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Android based application for visually impaired using deep learning approach

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ABSTRACT

People with visually impaired had difficulties in doing activities related to environment, social and technology. Furthermore, they are having issues with independent and safe in their daily routine. This research propose deep learning based visual object recognition model to help the visually impaired people in their daily basis using the android application platform. This research is mainly focused on the recognition of the money, cloth and other basic things to make their life easier. The convolution neural network (CNN) based visual recognition model by TensorFlow object application programming interface (API) that used single shot detector (SSD) with a pre-trained model from Mobile V2 is developed at Google dataset. Visually impaired persons capture the image and will be compared with the preloaded image dataset for dataset recognition. The verbal message with the name of the image will let the blind used know the captured image. The object recognition achieved high accuracy and can be used without using internet connection. The visually impaired specifically are largely benefited by this research.

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1. INTRODUCTION

According to 2018 statistics from world health organization (WHO), at least 2.2 billion people from all over the world have vision impairment [1]. The visually impaired people face a lot of problems in their daily life. These people have difficulties to recognize and differentiate the objects around them thus they only rely on the guidance to help them especially for daily task. The most challenging for visually impaired are that the ability of them to recognize the colour, shape and differentiate the currency of the money. Nowadays, there are many of assistive technology that can help them as a sighted guidance and improves the quality life of visually impaired [2], [3]. The assistive technology based on computer is expected to help on the visually impaired daily task. It can be screen reading software, magnification software, dictation software, refreshable Braille displays, optical character recognition (OCR) systems, and many more [4]. The assistive technology growth from the simple technology devices to the sophisticated high technology solution using [5]-[7].

The visually impaired mostly now have the smartphone as it become a basic necessity of each individual. Thus, it provides a great platform to develop an application specifically for visually impaired to assist them. A survey done by Nora and the team have found that the person with visual impairments are

frequently used the mobile application for their daily activities [8]. Furthermore, they are looking for some improvement and new application that can help them to less dependent on others. An experimental study has been done by Manduchi on the specific mobile task as such landmark detection using the mobile phone. His findings become the platform on designing the technology that facilitates visually impaired [9].

Many studies have developed the assistive technology using android application which useful in today world and people with visually impaired can make use of this technology to help them accomplished on their daily routine. Tharkude *et al*. [10] and Parkhi *et al*. [11], the authors proposed a smart android application for blind people with the use of object detection. The developed apps are using mobile video camera to know the direction of object, voice instructions for current locations and directions as well as to gives warning of the obstacles in front of the user [10]. While in [11], the authors design an object detection from imaged captured by smartphone's camera. The performance of the apps is quite good however it is depending on the quality of the inbuilt camera of the smartphone. Kadam *et al*. [12], the authors designed an apps providing with the speech output for the objects detected by using ANN classification approach. However, the apps may give variable accuracy and still need improvement to be more efficient. Other than that a mobile application called Intelligent Eye with features of light, colour detection and object, banknote recognition is developed by using image deep learning, CNN architecture [13]. The survey of User acceptability test has been done and the results show that the apps is good in general and well accepted.

Deep learning has outstanding performance and provide high quality intelligent services on mobile devices applicationss. It is mainly applied to image and voice processing at can be empower more to make people's daily life more convenient [14]. Deep learning approach such as CNN model is knownly a method that provides high accuracy in image classification [15]. It provides numerical results between 0 and 1 which obtained faster and higher accuracy values for classification purposes.

This paper proposed mobile application through deep learning approach specifically by convolution neural network (CNN) that might help the visually impaired on their daily lives. The training set for CNN is developed at Google Dataset which is developed by Google for Big Data Analytics. CNN needs the cloud storage that able to analyse the big data analysis for decision making, classification, prediction with high accuracy [16]. The proposed application doesn't require internet connection to operates and it consists of three types of detection as mentioned in Methodology section. The developed application allows the visually impaired to capture things around them with their own smartphone and will help them recognize the captured object. This will make their life easier without depending to the people around them who somethimes insincere and just take advantage on them.

This paper is organized as: section 2 describes the method used to develop the application. The results and discussion will be covered in section 3 and finally in section 4 will conclude and mentions the future recommendation.

2. RESEARCH METHOD

2.1. Overview of the application

In the phase of android mobile application development, the various useful assistant are combined in single application as:

a. Object detection: it works on the image captured by the mobile phone's camera. It will be trained with the database objects to identify the image. It helps the person with visually impairment to find their items.
b. Colour detection: it works on the image taken which the colour name is based on the RGB values of the detected image. This feature may help in their daily routing such as cloth colour and shoe selection.
c. Currency note detection: The image taken from the camera will be compared with the trained dataset for recognition. This will help visually impaired people from being cheated by others.

