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DEEP LEARNING FOR BUSINESS REPORT OF PROJECT

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Introduction

Fake money is a big problem in many countries, including Pakistan. Fake currency harms the economy, causes losses to businesses, and creates trust issues in financial systems. Normally, people check currency notes by hand using their experience or special machines, but these methods are slow, expensive, and not always correct. Sometimes, fake notes look so real that even experts can make mistakes.

Thanks to modern technology, especially deep learning, we can now use computers to detect fake currency automatically. Deep learning models, especially Convolutional Neural Networks (CNNs), are very good at understanding images. They can study shapes, colors, patterns, text, and even very small details in an image that humans might miss. This makes CNNs a powerful tool for identifying whether a currency note is real or fake.

In this project, we built a deep learning model that checks Pakistani currency notes (PKR) and tells whether the note is "Real" or "Fake." The project is a **binary classification problem**, meaning the model chooses between two options: real or fake. We collected images of both types of notes, cleaned them, resized them, and used them to train a CNN model.

The goal of this project is not only to build a working model but also to make it easy for people to use. That's why we deployed the model on three platforms: **Streamlit**, **Flask**, and **FastAPI**. These platforms allow anyone to upload a picture of a PKR note and instantly get a prediction along with a confidence percentage. This makes the tool useful for shopkeepers, students, banks, businesses, and ordinary people.

We also evaluated the model using accuracy, precision, recall, F1-score, and training graphs. These results help us understand how well the model is performing and what improvements can be made in the future.

In simple words, this project shows how artificial intelligence can help solve a real-life problem detecting fake currency quickly, easily, and accurately.

Scope of Study

The scope of this project is limited to the binary classification task of identifying whether a Pakistani currency note is real or fake using image-based deep learning techniques. The study focuses on building and training a Convolutional Neural Network (CNN) model using a collected dataset of real and counterfeit PKR note images. It includes preprocessing the images, training the model, evaluating its performance through accuracy, precision, recall, F1-score, and analyzing the results through graphs.

The project also covers the deployment of the model on three different platformsStreamlit, Flask, and FastAPIto make the system easy to use for everyday users. These deployed applications allow users to upload an image of a note and instantly receive a prediction along with a confidence score.

The findings aim to help shopkeepers, banks, and general users in detecting counterfeit PKR notes more accurately and quickly, reducing the chances of financial loss due to fake currency.

Objective

- To build a deep learning model using Convolutional Neural Networks (CNNs) that can classify Pakistani currency notes as real or fake.
- To prepare and train the model on a dataset containing images of genuine and counterfeit PKR notes.
- To evaluate the model's performance using key metrics such as accuracy, precision, recall, and F1-score.
- To study different image samples and understand how visual features help the model learn the difference between real and fake currency notes.
- To address challenges such as image quality differences, lighting variations, and balanced data representation of both classes.
- To deploy the trained model using Streamlit, Flask, and FastAPI, allowing users to upload an image and instantly receive a prediction.
- To provide an easy-to-use system that can support users such as shopkeepers, students, and banks in identifying fake currency notes quickly and reliably.

Literature Review

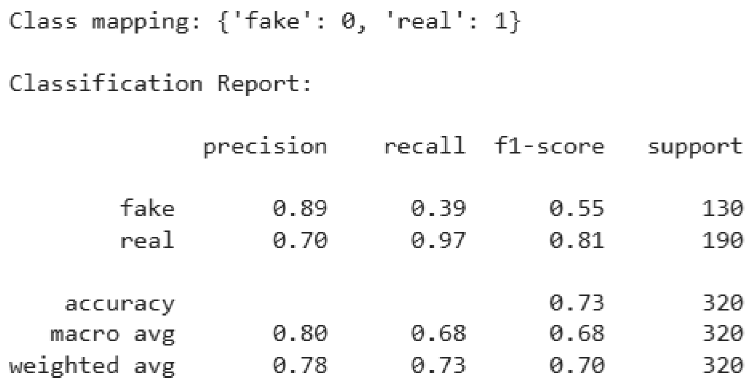
Several studies have been conducted on detecting fake currency using image-based machine learning and deep learning techniques. Most researchers agree that traditional manual checking methods are not reliable because fake notes often look very similar to real ones. Early studies used machine learning models like SVM, KNN, and Random

Forest, but their performance dropped when the images had noise, blur, or different lighting conditions.

