Coin Classification

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Abstract:
This project aims to create a machine capable of collecting, identifying, and sorting US coins based on their denomination, series, and coinage year. The extracted data can be compared to existing information in online coin marketplaces to determine the coins' value. To achieve this goal, a coin scanning and sorting machine is designed using CAD tools and 3D printed parts. The machine uses a camera to scan the coins and sort them into corresponding storage boxes based on their denomination. Once sorted, the scanned images are transferred to a computer and analyzed using MATLAB and OpenCV algorithms such as Canny Edge Detector and Orientated FAST and Rotated BRIEF to extract the intended parameters.

Background information:

- Coins have a rich history dating back to the 6th century BCE with millions of unique coins circulating worldwide.
- The diversity of coins has sparked interest in collecting, regardless of face value, making numismatics one of the most popular types of collecting.
- Identifying valuable coins is challenging due to the vast array and abundance of coins, particularly for those without extensive knowledge.

Fig 1. Coins in Anatolia in 4th century BCE

Fig 2. Saint-Gaudens Double Eagle ($20,165,000 in 2022)

Coin Grading and Pricing:

- Coin grading is currently carried out by intermediary institutions that provide collectors with a certificate specifying their features.
- The price of the coin is then determined by the current marketplace that can be monitored through websites, magazines and auctions.
- This process can be slow and expensive, particularly if the coin is not of significant value.

Problem Statement:

Given the concerns raised regarding numismatics and the potential value of rare coins, a key question arises: How can individuals effectively sort and determine the value of their coins? To address this question, a system must be designed that improves the coin identification and valuation process for collectors and enthusiasts, making it faster and more accessible without compromising accuracy. To achieve this, it is essential to identify the parameters that are significant for distinguishing each coin from others, understand how these parameters affect the coin's value for collectors, and develop methods for extracting this information from the coin itself.

Design Goals:

- **Accuracy:** the machine should be able to correctly identify coins and make accurate predictions about their prices.
- **Usability:** the device should be easy to use, with a minimal learning curve.
- **Reliability**: the machine should be capable of operating in a wide range of conditions.
- **Portability:** the device should have a small and compact design, making it easy to carry in a regular school backpack.
- **Cost:** the device should be reasonably priced, ideally costing a few hundred dollars or less

Mechanical Design

- **Camera Chamber:** a single Pi camera captures both sides of the coin and sends images to the processing software for identification.
- **Microprocessor:** This is where the microprocessor is housed and connected to various components, including LED lights, cameras, breadboard, and servos.
- **Support Frame:** supports ramps and linear servo that releases the coin from the chamber and ensures it follows a linear path.
- **Sorting and Storage:** coins are held in cylindrical containers, with the last one serving as a rejection location for unidentified coins that slide down the ramp.

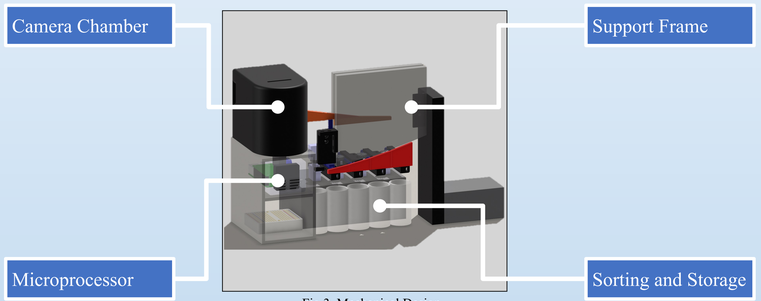


Fig 3. Mechanical Design

Bill of Materials:

We have utilized both library resources and scraps from the lab to 3D print materials that are not listed in the table.

