

Summer 2024 UG Fellowship program

Hellenic American University/ College Project Descriptions

Project #1

Supervisor's name	Didoe Prevedourou, https://www.linkedin.com/in/didoe-prevedourou-1b0804/
Project title	Guiding Ethical Research and Design of XR Technologies and Applications
Estimated group size	3 students
Estimated duration	6 weeks
Project description	<p>Extended reality (XR) technologies, including AR, VR, and mixed reality, will see pervasive and widespread adoption and revolutionize many aspects of everyday life in the coming decades. The autonomous and intelligent systems (A/IS) backbone enabling real-time personalization of any end-users' Extended Reality (XR) world raises a host of ethical and philosophical questions about the collection, control, and exploitation of user data within these ecosystems [1].</p> <p>Ethical design is user-centered or human-centered, meaning that the design work is governed by the needs and problems experienced by users, instead of by a primary focus on what is technically possible and economically viable.</p> <p>The present project aims to study ethical concerns in the context of XR, where a./ the breadth of sensing in XR enables XR applications and platforms to process captured data toward unanticipated and unintended ends; b./ on-line harassment behavior can occur in social and multi-user VR and be quite impactful; and c./ virtual clones with full fidelity (indistinguishable from the human individual) can be created resulting in the replication of identity which can become unethical or problematic.</p> <p>Students will be asked to review a number of XR applications with the view to identify unintended negative consequences that could diminish human well-being, express their feelings and thoughts about the negative consequences and propose design guidelines and mechanisms to prevent or counter-act them and drive the implementation of trustworthy systems.</p> <p>[1] The IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems - Extended Reality in A/IS [2] Independent High-Level Expert Group on Artificial Intelligence, https://digital-strategy.ec.europa.eu/en/library/ethics-guidelines-trustworthy-ai</p>

Project #2

Supervisor's name	Dr Sokratis Sofianopoulos
Project Title	Building a chatbot using Python and Large Language Models
Estimated group size	3-5 students
Estimated duration	6 weeks
Project description	<p>Summary of the proposal</p> <p>The project's goal is to create a functional chatbot using the Python programming language. With the emergence on chatGPT and the impact that huge language models have on our daily routines, conversational agents are on the spotlight. The focus will be on integrating Retrieve-and-Generate (RAG) models for enhancing the conversational experience. Participants will gain expertise in Natural Language Processing (NLP) fundamentals while exclusively exploring contemporary techniques driven by LLMs.</p> <p>The program will include lectures and hands-on exercises, that will allow participants to create their own chatbot in a specific domain of their choice. Throughout the program, participants will be expected to work on a project and will receive feedback and guidance using Python libraries such as Hugging Face Transformers. The goal is to empower participants to create a personalized chatbot within a specific domain, harnessing the power of RAG models. Finally, they will also have the opportunity to present their application to the group and receive feedback from their peers.</p> <ul style="list-style-type: none"> • Introduction to Chatbots and Natural Language Processing <ul style="list-style-type: none"> ○ Introduction to chatbots and their applications ○ Introduction to Python and the basics of NLP • Using pretrained LLMs through existing Python modules <ul style="list-style-type: none"> ○ Understanding the pivotal role of pretrained Language Models (LLMs) in NLP ○ Introduction to the basic concepts of LLMs ○ Using pretrained LLMs using an API call or from the huggingface library • Building a basic chatbot <ul style="list-style-type: none"> ○ From rule-based systems to AI ○ Exploration of dialogue generation using various pretrained LLMs ○ Comparative study of retrieval-based and generative-based approaches, focusing on RAG models

	<ul style="list-style-type: none"> ○ Building a chatbot using an RAG-based system for crafting contextually relevant responses ● Advanced Techniques with Pretrained LLMs <ul style="list-style-type: none"> ○ Implementing a chatbot using deep learning techniques with various advanced language models ○ Addressing intricate user queries through fine-tuning diverse pretrained LLMs <p>References</p> <ul style="list-style-type: none"> ● "Building Chatbots with Python: Using Natural Language Processing and Machine Learning" by Sumit Raj (2019) ● "Practical Natural Language Processing" by Sowmya Vajjala, Bodhisattwa Majumder, Anuj Gupta, and Harshit Surana (2019) ● "Python for Data Analysis" by Wes McKinney (2017)
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Project #3

