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Malaysia coin identification app using deep learning model

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ABSTRACT

Most of the human work has been replaced by computers in recent years. With the rise of mobile technology and Internet access, recent developments in machine learning (ML) have designed many algorithms to solve diverse human problems. However, due to a lack of exposure to image processing, identification technology is still not widely employed in Malaysia. This paper outlines the steps involved in creating a mobile application for coin identification using ML. In the literature review, the history of the coins is studied in more depth and the features of already existing coin identification mobile applications are compared by their advantages and disadvantages. In addition, using the neural network model, the classification accuracy of successfully identified coins is recorded and disclosed. This study includes the limitations of the prototype mobile application and future improvements that could be added.

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1. INTRODUCTION

The history of Malaysia's currency began when the name 'ringgit' and 'sen' were officially introduced to the country in August 1975. Previously, they were acknowledged formally as bucks and cents in English, and due to the countrys many races, it was known for a lot of various names. For example, 'emas kijang' for the Malayas, 'puat' in Penang Hokkien, 'veḷḷi' for the Tamils, and 'mas' for the Arabians. The first series of Malaysia's coins were introduced by the Bank Negara Malaysia on 12 June 1957. It was known as the 'Siri Parlimen' because of Malaysia's parliament building carved at the back. It has the value of 1 cent, 5 cent, 10 cent, 20 cent, 50 cent, and RM1. At one point in time, it stopped producing in 1988 because a new series, 'Siri Budaya Artifak' had been presented to the country. It was named after the assorted symbols of Malaysia's identity. For example, the wau, the keris and traditional games like gasing and papan congkak. The latest series which only consists of 5 cent, 10 cent, 20 cent, and 50 cent were then introduced to the country in 2011 named 'syiling peringatan Malaysia'. The sizes were smaller than the previous coin version. The design for these series is carved similarly to one another which has the country's national flower, the hibiscus, at the front. As for the back, the designs are based on the flora and traditional handicrafts found in Malaysia. Besides these three main series that are used for currency purposes, there are still a hundred more coins published by the BNM as commemorative event coins. For example, the anniversary of Bank Negara Malaysia, the anniversary of employees provident fund, the world wildlife conservation, or commemorative coins in conjunction to honour the countrys prime ministers.

Machine learning (ML) is an advanced system of algorithms and models based on computer technologies. It solves various problems using patterns instead of explicit conditions. ML has become a very widespread phenomenon in research and has been incorporated into a variety of applications. By using ML, the pattern and structure of coins can be calculated, identified, and examined with simplicity. The use of current technology in coin manufacturing assures a consistent visual look on the obverse and reverse sides in terms of shape, depictions, and legend [1]. Dataset is obtained by capturing the image of the coin from different rotations and doing it on both sides. The dataset will teach the machine how to recognize patterns and edges of a specific coin. Coins are then classified by registering and comparing them to a preselected subset of all reference coins [2]. As a result, image analysis systems based on traditional method such as geometric shape features, gradient, and eigenspace can obtain impressive classification rates [3]. The bigger the data set applied, the higher the accuracy of naming a coin could be achieved.

When compared to notes, separating each coin is harder because of the similar shape and color. Coin sorting and categorization must be done by hand and depends highly on coin expertise, which takes a longer amount of time and these coin experts are hardly known. Recognizing money quickly and accurately may appear even more difficult for someone who has problems seeing or is unfamiliar with the local currency. No coin recognition system using image processing for Malaysia's coins that have been researched or applied successfully despite the wide variety of coin designs. Besides image processing, some studies had implemented the coin identification system by using several methods such as the mechanical method, mechatronic method, and power electronic method. Although they could achieve a high success rate, they need to spend quite a cost to set up the needed hardware apparatus.

2. LITERATURE REVIEW

2.1. Overview of Malaysia's coin

Since the first official release of Malaysia's coin series, the coins have gone through changes depending on their mortgage value. The coins also have different weights and metals. In terms of metal, for example in the second series, the RM1 coin used copper-zinc-tin, 1 cent used copper-clad steel and the others used copper-nickel. The most important component to differentiate the coins from one another is that they have assorted symbols of Malaysia's identity, which are carved at the back of the coin. Like the third series, they have different design motifs crafted in the form of flora and fauna and, the traditional handicraft of Malaysia. Commemorative coins, mostly come in bigger and not widely used values like RM5, RM25, RM50, RM100, and RM500. They are also mainly made of pure silver or gold. The coins have a more variety of designs like the many prime minister faces the symbol of Malaysia's government, buildings and geometries, SEA sports, and even extinct animals [4].

