The Next Evolution of Technology "AI Robotics Vision and Automation": From Applied-Education, Academic-Research to Industrial Applications

Artificial Intelligence (AI) robot is the next evolution of technologies and applications for business, healthcare, Internet of Things (IoT), finance, education and social science (See Figure 1). The challenges of implementing the AI robot to be fully automated and with intelligence depends on the AI computational model design, speech and vision recognition, emotion detection and classification, scenario analysis and decision-making modelling. Although there are many research studies attempting to solve these problems, some problems such as low computation power of AI, methods to build the AI models in parallel and/or distributed architecture to accelerate the analysis, and data security and privacy issues are still unsolved.
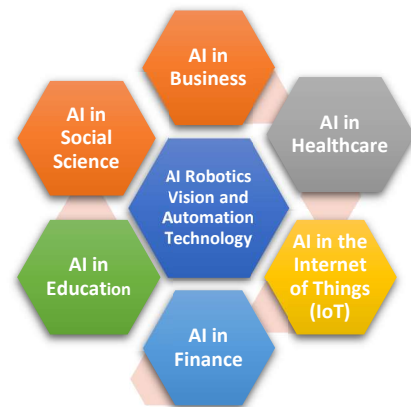

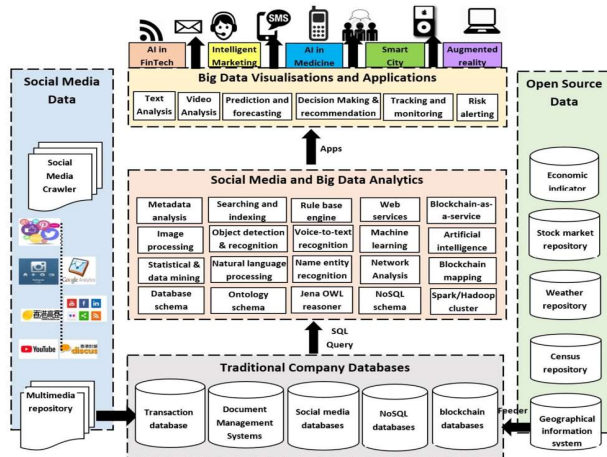Figure 1 AI Robotics Vision and Automation Technology Challenges

Figure 2 AI Developing an open source big data analytics platform and artificial intelligence tools in natural language processing, context-based name entity recognition, blockchain analysis, ontology building, distributed networks, image and video analyses. (https://saasweb.hku.hk/datasci/vision.php).

Although there are many research and education programs that are teaching and researching AI solutions, how we can nurture our next generation to learn from theory to practice, and to cultivate them with innovative thinking and applied-research skills for inventing new products and applications to meet the business need. The HKU's (3+1)Is strategy (see Figure 3) introduces the use of the Internationalisation, Innovation and Interdisciplinarity to create collective Impact. The Data Science Lab added a novel STEMIP education model (see Figure 5) on top of the HKU (3+1)Is strategy. STEMIP is an innovative learning model that integrates Science, Technology, Engineering, Mathematics, Innovation and Practical together to cultivate students' inquiry, critical thinking, analytical skills, communication skills and insight creation for creating innovative and practical solutions to business. It nurtures our future generations to be an applied-research scientist starting from junior, youth, to adult.

The HKU SAAS Data Science Lab (DSL) applied AI techniques on an ontology for modelling and analysing human dialogs and emotions. It invented some novel statistical and mathematical models and AI-based image/video analytics techniques in the edge computing AI chip device to detect and classify images, sounds, emotions and body movements, to predict risks and motions in images or videos (see Figure 2). The collaborators include some local companies, such as Marvel Digital AI Ltd, PricewaterhouseCoopers (PwC Mainland China and Hong Kong), etc. In 2021, the DSL provided several consultancies, internships, capstone projects, and an AI Robotics Vision and Automation Technology Challenges Competition to the local companies, institutions, and local secondary schools with STEM education in order to promote and develop some innovative solutions of using AI in finance/fintech, healthcare, business, IoT (Smart City), education, and social science areas.

Figure 3 The HKU's (3+1)Is: Internationalisation, Innovation and Interdisciplinarity, which converge to create collective Impact.

"We aim at integrating internationalisation, innovation and interdisciplinarity to create impacts to the society and nurture our next generation to be the great leader and applied-research scientists," said Professor Guosheng Yin, Head of HKU Department of Statistics and Actuarial Science.

Figure 4 Discussion how to bridge the gaps of secondary school education to tertiary school education. From left to right: Dr Eddy Lam, Mr Wong Tung Shek, Dr Adela Lau.

"We train our students learning from theories to practices (see Figure 4). Textbook is static content. Most knowledge can only be learnt from experience and practices. So, our school puts emphasis on the learning from practices rather than textbook content, student's self-motivation, and talent discovery. *If the youth can discover their talent in the early age, they can put the time and efforts in a specific area that can lead them to success,*" said Mr Wong, the mentor and teacher of the winning team in the AI Robot Competition 2021 (secondary group - Heung To Secondary School – Tseung Kwan O).

"*Studying should not aim at the grades (求學不是求分數). Ability to put theories and knowledge into practice is more important. (學以致用才是最重要).* We streamline the STEMIP education from junior, youth to adult by collaborating with the secondary schools in STEM education, institutions, and our business partners in local and overseas to offer business problems and potential solutions to the students in local schools and tertiary institutions," *said Dr Adela Lau, Deputy Director of HKU SAAS Data Science Lab.*

"Data Science Lab promotes education through applied research, connects local and overseas companies and professionals to students so as to create new inventions, and to learn to apply the theories to practice. *Through the competition, workshops, internships, knowledge exchange, consultancy, and capstone projects with our industrial and institutional partners, we cultivate future leaders, inventors, and entrepreneur,*" said *Dr Eddy Lam, Director of HKU SAAS Data Science Lab*.