Pi camera module v2
Raspberry Pi 2
Breadboard
MG 996R Servo
100mm arm
Clear Plastic Sheets
Pinion Gear
9G Servo
Coin Storage Tubes

Table 1. BOM

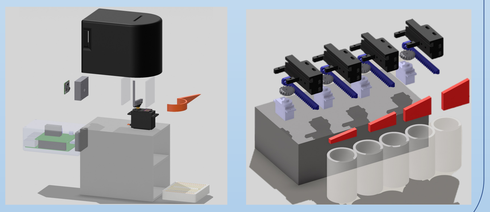


Fig 4. Exploded view of key components

Testing and Image Collection:

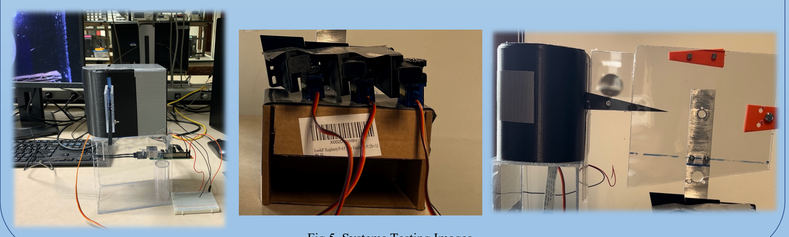
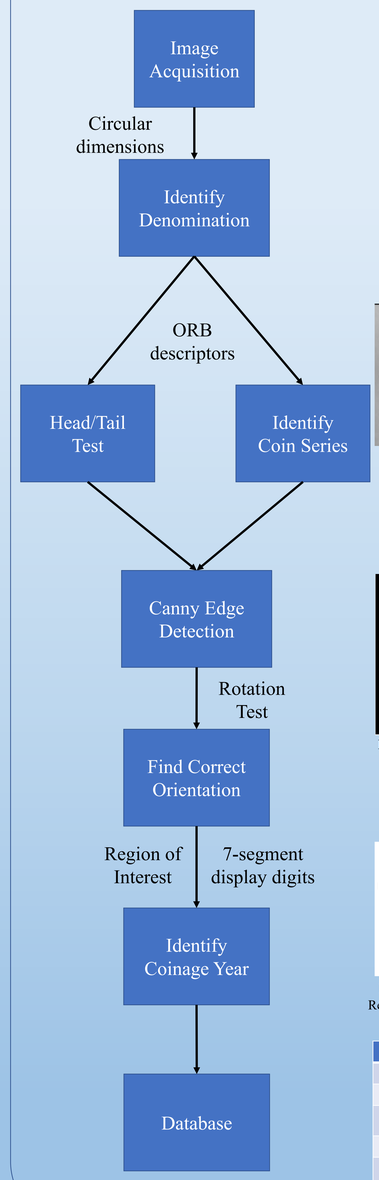


Fig 5. Systems Testing Images

Image Processing:



Circle Detection

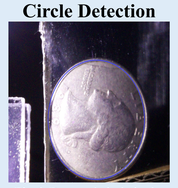


Fig 6. Detected circle in the scanned image

Oriented FAST and Rotated BRIEF

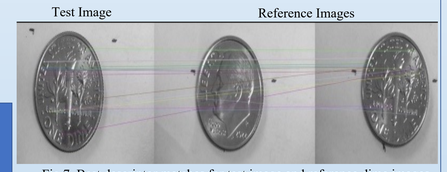


Fig 7. Best descriptor matches for test image and reference dime images for both sides

Edge Detection

Fig 8. Head Side Image of a US Penny

Fig 9. Edge Detected Version of a US Penny

Optical Character Recognition

Fig 10. Seven Segment Representation of Numbers

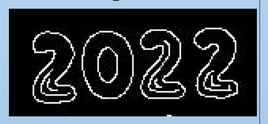


Fig 11. Extracted Region of Interest for coinage year

Filename	Denomination	Side	Series	Year
penny1a	penny	head	Lincoln	2001
penny1b	penny	tail	Memorial	2001
⋮	⋮	⋮	⋮	⋮
quarter15a	quarter	tail	Bald Eagle	1973
quarter15b	quarter	head	Liberty	1973

Table 2. Database format

References:
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3. Pan, X., & Tougne, L. (2018). Image analysis and deep learning for aiding professional coin grading. In R. Su (Ed.), *2018 International Conference on Image and Video Processing, and Artificial Intelligence* (p. 18). SPIE.
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5. Gonzalez, R. C., Woods, R. E., & Eddins, S. L. (2020). *Digital image processing using MATLAB* (Third edition). Gatesmark Publishing.

Acknowledgment:
- Andrew Musulin
- Trinity College Engineering Department
- Student Technology Assistant Desk