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# Supporting Patients of Age-related Macular Degeneration in Malaysia using Mobile Application enabled with Object and Text Recognition

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**KEYWORDS**

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**ABSTRACT**

Patients contracting Age-related Macular Degeneration (AMD) disease cannot properly recognize objects or text through their central vision. After literature reviewed, there is still lack of empirical study how lightweight mobile application, operates without Internet but with object and text recognition capability can help Malaysian AMD patients to see better. This research developed a simple yet useful mobile application using Kotlin Programming and Android Studio with object and text recognition capability to generate audio speech for patients to perceive and understand better. The application yields average precision (mAP) of 42% for object recognition and 83% for text recognition. Despite lower mAP for object recognition, through Unit and Usability Testing conducted on AMD patients, the test results met the requirements and the application successfully supported them to have a better grasp of their surroundings. This research contributed a small step in relieving Malaysian AMD patients to see better and live more independently. Limitations and future improvements were also provided.



## 1. INTRODUCTION

Age-related Macular Degeneration (AMD) disease has caused loss of central vision of many aging people whereby they are not fully blind [1]. The following two pictures in Figure 1 depict a vision of a normal person and the vision of an AMD patient.


**Fig. 1.** Normal Person and AMD Patient Visions [2]

Due to AMD, patients need to adjust their head or sometimes even their body movement so that they can see or walk better. This vision impairment, awkward physical body adjustment and loss of independence have impacted AMD patients' self-reliance and self-confidence [3], [4]. As of now, there is no cure or way to reverse the damage already caused by AMD disease. In order to support AMD patients to see better, some assistive technologies have been invented like low vision devices e.g. magnifying glass, artificial intelligence, machine learning, virtual reality headset, objects and images recognition software like Microsoft Seeing AI, Google Lens et al. [5], [6], [7], [8].

There is research on how the above assistive technologies can help vision impaired and AMD patients in developed or western countries to see better [9], [10], [3], [4], [6], [11], [12]. However, problem statement is lack of empirical study how a mobile application, in the absence of Internet with object and text recognition functionalities actually help AMD patients to see better especially in developing countries like Malaysia. The mobile application will be developed to run on Android phone because more than 65% of Malaysian are Android phone users [13]. Although this research is conducted in English but most of the Malaysians are multi-linguals whereby English generally is not their first language especially for those above 60 years old. Hence, it is interesting to evaluate how AMD

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patients in Malaysia are reacting towards the mobile application developed and administered in English. In addition, AMD patients above age of 60 in Malaysia are generally at retirement age whereby their financial independence and socioeconomic status are different from their counterparts in developed or western countries who are still under employment or below the retirement age. Moreover, this mobile application should be light-weight, user friendly and helpful so that AMD patients still can perceive properly despite unavailability of Internet connection or telecommunication signal in certain environments e.g. in shielded or signal blocking rooms, buildings, car parks, remote locations et al.

The objective of this applied research is to understand and develop a mobile application based on object and text recognition functionalities in helping Malaysian AMD patients to perceive better their surrounding environment. Research questions for this study includes:

- RQ1: Generally, how useful is the mobile application based on object and text recognition capabilities in helping AMD patients to perceive the surrounding environment better?
- RQ2: Are the provided features or functions in the mobile application are ease of use?

Above research questions will be answered after the study is completed.

Following Figure 2 illustrates an overview of the mobile application architecture and design.

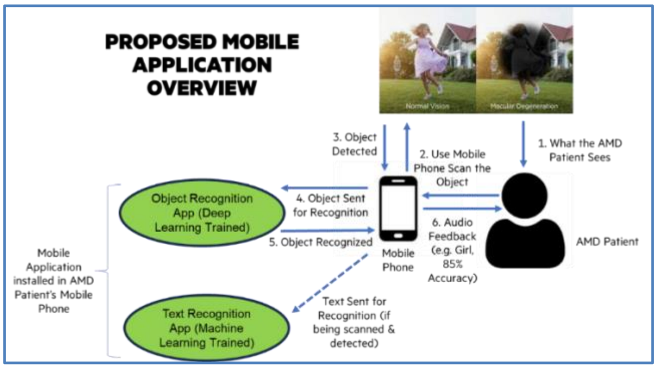


**Fig. 2.** Proposed Mobile Application Overview

In order to compensate AMD patients for what they can't see properly, they can use their mobile phone to scan an object or text before letting the mobile application to infer and respond with audio feedback on what they are seeing as illustrated from Step1 to 6 of the above Figure 2. Likewise, similar audio feedback will be generated when text is scanned by the AMD patient's mobile phone.