The features of the application are associated with audio output of verbal message for user notification as it is important for visually impaired person to identify the object [17]-[19]. Overal, this application features include:

a. Android based mobile application that can be accessed at anytime and anymwhere without internet connection. This is to ensure to secure the user personal data from third party [20], [21].
b. The input from user can be swipe gesture, and speech input which is specially designed for visually impaired for easy usage [22].
c. Incorporated with deep learning, CNN for fast and accurate image processing for detection and prediction.
d. The application consists of three different modes, object detection, colour detection and currency detection. The user can anaytime turning the mode by swiping or voice input.
e. Incorporated with output of verbal message to notify the user on the identified objects.

Figure 1 shows the flowchart of the application on how it operates from starting the application is ready to use by the user. It started with the Main menu which consists of three different modes where the user can choose by click the menu or by the speech voice input. The camera will automatically on, and the user can capture the image for detection and prediction using CNN model. The application will notify the user through the audio output.

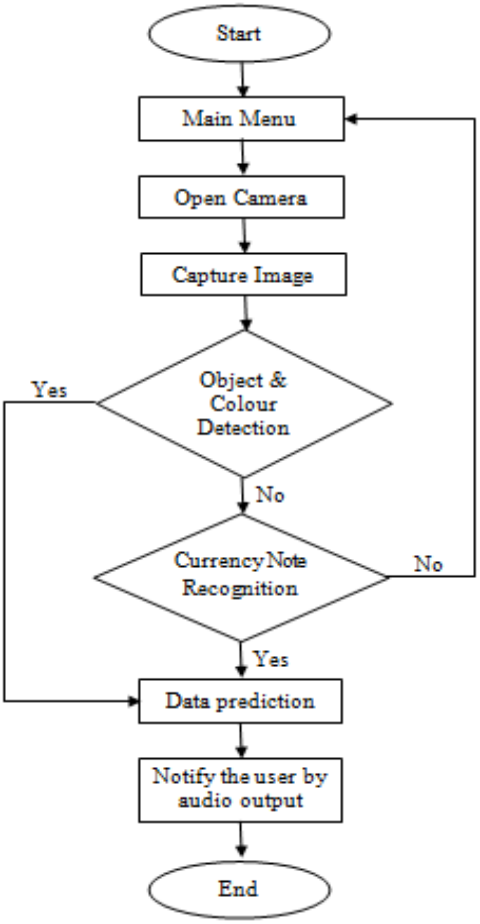


Figure 1. Flowchart of the android application system

2.2. Application architecture

The application is mainly developed by Android Studio and being configured by a TensorFlow Object Detection API for object detection and recognition by using CNN model. The CNN is adapted for data training approach which uses single shot detector (SSD) with a pre-trained model from MobileNet V2 which developed at Google dataset. Basically, the image captured by the user's mobile phone will be compared with the pre-trained image in database. The image loaded by the camera will be extracted and classified through the prediction prosess using TensorFlow algorithm. The application will notify the user through the audio output with the predicted image. Figure 2 shows the application architecture in general.

TensorFlow is an end-to-end open source deep learning models developed by Google that can be deployed into a mobile or embedded devices. It has greatly easier model building with intuitive high level APIs which makes it for immediate easy debugging for any application. TensorFlow also provides a platform to excute machine learning algorithms which can be carried in wide range of heterogeneous systems from mobile phone to large scale of systems. The models can be train easily and accelerates the application of CNN due to the optimization of GPU usage [23].

The block diagram involved in image classification using the TensorFlow is shown in Figure 3. The data set are stored in IDX format with image and label information for both data test testing and training.

In this paper, the data set contains about 1000 training image for 1 testing data. So grossly, there are almost 50,000 training image for 50 testing data with different situation of images. This is to make sure that

the image classification will produce high accuracy. In the second stage of designing the algorithm of CNN model using TensorFlow, the parameter with 10,000 iterations were processed with different epochs. The results of the training accuracy for 10 and 100 epochs are shown in section 4. In last stage for image classification performance, the different images were testing, and the accuracy percentage based on CNN image classification were calculated.