"*Let's see how AI changes our society and creates innovation! (人工智能如何改變我們的世界) and what we have been done in our Data Science Lab with STEMIP in 2021.*" 🧠 ⚙️ 👁 🔍
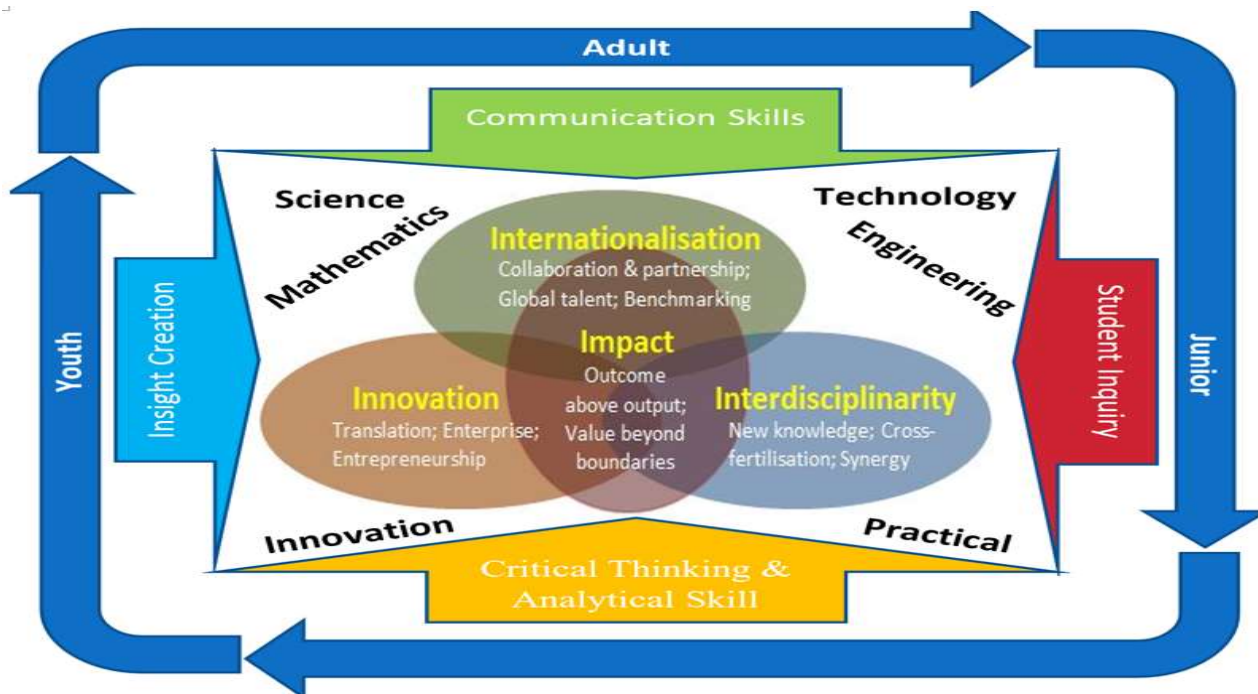

Figure 5 The novel education model of STEMIP that was added on the top of the HKU's (3+1)Is strategy : Internationalisation, Innovation and Interdisciplinarity, which converge to create collective Impact.

AI in Business

AI Robotic Automation and Vision for Office Assistant
(Consultancy Project with Applied-Research and Joint-Research Paper Publication)
Using a Novel Logic Gate with EfficientNets to Solve Fine-Grained Problem of Object Identification and Classification

By Prof G.S.Yin, Dr Adela Lau, Mr Howard Chan, Dr Herbert Lee (MDAI Ltd.) and Dr Patrick Ma (MDAI Ltd.)
(https://dslab.saas.hku.hk/cgi-bin/application1.cgi/)

Figure 1 Project Meeting with Marvel Digital AI Limited at Hong Kong Science Park. From left to right: Dr Patrick Ma, , Prof G.S. Yin, Dr Herbert Lee, and Dr Adela Lau
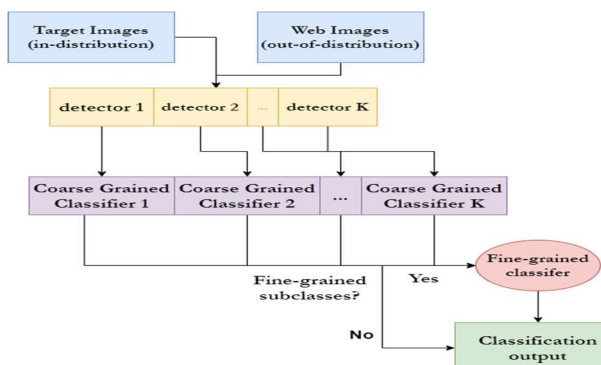

Figure 2 Our proposed novel logic gate architecture with multiple EfficientNets for solving the fine-grained problem of object classification.
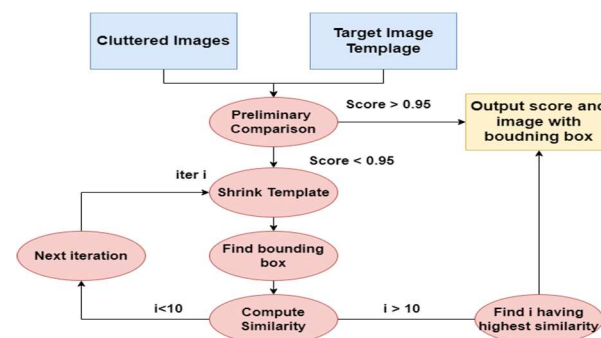

Figure 3. The object template mapping algorithm

"Your team did an amazing work! The novel object identification and classification model with high accuracy rate and has high potential to be used in other image/video analytic problems and commercialization," said Dr Herbert Lee, Chairman of Marvel Digital AI Ltd, and Dr Patrick Ma, CEO of Marvel Digital AI Ltd .

Marvel Digital AI Limited is a high-tech company that focuses on developing innovative AI and Big Data Analytics solutions. In 2021, it offered Data Science Lab two object identification and classification consultancy projects. These projects aim to identify and classify the fine-grained objects. The challenges of the object identification and classification are how to determine the variation of scale, view-point, intra-class, occlusion, illumination and background clutter of the object.

The HKU SAAS Data Science Lab developed a novel **Logic Gate Architecture with EfficientNets** for differentiating the tiny difference of the object classes (see Figure 2), and trained the models in different layers based on the object's unique features. It used the geometric and simulation approaches to simulate the distorted and similar object images for training images with scale, view-point, intra-class, and illumination variations. The accuracy rate of the model can achieve around 95%, which outperforms the existing model with 90.5% accuracy rate for solving the fine-grained image classification problem.

To solve the image occlusion and background clutter variation problems, we developed a novel template matching algorithm (see Figure 3) to match the target image template (user updated image) from the image templates with a sliding window. We compute the similarity of the target template and the matched template. The flow of the template identification was shown in Figure 2. The program iteratively shrinks the template and uses match_template in openCV to compute the region of the target template that can best match the template in the cluttered image. The matched template is then cropped out and similarity score is computed for this iteration. This process are repeated several times to outline the bounding box with the highest similarity score.

"It is excited working on an applied research project with MDAI Ltd for knowledge transfer, innovation discovery, and academic publication with our faculty staff and postgraduate students," said Prof Yin, HKU SAAS Department Head.

AI in Business/FinTech (Applied-Research Collaboration Project with Joint-Research Paper Publication)
Using Three-Layer Detector for Seal Recognition and Verification

By Mr Jasper Chan, Dr Adela Lau and Mr Leo Hsu (PwC Mainland China and Hong Kong)
(https://dslab.saas.hku.hk/cgi-bin/application1.cgi/)

In order to recognise and verify the company seal, PwC collaborated with the HKU SAAS Data Science Lab to develop a novel three-layer detector using AI to locate the seal in the scanned document, to estimate the distortion of the seal, and to classify the seal of the company. The challenges of this project include how to detect the boundary box of the seal in the scanned document, use the color and intensity levels of the seal to estimate the distortion of the seal for real or fake seal verification, and to differentiate the seal of the company with the other seals with similar shape and pattern. The limitations of the existing statistical and AI methods are its low accuracy rate in noisy background filtering for seal detection, the lack of algorithm for ink deterioration and intensity measurement and classification of objects with similar shapes, and overfitting problem of the classification models.

The HKU SAAS Data Science Lab developed a novel three-layer detector with Pseudo-Siamese Network with LSTM model, Quadruplet Network with ResNet50 and a modified loss function for seal recognition and verification (see Figure 1). It used a novel clustered Efficientdet with EfficientNetb3 feature extractor for seal detection with 98.5% precision and 99.0% recall. Our model outperforms the existing methods as the best results in existing research are 92.7% (D-StaR), MAP (92.7%), and MAR (84.2%).