## 2. LITERATURE REVIEW

As we aged, some of us above 60 years old can suffer from Age-related Macular Degeneration (AMD) disease whereby the central part of our vision is lost [1]. The loss of central vision can continue to spread until total blindness covers both eyes. According to [1] besides aging, other risk factors like genetics, hypertension, overweight, smoking and imbalance dietary lacking carotenoids intake also contributing to AMD. Patients suffering from AMD are not immediately blind but rather losing the central part of the vision to black or grey spots whereby they need to adjust their head or body movement to see better. This vision impairment, awkward physical actions or positions and lack of independence have profound impact on AMD patients' self-reliance and self-confidence in terms of working, walking, reading, writing et al. as well as socioeconomic consequences. The loss of productivity and cost incurred to rehabilitate the impaired vision amounted to significant economic burden for the AMD patient, their family and society [3], [4]. As of now, there is no cure or way to reverse the damage already caused by AMD disease.

While there are different ways of AMD treatments to lessen the impact and preventive measures available from medical field; parallelly there are several assistive technologies being researched and deployed to support AMD patients to see or understand better their surrounding environment. From literature reviewed, these assistive technologies are divided into 3 categories: 1) Low vision devices, 2) Navigation Systems, 3) Entity Recognition.

Low vision devices including magnifying glass or electronic visual enhancements et al. that can manipulate the image formed in the eye's retina by adjusting contrast, color correction, luminance, remapping and spatial frequency filtering [5]. Low vision devices are still relying on AMD patient's impaired eyesight to see whereby there is limited field of vision due to object or text enlargement and enhancement as well as causing eye fatigue or discomfort. Moreover, these devices or technologies are outdated compared to other more advanced assistive technologies like entity recognition [5]. Hence, low vision devices are not adopted as the approach to support AMD patients in this research.

Navigation systems sometimes also addressed as traveling aid systems or walking assistants [12]. Regardless of the terminology, assistive navigation systems provide directions to users to navigate from one location to another. Navigation systems are complex as they encompass technologies that monitor the surrounding environment and rely on Global Positioning System (GPS) as well as require various methods of user interaction [12]. Due to its technological complexity and higher cost of acquisition and ownership, navigation systems are also not considered in this research.

Entity recognition includes object, text, color, image and people recognition and then converting them into audio or speech by leveraging Deep Learning or Machine Learning [6], [7], [8], [12]. Some of the simpler entity recognitions e.g. object and text recognition can operate without Internet whereas more complex entity recognitions like image, people, facial et al. require larger model size or even Internet connection. Some complex entity recognition running as mobile application includes Microsoft Seeing AI, Google Lens, Be My Eyes, virtual reality headset whereby connection to Internet or public cloud is highly desirable for optimal performance [14], [12]. Despite Deep Learning or Machine Learning is adopted in entity recognition, they are also being used to develop various learning models to train, predict and diagnose AMD disease [15], [16]. In such use cases, they are not considered as part of these assistive technologies for AMD patients to perceive their surrounding environment. Among the different assistive technologies within the umbrella of entity recognition, highly desired technology's attributes include the essential features of object and text recognition based on lightweight trained deep learning and machine learning models. Moreover, the technology should be operational without Internet connectivity, ease of use and useful to AMD patients. Furthermore, there should be low cost of technology development and deployment, low cost of mobile device acquisition and ownership. Based on above criteria, a mobile application is developed from scratch and to be tested by AMD patients in Malaysia. From literature reviewed, there is still lacking of empirical study how the earlier mentioned mobile application can help AMD patients to see better which is the intention of this research.

Estimated 6.8 billion users worldwide are using mobile phones in 2023 whereby more than 50% of them are actively using this tool for various activities in their daily lives [17]. One of the contributors towards the wide adoption of mobile phone is the proliferation of various applications development that produce different mobile applications installed into the mobile phone. Mobile phone as an indispensable tool to mankind is continuously improving throughout different generations which encompass improved capabilities in Short Messaging Service (SMS), Multi-media Messaging Service (MMS), video calling, Internet access, various application functionalities as well as increased data bandwidth [18]. Hence, mobile phones which are easily accessible and are suitable tools to install the object and text recognition application to better support AMD patients.

To develop the mobile application that is capable of object recognition, TensorFlow Lite Machine Learning (ML) model is adopted because it is Open Source-based, lightweight and efficient ML that the application is easier to run in Android-based mobile phone compares to original TensorFlow models [19]. The Android phone is selected instead of other mobile phone Operating System (OS) e.g. iOS, Windows et al. due to its comparatively lower cost of development and mobile device acquisition. In-built TensorFlow visualization tool i.e. TensorBoard is used to support ML experimentation by visualizing and tracking accuracy and loss metrics. Common models adopted for object recognition include Convolutional Neural Networks (CNN), Single Shot Detector (SSD), You Only Look Once (YOLO) and EfficientDet [20], [21], [22], [23], [24]. All these models have their own strengths and weaknesses. After detailed evaluations, EfficientDet is selected as the model used in this research due to its overall effectiveness compared to other models' capabilities in terms of accuracy, speed and scalability. Despite EfficientDet model is complex but it is still worth the effort to deploy in exchanging for achieving other beneficial outcomes to support AMD patients.

