Science Essence Journal Vol. 41 No. 1 (2025) | 12-23

Research Article

Hi-Tech Plant Leaf Classification Using Artificial Intelligence (AI)

Benjamas Dhinnabutra[1], Jetsada Kumphong[2*], Parinyawatr Dhinnabutra[2] and Chayakom Phurimsak[3]

Received: 7 January 2025
Revised: 18 February 2025
Accepted: 20 February 2025

ABSTRACT

This study was aimed at surveying wild fruit plant species in the Khok Phu Taka forest area and developing a system of plant leaf classification using AI technology (*Polylthia debilis Finet & Gagnep* and other plant species). Data were collected from the Khok Phu Taka forest, and the AI system (development of AI by training images (N=145)) was developed to classify the leaves of *Polylthia debilis Finet & Gagnep* and other plant species. The system accuracy was verified of 10% of the images by using YOLO v4. The data were analyzed by Confusion Matrix. The findings revealed that plant species in the study area include *Polylthia debilis Finet & Gagnep*, *Polyalthia evecta (Pierre) Finet & Gagnep*, Indian gooseberry (*Phyllanthus emblica*), and *Ziziphus oenoplia (L.) Mill. var. oenoplia*, etc. The data were then labeled to develop the system, and an accuracy of 93 % was achieved in classifying *Polylthia debilis Finet & Gagnep* leaves and other species. In conclusion, the developed AI system increases the efficiency of plant species identification through leaf classification, while it provides the method to identify various plant species in the future.

Keywords: AI, forest, Khok Phu Taka, survey, system, *Polylthia debilis Finet & Gagnep*.

[1] Rajamangala University of Technology Isan Khon Kaen Campus, Khon Kaen 40000, Thailand

[2] Faculty of Technical Education, Rajamangala University of Technology Isan Khon Kaen Campus, Khon Kaen 40000, Thailand

[3] Faculty of Engineering, Rajamangala University of Technology Isan Khon Kaen Campus, Khon Kaen 40000, Thailand

*Corresponding author, email: jetsada.ku@rmuti.ac.th

Introduction

In Thailand, the Plant Genetic Conservation Project under the Royal Initiative (RSPG), which has been founded for over 20 years, is a project that works on 3 frames and 8 activities as a learning resource and preservation of the nature. Its work is operated by the government, private agencies, official organizations and universities, covering regions with consideration of local contexts [1-6]. The 3 knowledge frames include resource learning, utilization, and building of conscience awareness, while 8 activities are incorporated, i.e.: 1) protection of plant genetics, 2) survey and collection of plant genetics, 3) cultivating and preservation of plant genetics, 4) conservation and utilization of plant genetics, 5) operation of Plant Genetic Information Center, 6) Planning of plant breeding, 7) creating of conscience for plant genetic conservation, and 8) implementation of special activities to support plant genetic conservation [1].

The first activity, protection of plant genetics, involves provision and distribution of natural forest areas across the country in all phytogeographical zones. The operation has been carried out outside the responsible areas of the Royal Forest Department and the Department of National Parks, Wildlife and Plant Conservation. The work has been implemented in natural forests under the management of government agencies, research centers, experimental stations, educational institutions, and areas undergoing community conservation. Survey and registration of trees and other biological resources such as animals and microorganisms have then been carried out, with observation to preserve former genetics, in order to conduct future studies and utilization when ready [1, 3].

In 2024, Rajamangala University of Technology Isan, Khon Kaen Campus, implemented Activity 1, the Plant Genetic Conservation Project under the Royal Initiative at Khok Phu Taka, Muang Kao Phattana Sub-district, Phu Wiang District, Khon Kaen Province, as a community-preserved forest, a forest in an educational institution, and a zoo forest. Activities were conducted involving surveying, encoding trees, and coding of geographical positions [7-9].

Accurate classification of plant species during forest surveys is crucial. This requires surveyors who possess extensive knowledge of plant species and are significantly experienced. Thus, they had to collaborate with local sages. However, in implementation of the project each year, there were new research members, who were without prior experience in plant species classification. Additionally, local sages were not always available to provide their opinions to the researchers. Therefore, this research was only aimed at developing an artificial intelligence (AI) system to classify plant species using mobile phone images.

