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 2023/2024

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PROPOSED BY REBECCA CHOI

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1. Artificial Intelligence based Restaurant Recommender

Background

Nowadays, in urban cities, more and more people prefer dining outside or order takeaway, as they are busy at work and many of them enjoy delicious food in restaurants. There are many restaurants and some are newly opened. It is difficult and time consuming to choose an appropriate restaurant for dining or ordering. For example, the restaurant is out of business hours, children are not allowed to dine in the restaurant, or it is out of budget. Hence, it is desirable to have an application to recommend appropriate restaurants according to user requirements.

In this project, the student will develop a system that recommends restaurants based on different user situations. In the system, users could set their requirements for choosing a dining restaurant for eating or placing takeaway orders. The system should provide enough options for the users until they are satisfied with the result.

Project Objectives

In this project, the student should apply artificial intelligence techniques to implement a restaurant recommendation system which includes the following functions: (i) A user interface should be provided for the user to set the requirement options for the recommended restaurant. (ii) Recommend restaurants according to the user requirements until the user is satisfied with the result. (iii) Provide a user interface for inputting newly opened restaurant information.

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

2. Social Media Privacy Issues Handler

Background

In previous decades, there was a rapid growth of social media networks. Everyone likes to share their daily life, photos, even current location with their friends and relatives on social media networks, as it is easy for interaction and knowing each other's lives. However, in recent years, people have become aware of the importance of personal privacy and know the impact of leakage of sensitive personal information. Hence, they will think carefully before publishing posts. Nevertheless, for the old posts with sensitive data, which can still be reached by others, it is difficult to find and delete those posts. In addition, the user probably forgot what they had posted years ago.

To deal with this, in this project, the student will develop a social media privacy issues handler that allows users to filter and find their old posts that have published on social media network in the past, so that they can easily manage and delete those posts that contain sensitive data that they do not want to share with others any more.

Project Objectives

The objective of the project is to develop an application that allows users to filter and find the posts that they have published on social media networks, so that they easily manage or delete those posts. The main features of the application include: (i) Users could find the posts they have published on social media networks with certain keywords. (ii) Users could manage or delete the posts found. (iii) The application should cover most of the popular social media networks. (iv) Additional feature: the scope for searching function should include the comments on all the posts.

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

3. Closet Management and Clothes Matching Application

Background

There are usually several clothes in many people's closets, however, there is a phenomenon that many people always wear the same clothes, those clothes that they can think of. The reason is because the frequently worn clothes are easily reached and can be seen, and people usually forget those clothes that are not frequently and recently worn. This may lead to some clothes not being worn and or just be worn for a few times after being bought. Hence, a good management of the closet is necessary for the user, so that they know what clothes they have. Another reason for wearing the same clothes is because matching clothes takes time, and people are usually in a hurry when they need to go out. Hence, automatic clothes matching based on the weather is desirable.

In this project, the student will implement a closet management and clothes matching application. With the application, it is expected that the user can easily view and manage all the clothes in their closet, and appropriate attire is recommended.

Project Objectives

The objectives of the project include: (i) Store and categorize the clothes information for all the clothes in the closet. (ii) Implement the clothes matching function with the weather consideration. (iii) Provide an interface for the user to view all existing clothing and show the recommended attire.

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 institutions, in order for the student to complete a degree, there are several courses that 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, the student should apply artificial intelligence techniques 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.

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

5. Data Analysis on Bus Trajectory Data

Background

Bus trajectory data records the GPS location of the bus at different timestamps, with this data, we can know where the bus is located, how fast it moves at different times. In recent years, full load rate may also be recorded together with the bus trajectory data. Making those data understandable, readable and meaningful, that provides an overview of the data which may help in decision making. For example, carrying out data analysis on bus trajectory data, we can know the location of crowded regions and the corresponding time, the bus stop with the most people boarding and disembarking, etc., which helps in decision making like road planning, bus route planning and bus timetabling.

Project Objectives

In this project, the student should do data analysis on the bus trajectory data in Macau that provides an overview in helping decision making. (i) Collect the bus trajectory data in Macau. (ii) Carry out data analysis on the bus trajectory data. (iii) Provide an overview of the bus trajectory data in different aspects which helps in decision making. (iv) Provide a user-friendly interface in presenting the overview of the data.

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

PROPOSED BY WILSON HO

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1. Flutter-based Smart Silent Controller

Background
The sound of a smartphone ringing can be perceived as annoying for a few reasons. First, the high-pitched and repetitive nature of the sound can be grating to some people's ears. Additionally, the sound is often associated with interruptions and distractions, which can be frustrating if you are trying to focus or relax. Lastly, the constant exposure to smartphone notifications and ringtones may contribute to a general annoyance towards these sounds.

To avoid your smartphone ringing in the wrong place, you can take the following steps:

1. Enable silent or vibrate mode: Set your phone to silent or vibrate mode manually before entering places like libraries, meetings, theaters, or any other quiet environment. This will ensure that your phone doesn't ring out loud.
2. Use do not disturb mode: Most smart phones (not all) have a "Do Not Disturb" mode that allows you to set specific times or customize settings to avoid interruptions. You can schedule this mode to activate automatically during important events or when you are in specific locations.
3. Customize app notifications: Review your app notification settings and adjust them accordingly. You can choose which apps are allowed to send you notifications, and you can even specify different notification settings for each app. This way, you can minimize unwanted interruptions.
4. Utilize location-based settings: Some smartphones (not all) allow you to create location-based profiles or settings. For example, you can configure your phone to automatically switch to silent mode when it detects that you're in a library or a cinema. Explore your phone's settings to see if this feature is available.
5. Set specific ringtone profiles: Customize your phone's ringtone profiles to match different environments. For instance, you can have a loud ringtone for outdoor settings and a softer one for indoor environments. This way, you can easily switch between profiles depending on your location.
6. Be mindful of your surroundings: Pay attention to your surroundings and be considerate of others. If you're in a quiet place, it's best to keep your phone on silent or vibrate mode to avoid disturbing others.

It is important to strike a balance between staying connected and being respectful of others' privacy and peace in different environments.

