Department of Artificial Intelligence and Data Sciences

AI-Driven Document Intelligence: A Comprehensive Approach to Classification, Q&A Handling, and Fraud Detection

Submitted By: Group 1

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INTRODUCTION

With the growth in dependency on electronic verification systems used by both government and private organizations, there has been an increase in the usage of digitized manuscripts. This demands user-friendly and efficient document interaction tools.

Optimization of the document management process has become AI-driven with features like identity document classification, authenticity checking algorithms, and interactive question answering.

If we effectively identify the document type, we can streamline workflows and enable secure verification processes. The project employs Deep Learning techniques to classify documents like PAN cards, Aadhar cards, etc.

Additionally, we employ a Similar Document Template Matching Algorithm which can seamlessly extract features, match the template with a real document, and thereby detect fraud.

Furthermore, Large Language Models (LLMs) have been leveraged to enable interactive question answering over documents. Alongside these primary features, we have integrated additional functionalities such as paraphrasing, grammar checking, read aloud, and summarization. These enhancements aim to improve user interaction, making the system more versatile and accessible.

Experimental findings in our study showed the effectiveness of our work in improving efficiency, accuracy, and usability in document management.

LITERATURE REVIEW

REF NO	METHODOLOGY ADOPTED	RESEARCH GAPS	YEAR
01	CNN, VGG-16 and YOLO	Long training time and image-containing documents require feature extraction. Deep learning uses the image directly for classification but is time-consuming and requires hyperparameter tuning.	2021
02	OCR and Similarity Score	Only looks at only one saved sample to predict the outputs, can be made to predict based on all saved samples of the specific template to generalize better and improve overall accuracy	2019
03	OCR and SSIM	Concerns persist due to variations in document layouts, necessitating comprehensive labeled datasets, scalability for large data, and adaptability to real-world scenarios.	2023

REF NO	METHODOLOGY ADOPTED	RESEARCH GAP	YEAR
04	Closed-book Generation (T5) and (BART) Retrieval-augmented Generation(RAG) LLM-based Generation models (gpt-3.5-turbo-0613) and (LLaMA2-13B-Chat)	The study lacks a comparative analysis of the integrated UniGen framework against separate models for Generative Document Retrieval (GDR) and Grounded Answer Generation (GAR), hindering understanding of its comparative advantages.	2024
05	Automated question generation with human-guided templates.	ToolQA heavily relies on external tools for question answering, which could introduce biases or limitations based on the effectiveness and coverage of these tools.	2024

