澳門理工大學
Universidade Politécnica de Macau
Macao Polytechnic University

Faculty of Applied Sciences

Bachelor of Science in Computing

Proposed Project List (by Teachers) for COMP490 Final Year Project

Academic Year 2022/2023

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PROPOSED BY REBECCA CHOI

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1. Smart Photograph Cropping Tool

Background

In daily life, we often need to submit photos for different applications, for example, driver license, visitor visa, membership, etc. As nowadays everything turns into digital, it is common that the photo needs to be submitted in digital form. However, if you take photo in a photography shop, it is common that the shop just gives you the original photo without cropping, which is very inconvenient if you need to submit a soft copy with certain requirements, like image dimensions, eye height proportion and from chin to crown proportion.

With the technique of face recognition, the position of face and eyes can be recognised, hence, it can help in automate the cropping process, which fulfils the image dimensions requirement, keeps the face to be centred and maintains the given proportion. For the photography shop, as they take photos for several customers every day, it is preferable the cropping process can be done in a batch.

In this project, student will develop an application which helps in cropping photograph automatically according to the given requirements, options like identity card and visitor visa will be provided for the user to choose, which predefines different photograph requirements. In addition, user can also customize different photo requirements like image dimensions, head size, file size, etc. For commercial use, batch processing is also provided in the application for cropping a batch of photos in photography shop.

Project Objectives

In this project, the main objectives are as follows: (i) Develop an application which helps in cropping photograph automatically according to the given requirements. (ii) The resultant photo should keep the face to be centred with the technique of face recognition. (iii) Provide some options with predefined photograph requirements for user to choose. (iv) Implement batch processing to crop images in a batch.

The student is expected to have good programming skills and basic knowledge about database.

2. Supermarket Discount and Promotion News Sharing Platform

Background

In recent decades, there is a rapid growth of supermarkets in Macau. In order to attract consumers out of other competitors, there are discounts and promotions for certain goods constantly, usually in limited time or specified period. As a consumer, it is desirable to know all these news and information. However, modern people have busy life, they may not get notice of these promotion information which come from different supermarkets in time. Nowadays, urban people always connect to the internet with their mobile devices, they share news in a speedy manner. It is good and efficient that this promotion news come from different supermarkets could be spread by the consumer themselves voluntarily and collaboratively.

To deal with this, in this project, the student will develop a mobile platform that allows consumers to fill in promotion news carried out in different supermarkets, so that others could know the promotion news in time. In addition, for efficient display, different filtering function will be provided for viewing information, for example, outdated news could be hidden.

Project Objectives

The objective of the project is to develop a mobile platform that allows consumers to share on going discount and promotion information of various goods that carry out in different supermarkets. The main features of the mobile platform include: (i) Consumers could fill in promotion information in given format, that includes product name, discounted price and location. (ii) Filtering and searching function should be provided for the information access. (iii) GPS data is accessed for auto-filling promotion location information. (iv) Barcode scanning function is provided for auto-filling product information.

The student is expected to have good programming skills and basic knowledge about database.

Proposed by Rebecca Choi

3. Travel Itinerary Planning Algorithm based on Genetic Algorithm

Background

Nowadays, people like to travel around for their vocation, and a good travel experience requires detailed planning. However, Itinerary planning is a time consuming task, it takes time to do research on tourist attractions, transportation, stores and hotels. A good itinerary should not have unnecessary loops in the routes to minimize the travelling time; and should include as much high rating tourist attractions as possible to increase the tourist satisfaction. For itinerary planning, it is also desirable to make sure that the tourist attractions or stores are opening when the tourist visits them.

In this project, the student will propose an algorithm for travel itinerary planning problem based on genetic algorithm. With the algorithm, it is expected that a schedule with highly rated tourist attractions will be generated, and the route should be efficient and prevent unnecessary loops.

Project Objectives

The objectives of the algorithm include: (i) An itinerary with highly rated tourist attraction should be generated. (ii) The route of the itinerary should be efficient and prevents wasting time on travelling. (iii) Time window for the operation hours of tourist attractions or stores should be handled. (iv) Extra features like restaurant and/or hotel suggestion will be implemented if possible.

The student is expected to have good programming skills and basic knowledge about database.

4. Artificial Intelligence based Class Timetable Scheduling System

Background

In higher education institution, in order for the student to complete a degree, there are several courses need to be taken. For scheduling a feasible timetable, it needs to prevent all the time conflicts that may arise not only for students, teachers and also venues. It should be ensured that at a given time, teachers would not have more than one class; students would not have class for more than one course, and venues would not be scheduled for more than one class. Moreover, the scheduled venue should provide necessary equipment for the course and enough seats for enrolled students. Furthermore, in some emergency situations the class may be cancelled (e.g. the teacher is sick), it would need to handle the make-up classes. The timetable may need to be updated accordingly.

Project Objectives

In this project, student should apply artificial intelligence technique to implement a class timetable scheduling system which includes the following functions: (i) A user interface should be provided for the administrator to insert or modify the attributes for given courses and venues. (ii) Schedule a conflicts-free class timetable based on artificial intelligence technology. (iii) Develop a function for updating the schedule to handle make-up class and/or cancelled class. (iv) Provide different views of timetable which includes student timetable, teacher timetable and venue timetable.

Proposed by Rebecca Choi

The student is expected to have good programming skills and basic knowledge about database.

5. MPU Navigation System

Background

Macao Polytechnic University is convenient to access by public transport and reachable by walking distance. The visitors can move around the campus by walking, even though Macao Polytechnic University is not big, there are several buildings and facilities in the campus. Visitors may not know the direction to different buildings, or how to walk through different venues of the building. In most of the buildings in MPU, there are usually more than one paths to reach the venues, and the room numbers are usually not straightforward. Hence, not only the visitors, the staffs and students may also make a detour. It is desirable to have a navigation system to guide people to the designated venues. Moreover, due to epidemic or other events, some paths or gates are blocked, it is more convenient for people to get notice of the updates with the navigation system.

Project Objectives

In this project, student should implement a navigation system for Macao Polytechnic University which includes the following functions: (i) Provide a map which includes all the venues in Macao Polytechnic University (ii) Design a user interface for people to enter the current location and the designated destination. (iii) Develop the function and provide an interface for the administrator to update the state of path and gate. (iv) Generate a shortest path to reach the designated location without passing the blocked gate and path.

The student is expected to have good programming skills and basic knowledge about database.

Proposed by Rebecca Choi

PROPOSED BY WILSON HO

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1. Mobile App for finding Electric Vehicle Charging Stations

Background
As the global auto industry spends billions to go green, the number of electric vehicles in Macao is growing rapidly. Most EV owners cannot charge their vehicles at home. It is hard to find available electric vehicle charging stations for EV owners to charge their vehicles as there are not sufficient public EV charging stations in Macao. Unfortunately, there is no mobile app available for local EV owners to find available nearby charging stations. Hence, this project aims at building a handy mobile app to locate available charging stations near the user. The goal is to minimize time spent in the searching process.

Project Objectives
The student is required to:
- explore various web data extraction techniques and mobile GPS technology;
- identify the functional and non-functional requirements of the system;
- design the system architecture and the functions of system;
- develop a mobile app (Android/IOS) for searching available nearby charging stations;
- develop the front-end and back-end systems for information processing;
- Compose a final project report.

References
https://ev.cem-macau.com/zh/WhereToCharge
http://www.hkevpower.com/apps/eng/index.html App EVPower (HK)

2. Taking Student Attendance by Using RFID

Background

Taking attendance in the classroom is easy when there are 5-10 students. But what if there are 40 or even 100 students in the classroom? It is definitely a time-consuming task and hinder the teaching progress of teachers.

By using RFID, taking attendance in the classroom is easier and faster. It only requires minimal teacher interventions. It also greatly reduces the amount of paper resources needed in attendance data management.

A normal/long range RFID reader is placed in each classroom. A student can self-record his/her attendance by using his/her smart phone as a unique RFID tag during the timetabled session period. His/her relevant attendance record can then be recorded in the system.
At the end of the class, the teacher can make any necessary changes in the attendance record and submit the attendance for the whole class.

Project Objectives

The student is required to:
- do literature review on RFID technology;
- explore the features of normal and long range RFID readers and decide which one is suitable to be used in this project;
- identify the functional and non-functional requirements of the system;
- design the system architecture and the functions of system;
- develop a mobile app for self-recording by using Google Flutter
- develop the front-end and back-end systems for information processing;
- provide weekly and monthly attendance report generation for both teachers and students;
- Compose a final project report.