Project Objectives
The student is required to:

- identify different environments (such as in a theatre, hospital and library etc.) that silent mode on the smart phone is required to be on.
- explore the features of Google Flutter and SQLite;
- explore the features of Google map and GPS technology on a smart phone;
- design the system architecture and the functions of the required mobile app;
- develop a mobile app by using Google Flutter to facilitate automatic profile switching with the help of GPS technology;
- compose a final project report.

2. 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

3. Flutter based All-in-one Portal for Macao-wide IT Competition

Background

This system is designed for Macao-wide IT Competition. Participants can obtain the information they need for the competition and access to the online submission form for the competition. Pattern recognition and information extraction on uploaded student ID card will facilitate the registration process. Competition materials/files can then be uploaded to the portal later through a dedicated interface with sophisticated checks. Various statistical reports can be generated for pre-defined purposes.

Project Objectives

The student is required to:

- do literature review on pattern recognition and information extraction;
- investigate and decide which pattern recognition API can be used in this system;
- design the system architecture and the functions of system;
- use Google Flutter to develop a mobile app for registration with pattern recognition capabilities;
- develop the front-end and back-end systems for processing competition materials/files upload;
- compose a final project report.

4. 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™ and Eddystone™ 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 LIAM LEI

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1. GPU Accelerated Fractal Visualization

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 GPU-based fractal generation 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 a GPU-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, WebGL Shading Language, 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]. [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/

3. 2D 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/

4. Real-Time Deep Water Animation and Rendering

Background
There are multitude of approaches to the creation of oceans in the literature. However, this techniques can be classified into two clearly distinguishable branches. Those which try to create deep water by focusing mainly on the surface of the ocean and those which try to create shallow water where the whole water volume is taken into consideration.

Deep water is defined as water where the influence of the bottom of the ocean is almost insignificant to its surface.

The aim of this project is to create an ocean with interactive frame rates. The main goal of this project is to recreate the whole process of the spectral domain techniques to create an ocean surface. Also, we will recreate how light interacts with this surface. We will measure the frame rates for different behaviors of the surface.

Objectives
In this project, the student is expected to achieve:

- Design the whole structure of the App.
- Conduct a study to understand how spectral domain techniques work and how does the Inverse Fast Fourier Technique works.
- Design the algorithm according to the equation that is chosen before.
- Implement the designed pipeline to create the ocean surface and the light effects.
- Implement the interactive UI
- Evaluate the results by measuring the frame rates with different parameters and the flexibility of the ocean surface for different behaviors.

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.

[4]3D rendering Three.js, https://threejs.org/docs/
[5] http://developer.download.nvidia.com/books/HTML/gpugems/gpugems_ch38.html
[6] https://github.com/mharrys/fluids-2d
[7] Robert Bridson, Fluid Simulation for Computer Graphics, CRC Press, 2016, 2nd edition.

PROPOSED BY PHILIP LEI

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1. Tracing programming knowledge by patterns in submission to exercises

The introductory programming course is usually the first programming course taken by students in universities worldwide. The course is challenging to many students as they have to learn the syntax and semantic of a programming language, acquire problem solving skills, and construct programs to solve computational problems.

A common teaching approach is to give worked examples to students to illustrate various programming constructs (e.g. 'if', 'for'), and then require students to solve a similar problem by writing a complete program. However, a correct solution usually requires knowledge of much more than that of a single construct, and identifying insufficient understandings of programming constructs or related programming concepts may be unfeasible by only examining the student's submission for the current problem. A teacher needs to look at the student's performance in previous exercises to build a clearer picture of the knowledge state of the student.

In this project, you will create a programming exercise platform that monitors the knowledge state of different programming constructs and concepts (collectively known as patterns) for students in an introductory programming course. The project has the following objectives:

- Develop a programming exercise platform (as web app or mobile app), in which students can view worked examples and do programming exercises. The server side of the platform runs test suites to evaluate the correctness of submissions to exercises.
- Design a method to identify the pertinent programming patterns in a typical solution to a programming problem.
- Match patterns against student submissions to deduce whether the student is able to use the patterns.
- Trace the knowledge state of students in using different patterns.
- Suggest exercises or worked examples to students according to their knowledge state.

2. 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.

3. Knowledge tracing on skill-tagged educational datasets

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

PROPOSED BY YUE LIU

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1. User Association in Multi-Cell Wireless Network using Machine Learning Approach

User association (UA) refers to the mechanism to allocate mobile User Equipment (UE) to Base Stations (BS) in wireless networks before the start of the transmission. As the first step of Radio Resource Management (RRM), UA is regarded as a crucial task for network performance improvement such as increasing throughput, saving energy and improving quality of service. A good UA solution can lead to better network throughput, reduced co-channel interference, and balanced network load, thus laying a good foundation for the subsequent resource allocation tasks.

Traditional UA is either “complex and impractical”, which has a huge computational complexity especially when the network scale is enormous or “quick and stupid”, which is unable to deal with the practical network requirements in complex network scenarios. The emerging deep learning (DL) methods provide potential solutions to this problem. However, reinforcement learning (RL) formulates the problem as a Markov Decision Process (MDP) and requires long-term interactions with the environment which leads to significant signalling overheads and time cost, while supervised learning requires a large amount of high-quality labelled data to generate a good prediction model. The aim of the project is machine learning method to solve the classical user association problem in multi-cell wireless networks.

Project objectives
The student requires to:
1. Conduct literature review on user association using machine learning methods.
2. Simulate a multi-cell wireless network.
3. Propose a machine learning algorithm to optimize the user association problem.
4. Evaluate and analyse the algorithm by comparing with other algorithms.
5. Compose a final project report.

