Automatic Coin Classification Project Documentation

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Abstract

The "Automatic Classification of Coins" project presents a comprehensive system for automating the classification and identification of various coin types based on their visual characteristics. In this project, a dataset of coin images was collected, and a series of image processing and machine learning techniques were applied to achieve accurate coin recognition. The project's core components include data preprocessing, feature extraction, feature selection, a chosen classification algorithm, and a user-friendly interface for input. The project resulted in a functional coin classification system that provides a valuable tool for numismatists, collectors, and automated vending machines. The methodology and results are documented in this report, offering a foundation for further developments in coin recognition technology. Future enhancements and refinements are discussed, which could potentially extend the system's capabilities and its practical utility in the field of coin classification and related applications.

1.Introduction

Coins are a fundamental form of currency used worldwide, and they often bear unique characteristics, such as denomination, design, and country of origin. The process of manually sorting and classifying coins can be time-consuming, error-prone, and subject to the limitations of human perception. To address these challenges, the field of computer vision and machine learning offers a promising solution – the automatic classification of coins.

The automatic classification of coins is a compelling application of image processing and machine learning techniques that aims to develop systems capable of identifying and categorizing coins based on their visual attributes. These attributes may include characteristics such as size, shape, color, design details, and other distinctive features.

2.Related Works

- Automatic Coin Classification, an automatic system which classifies coins is presented and discussed. The system is flexible, being able to identify coins with various appearances and photographed in different light conditions. For this purpose, a set of robust techniques for thresholding, edge detection and frequency transform were employed in order to generate a fingerprint as significant as possible and as invariant as possible for every coin class.

Link: https://www.researchgate.net/publication/263541744_Automatic_Coin_Classification

-Image Processing Based Systems and Techniques for the Recognition of Ancient and Modern Coins, Coins are frequently used in everyday life at various places like in banks, grocery stores, supermarkets, automated weighing machines, vending machines etc. So, there is a basic need to automate the counting and sorting of coins. For these machines need to recognize the coins very fast and accurately, as further transaction processing depends on this recognition. Three types of systems are available in the market: Mechanical method-based systems, Electromagnetic method-based systems and Image processing-based systems. This paper presents an overview of available systems and techniques based on image processing to recognize ancient and modern coins.

Link:

https://citeseerx.ist.psu.edu/viewdoc/download;jsessionid=2837BF6237EFF8D57BA0CE5%203FC579B8F?doi=10.1.1.258.8676&rep=rep1&type=pdf

- Classification of Ancient Roman Coins by Denomination Using Colour, a Forgotten Feature in Automatic Ancient Coin Analysis by Yuanyuan Ma and Ognjen Arandjelović, * ancient numismatics, the study of ancient currencies such as coins, has recently gained increased interest in the application of computer vision and machine learning techniques. However, despite various methodological approaches and research articles on the subject, there has been a notable oversight in the use of color. Most research has exclusively focused on grayscale images of coins. This article challenges this conventional approach and suggests that color should not be ignored.

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Link: https://doi.org/10.3390/sci2020037 **or** https://www.mdpi.com/733422

- Deep ancient Roman Republican coin classification via feature fusion and attention, the study focuses on classifying ancient Roman Republican coins based on their reverse motifs, which depict various objects, faces, scenes, animals, and buildings along with legends. These coins often suffer from erosion due to their age and preservation, making visual recognition challenging. Variations in the positions of key symbols on the reverse motifs and factors like in-plane orientations, uneven illumination, and background clutter further complicate the classification task.

To address these challenges, the authors introduce a novel network model called CoinNet. This model utilizes compact bilinear pooling, residual groups, and feature attention layers. The study includes a comprehensive dataset of over 18,000 images representing 228 different reverse motifs of Roman Republican coins. CoinNet achieves a remarkable classification accuracy of over 98% on this dataset, surpassing traditional bag-of-visual-words methods and recent deep learning techniques. The study also includes a detailed analysis of the network's architecture and its ability to generalize to various coin motifs.

Link: https://doi.org/10.1016/j.patcog.2021.107871

- Automatic Coin Classification and Identification, the study focuses on object recognition and classification, particularly in scenarios involving a large number of classes and the identification of highly similar individual objects. Real-world datasets were collected for both classification and identification tasks. In the classification task, the goal is to distinguish between hundreds of different classes of modern coins. For ancient coins, identification is the primary objective, with the unique appearance of individual hand-made coins allowing for this task. Modern coin classification is challenging due to the wear and abrasion that creates high intra-class variance and small inter-class differences. In contrast, the identification of ancient coins is made possible by the substantial intra-class variance.

Link: https://cdn.intechopen.com/pdfs/36682/InTech Automatic_coin_classification_and_identification.pdf

3.Dataset:

This dataset comprises a collection of 29,473 images of U.S. coins, covering 44 out of 77-coin categories.

The dataset is in its beta version and currently includes images of Jefferson Nickels (1938-Date), Lincoln Cents (1909-Date), and Washington Quarters (1932-1998). The images are collected (mostly web scrapping) from various sources and can be used for numismatic analysis, coin recognition, and machine learning tasks. The dataset will be updated periodically with more coin images to expand the coverage of different U.S. coin categories. The images are in various resolutions. The dataset can serve as a valuable resource for researchers, coin collectors, and machine learning practitioners interested in U.S. coins. We will take 20% of the total number of coin images place them into the test set, leaving the rest 80% for the training set. Which leaves us with 3,000 drawing in total for the training and 750 for the testing.

