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Detection of Rupiah Nominal Values Based on Computer Vision and OCR for Low Vision Accessibility

Doucoure Mohammed Hakeem[1*], Trisna Almuti[2], Syahbil Afriza Baharaji[3], Muhammad Iqbal[4], Albert Riyandi[5]

[1,2,3,4,5]Teknologi Informasi, Universitas Bina Sarana Informatika

[1*]Keemdoucoure@gmail.com, [2]trisnawisesa20@gmail.com, [3]abilbahar86@gmail.com, [4]muuhiqbal7@gmail.com, [5]Albert.abe@bsi.ac.id

Abstract

The ability to recognize banknotes' nominal value is a fundamental skill in daily economic transactions. However, for low-vision individuals, this simple task poses a major challenge, risking transaction errors and fraud. This study aims to build a web-based application capable of detecting Rupiah currency nominals in real-time by integrating computer vision and Optical Character Recognition (OCR) as an independent accessibility feature. The method combines a custom object detection model based on the YOLO architecture via the Roboflow platform and Tesseract OCR for nominal text verification, which is then integrated with the Web Speech API for voice-based output (Text-to-Speech). The system test results indicate that the combined "Roboflow + OCR" approach significantly improves detection reliability compared to using the object model alone. The system achieved a classification accuracy rate of 94.5% under optimal lighting conditions, with an average Text-to-Speech response latency of 1.8 seconds. This implementation proves that the synergy of image processing and OCR can provide an effective and inclusive assistive technology solution for visually impaired groups in Indonesia.

Keyword : *Computer Vision, Low Vision, OCR, Image Processing, Rupiah Currency*

1. INTRODUCTION

Money is a highly functional instrument in the daily economic life of society. The ability to accurately recognize the nominal value of banknotes is a basic skill needed by every individual in carrying out financial transactions. For some people, especially those with low vision, this seemingly simple activity actually becomes a quite significant real challenge. The inability to independently distinguish currency denominations can lead to various losses, ranging from transaction change errors to potential fraud that harms this vulnerable group. The utilization of assistive technology is currently proven to be able to increase the level of independence of this disability group in carrying out daily routines without full reliance on the help of others [1]The development of image technology-based assistive applications is now a cutting-edge solution to increase social inclusivity in the community [2].

Digital image processing has expanded widely in its use, including for object recognition systems that require a high level of accuracy such as banknote identification. Various artificial intelligence-based image analysis techniques, such as object detection using deep learning and text recognition through Optical Character Recognition (OCR), are now mature enough to be applied in practical applications [3]. Conventional classification methods that only rely on static color and size features are often constrained in their accuracy and consistency when faced with variations in camera shooting angles and extreme lighting [4]. Therefore, the adoption of smart models based on computer vision becomes a primary necessity that cannot be compromised [5].

Several studies over the last five years have focused on the utilization of artificial intelligence technology for processing the Rupiah currency. The physical characteristics of banknotes circulating in the community can be identified by their patterns using artificial neural network algorithms or Convolutional Neural Network (CNN)[6]. Furthermore, the implementation of the You Only Look Once (YOLO) model is widely chosen for real-time object recognition needs because of its ability to process images through a single network inference [7]. The use of the YOLO architecture specifically for recognizing Rupiah currency nominals is also proven to be stable and responsive [8]. On the other hand, the utilization of the OCR module using the Tesseract engine also shows a good level of maturity in extracting variations of numerical text and digital characters in images[9].

Although previous studies have shown high accuracy results in their respective fields, most of the developed systems still stand alone as pure visual detection models and have not been combined with an integrated textual verification system. Pure visual detection-based models are prone to misclassification if the tested banknotes are in physically folded, wrinkled, or worn conditions due to daily use. Therefore, this study aims to build a web application-based Rupiah nominal detection system that integrates the Roboflow object detection model (based on the YOLO architecture) and Tesseract OCR technology as an additional verification layer [10]. The main advantage of this research is the provision of an accessibility feature in the form of automatic Text-to-Speech (TTS) through the Web Speech API to provide instant voice feedback without burdening hardware memory [11] It is hoped that this application can make a real contribution to the low vision community in conducting financial transactions independently, safely, and inclusively in Indonesia [12].