Presently, the advanced CCTV camera efficiently develops data into artificial intelligence. Required images can be collected for analysis and transformation into an automatic system by constructing machine learning or AI. This can further be developed to detect an object or different behavioural images. For instance, a traffic organization with a mission to detect the helmet wearing behaviour can collect a lot of images of riders' behaviors during their trip and develop machine learning of the behavioral images. The CCTV camera is enabled to recognize and detect such behaviors automatically [10].

The smart camera with AI and image classification at present works on the basis of "You Only Look Once Version 4". This means application of AI and Deep Learning to distinguish images, using the YOLO v4 model, which is one of the Object Detection Algorithm with high accuracy and speed [10-11]. YOLO v4 is a model used to analyze and detect objects. It has been developed after YOLO v3. The accuracy and performance of which has also been improved so that it suits the real-time detection mission. Past research has relied on dataset of different types of leaves for pre-processing training, for example, management of light, colors and background in order for the model to learn better. Some research applies Bounding Box & Labeling to set the boundary of each type of leaves using GPU to increase the computation efficiency. This is popular in the agricultural sector since it is able to detect plants' breeds and analyze the characteristics of seeds or leaf health, for instance, it can detect plant diseases. In addition, it is used in the environmental science and nature conservation fields. However, the quality of dataset has an effect on the model accuracy and complexity of each type of leaves, e.g., leaves with similar characteristics that may lead to errors of classification [11].

Each year, however, new members join the research team, often without prior experience in plant species identification. Furthermore, local wisdom experts are not always available during fieldwork. Therefore, this research is aimed at developing an AI system capable of identifying plant species through using mobile phone images. Therefore, the objectives of this study are 1) to survey wild fruit plant species in the Khok Phu Taka area and 2) to develop a plant leaf classification system using AI technology (Case Study of Leaf Classification by *Polylthia debilis Finet & Gagnep* and Other plants).

Materials and Methods

Study Area and Set Determinants

Khok Phu Taka is a natural conservation tourism area under the Plant Genetic Conservation Project initiated by Her Royal Highness Princess Maha Chakri Sirindhorn. The area consists of dipterocarp forest with a variety of plant species, including perennial trees (*Shorea obtusa*, *Shorea siamensis*, *Xylia xylocarpa*, *Wrightia tomentosa*, *Pterocarpus macrocarpus*, *Afzelia xylocarpa*), shrubs (*Bauhinia spp.*, *Chromolaena odorata*, *Dendrocalamus membranaceus*, *Melastoma malabathricum*, *Morinda citrifolia*), climbers (*Dischidia spp.*, *Ficus spp.*, *Entada rheedii*), perennial grasses (*Bambusa bambos*, *Vetiveria zizanioides*), and herbaceous plants (*Curcuma alismatifolia*).

Khok Phu Taka, a distance of 78 km from the urban area, is located in Ban Muang Kao, Village No. 3, Muang Kao Phattana Sub-district, Wiang Kao District, Khon Kaen Province. The transportation route by paved roads from Khon Kaen passes Wiang Kao District and another 12 km to Khok Phu Taka. The area is conveniently located near 3 key provincial attractions: Phu Wiang National Park, Si Wiang Dinosaur Park, and Phu Wiang Dinosaur Museum [7-9].

This study classified plants into two groups: Group 1: *Polyalthia debilis Finet et Gagnep.* Scientific Name: *Polyalthia debilis Finet et Gagnep.* Family: Annonaceae. Description: A small shrub approximately 1 meter tall with simple, alternately arranged leaves in a single plane. The leaves have

parallel edges to reverse-ovate lanceolate, with 7–10 pairs of secondary veins, Group 2: other plant species as depicted in Figure 1.

Figure 1 Examples of data collection: (A) *Polylthia debilis Finet & Gagnep* (B) other plants.