To recognize texts detected before converting them into speech in Android application, both Play Services ML Kit Text Recognition [25] and Firebase ML Kit Text Recognition [26] have been evaluated whereby there are differences between them in terms of architecture, integration and feature set. After detailed comparisons, Play Services ML Kit is a better option for text recognition deployment in mobile phone due to its smaller library size and work offline without Internet connection.

Camera2Api is Android low level software used to streamline the linking of application and mobile phone hardware's camera so that to successfully capture the AMD patient's surrounding in real time. LabelImg as Open Source and lightweight image annotation tool is used to label the boundary box of detected object in image [27]. Respective Java-based programming language Kotlin and Python are used for application development and ML training due to their mobile phone OS flexibility, robustness, security rich features, built-in mobile development function, straightforward syntax and lower cost option [28], [29].

## 3. METHODS AND MATERIALS

### *3.1 Requirements*

Based on interaction with some AMD patients that are also using mobile phone in their daily lives, requirements for the mobile application include: various object classes recognition, user's camera clearly detect one object or text at a time within 2 meters away from the user, capable to work without Internet connection, displaying boundary boxes around object detected, displaying confidence score and object name as well as discarding incorrectly detected recognition results lower than 70% of confidence score.

### *3.2 Object Recognition Model Preparation*

Since EfficientDet model is selected, this research will consider following four EfficientDet Lite models of different sizes that have already undergone sufficient training by the TensorFlow team.

1. Model1: lite-model_efficientdet_lite2_detection_metadata_1.tflite (size 7.4MB)
2. Model2: lite-model_efficientdet_lite3_detection_metadata_1.tflite (size 11.7MB)
3. Model3: lite-model_efficientdet_lite3x_detection_metadata_1.tflite (size 13.6MB)
4. Model4: lite-model_efficientdet_lite4_detection_metadata_2.tflite (size 20.4MB)

Each file from the above list is a merger of their respective TensorFlow Lite (TFLite) Model and its metadata file combined to enable seamless deployment and management of the TFLite models. These models are used to develop a mobile application that can assist AMD patients to listen and understand what is being detected and recognized by the application through their own mobile phones.

### *3.3 Text Recognition Model Preparation*

For text recognition, TextRecognizer from ML Kit under Google is adopted to perform Optical Character Recognition (OCR) on sign images or documents to extract the required text.

### *3.4 Mobile Application Design and Development*

In order to help AMD patients to recognize objects or texts in their surrounding environment, an Android-based mobile application will be developed to detect both the object and text and then convert them into speech. This mobile application will be developed using Kotlin programming language which makes coding concise, cross-platform and interoperate fully with Java. In addition, Kotlin is Google preferred programming language for Android applications development [28].

The following Figure 3 shows the wireframing of the mobile application which serves as a visual blueprint for the application structure and functionality.

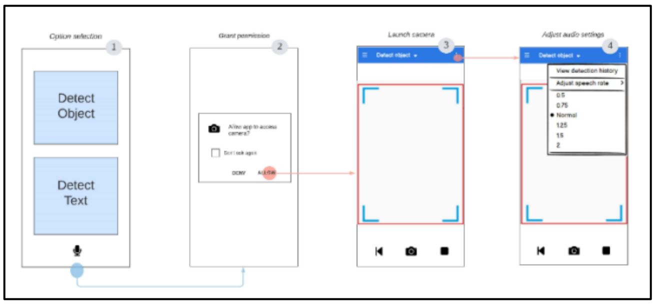


**Fig. 3.** Wireframe of the Mobile Application

After wireframe is completed, Kotlin source codes are developed and compiled into Android mobile application. The application is divided into three modules as depicted in the following Figure 4.

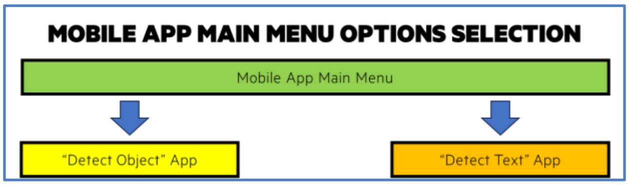


**Fig. 4.** Process Flow of Main Menu Application

When an AMD patient activates the mobile application, the main menu module will be launched first to receive selection from the patient. Depending on the selection, the main menu will connect to either object or text detection application module. Each object or text detection application module will execute their respective functional codes as described in Figure 5 and 6.

