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# **GRP Project Catalogue 2024-2025**

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## **Introduction**

This catalogue of project briefs should be read in conjunction with the GRP handbook, available through Moodle.

## Projects

### [P2024-01] Immersive Extended Reality-Based Educational Treasure Hunt Game

#### Requirements

This project requires a team of individuals who are enthusiastic about gaming, especially those skilled in game design and proficient in relevant graphic modelling tools like Blender, Photoshop, Maya, 3D Max, Unity3D, or Unreal Engine, as well as the C# programming language.

#### Background

The integration of extended reality (XR) with treasure hunt games is becoming increasingly popular for enhancing enjoyment and engagement in the learning journey. Puzzles, a key component of these games, are commonly used for educational purposes, promoting teamwork skills and domain-specific knowledge acquisition. Research indicates that individuals learning through XR demonstrate greater short-term memory retention compared to those using traditional methods. These results highlight the promising prospects of combining XR and puzzles in treasure hunt games for educational purposes in the future.

#### Outline

The primary objective of this project is to investigate how integrating collaborative mechanisms into puzzle-based treasure hunt games can improve cognitive skills like attention span, short-term memory, reasoning, and analytical abilities. Additionally, it aims to assess whether participants exhibit greater interest and engagement when puzzles are utilized as educational tools, particularly when combined with immersive XR (IXR). Moreover, the project focuses on designing collaborative puzzles that allow teams of two to three members to work together to solve puzzles, thereby enhancing learning outcomes through collaboration. The team is expected to apply software engineering and human-computer interaction methodologies in the development of the treasure hunt game.

#### Tasks & Deliverables

The project entails developing an XR-based educational treasure hunt game following gamification or game-based learning principles, focusing on effective gaming elements using suitable resources and techniques. Key tasks and deliverables include:

- Designing the treasure hunt game in mixed reality to integrate virtual puzzles and respective elements like clues and items into the real environment, spanning at least a building floor.
- Designing a minimum of five unique engaging puzzles to form the treasure hunt game, targeting the enhancement of cognitive skills of students, including attention span, short-term memory, reasoning, and analytical abilities.
- Designing puzzles that enforce collaborative work through various approaches, such as social and virtual interactions.
- Integrating gaming mechanisms like rewards, challenges, hints, and haptic feedback (e.g., vibrations, visual cues, and auditory effects) into an interactive and visually appealing UI design.
- Conducting software testing (e.g., unit, module, and system testing) along with thorough documentation comprising diagrams, [project design documents](#), test plans, user manuals, and other materials aligning with the software engineering phases of specification, development, and testing.
- (Optional) Conducting experiments to gather user experiences and feedback on the game design, followed by evaluation analysis based on the collected data.

### **Additional Information**

Should the team have interest to submit the work to conference or journal, scientific experiment results are necessary to meet publication standards. Valuable tips for initiating this project include:

- Ensuring that puzzle-solving clues offer ample assistance to players, mitigating boredom and sustaining player motivation.
- Strategically concealing clues or essential items needed to solve puzzles in different locations within the game to promote players to explore within the environments.



## **[P2024-02] Recommendation System for Online Shopping**

### **Requirements**

- Able to understand and deploy software engineering principles, methods, and tools
- Able to conduct a literature survey of existing online shopping recommendation systems
- Able to determine the user requirements and the scope of the project
- Able to determine the overall methodology to be adopted for the project
- Able to design the system using appropriate diagramming tools
- Able to implement the design using appropriate programming languages
- Able to test the correctness and the user acceptance for the system
- Able to produce proper documentations
- Able to present the work progress as well as the final product clearly

### **Background**

A shopping recommendation system based on artificial intelligence is a specialized type of recommendation system developed using knowledge engineering and machine learning techniques. It analyses users' historical purchase records, personal preferences, browsing behaviour, and other relevant data to predict their preferences and needs, thereby recommending products or services that they may be interested in. The primary purpose of this system is to offer personalized recommendations that cater to the preferences and requirements of users while maintaining the regular shopping functionality.

### **Outline**

This project will primarily focus on utilizing knowledge engineering and machine learning to predict user preferences and provide those predictions as recommendations within the system. The system is capable of handling vast amounts of shopping data and uncovering hidden patterns and associations. Specific knowledge engineering and machine learning algorithms will be determined and deployed following the software engineering process of developing the shopping recommendation system. If more resources and time are available, additional methods such as causal reasoning can be explored to improve prediction accuracy and enhance the overall functionality of the recommendation system.

**Tasks & Deliverables**

- To produce necessary and appropriate software engineering deliverables
- To produce a comparison table for the main features of existing applications
- To produce a list of user requirements for the proposed application
- To produce a write-up on the proposed method, the tools, and the programming languages to be used
- To produce various design level diagrams which will properly describe the proposed system
- To produce a working prototype of the system which is able to show the full functionality of the system
- To produce test cases for the correctness and the final user acceptance test results
- To compile all the above into a final documentation for the project
- To present the work progress as well as the final product clearly

**Additional Information**

Recommendation Systems Overview (Building Recommendation Systems with TensorFlow)

<https://www.youtube.com/watch?v=BthUPVwA59s&list=PLQY2H8rRoyvy2MiyUBz5RWZr5MPFkV3qz&index=2>

A Helpful Overview on eCommerce Recommendation Systems

<https://influencermarketinghub.com/ecommerce-recommendation-system/>

Recommendation System for Supermarket Online Shopping

[https://upcommons.upc.edu/bitstream/handle/2117/377456/MATT\\_TFM\\_BadalCai\\_final.pdf?sequence=2](https://upcommons.upc.edu/bitstream/handle/2117/377456/MATT_TFM_BadalCai_final.pdf?sequence=2)

**[P2024-03] Smart Breathing Analysis App****Requirements**

This project requires students with an interest in mobile and desktop application development, computer vision (CV), audio processing and machine learning. Experience with Flutter (<https://flutter.dev>) or a willingness to learn is essential. Knowledge of signal processing techniques and classification algorithms would be an advantage.

**Background**

Breath awareness is a key component of many health and wellness practices, including meditation and respiratory rehabilitation. However, accurately tracking breathing patterns can be challenging without specialised equipment. Signal processing techniques can be used in combination with everyday computing devices such as smartphones and laptops to monitor physiological processes in a non-invasive and unobtrusive way.

**Outline**

This project aims to develop a cross-platform application using Flutter that can accurately detect and classify a user's breathing stages (inhale, hold and exhale) using relevant signal processing and classification techniques. The application will use either a laptop webcam or a smartphone front-facing camera to analyse the subtle movements and sounds associated with breathing to determine the user's current breathing stage.

**Tasks & Deliverables**

The group will design and implement a Flutter application that will run on desktop, smartphone and possibly web platforms. They will develop algorithms to process video and audio input to classify breathing phases in real time. The group will also develop a user-friendly interface to display breathing information and possibly guide users through breathing exercises. The application will be tested and optimised on different devices.

**Additional Information**

Potential applications for this technology include meditation support, respiratory rehabilitation and stress management. The team may explore the integration of respiration detection with other health-

related features, or connect to external devices for more comprehensive health monitoring. The following work may be of interest:

Reyes, B.A., Reljin, N., Kong, Y., Nam, Y., & Chon, K.H. (2016). Towards the Development of a Mobile Phonopneumogram: Automatic Breath-Phase Classification Using Smartphones. *Annals of Biomedical Engineering*, 44(9), 2746-2759. <https://doi.org/10.1007/s10439-016-1554-1>

Lee, Y.C., Syakura, A., Khalil, M.A., Wu, C.H., Ding, Y.F., & Wang, C.W. (2021). A real-time camera-based adaptive breathing monitoring system. *Medical & Biological Engineering & Computing*, 59(6), 1285-1298. <https://doi.org/10.1007/s11517-021-02371-5>

Kolosov, D.; Kelefouras, V.; Kourtessis, P.; Mporas, I. Contactless Camera-Based Heart Rate and Respiratory Rate Monitoring Using AI on Hardware. *Sensors* **2023**, 23, 4550. <https://doi.org/10.3390/s23094550>

## **[P2024-04] Motion Capture System Based on Multi-Sensor Fusion and Artificial Intelligence**

### **Requirements**

This project demands a high level of programming proficiency, particularly in Python, along with specialized expertise in libraries such as OpenCV and PyTorch. Additionally, a broad understanding of visualization techniques, software engineering principles, image processing methods, and sensor technology is essential.

