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Utilization of Convolutional Neural Networks in Coin Grading for BSP Series One Peso Coins

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Abstract

Identifying the grade of the coin is one of the methods used in numismatics to get the condition and collector's values of a coin. Coin grading is subjective and sensitive in nature in which at least three (3) numismatists or coin graders or experts are needed to have a persuasive result or coin grade. This paper aimed to develop a tool that will give an accurate and objective grade of a coin. The main objective of this paper is to check whether a developed tool can accurately grade a coin based on its image only. This study used a Convolutional Neural Network (CNN) as image analysis algorithm for the developed tool and three hundred (300) BSP Series one peso coin images for each of the five-coin grades were also generated as dataset for the tool to perform its function. Major results produced a more accurate tool that gave a specific grade of a coin. A group of numismatists or coin graders or experts evaluated the developed coin grading tool in which it acquired very satisfactory results. Convolutional neural network is proven to be effective in accurately and objectively grading coin images and can be a great help for numismatist in appraising coins. This can be improved by considering variety of coins for grading.

Keywords: BSP Coin Series, Coin Grading, Convolutional Neural Network, Image Analysis, Numismatics

INTRODUCTION

Coins have two values: (a) Face Value is the printed value of the coin located on its surface; and (b) actual or collector's value of the coin based on different key factors (Knell, 2017). One peso coin has a face value of one peso but may have an actual or collector's value of more than one peso. That's why it is not surprising that there are posts online selling coins or banknotes with prices higher than the face value. The factors that may affect a coin's actual or collector's value include mint year, historic value, rarity, and grade, to name a few. This is where the numismatic field takes place.

Numismatics is the process of collection and/or scientific study of money, including but not limited to coins, banknotes, and tokens. People who are collecting and/or studying these items are called numismatists. Coin collecting started as early as the reign of Augustus Caesar wherein he gave coins as gifts to his wife, Saturnalia (Suetonius, 2019). Since then, coin collections were made as a hobby, or were given as a gift to other people.

Before one can start collecting and even grading coins, it is best to familiarize one with the coin's anatomy and basic terminologies. These parts of the coin are vital in checking the coin's condition. (Illustrated in Figure 1 are the parts of the coin).

Figure 1
Anatomy of a coin

One of the processes of coin collecting is coin grading. Circulated coins were graded according to its surface condition, whether the coin's surface has wears or not. Coin grading allows numismatist to: (a) communicate appearance (the ability to distinguish two same coins); (b) establish relative rarity (coins that are of higher grade are rare); and (c) determine its collector's value (higher grade coins are

more expensive than lower grade coins) (Sherman, 2017). Grades vary from Poor, which is the lowest grade, up to Mint State, which is the highest grade. Most of the numismatists want to know the grade of their collections as these will affect the value of their coins. Usually, they go to a professional coin grading institutions such as Professional Coin Grading Service (PCGS), Numismatic Guaranty Corporation (NGC), and American Numismatic Association Certification Service (ANACS) to name a few, to have their coins graded.

In the Philippines, organizations that provide coin grading are rare. Normally, one can make a coin collection graded to a numismatist or a group of numismatists. However, if one wishes to have your coin graded professionally and have it certified, he/she needs to send the coin to the following top professional coin grading organizations (McMorrow-Hernandez, 2023). However, these coin grading organizations do not have locations here in the Philippines. Thus, one needs to send the coin abroad. The closest one can get is China or Hong Kong (Cobin, 2014).

In addition, one of the challenges in this field is that grading itself is subjective and sensitive in nature that even experts can disagree about the condition and grade of the coin. Thus, for the result to be persuasive enough, this process shall be done by at least three numismatists or coin experts (Feng, et al, 2016). There are some studies that tried to address this problem, however, most of them are limited only to generic grades such as Uncirculated, Circulated, and Mint State (Atighehchian, 2017). One of the challenges also is to come up with a grading tool that provides a more specific grade of a coin. Although the subjectivity of coin grading had been addressed by having professional coin grading services mentioned earlier, in which coins are encapsulated with a plastic case with the grade on it (Liberatori, Jr, 2021), there is no study or coin grading application has been made yet that provides a more specific grade of the coin.