2.2. Overview of machine learning

The main purpose of ML is to enable computers to learn by themselves. It is a self-learning algorithm that teaches itself from previous experience to have the best output without the need for human assistance [5], [6]. The approaches in ML are categorized into three main areas, supervised learning, unsupervised learning, and reinforcement learning [6]. Supervised learning is task-driven where it requires external information provided by the user. The input is then separated into training and testing datasets. During the training process, the algorithm will self-learn by itself using the datasets to create patterns. Then, it will implement these patterns in the testing database. By the end of the process, the output is either predicted in estimation, regression, or classified [7]. Classification is a ML technique for predicting data instance group membership. Although there are a variety of ML approaches available, classification is the most widely used as it has improved the accuracy of several ML tasks significantly. In ML, classification is a valued activity, especially in future planning and information discovery [8].

In 2003 at the ARC Seibersdorf, Nölle *et al.* [9] developed a coin recognition as well as a coin sorting system named Dagobert. The purpose of the system is to perform a fast classification of a huge number of modern coins from 30 different countries. 12,949 coins were experimented on and a 99.24% recognition rate was achieved. McNeill *et al.* [10] presented the first ever coin recognition system for US coins using vector quantization and histogram modeling. Based on 200 different image textures, 188 coins were correctly classified. Thus, a 94% recognition accuracy rate was achieved. In 2005 a multistage approach for coin classification using eigenspace as well as bayesian fusion was offered [11]. The coin class probabilities for both coin sides are combined through Bayesian fusion including a rejection mechanism. They achieved a promising accuracy rate with 93.23% of 11,949 coins from 30 different countries correctly classified. Bremananth *et al.* [12] presented an approach using a neural network for coin recognition. To achieve a high accuracy result that is not affected by the different rotations of the coin, gabor filters, and back propagation neural network are used. The experiments are performed on 1-rupee, 2-rupee as well as 5-rupee coins and managed to reach a 92.43% recognition accuracy rate. Maaten *et al*. [13] in 2006 developed a fast system for reliable coin categorization called coin-o-matic. In this scheme, the coin classification is done

based on edge-based statistical features. Khashman *et al*. [14] presented an intelligent coin identification system (ICIS). ICIS uses the neural network as well as pattern averaging to recognize rotated coins from various degrees. ICIS showed very encouraging results compared to the experiments done before with a 96.3% accuracy result. 77 out of 80 variably rotated coin images were correctly identified. One of the many previous research projects that have the neural network technique is by [15] in 2018 where not only did they have a successful accuracy rate of 98.75%, but they also succeeded to calculate the total value of the Indian coins from the coin image. Another successful research with an accuracy of 98.71% is by development of an accurate neural network for coin recognition in 2021, which uses Russian coins [16]. Another recent study that explores all classification technique is from [17] in 2021. They studied two different types of feature extraction, gray-level cooccurrence matrix (GLCM) and histogram-oriented gradients (HOG), and trained them using six various classification technique. From their research, they concluded that the best accuracy for the GLCM feature extraction is the AdaBoost classifier and the worst accuracy is the K-nearest neighbor (KNN) classifier. Meanwhile, the best accuracy for the HOG feature extraction is the artificial neural network (ANN) classifier, and the worst accuracy is the linear discriminant analysis (LDA) classifier.

2.3. Related application

Coin identification application is not a foreign area in the computer science field, yet many prefer to sort coins by the type of metal and their size, like how it had been implemented in vending machines or automated washing machines. Most applications also have the same purpose of research which are to help the visually impaired and to study more about the cultural heritage of their country. This section explains briefly about the existing mobile application that implements coin identification. Coin Identifier is a worldwide coin identification website by Numiis. It goes by various names like coin finder and coin checker hence when a person wants to identify a coin, the website will be among the first search result. It can identify any coin, including the year and mint, by a photo from either side of the coin. Besides that, the website also states that it can identify any range of coins, medals, or tokens. It uses artificial intelligence and ML technology to recognize an image and is still training the AI every day. Made in 2019, its mission is to organize all information for every currency from every region and era, including making it instantly accessible. It also thrives to provide constant insights and intelligence for collectors and investors to make smart purchases. The website is coined by the numismatic database project and was started by grant powell, the Numiis CEO, digital innovator, and coins valuation expert [18]. Next is coinoscope which is made in 2017. It is available on Android and iOS while having a website of its own. It has around 50,000 monthly users and has an average rating of 4.5 in Google Play and Appstore. It is a free mobile application but also has a premium version if a user wishes to disable advertisements. The main feature of this application is that it takes one side of a coin image either from the phone gallery or through the camera They also have a zoom feature with a max 8.0x distance and their search speed is in seconds. In the search results, it will show a list of websites that has information about the coin image. This shows that the application does not have a coin database and depends on another website to do it for them [19].