2. METHOD

Research Stages

This research was conducted through five structured stages that describe the logical sequence from needs analysis to system performance testing. The research stages include[13]:

a. Needs Analysis
   Identifying physical accessibility limitations for people with low vision and designing the functional requirements of the web interface.
b. Dataset Collection and Annotation
   Collecting image samples of the latest emission Rupiah banknote denominations circulating in Indonesia, then performing labeling through the Roboflow platform.
c. Model Training
   Training a custom deep learning architecture-based object detection model on the Roboflow computing cluster until reaching the minimum loss value convergence.
d. OCR and TTS Integration
   Building client-side (front-end) logic to capture video frames from the webcam, send them to the object detection API, perform nominal text extraction using the OCR module, and convert the text into speech (Web Speech API).
e. System Testing
   Testing the overall system performance to compare the accuracy level of the single mode with the combination mode.

Rupiah Detection Method

The main process in recognizing currency nominals in this system is supported by a dynamically designed web application interface. As shown in Figure 1, the main website display provides a control panel that allows users to choose between two main options, namely the "Roboflow Only" mode which focuses on pure object detection, and the "Roboflow + OCR" hybrid mode. This interface is designed to facilitate user navigation, while ensuring that the image processing flow from the camera capture can be executed and evaluated in real-time according to the currently activated mode.

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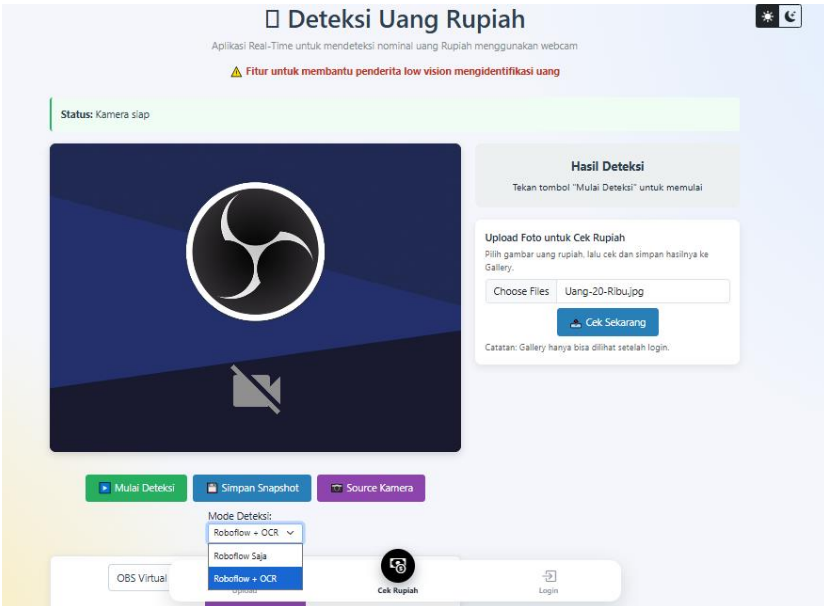

Figure 1. Main Page Display of Rupiah Money Detection

To support the flexibility of switching between the two modes, the system implements commands on the program lines. The main code snippet that plays a role in initializing the money detection while controlling the activation of the System's image processing mode.

Detection Mode Selection

```
if detection_mode == "roboflow_only":
    result = detect_with_roboflow(image)

elif detection_mode == "roboflow_ocr":
    result = detect_with_roboflow_and_ocr(image)
```

Explanation :

This code snippet shows that the system provides two detection methods, namely using the Roboflow model alone and a combination of Roboflow with OCR. The mode is selected based on parameters received from the user interface.

Roboflow Method

```
roboflow_result = roboflow.detect(image)
best_prediction = None
highest_confidence = 0
for prediction in roboflow_result:
    if prediction.confidence > highest_confidence:
        highest_confidence = prediction.confidence
        best_prediction = prediction.class_name
return best_prediction
```

Explanation:

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The Roboflow model performs inference on the input image and produces several object predictions. The system selects the prediction with the highest confidence value as the detected money nominal.

Roboflow + OCR Method

```
money = roboflow.detect(image)
ocr_text = ocr.read(image)
ocr_money = extract_nominal(ocr_text)
if money == ocr_money:
    return money
elif ocr.confidence > roboflow.confidence:
    return ocr_money
else:
    return money
```

Explanation :

After Roboflow produces a money nominal prediction, the system performs verification using OCR. If the results of both are the same, the result is considered valid. If they are different, the system chooses the result with the higher level of confidence (confidence).

