to accelerate the mapping, however doing so adds a new layers of multi-agent related complexities such as inter-agent collaborations and decentralized task allocation. The objective of this internship is to optimize the area mapping in UAV swarms while taking into account real-world limitations such as UAVs only having a partial observability of the world and having decentralized decision making in the swarm. Bio-inspired algorithms were explored in optimizing multi-agent problems and can prove to be a research direction worth exploring especially when coupled to Reinforcement Learning.

Keywords: GNSS-Denied, Bio-Inspired optimization, Reinforcement Learning, Multi-Agent

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8. Deep-RL for Collaborative Drone-UGV Exploration in GNSS Denied Environment

This internship focuses on enhancing the efficiency of a collaborative team of Unmanned Aerial Vehicles (UAVs) and Unmanned Ground Vehicles (UGVs) navigating an unknown, GNSS-denied area. It leverages and expands upon an existing work built in ROS and Gazebo that uses the A* algorithm to achieve the exploration task. We aim to improve the exploration algorithm by using deep reinforcement learning to the existing framework to enhance collaborative exploration efficiency. Specifically, Deep-RL approaches will be employed, allowing the vehicles to learn optimal behaviors by maximizing expected future rewards based on their interactions with the environment. These learned policies will guide the UAV and UGV in their collaborative exploration. We expect that having a better evaluation of the environment characteristics (e.g., presence of static and/or dynamic obstacles, changing the scale of the collaborating team.) with respect to performance and efficiency metrics (e.g., redundancy and task execution time) can guarantee robustness and the adaptability of the system. The main expectation is to create UAV-UGV cooperation that can efficiently perform exploratory tasks in GNSS-denied environments using Deep RL. The resulting system is expected to effectively adapt to various settings and team scales while minimizing redundancy and task completion time.

Keywords: Drones, Unmanned Ground Vehicles, Multi-Agent Deep Reinforcement Learning

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10. Enhancing Goal-Oriented Behavior and Reconciling Multiple Objectives in Chatbots using Hybrid Architectures

Large Language Models (LLMs) have made significant strides in incorporating vast amounts of knowledge. However, they lack inherent goal orientation, making it challenging to reconcile multiple objectives. Furthermore, their explainability can be challenging due to the inherently opaque decision-making processes of pure machine learning systems. To address this limitation, LLMs can benefit from guidance provided by well-designed and programmed systems, rather than relying solely on pure machine learning algorithms. Agent-oriented systems offer a natural abstraction of the object-oriented paradigm, enabling the development of autonomous interacting agents. An example

of such a system is the Belief-Desire-Intention (BDI) architecture, designed to create rational intelligent agents that exhibit logical behavior through the use of logical programming. This research end-of-study project intends to enhance the field of goal-oriented conversational AI agents by incorporating Belief--Desire--Intention (BDI) architectures that enables improved reasoning, planning capabilities, and better reconciliation of multiple objectives. In a first step, an overview of the most recent and pertinent research on the topic will be undertaken. This will involve a critical analysis of the methodologies employed, the findings obtained, and the gaps that need to be addressed. The second step will involve the design and the implementation of an architecture that combines the advantages of BDI systems and recent LLMs.

Keywords: Goal-oriented Chatbots, BDI systems, LLMs

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11. Enhancing OCR Accuracy for Arabic Documents

Advances in optical character recognition (OCR) systems have reached a remarkable level, opening the door to many innovative applications in various fields such as document scanning. On the other hand, documents written in Arabic contain complex structures, which makes this recognition task difficult to manage. This task includes two main operations, segmentation and classification of lines, words or even characters. The structure of non-segmented or over-segmented Arabic characters makes this task very complex at the segmentation and at the classification level. In this internship, we will focus on end-to-end computer vision models to develop an OCR system for specific Arabic written documents.