References:

https://docs.flutter.dev/get-started/install/windows

Remark:

Student should purchase a normal/long range RFID reader for project implementation.

Proposed by Wilson Ho

3. Taking Student Attendance by Using Beacon Technology

Background

Taking attendance in the classroom is easy when there are 5-10 students. But what if there are 40 or even 100 students in the classroom? It is definitely a time-consuming task and hinder the teaching progress of teachers.

By using Beacon technology, taking attendance in the classroom is easier and faster. It only requires minimal teacher interventions. It also greatly reduces the amount of paper resources needed in attendance data management.

A student can self-record his/her attendance by acknowledging a notification send by a beacon in the classroom on his/her mobile phone during the timetabled session period. His/her relevant attendance record can then be recorded after providing his/her student ID and correct password.
At the end of the class, the teacher can make any necessary changes in the attendance record and submit the attendance for the whole class.

Project Objectives

The student is required to:
- do literature review on Beacon technology;
- explore different types of beacons and decide which type can be used in this project;
- explore the features of 2 Beacon protocols (IBeacon^{TM} and Eddystone^{TM} Beacon) and decide which one is suitable to be used in this project;
- identify the functional and non-functional requirements of the system;
- design the system architecture and the functions of system;
- develop a mobile app/web application for self-recording
- develop the front-end and back-end systems for information processing;
- provide weekly and monthly attendance report generation for both teachers and students;
- Compose a final project report.

References:
https://en.wikipedia.org/wiki/Indoor_positioning_system
https://www.youtube.com/watch?v=2YorsgulwdU

Remark:
Student should purchase several beacons for project implementation.

Proposed by Wilson Ho

4. Android App for MPU FCA Open Day Scavenger Hunt by Using Beacon Technology

Background

MPU open day is a special occasion that we can invite members of the public to visit our university to which they do not usually have access. It is a perfect opportunity for visitors to ask questions, understand requirements for different programmes, and get a real feel for the learning environment at the Open Day. Visitors can also visit our research laboratories to find out our past research achievements and current research projects. In order to let our visitors actively engage in our open day, we normally provide a scavenger hunt for visitors to explore and identify key locations on campus (like computing laboratories and library etc.). Once a visitor can finish all the missions successfully, a souvenir will be given away. This project aims to use Google Flutter to develop an android app for FCA Open Day scavenger hunt.

Project Objectives

The student is required to:
- do literature review on Beacon technology;
- explore different types of beacons and decide which type can be used in this project;
- explore the features of Eddystone^{TM} Beacon;
- identify the functional and non-functional requirements of the system;
- design the system architecture and the functions of system;
- develop a mobile app for scavenger hunt by using Google Flutter
- develop the front-end and back-end systems for information processing and analysis;
- Compose a final project report.

References:

https://docs.flutter.dev/get-started/install/windows
https://www.scavify.com/blog/10-essential-college-scavenger-hunt-ideas-for-students#contact-form

Remark:

Student should purchase several beacons for project implementation.

Proposed by Wilson Ho

5. Flutter based Image Recognizer and Translator

Background

Image recognition technology is growing rapidly. With the help of technologies such as artificial intelligence and machine learning, drastic improvements were made to image recognition technology. There are many image recognition apps on Google Play Store or App Store and they allow users to find, recognize, and identify specific objects in images. For example, Google Lens is an image recognition mobile app that can identify objects through a mobile device's camera. Users take a photo of a physical object, and Google searches and retrieves information about the image. Unfortunately, recognition results are in English only and it is not good for non-native English users. This project aims to use Google Flutter to develop an android app for image recognition and result translation. The mobile app uses object detection features from Google Cloud vision API to recognize the object in the captured image and then translates the result into a preferred language such as Tradition Chinese by using Google Translation API. Text-to-speech feature will also be provided.

Project Objectives

The student is required to:
- do literature review on computer vision;
- explore the features of Google Cloud Vision API and Google Translation API;
- design the system architecture and the functions of system;
- develop a mobile app by using Google Flutter;
- Compose a final project report.

References

https://www.tekrevol.com/blogs/best-image-recognition-apps/
https://medium.com/dreamwod-tech/cloud-vision-vs-flutter-mlkit-for-ocr-detection-of-concept2-machine-514098f894af
https://pub.dev/packages/google_translator
https://play.google.com/store/apps/details?id=com.google.ar.lens&hl=en&gl=US
https://play.google.com/store/apps/details?id=com.ldqstudio.image_recognizer&hl=en_US&gl=US

Proposed by Wilson Ho

PROPOSED BY LIAM LEI

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1. Web-Based Fractal Visualization Application

Background
In mathematics, a fractal is an object or quantity that displays self-similarity. It processes structural self-similarity on multiple spatial scales, meaning that a fractal piece will always look like a whole. Most artificial objects have simple geometric shapes such as squares, cubes, circles, or spheres. But the natural objects such as a tree, a snowflake, blood vessels or, mountain ranges don't easily fit into this simple geometric category. Fractal is the most suitable mathematics tool that describes this kind of natural object. On the other hand, because of fractal's beautiful structures, it is also widely used in art.

The Web-based fractal visualization tools provide the functions that generate significant fractal models and visualize them. The models include Sierpinski carpet, Mandelbrot set, Julia set, Koch snowflake, etc. The user interface (UI)of the web page can be used to show the fractal image. The user can navigate the image detail through mouse and keyboard; interactively change different models and parameters to get different visual results.

Objectives
Implement such a web-based visualization tool requires developers familiar with conventional techniques for generating fractals that include Iterated function systems (IFS), L-system, strange attractor, finite subdivision rules, etc. Therefore, this project contains the following objectives:
- Do a literature review on the fractal.
- Develop a responsive web page that can automatically adjust for different screen sizes and viewports.
- Design a user interface that includes input fields, buttons, and sliders to adjust parameters through the interface elements.
- Using iterated function systems (IFSs) method to construct and draw some fractal entities
- Implement the L-system method to construct and draw some fractal plants.
- Implement the Random fractals method to construct and draw some fractal entities.

Skills required: The student who chooses this topic should be interested in Computer Graphics technologies and fractal models. He/she is expected to have the following skill sets: programming languages such as JavaScript and basic Web design knowledge (HTML/CSS).

References:
[1]. Fractal, Michael Barnsley, Fractals Everywhere, Academic Press, INC. 1988, ISBN: 0-12-0790-62-9.
[2]. Mozilla Foundation, WebGL Working Group, WebGL, https://www.khronos.org/webgl/
[3]. JavaScript Programming, Marijn Haverbeke, Eloquent JavaScript, 3rd Edition: A Modern Introduction to Programming. No Starch Press; 3 edition (December 4, 2018).
[4]. Front-end development, Francesco Strazzullo, Frameworkless Front-End Development: Do You Control Your Dependencies Or Are They Controlling You?, Apress, 2019, ISBN: 14-8424-966-6.
[5]. 3D rendering Three.js, https://threejs.org/docs/

2. Large Scale Terrain LOD Rendering

Background

In computer graphics and GIS (Geographic Information System), rendering large-scale terrain scenes in real-time is challenging, especially in the web environment. Because the large-scale terrain has enormous triangles, these triangles needed to be transferred from server to client. If the app starts rendering until all triangles have been transferred, the user has to wait a long time to see the 3D terrain scenes. On the other hand, rendering such great numbers of triangular mesh is a very time-consuming process. To improve the rendering and transfer speed, scholars have proposed the idea of static Level of Detail(LOD) representation for large-scale terrain models. Using LOD technology, people can reduce the amount of data at different levels. That accelerates the transfer and rendering time.

The LOD representation generally refers to the number of primitives need to present the model, as determined by the distance between the position of the 3D model in the scene and the view angle between the model and camera.

Objectives

In this project, the student is expected to achieve:
- Learn the relevant knowledge of 3D Mesh representation.
- Do the literature review on LOD
- Develop a responsive web page that can automatically adjust for different screen sizes and viewports
- Develop a LOD terrain model loader
- Develop a LOD terrain renderer
- Design and implement a user interface that includes input fields, buttons, and sliders to adjust LOD parameters through the interface elements.

Skills required: The student who chooses this topic should be interested in Computer Graphics technologies and LOD algorithms. He/she is expected to have the following skill sets: programming languages such as JavaScript and basic Web design knowledge (HTML/CSS).