Link: https://www.kaggle.com/datasets/sergiosaharovskiy/uscoins/data

Samples:

Figure 1

Figure 2

Figure 3

4. Methodology

1) Data Collection

- Gather a dataset of images representing the objects you want to classify. For example, if you're working with coins, collect a diverse set of images of different types of coins.

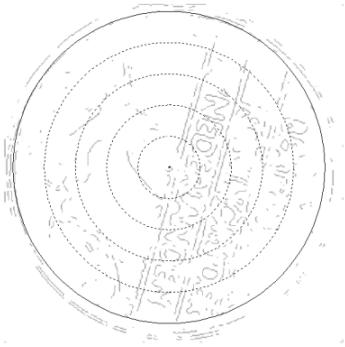
2) Data Preprocessing

- Resize all images to a consistent dimension, such as 100x100 pixels.
- Convert the images to grayscale to reduce computational complexity.
- Normalize pixel values to a common scale (e.g., 0 to 1).

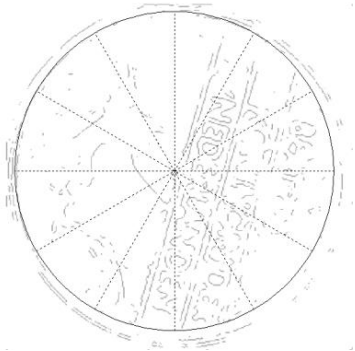
3) Feature Extraction

- Extract features from the preprocessed images.
- Histograms: Calculate histograms of pixel intensity values.
- Features: the chosen method in his project for feature extraction is **Color Histograms**. A color histogram represents the distribution of pixel intensities in different color channels (e.g., Red, Green, Blue).

Other methods: Edge Detection, that apply edge detection algorithms to find contours and edges (e.g., Distance distribution, Angle distribution).



Distance distribution



Angle distribution

4) Feature Selection

- Choose a subset of the most relevant features. Feature selection is essential to reduce dimensionality and improve classification performance.

5) Classification Algorithm

- **Random Forest:** is an ensemble learning method that constructs a multitude of decision trees during training and outputs the class that is the mode of the classes (classification) of the individual trees.

In this specific context, the Random Forest is being used to train a machine learning model for the task of coin classification based on features extracted from coin images. The 'RandomForestClassifier' is chosen for its ability to handle complex relationships in the data and its robustness against overfitting.

6) Training and Testing

- Split your dataset into training and testing sets (e.g., 80% training, 20% testing).
- Train your selected classification algorithm on the training data using the extracted and selected features.
- Evaluate the model's performance on the testing dataset using metrics like accuracy, precision, recall, and F1 score.

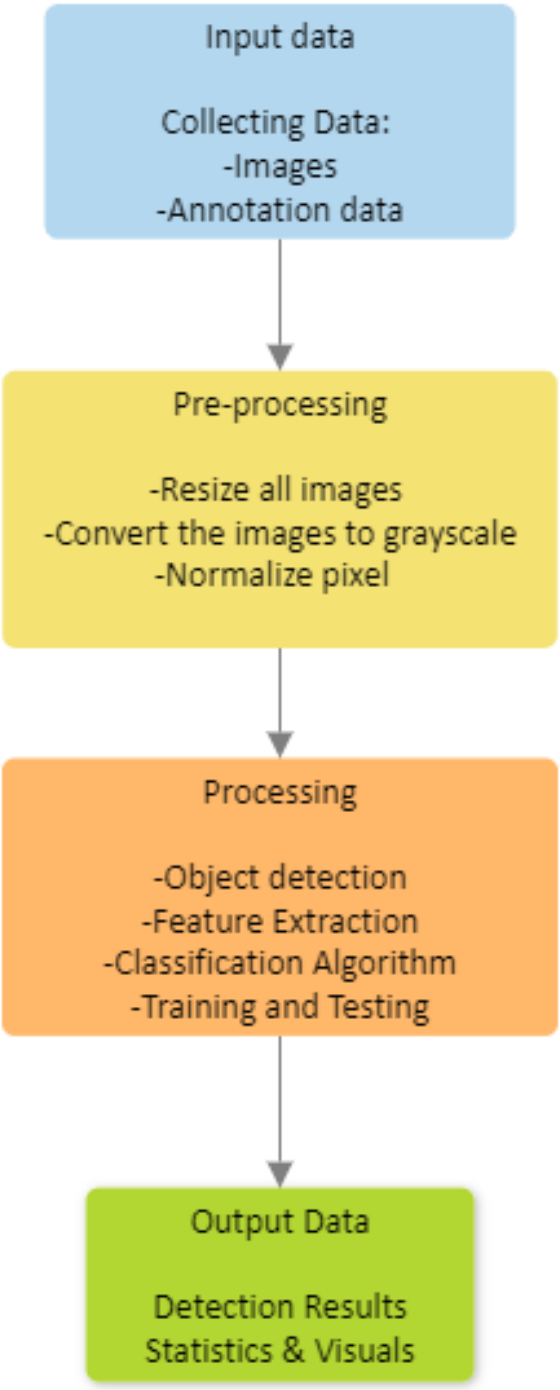
7) Model Refinement

- Adjust the model parameters or feature selection as needed to improve classification performance.

8) Testing and Validation

- Test the system with real-world images to ensure it performs well under various conditions. Collect user feedback and make improvements as necessary.

System Overview



5. Conclusion

The "Automatic Coin Classification" system offers a user-friendly, non-deep learning approach to classify and identify coins. By leveraging Naive Bayes and traditional computer vision techniques, it provides an accessible solution for numismatists and coin enthusiasts. The system's performance and ease of use make it a valuable tool for the coin classification domain.