Wild Plant Species Survey

A survey was conducted in the Khok Phu Taka area from July 13- 14, 2024, while samples of wild fruit plant species were collected. The survey covered observation of wild fruit trees, registration of data, labelling data including names of discovered species and trees, recording places of discovery, taking photographs, and collecting data, all of which were done during daytime from 8:00 a.m. to 4:00 p.m. as depicted in Figure 2.

Figure 2 Survey of plant species and sample labelling.

Development of AI for Plant Species Identification through Leaf Classification

An AI system integrated with mobile phone cameras was developed, and a dataset of 145 plant images was used as the basis for training the machine learning model with the YOLO v4 program. Training was conducted in 1,000 iterations [10-13]. Next, data were collected to validate the accuracy

of 14 images or 10% of the total of training dataset. Subsequently, AI's accuracy was analyzed through image-by-image detection. The results were finally analyzed using descriptive statistics, i.e., frequency and percentage as depicted in Figure 3 [14-16].

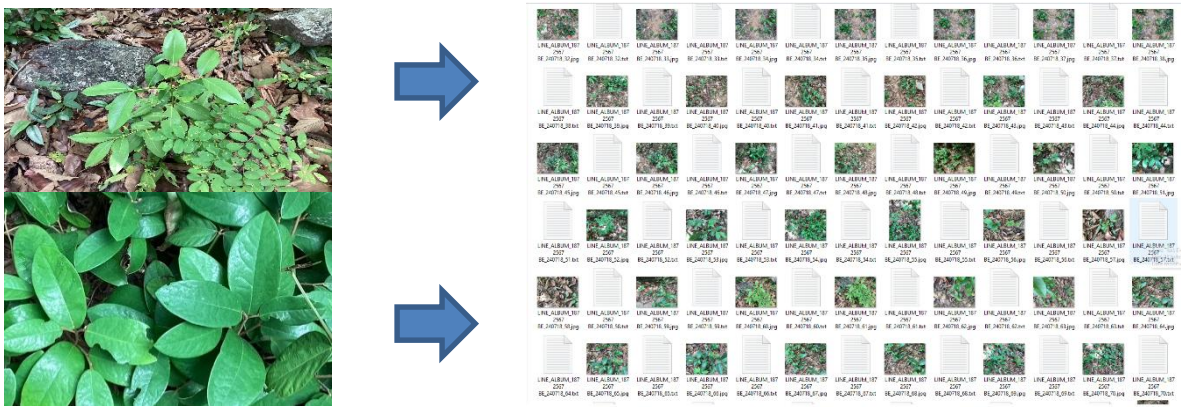

Figure 3 Examples of transfer from image data to txt. Data prior to training.

Step in detection mission: Open the video file obtained from site visit with the use of the data collection camera, use Yolo to classify the plant type, and Yolo detects the material within the frame by focusing the central point of each material and frame it in a rectangular box (Rectangle object). Next, it presents what the object is using the data from the basic model trained and filed for the preprocessing data as explained above. There are two types of plants, namely, *Polylthia debilis Finet & Gagnep* B. and other plants. Finally, it reports the results (Figure 4).

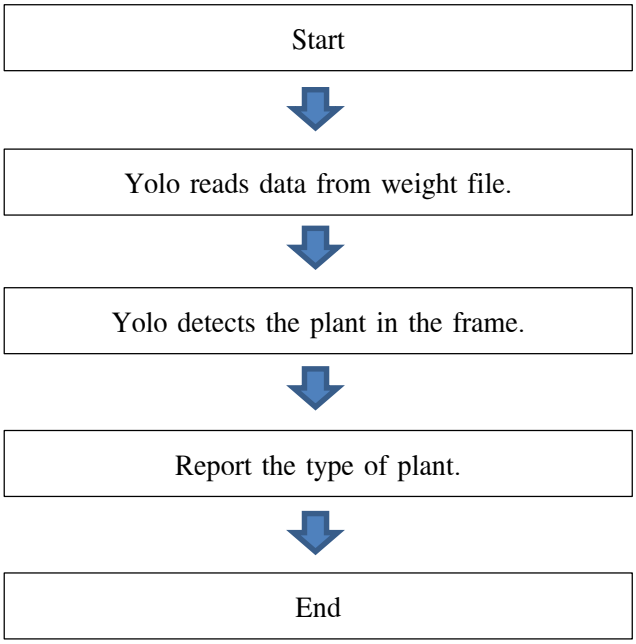

Figure 4 Steps of work.