"It is delighted to collaborate with HKU SAAS Data Science Lab as a community of solvers coming together to deliver outcomes while building trust across the value chain. The three-layer detector is how ingenuity combines with new technology innovation and experiences. It can be deployed to other business applications such as identity verification, fraud document detection, etc," said Mr Leo Hsu, Digital Trust & Analytic Partner of PwC Mainland China & Hong Kong.

To determine the real or fake seal, we simulated a set of images with seal distortion (see Figure 2). We used the Pseudo-Siamese Network with LSTM model, that no research study uses this method before, for seal intensity measurement with accuracy rate 92.1% to estimate the distortion of the seal. We implemented a time-series model of the seal distortion as one of the features to determine the real or fake of the seal.
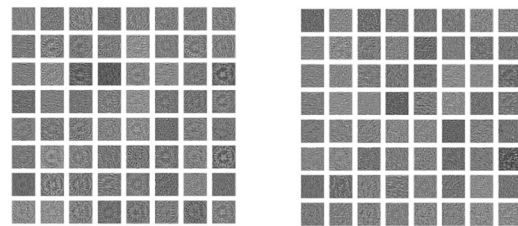

Figure 2 The first 64 filter results of original circular seal passed through the 20th convolution layer of ResNet (Left) and the first 64 filter results of simulated circular seal passed through the 20th convolution layer of ResNet (Right) using Pseudo-Siamese Network with LSTM.

Finally, we developed a novel Quadruplet Network with ResNet50 and a modified loss function for seal classification with 98.6% accuracy rate. Our model outperforms the current research work as the best results in tackling object detection in previous research is 95.46% (CSRS)..
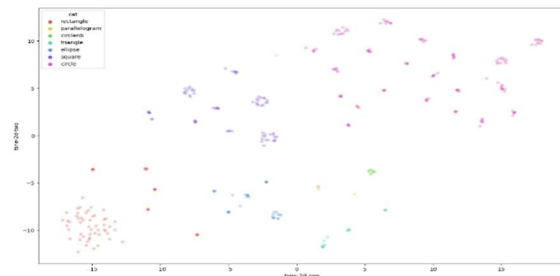

Figure 3 Quadruplet Network with ResNet50 and modified loss function and sampling ($m = 0.6$, $n = 0.3$, $a = 0.8$, $b = 0.4$, $g = 0.01$)

"It is excited for Data Science Lab to collaborate with PwC Mainland China and Hong Kong to apply our innovation to a real business problem. We engage to work with industrial partners on applied research collaboration," said Dr Adela Lau, Deputy Director of HKU SAAS Data Science Lab.
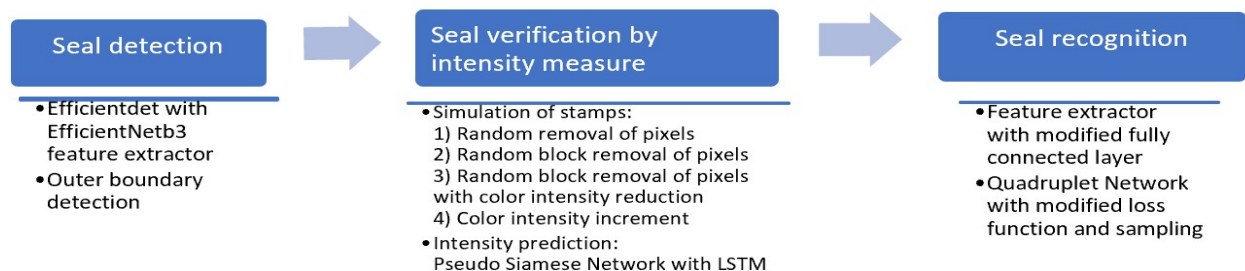
Seal detection
- Efficientdet with EfficientNetb3 feature extractor
- Outer boundary detection

Seal verification by intensity measure
- Simulation of stamps:
  1) Random removal of pixels
  2) Random block removal of pixels
  3) Random block removal of pixels with color intensity reduction
  4) Color intensity increment
- Intensity prediction: Pseudo Siamese Network with LSTM

Seal recognition
- Feature extractor with modified fully connected layer
- Quadruplet Network with modified loss function and sampling

Figure 1 Three-Layer Detector for Seal Recognition and Verification

AI in Finance (Applied-Research Collaboration Project with Joint Research Papers Publication)
Using AI on the Ontology for Intelligent Big Data Visualization

By Ms Ruoyang Hu, Mr Liege Cheung (UIUC), Ms Yun Wang, Mr Jun Li, Dr Adela Lau, Mr Rogers Chan (ImpactInvest Limited)
(https://dslab.saas.hku.hk)

To predict the future price, the commonly used statistical or AI methods include correlation analysis, time series, regression analysis, etc. These methods mainly focus on numerical data for price prediction. However, a recent study found that future price is sensitive to the news and social media. A good example is the GameStop and AMC stocks going up and down sharply in 2021 after the frequent social media and news discussions. ImpactInvest Limited, which is a fund investment company, collaborated with HKU SAAS Data Science Lab in 2021 to explore how AI can be used to detect the market patterns and its correlated information accurately.

To learn the market behaviours and scenarios, HKU SAAS Data Science Lab developed an ontology-based 2D/3D clustered CNN model for price prediction, and built a big data visualization tool for visualizing the related news, prices, and other factors in a dashboard. The Data Science Lab collected the 10 years import and export trading data, environmental data, news data, and future price data of five crops in China, India, Thailand, Russian Federation, Australia and United States market for building the AI-based big data visualisation tool to predict the future market trend, and to visualise the correlated information.
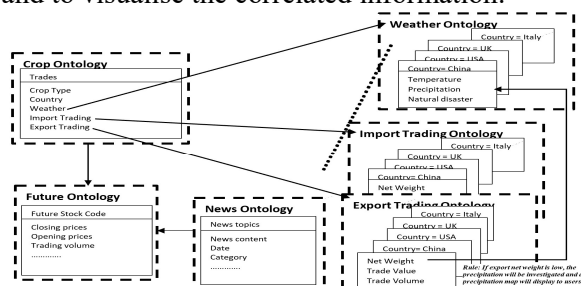

Figure 1 An ontology to describe the relationships between and within the data objects.

"With the big data visualisation, it can help fund manager to identify the related information for further analysis. As information overload is one of the greatest challenges to us, this tool can help us to shorten the information searching time for performing quicker response to the market changes," said Mr Rogers Chan, Partner of ImpactInvest Limited.