References:

[1].LOD, Level of detail for 3D graphics, David Luebke, Morgan Kaufmann Publishers.
[2]. Mozilla Foundation, WebGL Working Group, WebGL, https://www.khronos.org/webgl/
[3]. JavaScript Programming, Marijn Haverbeke, Eloquent JavaScript, 3rd Edition: A Modern Introduction to Programming. No Starch Press; 3 edition (December 4, 2018).
[4]. Front-end development, Francesco Strazzullo, Frameworkless Front-End Development: Do You Control Your Dependencies Or Are They Controlling You?, Apress, 2019, ISBN: 14-8424-966-6.
[5].3D rendering Three.js, https://threejs.org/docs/

Proposed by Liam Lei

3. Shader-Based Image processing Tools

Background
Digital Image Processing is an area that uses a digital computer to process digital images through algorithms. The generation and development of digital image processing are mainly affected by three factors:
1. The development of computers;
2. The development of mathematics;
3. The demand for a wide range of applications in the environment.

Today's image processing software is widely used in agriculture, military, industry, medical science, etc. These algorithms can be separated into different categories: image transformations, denoising, filtering, etc.

A virtual digital image representation in the modern computer is a two dimensions (perhaps more) array, so many algorithms must manipulate every element in the array. In most cases, this operation is time-consuming. Everybody who tries to implement a good algorithm quickly understands he now has severe performance issues. Luckily people found a solution and invented GPUs. GPUs are especially good at doing things simultaneously. While modern processors usually have 4-8 cores, any decent graphics card has thousands. So in this project, ask the student to use modern GPUs to implement some frequently used image processing algorithms.

Objectives
In this project, the student is expected to achieve:
- Learning the relevant knowledge of digital image processing
- Learning how to deal with the multidimensional array in Shader Language (GLSL)
- Go through all the steps of the system design process.
- Develop a user-friendly UI for user interaction.
- Develop Image transformation algorithms like image flick, image twist, etc.
- Develop Image filtering algorithms like image enhancement, image blur, etc.

Skills required: The student who chooses this project should be interested in digital image processing. They are expected to have the following skill sets: know the basic concept of programming languages such as JavaScript and basic Web design knowledge (HTML/CSS). See how the basic concepts of digital image processing, like what is an image filter and also need to know some fundamental mathematics concepts about matrices and vectors and operations on them.

References:
[1]. Mozilla Foundation, WebGL Working Group, WebGL, https://www.khronos.org/webgl/

[2]. JavaScript Programming, Marijn Haverbeke, Eloquent JavaScript, 3rd Edition: A Modern Introduction to Programming. No Starch Press; 3 edition (December 4, 2018).

[3]. Front-end development, Francesco Strazzullo, Frameworkless Front-End Development: Do You Control Your Dependencies Or Are They Controlling You?, Apress, 2019, ISBN: 14-8424-966-6.

[5]3D rendering Three.js, https://threejs.org/docs/
[6] Rafael C. Gonzalez, Richard E. Woods - Digital Image Processing (2008, Prentice Hall)
[7] David Wolff, OpenGL 4 Shading Language Cookbook, Packt publication

Proposed by Liam Lei

4. Indie Game Design and Development

Background
Creating a video game is so fascinating and challenging. The game design and development need a wide range of knowledge and skills. A game involves interaction with a user interface or input device to generate visual feedback. This feedback is most commonly shown on a video display device. Video games are defined based on their platform, including arcade, console, PC, and mobile games. As indie game designers, they must take care of all game parts, including character design, level design, modelling, physic, developing, rendering …

When you create a game as an individual developer, there are lots of design decisions you need to make. You need to design which platform you want to deploy. what kind of game do you want to implement, 2D shote, 3D shote, RPG, or ACT? Create the character models, maps, enemies, and audio you want to use in the game. So there are lots of game design and development challenges, especially as an indie game designer.

Objectives
In this project, the student is expected to achieve:
- Design the whole structure of the game.
- Design the game logic and game background.
- Create the player and enemies
- Create the video and sound effects that are used in the game.
- Develop the game interface
- Develop the different game level
- Develop the game score system
- Develop the game interaction system

Skills required: The student who chooses this project should be interested in game design and development. They are expected to have the following skill sets: know the basic concept of programming languages such as C# and GDScript. Understand the basic concepts of game design and development. Have entry-level game engine experiences. They know how to create a simple scene and move a character from one place to another.

References:
[1] https://en.wikipedia.org/wiki/Indie_game
[2] Jesse Schell, The Art of Game Design: A Book of Lenses, CRC Press; 3rd edition (July 31, 2019)
[3]Learning Unity, https://learn.unity.com/
[4] Learning Godot, https://docs.godotengine.org/en/stable/
[5] Learning Game Design, https://www.extracredits.site/

Proposed by Liam Lei

5. Shader-based Online Interactive Fluid Simulator

Background
In computer graphics, a shader is a computer program that calculates the appropriate levels of light, darkness, and color during the rendering of a 3D scene. Shaders have evolved to perform a variety of specialized functions in computer graphics special effects and video post-processing, as well as general-purpose computing on GPUs. Shaders are used widely in cinema post-processing, computer-generated imagery, and video games to produce a range of effects. Beyond simple lighting models.

The Shader-based online Interactive Fluid Simulator is a web application that renders the fluid simulate result according to the user inputs and group of parameters. The term "shader-based " means that this application uses the shader technology, and all the simulations are accomplished on the GPU by shader programs. The aim of the shader programs are to produce the calculated result of the color of every pixel on the screen.

Objectives
In this project, the student is expected to achieve:
- Design the whole structure of the App.
- Choose the fluids simulation equation that is used in this project.
- Design the algorithm according to the equation that is chosen before.
- Implement the simulation algorithm
- Implement the interactive UI
- Implement the simulation shader programs.

Skills required: The student who chooses this project should be interested in computer graphics. They are expected to have the following skill sets: know the basic concept of programming languages such as JavaScript and basic Web design knowledge (HTML/CSS). See how the basic concepts of fluids simulation, like what is the aim of the fluid simulation for. Prefer to know some fundamental mathematics concepts about matrix, vector, limit, derivative, and operations on them.

References:
[1]. Mozilla Foundation, WebGL Working Group, WebGL, https://www.khronos.org/webgl/

[2]. JavaScript Programming, Marijn Haverbeke, Eloquent JavaScript, 3rd Edition: A Modern Introduction to Programming. No Starch Press; 3 edition (December 4, 2018).

[3]. Front-end development, Francesco Strazzullo, Frameworkless Front-End Development: Do You Control Your Dependencies Or Are They Controlling You?, Apress, 2019, ISBN: 14-8424-966-6.

[5]3D rendering Three.js, https://threejs.org/docs/
[6] http://developer.download.nvidia.com/books/HTML/gpugems/gpugems_ch38.html
[7] https://github.com/mharrys/fluids-2d
[8] Robert Bridson, Fluid Simulation for Computer Graphics, CRC Press, 2016, 2nd edition

Proposed by Liam Lei

PROPOSED BY PHILIP LEI

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1. Knowledge tracing based on skill-tagged educational dataset

Massive Online Open Courses (MOOCs) and mobile learning systems allows a large number of students to enrol, participate in learning activities, and attempt assessments in diverse pace of learning. These technologies have given worldwide students of various social classes the opportunities to obtain high-quality education. However, a common issue in online and mobile learning system is a high dropout rate. Learning progression that is inappropriate for a student's knowledge level may readily discourage the student, resulting in low motivation and eventual dropout.

One approach to mitigate these issues is to apply machine learning techniques to gauge the knowledge level of different skills (also known as knowledge components) of a student, and to provide suitable suggestion for revision of difficult skills for the student. One can also employ machine learning techniques to detect students with a high probability of early dropout, and redirect the students to human tutors if necessary.

This project aims to apply educational data mining on existing massive educational dataset (e.g., EdNet, https://github.com/riiid/ednet) to model the learning pace of students and/or probability of dropout. Some possible objectives are:

- Investigate the various factors, available in the dataset, that may reflect the knowledge levels of students of different knowledge components. These include the multiple skills that each problem requires in the performance data of students.
- Review knowledge tracing models and/or dropout detection algorithms in the literature.
- Design and evaluate educational data mining algorithms that exploit newly available factors for more accurate prediction.
- Perform classification of students in the dataset to distinguish different learning pace and style, and study whether classification can improve the accuracy of knowledge tracing.

Related skills and technologies:
- Machine learning, artificial neural networks, Python

Further information:
- https://paperswithcode.com/dataset/ednet
- https://sites.google.com/ncsu.edu/csedm-dc-2021/home
- https://github.com/CAHLR/pyBKT

2. Parsons problem generator and solver

Programming is challenging to many learners. They have to master numerous problem-solving skills and acquire knowledge of the syntax and semantic of different programming language features in order to write correct solution to solve programming problems. To mitigate the steep learning curve, various exercises have been designed in the literature to assist learners to study programming.