To be able to address the problem and give solution thereof, the researcher aims to prove that developing a tool that will be able to give an accurate coin grade based on the uploaded images of coins using image analysis algorithm/s is possible. This study aimed to develop an application that will automatically grade a coin using an image analysis algorithm to provide fast and objective coin grading tool and will answer the following questions:

1. What is the level of coin grading accuracy of the developed tool for the following coin grades: Almost Uncirculated, Extremely Fine, Very Fine, Fine, and Very Good?

2. What is the user's level of acceptance of the developed tool in terms of Functional Suitability, Performance Efficiency, Compatibility, Usability, and Portability?

This study only focused on the effectiveness of an image analysis algorithm in grading One Peso coin/s. The One Peso coins of the Bangko Sentral ng Pilipinas (BSP) Series which was circulated from 1995 to 2017 were used in the data collection. The study did not cover coin identification and counterfeit detection. Other coins such as 1 sentimo, 5 sentimos, 10 sentimos, 25 sentimos, 5 piso, and 10 piso coins in the BSP Series were not within the scope of this study. As for the grades, only One Peso coins with grades from Very Good (VG), Fine (F), Very Fine (VF), Extremely Fine (XF), and Almost Uncirculated (AU) were used in this study since their grades were currently widely available in circulation. Damaged and error coins were not included since these coins defied the basic rules in coin grading. Commemorative one-peso coins issued under the BSP Series were also not part of the scope of this study. Lastly, only the obverse image of the coin will be used in this study.

Coin grading is very important in numismatics as it determines the value of a coin. Coins undergo the process of determining its condition through these criteria: strike, preservation, luster, color, attractiveness, and rarity (Winter, 2010; Gumbinas, 2020). This also determines the value of a coin, or as a guide in pricing the coin.

The process of coin grading includes checking whether the coin is authentic or counterfeit, checking for any alterations made to the coin, and then lastly, assigning a grade to a coin based on the criteria stated above (PCGS, 2021). During the earlier times, there were only three types of grades given to the coin: Good, Fine, and Uncirculated.

In the late 1800s to early 1900s, the collector market for coins expanded quickly. Hence, a more detailed grading system was needed. Many coins were clearly finer than others, and some uncirculated coins showed more lust and even less markings than others. The terminologies "uncirculated," “extremely fine,” and "very fine" have started to see use, as more precise rating details have allowed for more accurate pricing for the booming collector market. In 1948, a well-known numismatist named Dr. William Sheldon sought to standardize coin grading by introducing what is now known as the Sheldon Scale (Ruddy, 2005).

Today, several grading systems were used such as the European Grading System and the American Numismatic Association scale, in which both originated from the Sheldon Scale. Sheldon Scale was originally devised by Dr. William Herber Sheldon specifically for United States large cents, but it is now applied to all series. Table 1 shows the scale wherein 1 is the lowest where coins are unrecognizable and 70 is the highest which means that the coin is in mint state and no wears, or any impurities found on its surface. Note that from 60, even though it is mint state, it means that the coin has little wear but still considered as uncirculated. There is a direct mapping from this scale to the older descriptive terms, but they are not always used the same (Androulakis, 2019).

LITERATURES

Image analysis by using different image recognition algorithms in coin classification and recognition were already developed in the past for various uses. Many studies on coin recognition using image analysis have been conducted to address the need for a counterfeit detector application. Some of these studies only include coin recognition in detection fake coins (Modi & Bawa, 2011; Al-Frajat, 2018) while some studies include coin grading (Atighehchian, 2017; Feng, et al., 2016; Gakhar, 2020).

One of those coin recognition studies is the use of Robust Correlation Algorithm for feature matching, Hungarian algorithm for shape matching, and Scale Invariant Feature Transform (SIFT) for object recognition to address the need of reliable automatic coin recognition for ancient coins (Zaharieva, et al., 2007; MacDonald, et al., 2017). The SIFT algorithm is also used in a study of Zambanini, and Kampel (2011) in coin classification from 2D images of ancient Roman coins. Although these studies were successful, computations using SIFT were slow thus affecting the performance of the tool. One promising automated coin recognition system was the use of Artificial Neural Networks in the study of Modi, and Bawa (2017) in which the study shows 97.74% recognition rate on coins.