Figure 2. Application architecture

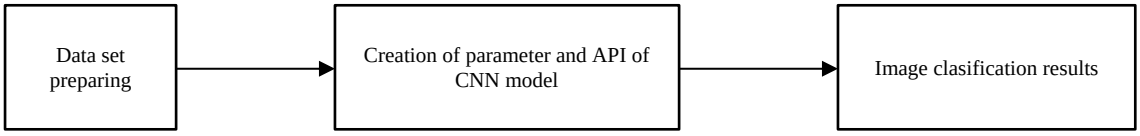


Figure 3. Proposed block diagram of utilizing CNN by TensorFlow

3. RESULTS AND DISCUSSION

3.1. Object detection and recognition classifier training

In prior of object detection and recognition development, the classifier training accuracy analysis is a must step to make sure that the application provides high accuracy percentage. About 250 images for each class is collected with variety of backgrounds, orientation and conditions. The images will be trained with different epoch to see the training and validation accuracy. Figure 4 and Figure 5 show the training and accuracy result using 10 and 100 epochs respectively.

As can be seen from both Figure 4 and Figure 5, the highest value of accuracy is 1.0 while the highest value for validation is 0.717 at 100 epochs. Based on the results, it clearly shows that the more epochs are, the highest value of validation accuracy can be achieved.

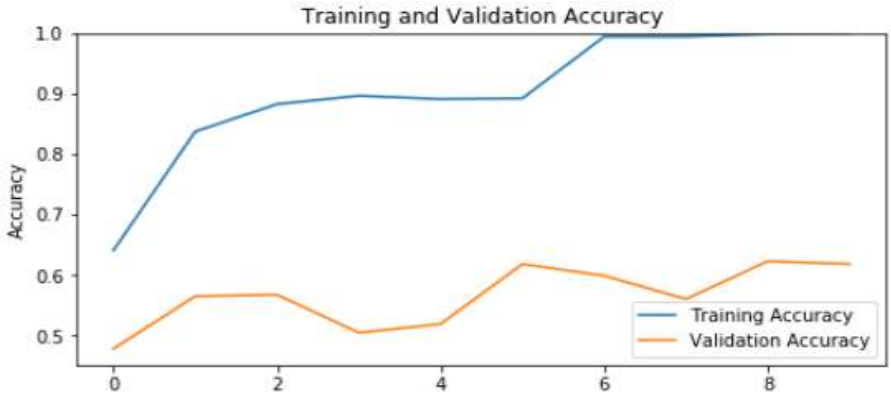


Figure 4. The training and validation accuracy based on 10 epochs

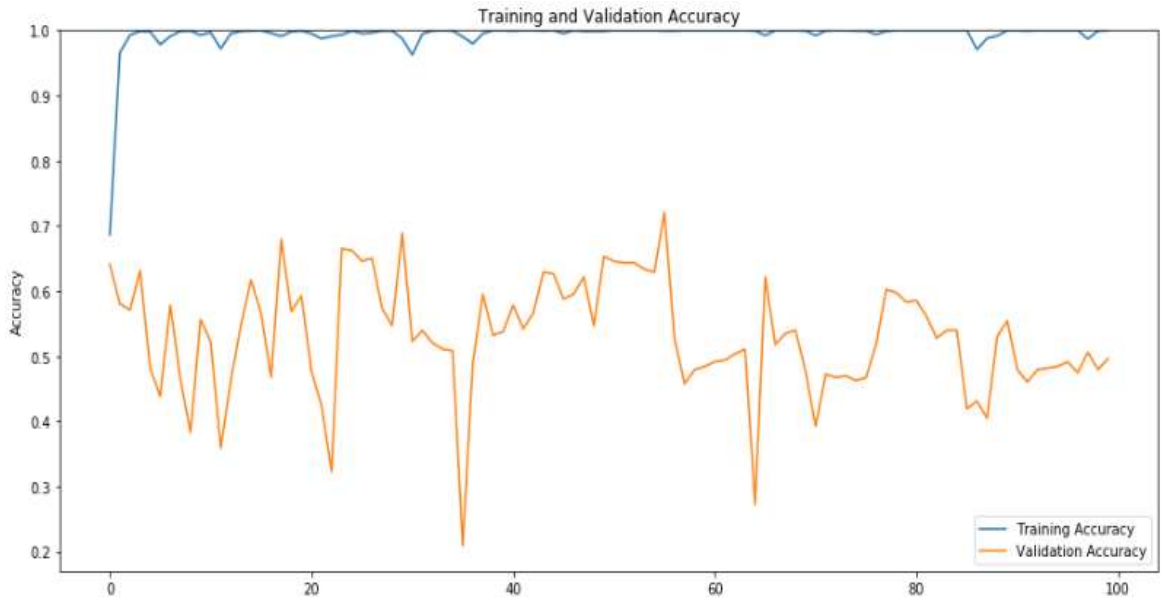


Figure 5. The training and validation accuracy based on 100 epochs

3.2. Application testing

The application is design with simple interface to make it user friendly for visually impaired. It contains with 3 menu buttons, currency note detector, colour detector, and explore things as object detector as shown in Figure 6. The menu can be selected by touching the screen or use talkback function.