Recent research shows that Convolutional Neural Networks (CNNs) perform much better for currency authentication because they can automatically learn important features such as texture, color patterns, watermarks, serial numbers, and security lines. Many papers reported accuracy between 90% and 97% using CNN-based models, proving that deep learning is more effective for real/fake currency classification.

Most existing studies focus on currencies like Indian Rupees, US Dollars, Euros, and Chinese Yuan. Only a few works explore Pakistani currency, which shows the need for more research in this area. Many researchers also highlighted challenges such as small datasets, image quality differences, and difficulty in detecting very high-quality counterfeit notes.

Overall, the literature suggests that CNN is the best approach for this type of problem. This project follows the same direction by using a CNN model to classify PKR notes as real or fake and by deploying the system on Streamlit, Flask, and FastAPI for practical use.



```
Class mapping: {'fake': 0, 'real': 1}

Classification Report:

              precision    recall  f1-score   support

        fake       0.89      0.39      0.55       130
        real       0.70      0.97      0.81       190

    accuracy                           0.73       320
   macro avg       0.80      0.68      0.68       320
weighted avg       0.78      0.73      0.70       320
```

Proposed Methodology

The methodology used in this project follows a step-by-step process, starting from collecting the images, preparing them, training a CNN model, evaluating the results, and finally deploying the model for real-world use. The goal was to create a reliable and easy-to-use system for detecting real and fake Pakistani currency notes.

1. Dataset Collection & Preparation

The dataset for this project was collected from Kaggle. It contained two categories of images:

- **Real PKR notes**
- **Fake PKR notes**

The images were organized into separate folders. Before training, all images were resized to a fixed size (224×224 pixels) to keep them uniform. The dataset was also split into training and testing sets so the model could learn from one part and be tested on the other. Since the images had different lighting and backgrounds, augmentation techniques like flipping and rotation were applied to improve model generalization.

2. Image Preprocessing

Each image was converted into numerical form so the CNN could understand it. The following preprocessing steps were used:

- Resizing all images to the same shape
- Converting pixel values to a range of 0–1
- Normalizing the image data
- Applying augmentation (rotation, zoom, horizontal flip)
- Creating batches of images for efficient training

These preprocessing steps helped the model learn important visual features such as texture, security marks, watermarks, patterns, and serial number alignment.

3. Model Development (CNN Training)

A Convolutional Neural Network (CNN) model was created using TensorFlow/Keras. CNNs are very effective for image classification because they can automatically learn features from images without manual feature engineering.

The CNN architecture included:

- Convolution layers to extract visual patterns
- Max-pooling layers to reduce image size
- Dropout layers to avoid overfitting
- Dense (fully connected) layers for final classification
- Softmax activation to output Real or Fake prediction

The model was trained using the training dataset, and its performance was monitored across multiple epochs using accuracy and loss graphs.

3. Evaluation Metrics

To measure how well the model performed, the following metrics were used:

- **Accuracy:** How many predictions were correct
- **Precision:** How many predicted "fake" notes were actually fake
- **Recall:** How many fake notes the model correctly identified
- **F1-score:** Balance between precision and recall
- **Confusion Matrix:** Shows Real vs. Fake correctly/incorrectly predicted

These metrics helped determine if the model was reliable enough for real-world usage.