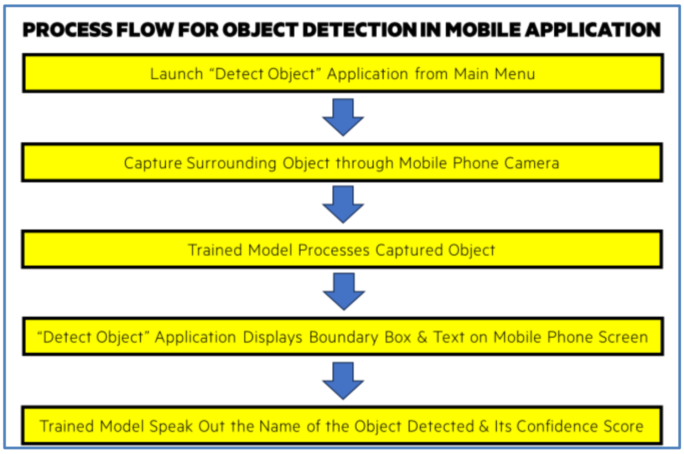


**Fig. 5.** Process Flow of Object Detection Application Module

Upon the application is launched from the user's mobile phone without Internet connection, a menu of two options is displayed i.e. detect object or detect text. Once an option is selected, the user can select "allow" to activate the camera function of the mobile phone before an object or text can be detected.

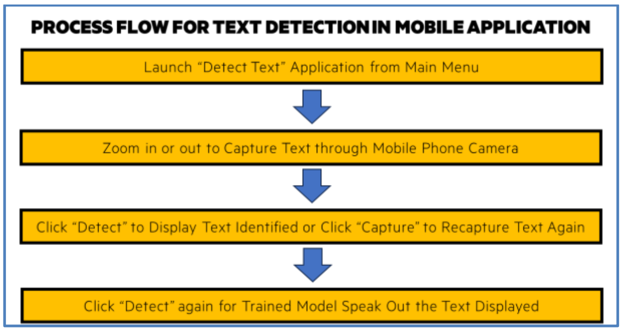


**Fig. 6.** Process Flow of Text Detection Application Module

Upon successful detection and recognition, a voice message will be generated to inform the AMD patient. For object recognition, confidence score also will be read out. Figures 7 and 8 below show the user interface design of the mobile application to detect object and text respectively.


**Fig. 7.** User Interface Design for Object Recognition Screen.

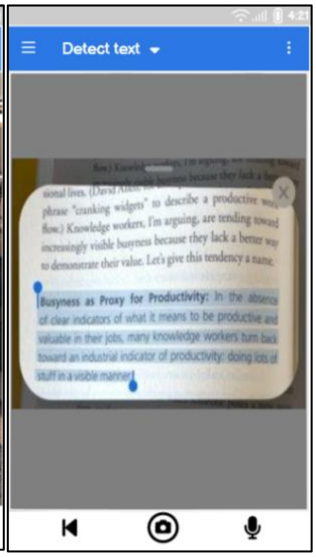


**Fig. 8.** User Interface Design for Text Recognition Screen.

For an object detected as shown in Figure 7, a bounding box appears around the object on screen and labels it with the recognized name in addition to the computed confidence score. Similarly for text detection as shown in Figure 8, detected text will be picked out and highlighted on screen which will be read out by the application. After the mobile application is successfully developed, pilot tested and deployed into AMD patients' mobile phones, three AMD patients are conveniently selected to use and evaluate the mobile application for both object and text recognition. Out of the three AMD patients, only two have Android phones. A separate Android phone was prepared and lent to the third patient for testing. All three patients initially took a while to adapt using the mobile phone to point and detect any object or text as they can't see clearly through their central vision. But after several attempts they managed to do so without assistance.

### *3.5 Mobile Application Testing*

Testing methodology for this research encompasses the following three areas which will be tested in the sequence:

1. *Object and Text Recognition Model Testing* – this test will measure the mean Average Precision (mAP) or accuracy of the Deep Learning Model for the Object Recognition Module as well as Machine Learning Model for the Text Recognition Module.
2. *Unit Testing* – this test is to assess how the mobile application developed is meeting the features and functionalities as collected during requirement study.
3. *Usability Testing* – this test is to evaluate three users or AMD patients' ratings and comments about attributes on the ease of use and usefulness of the mobile application. Ease of use referring to how user friendly in using the mobile application whereas usefulness referring to the outcomes achieved after using the mobile application.

## 4. RESULTS AND DISCUSSIONS

### *4.1 Object Recognition Model Performance*

Following Table 1 depicts the Object Recognition Performance for all the 4 models tested.