One popular type of programming exercises is Parsons problems. In these problems, both the programming problem prompts and the solution source codes are provided. However, the solution codes are broken into units (e.g. 1 or more line of code). Learners will rearrange the units (e.g. by drag-and-drop) to re-create a correct solution.

In this project, a student will create a Parsons problem generator with a user interface to solve the problem. The project has the following objectives:
- Study the literature for the application and variations of Parsons problems in learning programming.
- Design a Parsons problem generator for Python (or other language chosen by the student).
- Introduce new feature, e.g. distractor lines that are similar to the correct lines, but contain subtle bugs like incorrect variables.
- Implement a user interface for learners to solve the generated Parsons problems.

Reference:
- Yuemeng Du, Andrew Luxton-Reilly, and Paul Denny. 2020. A Review of Research on Parsons Problems. In Proceedings of the Twenty-Second Australasian Computing Education Conference (ACE'20). Association for Computing Machinery, New York, NY, USA, 195–202.
- https://js-parsons.github.io/

Proposed by Philip Lei

3. Program tracing exercise tool

Program tracing exercise is an effective assessment tool to test whether learners know the run-time behavior of simple programs. Typically, a short program is given, which includes one or more checkpoints in which the program displays the value of some variables or some messages. The learners then determine the values of variables and/or the output of the program by manual tracing (without actually running the program using a computer).

In this project, students will study the current usage of program tracing in programming education and assessment, and design a tool for generating program tracing problems and auto-grader. The objectives of the project are as follows:

- Study the literature for variations of program tracing exercises.
- Design a tool for generating program tracing exercises.
- Propose new schemes to overcome limitation of current program tracing tools, e.g. partial marks, problem template that can produce slight variation of problems that can discourage online exam cheating.
- Implement an auto-grader for the program tracing tool.

References:
- Wei Jin. 2020. Automatic Grading for Program Tracing Exercises. Proceedings of the 51st ACM Technical Symposium on Computer Science Education. Association for Computing Machinery, New York, NY, USA, 1409.

4. Spaced practice with study progress tracking

As evidenced in research in educational psychology, spaced practice has been proved to be a more effective strategy than cramming, and to improve retention and possibly deepen understanding. However, an optimal scheme to space out review and practice is not enough. A study tool also needs to consider the study progress of individual item, and arrange suitable frequency for the distributed practice. In addition, learners may become bored when they encounter identical exercises repeatedly within a short period. In this project, students will study the previous work in spaced practise, and investigate how to apply existing knowledge in a chosen domain of study. The project objectives are the following.

- Review the literature on spaced practice and study progress tracking.
- Choose a domain of study and identify the common kinds of practice in the domain.
- Investigate how to organize the practice exercises (e.g. by topics/skills) and if appropriate, generate variation of an exercise.
- Design a suitable method to space out practice, including a suitable mix of reviewed topics, weak topics and new topics.
- Track the study progress by auto-grading the exercises.
- Implement the above functions in user-friendly study tool.

References:
- https://psychology.ucsd.edu/undergraduate-program/undergraduate-resources/academic-writing-resources/effective-studying/spaced-practice.html
- Iman YeckehZaare, Paul Resnick, and Barbara Ericson. 2019. A Spaced, Interleaved Retrieval Practice Tool that is Motivating and Effective. In Proceedings of the 2019 ACM Conference on International Computing Education Research (ICER '19). Association for Computing Machinery, New York, NY, USA, 71–79.

Proposed by Philip Lei

5. Blockchain-enabled professional profile management

The Ethereum blockchain platform provides a distributed computing foundation to implement decentralized, robust and non-repudiable transactional systems. Distributed applications known as DApp in Ethereum provides a promising platform for designing and implementing auditable information systems that involve many users and servers with little trust with one another.

In this project, students will study the DApp development platform and build a decentralized professional profile management system. Professional profile of a person usually includes his/her contact information, education, working experience, professional qualification, skills, academic publication and CPD (continuous professional development). The professional profile is owned by the person, but can be shared to potential employers or the public (fully or partially). The owner can also authorize third-party (e.g. university and professional certification authorities) to append entries.

Project objectives are the following:
- Identify the major stakeholders of professional profile management, and the operations they are allowed on the profile.
- Investigate how blockchain technology like Ethereum can enforce the ownership of the profile information, and ensure the authenticity of entries about educational and professional qualifications.
- Design a professional profile management system with a distributed architecture, which consists of both on-chain and off-chain components.
- Implement and evaluate a prototype of the professional profile management system as a distributed app (DApp) on blockchain.

Reference
- A.M. Antonopoulos, G. Wood. *Mastering Ethereum: building smart contracts and dapps*, 1st edition, O'Reilly
- K. Iyer, C. Dannen. *Building Games with Ethereum Smart Contracts: Intermediate Projects for Solidity Developers*, 1st edition, Apress
- https://ethereum.org/en/dapps/
- https://research.csiro.au/blockchainpatterns/

Proposed by Philip Lei

PROPOSED BY YUE LIU

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1. Algorithms and applications for Reinforcement Learning game confrontation

In March 2016, AlphaGo played against South Korean professional Go player Lee Sedol, ranked 9th dan and one of the best players in Go, which was video-streamed. Reinforcement Learning (RL) then entered the picture, capable of learning and surpassing millennia of human wisdom in a fixed domain. The common types of confrontation in the game are PVE and PVP, and the game types are cooperative settings, competitive settings, and hybrid settings. The project uses team-based combat games for simulation and learning, i.e., teams play against each other and cooperate within the group. The base objective of this project requires students to build a game based on Markovian decision processes or to implement a python interface to an existing game. Afterward, the Multi-agent algorithm is successfully run in a new game environment. The advanced goal is that students will need to design or modify the Multi-agent algorithm for any model and use it to compare with other algorithms. Can Multi-Agents achieve a higher win rate than humans in a game? Will Multi-Agents create a team spirit in games that humans have or have not seen before? Will humans learn from the Multi-Agent experience and ultimately improve their win rate? All these questions will be explored and answered in this project.

Project objectives
The student requires to:
1. Learn about QMIX algorithm via reference [1].
2. Learn about Markov decision process and Reinforcement Learning.
3. Find or design a game interface.
4. Implement multi-agent training in games and achieving better results. Comparing human experience and mining multi-agent-generated experience.
5. Compose a final project report.

Programming language/tool: Python

Reference Reading
1. The video demo of QMIX algorithm: https://www.youtube.com/watch?v=r5zlu7A1Om8
2. SMAC environment introduction: https://github.com/oxwhirl/smac
3. Introduction of Markov decision process:
   https://en.wikipedia.org/wiki/Markov_decision_process
4. Introduction of Reinforcement Learning:
   https://en.wikipedia.org/wiki/Reinforcement_learning
5. TensorFlow, tutorial and examples: https://www.tensorflow.org/overview/
6. PyTorch, documentation, https://pytorch.org/

Notes
1. Much engagement time and an active spirit of learning and exploration are required.

2. Machine Learning and Data Visualization from Titanic Disaster

On 15 April 1912, on her maiden voyage, the Titanic, widely regarded as 'unsinkable', sank after colliding with an iceberg. Unfortunately, there were not enough lifeboats for everyone on board, resulting in the deaths of 1,502 of the 2,224 passengers and crew. In the face of disasters such as these, humans want to apply machine learning to gain experience and explore the potential connections between the various factors involved. The fundamental objective of this project is to explore the association between survival rates and other information and to construct machine learning models to predict survival rates through machine learning models. Statistical analysis of the data is also one of the fundamental objectives. The advanced goal is to show the shape of the data, the correlation of the data, the machine learning process, and the conclusions through data visualization. And to explore the connections between data other than survival rates.

Project objectives
The student requires to:
1. Learn about Machine Learning, Deep Learning and other related technologies.
2. Find or generate datasets for training.
3. Complete the implementation of prediction, visualization, and data analysis of the survival rate of the Titanic passengers.
4. Compose a final project report.

Programming language/tool: Python

Reference Reading
1. Topic website: https://www.kaggle.com/competitions/titanic
2. Introduction of Machine Learning: https://en.wikipedia.org/wiki/Machine_learning
3. TensorFlow, tutorial and examples: https://www.tensorflow.org/overview/
4. PyTorch, documentation, https://pytorch.org/
5. Keras, documentation, https://keras.io/

Notes:
1. Much engagement time and an active spirit of learning and exploration are required.