Coin grading is also one of the methods to detect counterfeit coins (Atighehchian, 2017). There are only a few studies about automatic coin grading as it was believed that it was subjective in nature and could never be done automatically. One of the earliest attempts to automate coin grading was done by Crain (1993) which ended as a patent. The said coin grading system is composed of image acquisition apparatus such as a camera and mechanical coin positioning equipment. However, as research on machine learning is booming, there some attempts to create an automatic coin grading application using various algorithms (Feng, et al, 2016; Atighehcian, 2017; Pan, Tougne, 2018; Gakhar, 2020). For instance, neural networks, along with other algorithms to increase the precision of the recognition, already proved to have higher accuracy rate in coin recognition. One attempt at automated coin grading is the study of Atighehchian (2017) which analyses the wear of the coin to get its grade. The study used SIFT method to analyze the wear in coins which yielded 93% accuracy rate. Even so, there are still limits on the grade categories as the study is only categorized as uncirculated (UC), choice extremely fine (EF+),

and very fine (VF). Instead of wear, Pan, et al.15 proposed that coin scratches will be used to define the grade of the coin. Although the study produced promising results, they only used an objective indicator, called the Grading Guide (GG), and not a specific coin grade as results.

Table 1
Sheldon Coin Grading Scale

Abbreviation	Grade	Description
PO	Basal State / Poor	Extremely worn. Coin is barely identifiable.
FR	Fair	Heavily worn but some letterings and features are identifiable
AG	About Good	Rims are worn including the top portions of the lettering.
G	Good	Rims are full but flat. Many details are also flat.
VG	Very Good	Central design worn flat. Lettings show light to moderate wear.
F	Fine	Letterings are now sharp and clear. Slight to moderate wear in some areas.
VF	Very Fine	Details are complete or mostly complete. Moderate wear in high areas
XF	Extremely Fine	Light wear in high areas. Traces of mint luster can be shown
AU	Almost Uncirculated	Traces of light wear can be shown in high area. Most of the mint luster are present.
MS	Mint State	Mint luster is full. No wear but some hairlines are present.

METHODS

Research Design. The researcher used experimental and descriptive research design in this study because it best served to answer the questions and the purposes of the study. This study is also concerned with the development of an image analysis tool that aims to identify the grade of a coin. The experimental research design aims to get the accuracy rate of the tool in terms of distance from the camera, lighting, and angle. This study used the Post-test Only Control Group Design wherein the experimental group which are the coins are treated and the post-test is conducted to assess the effects of the treatment. The descriptive research design uses surveys as instruments to study a group of people by collecting and analyzing data from several people considered to be representative of the entire group (Zimmerman, et al., 2018). This study seeks to understand how users assess the developed system in terms of usability, functionality, reliability, and performance.

Sources of Data. The data that is employed in this study is collected for the following purposes: (a) the experimental part of the study; and (b) the level of acceptance of the developed tool. The population frame of this study consisted of One Peso (1-Piso) coins from the Philippine BSP Series (1995 to 2017), as shown in the Figure 2. One Peso coins under this series are the widely used coin denomination in the Philippines, therefore enough coins can be collected for the dataset. The coins may have presence of wear or with crisp detail. As for the sampling technique, stratified sampling is used to select the samples from the population.

Figure 2
The Bangko Sentral ng Pilipinas Coin Series that was minted from 1995 to 2017

The respondents of this study comprised of coin collectors, coin experts, or numismatists. The respondent has to be working closely in coin grading and have sufficient background about coin grades. The inputs from the respondents were used for the calculation and improvement of the accuracy rate of the developed tool. Data was acquired for the responses of thirty (30) numismatists. Majority of these numismatists were members of various numismatic groups such as the Bayanihan Collectors Club, and Philippine Numismatic and Antiquarian Society (PNAS), to name a few. The sampling technique used in this study is Purposive Sampling in which respondents in this survey are determined based on their level of experience in collecting and grading coins.

For the evaluation of the accuracy of the grading tool, the researcher used the experiment paper. In this paper, the researcher has been able to determine the accuracy rate of the developed system for the given factors. For this research instrument, the following elements would be necessary: (a) representative sample of coins was chosen for the investigation, covering a variety of conditions and grades; (b) a group of experts in coin grading or numismatists evaluated each coin in the sample separately, in which they made use of accepted grading

guidelines and consider a coin's condition, strike, luster, and other characteristics that can affect its grade; (c) the coin grading tool was used to grade each coin in the sample, after which, the tool will be evaluated by its performance; and (d) the accuracy of the tool was calculated by determining the percentage of coins for which the tool and expert grades agreed.