Analysis of Confusion Matrix

The research in developing detection or classification of images has undergone efficiency validation using the principle of Confusion Matrix, as shown in Table 1 [12, 17] and the accuracy in data classification can be analyzed in detail, as shown in Table 2.

Table 1 Principle of Confusion Matrix.

Predicted / actual	Positive	Negative
Positive	TP	FP
Negative	FN	TN

Note: True Positive (TP)- True Negative (TN) - False Positive (FP) - False Negative (FN)

Table 2 Analytical Details of Performance Metrics.

Performance metrics	Derivations
True Positive Rate (TPR)	TP/TP+FN
True Negative Rate (TNR)	TN/FP+TN
Precision	TP/TP+FP
Recall	TP/TP+FN
F1-score	2×Precision×Recall /Precision+Recall
Accuracy	TP+TN/TP+FN+FP+TN

Results and Discussion

The plant survey conducted in the study area showed various species, including *Polylthia debilis Finet & Gagnep.*, *Polyalthia evecta (Pierre) Finet & Gagnep*, Indian gooseberry (*Phyllanthus emblica*), *Ziziphus oenoplia (L.) Mill. var. oenoplia*, *Lithocarpus ceriferus*, *Antidesma thwaitesianum Muell. Arg.*, *Irvingia malayana Oliv. ex A.W. Benn.*, *Canarium sublatum Guillaumin*, *Flacourtia indica (Burn.f.) Merr.*, *Syzygium cumini (L.) Skeels*, *Mangifera coloneura Kurz*, *Aegle marmelos*, *Parinari anamensis Hance*, *Adenanthera pavonina L.*, *Sindora siamensis Miq.*, *Rothmannia wittii (Craib.) Bremek.*, *Baccaurea ramiflora Lour.*, *Pavetta indica L.*, *Ardisia crenata Sims*, *Uvaria rufa Blume*, and *Dialium cochinchinense Pierre*. The findings are presented in scientific nomenclature.

In machine training of plant images, the researchers classified the data into 2 groups, namely, the leaves of *Polylthia debilis Finet & Gagnep* and leaves of other plant species. The program achieved an accuracy of 93% when tested with the images of other plants' leaves under the condition in which a single species was presented, as depicted in Tables 3-4 and Figure 5.

Table 3 Analytical Results of Confusion Matrix (N=14).

Predicted / actual	Positive	Negative
Positive	6	1
Negative	0	7

Table 4 Analytical Results of Performance Metrics.

Performance metrics	Scores
True Positive Rate (TPR)	1
True Negative Rate (TNR)	0.875
Precision	1
Recall	0.857
F1-score	0.923
Accuracy	0.928

Figure 5 Validation of images of other plants with leaves only.

In contrast, the program was tested using images of plants containing leaves only, namely, *Polylthia debilis Finet & Gagnep*. It was shown that the program performed effectively, as shown in Figure 6. In addition, images of multiple-characteristic plants, *Polylthia debilis Finet & Gagnep*., and other plant species were selected. The results showed that the program was able to accurately distinguish them, as illustrated in Figure 7.

Figure 6 Validation of images of a plant with leaves only (*Polylthia debilis Finet & Gagnep*).