Proposed by Yue Liu

PROPOSED BY BETTY LO

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1. Online Weather Station

Weather refers to the conditions of the atmosphere around the Earth. The major components in weather includes temperature, pressure, wind speed & direction, humidity, precipitation, and cloudiness and they together describes the weather at any given time. Weather can affect people's daily lives. It can be destructive or manipulated to help people. Agriculture industries depends on rain and certain climates. However flash floods or typhoons can cause disasters. As technology advanced, we can now forecast these harmful weather conditions and prepare for these catastrophes before they happened.

What is the first thing you do every morning when you wake up? Look out of the window and see what the weather like? Knowing current weather and listening to weather forecast helps you to decide what to wear and may affect what you do throughout the day. Nowadays with the advanced technology we can easily get the weather information through internet.

The aim of this project is to develop an Android mobile application that collects weather information through APIs, store them in the database and visualize the real time and forecast weather information in the mobile application. Student also needs to analysis the information and provide suitable clothing and outdoors activities accommodations. Finally alert user when there is severe weather condition.

Project objectives:
- Design and develop an android mobile application
- Retrieve weather information
- Visualize the collected information
- Analysis the collected information and provide suitable clothing and outdoor activities recommendations
- Alert user in severe weather condition
- Provide basic user's customization

Skills required:
Student is expected to process good programming skill, basic knowledge on mobile application development, SQL and database administration.

References:
Open Weather Map, https://openweathermap.org/api
Weather API, https://www.weatherapi.com/api.aspx
Android Studio, https://developer.android.com/studio/intro
Java, https://developer.android.com/codelabs/build-your-first-android-app#0
Flutter, https://docs.flutter.dev/

2. Pet Tracker

Many people like to keep pets because pets can help manage loneliness and depression by giving us companionship. Most common types of pets are dog, cats, fish, rabbits… etc. To be a pet owner is not easy. Not only does he need to know his pet characteristics, temperament and treats it accordingly, he also has to take care of every aspect of his pet. Dogs or cats need to be groomed regularly, get vaccinations or dental check up on schedule, renew license annually and as a owner he has to note any allergies too. Most pet owners have trouble in keeping their pets information organized, particularly for the multi pets' owners. Therefore it will be great to have an application that can help the pet owners to record their pets' information, vaccine records, grooming, health check or prescription refills schedules in his mobile. In case of accident or sudden illness it would be helpful if this application can provide the nearby veterinary care centre information.

There are different types of pets, for those who wish to become a pet owner and want to find out more about various breeds of pets, it will be helpful if they can just use their phone, take a picture of the pet they met and obtain detail information and interesting facts about that animal.

The major objectives of this project is to design and develop an Android mobile application, to help the pet owners to record their pets basic information, health records, insurance details… etc. It allows the owner to put all of their pets' necessary information in one place. In case of emergency need, this application can help the pet owner to find the nearest veterinary clinic. To help user to understand different types/breeds of pet this application will have a pet recognition function which can provide basic information of different type/breeds of pets.

Project objectives:
The main project objectives includes:
- Design and develop an Android mobile application,
- Implement pet recognition function and provide the basic pet information
- Record the pets information,
- Keeping track of the pet's different appointments
- Locate the nearest veterinary care center

Skills required:
Student should have good programming skill, basic knowledge of mobile application development, SQL and database administration.

References:
Android Studio, https://developer.android.com/studio/intro
Java, https://developer.android.com/codelabs/build-your-first-android-app#0
Flutter, https://docs.flutter.dev/
Google Map, https://developers.google.com/maps
Teachable Machine, https://teachablemachine.withgoogle.com/

Proposed by Betty Lo

PROPOSED BY EVELYN LO

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1. Foreign language Learning App

Background:

Learning a foreign language through online courses [1] can have many benefits such as using multimedia, repetition, different learning methods, accessibility and autonomy. Currently, multimedia features applied to learn in e-learning such as videos, audio, chat rooms, webcams, online web page and even mobile apps. However, technology innovation cannot make to learn a foreign language easier. Usually, learning a new language will need a perpetuated period of study, patience and time, not many people pick up new language lessons on their first attempt, indeed, repetition and exercise practicing will help students to master a new language. Moreover, students can learn at their own pace through e-learning which provides a solid and comprehensive education at any time of their own.

How to learn foreign language effectively? Online can find several web tools that are really helpful in learning vocabulary [2]. Learn Portuguese online can be very interesting [3, 4]. Following the course step-by-step students can quickly learn their vocabulary [5].

Project objectives:

- Design an interactive and user-friendly interface,
- design different levels of learning in interesting way, build up a vocabulary database,
- then implement the system.
- Compose a final project report

Skill required:

Students need to apply the programming skills in Java, PHP, SQL, Android Studio, TTS, STT, API etc.

References:

[1] Benefits of Learning Foreign Language Online, https://elearningindustry.com/5-essential-benefits-of-learning-foreign-languages-online

[2] Learning Vocabulary online, https://www.learning-english-online.net/vocabulary/

[3] Babbel, https://www.babbel.com/learn-portuguese-online

[4] Portuguese Language Lesson, http://ielanguages.com/portuguese.html

[5] Fala! - a Portuguese learning application from Education and Youth Affairs Bureau (DSEJ).

2. Employee Roster and Attendance Management System - Face Recognition

Background:

Nowadays, 24 hours working shifts companies can be easily found in Macao. The HR of the organization are also concerned about the work time of their employees for handling their payroll, overtime and annual leave and etc. From the traditional punch cards to modern access cards and even the biometric systems, to track out the employee working hours is an essential process. Employees need to keep track of their check-in time when they arrive to work and keep the check-out time when they leave their work. There will be more time consuming and difficult to handle if there is not a electronic data point for connecting in such a big volume of paper works. Hence, the requirement with computer-based face recognition attendance management system which can assist for maintaining employee attendance records automatically is recommended.

This project needs to prepare the first part data for the employee roster working in different shifts of the day. And create an attendance management system for HR administration and the employee to check up their working hours.

Project Main Objectives:

- Implement a web-based attendance management system
- Create a user-friendly interface
- Create the employee roster
- Implement the face recognition technology for the check-in and check-out time
- Provide the work time checking method
- Implement and test the system
- Compose a final project report

Skill required:

Django, Python, MySQL, OpenCV, dlib, etc….

Proposed by Evelyn Lo

PROPOSED BY PATRICK PANG

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1. Web-based Interactive Data Exploration

Search engines are great but they are not always useful. For example, when you want to find something to read, but you don't even know the name of a book. In this case, people will explore rather than search. In a computing environment, showing all data items for users to browse is one way to explore, but there are some challenges: the screen may not be large enough to show everything, the screen may have different sizes (e.g. computers vs. mobile phones), what items should be shown on the first page, which items should be placed next to another, etc. If these issues can be solved, there will be many applications for data exploration: finding books, looking for research supervisors, and choosing a restaurant for dinner – just to name a few.

In this project, you will build a web-based application to solve these problems. You will work with some multi-dimensional datasets and you may need to collect additional data. You will identify suitable techniques to reduce them to 2D or 3D data using Python. Then, you will use this data as coordinates to present these data items on a web page. This application needs to work on different screen sizes (e.g. mobile phones) by employing responsive design. The user interface should look professional and easy-to-use. Finally, you may need to evaluate the usability of this application.

A sample of this type of application can be found in the video below [1]. However, this is for reference only and you don't have to use the same design.

Skills required: Python (for data processing), web development (HTML, CSS, JavaScript, …)

Further readings:

1. http://ppgweb.s3.amazonaws.com/share/pacis2016_20160630_explore.mov

2. Pang, P. C. I., Verspoor, K., Pearce, J., & Chang, S. (2015, December). Better Health Explorer: Designing for health information seekers. In *Proceedings of the Annual Meeting of the Australian Special Interest Group for Computer Human Interaction* (pp. 588-597).

3. Pearce, J., Chang, S., Kennedy, G., Ely, R. B., & Ainley, M. (2012, November). Search and explore: more than one way to find what you want. In *Proceedings of the 24th Australian Computer-Human Interaction Conference* (pp. 469-478).

4. Pearce, Jon, and Shanton Chang. "Exploration without keywords: the Bookfish case." *Proceedings of the 26th Australian Computer-Human Interaction Conference on Designing Futures: The Future of Design.* 2014.