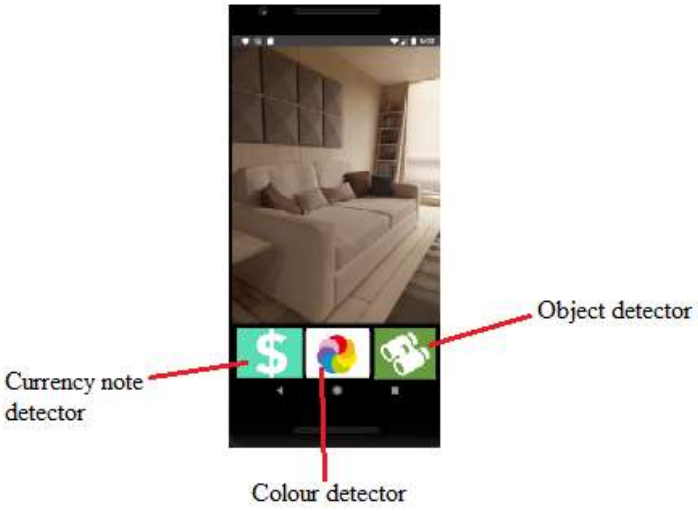


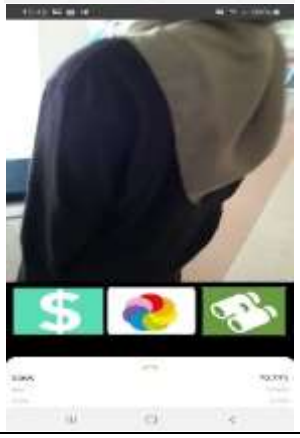
Figure 6. User interface design of android application

The application is tested in real time with currency note and colour detection. The results with the accuracy percentage are presented in Table 1 and Table 2. Based on the both tables, the detection accuracy is relatively good with high confidence and accuracy level. The application is able to detect the image captured with high accuracy.

Table 1. Results of currency note detection

Image captured	Accuracy (%)	Result
	99.73	Ten Ringgit Malaysia (RM 10) True
	97.92	One Ringgit Malaysia (RM1) True
	98.88	Twenty Ringgit Malaysia (RM20) True

Table 2. Results of colour detection

Image captured	Accuracy (%)	Result
	99.95	Red Colour True
	95.07	Blue Colour True
	70.74	Black Colour True

3.3. Site testing implementation

The site testing application is implemented with the real subject, the people with visually impaired at the reflexology centre in Melaka Mall. Before they use the application, the demonstration with explanation was done. As they are totally cannot see, the talkback function is used as the input for menu selection. Figure 7 shows the photo of the subject use the application by themselves.

The feedback from them was taken after the testing. They are very excited with the application as the application is able to detect things in front of them accurately and effectively. The feature in this application are really needed by them and hoping that they can be more accessible to their surroundings.

Figure 7. The photo taken during the site testing implementation

3.4. Comparison to the other application

B. S. Lin *et al*. has proposed computer image recognition as guided system which recognize multicle obstacels in every image using CNN algorithm. The accuracy of recognition is reached only 60% [24]. Other applications presented by Anitha which focus on real time object detection has achieved upto 92.16%. It is quite efficient with that number of image classification accuracy percentage [25]. However, compared to other applications, the proposed application in this paper is considered has higher accuracy in image classification. The accuracy of the proposed application is up to 99.95%. The novelty of this application compared to the existing are:

a. An assistive mobile application to help make the world more accessible to the visually impaired people which using deep learning approach to process image from phone's camera to do image classification
b. This application is able to give fast and more accurate results because it is using on device image recognition from deep learning approach
c. As it using on device image recognition, no internet connection is required. So the user can use the application at anywhere and anytime
d. Additionally, with no internet connection required the personal data is safe and secure. There will be no 3rd party involves in retrieving the data
e. The application is user friendly. The application only consists of simple interface with no distraction from complicated settings so that it can be easily been used by the visually impaired

4. CONCLUSION

This paper has presented the development of android application for people with visually impairment with some novelty compare to the existing application. Based on the results, the application is able to predict the image captured by the user with high accuracy up to 99.95%. On top of that, the site testing with visually impaired people has been done with positive feedback received. As for future work, the additional feature can be added as well as the inclusion of internet of things (IoT) for more advance application.

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