### **Background**

The motion capture system is an advanced technological apparatus designed for the precise measurement of object movements within three-dimensional space. Operating on the fundamentals of sensor and sensing technologies, it features an array of sensors strategically positioned to detect the location and orientation of the target object. Through comprehensive analysis of the data collected by the sensor array, the system should be capable of calculating the object's spatial coordinates (X, Y, Z) and orientation, defined by roll, pitch, and yaw angles.

### **Outline**

The objective of this project is to investigate and construct a sophisticated motion capture system that integrates an array of sensors, with cameras serving as the primary element and robotics as an auxiliary technology. Leveraging artificial intelligence techniques to thoroughly analyse sensor data, the system is designed to facilitate the employment of standard industrial cameras for capturing images. The execution of this project will involve the amalgamation of established deep learning algorithms and multi-sensor fusion, culminating in a comprehensive motion capture system.

### **Tasks & Deliverables**

- **Data Collection and Preprocessing:** Gathering sensor data and preparing it for model input.
- **Model Selection and Architecture Implementation:** Choosing appropriate deep learning models and designing the system architecture.
- **Model Training and Validation:** Training the models with collected data and validating their accuracy.
- **Real-time Application Development:** Implementing the system for real-time motion capture and processing.

- **User Interface and Visualization:** Developing a user interface and visual representation of the motion capture data.
- **Documentation:** Creating detailed documentation of the project, including the technical aspects and user guide.
- **Presentation and Demonstration:** Preparing a final presentation and live demonstration of the developed system.

### **Additional Information**

This project's motion capture system is poised to revolutionize various industries, including robotics, animation, and industrial automation, by providing an affordable and efficient method for precise motion tracking. Utilizing standard sensors, the system promises to deliver accurate motion capture capabilities, making sophisticated tracking technology more accessible across these dynamic fields.

**[P2024-05] Real-Time Fitness Tracker with Pose Analysis****Requirements**

This project requires strong programming skills, particularly in developing applications with frameworks and tools for computer vision. Familiarity with deep learning frameworks such as TensorFlow or PyTorch, and experience with multimedia processing is preferred. Students should be comfortable developing user-friendly interfaces and implementing real-time processing algorithms.

**References:**

- Chen, S., & Yang, R.R. (2020). Pose trainer: Correcting exercise posture using pose estimation. *arXiv preprint arXiv:2006.11718*.
- Kanase, R.R., Kumavat, A.N., Sinalkar, R.D., & Somani, S. (2021). Pose estimation and correcting exercise posture. *ITM Web of Conferences*, 40, 03031. EDP Sciences.
- Rangari, T., Kumar, S., Roy, P.P., Dogra, D.P., & Kim, B.G. (2022). Video-based exercise recognition and correct pose detection. *Multimedia Tools and Applications*, 81(21), 30267-30282.

**Background**

Fitness trackers are increasingly popular due to their ability to provide valuable feedback on exercise routines, helping users improve their performance. Traditional methods, which often rely on wearable sensors or manual input, can be cumbersome and less accurate. Recent advancements in computer vision and deep learning have enabled the development of fitness trackers that use real-time video analysis to monitor and provide feedback on exercise form and performance. This approach offers several benefits, including personalized feedback, progress tracking, and increased accessibility.

**Outline**

The aim of this project is to develop a fitness tracker application that utilizes real-time video analysis and computer vision to provide users with personalized feedback on their exercise form, track their performance over time, and enhance accessibility to accurate exercise guidance. The system will allow users to select exercises and either upload pre-recorded videos or stream live workouts. It will employ pose estimation models to analyze body posture and movements in real time, providing immediate visual feedback on alignment and technique. Intelligent algorithms will assess exercise form against predefined standards, offering real-time corrections and suggestions for improvement.

Additionally, the application will track and store performance metrics such as repetitions, sets, duration, and form accuracy, providing users with historical data and progress reports. The user interface will be designed to facilitate easy interaction with these features, including video upload/streaming, exercise selection, and feedback display.

### **Tasks & Deliverables**

1. Develop a User Interface:
  - Design and implement a user-friendly interface for video upload/streaming, exercise selection, and feedback display.
  - Include features for real-time corrections and progress tracking.
2. Build the Core Application:
  - Develop the backend system to handle video processing, pose estimation, and analysis.
  - Integrate machine learning models for pose detection and form analysis.
3. Implement Real-Time Analysis:
  - Utilize computer vision libraries (e.g., OpenCV, MediaPipe) and deep learning frameworks to process video input and analyze exercise form.
4. Progress Tracking:
  - Implement functionality to track and store performance metrics over time.
  - Develop features for generating progress reports and visualizing improvements.
5. Testing and Documentation:
  - Thoroughly test the application to ensure accuracy and reliability of the feedback.
  - Document the code and provide user manuals to enable future extensions and maintenance.

### **Additional Information**

This project aims to leverage cutting-edge computer vision and deep learning technologies to create a practical and beneficial fitness tracking application, enhancing users' ability to monitor and improve their exercise performance effectively.



## **[P2024-06] AI-Powered Teaching Assistant for Generating Educational Materials**

### **Requirements**

This project focuses on creating an AI-powered teaching assistant platform that helps educators develop teaching materials, coursework, and exam questions using ChatGPT. It requires a team of students with a strong interest in applying cutting-edge AI techniques to enhance the teaching and learning process.

### **Background**

ChatGPT, a powerful AI language model, has the potential to revolutionize teaching by providing personalized assistance and automating repetitive tasks. By integrating ChatGPT into education, teachers can generate customized lesson plans, coursework, quizzes, and even exam questions tailored to specific topics and difficulty levels.

### **Outline**

This project is to create a software platform that helps teachers develop teaching materials, coursework, and exam questions using ChatGPT. The platform will assist instructors in generating content based on the course syllabus, providing automated suggestions for lessons, quizzes, and exams, and offering customization options for specific topics or difficulty levels. The platform will offer customizable features, adaptive question difficulty, and question bank management. It integrates with learning outcomes and provides real-time feedback, helping teachers design effective coursework while reducing preparation time, enabling them to focus more on student engagement and learning.

### **Tasks & Deliverables**

- The platform can automatically generate assignments or project ideas based on the topics provided by the teacher.
- Teachers can request different types of coursework (e.g., coding exercises, short-answer questions, essay prompts) and specify the type of feedback they want to include (e.g., hints or solutions).
- The AI suggests grading rubrics and evaluation criteria for each type of coursework.
- Teachers can use the platform to generate multiple-choice questions, short-answer questions, coding problems, or essay questions based on course content.

- Questions can be customized by topic, difficulty level, and question type (e.g., analytical, factual, applied).
- The system can also create randomized question banks for use in different exam versions.
- Teachers can also use the assistant to automatically generate practice quizzes with dynamic question pools.
- Teachers can save, categorize, and organize questions generated by ChatGPT into a question bank.
- The system allows filtering questions by topic, difficulty, or format, and teachers can reuse or edit questions for future exams or quizzes.

## [P2024-07] Developing Serious Games, and Sharing the Experiences

### Requirements

The University has been approached by Mr X, an enthusiast of the use of mixed reality in education. Mr X is an expert in pedagogy, product development, and modern tools for education (including for both teaching and independent learning). Mr X has invited the University to provide a *software engineering* (SE) team to complete an exciting project related to multiple ideas and technologies he has for the future of teaching and learning, including the development of serious games.

It has been said that serious games are games that have other purposes besides entertainment. They are designed to promote learning and behaviour change. Serious gaming is used in various areas, including education. A good serious game should be entertaining, engaging, and immersive. It combines learning strategies, knowledge and structures, and game elements to teach specific skills, knowledge, and attitudes.

This project relates to creating and/or evolving serious games. It involves various forms of mixed reality, including virtual reality (VR) and augmented reality (AR). Key to the success of the project will be investigating (and understanding and incorporating) not only the technology, but also the relevant theory.

Based on preliminary discussions with Mr X, the SE team will need to be motivated, capable of working independently, and willing to explore and innovate. The team will learn and work with new technologies, including elements not (yet) taught through the University's Computer Science programmes. His vision for the project is summarised as:

“When envisioning the future of education, tech-enhanced serious games (TSGs) emerge as powerful tools for developing essential 21st-century skills, which include creativity, critical thinking, communication, and collaboration. These games can be designed to challenge players with complex problems that require innovative solutions, nurturing both creativity and critical thinking. Additionally, by incorporating multiplayer, cooperative, teamwork elements, and real-time feedback, these games can facilitate effective communication and collaborative strategies, allowing players to work together to achieve common goals. The use of advanced technologies such as artificial intelligence (AI) and augmented reality (AR), combined with modern learning theories like collaborative learning and microlearning, can provide realistic and engaging environments where learners can safely hone these skills. As players navigate through these games, they develop technical proficiencies and soft skills that are increasingly valued in today's interconnected world. Ultimately, the vision for TSGs is to create an educational resource where learning is both enjoyable and deeply impactful. By leveraging both technological advancements and contemporary learning theories, we can enable students to thrive in the dynamic and collaborative land-

scape of the 21st century.”