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PROPOSED BY JACKY TANG

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1. Data-driven Li-ion Batteries State Estimation with Multi-Head Attention

Electric vehicle (EV) has been widely adopted because of the urge of greenhouse gas reduction. Lithium-ion (Li-ion) battery is the most common adopted power source for EV. State-of-Charge (SOC) and State-of-Health (SOH) are two important battery states to be monitored during the operation of EV to ensure safety and prolong the battery life. SOC indicates the current amount of available charge in a battery cell. SOH is an indicator of the battery aging status.

Data-driven approach is one of the common techniques for SOC and SOH estimation. It utilizes the historical battery cell operation data to establish a prediction model of the battery state. Machine learning is one of the popular approaches in data-driven battery state estimation. Typically, the battery cell operation data is a bunch of time-series data that contains the battery parameters at each time step such as terminal voltage, current and temperature. Recurrent neural networks are well suitable for time-series problem. In [1], we evaluated the use of deep LSTM for SOC estimation at various battery specification. Apart from recurrent neural networks, it is worth exploring other advanced techniques on the time-series based battery data.

This project is intended to further investigate the neural networks with multi-head attention [2] on battery state estimation. Students are expected to implement a SOC or SOH estimation model based on the public Li-ion battery datasets. Three public datasets are suitable for this project, namely UNIBO Powertools Dataset [3], LG 18650HG2 Li-ion Battery Data [4], and NASA Battery Dataset [5].

Objectives:
- Review knowledge of battery state estimation, neural networks, and multi-head attention
- Perform exploratory data analysis on the battery datasets
- Implementation of battery state estimation based on neural networks
- Evaluate and compare with another existing approaches

Related skills and technologies:
- Python programming
- Keras / Pytorch
- Artificial neural networks

Reference:
[1]   K. L. Wong, M. Bosello, R. Tse, C. Falcomer, C. Rossi, και G. Pau, 'Li-ion batteries state-of-charge estimation using deep lstm at various battery specifications and discharge cycles', στο Proceedings of the Conference on Information Technology for Social Good, 2021, σσ. 85–90.
[2]   A. Vaswani κ.ά., 'Attention is all you need', Advances in neural information processing systems, τ. 30, 2017.
[3]   Bosello, Michael; Pau, Giovanni (2021), "UNIBO Powertools Dataset", Mendeley Data, V1, doi: 10.17632/n6xg5fzsbv.1

[4]   Phillip Kollmeyer, Carlos Vidal, Mina Naguib, and Michael Skells. LG 18650HG2 Li-ion Battery Data and Example Deep Neural Network xEV SOC Estimator Script". Mendeley Data, V3. doi: 10.17632/cp3473x7xv.3.
[5]   B Saha and K Goebel. Battery data set. NASA AMES prognostics data repository, 2007.

2. Visual-thermal Image Dataset Creation for Fire Detection

With the development of science and technology, fire detection and automatic alarm system has become essential tools to help people find early fires and prevent the spread of fires. The traditional fire detection technology uses sensors to measure the relevant physical quantities of early physical phenomena such as smoke, heat, gas, and light in the process of fire development. These physical quantities and the preset threshold parameters can be used to judge fire occurrence. However, due to the performance limitations of the sensor itself, there are many drawbacks: the sensor is affected by temperature, humidity, air flotation, airflow, and other environmental factors, prone to false alarms and omissions; in addition, the detection distance of the sensor is limited. To make up for the shortcomings of traditional fire detection technology, image-based fire detection technology is generated.

In most fire scenes, there are flames and smoke. Image-based fire detection technology is based on recognizing flames or smoke in images to realize real-time monitoring of fire scenes. Since there are apparent color characteristics and temperature characteristics when a fire occurs, the current image-based fire recognition technology is mainly divided into two categories: based on visible light images and thermal images. Both fire detection approaches are significant and essential. However, there are few public fire thermal image datasets. Therefore, we will create a visual-thermal image dataset for future fire detection research that could be benefited from both approaches.

In this project, the student is expected to build a handheld device to collect visual and thermal images of flames and smoke in different environments. The device will be able to capture both visual and thermal image at the same time. The main delivery of this project is a visual-thermal image dataset that can be used for fire detection.

Project Objectives
- Design and prototype circuits based on Raspberry Pi 4 and other modules
- Assemble a visual-thermal dual cameras handheld device based on the designed circuits
- Collect visible light and thermal images of flames and smoke in multiple environments
- Label and pre-process the collected image data

Related skills and technologies
- Design and build hardware circuit systems
- Python, C or other programming language for embedded system development
- Image data pre-processing and labeling

Proposed by Jacky Tang

3. Text Detection and Recognition in Image-Based on Deep Learning

With the advent of the information age of massive pictures, picture information is full of all aspects of life. The image's information is rich and diverse, and the most direct one is the text information in the image. As the oldest information carrier, the text continues our civilization and is the ladder of human progress. This means that text as the carrier of people's daily communication has essential research significance. The text in the image is often a large amount of information concentration, so the text detection and recognition in the image are vital and valuable.

Traditional image recognition is based on surface image features. The general methods are image segmentation, feature extraction, and classifier recognition. Because of the particularity of text information, no fixed shape, and reasonable target boundary, the traditional image recognition method to identify the text information in natural scenes is relatively tricky. The deep learning technology does not rely on a manual to design the surface features of the image, which is driven by data and learns the features of the image spontaneously from the data. Therefore, this project is based on deep learning technology to achieve text detection and recognition in images.

In this project, students will complete the text location detection and text recognition of image information. Text location detection needs to determine the text area in the image according to the characteristics of the text. In the detection process, some non-text regions are classified as text regions because of interference factors, which need to exclude non-text regions according to some rules or statistical characteristics of candidate regions to locate the text regions in the picture accurately. After getting the text region, text recognition is needed.

Project Objectives
In this project, the main objectives are as follows.
(1) Implementation of a text target detection model
(2) Implementation of a text target recognition model

The student is expected to have good programming skills and basic knowledge about neural networks.

Reference Reading
Tian, Zhi, et al. "Detecting text in natural image with connectionist text proposal network." *European conference on computer vision*. Springer, Cham, 2016.
Shi, Baoguang, Xiang Bai, and Cong Yao. "An end-to-end trainable neural network for image-based sequence recognition and its application to scene text recognition." *IEEE transactions on pattern analysis and machine intelligence* 39.11 (2016): 2298-2304.

Proposed by Jacky Tang

4. Data Storage System on the Internet Computer Background

The Internet Computer (ICP) is defined as the third generation of the blockchain systems [T$^+$22], where the first generation is Bitcoin [Nak08], and the second generation is Ethereum [B$^+$14]. More in detail, the ICP provides an infinite blockchain where we may hold everything. Unlike previous blockchain systems, it aims to be scalable and to run at web speed. The main technical components of the Internet Computer are the Canister [Dfi21a] and the Network Nervous System (NNS) [Dfi21b]. The canister is a special type of smart contract, and it could be a web page or a decentralized financial application. Users may interact with a canister directly as long as they know the identity of the canister. In the ICP, communication between the different nodes is demanded to the Network Nervous System (NNS).

The ICP could be an important infrastructure for Web3 applications, i.e., personal data management system. In this project, students will design and implement a personal data management system using the Internet Computer.

Objectives
In this project, students will
- Be familiar with the background knowledge about blockchain and dapps. • Design a privacy perserving data storage system.
- Implement the system on the Internet Computer.
- Learn the high-level idea about emerging cryptography technologies.

Skills required
- Programming
- Distributed system engineering

References
[B$^+$14] Vitalik Buterin et al. A next-generation smart contract and decentralized application platform. white paper, 3(37), 2014.

[Dfi21a] Dfinity. A closer look at software canisters, an evolution of smart contracts, Sep 2021.

[Dfi21b] Dfinity. The network nervous system: Governing the internet computer, Sep 2021.

[Nak08] Satoshi Nakamoto. Bitcoin: A peer-to-peer electronic cash system. Decentralized Business Review, page 21260, 2008.

[T$^+$22] DFINITY Team et al. The internet computer for geeks. Cryptology ePrint Archive, 2022.

Proposed by Jacky Tang

5. Zero-Knowledge Proof on the Internet Computer

Zero-Knowledge Proof is a method by which a prover can prove to a verifier that a statement is true without revealing any other information. For example, the prover can prove a graph is three-colorable without giving a color scheme. This method has been widely adopted in the blockchain to provide a truly anonymous payment system [Gro16, GWC19, BSCG[+]14]. The Internet Computer(ICP) [T[+]22] is an emerging blockchain project with scalability and low transaction fee. However, the ICP lacks native support for zero-knowledge proof, and all transactions are transparent online. We want to improve the Internet Computer so that it can support anonymous transactions or even decentralized applications. In this project, students will implement zero-knowledge proof on the Internet Computer based on open source frameworks.