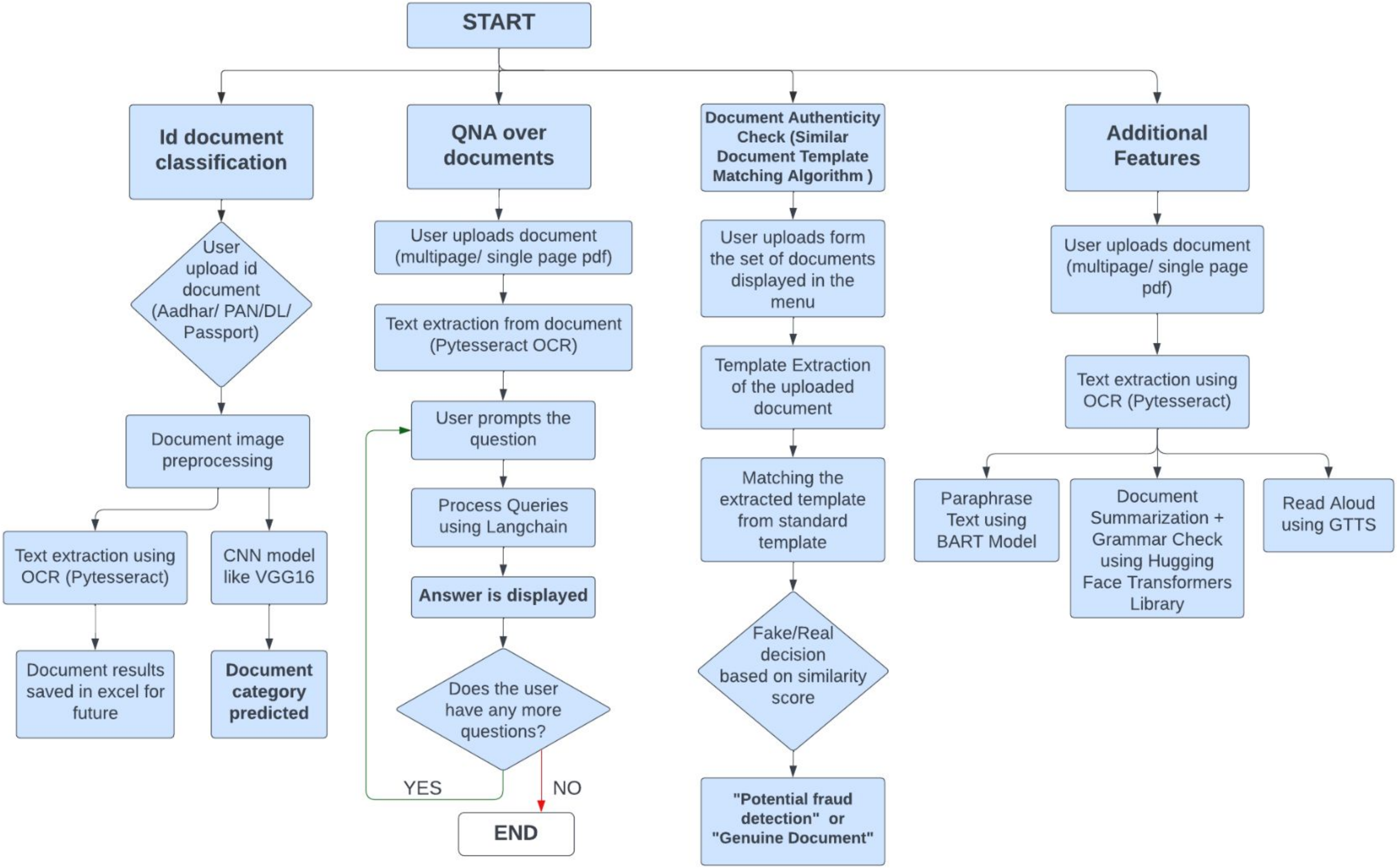
RESEARCH GAPS

1. **Integrated Technology Approach:**
   a. **Existing Gap**: Prior research often isolates document classification,OCR etc. Hence missing the synergy of combined technologies.
   b. **Our Contribution**: Seamlessly integrates classification, NLP, and speech synthesis etc for a unified solution.
2. **Robust Performance in Varied Conditions:**
   a. **Existing Gap**: Challenges in achieving consistent accuracy across different imaging conditions.
   b. **Our Contribution**: Employs advanced data augmentation and fine-tuning to ensure reliable classification and fraud detection in diverse environments and document types.
3. **Efficiency & Accuracy:**
   a. **Existing Gap**: Traditional CNN architectures, while powerful, are hampered by lengthy training times and intensive hyperparameter tuning when processing image-heavy documents.
   b. **Our Contribution**: Achieves an optimal balance between high accuracy and computational efficiency, leveraging pre-trained models.
4. **Integration Challenges in AI-Driven Q&A Systems:**
   a. **Existing Gap**: Recent tools are either too complex and resource-heavy or fail to connect information smoothly, making them inefficient for fast and large-scale applications.
   b. **Our Contribution**: Implements a streamlined, efficient Q&A system that balances resource usage with effective information retrieval, ensuring scalability and speed.