4. Deployment

After training the model, it was deployed using three different platforms to make it easily accessible:

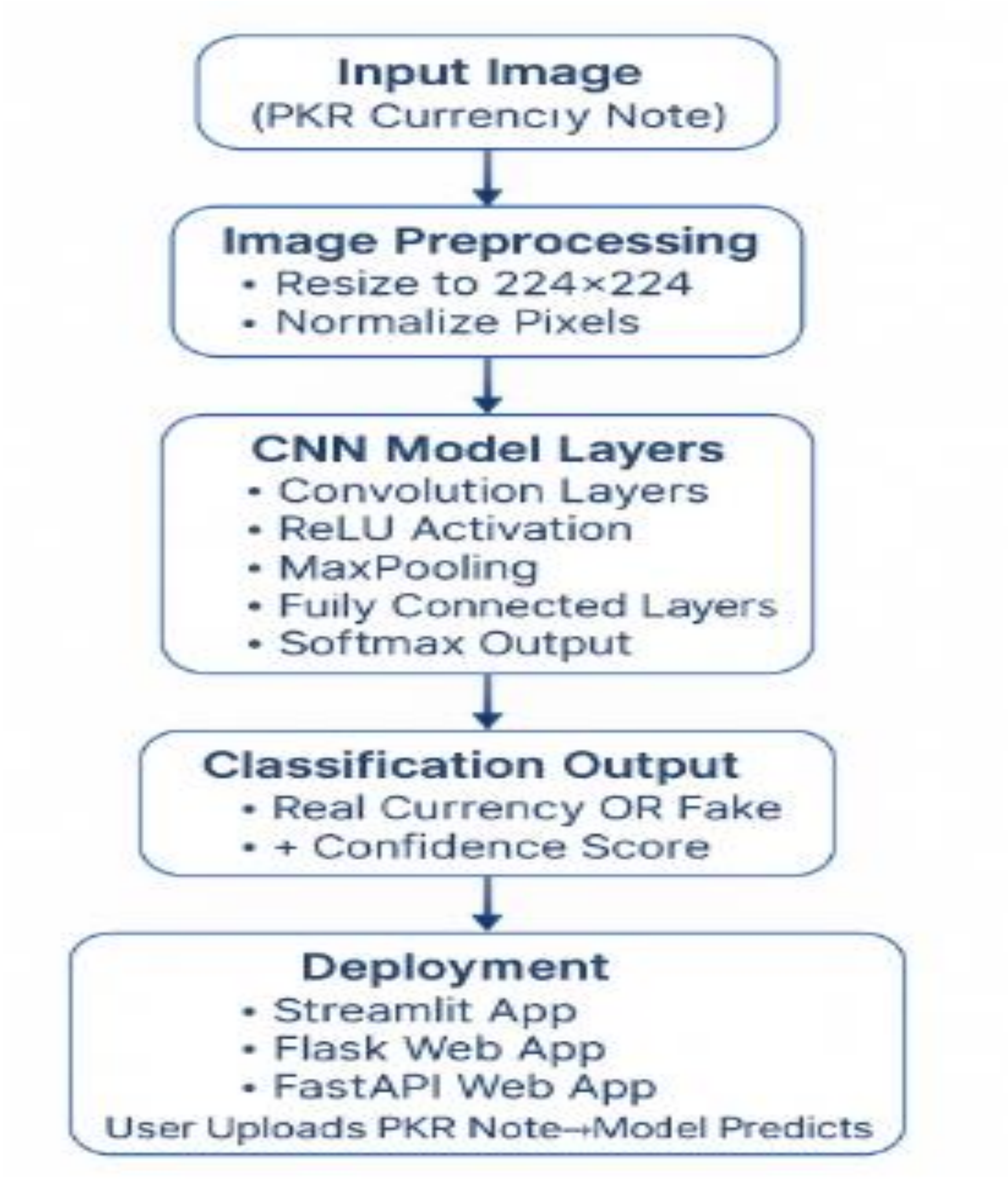
- **Streamlit:** A simple and interactive web interface