An ontology was built to describe the relationships of the news, prices, environmental factors, etc (see Figure 1). An ontology-based clustered 2D/3D CNN architecture was implemented to learn the historical price pattern (see Figure 2). The trained model can predict the future prices and the related information is extracted based on the ontology rules in the dashboard (see Figure 3).
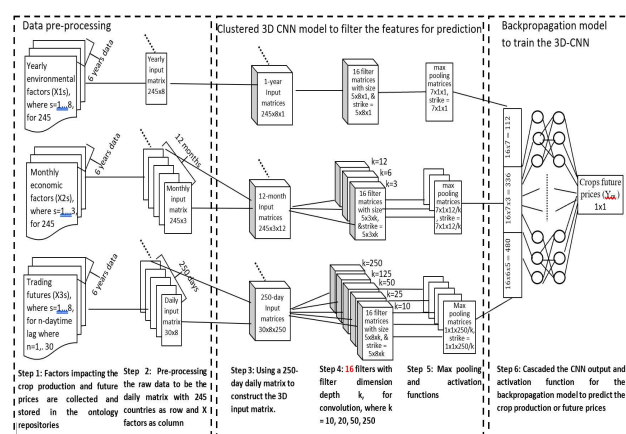

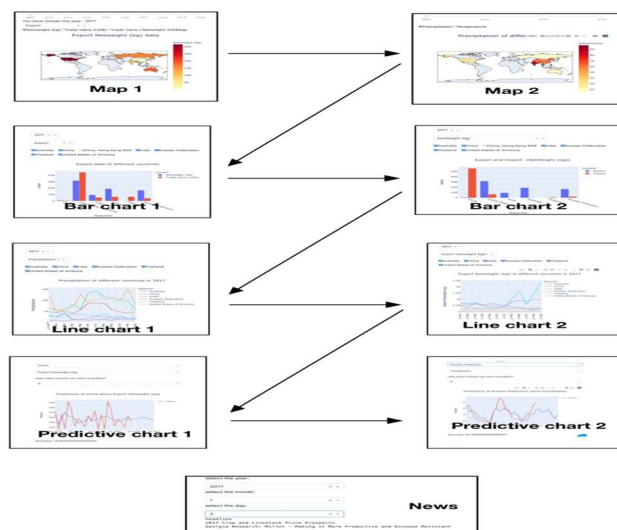Figure 2 An overview of the ontology-based clustered CNN architecture.

Figure 3 A dashboard to overview the related future prices, environmental factors, and related factors.

"Currently, the clustered 2D-CNN and 3D-CNN for price prediction was implemented. We have trained the model with big data inlcluding news, predicted price, and economic factors. A few applied-research papers had been or will be published based on findings fom this project," said Dr Adela Lau, Deputy Director of HKU SAAS Data Science Lab.

Using a novel Skip Gram, Knowledge Graph and Long Short-Term Memory (SGK-LSTM) model for Stock Price Prediction

By Mr Luk Tsz Kit, Mr Liege Cheung (UIUC), Dr Adela Lau, and Mr Rogers Chan (ImpactInvest Limited)
(https://dslab.saas.hku.hk/cgi-bin/application1.cgi/)

Financial news bring significant returns and volatility on stock market. A good example is the GameStop and AMC stock prices going up and down sharply in 2021 which were associated to social media and news discussions. This project aims to propose a novel methodology which uses financial news, ontology and knowledge graph to predict stock price movement. The Data Science Lab collected the stock price data and news from Yahoo finance. An Ontology based Named Entity Recognition (O-NER) is used to train the N-gram model for the news analysis and stock price movement prediction. A hybrid model of combining Skip-Gram, Knowledge Graph and Long Short-Term Memory (SKG-LSTM) is used to analyse the sentiment of the news. There are six components in the SKG-LSTM.

Data pre-processing model: It uses NLP techniques to extract the keywords from news title.

Graphical representation for news title: It converts the extracted words to graphical format based on the sentence structure.

Skip-gram model: It trains a model to embedded the extracted words into vectors based on similarity measurement.

Grouping nodes: It groups the nodes that have closed distance in vector representation.

Knowledge graph embedding (KGE): It embeds the sentence structure knowledge graph into a feature vector.

Stack long short-term memory (LSTM): It predicts the stock price movement based on the feature vector.

The results showed that the SKG-LSTM achieves a 69% accuracy rate. SKG-LSTM used sentence structure to construct KG for stock prediction that brings significant improvement comparing with the baseline model of "NER + SVM", which is commonly used with an accuracy rate of 54% only.

"News information is unstructured. The ontology can convert the unstructured news into knowledge for improving the stock price prediction," said Mr Dominic Wu, Partner of Vision Real Capital.
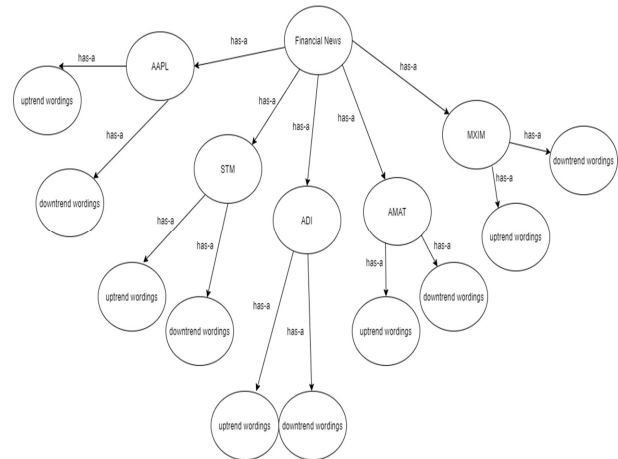

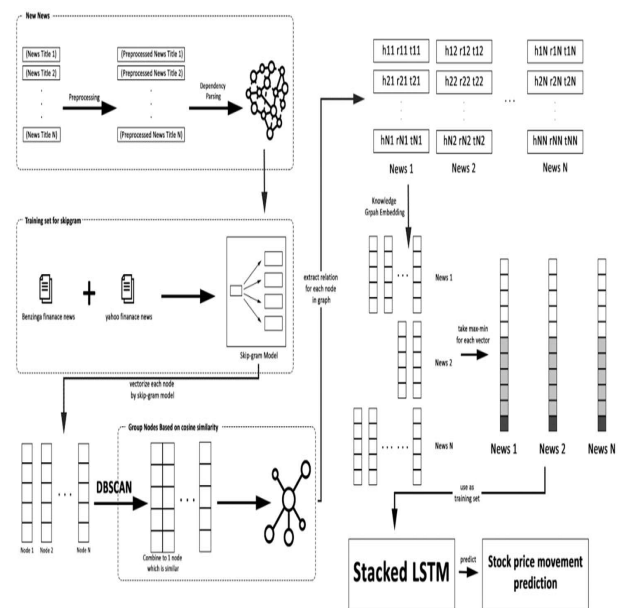Figure 1 Ontology of Financial News

Figure 2 An overview of the SKG-LSTM model

"Other than news, social media is another recent method for stock price prediction. The Data Science Lab always research some new methods for solving existing business problems with our business partners. The developed SKG-LSTM model can be applied to some other areas such as COVID19 preventive health policy control, mental health risk monitoring, etc.," said Dr Adela Lau, Deputy Director of HKU SAAS Data Science Lab.

AI in Healthcare

AI in HealthTech (Applied-Research Collaboration Project with Joint-Funding Application, Tools Development and Joint-Research Paper Publication)
AI-based Video Analytics for Monitoring Patient Risk: Using YoLov5 for Motion Detection

By Ms Janice Chan, Dr Adela Lau, Dr Eddy Lam and Mr Peter Lai (Adult ICU, QMH)
(https://dslab.saas.hku.hk/cgi-bin/application1.cgi/)

Falls and self-extubations are the most common problems and have caused serious harm to the patients at hospital all over the world. Approximately one fourth patients who self-extubated died in the US, and the death toll due to falls is approximately 650,000 globally each year. It is the second leading cause of unintentional injury deaths worldwide. The existing methods for detecting falls and self-extubation are sensor-based or vision-based approach. The limitations of sensor-based approach are its high cost and wearing device required by patients. Although the vision-based method, which uses machine learning to learn the computer vision, overcomes these problems, the error rate is high and training time is long.