Objectives
In this project, students will
- Be familiar with zero-knowledge proof and its applications. • Design a zero-knowledge proof solution.
- Implement the solution on the Internet Computer.

Skills required
- Programming

References

[BSCG[+]14] Eli Ben Sasson, Alessandro Chiesa, Christina Garman, Matthew Green, Ian Miers, Eran Tromer, and Madars Virza. Zerocash: Decentralized anonymous payments from bitcoin. In 2014 IEEE Symposium on Security and Privacy, pages 459–474, 2014.

[Gro16] Jens Groth. On the size of pairing-based non-interactive arguments. In Marc Fischlin and Jean-Sébastien Coron, editors, Advances in Cryptology – EUROCRYPT 2016, pages 305–326, Berlin, Heidelberg, 2016. Springer Berlin Heidelberg.

[GWC19] Ariel Gabizon, Zachary J. Williamson, and Oana Ciobotaru. Plonk: Permutations over lagrange-bases for oecumenical noninteractive arguments of knowledge. Cryptology ePrint Archive, Paper 2019/953, 2019. https://eprint.iacr.org/2019/953.

[T[+] 22] DFINITY Team et al. The internet computer for geeks. Cryptology ePrint Archive, 2022.

Proposed by Jacky Tang

PROPOSED BY RITA TSE

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1. Internet of Battery for the Electric Vehicle/Scooter by Sensing Device

Macao possessed many Internal Combustion Engine (ICE) vehicles (113,344 vehicles and 105,947 Scooters) by the end of 2021. When moving to electric vehicles, the biggest hurdle to widespread use is the charging and monitoring the battery. The battery is a kind of electrochemistry product that is dangerous (e.g., catching fires, especially on EV scooters) on improper operations. Battery monitoring on Electric Vehicles (EVs), EV scooters, and battery-swappable EVs allows drivers to manage their EVs better on driving, idling and charging. When the battery pack and cell information are available, it can reduce the workforce on maintaining the battery pack. Also, the actual power and charging cost can be calculated to give a better sense of the charging bill for the driver.

This project aims to bridge the gap between the driver and the EVs/Scooter by monitoring the vehicles' batteries. Some possible objectives are:
- Build a wireless sensor network (WSN) sensing device to collect the data (e.g., Battery voltage, current, ambient temperature, etc.) from vehicles on driving, idling, and charging. The device could be an off-the-shelf product (e.g., MCU, ESP32), but it requires customization on both hardware and software to adapt to different NEVs.
- The sensing data will be processed on the IoT device and sent to the server. An IoT to server upload protocol (e.g., TCP, UDP or HTTP) on apply is needed.
- The server will process the uploaded data and store it in DB (i.e., server-side reconstruction of the reading values and insert to DB).
- Backend retrieves the data from DB and sends it to the client-side for visualization. Specifically, read from DB and send to client by socket, AJAX, JSON.
- A visualization of the data in a web or mobile application (e.g., show the graph/tables about the reading).

Related skills and technologies:
- Arduino, C/C++, hardware circuit systems.
- Full-stack web development (IoT device to backend and backend to client). Web development programming languages and frameworks are not limited (e.g., Python-Django, Java-Spring, React).

Further information:
- https://github.com/espressif/arduino-esp32
- https://github.com/RalphBacon/ESP32-Dual-Core-Programming
- https://spring.io/projects/spring-framework

2. STEM-based Indoor/Smart Home Air Quality Sensing

Indoor air quality (AQ) sensing has become necessary in buildings, offices, and heritage. The Canarin II air sensing platform detects many different gases (PM1 to 10, CO2, temperature, RH, etc.) for further air conditioning control and alerts. This project aims to extend the current sensing platform to the smart home level by upgrading the exterior box, hardware, and software. To achieve this project requires a wide range of knowledge and craftwork. Specifically, this project will circulate through four major processes: hardware building, 3D modelling, software implementation, and analytics. To mitigate the complexities of this project, a STEM-based (which combines science, technology, engineering, and math) learning approach and instruction will be given on every process.

The objectives are:
- To add new hardware sensors. For example, the sensor of Formaldehyde, Carbon Monoxide (CO), Ammonia (NH3), Nitrogen Dioxide (NO2), and Oxygen (O2). Firmware implementation of reading out the value from these sensors is necessary. Update the data to the AWS database is very likely.
- 3D box modelling to contain the new sensors. Use the AutoCAD/Fusion 360 3D modelling to best allocate the new sensors according to their electrochemical characteristic.
- 3D printing realizes on the new modelled box with Ultimaker S5 3D printing machine.
- To install, test, and deployment of the newly developed sensors.
- Develop a web or mobile application to check or control the other machines.
- Post analytics on the scene based on the collected data through the web/mobile application for the user.

Related skills and technologies:
- Arduino, C/C++, hardware circuit systems, Python, Linux, AWS-Aurora (MySQL).
- AutoCAD/Fusion 360, Ultimaker S5 software and machinery.
- Web/Mobile application development.

Reference:
- https://dl.acm.org/doi/10.1145/3284869.3284876
- https://ultimaker.com/3d-printers/ultimaker-s5
- https://www.autodesk.com/products/fusion-360/overview
- https://www.udoo.org/udoo-neo/
- https://aws.amazon.com/rds/aurora/

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Proposed by Rita Tse

PROPOSED BY CHESTER WONG

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1. Fast Interaction Wave Generator for 3D Games and Animations

Background
Computer graphics (CG) has been developed extremely fast and widely used in multimedia industry such movies and video games. Waves caused by the interaction between floating objects, such as boats and the water surface are a key feature. Fluid simulation with fluid dynamics is the best solution to represent the dynamics of the water. But it is timing consuming because of its high computational complexity.

Common approaches such as the FLIP (Fluid-Implicit-Particle) simulation and the wave particle method had in implemented in modern CG tools and engines, for CG movies and game creation. However, there are pros and cons. FLIP simulation is high quality but time consuming, wave particle method has the trade-off between quality to performance. Therefore, FLIP simulation is mostly used for off-line pre-rendered CG such as CG movie. The wave particle method can be used for real-time rendering with limitation to the number and life cycle of the particles but the waves are not realistic or not physically correct enough.

Project Objectives
The goal of this project is to implement a fast interaction wave generator. It generates 2D displacement map of the height of the water surface with a user specified situation, such as the shape and the movement of the floating object, and the resolution of the displacement map (For example 128x128, 256x256). It should be able to generate a sequence of displacement maps of a time period with an increment time dt. For example, the generator output 10 files for the time period = [0.0, 0.9] dt = 0.1 .

In addition, an option to output an 3D mesh model data such as the simple .obj 3ds model data file should be provided, in order to be loaded/imported into a modern 3D modelling software such as 3ds Max or Maya for rendering the mesh of the ocean surface.

In this project, the main objectives are as follows:
- Investigate methods and algorithms to generate interaction wave between floating objects and the water surface
- Implement a fast interaction wave generator to generate displacement maps.
- Generate and output 3D mesh data of the interaction wave.
- Create CG animation of the ocean wave by using the generated data.

Optional/Bonus:
- Rendering the interaction wave using CG library such as OpenGL/Java3D directly instead of output a file.
- Generating and rendering the interaction wave with the floating objects in real-time.

Requirement
Student is expected to have good programming skills, interest and basic understanding to CG and related tools. Knowledge to numerical methods and mathematics will be advantages in this project.

Proposed by Chester Wong

2. Particle Based Fluid Simulation

Background

Particle based physics simulation is widely used in both computer graphics (CG) and scientific analysis area. One of the latest applications is the Covid-19 simulation done by RIKEN in Japan using the rank 1 supercomputer Fugaku. Particle based simulation is good in simulating micro scale phenomenon of multiple bodies such as the dynamics of granular materials, splash and spark.

Particle simulation or particle system has been implemented as a key feature in many 3D CG software such as 3ds Max and Maya to represent the visual effect (VFX) of splash, as well as the flying sands/dusts in the wind and storm.

However, the computational complexity of simulating massive particles is very high. Therefore, the number of the particles in the simulation is limited. Increase the number of the particles and performance enhancement is always a challenge topic.

Project Objectives

The goal of this project is to implement a particle-based simulation system of splash or water flow. Collision detection between particles and any boundaries, and neighbour searching are critical tasks that have to be solved, in order to simulate the interaction between the particles and boundaries.

To aim for a high-performance simulation with massive particles, a well design of data structure to handle a large number of particles' properties in an efficient way is the key to be investigated.