A final potential requirement for this project may be for the SE team to create some form of *open educational resource* (OER) [R-1] that will gather their knowledge, understanding, and developed tools together in one place. This resource could then be used by future associates of Mr X, or others, to help understand many of the challenges associated with this project and technologies. For example: It may eventually form part of an on-boarding training/induction for future workers or students of the technologies.

## Background

Not all game types are suitable for serious games, but the following five are frequently highlighted in the literature:

1. Adventure games are plot-driven and usually part of a narrative, with characters, weapons, and missions; they can be based on real-life or fantasy.
2. Simulation games replicate realistic interactions with real-life objects and scenarios; they are often used for practice and training in medical and technical fields.
3. Strategy games encourage strategic thinking based around growth or survival, involving civilizations, armies, and inventory; they are often based on history or fantasy.
4. Puzzle games encourage logical thinking; they can be highly complicated or simple and may not require complex programming or detailed visual graphics.
5. Edutainment games deliver educational goals through entertaining forms of gameplay; they are primarily for young children but can be adapted to suit adults and students.

An estimated 40% of the world’s largest organizations have implemented Game-Based Learning (GBL) in their workplace practices. The technique provides a methodology that can help to increase engagement and competition amongst the workforce and can be used to complement branding efforts or as an instrument for executing business strategy. Short-term benefits include workforce retention, increased training adoption, and improved work performance, while also improving overall productivity and workplace satisfaction in the long term.

In education, conventional approaches are falling out of favour, and concerns regarding student motivation and engagement are growing. Conversely “Digital Game-Based Learning” (DGBL), which is typically described as the use of game-like mechanics, aesthetics, and thinking to engage people, motivate action, and promote learning and problem-solving, can positively affect students’ engagement, motivation, and overall performance. In education, DGBL is particularly promising, having been used:

to make boring topics more appealing; attract and motivate students; and to explain and contextualize challenging and ambiguous concepts]. Additionally, DGBL provides opportunities for students to apply and evaluate skills and methodologies in simulated environments without many of the associated risks. Examples of education-related DGBL include: the Virtual Reality Studio (simulation game), where users can practice performing assembly tasks; the Monkey Wrench Conspiracy, a first-person shooter (adventure game) that encourages engineers to transition from 2D computer-aided design (CAD) systems to learning complicated 3D CAD systems while having fun and being motivated; and the Manikin (simulation game) that helps designers to better understand the relationship between their product designs and their users. These examples demonstrate the potential of DGBL in education and have been reported to have a positive impact on student satisfaction and performance.

## Outline

The selected students will form an SE team, and work together to complete a full cycle (maybe several full cycles) of the SE process. Relevant stakeholders (Mr X, his associates, and others from the University, and potentially elsewhere) will be identified, and *requirements engineering* processes used to identify the exact SE project requirements. A final project proposal will be prepared, and the project implemented over the course of the GRP time period.

Because the SE team will need to go through *requirements engineering*, part of this project will involve applying an appropriate requirements elicitation methodology. The requirements engineering, feasibility analysis, and project scoping will all need to be completed early in the GRP time frame.

The team will need to make informed decisions about which SE process approaches or methodologies to apply to this project. (Experiences from previous SE teams may prove useful.)

Over the course of the project, the SE team will need to produce several deliverables, which may include (but are not limited to):

- a report on the current situation
- a proposed system (or systems) to implement
- a system requirements specification
- design documentation
- team management and planning documentation
- prototypes
- progress reports
- verification and validation plans

- code and code documentation
- tests and test reports
- instructions/user manual(s)
- OER

The target goal of the SE project will be to deliver, on time, a system (or several systems) that meet the requirements of the various stakeholders (both Mr X and any others identified over the course of the project).

### **Tasks & Deliverables**

This unique project may have several groups of stakeholders, and will require significant project management skills to complete. In addition to the deliverables listed above, the team may also need to produce other resources, including recommended protocols or format specifications, or other advice for future evolution.

### **References**

[R-1] [https://en.wikipedia.org/wiki/Open\\_educational\\_resources](https://en.wikipedia.org/wiki/Open_educational_resources)

## [P2024-08] AI-Powered Digital Signage for Targeted and Personalized Advertisement

### Requirements

- Proficiency in programming languages such as Python.
- Knowledge of machine learning algorithms, particularly in the areas of computer vision and natural language processing.
- Familiarity with data analytics and data mining techniques.
- Understanding of marketing principles and strategies, with a focus on targeted and personalized advertising.
- Experience with relevant tools and frameworks for developing AI applications.
- Knowledge of training and optimizing AI models.

### Background

In the modern advertising landscape, digital signage has emerged as a powerful tool for delivering targeted and personalized advertisement to consumers. AI technologies offer immense potential in analyzing vast amounts of data to gain insights into consumer behavior, preferences, and trends. By leveraging computer vision and Large Language Models (LLMs), digital signage can analyze real-time data to understand the context and preferences of the audience, enabling more relevant and engaging advertisements. Computer vision can be used to analyze images and videos to determine customer demographics such as age and gender, while LLMs can generate personalized advertising messages based on the extracted information and the context.

### Outline

- Data Collection and Integration: The system will collect data from various sources, including camera feeds, sensors, and online platforms, to understand the demographics, behavior, and preferences of the audience in the vicinity of the digital signage. You may also use the online benchmark data that has no ethical and copyright issues.
- Computer Vision for Demographics Analysis: Using computer vision algorithms, the system will analyze the images and videos captured by the cameras to determine the age, gender, and emotions of the viewers. This information will be used to tailor the advertisements to the specific characteristics of the audience.
- Large Language Model for Personalized Advertising: Utilize an LLM to generate personalized

advertising messages based on the customer demographics and other relevant data. The LLM will be able to understand the language and preferences of the viewers to create more relevant and compelling content.

- **Targeted Advertising Delivery:** Based on the analysis of the audience data, the system will deliver targeted advertisements to the digital signage in real-time. The advertisements will be selected from a pool of pre-approved ads based on their relevance to the audience profile and the location context.
- **Interaction and Feedback:** The digital signage will enable interaction with the audience through touch screens or other input devices. Viewers will be able to provide feedback on the advertisements, which will be used to further refine the targeting and personalization algorithms.
- **Analytics and Optimization:** Provide detailed analytics and reporting on the performance of the advertisement campaigns. Use this data to optimize future campaigns by adjusting targeting, messaging, and timing.

### Tasks & Deliverables

- Develop and train the computer vision model for **demographics estimation**.
- **Integrate the LLM** into the platform for generating personalized advertising content.
- Build a **user-friendly interface** for managing the advertising campaigns and monitoring the performance of the system.
- Implement **data pipelines** for seamless data collection, processing, and integration.
- Conduct **testing and validation** to ensure the accuracy and reliability of the AI models.
- Deliver a working **prototype** of the AI-powered digital signage system.
- Provide **documentation** on the platform's functionality, usage, and technical details.

### Additional Information

- Ensure the **ethical use of data** by anonymizing the data whenever possible. Comply with all relevant privacy regulations and data protection laws.
- Provide **clear and transparent information** to the audience about the use of AI in the digital signage and how their data is being used.
- **Avoid any form of discrimination or bias** in the targeting and personalization algorithms. Ensure that the advertisements are presented in a fair and equitable manner to all viewers.



- Continuously update and improve the AI models based on new data and user feedback.
- Conduct A/B testing to compare the performance of different versions of the AI models or marketing strategies. This can help identify the most effective approaches and inform the ongoing improvement process.

**[P2024-09] Assessment, Scoring and Rank-ordering Software****Requirements**

Deliver a software system to help multiple assessors score and rank-order entities (people, artefacts, products, etc.).

**Background**

The requirement to score and rank-order people, entities or artefacts is important in many activities such as recruitment, assessment in education, product review, and loan applications, amongst others. In large organizations, several assessors may be used to rank over many entities. For example, several clients may rank across many suppliers.