YOLO is a recent method that can train the model and detect the objects fast The Data Science Lab used YOLOv5 deep learning algorithm for object detection and classification. YOLOv5 detects the bounding box (i.e. coordination of the target objects), classifies the objects, and determines whether the objects being in the boundary boxes or not at the same time that improves the accuracy rate and training time for the object detection. In this project, after all the images are labelled with the location and object name, model was trained with the images for object detection. The results showed that the precision for bed, patient and rmTube detection are 99.25%, 91.55% and 93.33% respectively. The recall for bed, patient and rmTube are 99.25%, 99.24% and 100% respectively. The average accuracy for predicting bed, patient and rmTube are 98.69%, 98.59% and 100% respectively. The results can provide a promising object detection for risk alerts.

To better monitor the patient risks and plan the staffing, a dashboard is implemented to measure the time and frequency of the patient risks such as falls, self-extubations, walking out of the bed, etc. It can provide a risk measurement and improve the quality of services of the hospital. To overcome the privacy and security issue, Data Science Lab has been working with a local company to deploy the video analytics functions *into a newly invented edge computing AI chip* that can run the video analytics in the device itself without transferring the image into cloud for analysis.
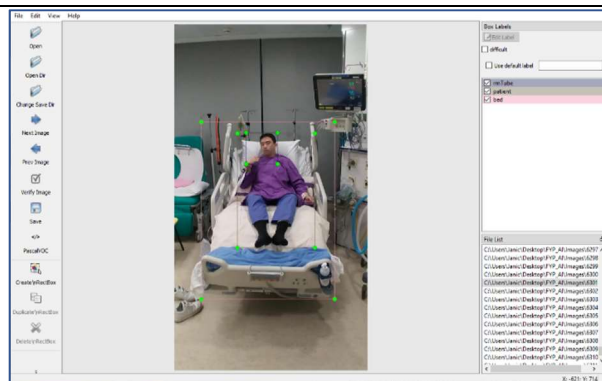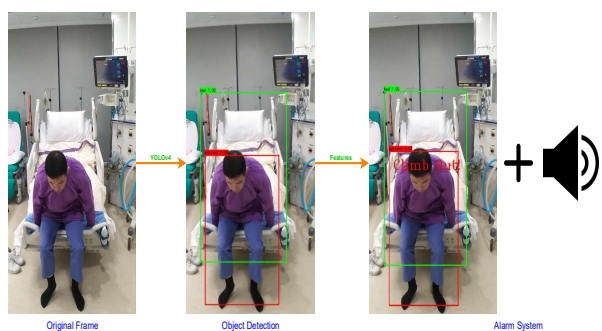

Figure 1 Image labelling for model training.
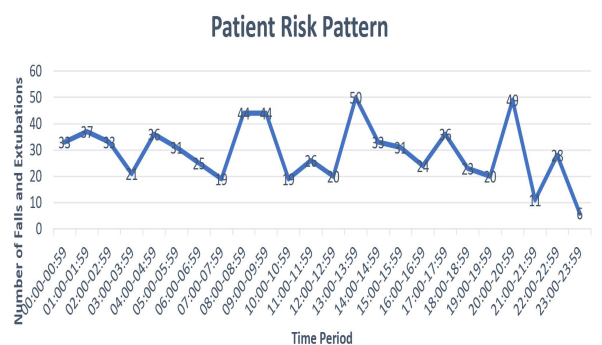

Figure 2 An object detection demo,

Figure 3 Risks Monitoring Dashboard for human resources planning and risk measurement.

"The AI video analytic system has great potential in enhancing patient safety in isolation facilities. In addition, it can protect the nursing/medical staff from directly interacting with the patients during the epidemic period," said Mr Peter Lai, Nursing Consultant (Intensive Care) of the Adult ICU of the Queen Mary Hospital.

AI in Infection Control and Public Health (University Internship with Applied-Research)
COVID-19 Data Visualisation Dashboard for Epidemic Monitoring

Department of 統計及精算學系 Statistics & Actuarial Science THE UNIVERSITY OF HONG KONG

Data Science Lab HKU SAAS

By Prof G.S.Yin, Mr Amruthraghav Gopalakrishnan, Ms Mahnoor Ahmed, Ms Sun Yifang
(https://dslab.saas.hku.hk/cgi-bin/application1.cgi/)

COVID-19 pandemic has caused a devastating social and economic disruption in the world. As the number of cases of coronavirus increases, there is a greater need for summarizing COVID-19 data and information in a way that countries can readily use to help them mitigating the negative impacts of the disease, and to reduce the infection rate. For this purpose, some students in the Bachelor of Science (Major in Decision Analytics) of HKU SAAS Department have created an interactive dashboard app using Dash in Python called CovTrack. The students used the data provided by Johns Hopkins University, and an online scientific publication called Our World in Data to implement it. The dashboard offers a wide variety of graphs and maps which help tracking the pandemic in real-time. It allows users to select different metrics, and to observe changes in the graphs.

In Figure 1, it displays the total confirmed cases, total deaths, and total recoveries for the whole world. It provides daily metrics of the globe, such as the number of new cases in the last 24 hours, the mortality rate and the recovery rate. These charts help users to understand the current status of COVID-19, its recovery and mortality rates. In Figure 2, it allows users to find information pertaining to different geographical regions. The table displays the total number of cases, deaths and recoveries for each country. In Figure 3, the treemaps compare the proportion of cases by each country towards the total cases. In Figure 4, the COVID-19 growth trajectory graph helps in analysing the growth of COVID-19. This graph gives the vital information about difference of the COVID-19 cases in each country. The shorter is the time frame, the steeper is the curve and the faster is the growth. Finally, Figure 5 provides the analysis of the COVID-19 impact in each country, the COVID-19 testing and vaccination status, and the COVID-19 lockdown and shopping area. It can help the policy maker to oversees the preventive health activities done by each region.

"This big data visualisation tool is user friendly and can provide up-to-date information for monitoring and tracking the epidemic spreading!" said Prof Yin, HKU SAAS Department Head.
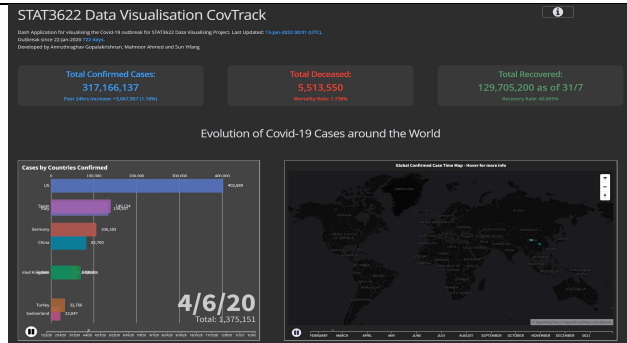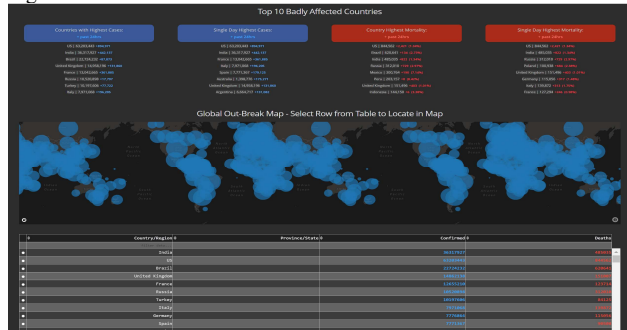

Figure 1 Overview the covid19 case around the world.