To simulate the fluid dynamics, the smooth particle hydrodynamics (SPH) method should be implemented. The system should output a sequence of the position of the particles of a time period and an increment time dt. For example, the generator output 10 files for time period = [0.0, 0.9] dt = 0.1 . In order to be loaded/imported into a 3D CG software to generate the animation.

In this project, the main objectives are as follows:
- Implement an efficient particle system for massive particles.
- Collision detection of the interactions between particles and boundaries, including efficient neighbour searching.
- Implement the SPH method.
- Output the position of the particles for visualization.
- Create CG animation using the simulation results.

Optional/Bonus:
- Rendering the simulation result using CG library such as OpenGL/Java3D directly.
- Rendering the animation of the particles in real-time.

Requirement

Student is expected to have good programming skills, interest and basic understanding to CG and related tools. Experience and knowledge in handling massive data in efficient way will be advantages.

Proposed by Chester Wong

3. Online Visualization Platform for Weather and Ocean Conditions

Background

Information of weather and ocean conditions are important to our daily life. The weather forecast is one of the most being watched TV program. Conditions of the weather, for example: Is it a rainy day? Will it be a typhoon? are closely related to our daily activities. Moreover, the conditions of the atmosphere and ocean are strongly affects to air transportation and ship transportation.

Data of the weather and ocean conditions information using specific format. And the elements can be quite different according to the diagnostic purposes. Therefore, most of the visualization tools are developed with the cooperation of the observation organization/laboratory, or served for a specific data format. If the information is increased by the improvement of the observation of simulation technologies, a new version of the data format, as well as the visualization tool might be required.

Project Objectives

The goal of this project is to develop a web-based open visualization platform to allow users to visualize the information of weather and ocean conditions in a flexible way. A simple and easy to use data format, data importer or converter of loading the data for visualization easily. Different visualization method for different purposes should be provided.

In this project, the main objectives are as follows:
- Design and implement an online visualization platform to display the information of weather and ocean conditions on a map of the earth/the world.
- Users should able to use the visualization platform via a web browser.
- Data format, data importer or converter of loading the data for visualization.

Optional/Bonus:
- 3D CG rendering.
- Good visualization methods.

Requirement

Student choose this project is expected to understand web/network programming, as well as displaying images or 3D graphics on a webpage. Experience and knowledge to network programming, file formats will also be advantages.

Proposed by Chester Wong

4. Procedural 3D City Model Creation System

Background

3D city models had widely applications. They can be found in computer graphics (CG) movies, games as well as navigation systems and visualization tools for urban information. And the need is increasing along the development of virtual reality (VR) projects such as virtual city projects.

Creating a 3D city model is a high workload task. The scale is large. The number of buildings is huge. The road is complex. Therefore, in many cases, creators use procedural approaches to generate the buildings automatically.

Project Objectives

The goal of this project is to implement a procedural 3D city model creation system. 3D city models are generated based on city map data automatically. The system can generate the 3D city model of a real city. Then the model can be used for VR projects, navigation systems, urban information visualization system, etc.

In this project, the main objectives are as follows:
- Design and implement a procedural 3D city model creation system to generate 3D city model automatically.
- Use the system to create virtual 3D city model based on a real city.

Optional/Bonus:
- Data structure, hierarchy to handle the elements, such as the buildings efficiency, quality.
- Capability to handle different kinds of buildings and historical buildings.
- 3D CG rendering system for the generated 3D city model.
- Capability to show urban information.

Requirement

Student is expected to have good programming skills, interest and basic understanding to CG and related tools. Knowledge to mathematics and creative thinking will be advantages in this project.

Proposed by Chester Wong

5. Rapid Antigen Test Result Recognition

Background
The COVID-19 pandemic has been affecting our daily life for these 2 years. And Macao is now facing an outbreak of the COVID19 new variant. The new variant is much contagious. It causes the largest impact to Macao compared to cases happened before. Most of the work and activities had been suspended. Residents need to take polymerase chain reaction (PCR) tests repeatedly and to take rapid antigen test (RAT) every day.

Thus, over 600, 000 RAT results are generated and uploaded every day. Each RAT result contains a user reported test result: positive, negative or invalid, selected by the user, and an uploaded photo of the RAT kit. The problem is that the user reported result could be wrong because of human errors. To guarantee the correctness, all the reported results and the uploaded photos should be checked. But the workload is huge.

Project Objectives
This project will implement a RAT result recognition application. It will classify results from the photos using image processing/pattern recognition technologies, and then confirm the correctness with the user reported results automatically. Since the results will be uploaded every day, not only the correctness, but also the fast speed are important to the application.

In this project, the main objectives are as follows:
*   Study and implement image classification and recognition for the RAT result from the photo.
*   Design and implement an RAT result recognition application.
*   The application should be able the handle large number of data and photo in a short time.

Optional/Bonus:
*   Any idea to improve the correctness or the efficiency.

Requirement
Students who choose this project are expected to be familiar image processing and pattern recognition. Experience and knowledge in writing program to work with database will be an advantage.

Proposed by Chester Wong

6. Online Training and Testing Platform for Programming Study

Background
Nowadays, online programming platforms are available for writing program remotely. Online programming skills test systems are available for testing the programming skills of the applicants in a job interview.

Studying and teaching programming is difficult. It is more important do practice rather than just reading. Besides, it is hard to test the real programming skills of a student. Traditionally, paper-based tests are used. Students have to memorized all the possible used functions and APIs to prepare for the test. Therefore, the questions should avoid to use some of the functions, or a cheat-sheet - a list of the function names - might be provided, which gives limitations in designing the test paper. Students are also easy to get point deduction by making mistakes in writing the code by hand that is not strongly reflected by their programming skills.

On the other hand, doing test on a computer is hard to be managed, in order to avoid cheating, for example.

Project Objectives
This project aims to develop an online programming platform which provide the capability for practice, doing assignments or tests in programming study. The system should be web based. No installation should be needed. The only requirement to use the system is a web browser.

In this project, the main objectives are as follows:
- Implement a web-based programming system which can writing code, compile, test and run the program via a web browser.
- After running the program, the results or error messages should be output to the user (client side).
- The development environment is setup on the server side.
- Capability to set questions, collect answers and grading of programming problems/tests.

Optional/Bonus:
- Support for multiple programming languages.
- Highlighting/colouring the keywords of the programming language.

Requirement
Student choose this project is expected to understand web programming, as well as managing files on web-based system. Experience and knowledge to string matching will be advantages.

Proposed by Chester Wong

PROPOSED BY XU YANG

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1. Using Adversarial Attacks as Data Augmentation Methods for Deep Learning

Background

In the last decade, convolutional neural networks (CNNs), which is one of the deep learning models, have achieved state-of-the-art performance on various computer vision tasks. However, training such CNN models requires a large amount of data. For instance, the ImageNet dataset for an image classification task contains over 1 million images with manually annotated classification labels. The data collection and manual annotation is an extremely expensive process. The data collection of medical images is even more challenging due to privacy concerns and the difficulty of professional data annotation. Therefore, the lack of data becomes a stumbling block for the development of deep learning.

Adversarial attack is a technique that can attack deep learning models to produce wrong predictions. For instance, assuming a panda image and a CNN classifier which can accurately classify the panda image as a panda. An adversarial attack technique (e.g., FGSM) can produce a perturbed panda image based on the original panda image. The difference between the perturbed image and the original image is unobservable by human perception. However, the CNN classifier classifies the perturbed panda image wrongly as others.

As an adversarial attack can produce human-imperceptible perturbed images to attack CNN models to produce wrong predictions. Therefore, it could potentially be an effective data augmentation method to enlarge the amount of training data. Thus, reducing the impact of the lack of data and improving the performance of trained CNN models.

Therefore, this project aims to study the feasibility of adversarial attack techniques as data augmentation methods to improve the performance of CNN models on different small-scale datasets. More specifically, in this project, the student is expected to apply an adversarial attack method (e.g., FGSM) and attempt to improve the performance of a CNN model on a small-scale dataset, then compare the performance with a CNN model trained with standard procedure.

Objectives
The student is expected to:
- Learn the relevant knowledge of deep learning, CNN, FGSM, etc.
- Do the literature review on using adversarial attacks as data augmentation methods.
- Learning how to use a deep learning framework (e.g., Keras) to run deep learning algorithms.
- Training CNN models using a given dataset.
- Applying an adversarial attack to attempt to improve the performance of CNN models.
- Result evaluation, comparison, and discussion.
- Compose a final report.