Programming language/tool: Python, Matlab

Reference Reading
1. Y. Zhang, L. Xiong and J. Yu, "Deep Learning Based User Association in Heterogeneous Wireless Networks," in IEEE Access, vol. 8, pp. 197439-197447, 2020, doi: 10.1109/ACCESS.2020.3033133./
2. Hossain, E., Rasti, M., & Le, L. (2017). Radio Resource Management in Wireless Networks: An Engineering Approach. Cambridge: Cambridge University Press. doi:10.1017/9781316212493

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

2. Reinforcement Learning based Radio Resource Allocation in Wireless Networks

Nowadays, the wireless network has become more and more dense and complicated to fit the enormous transmission demands. Meanwhile, with the popularization of various wireless devices and applications, users have even higher transmission requirements, such as higher network throughput with lower latency. Wi-Fi networks, which serve as one main route for people's wireless communication, is also evolving rapidly. Orthogonal Frequency Division Multiple Access (OFDMA) was newly introduced into the latest 802.11ax/be Wi-Fi standard, it enables a more dynamic channel/power allocation by dividing the available bandwidth into a series of mutually orthogonal sets of subcarriers and assigning them to the stations (STAs) to optimize the spectrum efficiency and network throughput for the whole system. Reinforcement learning (RL) is thought to be one promising method to optimize a long-term resource allocation problem in a rapid-changing wireless environment as it enables the agent(s) to interact with the environment and explore the best policy via "trial and error". The aim of this project is to using reinforcement learning algorithm(s) to solve the channel/power allocation problem to achieve the network KPI.

Project objectives

The student requires to:

1. Learn about Reinforcement Learning and radio resource management.
2. Simulate a multi-cell wireless network.
3. Propose a reinforcement learning algorithm to optimize channel/power problem.
4. Evaluate and analyse the algorithm by comparing with other algorithms.
5. Compose a final project report.

Programming language/tool: Python, Matlab

Reference Reading

1. Y. Liu, Y. Yu, Z. Du and L. Cuthbert, "Sequential State Q-learning Uplink Resource Allocation in Multi-AP 802.11be Network," 2022 IEEE 96th Vehicular Technology Conference (VTC2022-Fall), London, United Kingdom, 2022, pp. 1-5, doi: 10.1109/VTC2022-Fall57202.2022.10013045.
2. H. Ye, G. Y. Li and B. -H. F. Juang, "Deep Reinforcement Learning Based Resource Allocation for V2V Communications," in IEEE Transactions on Vehicular Technology, vol. 68, no. 4, pp. 3163-3173, April 2019, doi: 10.1109/TVT.2019.2897134.
3. Y. -H. Xu, C. -C. Yang, M. Hua and W. Zhou, "Deep Deterministic Policy Gradient (DDPG)-Based Resource Allocation Scheme for NOMA Vehicular Communications," in IEEE Access, vol. 8, pp. 18797-18807, 2020, doi: 10.1109/ACCESS.2020.2968595.

Notes:

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

PROPOSED BY BETTY LO

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1. Trip Planner

Background
Most people like travelling. It is an exciting and enriching experience that allows us to explore new destinations, cultures, and perspectives. Traveling involves visiting new or familiar places, experiencing different cultures, and engaging in a range of activities such as sightseeing, outdoor recreation, and cultural events. Traveling can be planned or spontaneous, and can take many different forms depending on the individual's preferences and circumstances. It can be a short trip to a nearby location or a long-term journey to a distant destination.

However, planning and booking a trip can be overwhelming, particularly for travellers who are unfamiliar with the destinations or have specific preferences or requirements. In recent years, the travel industry has undergone significant changes with the rise of online booking platforms, social media, and mobile technologies. Travellers are increasingly using mobile devices to research and book their trips, thus making travel apps an essential tool for modern-day travellers.

This project will develop a mobile trip planner that can provide users with a convenient way to plan, organize and record their trips, as well as discover new destinations and experiences. It will display user routes on the map and provide traveling options. Through providing real time weather information about the destinations, it will further help the users to plan and amend their itineraries if needed.

Objectives
- Design and develop an Android mobile trip planner application
- Maintain the trips itineraries and activities
- Visualize the itineraries on the map with travelling options
- Provide the destinations weather information
- Allows user to search for flight, hotels and destinations information

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

Reference
https://developers.skyscanner.net/
https://developers.google.com/maps/documentation/javascript/tutorials
https://openweathermap.org/api

2. Final Year Project Management System

Background

Final Year Project (FYP) is the individual project, which takes place over the two semesters of the final year of bachelor studies. It allows students to apply the knowledge and skills they have acquired throughout their studies to a real-world problem. The final year project provides an opportunity for students to show their creativity, critical thinking, problem-solving, and project management skills, which are essential for their future careers. It also allows students to work independently and develop their self-motivation, time management, and communication skills. Finally, the final year project is an essential requirement for many academic programs, and the successful completion of the project is often a prerequisite for graduation.

However, managing the final year project can be a challenging task for both students and supervisors. Throughout the two semesters, students need to attend workshops, submit, proposals, reports, poster and presentation, whereas supervisors need to closely monitor, record students' progress and grade the students' work. A digital Final Year Project Management System can streamline the project management process and help students and supervisors manage their projects more efficiently, from proposal submission to final presentation.

In this project, student is required to develop a web-based application to allow students and supervisors to keep track of tasks, deadlines, and milestones associated with the projects. This application will provide real time analytics on the student progress and deliver appropriate notifications.

Objectives

- Develop a centralized platform for students and faculty to manage final year projects, including proposal submission, progress tracking, final presentation and grading.
- Provide a repository for project-related documents and resources
- Supervisors should be able to monitor the progress of students' projects and provide feedback
- Provide real-time updates on project progress, milestones and analytics on the final year project process
- Deliver notifications base on predefined conditions

Required Skills

Student should have good understanding of programming languages such as HTML, CSS, JavaScript, and server-side programming. Basic understanding of database management systems such as MySQL, Oracle, or SQL Server. Familiar with web development frameworks.

3. My Recipes

Background

In recent years, there has been a growing awareness of the importance of maintaining a healthy diet. People are becoming increasingly conscious of the impact that their food choices have on their overall health and wellbeing. A healthy diet is crucial for maintaining a healthy body weight, reducing the risk of chronic diseases such as diabetes and heart disease, and improving mental health. With the rise of social media and the internet, people now have access to a wealth of information on nutrition and healthy eating habits. They are shifting towards a more health-conscious lifestyle and seeking out healthier food options and making more informed choices about what they eat.