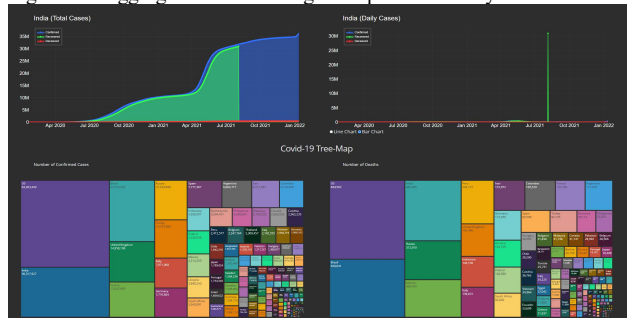Figure 2 Dragging down to investigate a specific country's cases
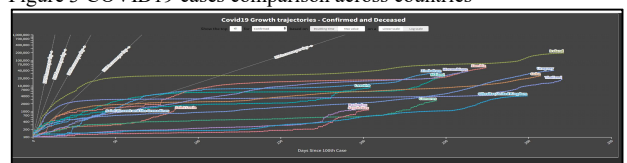

Figure 3 COVID19 cases comparison across countries

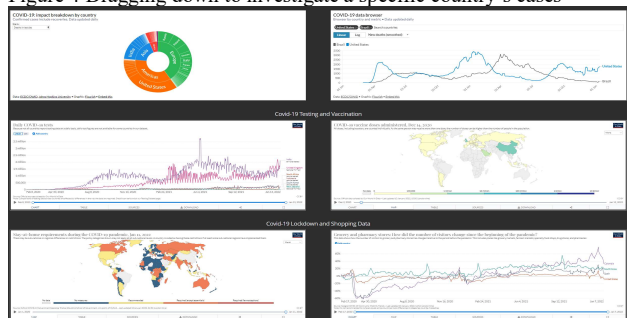Figure 4 Dragging down to investigate a specific country's cases

Figure 5 An overview of the preventive health program in each state

AI in Internet of Things (IoT) - Smart City

AI in Smart City (University Internship with Applied-Research with Tools Development)
Smart Home/Elderly/Child Safety Monitoring System

By Dr Adela Lau, Dr Eddy Lam, Mr Kries Ho, Ms Janice Chan
(https://dslab.saas.hku.hk/cgi-bin/application1.cgi/)

Home monitoring is one of the critical issues. This project aims to monitor home safety including baby movement, unexpected door open, home fire, etc. In 2020, there were more than 2000 burglary cases in Hong Kong. In order to monitor the risks, video analytics is one of the solutions to monitor home security and safety. There are two steps in video analysis: cropping the video and detecting the object's movement. The challenges of object detection are how to classify the objects, and to identify and locate the objects in the image.

The HKU SAAS Data Science Lab developed a set of libraries and a tool for detecting the risks and the unpredictable events at home. The tool first captures frames from video using OpenCV. There are two methods to detect the object: the two-stage method and one-stage method. The two-stage method (e.g. R-CNN) focuses on object localization and recognition tasks and this method has better detection accuracy rate. The one-stage method (e.g.YOLO) focuses on speed and real time analysis. Since home safety detection requires real time analysis, YOLOv5 was used to train the model in this project. The accuracy rate of the model is 99.88% and 97.63%, 99.25% for door movement detection, fire detection, and baby movement detection, respectively.

The challenges for video analytics are the time and resources in the preparation work of image collection and labelling. A fast GPU server is also required for training the images/videos. Privacy and security concern are some of the major barriers for using the video analytics in home monitoring. To overcome the privacy and security issue, Data Science Lab has been working with a local AI company to deploy the video analytics functions in an ***edge computing AI chip***. We run the video analytics in the device itself without transferring the image into cloud server for prediction. It can overcome the privacy and security concern.

"The video analytics techniques in this project can be widely used in home/hotel security monitoring, patient/elderly/child centre risk monitoring, etc.," said Dr Adela Lau, Deputy Director of HKU SAAS Data Science Lab.

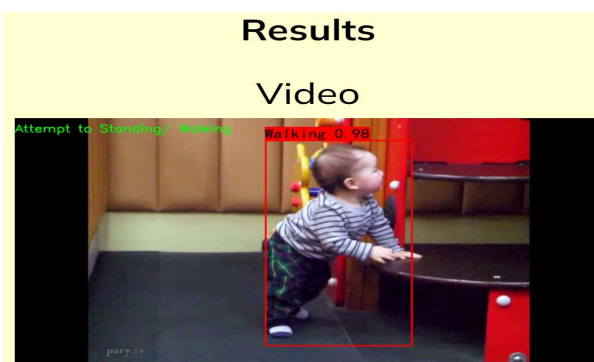Figure 1 Left: Detecting door open or close. Right: Fire alarming

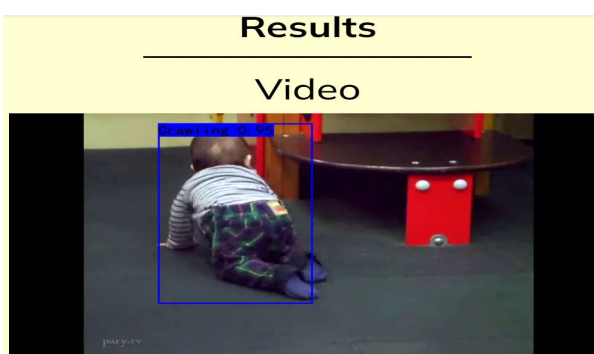Figure 2 Detecting baby's movement: walking.

Figure 3 Detecting baby's movement: crawling.

"We welcome companies or manufacturers to collaborate in this project with the Data Science Lab," said Dr Eddy Lam, Director of HKU SAAS Data Science Lab.

"We have introduced this newly invented tool of Data Science Lab to our business partners. This tool, deployed in an edge computing AI chip, has high potential for commercialization and can be widely used in different areas," said Mr Leo Tong, Partner of Vision Real Capital.

AI in Smart City (STEMIP Junior Nurture Program and Winner of Secondary School Group in the AI Robotics Vision and Automation Technology Challenges Competition)
Driver Drowsiness Detection System

將軍澳香島中學
Heung To Secondary School
(Tseung Kwan O)

Data Science Lab
HKU SAAS

By Tung Shek WONG (Mentor), Ho Shun Louisa LOUIE, Lo Yi Tiffany WONG, Chun Ting Issac WONG, Hin Wing Max TIN, Chung Ho Danny TSANG
(https://www.youtube.com/watch?app=desktop&v=5zoE5GPGjDU)

Figure 1 Driver Drowsiness Detection System - the winning team in the secondary school group

To detect drivers' drowsiness, drivers' eyes are detected first by Bayesian probability and then the Eye-Aspect-Ratio (EAR) is calculated based on the length and width of the drivers' eyes by simple arithmetic operation. Transport companies can analyse the drivers' drowsiness records using simple statistical methods such as calculation of mean, average of drowsiness and presentation of drivers' drowsiness frequencies. The analysis result can be presented using bar chart. Transport companies can analyse the statistics and schedule the rest time of the drivers to ensure that no driver works in a fatigue status. The experimental results showed that the system is able to detect the driver's drowsiness with 95% accuracy, even if the driver wears a mask or glasses.
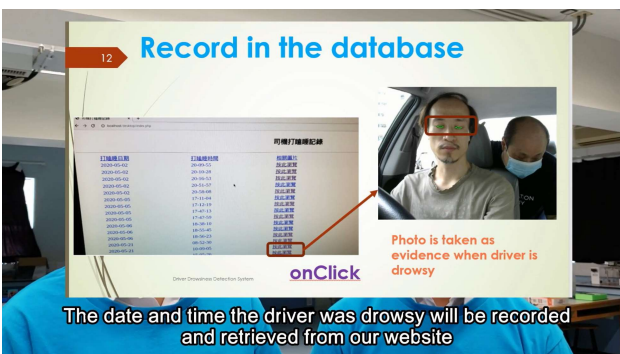

Figure 3 Driver Drowsiness Detection System - the winning team in the secondary school group.