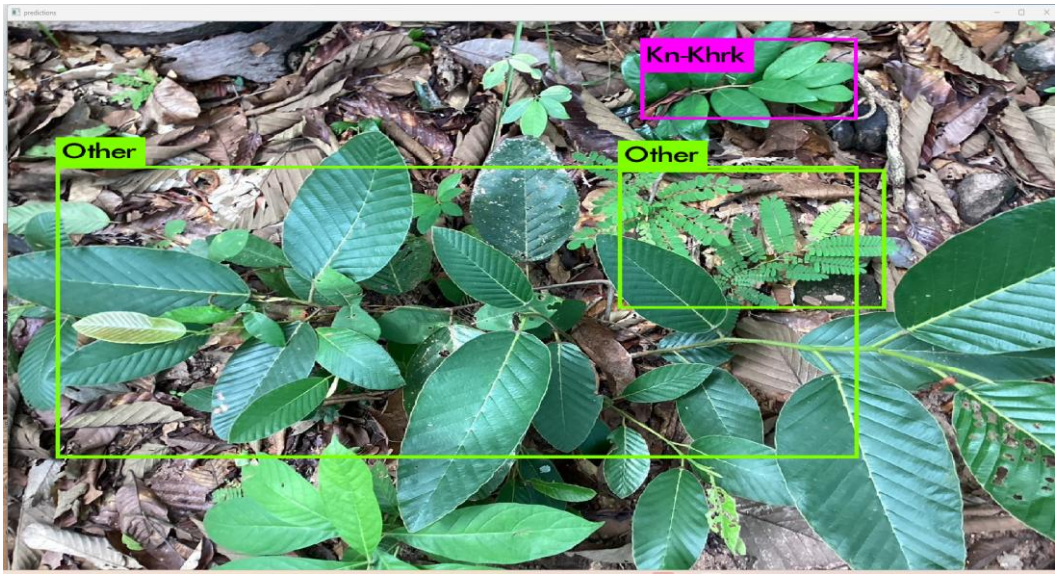

Figure 7 Validation by classifying plants with characteristic varieties.

The findings of the research team from Rajamangala University of Technology Isan, Khon Kaen Campus, under the Plant Genetic Conservation Project initiated by Her Royal Highness Princess Maha Chakri Sirindhorn by surveying and encoding the trees in Khok Phu Taka, Muang Kao Phattana Sub-district, Phu Wiang District, Khon Kaen Province, revealed wild fruit species. The results are consistent with previous studies conducted by Khon Kaen University researchers [1].

Nevertheless, this research introduced accurate classification of plant genetics using high-technology AI. Surveyors can precisely classify plants from the characteristics of their leaves. This corresponds to previous research that was based on AI to validate the diseases occurred on plant leaves and identify the cause [18-20]. AI can also be used to identify the varieties of corn seeds. The development of the detection system showed promising trends with over 90% of accuracy [13, 21, 22]. Classification can be done with over 2 categories, whereas other studies have successfully categorized more than six categories using AI technology [10, 23].

In this study, although inexperienced and new researchers could not rely on local sages to classify plant species, they could enhance their knowledge base using technology as a foundation, for instance, obtaining knowledge by self-learning methods, such as using Augmented Reality (AR) or Computer Assisted Instruction (CAI) technologies [24, 25].

Furthermore, the AI system development was able to identify the leaves of *Polylthis debilis Finet & Gagnep.* and other plant leaves with a 93% accuracy, offering future development. Thus, the following further studies are recommended: 1) Survey should be expanded to cover other rare species with specific characteristics in the area in order to follow-up conditions, such as *Neonothopanus nambi Speg.* [26, 27], 2) There should be more samples of images for AI training to increase the diversity of images and species, 3) A geographic information system (GIS) should be developed, which provides clear geographical position and quantity of up-to-date data to enhance the efficiency of analysis,

4) With the present concern of air pollution such as PM 2.5, different organizations have continuously attempted to solve the problem. The Communication Ministry that is responsible for traffic areas has come up with an idea to increase the green zone at the road center island or to provide plants that can do away with air and noise pollution [28-32].

Conclusion

In the study on surveying wild fruit plant species in the Khok Phu Taka area and developing an AI classification system of plant leaves, the data were first collected from the forest. The AI system accurately classified the leaves of *Polylthia debilis Finet & Gagnep.* and other plant species. Various plant species were found present in the area. The survey activity included labelling geographical data of, for instance, *Polylthia debilis Finet & Gagnep.*, *Polyalthia evecta (Pierre) Finet & Gagnep.*, Indian gooseberry (*Phyllanthus emblica*), and *Ziziphus oenoplia (L.) Mill. var. oenoplia*. Additionally, the AI system showed a 93% accuracy, demonstrating future development capacity.