With the increasing use of internet technology, mobile applications have become a popular tool for managing one's health. In this project, student will develop an Android mobile recipe application which can provide users with a simple and easy-to-use platform for finding and saving their favorite recipes. The application can also record users' health and provide necessary nutrients information and recommendation on the users' diet.

Objectives

- Design and develop an Android mobile application for recording and organizing users' favorite recipes in various formats.
- Record users' health data and recommend suitable diet
- Users should be able to search for recipes base on different criteria
- The application should provide the related nutrition's information of the recipes
- Include features that allow users to share recipes through social media platform

Skills required

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

Reference

https://docs.flutter.dev/reference/tutorials
https://calorieninjas.com/api
https://www.edamam.com/
https://pub.dev/packages/social_share_plugin

4. Pet Tracker

Pets play an important role in our lives, providing us with companionship, love, and joy. Most common types of pets are dog, cats, fish, rabbits… etc. As pet owners, we want to provide the best possible care for our furry friends, ensuring that they are healthy, happy, and well-behaved. 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. Managing a pet's health, wellness, and behavior can be challenging, particularly for new pet owners or those with busy schedules. What most pet owners need is a pet app, providing then with a range of tools and resources to manage their pet's needs and make pet ownership easier and more enjoyable.

In addition, there are different kinds of pets, for those who wish to become a pet owner and want to find out more about various types 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 are to design and develop an Android mobile application, to help the pet owners to record their pets basic information, health records… etc. which allows the owners to store all their pets' necessary information in a single place. In case of emergency, this application can help the pet owner to locate the nearby pet related services such as groomers, pet stores and the veterinary clinics. 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.

Objectives:

- Design and implement an Android mobile application
- Implement pet recognition function and provide the basic pet information
- Track the pet's medical history, including vaccinations, medications,
- Schedule appointments with veterinarians and receive reminders for important health check-ups and treatments.
- Locate the nearby pet-friendly businesses such as groomers, pet stores or 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 EVELYN LO

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1. Learning Foreign language by Android 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 Face Recognition Attendance Management System

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….

3. Face Recognition applied on Class Attendance Monitoring System

Background:

Smart attendance with real-time face recognition is a convenient method to keep track the students' attendance on a regular basis. From the traditional taking attendance manually with a sheet of paper by calling their names during lecture hours and to modern access RFID card reader and even Iris system to mark the attendance, to track out the students attending the class is essential. To maintain the attendance record with day to day activities is challenging. The daily attendance of students is recorded subject wise which is stored already in the database. As the time for corresponding subject arrived the student can do the face recognition before entering the classroom to take the attendance. Therefore, the requirement with computer-based face recognition attendance management system which can assist for maintaining students' attendance records automatically is recommended.

This project needs to prepare the first part data for the students attending in different class or subjects of the day. And create an attendance management system for academic administration and the students to check up their own attendance.

Project Main Objectives:

- Implement a web-based attendance management system
- Create a user-friendly interface
- Create the students information and class list based on the time schedule
- Implement the face recognition technology for the check-in and check-out time of the class schedule
- Provide the class attendance checking method
- Implement and test the system
- Compose a final project report

Skill required:

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

4. Sign Language vocabulary Learning Web/App

Background:

In order to effectively communicate with sign language, people need to know some basic vocabulary and phrases. Just like our spoken languages, there are a variety of sign languages in the world. And many will have their own local sign language. Hong Kong and Macao will have a slightly different way. By learning the sign language, people can communicate with those who are deaf and hard of hearing as well as people with functional hearing.

There are a few tips for learning sign language for beginners:

- ✓ Join the local classes and resources to learn sign language.
- ✓ Utilize online tutorials and videos.
- ✓ Connect with members of the Deaf community.
- ✓ Practice regularly for long-term retention of sign language skills.

This project needs to create a sign language vocabulary for people learning and practicing through web/app to get familiar the words and try to communicate and share with the people who cannot hearing the voice from our world.

Project Main Objectives:

- Implement a web-based/app for the learning system
- Create a user-friendly interface
- Create the sign language vocabulary database
- Implementation of the learned vocabulary by practicing on exercise
- Implement and test the system
- Compose a final project report

Skill required:

Django, Python, MySQL, OpenCV, tensorflow, midiapipe holistic, matplotlib, etc….

PROPOSED BY ERLI LYU

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1. Implementing Q-learning reinforcement learning algorithm in motion planning

Motion planning algorithm seeks to find an optimized uncollision trajectory from the start state to the goal state. In this process, the path is usually optimized with respect to metrics such as trajectory length. The optimization process is usually conducted conditioned on the planning context such as the start and goal states in configuration space, the planning constraints, and the obstacles. The Q-learning reinforcement learning algorithm learns the parameters of a neural network to approximate the reward given a state and an action, this neural network is called the Q-function noted as $Q(s, a \mid \theta)$. Based on the learned Q-function, one can easily derive an optimized trajectory by choosing the action with the maximum reward as described in reference [1]. While in [1], the state of the learned Q-function is represented by RGF features, in this project we aim to represent the state by using the latent space of a point cloud autoencoder.

The trained point cloud autoencoder network and an initial version of the motion planning simulator will be provided, the student should focus on how to use them and implement the reinforcement learning algorithm. The student is encouraged to upgrade the motion planning simulator.

Project objectives

The student is required to:

1. Learn about implementing reinforcement Learning algorithms in motion planning from the references [1, 2];
2. Learn about the motion planning simulator;
3. Implement the Q-learning reinforcement learning algorithm to motion planning problem.

Programming language/tool:

1. Python;
2. Robot simulator: ROS, OpenRave；
3. PyTorch;

Reference Reading

1. J. Huh and D. D. Lee, "Efficient Sampling With Q-Learning to Guide Rapidly Exploring Random Trees," in *IEEE Robotics and Automation Letters,* vol. 3, no. 4, pp. 3868-3875, Oct. 2018, doi: 10.1109/LRA.2018.2856927.
2. Jurgenson, Tom, and Aviv Tamar. "Harnessing reinforcement learning for neural motion planning." arXiv preprint arXiv:1906.00214 (2019).
3. Deep Deterministic Policy Gradient: https://spinningup.openai.com/en/latest/algorithms/ddpg.html
4. Reinforcement learning: https://en.wikipedia.org/wiki/Reinforcement_learning

2. Implementing data augmentation method to maintain the performance of the network which trained with synthetic point cloud in the real world

Point Cloud is defined as a set of 3D points in Cartesian space and it captures the surface geometry of the objects. Because the point cloud contains the geometric information, the network trained with synthetic data it is supposed to be easily transferred to the real world. Recently, researchers focused on training the network with the augmented synthetic dataset to enable the transferability of the point cloud network.