**Outline**

In this project, you will design and deliver software to help manage a scoring and rank-ordering multi-user system. It will support adjustment for assessor bias, the use of decision thresholds, handling borderline cases and assessment variability. The scoring system is an optimization problem, and the student team will be responsible for developing this using calculus and linear algebra, and implementing the scoring system in the software. The use-case will be to design an employee peer review system. The students taking this project are responsible for all aspects of software development: eliciting requirement specification, mathematical optimization, design, implementation, and testing. They will also select the appropriate software development tools and languages to implement the project.

*Example*

Three managers rate four employees out of 5:

Manager	Emp 1	Emp 2	Emp 3	Emp 4
A	1	3	0	1
B	0	4	1	2
C	3	5	4	
Avg	2	4	1.667	1.5

We can see that Emp 2 is ranked best overall. We could create a ranking for each employee by simply averaging all given managers' scores. However, manager C is giving inflated figures and is also missing

a ranking for Emp 4. If manager C's scores are not adjusted, this may mean that Emp 4 is unfairly ranked last. *How can you fix this?*

**Tasks & Deliverables**

- Elicit requirement specification;
- Mathematical optimization of scoring system;
- Consider user-friendly design approach;
- Design, implementation, and testing of software;
- Documentation and user guide.

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## **[P2024-10] A Tool for Visualizing Geospatial Knowledge in Knowledge Graphs**

### **Requirements**

This project will require that the students are interested in geospatial data analysis and have good programming skills.

### **Background**

A knowledge graph represents entities and their relationships. Geospatial knowledge mainly includes quantitative geospatial knowledge and qualitative geospatial knowledge. Quantitative geospatial knowledge includes geometries and coordinates of spatial objects. Geometry information of spatial objects (e.g., cities, airports) has been provided in several knowledge graphs, including DBpedia, Yago, Yago2geo. The geometries are usually represented in the well-known text (WKT) format, and they can be visualised in a 2D Euclidean space. Qualitative geospatial knowledge refers to qualitative spatial relations between objects. In general, qualitative spatial relations can be classified into directional relations, qualitative distance relations and topological relations.

### **Outline**

This project aims to develop a software tool for visualising geospatial knowledge in knowledge graphs.

### **Tasks & Deliverables**

- Provide an expanded description of the problem to be solved, identify the main challenges in visualising geospatial knowledge in knowledge graphs.
- Review existing similar software tools and analyse their advantages and limitations, write this up in a chapter of literature review.
- Specify functional and non-functional requirements, and write this up in a chapter of requirement specification.
- Design a software making use of the knowledge and skills learnt in software engineering modules, and write this up in a chapter of software design.
- Implement the software using Java, C/C++, Python or other programming languages and write this up in a chapter of software implementation.

- Evaluate and test the implemented software making use of the knowledge and skills learnt in software engineering modules, and write this up in a chapter of evaluation and testing.
- Provide a user manual of the software.
- Work in a team, collaborate and learn from each other. Write an individual reflection report.

For more details, please refer to the GRP module handbook.

**[P2024-11] Swarm Intelligent Doctor: Medical Auxiliary Diagnosis****Requirements**

This project will require students to have knowledge and skills in web-based system development and machine learning methods, including HTML, Python, SQL, classification, segmentation, image processing, etc.

**Background**

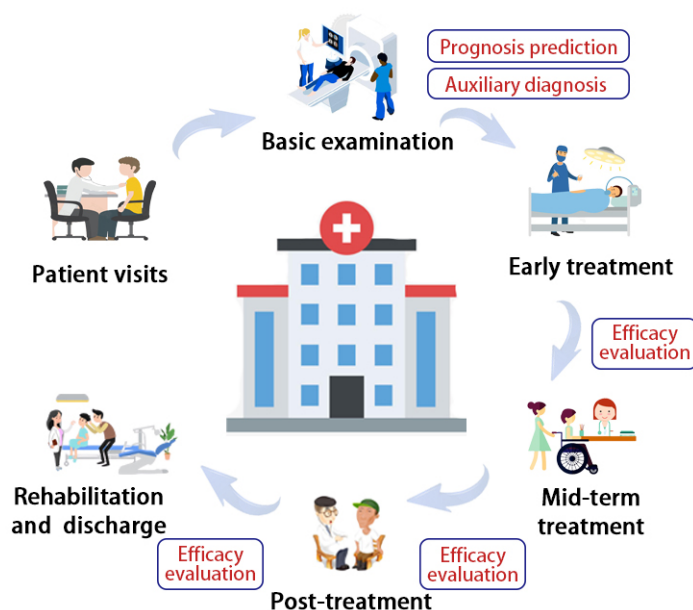
With the rapid economic development of China, the basic medical needs of residents are constantly increasing. The existing basic medical system is faced with the problems of imperfect layout and unreasonable allocation of medical resources, which cannot effectively meet the surge in demand for various services. In this context, hierarchical medical has become the key content of deepening medical reform in the new era. "Promoting Internet diagnosis and treatment services, giving full play to the role of Internet hospitals in primary medical services, guiding the focus move down, sinking resources into grass-roots, and promoting hierarchical medical orderly" are the latest notices in "Internet + Medical Health" and "Five Ones" Service Actions issued by the Health Commission. Primary medical care at the grassroots level is the basis of "hierarchical medical." Primary medical institutions in China are facing a shortage of resources. Among them, the shortage of clinicians and the uneven distribution of talents are particularly serious. "AI+ Medical" can effectively empower grass-roots medical institutions, and use intelligent means to assist grass-roots doctors to improve the level of general practice.

For that consideration, we hope to propose a Swarm Intelligent (SI) based platform, named SI doctor, to assist doctors with disease diagnosis. The SI doctor is built as a complete and stable algorithm system, embedded with image processing, text mining, feature selection, and other technologies. A complete framework is proposed, including data collection, data verification, model design, software development, and result testing modules, covering functions of auxiliary diagnosis, patient follow-up, and disease retrieval. This project aims to provide convenient, accurate, and efficient clinical assistant diagnosis and treatment services for the majority of citizens. It will bring many changes in diagnosis and treatment modes, disease management, and other aspects to the primary medical field. This platform is dedicated to alleviate the pressure of uneven distribution of medical resources and improve the quality of medical services.

**Outline**

The auxiliary diagnosis function of SI Doctor is mainly realized through three major links: prognosis prediction, disease diagnosis, and curative effect evaluation, covering the main links from patient

consultation to rehabilitation and discharge in the doctor's consultation process, as shown below:



#### (1) prognosis prediction

Before the patient sees a doctor, the doctor can log in to the SI Doctor platform in the early stage, and formulate the corresponding diagnosis and treatment plan to predict the possible course and outcome of the disease based on the data of the specific patient population in the back-end database.

The SI Doctor system back-end database will be connected with the hospital's doctor information database after the hospital purchases the right to use this product, automatically enter the doctor's information, and automatically generate the initial password.

#### (2) Disease diagnosis

In the process of patient consultation, doctors can use SI Doctor to quickly read and identify the patient's images, medical records, and other data after a series of basic examinations, and obtain detailed information about the disease based on this, and then perform disease diagnosis, realizing the intelligent auxiliary diagnosis of this product core function.

#### (3) Efficacy evaluation

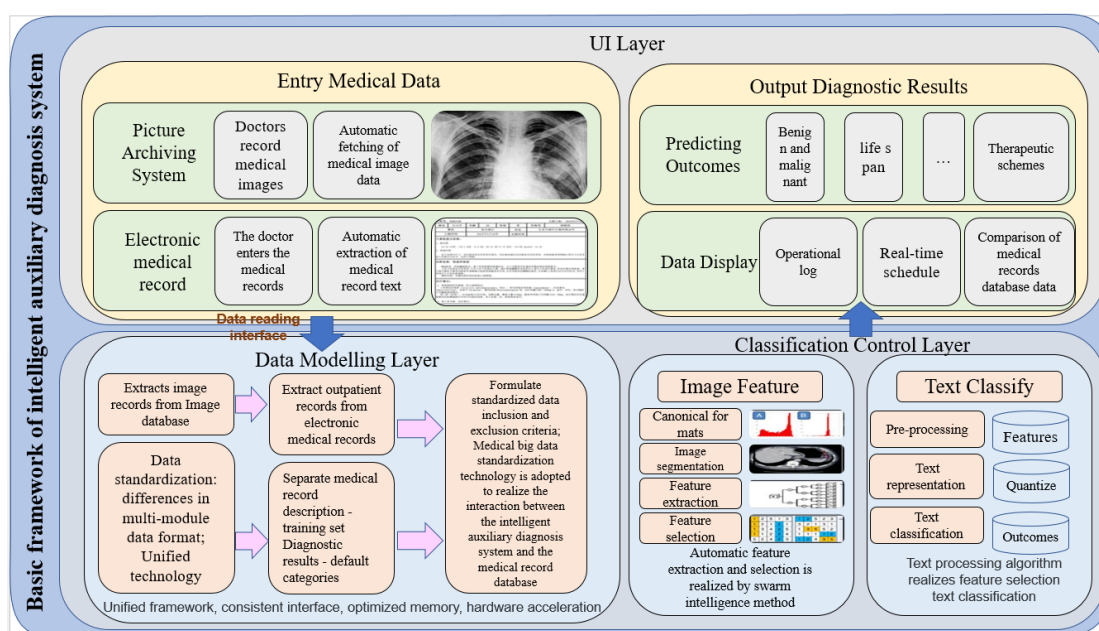
When the patient receives treatment and enters a specific stage, the doctor can know the patient's treatment effect through SI Doctor at any time and determine whether the treatment needs to be continued.