Table 2
Interpretation of the Weighted Mean

Numerical Scale	Verbal Interpretation
4.20 – 5.00	Highly Acceptable
3.40 – 4.19	Moderately Acceptable
2.60 – 3.39	Acceptable
1.80 – 2.59	Slightly Acceptable
1.00 – 1.79	Not Acceptable

Data Generation Procedure. Data is acquired by capturing photos of obverse images of BSP Series One Peso Coins. In coin grading, the grade of the coin is usually defined by the coin's observed image. The reverse side of the coin is often used as tie breaker if two obverse images are the same. For the dataset, three hundred (300) coins per grade or a total of one thousand five hundred (1,500) coins are captured using controlled or defined angle, distance from the camera, and lighting. For the experiment, 60% or 900 out of 1500 of total coin images were used for training, while 20% or 300 coin images were used for testing, and another 20% or 300 coin images were used for test validation.

Various steps were taken to acquire necessary data for the study. These procedures include: (a) seeking professional help and advice about the coin grading guide that the researcher will be using as well as validating it; (b) the validated guide will be the base of producing datasets that will be in the database of the system; (c) standard scenario for the experiment is composed of normal lighting, a distance of 5 inches from the coin, coins with diameter of no less that 24mm, and a zero (0) degree angle for the phone.

Figure 3
Developed Grading Scale for One Peso Coins

The procedures to acquire data are the following:

1. Coins are graded by a group of numismatists;
2. Sorting the coins based on its grade (from Very Good to Almost Uncirculated) to be used as data set for this study;
3. Capturing of individual coin's image using mobile phone;
4. Image quality (at least 13 megapixels);
5. Background color (plain white or black);
6. No artificial light (e.g. camera flash, lamp, etc.) used; and,
7. View/angle (top view to at most 45°).

Choosing a numismatist or coin grading expert to help in grading the coins and validating the initial grade made by the researcher since the researcher is a numismatist. This data will then be used as training data for the developed grading tool. With this, a grading scale customized to One Peso coin is developed as illustrated in Figure 3.

To determine the accuracy of a coin grading tool, an experiment was conducted to evaluate its performance. The researcher used the experiment paper to acquire the results for the study. These procedures are as follows: (a) collection of a representative sample of coins to be evaluated by the grading tool. The coins should span a range of grades and conditions, including examples of uncirculated, lightly circulated, and heavily circulated coins.

1. Labeling of coins with their corresponding grades such as Very Good (VG), Fine (F), Very Fine (VF), Extremely Fine (XF), and Almost Uncirculated (AU) using the Sheldon scale.
2. Gathering of coin images for the testing of the developed coin grading tool.
3. The gathered sample coins were evaluated using the developed coin grading tool. After which, the results were recorded.
4. Answering the experiment paper with the help of a numismatist or coin grading expert. This will serve as the basis of the developed grading tool's accuracy.

To determine the level of acceptance of the developed tool, close-ended questions were asked through a survey to a group of numismatists. They will rate the developed coin grading tool on a scale of 1 to 5 based on Functional Suitability, Performance Efficiency, Compatibility, Usability, and Portability which were based on ISO 25010.

Data Case Analysis. Accuracy rate was used to determine the accuracy of the system by computing the number of coins correctly graded over the total number of coins with the use of the experiment. To get the accuracy rate, the following formula is used:

$$\text{Accuracy Rate} = \frac{\text{TP} + \text{TN}}{\text{TP} + \text{TN} + \text{FP} + \text{FN}} \text{ x } 100$$

where:

TP – *True Positive.* This refers to when the coin grading tool correctly identifies a coin as being in the expected grade. For example, if the tool identifies a coin as being in "almost uncirculated" condition and it is indeed in that condition, this would be a true positive.

TN – *True Negative.* This refers to when the coin grading tool correctly identifies a coin as not being in the expected grade. For example, if the tool identifies a coin as not being in "almost uncirculated" condition and it is indeed not in that condition, this would be a true negative.

FP – *False Positive.* This refers to when the coin grading tool incorrectly identifies a coin as being in the expected grade when it is not in that particular grade. For example, if the tool identifies a coin as being in "almost uncirculated" condition when it is actually in a lower grade, this would be a false positive.