RESEARCH OBJECTIVES

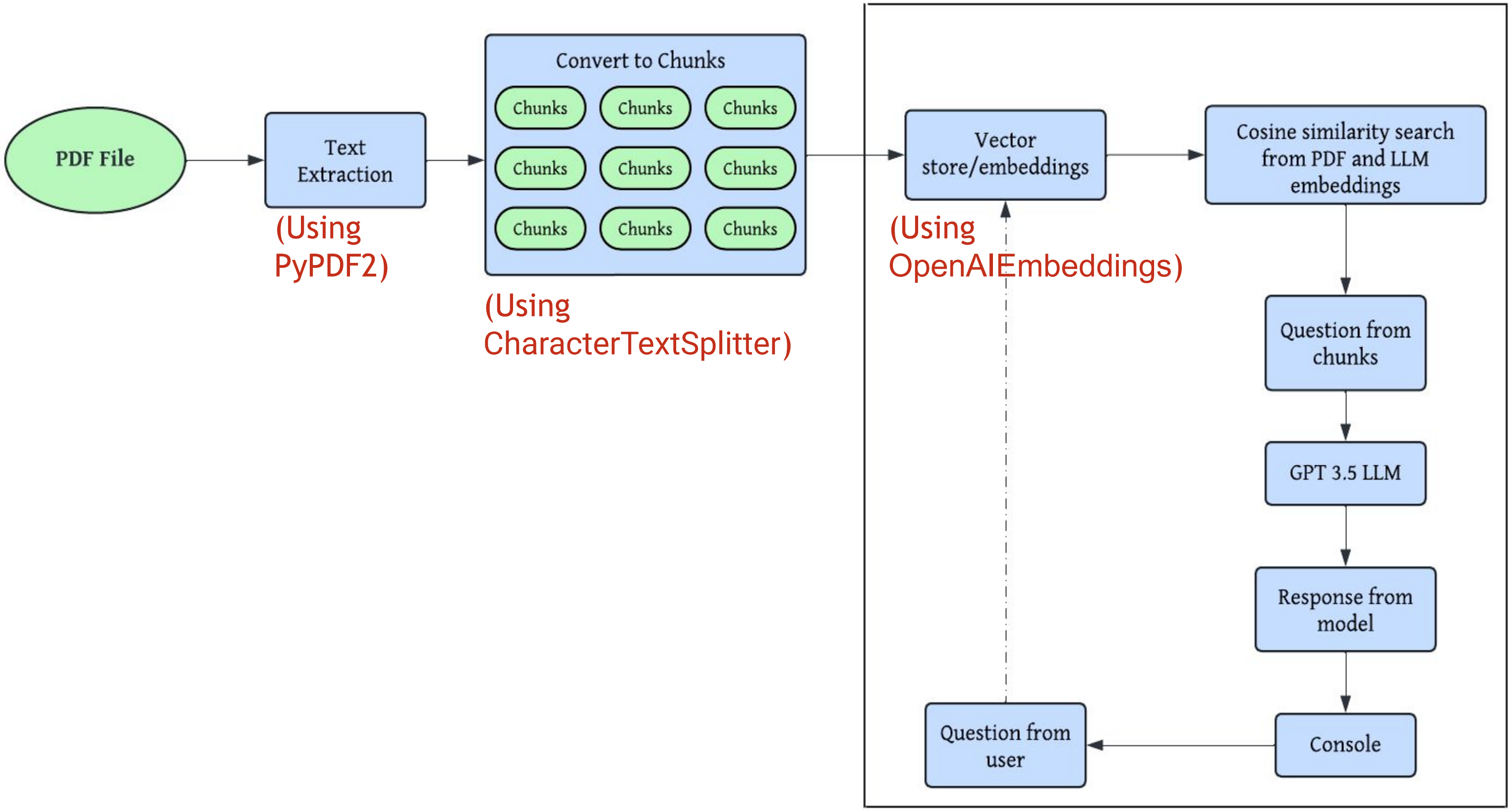
1. **Optimizing Architectures:**
   - Improve performance by modifying custom CNN architecture.
   - Evaluate the impact of pretrained models (e.g., VGG16, VGG19).
2. **Dataset Formulation:**
   - Utilize advanced data augmentation for robust classification model training.
   - Create test cases to detect subtle document fraud variations.
3. **Real-Time Document Processing:**
   - Develop efficient models for real-time classification, interactive query answering, and fraud detection.
4. **Efficient Information Retrieval Systems:**
   - Implement sophisticated question answering systems using NLP and semantic search for real-time information extraction from unstructured PDFs.
5. **Quality Fraud Detection Mechanisms:**
   - Create robust template matching algorithms with ORB feature descriptors to detect subtle identity document forgeries.
6. **Enhancement of Document Accessibility and Quality:**
   - Incorporate auxiliary features like text-to-speech, summarization, grammar checking, and paraphrasing to improve accessibility, comprehension, and quality.