## Tasks & Deliverables

**(1) User interface layer design:** the functional modules directly displayed to users by the development system. Design different interfaces for users to input medical record descriptions or medical images into the system, and to show the results of diseases diagnosed by the system to users. Further, the user interface layer is the data interface with the data model layer and the classification control layer.

**(2) Data model layer design:** develop a module for interaction between the system and the case database. Formulate standardized and unified data inclusion standards, collect and integrate medical big data, and standardize the processing of case database data. Provide the user interface layer data input interface to realize the rapid interaction between the user interface layer and the case database.

**(3) Classification and control layer design:** Develop a calculation module that realizes classification and returns the diagnosis result with interpretability information to the user interface layer. Data (feature) analysis and sharing are realized through standard data input at the data model layer and quantitative feature extraction; through the standardization of input and output, real-time online analysis realizes auxiliary diagnosis and realizes the whole process of online analysis and processing from data characteristics to auxiliary diagnosis results.





## **[P2024-12] An Explainable Recommender System**

### **Requirements**

- Proficient in programming with Python/Java
- Familiar with database systems
- Good knowledge background on linear algebra
- Understand the basic concepts of recommender systems

### **Background**

Recommender systems are an indispensable component of online e-commerce platforms that aim to provide suggestions for items that are most pertinent to a particular user. Through the effective recommendation mechanisms, recommender systems have significantly increased the economic incomes of online retailers and endowed customers with pleasant online purchase experiences. However, current recommender systems are mainly operated in an opaque way, with no convincing recommendation reasons provided to customers. This project aims to develop a virtual recommender system and mimic the operation workflows of real-world recommender systems, but offer recommendation explanations with the purpose of convincing more potential customers and increasing online transactions.

### **Outline**

This project requires to develop a virtual online recommender system including an interface for collecting users' online purchase data, and implement the function of explaining recommendation reasons.

### **Tasks & Deliverables**

1. Build up a database system to store the profiles of customers and products, as well as customers' purchase/browse/saving records.
2. Develop a virtual online e-commerce platform as a web application, allow users to browse, save and purchase products of different categories.
3. Implement the basic recommendation algorithms, including content-based filtering and collaborative filtering.

4. Compile the intermediate results of the implemented recommender system into textual descriptions as recommendation reasons.
5. Evaluate the reliability of the recommendation results by considering the cold-start and data sparsity problems, and explain the reliability to users.
6. Design test cases to test the correctness of base components of the developed recommender system.

**Additional Information**

1. [https://en.wikipedia.org/wiki/Recommender\\_system](https://en.wikipedia.org/wiki/Recommender_system)
2. Zhang, Yongfeng, and Xu Chen. "Explainable recommendation: A survey and new perspectives." Foundations and Trends® in Information Retrieval 14.1 (2020): 1-101.

**[P2024-13] Multi-agent Game****Requirements**

This project requires a good understanding of the following knowledge and skills:

- Software engineering
- Graphical user interface
- Good programming skills (Java, Python, C++ or JavaScript)

**Background**

Multi-agent systems, especially those involving both human and AI agents are becoming a hot topic in AI and HCI-related research. In those hybrid, heterogeneous multi-agent systems, how to determine the agents' behaviours to maximise the global goals or to compete with each other is one of the key challenges. Apart from the algorithms, strategies or solutions to the problem, how and where we should experiment with those algorithms is yet another interesting topic.

**Outline**

This project aims to develop a game which involves both humans and AI agents. This game could be a strategy game or even a simulation game, however, it must involve decision-making and interactions among the agents. Ideally, the game should be developed using one of the well-known game engines to ensure its quality. The output of this project is expected to be a single software (game) in which the human player can play with AI or other human players.

**Tasks & Deliverables**

- A comprehensive review on existing multi-agent games and game engines.
- Specify all functional and non-functional requirements.
- Provide a complete software design of the system.
- Implement the software such that it satisfies all the requirements mentioned above.
- Design and implement a user-friendly UI for the software (as this project is to develop a game, the requirement for UI will be higher compared to other software).
- A complete testing and evaluation on the performance of the software including users' feedback.

- Provide a user manual for the software.
- Work in a team, collaborate and learn from each other.

**[P2024-14] Body Language Detection-Based Emotionally Controlled Music Player****Requirements**

This project needs the knowledge of AI, image/video processing, and Python.

**Background**

People often choose to listen to different music based on their moods and emotions to refresh their minds and restore their emotions. Body language is one of the key reflection of one's emotion. Body language may involve hand movements, facial expressions and hints, eye movements, tone of voice, body movements and positions, gestures, use of space, and the like. So we can use the body language of a person to prepare a playlist and control the music player according to his emotions automatically.

**Outline**

In this proposed music player, the hand movements, facial expressions and hints, eye movements, body movements, positions, and gestures extracted will generate a playlist and control sound automatically thereby reducing the effort and time involved in rendering the process manually. The proposed music player will provide customized control of it based on individual preference and emotion.

**Tasks & Deliverables**

The prospective team will have familiarity with AI, emotion detection through image/video processing, and Python.

## **[P2024-15] Food Wastage Detection and Prevention**

### **Requirements**

This project requires the following knowledge and skills:

- Some knowledge on computer vision techniques, especially on class-agnostic counting. Hands-on experience on OpenCV is preferred.
- Some knowledge on machine learning, pattern recognition and deep learning. Hands-on experience on building a convolutional neural network is preferred.
- General knowledge on software development.
- Some teamwork experience is preferred.

### **Background**

Deep learning techniques have been advanced significantly and many large models for computer vision tasks have been developed. The developed techniques have been widely applied in many applications, e.g., face recognition, autonomous vehicle driving, robotics, and so on. On the other hand, food wastage has become a significant problem, e.g., according to the USDA, in the United States alone, 30-40 percent of the food supply is wasted. It is important to develop a system to detect possible food wastage and implement some possible prevention measures.

In this project, you are expected to develop and implement a system that could detect possible food wastage in a tray, determine the type of food and the amount of food leftover, record the associated face image, and keep the record in the system. Then, some query about food wastage could be made, e.g., 1) check who, when, where and how much is the food wastage. 2) Check what kind of food is most likely leftover and recommend the change to the menu. 3) Other possible innovative functions.

### **Outline**

More specifically, you are expected to firstly construct a food wastage detection system. In this system, you need to detect the category of food, the amount of wastage, the face associated with the tray, and store all the information in a database. Secondly, you need to build a database to store all the information captured, and facilitate various query functions, e.g., 1) The list of food wastage for a specific face. 2) The type of food that is most often wasted. Finally, you need to build an interface to manage the system and interact with users.

You are advised that this project requires knowledge in more than one area, and it requires a good teamwork spirit to make the project succeed. At the end of the project, you will be able to learn

knowledge and have hands-on experience in many different areas, such as database design, object detection, class-agnostic counting.

You should use existing technology to implement your system whenever possible.

### **Tasks & Deliverables**

The following functionalities are expected for the system:

- A food wastage detection system.
- A database storing all the information.
- A user interface to interact with the user.
- Query the food wastage for a specific face.
- Query the type of food that is most likely to be leftover
- A summary of food wastage.
- Provide some valuable recommendations to prevent food wastage.

At the end of the project, you are expected to deliver a live demo for the system.

### **Additional Information**

Algorithms, codes and papers on machine learning/computer vision:

<https://paperswithcode.com/>

<https://github.com/>

## **[P2024-16] Online Virtual Dressing Room with Advanced Try-On and Clothing Retrieval Features**

### **Requirements**

The project aims to combine advanced computer vision, image captioning, and recommendation algorithms to create an immersive and efficient virtual dressing room experience. By providing users with the ability to search for clothing through descriptions, receive personalized recommendations, and browse outfits efficiently, the application will deliver an enhanced online shopping experience.