FN – *False Negative.* This refers to when the coin grading tool incorrectly identifies a coin as not being in a particular grade when it is in that grade. For example, if the tool identifies a coin as not being in "almost uncirculated" condition when it is actually in that condition, this would be a false negative.

Precision measures how accurate the coin grading tool is when it identifies a coin as being in a particular grade. Imagine that the tool identifies a coin as being in "almost uncirculated" condition. Precision measures the percentage of times that the coin is actually in "almost uncirculated" condition. A high precision score would indicate that the developed coin grading tool is accurate in identifying the grade of the coin. To get the precision, the formula below is used:

$$\text{Precision} = \frac{\text{TP}}{\text{TP} + \text{FP}} \text{ x } 100$$

Recall, also referred to as sensitivity or the true positive rate, is the proportion of properly predicted positive observations to all of the real class observations. Recall measures how well the coin grading tool is able to identify all the coins that are actually in a particular grade. Imagine that there are 200 coins in "almost uncirculated" condition. Recall measures the percentage of those coins that the tool is able to correctly identify as being in "almost uncirculated" condition. It offers us a sense of how many of the data's encouraging observations were correctly predicted. A high recall score shows that the grading tool can identify all coins with a correct grade and makes a small number of false negative predictions. To get the recall, the following formula is used:

$$\text{Recall} = \frac{\text{TP}}{\text{TP} + \text{FN}} \text{ x } 100$$

In addition to the formula given above, the researcher used the ISO 25010 to evaluate the system quality. Therefore, the tabulation of the result follows a standard formula in obtaining the mean of each software quality characteristics, and the overall means of all software quality characteristics combined. This is computed using the following formula:

$$\text{Weighted Mean} = \frac{\text{TWF}}{\text{N}}$$

where:

TWF – Total of the Products of the Weights Multiplied by their Corresponding Frequencies

N – Number of Raters

To obtain the overall mean of the responses per category, the following formula for the composite mean is used.

$$\text{Composite Mean} = \frac{\sum \bar{\mathbf{x}}}{\mathbf{N}}$$

where:

$\sum \bar{x}$ – Summation of weighted mean
N – Population

System Architecture

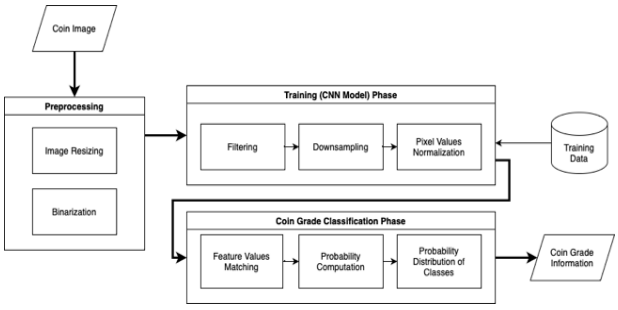

Figure 4
System Architecture of the Coin Grading Tool

Figure 4 shows the system architecture of the coin grading tool using Convolutional Neural Network (CNN). The tool starts with an input of the coin's image. The user uploaded an image of the coin in the developed tool. After which, the input image underwent pre-processing which included the resizing of the image and binarization after. Binarization is the process of conversion of the coin's image from colored to black and white, as illustrated in Figure 5.

(a) (b)

Figure 5
A normal coin's image (a), and an image that undergone binarization (b)

After the pre-processing, the coin's image underwent to the trained CNN model. The following are the steps in the said model:

1. *Filtering.* To extract pertinent elements from input photos of coins, coin grading uses filtering. In CNN's convolutional layers, filters are applied to the input images to create feature maps that emphasize particular facets of the coin's design or condition. Filters can be used, for instance, to find patterns, corners, or edges in a coin's image.

2. *Downsampling.* The spatial resolution of the feature maps generated by the filters is decreased through downsampling, as shown in Figure 6. This can help with coin grading by lowering the size of the input to the network, improving its computational efficiency, and strengthening the features' resistance to small variations in the input image. Pooling layers in the network, which merge the values of nearby pixels into a single value in the feature map, are often used to do this.