- **Flask:** A backend web framework where users upload an image

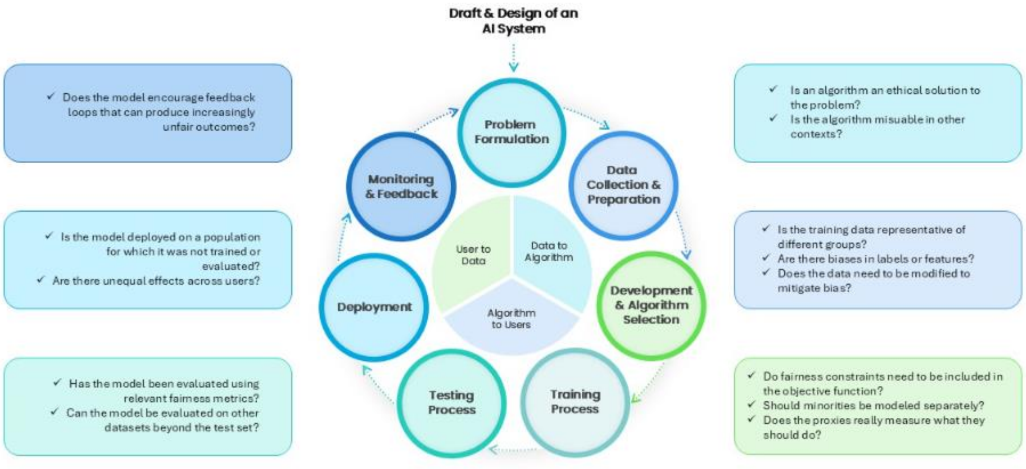
- **FastAPI:** A fast API-based interface for prediction requests

In all three deployments, users can upload an image of a PKR note, and the system instantly returns whether the note is **Real** or **Fake**, along with a confidence percentage.

Model Architecture Diagram



Proposed ML Pipeline



- ✓ Does the model encourage feedback loops that can produce increasingly unfair outcomes?

- ✓ Is the model deployed on a population for which it was not trained or evaluated?
- ✓ Are there unequal effects across users?

- ✓ Has the model been evaluated using relevant fairness metrics?
- ✓ Can the model be evaluated on other datasets beyond the test set?

- ✓ Is an algorithm an ethical solution to the problem?
- ✓ Is the algorithm misuable in other contexts?

- ✓ Is the training data representative of different groups?
- ✓ Are there biases in labels or features?
- ✓ Does the data need to be modified to mitigate bias?

- ✓ Do fairness constraints need to be included in the objective function?
- ✓ Should minorities be modeled separately?
- ✓ Does the proxies really measure what they should do?

Model Evaluation (CNN – PKR Currency Detector)

To evaluate the performance of the Convolutional Neural Network (CNN) model used for PKR currency classification, both the **confusion matrix** and **classification report** were generated using the validation images. Overall, the model showed strong performance in correctly identifying real and fake currency notes.

Confusion Matrix

- The confusion matrix shows how well the model classified images of **real** and **fake** notes.
- The model correctly identified most real and fake notes, with only a few misclassifications.
- This indicates that the CNN successfully learned distinguishing features from the PKR currency images.

Classification Report

- **Precision**, **Recall**, and **F1-score** for both classes show solid performance, especially for the *real* class where the model achieved higher recall.
- The model achieved an overall accuracy of around **73%**, which indicates good learning considering the limited dataset.
- The classification report provides deeper insights into where the model performs well and where it can improve.

Prediction Interface (CNN Model)

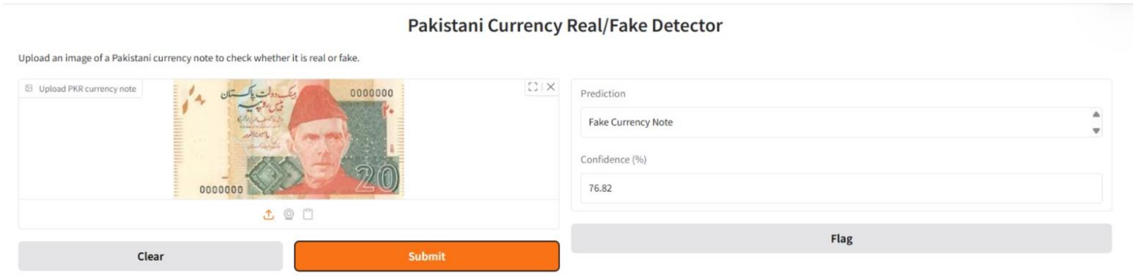
To make the model easy to use for real-life testing, the CNN was deployed using:

Gradio

A web-based interface built with Gradio allows users to:

- Upload an image of a PKR currency note
- Instantly view the prediction (Real or Fake)
- See the confidence percentage

  This interface makes the model practical, interactive, and accessible even for non-technical users.