Acknowledgements

This project is under the “Plant Genetic Conservation Project under the Royal Initiative: RSPG-RMUTI in which the research team was appointed to conduct the survey and collection of wild fruit plant species in the Khok Phu Taka area (Order No. 333/2567, Rajamangala University of Technology Isan).

References

1. Peerapatchara C. Plant genetic conservation project under the royal initiative of her Royal Highness Princess Maha Chakri Sirindhorn conducted by Rajamangala University of Technology Phra Nakhon (RSPG–RMUTP). RMUTP Research Journal. 2014;8(1):1-12. (in Thai)
2. Muneenam U, Suwannattachote P. Survey of local wisdom in the plant genetic conservation project under the royal initiative of Her Royal Highness Princess Maha Chakri Sirindhorn (RSPG) at the Rajjaprabha Dam, Electricity Generating Authority of Thailand. Kasetsart J Soc Sci. 2012;33(2):286-96. (in Thai)
3. Rassami W, Koolkalya S, Chaiyakul K, Sawarit S. Species diversity of insect pollinators in the area of plant genetics conservation project under the royal initiation of Her Royal Highness Princess Maha Chakri Sirindhorn (RSPG) at the Rambhai Barni Rajabhat University, Chanthaburi province; Thailand. International Journal of Agricultural Technology. 2017;13(7.1):1259-67.
4. Sootanan P, Dumrangrojwattana P, Chwapreecha B, Khachonpisitsak S, Sukparangsi W, Tangkrock-olan N, et al. RSPG-Burapha: additions and improvements of database and web application of eastern local resources. Burapha Science Journal. 2023;1723-48. (in Thai)

5. Sootanan P, Dumrangrojwattana P, Chwapreecha B, Khachonpisitsak S, Sukparangsi W, Tangkrock-olan N, et al. RSPG-enhancing the database of local resources to support a learning ecosystem in the eastern region. Burapha Science Journal. 2024;29(3):925-51. (in Thai)
6. Sootanan P, Dumrangrojwattana P, Chwapreecha B, Khachonpisitsak S, Sukparangsi W, Tangkrock-olan N, et al. RSPG-Burapha: database and web application of eastern local resources. Burapha Science Journal. 2022;27(3):1490-516. (in Thai)
7. Thathong K. The development of integrated instruction for natural resources conservation using forest in Khok Phu Taka as the learning resource for schools in Phu Wieng areas. Int J Educ. 2010;33(2):56-66.
8. Traiperm P, Kethirun L, Swangpol SC, Boonkerd T, Chantaranothai P. A revision of Mnesithea Kunth (Poaceae) in Thailand. Tropical Natural History. 2016;16(2):79–95.
9. Bunnag S, Theerakulpisut P, Hongthongkham J, Sankhao S. (2012). Genetic conservation of Cleisostoma arietinum (Rchb. f.) Garay in the region of Khok Phu Taka by encapsulation-dehydration. Thai Journal of Botany. 2012;4:73-82. (in Thai)
10. Kumphong J, Chawapattanayoth N. Developing A CCTV-AI system with the capability to accurately detect and recognize individuals who are wearing helmets, specifically targeting riders and passengers. Journal of Industrial Technology Surin Rajabhat University. 2024;9(2):210-24.
11. Aldakheel EA, Zakariah M, Alabdalall AH. Detection and identification of plant leaf diseases using YOLOv4. Front Plant Sci. 2024;15:1355941.
12. Kumphong J, Ung-arunyawee R. Development of smart camera network platform using Pineapple program for the CCTV system of provincial police region 4. Def Technol Acad J. 2025;6(14):1-15 (in Thai)
13. Kozan Hi, Akyürek HA. Efficient and rapid classification of various maize seeds using transfer learning and advanced AI techniques. ASEAN J Sci Technol Report. 2025;28(1):e255200.
14. Farooq MA, Gao S, Hassan MA, Huang Z, Rasheed A, Hearne S, et al. Artificial intelligence in plant breeding. Trends in Genetics; 2024.
15. Morimoto T, Hashimoto Y. AI approaches to identification and control of total plant production systems. Control Eng Pract. 2000;8(5):555-67.
16. Azadnia R, Al-Amidi MM, Mohammadi H, Cifci MA, Daryab A, Cavallo E. An AI based approach for medicinal plant identification using deep CNN based on global average pooling. Agronomy. 2022;12(11):2723.
17. Waris T, Asif M, Ahmad MB, Mahmood T, Zafar S, Shah M, et al. CNN-based automatic helmet violation detection of motorcyclists for an intelligent transportation system. Math Probl Eng. 2022;2022(1):8246776.