"It is an amazing piece of work! The system can be used in driving safety monitoring, and some other applications like pilot safety control, security guard monitoring, classroom supervision, patient risks monitoring, etc," said Dr Adela Lau, Deputy Director of HKU SAAS Data Science Lab.

Through collaboration with HKU SAAS Data Science Lab in the STEMIP Junior Nurture Program (the competition), the student group from Heung To Secondary School (Tseung Kwan O) invented the Driver Drowsiness Detection System (DDDS) and converted the STEM education into innovation and practice (STEMIP). The DDDS involves STEM knowledge and skills such as Mathematics (probability), Engineering (Microcontroller and electronic appliances), and Technology (Python programming skills). The system integrates a new feature of voice and email system to give immediate alerts to the driver and the transportation company for risk assistance. It can greatly reduce the accident rate caused by driver's drowsiness.

Figure 2 Driver Drowsiness Detection System - the winning team in the secondary school group

The Bayesian probability, one of the basic AI models that the secondary school students have already learnt, is a simple machine learning tool of the AI family. The detection is based on the calculated posterior probability according to the Bayes' theorem given by

$$P(D_i|x_i) = \frac{P(D_i) * P(x_i|D_i)}{P(x_i)}$$

where $P(D_i)$ is the probability of drowsy state, $P(x_i)$ is the probability of occurrence of characteristic x, $P(x_i|D_i)$ is the probability of occurrence of characteristic x_i during the drowsy state, $P(D_i|x_i)$ is the probability of drowsy state when characteristic x_i occurs. Through this competition, students can reflect their learning and apply the STEM into innovation and practice.
"You and I can do it! (你和我都能做得到!)," said Mr Tung Shek WONG (the project mentor & teacher) and Mr Fei TANG (the Principal).

AI in Education (New StartUp Collaboration for Innovative Entrepreneurship)
AI-based Automation Exam Paper Marking System

By Prof G.S.Yin, Dr Eddy Lam, Dr Adela Lau, Dr Lequan, Mr Johnny Wan, Mr Zedric Cheung, Mr Raymond Chan
(https://dslab.saas.hku.hk)

Figure 1 ITF Project Meeting with Mach Innovation at Hong Kong Science Park. From left to right: Dr Lequan Yu, Dr Adela Lau, Prof G.S. Yin, Dr Eddy Lam, Mr Johnny Wan, Mr Zedric Cheung, Mr Raymond Chan
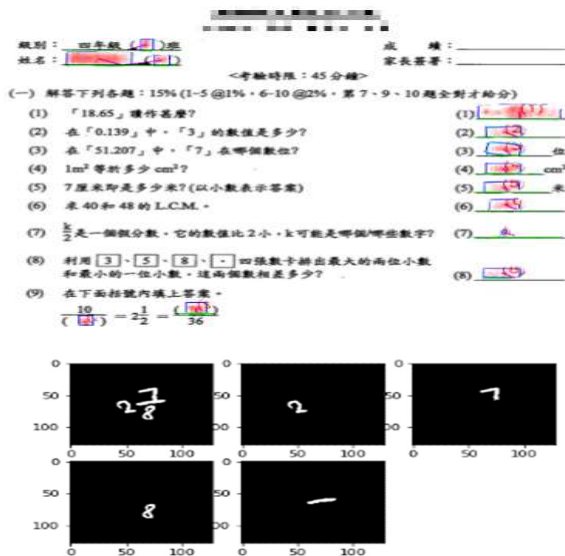

Figure 2 The result illustration for text boundary box detection (up) and text segmentation using deep learning algorithms (down)

"Zedric and Raymond are graduates of HKU Master of Data Science and MSc in Computer Science, respectively. The three co-founders have different undergraduate backgrounds such as Economics and Finance, Mechanical and Automation Engineering. Mach Innovation applies the theories of science, technology, mathematics, and engineering to real practices and create innovation in their business. It is the ultimate goal of our STEMIP education," said Prof. G.S. Yin, Head of HKU Department of Statistics and Actuarial Science.

"The Data Science Lab aims to nurture our graduates to be the research scientists and entrepreners. We provide mentorship, support and innovative development to current and graduated students, to equip them with the core competencies and qualities to become future great leaders, to make an impact and contribute back to the society," said Dr Eddy Lam, Director of the HKU SAAS Data Science Lab.

Mach Innovation is a modern AI and big data company that works with a group of professors in the HKU SAAS Data Science Lab. Its current product includes an AI-based automatic exam paper marking system that assists primary school teachers in marking the exam papers effectively and accurately. The challenges of making the scanned exam paper include image-to-text processing, boundary box detection, sentence-to-word segmentation, word recognition, word mapping and comparison. Although some existing AI models and natural language processing techniques can perform the above tasks, but there is a lack of trained AI models for mathematics and science subjects' text and symbols.

Mach Innovation developed a new AI-based mathematics paper marking system for the schools. It used a novel model for image segmentation and recognition that can convert handwritten digits, symbols and letters into computer typed text which assists to mark the scanned exam papers automatically. The models used the cutting-edge deep learning models such as Xception, ResNet and UNet, and were trained with real handwriting data that were collected from the schools (see Figure 2 on the left column). The accuracy rate of the automatic marking is more than 97% for an end-to-end process.

In order to help teachers to better evaluate students' performance and to accelerate their learning, Mach Innovation developed the outcome-based learning metrics and used a hierarchical clustering technique to classify and group the students with similar performance together for group-based personalised learning to boost up their learning efficiency. We have run a trial scheme with some of our school partners and will launch the system to their school phase by phase for final testing.

"Mach Innovation uses an open platform for their business, and is engaging to work with a wide spectrum of professors and business partners. If any schools or parties are interested in our products, you are welcome to contact Mach Technology," said Mr Johnny Wan, Zedric Cheung, and Raymond Chan, the founders of the Mach Innovation.