This project will require students to have knowledge and skills in web-based system development and machine learning methods, including HTML, Python, SQL, classification, face detection, image processing, etc.

### **Background**

The traditional shopping experience often involves visiting physical stores and trying on multiple clothing items to find the right fit and style. However, this process can be time-consuming, inconvenient, and limited by factors such as store availability and fitting room spaces. The concept of a virtual dressing room software stems from the desire to provide users with a convenient and immersive way to try on different outfits without physically wearing them. This technology has gained popularity in recent years due to advancements in computer vision, augmented reality, and e-commerce.

### **Outline**

The objective of this project is to design a comprehensive online virtual dressing room application that allows users to try on clothes virtually, with enhanced functionalities such as clothing retrieval based on descriptions, efficient browsing, and personalized recommendations. The software will also focus on building a try-on clothing dataset, linking each clothing item with a corresponding text description for improved search and recommendation accuracy. The key requirements for this software are as follows:

- **Image Capture:** The software must capture user images through the device's camera or webcam.
- **2D Dress Try-On Algorithm:** The group will be provided with a pre-built algorithm for fitting 2D clothing onto the user's captured image.
- **Intelligent Face Replacement:** The application will process captured images by intelligently replacing the user's head with the chosen outfit's image.



- **Outfit Selection and Styling:** Users will have access to a wide range of clothing items and styles from a virtual clothing catalog, which includes various categories like tops, bottoms, and dresses.
- **Clothing Dataset Development:** The group will develop a comprehensive try-on clothing dataset. Each item in the dataset will be linked to a corresponding text description to facilitate accurate retrieval and recommendations.
- **Text-Based Clothing Retrieval:** Users will be able to search for outfits using descriptive keywords, with the system retrieving relevant clothing items based on the text descriptions.
- **Efficient Browsing and Recommendations:** The application will allow for quick browsing of search results, with suggestions and recommendations based on user preferences and previous interactions.
- **Feature Fusion and Fast Outfit Switching:** Users will be able to switch between outfits quickly, with minimal delay, and view results efficiently within the virtual dressing room.
- **Clothing Categorization and Recommendations:** A recommendation system will categorize clothing items and suggest outfit combinations, enhancing the user experience.
- **Image Captioning Algorithm:** The group will be provided with an image captioning tool that links clothing images with their text descriptions to improve search and retrieval functions.
- **User Interface and Experience:** The application must offer a user-friendly interface, enabling seamless navigation between different outfits, searching, and trying on clothes virtually.
- **Save and Share Functionality:** Users can save their favorite outfit combinations and share them on social platforms.

### **Tasks & Deliverables**

- A web-based application with an intuitive user interface.
- A developed clothing dataset with corresponding text descriptions.
- Functional clothing retrieval and recommendation systems.
- Efficient browsing and try-on experience with integrated search functions based on text descriptions.

### **Tools Provided:**

- **2D Dress Try-On Algorithm:** A pre-built algorithm to overlay 2D clothing onto the user's image.

- Image Captioning Algorithm: A tool to generate descriptive captions for clothing images, linking them to text for retrieval purposes.

**[P2024-17] AI-based 3D point cloud recognition for autonomous vehicles****Requirements**

This project requires students to possess, or be enthusiastic in, necessary technical knowledge including **Autonomous vehicle, Embedded systems, AI, Python**, etc.

**Background**

3D cloud recognition involves identifying and analyzing three-dimensional point clouds, which are generated using technologies like LiDAR and stereo vision. These point clouds capture detailed spatial information about environments and objects. AI-based 3D cloud recognition enhances this process by using **machine learning algorithms, particularly deep learning**, to accurately classify and segment objects within the data. Techniques such as PointNet and convolutional neural networks are employed to extract meaningful features from the complex data.

This technology is crucial for autonomous vehicles, as it enables them to perceive their surroundings with high precision. By recognizing obstacles, pedestrians, and road conditions in real-time, AI-based 3D cloud recognition significantly enhances navigation and path planning. It contributes to the safety and reliability of autonomous systems by improving object detection and situational awareness, ultimately facilitating safer and more efficient transportation.

**Outline**

This project is to design, develop, and test a software system – used in conjunction with a realistic toy car – that visualizes, trains, and commands the process of AI-based point cloud recognition models and algorithms, with point cloud collected from the toy car equipped with necessary sensors. In this project, you will firstly survey (and then implement one or more of) the state-of-the-art AI-based 3D reconstruction/recognition models, algorithms, datasets, etc. Then, you are provided with a mini autonomous vehicle, equipped with the LiDAR and stereo camera. You are expected to collect the point cloud data using them, and then apply the implemented 3D point cloud recognition models to achieve accurate reconstruction results to reflect the realistic environment of the vehicle. Your software system should wrap the abovementioned functionality, in addition to visualize the point cloud, visualize the recognition results, select and train the AI models, etc.

You may assume that your team is a small enterprise start-up, and this project will be one that you have to successfully complete to grasp your company's first pot of gold. The client of the project is your GRP supervisor who acts as a business stakeholder who may not have a full plan on every detail of this application, thus you may need to further discuss with him to figure out the whole picture

(or even convince him to remove some unrealistic requirements), and prepare your project as one that is as maintainable as possible to adapt/accommodate any possible last-minute change from the client.

**Tasks & Deliverables**

Your team is expected to deliver a software as described above.

**Additional Information**

The expected toy car can be found [here](#).

## **[P2024-18] Dynamic Restaurant Staff Scheduling Tool**

### **Requirements**

The goal of this project is to create an advanced staff scheduling tool that facilitates efficient management by a human planner, allowing for dynamic planning in response to the latest data.

### **Background**

The typical process of personnel scheduling consists of several stages.

If the demand is time-based (e.g. 3 workers are required on Tuesday 7am-8am) and the worker assignment is shift-based (e.g. worker A is on a morning shift from 7am to 11am), then these stages can be broadly classified into three main ones as follows. The first stage,

demand modelling determines how many workers are required at different times over a planning horizon, which is typically of one week. The second stage, the shift designing involves

designing a set of shifts and calculating their required workers to meet the demand. The third stage, shift assignment is to allocate workers to each individual shift, while satisfying demand.

### **Outline**

The tool is designed to cater to the needs of restaurant managers, enabling them to automatically and adaptively schedule staff shifts over a planning horizon ranging from one week to one month. Shift durations typically vary between 2 to 12 hours.

### **Tasks & Deliverables**

The system must incorporate at least five essential features: 1) the capability to import and export shift data using Excel, 2) the provision of comprehensive summary statistics, and 3) the ability to update the schedule in real-time based on the most current information, such as unexpected surges in demand or employee tardiness, which will be simulated within the system.

## [P2024-19] Logic Diagram Generation Software

### Requirements

- **Technical Requirements:**

- Programming Languages: Python for backend development, frontend interactions can be flexible.
- Libraries: NLTK or spaCy for NLP; D3.js or Graphviz for flowchart visualization.
- Development Environment: Integrated Development Environment (IDE) such as PyCharm or Visual Studio Code.

- **User Requirements:**

- A user-friendly interface that accommodates users with varying levels of technical expertise.
- Capability to handle diverse text inputs, including but not limited to technical documentation, business proposals, and educational materials.

### Background

This project aims to develop a software application that enables users to input extensive textual logic descriptions and subsequently generates corresponding flowcharts by recognizing the logical relationships within the text. The application will integrate a natural language processing (NLP) algorithm designed to analyze the semantic structure of the input text, thereby facilitating the automatic creation of flowcharts that adhere to standard conventions, including initiation, decision points, and termination.

In the contemporary landscape of software engineering, the ability to transform unstructured textual information into structured visual representations is invaluable. Flowcharts serve as essential tools in various domains, including software development, business process modeling, and educational contexts. This project addresses the need for a user-friendly application that simplifies the process of flowchart generation from verbose text, thereby enhancing comprehension and facilitating better communication of complex ideas.

### Outline

1. **Literature Review:**

- Conduct a thorough review of existing literature on natural language processing, flowchart generation, and user interface design to inform the development process.

## **2. Algorithm Development:**

- Develop the NLP algorithm which focusing on extraction of logical relationships.
- Test the algorithm on a diverse set of textual inputs to ensure robustness and adaptability.

## **3. Flowchart Design:**

- Utilize libraries such as Graphviz or D3.js to facilitate flowchart rendering, ensuring adaptability to various screen sizes and formats.