PROPOSED METHODOLOGY


START
Id document classification
User upload id document (Aadhar/ PAN/DL/ Passport)
Document image preprocessing
Text extraction using OCR (Pytesseract)
CNN model like VGG16
Document results saved in excel for future
Document category predicted
QNA over documents
User uploads document (multipage/ single page pdf)
Text extraction from document (Pytesseract OCR)
User prompts the question
Process Queries using Langchain
Answer is displayed
Does the user have any more questions?
YES
NO
END
Document Authenticity Check (Similar Document Template Matching Algorithm)
User uploads form the set of documents displayed in the menu
Template Extraction of the uploaded document
Matching the extracted template from standard template
Fake/Real decision based on similarity score
"Potential fraud detection" or "Genuine Document"
Additional Features
User uploads document (multipage/ single page pdf)
Text extraction using OCR (Pytesseract)
Paraphrase Text using BART Model
Document Summarization + Grammar Check using Hugging Face Transformers Library
Read Aloud using GTTS

I) INTERACTIVE QUERY ANSWERING

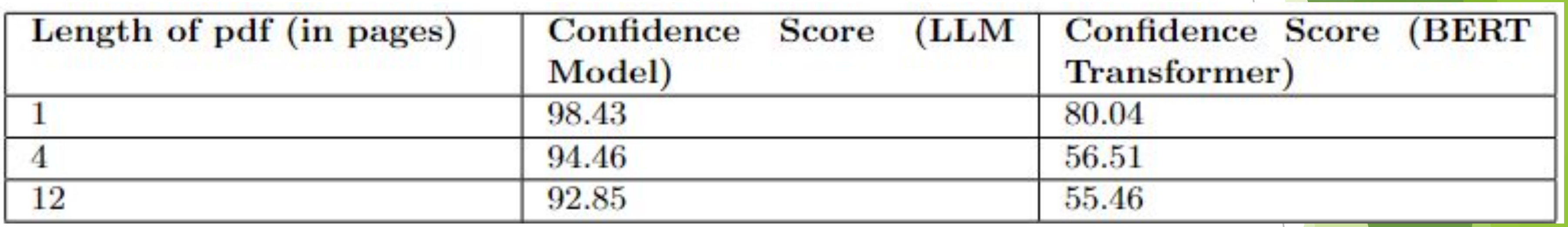
Leverages advanced Language Learning Models (LLMs) combined with OpenAI embeddings to iteratively extract and provide accurate answers from documents. This approach ensures enhanced context understanding and precise information retrieval, improving the overall efficiency and reliability of the QnA process



System Architecture of Interactive Query Answering

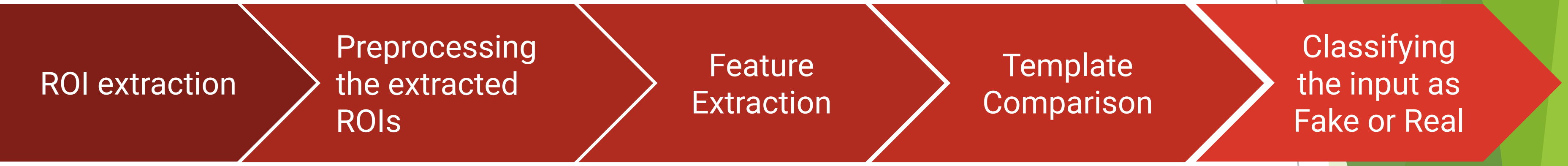
EXPERIMENTAL RESULTS

Comparison between LLM and BERT



Length of pdf (in pages)	Confidence Score (LLM Model)	Confidence Score (BERT Transformer)
1	98.43	80.04
4	94.46	56.51
12	92.85	55.46

II) SIMILAR TEMPLATE MATCHING ALGORITHM (Code)



ROI extraction

Preprocessing the extracted ROIs

Feature Extraction

Template Comparison

Classifying the input as Fake or Real

Identify crucial sections such as text blocks and image areas, that contain key information for analysis.

Enhance image quality by reducing noise and improving contrast to facilitate feature detection.