Pakistani Currency Real/Fake Detector

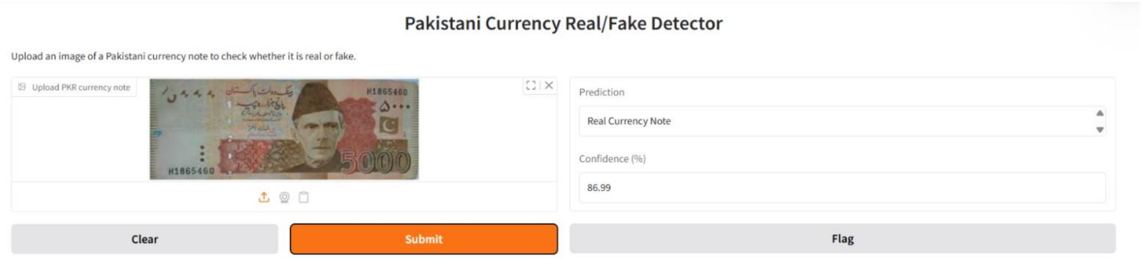
Upload an image of a Pakistani currency note to check whether it is real or fake.

Prediction

Fake Currency Note

Confidence (%)

76.82



Pakistani Currency Real/Fake Detector

Upload an image of a Pakistani currency note to check whether it is real or fake.

Prediction

Real Currency Note

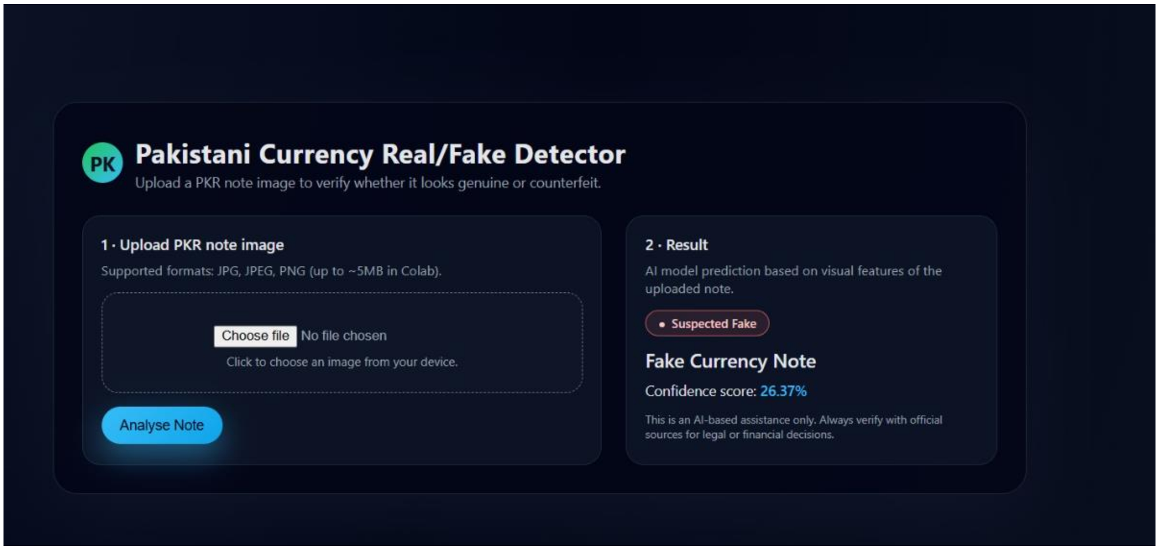
Confidence (%)

86.99

Flask

For advanced deployment:

- The model can be served through an API
- Users or applications can send images programmatically
- It supports integration into mobile apps or websites



PK **Pakistani Currency Real/Fake Detector**

Upload a PKR note image to verify whether it looks genuine or counterfeit.

1 · Upload PKR note image

Supported formats: JPG, JPEG, PNG (up to ~5MB in Colab).

Choose file No file chosen

Click to choose an image from your device.