Supervisor's name	Dr Sokratis Sofianopoulos
Project Title	Text collection and analysis with Python
Estimated group size	2-4 students
Estimated duration	6 weeks
Project description	<p>This course introduces students to the exciting world of Text Analysis using Python and Natural Language Processing (NLP). The course covers a range of topics including sentiment analysis, text categorization, text similarity, machine translation, language models, and data acquisition. Students will also learn how to leverage web APIs for data collection and service usage. By the end of this course, students will be equipped with the skills to analyze and interpret complex textual data. Some of the NLP tasks that we will be focusing on are:</p> <ul style="list-style-type: none"> ● Sentiment analysis: Analyse tweets and return the overall sentiment (positive, negative, or neutral) using state-of-the-art natural language processing (NLP) techniques. ● Trend analysis: Collect data on popular hashtags or keywords over time to see how they've changed in popularity.

- Text categorization: Classify text on specific categories using classification and clustering techniques.
- Text similarity: Calculate the similarity between pieces of text using vector embeddings.

The program will include lectures and hands-on exercises, that will allow participants to create their own applications in a specific domain of their choice. Throughout the program, participants will be expected to work on a project and will receive feedback and guidance. In the end, they will have a solid understanding of the principles of text data collection and analysis. Finally, they will also have the opportunity to present their application to the group and receive feedback from their peers.

Course plan

- Introduction to Python and NLP
 - Introduction to Natural Language Processing
 - Introduction to Python
- Data Collection
 - Techniques for collecting text data, including web scraping and using APIs
 - Hands-on experience with Python libraries like BeautifulSoup and requests
- Text Preprocessing
 - Techniques for cleaning and preprocessing text data for NLP tasks (tokenization, stemming, lemmatization, stop word removal)
 - Introduction to text categorization and its applications (Bag of Words and TF-IDF for feature extraction)
- Text Categorization
 - Machine learning algorithms for text categorization
 - Hands-on session on building a text categorization model
- Language Models (LLMs)
 - Introduction to language models, n-grams, and sequence prediction
 - Discussion on the role of language models in NLP
- Using Web APIs
 - Leveraging web APIs for NLP tasks

- Hands-on session on using APIs for data collection and accessing NLP services
- Sentiment analysis of Twitter data
 - Sentiment analysis techniques
 - Creating a sentiment analyser for Twitter data
 - Applying the service to new data

References

- "Python for Data Analysis" by Wes McKinney
- "Mining the Social Web: Data Mining Facebook, Twitter, LinkedIn, Google+, GitHub, and More" by Matthew A. Russell
- "Text Analytics with Python: A Practical Real-World Approach to Gaining Actionable Insights from your Data" by Dipanjan Sarkar
- "Sentiment Analysis: Mining Opinions, Sentiments, and Emotions" by Bing Liu
- "Natural Language Processing with Python: Analyzing Text with the Natural Language Toolkit.", by Bird, S., Klein, E., & Loper, E. (2009, O'Reilly Media, Inc.)

Project #4

Supervisor's name	Didoe Prevedourou, https://www.linkedin.com/in/didoe-prevedourou-1b0804/
Project title	Digital Twins (DTs) of Smart Cities
Estimated group size	3 students
Estimated duration	6 weeks
Project description	Digital Twins (DTs) of smart cities offer tangible digital replicas of several aspects of a city (from social, business, cultural dynamics to actual infrastructure) and allow various parties, policymakers, urban planners, engineers, developers, entrepreneurs, citizens etc., to assess the effects of any changes before investments and implementations of strategic plans occur. Cities are faced with complex major challenges for reducing issues such as air pollution, noise nuisance and traffic overload in the city center. They need to keep urban areas attractive, liveable, and healthy. Action to improve the situation in a particular area may have an impact on multiple factors and/or locations elsewhere in a city. Digital Twins build a bridge between the digital and physical urban world. By first modifying livability factors digitally, their effects on the city can be simulated and tested properly.