**Table 1.** Object Recognition Model Performance

| Model | Size (MB) | Latency (ms) | Average Precision (mAP) |
|---|---|---|---|
| EfficientDet-Lite2 | 7.4 | 69 | 33.97% |
| EfficientDet-Lite3 | 11.7 | 116 | 37.70% |
| EfficientDet-Lite3x | 13.6 | 208 | 40.98% |
| EfficientDet-Lite4 | 20.4 | 260 | 41.96% |

Above shown EfficientDet-Lite4 model exceeds other models in terms of mean Average Precision (mAP) despite having the largest model file size (20.4MB), highest latency (260 milliseconds) and mAP value (41.96%). After using the developed mobile application to test on individual model, it shows file size and higher latency of a model doesn't significantly hinder its effectiveness in detecting and recognizing objects. However, we can increase the mAP by exploring the latest EfficientDet-Lite models once they are published or apply transfer learning so that the above model is ingested and trained with more localized images captured in Malaysia. Despite more object images and model training can improve mAP but at the same time we need to monitor the model size and latency closely. This is achieved through consistent mobile application testing so that it is not too bulky to install and need to wait long before audio speech is generated.

### *4.2 Text Recognition Model Performance*

For the text recognition model performance based on Google's Play Services ML Kit Text Recognition library, mean Average Precision (mAP) of 82.73% which is considered acceptable as the library typically achieves mAP value in the range of 0.8 to 0.9 for text recognition tasks. TextRecognition library that process an image of text and return the recognized text yields latency of 221 milliseconds which is within the norm of less than few hundred milliseconds depending on the mobile phone capability and image size of the text. Above result findings indicate we can continue to adopt Play Services ML Kit model as the TextRecognition library in the "Detect Text" Application for this mobile application.

### *4.3 Mobile Application Testing*

Mobile application testing consists of 2 parts i.e. unit testing and usability testing.

#### *a) Unit Testing Performance*

Unit testing is to test the application features and functionalities as per requirement collected which includes object and text recognition as well as their respective audio feedback as depicted in Table 2-5.

**Table 2.** Unit Testing of Object Recognition Module

| Test Case | Test Steps | Test Data | Expected Result | Status |
|---|---|---|---|---|
| **1) S*can user's surrounding*** | a) Launch application | User's current surrounding | App can consistently capture and display user's surrounding clearly. | Pass |
| **2) *Detect* and *recognise* an *object* which yields a confidence score *higher than set threshold*** | a) Capture a scene with one object | A scene of a chair, returning confidence score higher than 70% | App will produce a bounding box around the detected chair in addition to displaying the object's name and confidence score. | Pass |
| **3) *Detect* and *recognise* an *object* which yields a confidence score *lower than set threshold*** | a) Capture a scene with one object | A scene of a doll, returning a confidence score lower than 70% | Item is not detected by the system; app will not display any object name, bounding box and confidence score. | Pass |
| **4) *No object* to be *detected* and *recognised*** | a) Capture a scene without any item | A scene of a blank wall. | App will not display any object name, bounding box and confidence score. | Pass |

**Table 3.** Unit Testing of Audio Feedback for Object Recognition Module

| Test Case | Test Steps | Test Data | Expected Result | Status |
|---|---|---|---|---|
| **1) *Detect* and *recognise* one *object* in a frame which yields a confidence score *higher than set threshold*** | a) Capture user's current surrounding b) Process the captured frame | Detection result returns a chair where the confidence score is higher than 70% | "Chair with ≥70% accuracy" is spoken as audio feedback | Pass |
| **2) *Detect* and *recognise* an *object* which yields a confidence score *lower than set threshold*** | a) Capture user's current surrounding b) Process the captured frame | Detection result returns a doll with a confidence score lower than 70% | No audio feedback is provided by the system. | Pass |
| **3) *No object* to be *detected* and *recognised*** | a) Capture user's current surrounding b) Process the captured frame | Detection result returns null | App will not display any object name, bounding box and confidence score. | Pass |

**Table 4.** Unit Testing of Text Recognition Module

| Test Case | Test Steps | Test Data | Expected Result | Status |
|---|---|---|---|---|
| **Clearly *detect* and *recognise* text phrases *without spelling error*** | a) Capture text phrases found within user's current surrounding<br>b) Process the captured frame | Detection result returns the phrase "Puzzle for the Secret Seven" from a book cover | App is able to clearly display the phrase from captured photo without any spelling error. | Pass |

**Table 5.** Unit Testing of Audio Feedback for Text Recognition Module

| Test Case | Test Steps | Test Data | Expected Result | Status |
|---|---|---|---|---|
| **Clearly read aloud detected text phrases without reading error** | a) Capture text phrases found within user's current surrounding<br>b) Process the captured frame | Detection result returns the phrase "Puzzle for the Secret Seven" from a book cover. | Audio feedback is provided where the system reads out "Puzzle for the Secret Seven" in English. | Pass |

Result findings from the above tables confirmed the developed mobile application can perform the functions as intended in terms of both object and text recognition. Moreover, positive feedback also received from the three AMD patients after initial issue faced in accessing the application from their Android mobile phone as well as pointing their mobile phone at the right direction before an object or text being detected and scanned. In addition, this lightweight mobile application is operational without Internet connection making it useable at any time anywhere if there is enough battery to power the mobile phone. Hence, the unit testing is completed successfully.