## **4. User Testing:**

- Implement a user testing phase to gather feedback on usability and functionality, making iterative improvements based on user insights.

# **Tasks & Deliverables**

## **1. Text Input and Preprocessing:**

- Develop an intuitive user interface that allows users to input large text blocks seamlessly.
- Implement preprocessing techniques to clean and prepare the text for analysis, including tokenization, stemming, and removal of stop words.

## **2. Logical Relationship Identification:**

- Design and integrate an NLP algorithm capable of identifying logical constructs within the text, such as conditions, actions, and sequences.
- Utilize techniques such as dependency parsing and semantic analysis to understand the relationships between different components of the text.

## **3. Flowchart Generation:**

- Establish a framework for generating flowcharts based on identified logical relationships, adhering to standard flowchart symbols (e.g., ovals for start and end, diamonds for decisions).
- Ensure that the generated flowcharts are clear, coherent, and accurately represent the input text.

## **4. User Interaction and Feedback:**

- Create a system for users to review and modify the generated flowcharts, allowing for customization and refinement.



## **[P2024-20] Augmented Reality based Immersive App**

### **Requirements**

This Software Engineering (SE) project is required to utilize Augmented Reality (AR) techniques to develop an immersive App. The educational value of the app makes it a valuable tool for educators. It can be used to teach subjects in a more engaging and interactive way, helping students to better understand and retain information.

### **Background**

In today's digital age, AR has emerged as a powerful technology that can transform the way we experience and interact with stories. An AR based Immersive App combines the magic of AR with captivating narratives to create an engaging and unforgettable user experience.

### **Outline**

With its AR integration, immersive narratives, user interaction, social sharing, and educational value, the Immersive Storytelling App offers a unique and engaging experience that can be enjoyed by users.

This SE project aims to use software, App, and AR hardware to overlay digital content in the form of graphics, text, audio and other virtual enhancements onto real-life environments and objects for storytelling. Meanwhile, haptic rendering will also be implemented. The selected students will form a software engineering team, and work together to complete a full cycle of this software engineering process, resulting in delivery of an App.

The SE team will go through a complete requirements of SE process to identify the exact SE project requirements with Olive Tree Children Develop Center. Part of this will involve applying an appropriate requirements elicitation methodology.

The SE team will need to make informed decisions about which SE process approaches or methodologies will apply to this project.

### **Tasks & Deliverables**

Tasks are as follows:

**AR Integration:** The app uses augmented reality to bring stories to life by overlaying digital elements onto the real world. This can include characters, animations, and interactive objects that enhance the user experience.

**Immersive Narratives:** The app offers a wide range of immersive stories that transport users to different worlds and times. These stories are carefully crafted to engage the user's emotions and imagination.

**User Interaction:** Users can interact with the story elements in real-time, making choices that affect the outcome of the story. This adds an element of personalization to the storytelling process.

**Social Sharing:** The app allows users to share their experiences with friends and family on social media platforms, increasing the app's reach and popularity.

**Educational Value:** Many of the stories offered by the app can have educational value, teaching users about history, science, and other subjects in an engaging and interactive way.

Deliverables are as follows:

The prospective SE team will have familiarity with SE process. Over the course of this project, the SE team will need to produce several artefacts, including (but not limited to): a report on the current situation, a system requirements specification, design documentation, team management and planning documentation, prototypes, progress reports, verification and validation plans, code, code documentation, and instructions manual.

## **[P2024-21] Boat Scheduler for Berthing**

### **Requirements**

This project will require the following skills and interest:

- Proficiency in programming, especially Java or Python
- Familiar or willing to learn UI development and optimization techniques

### **Background**

In computer science, scheduling aims to make optimal schedules under certain real-world constraints. For modern ports such as Ningbo Port, tug boats are used to help container boats to berth. Tug boats are required due to the fact that container boats are usually very large and it is very difficult for them to berth by themselves. In contrast tug boats are usually very small but powerful which can pull and push container boats for better control. Usually 3 or 4 tug boats are used for berthing a single container boat. A tug boat scheduler can automatically make tug boat schedules for each day so that all the tug boats are fully utilized to help berthing without wasting any costs such as fuel or labor. For example, if three tug boats are already waiting for new job at Berth 3, there is no reason to schedule another three tug boats to come to Berth 3 from other berths for helping the container boats at Berth 3. You can expected to develop both scheduling algorithms and simple web-based UIs to complete the project. Possible techniques employed in this project include hyper-heuristics and reinforcement learning.

### **Outline**

This project aims to develop a boat scheduler that can automatically make schedule for tug boats each day. The software should at least be able to: 1) automatically make daily schedules; 2) allow manual updating the existing schedules; 3) display tug boat schedules; 4) input berthing tasks and related information, etc.

### **Tasks & Deliverables**

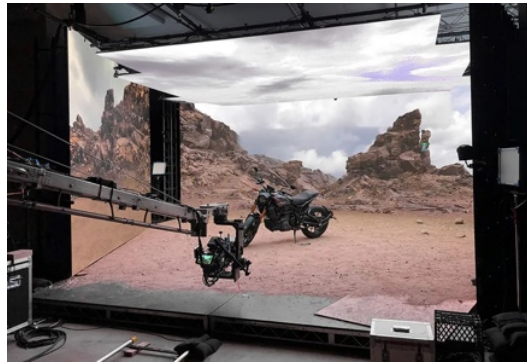
Tasks to be accomplished include: 1) overall system design; 2) GUI design and development; 3) scheduling algorithm design and development; 4) testing at different levels. The deliverable will be a boat scheduler.

**Additional Information**

Students should worry much about developing new scheduling algorithms. The project mainly focuses on the whole system other than novel scheduling algorithm.

## **[P2024-22] The Revolution is Underway: Virtual Production and Motion Capture Filmmaking – Where the Virtual and Real Collide**

### **Requirements**



**Figure 1:** Example VP and MC Studio, with Disney's Mandalorian (2019–).

The University has been approached by Dr X and Dr Y, experts in Audio-Visual Technology, to secure expertise to support the realisation of a narratively powerful and engaging short-film project using a cutting-edge Virtual Production (VP) and Motion Capture (MC) Studio in Ningbo. Planned for unveiling in February 2025, this studio offers exciting collaboration opportunities with these experts and their award-winning filmmaking team.

The project will mark the debut VP short film by these experts and their talented colleagues, using this state-of-the-art facility, with filming set to formally begin in July 2025.



**Figure 2:** Brain-Bar Example.

Based on discussions with Dr X and Dr Y, the SE team must be motivated, pay attention to detail, be capable of working both independently and collaboratively, and eager to explore and innovate to support the creative realisation of the film. The team will engage with VP technologies, including

elements not yet covered in the University's Computer Science programmes. The project vision includes:

- Engaging from the pre-production stage to devise a bespoke workflow that ensures the successful realisation of this short film.
- Creating a highly realistic virtual background, serving as the cornerstone of the production, projected on an LED Wall (see *figure 1* as example).
- A series of virtual assets manipulated and controlled using Unreal Engine, synchronised with lighting and camera systems in the VP and MC Studio (see *figure 2*).
- This resource will inspire the film crew to produce the short-film and tackle the challenges of this ground-breaking filmmaking technology.
- Additional opportunities exist for the SE team, such as leading the operation of the brain-bar during production, utilising Unreal Engine to support key creative stakeholders.

Finally, the complexity of VP filmmaking demands unique skills from diverse disciplines. Expertise in computer technology is indeed critical, driving the potential to fully harness and exploit this revolutionary approach to filmmaking.

A final potential requirement for this project may be for the SE team to create some form of *open educational resource* (OER) [R-1] that will gather their knowledge, understanding, and developed tools together in one place. This resource could then be used by future associates of Dr X, or others, to help understand many of the challenges associated with this project and technologies. For example: It may eventually form part of an on-boarding training/induction for future workers or students of the technologies.

## Background

Dr X and Dr Y bring a wealth of experience in producing traditional short films that includes guiding novice filmmakers to create professional content that resonates with international audiences. Their expertise now extends into virtual production, aiming to produce a ground-breaking short film using this revolutionary technology to support its maturity and adoption across the global film industry.

## Outline

The selected students will form an SE team and work together to complete a full cycle (maybe several full cycles) of the SE process. Relevant stakeholders (Dr X and Dr Y, their associates, and others from the University, and potentially elsewhere) will be identified, and *requirements engineering* processes

used to identify the exact SE project requirements. A final project proposal will be prepared, and the project implemented over the course of the GRP time period.