Detect unique & distinguishing features like edges, corners & contours from preprocessed ROIs

Compare extracted features with standard templates, accounting for minor variations.

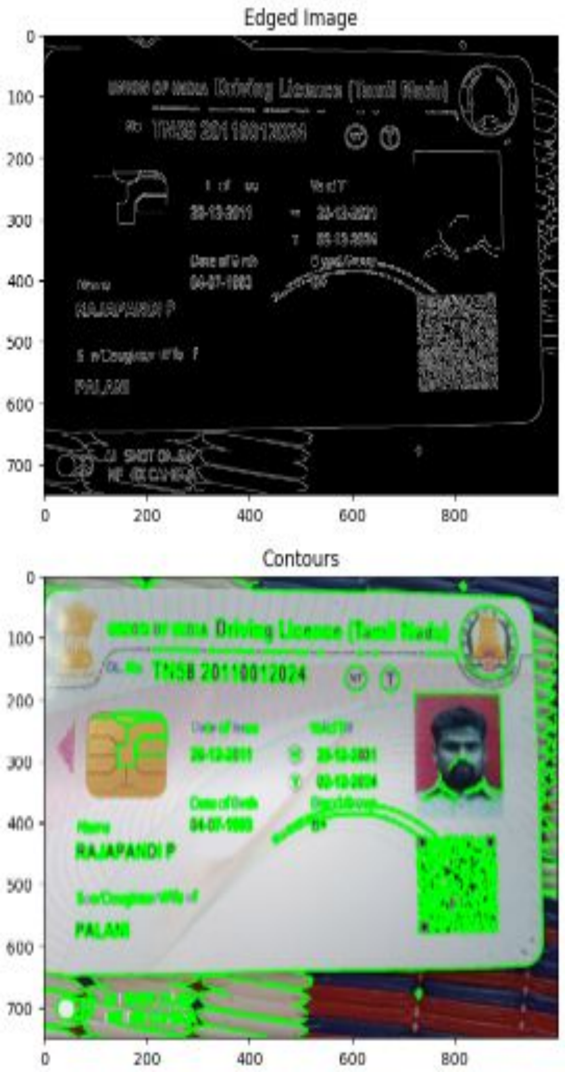
Determine if the document is "Fake" or "Real" based on similarity scores and thresholds.