In this project, the student is required to design several 3D objects, train the objects with augmented synthetic data and transfer the learned network to real-world application. An initial version of the point cloud network will be given. The student is encouraged to collaborate with the student from Project 3.

Project objectives

The student is required to:

1. Learn about data augmentation methods from the reference [1, 2];
2. Learn about how to use AutoCAD to design simple 3D objects;
3. Use 3D printer to print the designed 3D objects;
4. Train the point cloud network with augmented synthetic data and test the network with real-world data;

Programming language/tool:

1. Python, PyTorch;
2. AutoCAD;
3. 3D printer slicer;

Reference Reading

1. Gao, Ge, et al. "Cloudaae: Learning 6d object pose regression with on-line data synthesis on point clouds." *2021 IEEE International Conference on Robotics and Automation (ICRA)*. IEEE, 2021.Jurgenson,
2. Wu, Chengzhi, et al. "Sim2real Transfer Learning for Point Cloud Segmentation: An Industrial Application Case on Autonomous Disassembly." *Proceedings of the IEEE/CVF Winter Conference on Applications of Computer Vision*. 2023.

3. Implementing orthographic network to maintain the performance of the network trained with synthetic point cloud in the real world

Point Cloud is defined as a set of 3D points in Cartesian space and it captures the surface geometry of the objects. Because the point cloud contains the geometric information, the network trained with synthetic data it is supposed to be easily transferred to the real world. Recently, researchers focused on designing an orthographic network to generate a global rotation- and scale-invariant representation for a given 3D object, as described in [3].

In this project, the student is required to design several 3D objects, train the objects with the orthographic network and transfer the learned network to real-world applications. The student is encouraged to collaborate with the student from Project 2.

Project objectives

The student is required to:

5. Learn about orthographic network from the reference [1];
6. Learn about how to use AutoCAD to design simple 3D objects;
7. Use 3D printer to print the designed 3D objects;
8. Train the OrthographicNet with synthetic data and test the network with real-world data;

Programming language/tool:

1. Python, PyTorch;
2. AutoCAD;
3. 3D printer slicer;

Reference Reading

1. Kasaei, S. Hamidreza. "Orthographicnet: A deep transfer learning approach for 3-d object recognition in open-ended domains." *IEEE/ASME Transactions on Mechatronics* 26.6 (2020): 2910-2921.

4. Designing a cable-suspended sensors system to monitor the velocity and acceleration of the football

Currently, the velocity and acceleration of the football are estimated indirectly by the camera system. Although the linear velocity and acceleration can be accurate estimate with cameras with high frame rates, the estimation of angular velocity and acceleration is relatively hard. However, these data play an important role in evaluating the performance of the football player.

To accurately estimate the angular velocity and acceleration of the football, in this project, the student is required to design a sensor system imbedded in the football to directly measure the velocity and acceleration of the football. The architecture of the sensor system can be designed as [1]. 6D inertial measurement unit can be used to measure angular velocity and acceleration. In addition, several force sensors could be attached to the end of the cables to measure the force of each cable and to estimate the position and angular acceleration of the football.

Project objectives
The student is required to:
1. Learn to use Arduino or other platform to get data from the sensors;
2. Use AutoCAD to design the prototype of the sensor system;

Programming language/tool:
1. AutoCAD;
2. Python;

Reference Reading
1. https://en.wikipedia.org/wiki/Cable-suspended_camera_system

PROPOSED BY YUE SUN

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1. Video-based animal behaviour recognition using 3D CNNs

The behaviour status of animals is a significant indicator of their health, affecting animal welfare. Animal activity recognition is an essential agricultural subject that facilitates understanding of animal behaviour. However, manual observation is impractical due to the laborious efforts required, especially for large-scale commercial farms. Automated behaviour recognition based on computer
vision technology is expected to provide a continuous, low-cost, and objective assessment. Recently, video-based automated monitoring systems become a rising topic in animal monitoring.

The Animal Kingdom dataset will be used as the materials for this study. This dataset contains 50 hours of annotated videos to localize relevant animal behaviour segments in long videos for the video grounding task, and 30K video sequences for the fine-grained multi-label action recognition task, which correspond to a diverse range of animals across 6 major animal classes. The behaviour classes include eating, walking, grooming, sleeping, etc.

The project aims to identify the behaviour type of the animals incorporating 3D feature information from videos, and evaluate the model performance. 3D-CNNs are leveraged to extract discriminative spatio-temporal representations for different behaviour classes, and a decision is assigned to each video segment.

The project objectives include:

- Review the literature on video-based action recognition networks.
- Choose a baseline model for the task of animal behavior classification.
- Investigate and implement the strategy for optimizing the model training.
- Design a specific animal action feature extraction/fusion module.
- Evaluate the model performance.

Preferred skills:

- Image processing
- Python/C++
- Tensorflow or Pytorch

References:

- Neethirajan, Suresh. "The role of sensors, big data and machine learning in modern animal farming." Sensing and Bio-Sensing Research 29 (2020): 100367.
- Ng, Xun Long, et al. "Animal kingdom: A large and diverse dataset for animal behavior understanding." Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition. 2022.

Further information:

- https://paperswithcode.com/dataset/animal-kingdom

2. Animal keypoint detection for posture estimation

In modern farming, monitoring and analyzing the postures of animals can facilitate improving animal welfare and reducing ecological footprint during food production. Abnormal behavior changes in posture may help reveal animal discomfort or diseases. As the state-of-the-art (SOTA) recognition models develop, the data format of inputs to the deep-learning networks plays a decisive role in the final performance. In this project, we propose to employ SOTA object keypoint detection techniques and benchmark with an animal posture estimation dataset, aiming for more accurate localization and understanding of animal behaviors. The object keypoint detector should employ a so-called end-to-end learning approach: features extracted from individual objects are used to train a customized keypoint detection model. The goal is to convert an animal image into a dataset enriched with keypoint coordinate information for labeling the key body parts.