3. RESULTS AND DISCUSSION

The "Rupiah Money Detection" application has been successfully implemented as a web-based platform using pure HTML5, CSS3, and JavaScript on the front-end side. The interface is deliberately designed to be as simple as possible without many decorative elements. The main page is dominated by a camera viewfinder area and large control buttons with high color contrast to support low vision accessibility. The system also provides additional features in the form of photo uploads from the local gallery and storage of detection result history (snapshots).

Model Performance Testing and Analysis

The dataset used in this study amounted to 1,400 images of Rupiah banknotes which were divided into 80% training data, 10% validation data, and 10% test data. The object detection model was trained using the YOLO architecture through the Roboflow platform. To answer the problem formulation regarding the effectiveness of the method, a comparative test was conducted between the independent use of the Roboflow model and the combination of the Roboflow and OCR methods. Testing was conducted using 70 samples of Rupiah banknotes with various physical condition variations (smooth, folded, and worn) under regular lighting conditions.

Table 1. Accuracy Comparison Table Based on Physical Condition

Physical Condition of Banknotes	Number of Samples	Roboflow Only Mode Accuracy	Roboflow + OCR Mode Accuracy
Smooth / New	30	96.6%	96.6%
Folded / Partial	20	85.0%	95.0%
Worn / Wrinkled	20	75.0%	90.0%
Overall Average	70	86.8%	94.5%

Based on the data in Table 2, the use of the "Roboflow + OCR" combination mode is proven to provide a significant average accuracy increase, which is from 86.8% to 94.5%. On banknotes with worn

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or wrinkled physical conditions, pure object models often experience a decrease in accuracy (only 75.0%) due to distortion of the main visual characteristics of the banknotes. Appropriate image preprocessing and character area cropping (ROI cropping) before entering the OCR engine play a crucial role in saving text recognition accuracy from background distortion interference. With the presence of the OCR verification layer, the classification failure rate can be drastically suppressed up.

Evaluation of Voice Accessibility Feature

Testing of the accessibility feature in the form of sending detection result text data to the Text-to-Speech (TTS) component runs in real-time. Based on computational performance testing, the average latency (delay) of the system from the first time the camera captures the object until the nominal voice is read is 1.8 seconds. The Web Speech API integration is proven to produce constant, lightweight, and reliable audio output response times. Maintaining the audio update interval is effective in preventing audio overlapping when the user moves the money in front of the camera. Users can utilize this application independently via speakers or headphones without needing to look at the screen.