Keywords: Computer vision, NLP, OCR , Arabic documents

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12. Moroccan Dialect Understanding using GPT-based Architectures

The emergence of big data has led to the generation of large-scale textual Arabic corpuses from social networks. These data contain valuable information relating to a variety of fields including economics, politics, health, and sport, to name a few. However, for deep learning models to understand the data, they need to be processed and represented in an adequate format. In particular, the Moroccan dialect has a complex morphological syntax and rich linguistic content. It is composed of several different languages, making it challenging to deal with. As the current state of research on this topic is limited, developing a tool to improve Moroccan dialect understanding is our primary objective. To provide a full representation of Moroccan Arabic, the objective of this internship is to study Generative Pre-trained Transformers (GPTs) and finetuning open-source versions of these models to develop an adapted one specific to the Moroccan context.

Keywords: Moroccan Dialect, Language Understanding, NLP, GPT

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13. Emotion Control of a Conversational Robot by Supervised and Reinforcement Learning

Artificial assistants embodied in conversational agents have made great progress in recent years. Recent conversational robots can conduct conversations autonomously, thanks to the development of large language models (LLMs), which can process a large amount of information and generate human-like text. However, text generation is just one aspect of human-robot interaction. Conversational robots must generate autonomously realistic emotions and facial expressions during interactions. The goal of this internship is the creation of a conversational agent able to control its emotions from multimodal conversational signals (audio and video) and from the context of the interaction in order to conduct realistic interactions in real time and to maximize the engagement with the interlocutor. The approach to be addressed will be based on a first stage of supervised learning followed by an

online stage that rests on reinforcement learning to ensure progressive improvement in real-time conversations.

Keywords: Multimodal Deep Learning, Reinforcement Learning, Emotion Control

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14. Decoding Audio and Text from fMRI Recordings

The objective of this internship is to study recent advances in generative deep learning and apply them in the context of Human-Machine Interaction. The specific objective is to decode text and audio from brain recordings. The student will have the opportunity to work with datasets consisting of human-human and human-robot interactions, which include various types of multimodal conversational signals, including fMRI recordings. The first step is to perform a comprehensive review of deep learning methods for decoding text and audio from fMRI signals, and then to adapt and possibly improve them for the dataset under study.

Keywords: Generative AI, Brain Decoding

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15. Real-time Video Analysis for Surveillance and Monitoring

As part of a project which aims to deploy autonomous drones for site surveillance, the objective of this internship is the implementation of video analysis models by computer vision for surveillance purposes, including detection and tracking of dynamic objects in real time and recognition of human activity. The main stages of the internship will be to study the state of the art by exploring new models that cover this research area, to conduct a comparative study on real datasets, then to implement and test the deploy the appropriate models.

Keywords: Computer Vision, Tracking, Human Activity Recognition

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16. Multi-criteria Decision aid in Fuzzy Logic for diagnosis failure machine

Fault detection is a multi-classification problem that can be solved with the Fuzzy Logic model (FL). FL is considered a valuable tool in classification tasks due to its ability to deal with uncertainty and vagueness, as well as its simplicity and interpretability. Achieving high performance rates in terms of accuracy and computation time. However, FL has some limitations that must be addressed regarding the subjective judgments of decision-makers. A wrong input to FL can lead to some misclassifications, consequently, a bad decision can be made. Therefore, this subjectivity must be handled. This internship aims to review the state of the art the existing approaches combining FL and multi-criteria decision aid methods, implement and understand the existing models, and propose a new model on using multi-criteria decision aid methods such as Analytical Hierarchical Process in the FL model to reduce the subjectivity of the experts giving their expertise and knowledge required to ameliorate and enhance the FL model in classifying the data.

Keywords: fuzzy logic, muti-criteria decision aid, fault detection, Analytical Hierarchical Process, multi-classification

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17. Exploiting knowledge graph and learning methods for proactive maintenance

Recently, with the emergence of Industry 4.0, proactive maintenance (PrM) based on data-driven methods has become the most effective solution to address smart manufacturing and industrial big data, especially for performing health perception (e.g. fault diagnosis and remaining useful life (RUL) estimation). PrM relies on the continuous monitoring of the equipment/machine to provide valuable information regarding their status. It's crucial to have a graphical structure to integrate this

information and proactively predict failures based on the extracted features. This internship aims to explore the potential of knowledge graphs in the field of maintenance by developing a knowledge graph schema based on the time-dependent model to incorporate historical sensor data, use node embedding for features extraction, and then use machine learning models to estimate remaining useful life.