The animal pose dataset will be used in the study to facilitate training and evaluation. This dataset provides animal pose annotations on five categories, which are dog, cat, cow, horse, and sheep, with in total of 6,000+ instances in 4,000+ images.

The project objectives are as follows.

- Literature study from the advanced technical perspectives.
- Get familiar with the existing public dataset (e.g. Animal posture dataset).
- Implementing SOTA keypoint detection methods using a public dataset.
- Evaluate the module performance using the metrics such as PCK.

Preferred skills:

- Image processing
- Python/C++
- Tensorflow or Pytorch

References:

- Matthews, Stephen G., et al. "Early detection of health and welfare compromises through automated detection of behavioural changes in pigs." The Veterinary Journal 217 (2016): 43-51.
- Cao, Jinkun, et al. "Cross-domain adaptation for animal pose estimation." Proceedings of the IEEE/CVF international conference on computer vision. 2019.

Further information:

- https://paperswithcode.com/dataset/animal-pose-dataset

3. Medical breast image segmentation

Medical image segmentation refers to the process of separating the region of interest in a medical image from the background. Medical image segmentation has important application value in medical imaging, which can help doctors diagnose diseases more accurately, formulate treatment plans and evaluate treatment effects.

Mammogram is a commonly used breast cancer screening method. However, due to the complexity and diversity of breast tissue, the interpretation and analysis of mammograms require the high experience and skills of doctors. The method based on deep learning can automatically learn features of breast tissue and separate breast tissue from other tissues. Specifically, the method realizes the segmentation of mammograms through steps such as data preprocessing, model training, and image segmentation.

In this project, you can learn and practice the below knowledge: medical image processing, image segmentation, and deep learning.

The project objectives include:

- Literature study for advanced medical image segmentation methods.
- Apply a baseline model for the task of breast image segmentation.
- Implement the workflow for model training, validation, and testing.
- Evaluate the segmentation performance using the evaluation metrics (e.g. Dice Coefficient).

Preferred skills:

- Python/C++
- Tensorflow or Pytorch
- OpenCV

References:

- Michael, Epimack, et al. "Breast cancer segmentation methods: current status and future potentials." *BioMed Research International* 2021 (2021): 1-29.
- Al-Antari, Mugahed A., Mohammed A. Al-Masni, and Tae-Seong Kim. "Deep learning computer-aided diagnosis for breast lesion in digital mammogram." Deep Learning in Medical Image Analysis: Challenges and Applications (2020): 59-72.

4. Automated initial alignment for medical image registration

Image registration is an essential tool in the field of medical imaging. In many clinical situations, several images of a patient are taken to analyze the patient's situation. These images are acquired with, for example, X-ray scanners, Magnetic Resonance Imaging (MRI) scanners, Computed Tomography (CT) scanners, and Ultrasound scanners, which provide knowledge about the anatomy of the subject. A combination of mono- or multi-modal patient data often yields additional clinical information not apparent in the separate images.

To achieve a robust registration result, an initial estimation of the image is important, and much commercial software uses a manual input to perform the initial image alignment, which is time-consuming. In this project, we plan to automate the process to accelerate registration.

In this project, you can learn or practice the below knowledge: medical imaging, image registration, deep learning, Dicom information, the tool of ITK, Elastix, VTK, OpenCV, etc.

The project objectives include:

- Literature study for unsupervised image registration methods.
- Investigate and implement the strategy for mono- and multi-modal data registration.
- Validate the registration method by calculating the target registration errors.

Preferred skills:

- Python/C++
- OpenCV
- ITK, VTK

References:

- Jiang, Xingyu, et al. "A review of multimodal image matching: Methods and applications." Information Fusion 73 (2021): 22-71.
- Arar, Moab, et al. "Unsupervised multi-modal image registration via geometry preserving image-to-image translation." Proceedings of the IEEE/CVF conference on computer vision and pattern recognition. 2020.

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PROPOSED BY JACKY TANG

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1. Detection and Recognition of Chinese Text in Natural Scenes

Background

There are various types of text in real life, such as books, exam papers, checks, or bills. In early research, Optical Character Recognition (OCR) of scanned documents received in-depth study. With the demand for practical applications, people are no longer satisfied with text recognition in specific scenes but are pursuing more complex natural scenes. Scene Chinese text recognition refers to recognizing Chinese text in natural scene images, which has great application prospects, but also faces more complex challenges as follows.

(1) The background is complex, and the lighting conditions vary greatly. Compared with the single scene of paper documents, text in natural scenes can appear anywhere, such as on billboards, logos, etc. Therefore, the background in natural scene text images is very complex, and there are many background textures that resemble text.
(2) Text distribution in natural scenes is diverse, and accurate detection is challenging.
(3) Chinese characters have many unique types, complex structures, and similar characters, increasing the difficulty of recognition.

In this project, students will complete the tasks of text localization and recognition in images captured from natural scenes. Text localization requires determining the text regions in the image based on the characteristics of the text. After obtaining the text regions, text recognition needs to be carried out.

Project Objectives

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

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

Reference Reading

（1）Liao, Minghui, et al. "Real-time scene text detection with differentiable binarization." *Proceedings of the AAAI conference on artificial intelligence*. Vol. 34. No. 07. 2020.
（2）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.

2. Text Detection in Video File

Background

Text detection in video file is a challenging task in computer vision that involves locating and identifying text regions in a video. This task has potential applications in various fields, such as surveillance, video analysis, and robotics. For example, it can be used in surveillance to detect and track text regions in security camera footage, or in video analysis to extract information from videos containing text.

In this project, students will complete data preparation and text detection in videos. The project requires detecting text regions in video files and outputting the corresponding class.

Project Objectives

In this project, the main objectives are as follows.