3. *Pixel Values Normalization.* The pixel values of the coin pictures are changed to fall within a certain range using pixel value

normalization. The usual method for doing this is to transform the values to have a mean of 0 and a standard deviation of 1, which is accomplished by removing the mean of the pixel values and dividing by their standard deviation. Normalization is used in coin grading to make sure that each feature, such as the coin's color, texture, or shape, has an equal impact on the network's output.

4. *Feature Values Matching.* When feature values are matched, a set of predefined values or templates are compared to the feature values that were extracted by the CNN's filters. These templates may correspond to various coin grades or situations in coin grading. The retrieved feature values are compared to these templates by the network to identify the coin's most likely grade or condition.

5. *Probability Computation.* Using the attributes that were retrieved from the coin's image, probability computation determines the likelihood of each class or grade. This is commonly accomplished in a CNN for coin grading using a fully connected layer that receives the extracted characteristics as input and produces a set of probabilities for each class. Using these probabilities, one can then forecast the grade or condition of the coin.

6. *Probability Distribution of Classes.* The probability distribution is utilized in a CNN for coin grading to identify the most probable class or grade given the retrieved features. The final forecast can be made by choosing the class with the highest probability or by considering a threshold value to ensure that the prediction is made with a specific level of confidence. After going through a series of processes, the application was able to output the grade of the coin.

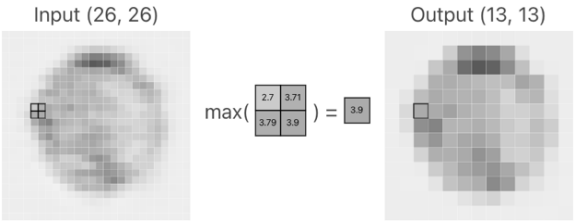

Figure 6
Sample down sampled coin's image

Development. The tool used in coin grading was developed using Python programming language in Jupyter Notebook. For image analysis and machine learning, the researcher used TensorFlow. TensorFlow library was used for building the Convolutional Neural Network (CNN) which is used to predict the grade of a coin. Coins were captured using an android mobile phone and used as training data of the developed tool.

Since there is a software development involved in this study, the researcher used the Prototyping Development Model as shown in Figure 7. Under this model, the researcher developed a prototype, tested it and reworked it until it is acceptable. As for the user interface of the grading tool, the researcher used StreamLit framework since it was compatible with Python libraries used in machine learning. It is also open source therefore it can be customized.

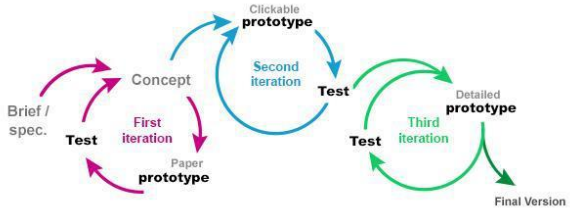

Figure 7
The Prototyping Model

RESULTS

For the researchers to be able to answer the afore-mentioned questions in this study, the researchers conducted experimentations and analysis of the results gathered. With the help from the numismatists, the researchers tested the developed tool on 300 samples of coin images. The results were recorded and used for

the calculation of the overall accuracy rate of the system in the classification of the grade of the coin.

Based on the experiments carried out by the researchers, the developed coin grading tool performed well in determining the grade of the coin. It obtained an overall accuracy rate of 0.9133 or 91.33%. For the classification of Almost Uncirculated coins, the developed tool obtained 0.9000 or 90.00% accuracy rate. An accuracy rate of 0.8500 or 85.00% was obtained by the developed tool for the classification of Extremely Fine coins. As for the classification of Very Fine coins, the developed tool got 0.9667 or 96.67% accuracy rate, which is the highest among coin grades in this study. While 0.9167 or 91.67% accuracy rate was obtained by the developed tool in the classification of Fine coins. Lastly, the developed tool acquired an accuracy rate of 0.9333 or 93.33% for the classification of Very Good coins. Table 3 shows the overall result for the accuracy of the developed coin grading tool.