	<p>The project aims to familiarize students with Digital Twins (DTs) of smart cities as a concept and as a tool. During the project students will be asked to:</p> <ol style="list-style-type: none"> 1./ survey digital twins of smart cities around the world, such as Singapore, Amaravati in India, and a number of cities in Europe, in terms of use cases addressed and technologies used such as AI, high performance computing, data and cloud infrastructures, 5G connectivity; 2./ identify reference architectures, open frameworks (e.g., Open Digital Twin Framework, ODTF), tools that have been commonly used in the development of digital twins of smart cities; and 3./ take a glimpse into Metaverse cities: collect younger generations' views and visions.
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Project #5

Supervisor's name	Dr Panayotis Kalozoumis (LinkedIn)
Project Title	Quantum Computing and Quantum Technologies
Estimated group size	2-4 students
Estimated duration	6 weeks
Project description	<p>Project description and plan</p> <p>Quantum computers and quantum technologies are the main pillars of the second quantum revolution, which has already shown tremendous potential towards emerging technologies with unprecedented impact on sciences, industry, health, and everyday life. With quantum computers, specific problems that would take thousands of years to be solved in classical computers, will be tackled within minutes.</p> <p>Throughout the project students will become familiar with the principles of quantum mechanics and how to use them in quantum computers. They will write our own codes and understand how real quantum computers work. A high school level of mathematical knowledge is adequate. The programming language will be Python and no prior knowledge is required.</p> <p>Throughout the course we will discuss topics such as:</p> <ul style="list-style-type: none"> • Principles of Quantum and Classical Computers • Superposition • Entanglement • Qubits • Quantum Teleportation

	<ul style="list-style-type: none"> • Shor Algorithm • Deutsch Algorithm • Grover Algorithm <p>By the end of the project students will have a basic theoretical and practical knowledge of Quantum Computing, they will be able to write their own circuits and execute codes on real quantum computers.</p> <p>References: P. Kaye, R. Laflamme, and M. Mosca, <i>“An Introduction to Quantum Computing An Introduction to Quantum Computing,”</i> Oxford University Press (2007).</p>
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Project #6

Supervisor’s name	Dr Panayotis Kaloizoumis (LinkedIn)
Project Title	Manipulation of light in nanophotonic waveguides
Estimated group size	2-4 students
Estimated duration	6 weeks
Project description	<p>Project description and plan</p> <p>Discrete optics [1] is one of the most active and promising fields in Engineering, Physics, and technology. Devices based on this concept offer unique opportunities to control and manipulate the flow of light [2]. Discretizing light behavior requires optical elements that can confine optical energy at distinct sites.</p> <p>In this project, students will be introduced to the concepts of nanophotonic devices, discrete optics, the cutting-edge technology that emerges, existing applications, and future perspectives. Students will:</p> <ul style="list-style-type: none"> • become familiar with the basic elements of coupled mode theory. • explore the propagation properties of light in waveguide arrays via analytical and numerical techniques. • consider the case of active materials • build appropriate codes to model the corresponding systems and investigate the behavior under different parameter choices. <p>Both analytical and computational tools will be employed. Familiarity with MATLAB, Mathematica or any coding language is desirable.</p>

	<ol style="list-style-type: none"> 1. A. Szameit and S. Nolte, <i>J. Phys. B: At. Mol. Opt. Phys.</i> 43, 163001 (2010). 2. P. A. Kalozoumis, C. V. Morfonios, F. K. Diakonou, and P. Schmelcher, <i>Phys. Rev. A</i> 93, 063831 (2016)
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Project #9