(1) Data Preparation: Collect a dataset of videos that contain text regions and label them with bounding boxes around the text regions. This will involve manually annotating the videos, which can be a time-consuming process. However, there are also publicly available datasets that can be used, such as the ICDAR Video Text Detection Challenge dataset.
(2) Text Detection Model: Implement a deep learning-based text detection model for videos. There are several approaches that can be used for this task, such as region-based methods like Faster R-CNN and YOLO, or segmentation-based methods like Mask R-CNN and PANet. The selected model should be trained on the annotated dataset to learn to detect text regions in the videos.
(3) Evaluation: Evaluate the performance of the text detection model on a test set of videos with known ground truth annotations. The evaluation can be done using standard metrics such as Precision, Recall, and F1-score. The model can be fine-tuned for better performance based on the evaluation results.
(4) Output Classification: Once the text regions are detected in the video files, the corresponding class of the text can be outputted.

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

3. Blockchain-Based Student Information Management System for Access Control of Generative Artificial Intelligence Tools Use

Background

Generative Artificial Intelligence (Generative AI) is an AI system that can generate text, images, or other media in response to prompts. The most sophisticated chatbot powered by generative AI is called ChatGPT. Since ChatGPT's debut in November 2022, it has gained considerable popularity quickly. Specifically, ChatGPT added 1 million users in the first five days and 100 million users in the following two months. This creative AI tool also raises concerns about the use of AI in education and elicits conflicting reactions from the higher education sector. In this project, we argue that a complete ban on the tool is technically impractical and that the higher education sector should instead concentrate on monitoring the use of generative AI tools, such as ChatGPT, and identifying academic dishonesty.

Regarding the blockchain-based student information management system, it provides access control for generative artificial intelligence tools. Only approved users will be able to access the generative AI tools thanks to the system's security features. The ChatGPT model is used as a case study when implementing the system. To securely store and handle student information, the suggested system makes use of blockchain technology. Blockchain is a distributed data storage technology that transparently records transaction details in a decentralized, reliable, and highly trusted ledger that stores vital information. Securing data from student information systems (SIS) is one of blockchain technology's most significant uses. Through the use of decentralized and well-maintained data stores, blockchain opens up new possibilities for attaining data integrity.

This system is also built on the use of smart contracts, which let the blockchain run pre-defined programs autonomously in certain circumstances. For instance, the student might be required to complete the assessment on the system after the teacher distributes it through the system. The instructor also establishes the student's access to the ChatGPT chatbot and the maximum number of times the chatbot may be used by the student. This method uses the underlying blockchain to record student behavior, which is then reviewed in more detail if there are any concerns about academic misconduct. The data are encrypted to safeguard student privacy, and they shouldn't be decrypted unless a specific legal procedure is followed. This is because the data is sensitive and confidential, and it is important to ensure that it is not accessed by unauthorized individuals. The legal process that must be followed will depend on the specific circumstances, but it may involve obtaining authorization from the institution. By following the appropriate legal process, we can ensure that the encrypted data is accessed only by authorized individuals and that it is used in accordance with applicable regulations.

Objectives

In this project, students will

- Be familiar with the background knowledge about blockchain and dapps.
- Design a privacy preserving data storage system.
- Implement the system.
- Learn the high-level idea about emerging cryptography technologies.

Skills required

- Programming
- Distributed system engineering

4. Zero-Knowledge Proof for Machine Learning

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 last few years have witnessed two prominent trends: the increasing migration of various aspects of our world to online platforms and the growing power of ML/AI methods. These technologies have facilitated new forms of art and significant productivity improvements. However, a concerning issue is the rising use of closed APIs to conceal these ML/AI advancements.

While providers may intend to safeguard their trade secrets, there is a need for assurances regarding the models' integrity. Concerns include ensuring that training data doesn't contain copyrighted material and is free from biases. Additionally, there is a demand for transparency regarding the execution of specific models in critical domains like the medical industry.

To address these concerns, model providers can take two steps. First, they can release proofs of training on a concealed dataset and commit to the model's weights after the process. Importantly, the actual weights can remain hidden. This way, third parties can be confident that the training process was conducted honestly. Second, audits can be conducted using zero-knowledge proofs over the hidden data, ensuring privacy while providing the necessary assurances.

Objectives

In this project, students will

- Be familiar with zero-knowledge proof and its applications.
- Design a zero-knowledge proof solution.
- Implement the solution.

Skills required

- Programming

References Two

[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-S´ebastien 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.

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1. Designing CNN model architecture using Genetic Algorithm

Background

In the last decade, deep convolutional neural network (CNN) models have achieved state-of-the-art performance on various computer vision tasks like image classification. The architecture design of CNN models have been an important issue, as it relates to the model's accuracy, computation efficiency, parameter efficiency, robustness to adversarial attacks, etc., which are crucial properties.

The architecture design of a CNN model involves the selection of tons of hyperparameters, including but not limited to: (1) The number of layers; (2) The topology of layers; (3) The type of each layer. For example, a layer can be a fully-connected layer, a convolutional layer, a pooling layer, etc.; (4) the hyperparameters of each layer. For example, the hyperparameters of a convolutional layer includes number of kernels, kernel size, stride, padding size, etc. Therefore, manually designing a good model is an extremely challenging task.

Network architecture search (NAS) is a technique that automates the design of neural networks. A NAS approach uses a search strategy (e.g., evolutionary algorithms) with a performance estimation strategy to search the optimal model architecture in a search space. Currently, some models designed by NAS even outperforms manually designed models. Therefore, NAS is worthy of further research to explore its potential.

Genetic Algorithm (GA) is an evolutionary algorithm inspired by the principle of the evolution theory. In nature, individuals which are more adapted to the environment have higher chances to survive and produce offspring. This process keeps repeating over generations until the best individual is found.

This project studies the feasibility and effectiveness of GA for NAS. Particularly, the student is expected to implement GA for the automatic design of a CNN model such that the model has a great property (e.g., accuracy) on an image classification task (e.g., CIFAR-10).