AI in STEM Education (Knowledge Exchange and Company Training)
AI in Robot Automation and Vision Workshop

By Dr Adela Lau, Mr Benny Lam (Kinth Technology (HK) Ltd), Mr Bernie Kwok (Kinth Technology (HK) Ltd), and Mr Chiang (Hong Kong & Kowloon Kaifong Women's Association Sun Fong Chung College)
(https://dslab.saas.hku.hk)

Figure 1 : The "STEM AI in Robotic Starter" workshop for the Hong Kong & Kowloon Kaifong Women's Association Sun Fong Chung College. In the first figure: Mr Benny Cheung and Bernie Kwok (the first two from the leftmost), Dr Adela Lau (the fifth from the leftmost), and Mr Chiang (the sixth from the leftmost)

Figure 2 Students implemented 4 robots with an automatic control module within a one-day workshop

"Kinth Technology (HK) Ltd is a company which aims at providing big data and AI solutions. We engage in promoting innovative technology and supporting our future generations and local companies in innovative applications," said Mr Benny Lam, CTO of the Kinth Technology (HK) Ltd.

In response to the changing needs in our society, the Education Bureau promoted a new education model, STEM, through Science, Technology, Engineering, and Mathematics to nurture the secondary school students' creativity, collaboration, problem solving skills, and entrepreneurial spirit in the 21st century. The Office of the Government Chief Information Officer (OGCIO) implemented the IT Innovation Lab for supporting the secondary schools to organise extra-curricular activities to deepen students' knowledge of cutting-edge IT, such as artificial intelligence, to build an IT foundation in their early ages, and to close the gaps of the secondary school's curriculum to the university one in terms of knowledge integration, innovation and practical.

The Hong Kong & Kowloon Kaifong Women's Association Sun Fong Chung College is one of the schools which includes STEM education and IT innovations in her curriculum. The HKU SAAS Data Science Lab provided a one-day workshop to the school with Kinth Technology (HK) Ltd in 2021 in order to support the education bureau and the OGCIO's visions. They nurture the secondary school's students and teachers on developing the cutting-edge IT curriculum in their school. The workshop included the real practices of using AI in robot control. In the workshop, Dr Lau provided a lecture on the foundation of AI and the evolution of the AI robots. Kinth Technology (HK) Ltd taught students some hands-on practices such as implementing a physical robot, and writing an introductory program code for controlling the robot.

"To promote innovative technology such as AI, Data Science Lab provides workshops, company trainings, and seminars to our business and school partners for knowledge exchange and professional training development, and to foster their innovation and entrepreneurial spirit. In the coming years, we will have some AI in robotic programming workshops with HKUSPACE to promote the use of AI for robotic development, and to train more adult professionals and companies to have a better understanding of know-how and deployment of AI," said Dr Lau, Deputy Director of the HKU SAAS Data Science Lab.

AI in Social Science

AI in Behavioural Intelligence (Winning Project of University Group in the AI Robotics Vision and Automation Technology Challenges Competition)
Artificial Intelligence Video Interview Analyser

By Mr. Jason Jin An CHAN, Mr. Tsz Hin CHAN, Miss Si Man TONG, Mr. Tsin Wai YAU, Dr Adela Lau (Mentor)
(https://youtu.be/Rpmk8R4uKtE)

In order to achieve better performance at job interviews, candidates desire and incline to have some mock interview practices. However, the relevant resources are very limited for this new norm. Therefore, our team from the Master of Statistics programme of the HKU SAAS Department developed an Artificial Intelligence Video Interview Analyser with three modules of video interview assessment, writing assessment, and performance review to analyse the facial expression of the candidates during interview, to assess the candidate's job knowledge with written assessment, and to calculate and visualise the candidate's overall performance respectively.

Figure 1. A module overview of the Artificial Intelligence Video Interview Analyser.

We used Haar Cascade with tuned parameters to detect the bounding box of the face, and apply the CNN model (with 4 Blocks of 2D Conv and Batch Normalization) to train the facial expression dataset (FER2013 dataset from Kaggle) with six emotions: anger, disgust, fear, happiness, sadness, and surprise. We used the trained model to predict the self-confidence level of the candidate. Positive facial expression reflects a higher confidence level during interview. All the results will be stored in a data frame for further analysis and score computation.
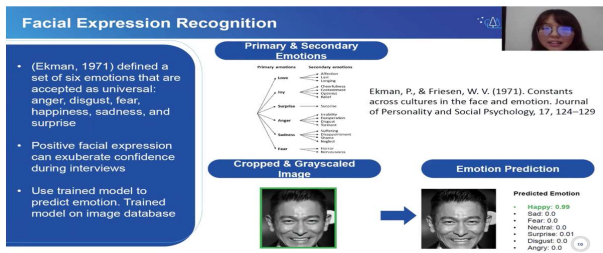

Figure 2 Facial expression classification with Haar Cascade and CNN.

Other than facial expression, since eye gaze is an essential part of body language that can determine important nonverbal behaviours, it can be used to understand a person's intentions. The team used the python GazeTracking library to measure where the eyes of the candidate are focusing at. Candidates with gaze at the centre with direct eye contact are associated with high self-confidence and considered more passionate on getting the job.
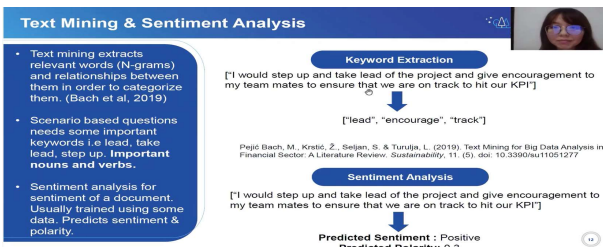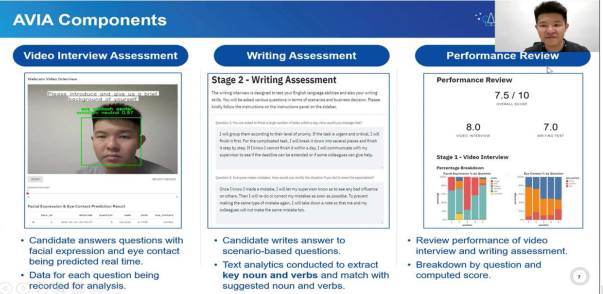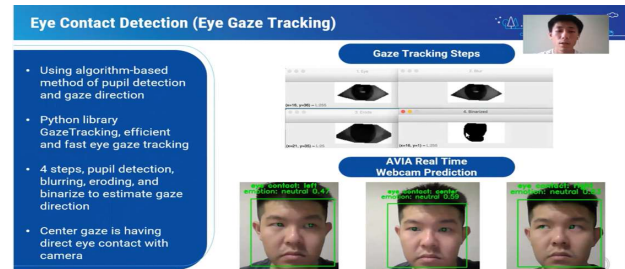

Figure 3. Eye gaze detection with python GazeTracking library.

Finally, we used TextBlob models for extracting the keywords and sentiment analysis, and compare them with the model answer to calculate the written performance score of the candidate. The results of the video interview and written assessments are then summarised in the dashboard.

Figure 4 Facial expression classification with Haar Cascade and CNN.

"The facial expression system can be used in the surveillance, security, and communication field. We welcome business partners to work with the Data Science Lab and our students for a startup collaboration" said Dr Adela Lau, the Deputy Director of HKU SAAS Data Science Lab.
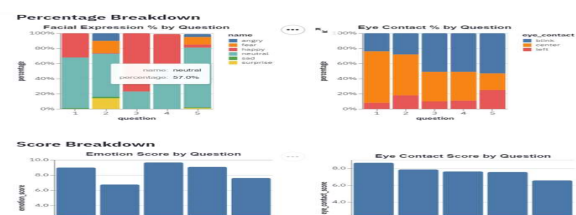

Figure 5. A dashboard to show the interview results of the candidate.