*b) Usability Testing Performance*

Usability testing is to evaluate the ease of use and usefulness of the mobile application as perceived by three AMD patients. Despite earlier unit test result is important but usability test result is even more important as the latter will determine how user is going to use the application. The three AMD patients are asked to answer a set of questionnaires based on their interaction with the mobile application, assigning scores ranging from 1 (strongly disagree) to 5 (strongly agree) when answering each question. Following Table 6 describes the respective score from them on each question asked:

**Table 6.** Results from Usability Test

| Questions | User 1 | User 2 | User 3 |
|---|---|---|---|
| **1) The application assists you in better identifying objects or texts in your surroundings** | 4 | 3 | 4 |
| **2) The application accurately identifies objects or texts found in your surroundings** | 4 | 2 | 3 |
| **3) The application can quickly identify objects or texts found in your surroundings** | 3 | 4 | 4 |
| **4) The audio feedback provided is clear and comprehensible.** | 5 | 5 | 4 |
| **5) This application is over complicated than necessary.** | 1 | 2 | 2 |
| **6) This application is easy to use.** | 5 | 4 | 4 |
| **7) I can quickly learn to use and navigate this application.** | 4 | 4 | 4 |
| **8) I do not need to remember too many steps to use this app.** | 4 | 3 | 3 |
| **9) I feel more confident in navigating my surroundings when using this application.** | 4 | 4 | 3 |
| **10) What about the application did you like the most?** | Easy and straightforward to use. Simple user interface. | It is good that the app can be used without Internet. | No need use internet connection. Also, good voice feedback. |
| **11) What about the application did you like the least?** | It is helpful in identifying objects but audio feedback when reading texts are not always very clear. | Robotic voice feedback provided. Detection can be confusing sometimes since it also reads out items from very far away. | App sometimes struggle to detect objects when camera is shaky. |
| **12) How would you describe this application to others?** | Good way of assisting people in their daily life. Thank you to developers for this app. | This app is not just a tool but act as stability for visually impaired people (Age-related Macular Degradation). It will make a big difference in peoples' lives. | App is a good start, has potential. But requires more enhancements for better convenience for people with poor vision. |
| **13) Final comments** | I found this app very helpful in my daily life. It can help me identify objects I usually cannot see clearly like food labels and clothing tags. | Impressed with the accuracy of this mobile app. Would be better if can provide audio feedback in other languages (for object recognition) as not everyone is fluent in English language. | More improvements can be made to the mobile app. Would like a version that uses less time for detection and is not easily affected by shakiness of camera. |

The result findings from above usability test generally indicate the mobile phone application developed based on the selected object and text recognition models are well received by the three AMD patients quantitatively and qualitatively despite administered in English. AMD patients understood the English used from the mobile application be it on the mobile phone's screen output or audio speech generated. Upon investigation on User1's comment about unclear audio feedback, that was expected because the scanned texts were not in English but rather Bahasa Malaysia whereby Text-To-Speech (TTS) module still using English pronunciation. In future this issue can be addressed through switching language from English to Bahasa Malysia or other language pronunciations in TTS after the text is scanned by mobile phone camera. However, above action needs to be performed manually by AMD patients. Alternatively, multilingual OCR tools, APIs or libraries can be installed into the mobile application so that TTS can convert accordingly and automatically.

Pertaining to User2's` comment, robotic voice can be improved to human voice through several ways which include choosing higher quality of TTS engine or adopting Natural Language Processing (NLP) which understands the context of text before generating more natural sounding speech. In order to avoid detecting other object which is faraway instead of closer object as focal point, user can be trained to use digital zoom or digital focus lock in their mobile phone's camera to narrow the field of view to focus on the closer object.

Alternatively, mobile phone with higher resolution camera can be used as low resolution camera is struggling to differentiate between close and distant objects. Moreover, object recognition model that is capable to handle depth filtering or distance-base prioritization can be implemented whereby its algorithm can favor object closer to the camera.

In order to successfully scan or detect object when the camera is shaky as commented by User3, better mobile phone's camera can be used i.e. it can support either or both hardware and software-based image stabilization so that it can estimate the movement and compensate for camera shake. Moreover, modern mobile phone's camera also can adjust its shutter speed automatically e.g. auto-adjust to faster shutter speed can reduce motion blur caused by camera shake. Last but not least, many mobile phone's camera can lock the focus on a specific object so that even when the camera moves, the object remains in focus to be scanned or detected. In general, this empirical study provides evidence that this simple mobile application is useful and capable to serves as an augmented vision to AMD patients in Malaysia.