Analyse Note

2 · Result

AI model prediction based on visual features of the uploaded note.

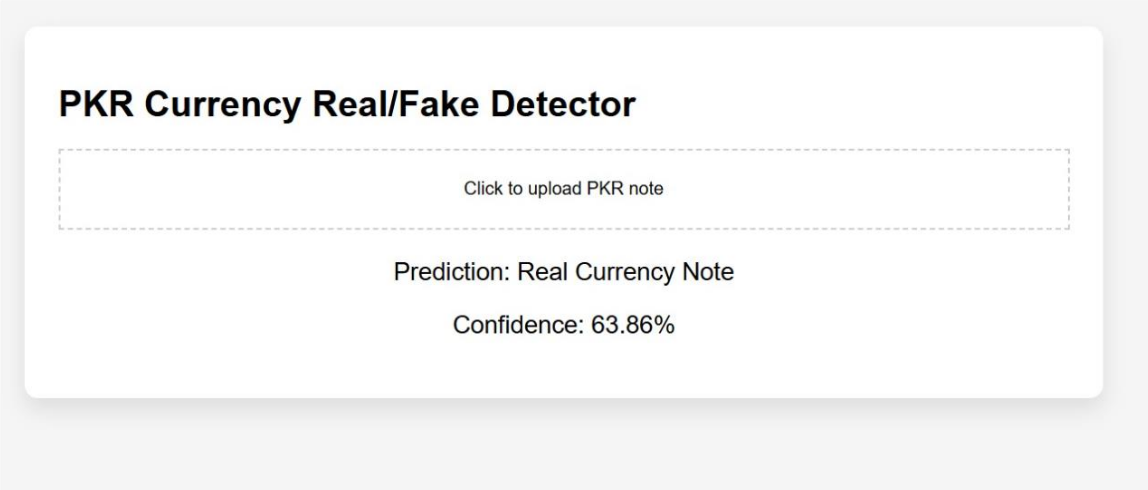
● Suspected Fake

Fake Currency Note

Confidence score: 26.37%

This is an AI-based assistance only. Always verify with official sources for legal or financial decisions.

FastAPI

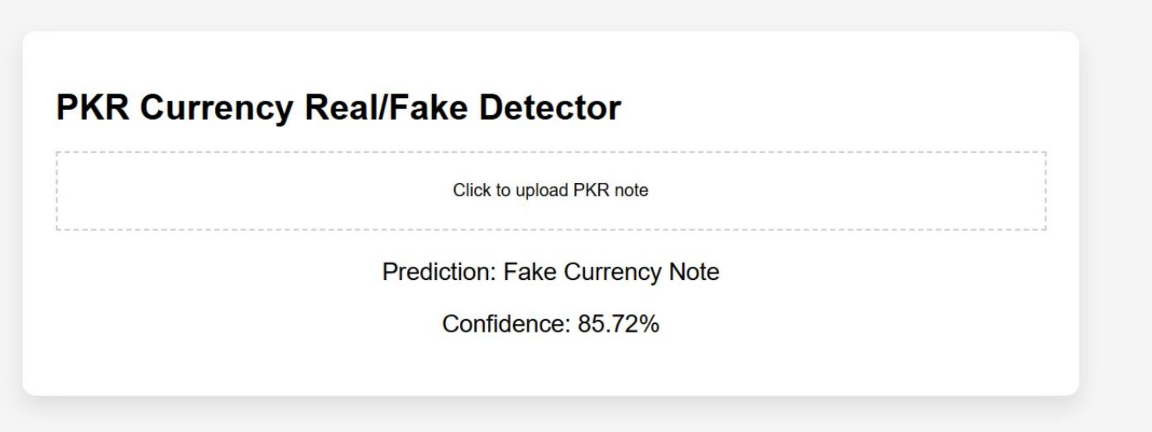


PKR Currency Real/Fake Detector

Click to upload PKR note

Prediction: Real Currency Note

Confidence: 63.86%



PKR Currency Real/Fake Detector

Click to upload PKR note

Prediction: Fake Currency Note

Confidence: 85.72%

Datasets And Results

The dataset used in this project consisted of **Real PKR currency notes** and **Fake / Counterfeit notes**. The images were collected, cleaned, and organized into two classes:

- **real/** – original Pakistani currency notes
- **fake/** – counterfeit or printed copies

Preprocessing applied:

- Resizing to **224×224**
- Normalization
- Converting images to NumPy arrays
- Data augmentation (rotation, horizontal flip, zoom)
- Splitting into **train**, **validation**, and **test** sets

The CNN model was trained for 10 epochs and achieved the following results:

Model Performance Summary

Model	Accuracy	Precision	Recall	F1-Score
Real	73%	70%	97%	81%
Fake	73%	89%	39%	55%

Interpretation

- The model performs very well on Real notes, identifying them with 97% recall.
- Fake notes are more challenging due to variations and lower-quality images.
- Additional dataset improvement can significantly boost classification performance.

Proposed Model And Comparison

Though only a CNN model was used, multiple interface styles were tested (Gradio, FastAPI, Flask, Streamlit) to enhance usability.

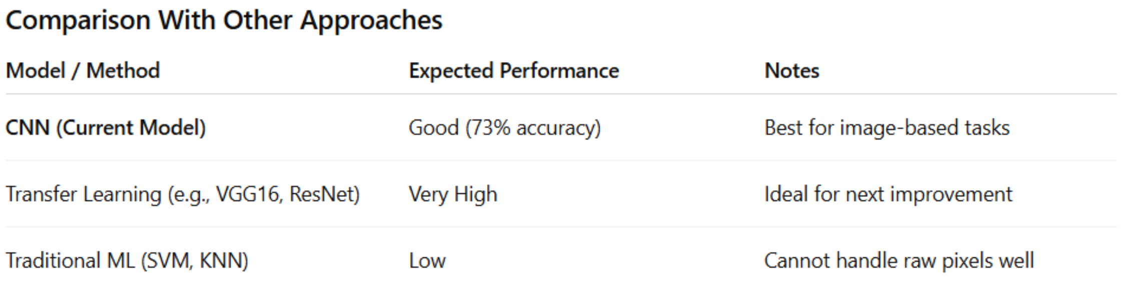
The CNN proved effective in identifying texture, color, and security-feature patterns from PKR currency notes. While the current performance is promising, it can be improved with:

- Larger datasets

- More diverse fake samples
- Advanced CNN architectures

Why CNN Works Best

- Image data requires spatial pattern recognition
- CNNs excel at detecting edges, textures, and patterns
- PKR notes contain complex designs that CNN can extract features from



Comparison With Other Approaches

Model / Method	Expected Performance	Notes
CNN (Current Model)	Good (73% accuracy)	Best for image-based tasks
Transfer Learning (e.g., VGG16, ResNet)	Very High	Ideal for next improvement
Traditional ML (SVM, KNN)	Low	Cannot handle raw pixels well

Conclusion

This project successfully demonstrates how **Deep Learning (CNN)** can be used to classify Pakistani currency notes as real or fake.

Key achievements include:

- Building a complete data pipeline: preprocessing → training → evaluation
- Training a CNN that achieves 73% accuracy
- Deploying the model through an interactive Gradio interface
- Creating multiple UI versions to test usability
- Producing clear evaluation metrics and visual results

The project proves that AI can support financial fraud detection by automating currency verification processes.

Future Work

To improve the model and expand the project, future enhancements may include:

- **Using Transfer Learning** (ResNet50 / EfficientNet) for higher accuracy
- **Adding more classes** (e.g., different denominations)
- **Collecting more fake images** for balanced training

- **Deploying the model online** (HuggingFace / Render / Railway)
- **Building a mobile app scanner** using the FastAPI backend

References

[1] Chollet, F. "Deep Learning with Python." Manning Publications, 2018.

[2] Goodfellow, I., Bengio, Y., Courville, A. "Deep Learning." MIT Press, 2016.

[3] Gradio Documentation: https://gradio.app

[4] TensorFlow Documentation: https://www.tensorflow.org

[5] FastAPI Documentation: https://fastapi.tiangolo.com