Table 3
Summary of Results for the Accuracy of the Coin Grading Tool

Grade	Precision	Recall	Accuracy
Almost Uncirculated	0.9643	0.9310	0.9000
Extremely Fine	0.9091	0.9260	0.8500
Very Fine	1.000	0.9667	0.9667
Fine	0.9650	0.9483	0.9167
Very Good	0.9492	0.9825	0.9333
Overall	0.9575	0.9509	0.9133

For the precision and recall of the coin grading tool, Almost Uncirculated coins garnered a precision of 0.9643 or 96.43%, and 0.9310 or 93.10, respectively. On the other hand, 0.9091 or 90.91% precision and 0.9260 or 92.60% recall rates were achieved by Extremely Fine coins. Very Fine coins got a precision of 1.000 or 100.00% and a recall of 0.9667 or 96.67%. Fine coins got a precision and recall of 0.9650 or 96.50%, and 0.9483 or 94.83%, respectively. Lastly, a precision of 0.9492 or 94,92% and a recall of 0.9825 or 98.25% was achieved by Very Good coins.

For the level of acceptance of the developed tool by the respondents, they highly accept the Coin Grading tool with an overall mean of 4.51. Specifically, the results are 4.39 for Functional Suitability, 4.45 for Performance Efficiency, 4.52 for Compatibility, 4.49 for Usability, and 4.68 for Portability. With this, the respondents highly accept that the developed coin grading application can provide users with: (1) a reliable and efficient way to grade their coins and estimate their value; (2) a fast, accurate, and efficient way to grade their coins; (3) a flexible and accessible way to grade their coins, regardless of their technology setup; (4) a straightforward and user-friendly way to grade their coins and generate condition reports; and (5) convenient and flexible way to grade their coins. Table 4 shows the overall results of the respondent's level of acceptance.

In addition to these findings, the researcher also found out that the developed coin grading tool varies its grade output on the type of the coin that was uploaded. It was observed that the Philippine One Peso coins under the BSP Series undergone a series of changes throughout its circulation. With these changes, it also affects the performance of the coin grading tool.

Table 4
Overall Results for the Level of Acceptance of the Coin Grading Tool

Criteria	Weighted Mean	Verbal Interpretation
Functional Suitability	4.39	Highly Acceptable
Performance Efficiency	4.45	Highly Acceptable
Compatibility	4.52	Highly Acceptable
Usability	4.49	Highly Acceptable
Portability	4.68	Highly Acceptable
Overall Mean	4.51	Highly Acceptable

In addition, it should be noted that during the experimentation stage of this study, the researcher found out that the features of the Philippine Coins differ by year. As shown in Figure 8, both coins are in Almost Uncirculated condition, however, the difference between the two coins can be seen on Jose Rizal's hair (Figure 9). Jose Rizal is the person featured on one-peso coins. These differences in the coin's

patterns affect the grade displayed by the Coin Grader.

Figure 8
Almost uncirculated one-peso coins minted in 2015 (left) and minted in 2017 (right)

Figure 9
Jose Rizal's hair on one-peso coins minted in 2015 (left) and minted in 2017 (right)

DISCUSSION

After conducting experiment and analyzing the results of the developed Coin Grading tool, the researcher concluded that even though there are already studies made in coin recognition, the topic of having an automated and accurate coin grading tool is rarely explored. While there are some studies made with regards to coin grading, they are limited only to coin conditions whether they are circulated or not. Second, with the given overall accuracy rate of 91.33% it can be reliable in giving a more objective grade to a coin, which answered the problem stated. The results of this study showed evidence that coin grading can be automated through image analysis. Lastly, with the given overall mean of 4.51 for the level of acceptability from the survey, it was noted that the respondents highly accepted that the coin grading tool can be a useful tool in guiding numismatists and coin collectors for appraising coin collections. With these findings, it can be proven that grading a coin can be done objectively and accurately. This can be a start to advanced and automated methods in the field of numismatics.

Based on the findings of this study, the following recommendations are offered for further enhancement of the tool's performance and for the future studies in the field of coin grading and numismatics:

1. With 1500 images of coins used in this study, it was observed that the developed coin grading application's performance can be improved by adding more dataset to make the grading tool improve its accuracy and performance.

2. Since the developed coin grading tool is a web application, although it can be accessed through a mobile phone's browser, developing a coin grading tool wherein grading the coin can be done real-time should be considered.

3. As the coin grading application already proved to grade BSP Coin Series one-peso coins, future researchers and developers may consider applying this study to a variety of coins, and more grades may be included.

4. Although proven effective in grading coins, future researchers may investigate image analysis algorithms other than Convolutional Neural Network for coin grading.

5. Future researchers may apply this study to banknotes (paper bills) since these are more complicated to grade than coins.

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