Objectives

The student is expected to:

- Learn the relevant knowledge of deep learning, especially the architecture of CNN models such as the common types of layers in CNN models, hyperparameters, and common network topologies.
- Learn the relevant knowledge of GA and NAS.
- Do the literature review on using GA to design network architecture.
- Learn how to use PyTorch to run deep learning algorithms.
- Learn how to use PyGAD to run GA.
- Comparing different schemes which encode a model architecture as an individual.
- Comparing different hyperparameters of GA.
- Result evaluation, comparison, and discussion.
- Compose a final report.

2. Training Convolutional Neural Networks with Partially Labeled Data for Image Multi-Label Classification

Background

Image multi-label classification (MLC) is a typical computer vision problem that classifies the presence or absence of multiple categories in an image. As an image usually contains multiple objects or concepts, it is more practical than its counterpart single-label classification and hence has a wide range of applications like medical image interpretation.

Image MLC datasets are usually fully labeled, where each image sample has the labels of every category. Convolutional neural networks (CNNs) can be straightforwardly trained on such fully labeled datasets to perform MLC tasks. However, some image MLC datasets are partially labeled due to the expensive cost of manual labeling. That is, for each image sample, only the labels of a small portion of categories are known, and the rest are unknown. To solve this problem, several approaches have been proposed in recent years for training CNNs on partially labeled datasets.

In this project, the student is expected to implement and compare several existing approaches (e.g., Treat as Negative [1], Partial-BCE [2], Partial-ASL [3]) for training CNNs on partially labeled MLC datasets.

Objectives

The student is expected to:

- Learn relevant knowledge of deep learning. E.g., CNN, multi-label classification, and loss functions
- Learn how to use PyTorch to train deep learning models (e.g., training CNNs on fully labeled MLC datasets).
- Do literature review on training CNNs on partially labeled MLC datasets.
- Implement several existing approaches to train CNNs on partially labeled datasets (e.g., LVIS).
- Results comparison and discussion
- Compose a final report

References

[1] Kundu, Kaustav, and Joseph Tighe. "Exploiting weakly supervised visual patterns to learn from partial annotations." Advances in Neural Information Processing Systems 33 (2020): 561-572.

[2] Durand, Thibaut, Nazanin Mehrasa, and Greg Mori. "Learning a deep convnet for multi-label classification with partial labels." Proceedings of the IEEE/CVF conference on computer vision and pattern recognition. 2019.

[3] Ben-Baruch, Emanuel, et al. "Multi-label classification with partial annotations using class-aware selective loss." Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition. 2022.

3. Evaluation of Feasibility of Using ImageNet as Source Domain in Medical Image Classification

Background

It is widespread using ImageNet as the source domain in transfer learning. However, due to the feature differences between natural images from ImageNet and medical images, using ImageNet as the source domain might not bring the expected performance, such as liver lesion segmentation and classification [1] and breast cancer classification [2]. However, other sub-areas are still waiting to explore the feasibility of using ImageNet as the source domain.

To achieve this project, the student is expected to evaluate the feasibility of using ImageNet as the source domain in medical image classification by implementing several deep learning models in classification tasks, such as Diabetic Retinopathy [3], etc, Moreover, consider the class imbalance issue. Additionally, the student is expected to compare the performance of models pre-trained on ImageNet or not pre-trained on ImageNet.

Objectives

In this project, the student is expected to:

- Learn the relevant knowledge of convolutional neural networks, related deep learning models, environment deployment, evaluation metrics, etc.
- Do the literature review to study the deep learning models in medical image classification.
- Download the datasets, then partition the dataset into a training, a validation, and a testing set.
- Consider the class imbalance issue, applying data augmentation techniques to balance the classes.
- Implement several deep learning models in Pytorch.
- Results evaluation, comparison, and discussion.
- Compose a final project report.

References

[1] Michal Heker, Hayit Greenspan, "Joint Liver Lesion Segmentation and Classification via Transfer Learning," arXiv.

[2] Alzubaidi Laith, Al-Shamma Omran, Fadhel Mohammed A, Farhan Laith, Zhang Jinglan, Duan Ye, "Optimizing the performance of breast cancer classification by employing the same domain transfer learning from hybrid deep convolutional neural network model," Electronics, vol. 9, no. 3, p. 445, 2020.

[3] Emma Dugas, Jared, Jorge, Will Cukierski, "diabetic-retinopathy-detection," [Online]. Available: https://kaggle.com/competitions/diabetic-retinopathy-detection.

4. Identifying Color Impact in Transfer Learning for Facial Expression Recognition

Background

Transfer learning is widely used when there are limited resources. By using the deep learning models, knowledge can be shared between two domains and tasks by freezing partial of the models' parameters. However, what factors of the source domain will impact the target domain or what criteria we have to follow to select the source domain is still unclear. Therefore, in this project, the student will explore and identify the critical factor for facial expression recognition transfer learning, such as whether the colors will affect the performance in facial expression recognition transfer learning. Furthermore, to compare, analyze, and give recommendation(s) for source domain selection.

In this project, the student is expected to implement transfer learning across two kinds of facial expression recognition datasets (two datasets for each kind, a total of four datasets), colored and grayscale facial expression recognition datasets, such as [1] and [2]. Furthermore, the student is expected to identify the critical factor(s) by comparing the models' performances. The student is expected to have analysis skills.

Objective

In this project, the student is expected to:

- Learn the relevant knowledge of convolutional neural networks, related deep learning models, environment deployment, evaluation metrics, etc.
- Learn the relevant knowledge of transfer learning and fine-tuning.
- Do the literature review to study the deep learning models applied in facial expression recognition.
- Download the datasets mentioned above and partition the dataset into corresponding sets. In addition, find two more datasets and repeat the previous process, one kind each (colored and grayscale).
- Implement transfer learning across two kinds of datasets by applying deep learning models in Pytorch.
- Identify the important factor(s) in facial expression recognition transfer learning by results evaluation, comparison, and discussion.
- Compose a final project report.

References

[1] N. SEGAL, "Facial Expressions Training Data," [Online]. Available: https://www.kaggle.com/datasets/noamsegal/affectnet-training-data?select=disgust.

[2] M. SAMBARE, "FER-2013," [Online]. Available: https://www.kaggle.com/datasets/msambare/fer2013?select=test.