Lastly, Maktun: coin search by photo. This mobile application is available on Android and iOS. In Maktun, a user must take both sides of the coin to identify the coin image. Made in 2019, the application has over 100,000 downloads with an average rating of 4.6 in Google Play and Appstore. After the coin image is identified, Maktun provides details such as the country the coin is from, the nominal value, year of mintage, weight, and type of metal. There is a catalogue feature that has over 200,000 coins, sorted by countries, and a search function to search for a specific coin. Another feature is that it has estimate coin value and it will show the price lots from online auctions if a user wishes to buy or sell the coins. It is completely free with no advertisements [20].

3. PROJECT DESIGN AND IMPLEMENTATION

3.1. Neural network model

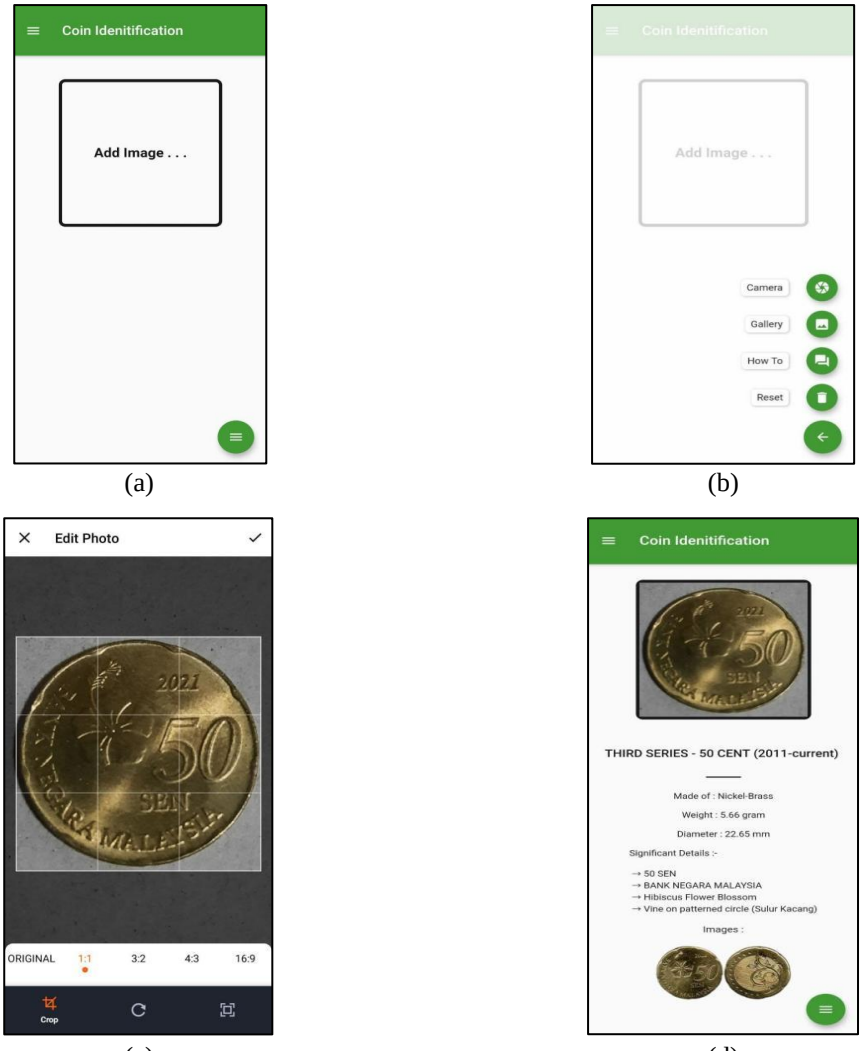
The ANN are the artificial representations of the human brain that simulate the learning process. It processes input data to output data connected with weight that consists of interconnected neurons [21]. Teachable machine is used to apply the deep learning algorithm. Teachable machine is a web-based tool that is fast, easy, and can be accessed by everyone with a Google account in creating ML models. This method requires fewer computing resources and is internet-based. Launched in 2017, the platform supports images, sounds, and poses. There are three simple steps involved here which are training the model, testing, and improving the accuracy of the model. Lastly, when training is done, there is the export model function to be used locally by various applications. 40 class coins were created inside the model with distinct labels. Then, by uploading 30 images per class, it will then go through the three simple steps, which are training the model, testing, and improving the accuracy of the model. Lastly, when training is done, there is the export model function for the tensorflow lite zip file to be downloaded. Tensorflow is an open-source platform for ML. It helps to build and train state-of-the-art models

without losing performance or speed. The zip file contains the tflite model and the 40-coin class labels that could be accessed in the mobile development for coin identification.