Moreover, for some of the Malaysian AMD patients that are at retirement age or above the age of 60 might find this application is cost effective to manage and not burdening them while incurring rehabilitation cost for their AMD medical treatments. In the contrary, for AMD patients aged 60s in other developed and western countries, generally they are still under employment or before retirement age whereby they still have the financial means to seek better medical treatment, purchase more expensive mobile devices or features rich mobile applications for entity recognition. However, this may not be the same scenario for AMD patients in Malaysia. Hence, seeking a low cost mobile application solution i.e. comparatively lower purchasing cost of Android mobile phone and capability of the mobile application to function without Internet connection are critical. In summary, the developed mobile application is user friendly to the AMD patients whereby this application can help reduce their financial burden while combatting with the AMD disease.

## 5. CONCLUSION

Patients suffering from AMD have impacted their lives or life styles due to partial vision loss. This applied research through the development of a mobile application capable to detect, recognize and convert object or text into speech can help Malaysian AMD patients in carrying out their daily activities and navigating more freely and safely. In answering the two research questions postulated earlier and based on the comment input from the three AMD patients, this mobile application generally is user friendly, useful and did enlighten them in perceiving the surrounding environment better.

One of the research limitations include too few the mobile phone users involved in the application testing whereby AMD patients are not easily available. Given ample time in the future, adequate random sample of AMD patients will be sourced to go through the usability testing again. The second limitation is the low mean Average Precision (mAP) of 42% for object recognition. There is planning to literally ingest more images into data sets to increase mAP and using TensorFlow algorithms to train EfficientDet Model on those data sets to generate better Graph files.

One of the future enhancements after completion of this research includes improving and expanding object and text recognition as well as speech generation quality to cover other common languages aside English in Malaysia i.e. Bahasa Malaysia, Chinese, Tamil, Iban, Kadazan et al. Moreover, the mobile application also will be developed in iOS version so that other ADM patients using iPhone can also benefits from this application. Finally, in future we can include transfer learning for object recognition because current images within existing models might be different from those taken in Malaysia directly due to cultural and geographical differences.

In conclusion, through amalgamation of deep learning, machine learning and mobile application development, this research contributed a small step into relieving AMD patients to have a better grasp of their surroundings.

## REFERENCES


[1] Lombardo, M., Serrao, S., & Lombardo, G. (2022) Challenges in Age-Related Macular Degeneration: From Risk Factors to Novel Diagnostics and Prevention Strategies. Front. Med. 9:887104. doi: 10.3389/fmed.2022.887104.

[2] Perski, T. (2022, October 27). Eccentric Viewing; Vision Rehabilitation for People with AMD. https://medium.com/@tomperski/eccentric-viewing-vision-rehabilitation-for-people-with-amd-184014e81764

[3] Moshfeghi, A. A., Lanitis, T., Kropat, G., Kuznik, A., Gibson, A., Feng, H. et al. (2020). Social cost of blindness due to AMD and diabetic retinopathy in the United States in 2020. Ophthalmic Surg Lasers Imaging Retina. 51:S6-14. doi: 10.3928/23258160-20200401-01.

[4] Jeffery R. C. H., Mukhtar, S. A., Lopez, D., Preen, D. B., McAllister, I. L., Mackey, D. A., et al. (2021). Incident of newly registered blindness from age-related macular degeneration in Australia over a 21-year period: 1996-2016. Asia Pac J Ophthalmol. 10:442-9.

[5] Macnamara, A., Chen, C. S., Davies, A., Sloan, C., & Loetscher, T. (2021). Low vision devices for age-related macular degeneration: a systematic review. Disability and Rehabilitation: Assistive Technology, 18(7), 998–1010. https://doi.org/10.1080/17483107.2021.1966523.

[6] Wang, J., Wang, S., & Zhang, Y. (2023). Artificial intelligence for visually impaired. Elsevier, Displays 77 (2023) 102391. https://doi.org/10.1016/j.displa.2023.102391.

[7] Honavar, S. G. (2023). Eye of the AI storm: Exploring the impact of AI tools in ophthalmology. Indian Journal of Ophthalmology 71(6):p 2328-2340, June 2023. | DOI: 10.4103/IJO.IJO_1478_23.

[8] Bali, J., & Bali, O. (2023). Eyes of the Future: A Comprehensive Mapping of the Evolving Landscape of Artificial Intelligence in Ophthalmology. Delhi Journal of Ophthalmology 33(3):p 237-245, Jul–Sep 2023. | DOI: 10.4103/DLJO.DLJO_135_23.

[9] Leonard, V. K., Jacko, J. A., & Pizzimenti, J. J. (2006). An investigation of handheld device use by older adults with age-related macular degeneration. Behaviour & Information Technology, 25(4), 313–332. https://doi.org/10.1080/01449290600636512.

[10] Hakobyan, L., Lumsden, J., O'Sullivan, D., & Bartlett, H. (2012). Understanding the IT-related attitudes and needs of persons with age-related macular degeneration: a case study. IN: Proceedings of BCS HCI 2012 - People and Computers XXVI. GBR: UNSPECIFIED.