Rupiah Currency Detection Testing

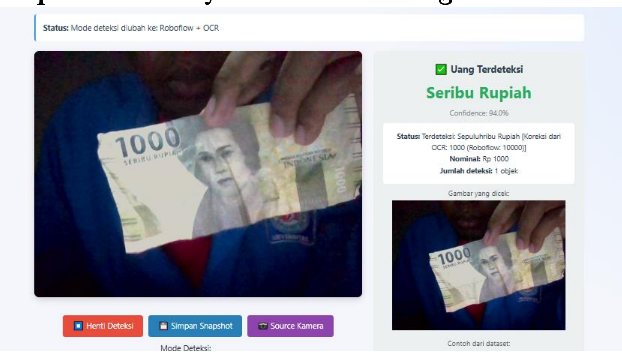

Figure 2. One Thousand Rupiah Detection

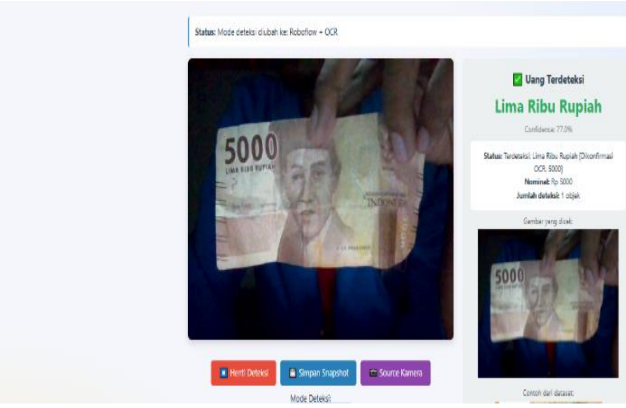

Figure 3. Five Thousand Rupiah Detection

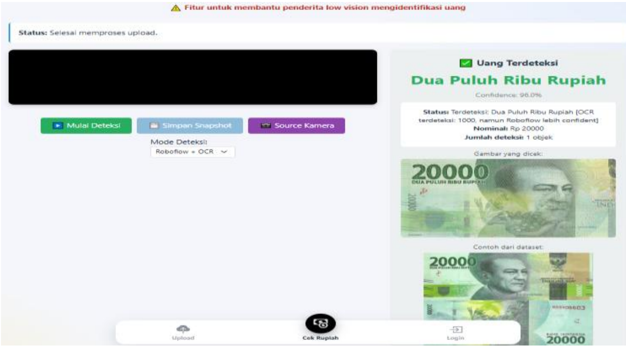

Figure 5. Twenty Thousand Rupiah Detection

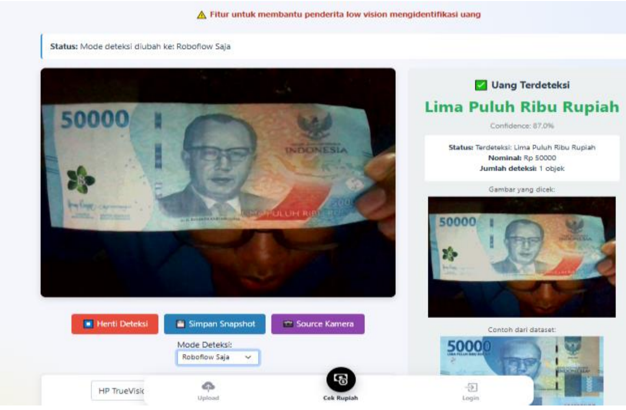

Figure 6. Fifty Thousand Rupiah Detection

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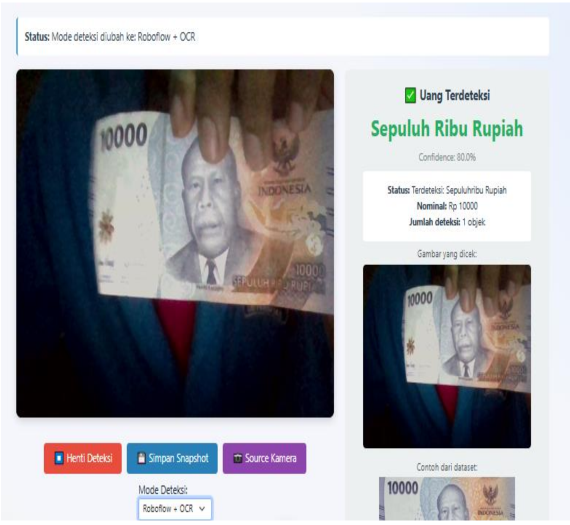

Figure 4. Ten Thousand Rupiah Detection

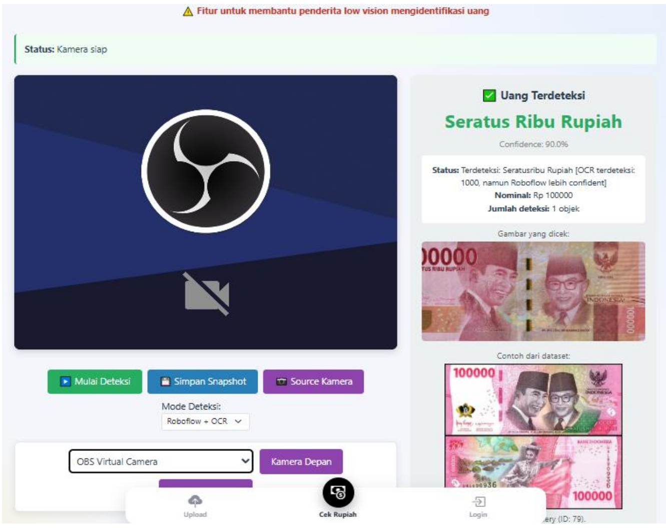

Figure 7. One Hundred Thousand Rupiah Detection

4. CONCLUSION

This research has successfully developed a web-based application to detect the nominal value of Rupiah banknotes that is accessible to people with low vision. The integration between a computer vision-based object detection model (Roboflow) and a textual character recognition system (OCR) is proven capable of overcoming the weaknesses of a single visual model, especially when identifying banknotes in folded or worn physical conditions. Through the application of this hybrid method, nominal recognition accuracy increased significantly reaching an average of 94.5%. Furthermore, the implementation of the Web Speech API as an automatic Text-to-Speech feature with an average response time of 1.8 seconds has successfully provided a practical, interactive, and independent assistive help function. It is hoped that this system can minimize the risk of financial transaction errors and provide a higher sense of security for visually impaired groups in Indonesia.

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