18. Bhandari M, Shahi TB, Neupane A, Walsh KB. Botanicx-ai: identification of tomato leaf diseases using an explanation-driven deep-learning model. J Imaging. 2023;9(2):53.
19. Almadhor A, Rauf HT, Lali MIU, Damaševičius R, Alouffi B, Alharbi A. AI-driven framework for recognition of guava plant diseases through machine learning from DSLR camera sensor based high resolution imagery. Sensors. 2021;21(11):3830.
20. Ahmed AA, Reddy GH. A mobile-based system for detecting plant leaf diseases using deep learning. AgriEngineering. 2021;3(3):478-93.
21. Ibrahim, NM, Gabr DG, Rahman, A, Musleh D, Alkhulaifi D, Alkharraa M. Transfer learning approach to seed taxonomy: a wild plant case study. Big Data Cogn Comput. 2023;7(3):128.
22. Thakur PS, Tiwari B, Kumar A, Gedam B, Bhatia V, Krejcar O, et al. Deep transfer learning based photonics sensor for assessment of seed-quality. Comput Electron Agr. 2022;196:106891.
23. Taninpong P, Minsan W, Thumrongnavasawat S, Luangdang K. Trend analysis of sea level change in the gulf of Thailand. SWU Sci J. 2021;37(2):64–77.
24. Kumphong J, Narongsak P, Sirisripetch Y, Wichaiyo T, Srichandum S, Tho-In T, et al. Production of learning materials using d of augmented reality (ar) technology to simulate pile foundation structure. Journal of Graduate MCU KhonKaen Campus. 2024;11(2):239-48. (in Thai)
25. Sopha P, Kumphong J, Amornpinyo P, Jantarakot S, Bubpi A, Phonkasi S. Production of learning materials using computer assisted instruction technology: case study on the topic of the road history. Journal of Graduate MCU KhonKaen Campus. 2024;11(3):108-19. (in Thai)
26. Buaart S, Udomsak B, Tangchitsomkid N, Saksirirat W. Efficacy of luminescent mushroom spawn, Neonothopanus nambi Speg. on Root-knot nematode (Meloidogyne incognita chitwood) in chilli. Thai Agricultural Research Journal. 2014;32(2):154-63. (in Thai)
27. Wisetsai A, Lekphrom R, Bua-Art S, Suebrasri T, Boonlue S, Tontapha S, et al. Scalarane sesterterpenoids with antibacterial and anti-proliferative activities from the mushroom Neonothopanus nambi. Molecules. 2021;26(24):7667.
28. Jantarakot S, Kumphong J. Study of solution for wrong-way riding behavior of motorcyclists by geometric design of roads and law enforcement with AI camera technology. Journal of Industrial Technology Surin Rajabhat University. 2023;8(2):124-36. (in Thai)
29. Zhai M, Wolff H. Air pollution and urban road transport: evidence from the world's largest low-emission zone in London. Environ Econ Policy. 2021;1-28.
30. Wu J, Luo K, Wang Y, Wang Z. Urban road greenbelt configuration: the perspective of PM2.5 removal and air quality regulation. Environ Int. 2021;157:106786.
31. Sakieh Y, Jaafari S, Ahmadi M, Danekar A. Green and calm: modeling the relationships between noise pollution propagation and spatial patterns of urban structures and green covers. Urban For Urban Green. 2017;24:195-211.

32. Van Renterghem T, Vermandere E, Lauwereys M. Road traffic noise annoyance mitigation by green window view: pptimizing green quantity and quality. Urban For Urban Green. 2023;88:128072.