Because the SE team will need to go through *requirements engineering*, part of this project will involve applying an appropriate requirements elicitation methodology. The requirements engineering, feasibility analysis, and project scoping will all need to be completed early in the GRP time frame.

The team will need to make informed decisions about which SE process approaches or methodologies to apply to this project. (Experiences from previous SE teams may prove useful.)

Over the course of the project, the SE team will need to produce several deliverables, which may include (but are not limited to):

- a report on the current situation
- a proposed system (or systems) to implement
- a system requirements specification
- design documentation
- team management and planning documentation
- prototypes
- progress reports
- verification and validation plans
- code and code documentation
- tests and test reports
- instructions/user manual(s)
- OER

The target goal of the SE project will be to deliver, on time, a system (or several systems) that meet the requirements of the various stakeholders (both Dr Filippo and Dr Levi Dean and any others identified over the course of the project).

### **Tasks & Deliverables**

This unique project may have several groups of stakeholders, and will require significant project management skills to complete. In addition to the deliverables listed above, the team may also need to produce other resources, including recommended protocols or format specifications, or other advice for future evolution.

## References

[R-1] [https://en.wikipedia.org/wiki/Open\\_educational\\_resources](https://en.wikipedia.org/wiki/Open_educational_resources)



## **[P2024-23] Interactive Automatic Image Labeling Platform Development**

### **Requirements**

The project necessitates an adept team well-versed in both deep learning techniques and web development. Team members should have hands-on experience with contemporary deep learning frameworks, computer vision tools, and Human-Computer Interactive (HCI) systems. A strong understanding of Segment Anything Model (SAM) and image segmentation tasks is essential.

### **Background**

Artificial intelligence (AI) models based on complicated deep learning techniques have been widely used in various computer vision fields. For example, computer-aided diagnostic systems play a crucial role in the medical field. By analyzing medical images such as X-rays, MRIs and CT scans, they assist medical experts to detect diseases more accurately and efficiently. This not only accelerates the diagnostic process, but also reduces human error, resulting in improved outcomes for patients. The versatility and effectiveness of AI in different fields highlights its transformative impact on modern technology and daily life. With the ongoing development of AI, its applications are expected to revolutionize various industries.

Furthermore, image segmentation is a fundamental task in computer vision that involves partitioning an image into multiple segments or regions to simplify its representation and facilitate understanding. Different from image classification, which assigns a single label to an entire image, image segmentation aims to label each pixel in an image with a specific category. This fine-grained analysis provides detailed information about the spatial layout of objects within an image, enabling AI models to comprehend and interpret visual data more effectively. However, training such models usually require a large number of pixel-level annotated samples, which is time-consuming and expensive for medical scenarios. Therefore, it is urgent to develop an automatic image labeling platform to eliminate the demand for these labor-intensive operations.

The SAM framework is a foundation segmentation model pre-trained on a large-scale dataset. It has demonstrated remarkable generalization capabilities on unseen domain by using manual prompts (e.g., box) to guide the segmentation area. Inspired by SAM, this project aims to build a human-computer interactive automatic image labeling platform that leverages labor-saving prompts to provide a precise annotation result for each image.

## Outline

The overarching goal is to develop a comprehensive website for an image labeling platform. This platform is envisioned to be a one-stop solution, offering image data management and box prompt-based image annotation services. To facilitate different labeling scenarios, it also provides model combination, model fine-tuning and extra post-processing functions.

## Tasks & Deliverables

### 1. Front-end Development:

- User Interface (UI) Design: Craft visually appealing interfaces ensuring a smooth user journey. Adopt responsive designs to ensure compatibility across various devices, including mobiles, tablets, and desktops.
- Technology Stack: Employ modern frameworks such as Gradio and fundamental website tools, e.g., html, CSS and JS.

### 2. Back-end Development:

- Database Management: Design a relational database schema using tools like MySQL or PostgreSQL. Ensure data integrity, security, and optimization for quick retrieval.
- Model Inference: Use frameworks like PyTorch and configuration yaml files to construct AI models. Implement Anaconda libraries to build environments.

### 3. System Testing:

- Testing Types: Functional Testing: Ensure all features work as intended. Performance Testing: Assess the platform's speed, responsiveness, and stability under load. Security Testing: Identify vulnerabilities, ensuring encrypted transactions and data protection.
- Feedback Loop: Implement continuous integration and continuous deployment (CI/CD) pipelines. Use platforms like Jenkins or GitHub Actions for automated testing and deployment.

### 4. Documentation & Deployment:

- Documentation: Craft comprehensive system design documents detailing architecture, data flow, and algorithms. Create user manuals with clear instructions and illustrations. Document API endpoints, expected payloads, and responses.
- Deployment: Utilize cloud platforms like Google Colab or Azure for deployment, ensuring scalability. Implement SSL certificates for secure HTTP transactions.

**Additional Information**

Given the project's academic nature, it is paramount for the team to stay updated with the latest outcomes of foundation segmentation models. Collaboration with industry professionals, attending webinars, or participating in computer vision forums can provide valuable insights. Regular team meetings, brainstorming sessions, and peer reviews will ensure that the project stays on track and meets the desired benchmarks.

## **[P2024-24] Mobile Application and Sensor Informatics for Real-time Driver's Behaviour Detection**

### **Requirements**

The data should be collected from built-in sensors (onboard and mobile sensors) such as GPS, accelerometer, gyroscope, magnetometer, and camera. The data related to speed, acceleration, deceleration, orientation, and location will be continuously collected. After the collection of data from different sensors, data synchronization is needed in real time to ensure consistent and accurate behavior analysis. This also needs sensor calibration routines to ensure that the sensor data is accurate and free from drift or noise.

The driver behavior detection can be based on event detection algorithms, like sudden braking, rapid acceleration, sharp turns, lane drifting, and speeding, etc. The behavior classification can be performed using machine learning or rule-based algorithms to classify detected behavior as safe, normal, or risky (e.g., distracted driving, aggressive driving). In this way, it will be ensured that the data is processed in real-time to provide immediate feedback to the driver using mobile phones on in-car display systems.

The user interface for information display should be a user-friendly dashboard that displays real-time information about the driver's current behavior, including visual indicators for safe and unsafe actions.

The data analytics should provide detailed driving reports (daily, weekly, or monthly) that summarize detected behavior, driving scores, and areas for improvement. The data analytics-based real-time alerts and notifications (audio, visual, or haptic feedback) to warn drivers of risky behavior or dangerous driving events.

The most important feature is to ensure data/user privacy and security, which can be achieved through data anonymization (driver's privacy protection) and using encryption (e.g., SSL/TLS) to securely transmit data between the mobile app and any backend servers (data security).

Furthermore, the students can focus on offline functionality, like data storage, basic behavior detection, cloud integration, and mobile updates, etc.

### **Background**

The project makes use of the available advanced sensor capabilities of smartphones/cars to monitor and analyse driver behavior in real time, aiming to enhance road safety and reduce accidents. Traditional driver monitoring systems, such as in-vehicle black boxes and telematics devices, often involve high costs and limited scalability, although we can attach some low-cost devices. In contrast,

smartphones provide a cost-effective, easily deployable solution for detecting behavior like distracted driving, speeding, and harsh braking using built-in sensors like GPS, accelerometers, and gyroscopes. This project also capitalizes on advancements in machine learning to analyse sensor data and deliver timely feedback to drivers, insurance companies, and fleet managers, promoting safer driving habits, enabling usage-based insurance, and contributing to smarter transportation systems. However, it must address challenges such as data privacy, battery consumption, and ensuring accuracy to be effective and widely adopted.

## **Outline**

The project aims to develop a scalable, cost-effective solution that effectively uses sensing devices and machine learning techniques to monitor and analyse driver behavior in real time. This project seeks to enhance road safety by detecting unsafe behavior like distracted driving, speeding, and aggressive manoeuvres, providing immediate feedback to drivers, and generating valuable insights for insurance companies and fleet managers. The project involves designing a mobile app with a user-friendly interface, integrating sensor data collection and processing capabilities, and deploying machine learning models for accurate behavior detection. It also addresses key challenges related to data privacy, battery consumption, and ensuring accuracy to encourage widespread adoption and promote a culture of responsible driving.

## **Tasks & Deliverables**

The prospective team has to perform the following tasks along with others. For example,

- Project planning
- Requirements elicitation
- Literature review
- System architecture
- Design documents
- Data collection framework
- Trained machine learning models
- Mobile application (Android and iOS) development
- Backend infrastructure
- Testing and evaluation

- User Feedback
- Data privacy and security compliance
- Final project report
- Project presentation.

### **Additional Information**

Something the students suggest.