3.2. Mobile application

Figure 1 illustrates the coin identification mobile application. The main screen as shown in Figure 1(a) has a floating button on the right corner of the screen, then by pressing it, the second page as shown in Figure 1(b). On this page, a user can choose either to capture a coin image by their phone camera, upload the coin image from their phone gallery, navigate to the instruction panel, or reset an image. Next, after selecting an image, the edit photo screen is displayed in Figure 1(c). A user can crop, resize, rotate, or even retake the image. The last step is that a user must press the tick button on the top right page for the mobile application to identify the image. The screenshot displayed in Figure 1(d) is the output of the identified coin which presents the general details of the coin.

The editor used to debug and develop the mobile application in Visual Studio code. It can also be run as an emulator to experiment with the application with each change. Flutter and dart are used to create the mobile application framework like the user interface and features in it. The dependencies used to run the main component of the mobile application are image_picker, image_cropper, and tflite. image_picker is a Flutter plugin for iOS and Android for picking images from the image library and taking new pictures with the camera. image_cropper can also be used for iOS and Android to crop any image. While tflite is a plugin to access the TensorFlow Lite API. Aside from image classification, it also supports object detection (SSD and YOLO), Pix2Pix and Deeplab, and PoseNet for both iOS and Android.



(a) (b) (c) (d)

Figure 1. Screenshots of the mobile application (a) main screen, (b) floating button screen, (c) edit photo screen, and (d) output screen

4. RESULTS AND DISCUSSION

This section is where the coin classification result of the project is recorded using the teachable machine with different epoch numbers. The batch size and the learning rate are set to default, 16 and 0.001 respectively. Epoch numbers however can increase the accuracy up to a certain limit. Therefore, this parameter needs to be tested to find the best classification result. This result is also needed as proof to show that the neural network model is functioning well. The images tested are not from the training model and are taken using the phone's camera. The coins in Table 1 are randomly selected to measure the accuracy using 50, 80, and 100 epochs respectively.

Based on the classification result table, the application succeeded to classify 14 out of 15 coins tested. The table also proved that the bigger the number of epochs does not mean a higher accuracy classification. 80 epochs were deemed the most appropriate as they achieved the highest accuracy result compared to 50 and 100 epochs with 80%. However, the model failed to identify a coin even though the coin's training class exists in the model. Besides that, even with the highest accuracy result, a total of three coins achieved an accuracy result below 70%. Factors that could affect the low rate are the background pixel of the coin, the lighting of a coin, or also due to the very similar carvings with other coin classes. The background image of a coin should be cropped to its maximum and more different shades of a coin should be added in the class to increase the accuracy classification rate. As a future work, the same study also can be applied in recognizing other objects other than coin such as handwriting character [22], car license plate [23], [24] and plant leaf [25]-[27].

Table 1. The coin classification result using teachable machine

Coin	50 epochs (%)	80 epochs (%)	100 epochs (%)
First series-rm1 (front)	82	94	99
First series-20 cents (back)	34	43	41
Second series-1 cent (front)	88	98	86
Second series-5 cent (front)	14	100	100
Second series-50 cent (back)	23	72	45
Third series-20 cents (front)	100	100	99
Third series-20 cents (back)	77	98	83
Ulangtahun ke-35 persidangan PATA	69	89	95
PATA	0	0	0
Sukan SEA ke-9	98	97	100
20 tahun merdeka 1957-1977	16	67	51
Ulang tahun ke-20 Bank Negara Malaysia	35	87	87
Ulang tahun ke-25 KWSP	55	72£	46
Rancangan Malaysia keempat 1981-1985 (front)	99	100	100
Rancangan Malaysia keempat 1981-1985 (back)	72	96	91

5. LIMITATIONS

First and foremost, only a quarter number of Malaysian coins could be stored in the training model. This was because to achieve a high accuracy rate during the project's allocated time given, the number of classes was suggested to be reduced to 40 coin classes with each having 30 coin images respectively. Moreover, current commemorative coins images from 2012 and onwards are very limited and could hardly be found on the internet. Besides that, a user must crop the coin image by themselves instead of using a more advanced artificial intelligence technology like object detection.

6. CONCLUSION

Coin Identification using ML mobile application was purposely developed to introduce to the general public the long history of Malaysian coins. Since there are nearly a hundred of them, a mobile application coin identifier that focuses solely on Malaysian coins is deemed appropriate to gain more knowledge about the country's cultural heritage. In conclusion to that, all the objectives that were initially created for this project were successfully achieved with satisfying results. In this project, the mobile application prototype was successfully developed to aid people who are unfamiliar with Malaysian coins like children or foreigners, beginner coin collectors, and short-sighted people. The mobile application should help them recognize the very similarly shaped coins in more accessible and more accurate ways. Most importantly, as a result of the accomplished project, the mobile application was able to reach a mean average accuracy of 80% and an average inference time of 0.04 seconds on detecting a coin.

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