[11] Reeves, B. C., Wickens, R., O'Connor, S. R., Gidman, E. A., Ward, E., Treanor, C., ... & Hogg, R. E. (2024). Descriptive study of the challenges when implementing an app for patients with neovascular age-related macular degeneration to monitor their vision at home. BMJ open, 14(3), e077196.

[12] Lavric, A., Beguni, C., Zadobrischi, E., Cailean A., Avatamanitei, S. (2024). A Comprehensive Survey on Emerging Assistive Technologies for Visually Impaired Persons: Lighting the Path with Visible Light Communications and Artificial Intelligence Innovations. Sensors 2024, 24, 4834.

[13] StatCounter Global Stats. (2024, August 4). Mobile Operating System Market Share Malaysia. https://gs.statcounter.com/os-market-share/mobile/malaysia.

[14] Akkara, J. D., Kuriakose, A. (2019). Role of Artificial Intelligence and Machine Learning in Ophthalmology. Kerala Journal Ophthalmology, Volume 31, Issue 2, May-August 2019, 150-160. DOI: 10.4103/kjo.kjo_54_19.

[15] Hwang, D. K., Hsu, C. C., Chang, K. J., Chao, D., Sun, C. H., Jheng, Y. C., ... & Chiou, S. H. (2019). Artificial intelligence-based decision-making for age-related macular degeneration. Theranostics, 9(1), 232.

[16] Romond, K., Alam, M., Kravets, S., Sisternes, L. D., Leng, T., Lim, J. I., ... & Hallak, J. A. (2021). Imaging and artificial intelligence for progression of age-related macular degeneration. Experimental Biology and Medicine, 246(20), 2159-2169.

[17] Lin, Y. (2023, January 26). 10 Mobile Usage Statistics Every Marketer Should Know in 2023. Oberlo. https://www.oberlo.com/blog/mobile-usage-statistics#:~:text=There%20are%206.8%20billion%20smartphone,approach%20an%20in%2Dstore%20employee.

[18] Ud Din Arshad, Q. K., Kashif, A. U., & Quershi, I. M. (2019, January 8-12). A review on the evolution of cellular technologies [Paper presentation]. Proceedings of 2019 16th International Bhurban Conference on Applied Sciences & Technology (IBCAST), Islamabad, Pakistan.

[19] TensorFlow. (2022, September 3). TensorFlow Lite for Android. https://www.tensorflow.org/lite/android.

[20] Hisham, Z. A. N., Faudzi, M. A., Ghapar, A. A., & Rahim, F. A. (2020, August 24-26). A systematic literature review of the mobile application for object recognition for visually impaired people [Paper presentation]. 2020 8th International Conference on Information Technology and Multimedia (ICIMU), Selangor, Malaysia.

[21] Nasir, H. M., Brahin, N. M. A., Aminuddin, M. M. M., Mispan, M. S., & Zulkifli, M. F. (2021). Android based application for visually impaired using deep learning approach. IAES International Journal of Artificial Intelligence (IJ-AI), 10(4), 879-888. https://doi.org/10.11591/ijai.v10.i4.pp879-888.

[22] Salunkhe, A., Raut, M., Santra, S., & Bhagwar, S. (2021). Android-based object recognition application for visually impaired. ITM Web of Conferences, 40, Article 03001. https://doi.org/10.1051/itmconf/20214003001.

[23] Martinez-Alpiste, I., Golcarenarenji, G., Wang, Q., & Alcaraz-Calero, J. M. (2022). Smartphone-based real-time object recognition architecture for portable and constrained systems. Journal of Real-Time Image Processing, 19, 103-113. https://doi.org/10.1007/s11554-021-01164-1.

[24] Jia, J., Fu, M., Liu, X., & Zheng, B. (2022). Underwater object detection based on improved EfficientDet. Remote Sensing, 14(18), Article 4487. https://doi.org/10.3390/rs14184487.

[25] Gonçalves, M. P. (2022). MLKit Text Recognition Evaluation.

[26] Charishma, K., Umar, M., Chettri, R., Singh, R. K., Hussain, T., & Ravindranath, R. (2021). Review of Android Based Portable Sign and Text Recognition System. International Journal of AH Research Education and Scientific Methods (IJARESM), ISSN: 2455-6211 Volume 9, Issue 5, May -2021, Impact Factor: 7.429.

[27] Boesch, G. (2022, July 9). LabelImg for Image Annotation. Viso. https://viso.ai/computer-vision/labelimg-for-image-annotation/#:~:text=LabelImg%20is%20a%20lightweight%20and,success%20of%20computer%20vision%20applications.

[28] Góis Mateus, B., & Martinez, M. (2019). An empirical study on quality of Android applications written in Kotlin language. Empirical Software Engineering, 24(6), 3356-3393.

[29] Saabith, A. S., Fareez, M. M. M., & Vinothraj, T. (2019). Python current trend applications-an overview. International Journal of Advance Engineering and Research Development, 6(10).