Supervisor's name	G. Kontaxis
Project Title	Managing IT projects
Estimated group size	3-5 students
Estimated duration.	6 weeks
Project description	<p>Description</p> <p>For this project students will choose an IT project of their preference and define the scope. They will have to collect the requirements needed to execute the project and estimate the overall duration and budget.</p> <p>By using Ms Project a schedule diagram (Gantt chart) will be created with all detailed tasks grouped into phase, work will be assigned to human resources and a procurement list will be planned.</p> <p>When the project starts, students will be able to generate reports for progress and costs spent.</p> <p>Required S/W:</p> <ul style="list-style-type: none"> • Ms Project: To develop a Gantt chart for Schedule, Cost and Resources • Ms Vision: To design a Work Breakdown Structure (WBS diagram) • Ms Word: To create a Project Charter document. • Ms Powerpoint: To present progress reports <p>To achieve this goal the following tasks will need to be completed:</p> <ul style="list-style-type: none"> • Develop a project charter to gain acceptance of the project. • Create a Scope Plan, by designing a Work Breakdown

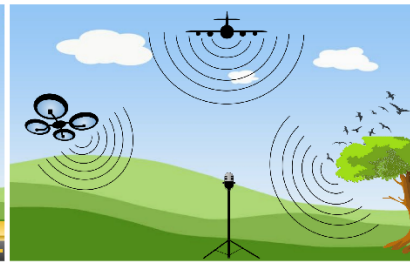
	<p>diagram.</p> <ul style="list-style-type: none"> • Create a Gantt chart, for planning Schedule, Costs and Resources • Generate reports and present progress during execution. <p>References:</p> <ol style="list-style-type: none"> 1. Project Management Institute, “Project Management Body of Knowledge”, 6th edition, 2016 2. C.Lewis, C. Chatfield, T. Johnson, “MS Project step by step”, 2019
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Project #10

Supervisor’s name	D. Doumenis
Project Title	Create a multi-microphone signal analyzer to attach to a drone
Estimated group size	3-5 students
Estimated duration.	6 weeks
Project description	<p>Description</p> <p>Students will create a multi-microphone signal analyzer to attach to a drone (e.g., multiple microphones attached to the drone) that can eliminate the noise of the drone engine and deduce a second drone that is nearby (by analyzing its noise and location) so as to locate its position.</p> <p>The project will use a microphone array to perform the following operations:</p> <ul style="list-style-type: none"> • Identify the existence of another drone (as opposed to other noises, traffic etc.)



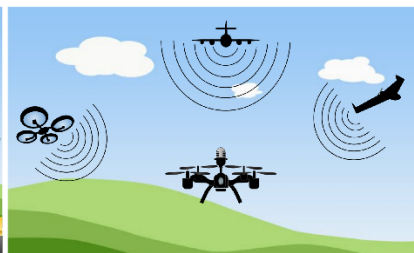
(a) Land-to-Land (LL)



(b) Air-to-Land (AL)



(c) Land-to-Air (LA)



(d) Air-to-Air (AA)

- Identify the location of the drone.



- Provide information to the drone engine to get closer to this drone.



	<p>Required hardware and software:</p> <p>Final device: An identification with a multitude of devices that can annotate the existence of a drone as opposed to other noises (e.g. from online files). As the microphones move (that will eventually be placed in a drone) the system can provide an indication (e.g. an arrow towards the location of the drone and an approximate distance from it).</p> <p>Originally a set of multiple microphones will be attached to a Raspberry Pi and all the code can be run to identify the drones and eventually track them.</p>
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Project #11

Supervisor's name	D. Doumenis
Project Title	4-WD-Robotic-Vehicle with Turret Crane to load /unload items autonomously from 2 Delivery Stations
Estimated group size	3-5 students
Estimated duration.	6 weeks
Project description	<p>Description</p> <p>The project is a continuation of a Capstone project held in 2023. It involves an automatic robot that can roam an internal region as autonomous vehicles successfully operate in an indoor industrial environment. A variety of cyber-physical systems have been used combining thus, together the necessary sensing, acting, controlling, communication, and data acquisition functions.</p> <p>The robot can help individuals identify specific items in a storeroom and lift the item to be transferred in a specific location for further identification or prepare for sending to a buyer. This project is looking forward to inspiring interested researchers, in developing and enriching further the hereby presented autonomous vehicle concept. The scope of this current project is to identify the circuits to be used, build the robot, and then apply it to specific product movement tasks. The hardware will be left at Hellenic American University so that future students can improve it further.</p>