Keywords: knowledge graph, time-dependent model, machine learning, node embedding, fault diagnosis, remaining useful life estimation

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18. Stochastic modeling of the routing problem with drones

Routing by drones has gained considerable attention due to their numerous sustainable real-world applications. The vehicle routing problem with drones is an extension of the classical vehicle routing problem. However, the aspect of stochasticity is usually neglected in the literature. It is assumed that all data are known in advance which is not the case in most real-world cases. The objective of this internships is to propose a mathematical model with uncertain customer demand and time windows based on fuzzy theory to minimize the makespan of serving all customers.

Keywords: vehicle routing problem with time windows, drones, stochastic optimization, fuzzy theory

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19. Integration of Machine Learning into the Branch-and-Bound Algorithm for the Vehicle Routing Problem (VRP)

The Vehicle Routing Problem (VRP) is a classic logistics challenge that involves determining the best way to deliver a set of customers using a given number of vehicles while minimizing the distance traveled or associated costs. The Branch-and-Bound algorithm is a common exact search approach used to solve the VRP by exhaustively exploring all possible solutions. However, due to the exponential complexity of this problem, computation time can become prohibitive for large instances. The objective of this internship is to explore the integration of Machine Learning (ML) into the Branch-and-Bound algorithm to enhance the efficiency of VRP resolution in terms of solution quality and computation time.

Keywords: vehicle routing problem, machine learning, brand-and-bound

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20. Human Interactions Generation with Denoising Diffusion Models

Modeling and generating realistic human behavior is a long-standing objective in computer vision. Indeed, the ability to model and reproduce the deformation patterns of the human body in the 3D world has a very high potential impact for important application fields such as film-making, game development, human-computer interaction, robotics, etc. In this internship, we aim to address the challenging task of human reaction generation, which aims to generate a corresponding reaction based on an input action. Most current studies lack a focus on generating such reactions, particularly when only the action is provided as input. To achieve this, we intend to exploit the capabilities of denoising diffusion models with reinforcement learning. The objective of this internship is to implement a denoising diffusion model that incorporates physical constraints into the diffusion process in order to generate realistic and coherence human interactions. The internship will start with a comparative study on the existing approaches for human interactions generation, then, the intern will work on the implementation of the new model. This project also includes a 3D data visualization part, in which the candidate will be in charge of using open-source models to transform the generated 3D skeletons to 3D human meshes, this will provide us with a qualitative comparison of the studied models to evaluate the realism and naturalness of the generated sequences.

Keywords: Human interactions, Generative models, Human body, Denoising diffusion models, Reinforcement learning

Contact: Dr. Naima Otberdout (naima.otberdout@um6p.ma)

21. Grasp Synthesis for Hand-Object Interactions

The advanced dexterity capabilities of the human hands allow us to safely and robustly manipulate objects of various shapes, sizes, and materials. Building machines inspired by human hands, with the functionality to autonomously pick up and manipulate objects has many applications in AR/VR, robotics and human-machine interaction. However, this task is very challenging and necessitates a deep understanding of human grasping and manipulation techniques. The aim of this project is to implement a deep learning based approach to model and generate realistic human-hand object interactions. Firstly, a comparative study of the recent solutions should be performed. Then a learning based approach should be implemented to synthesize a human-hand pose that correctly manipulates and grasp a given 3D object.

Keywords: Grasp Synthesis, generative models, hand-object interaction.

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22. 3D Scene Reconstruction from 3D Point Clouds

In today's rapidly evolving world of technology and innovation, the importance of 3D scene reconstruction has grown significantly. It has become a cornerstone in various applications across diverse industries, from autonomous navigation and augmented reality to cultural heritage preservation and environmental monitoring.

The primary aim of this internship is to implement potential 3D scene reconstruction methods and conduct a comprehensive comparative study.
The qualifications and skills required for a candidate to engage effectively with this project are:

- Strong programming skills in both C++ and Python.
- Solid understanding of computer vision and 3D modelling concepts.
- The ability to work collaboratively in a team environment.

The internship is an opportunity to gain hands-on experience in real-world applications of 3D scene reconstruction and access valuable resources and mentorship.

Keywords: Surface reconstruction, Point clouds, Deep learning.

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