Template Extraction

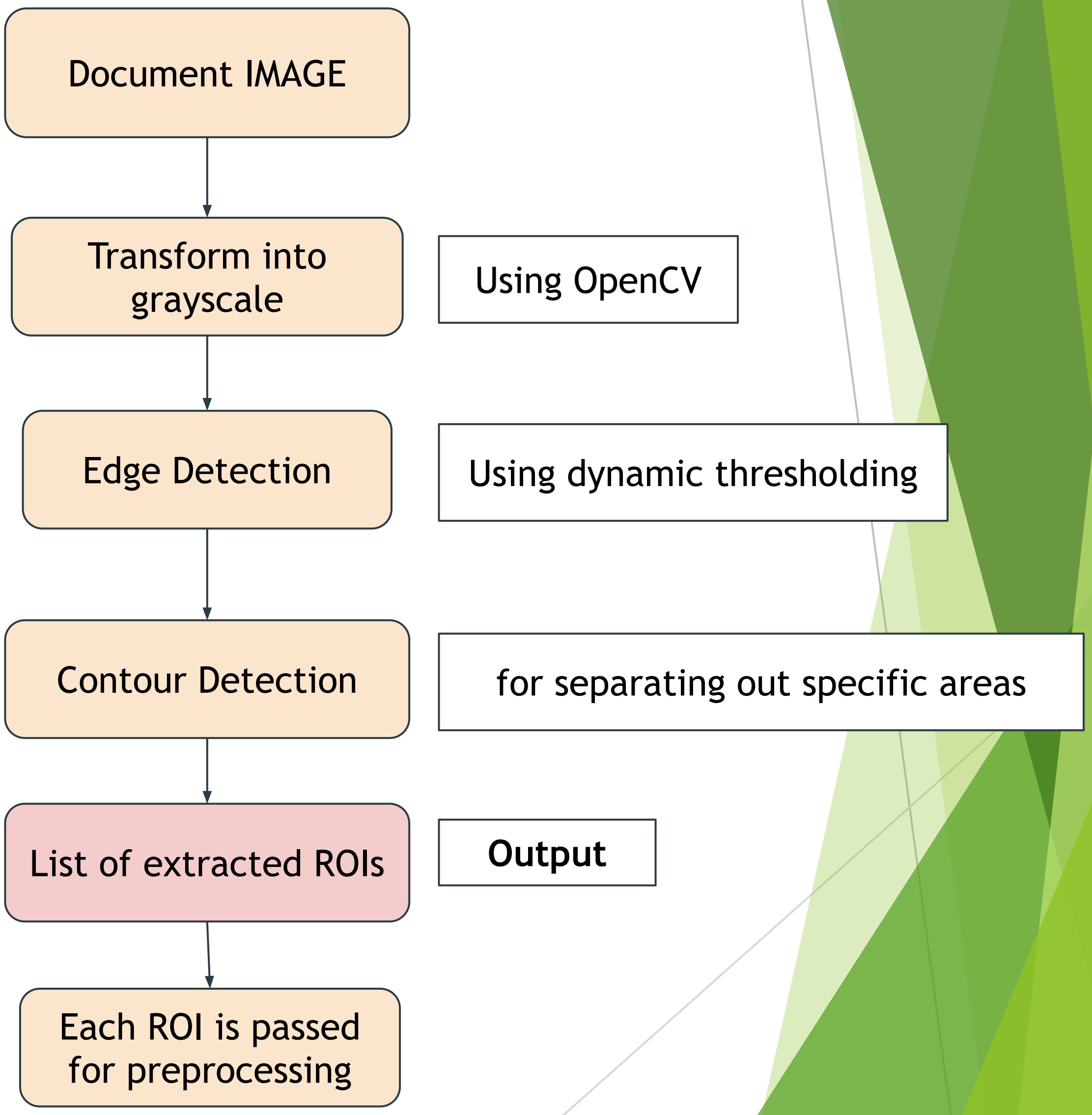
Template Matching

Fraud Detection

ROI extraction



Edge and Contour detection



Document IMAGE

Transform into grayscale

Using OpenCV

Edge Detection

Using dynamic thresholding

Contour Detection

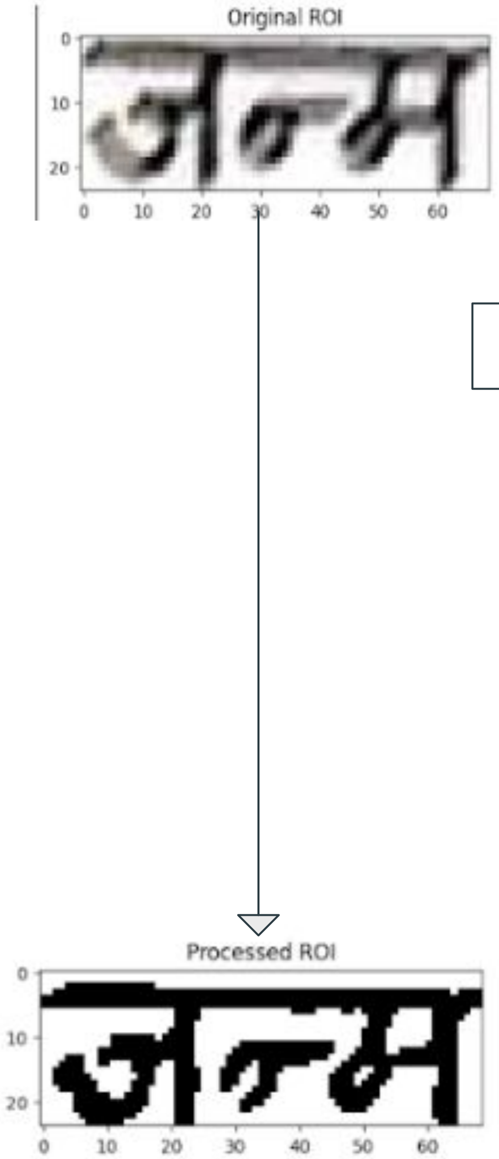
for separating out specific areas

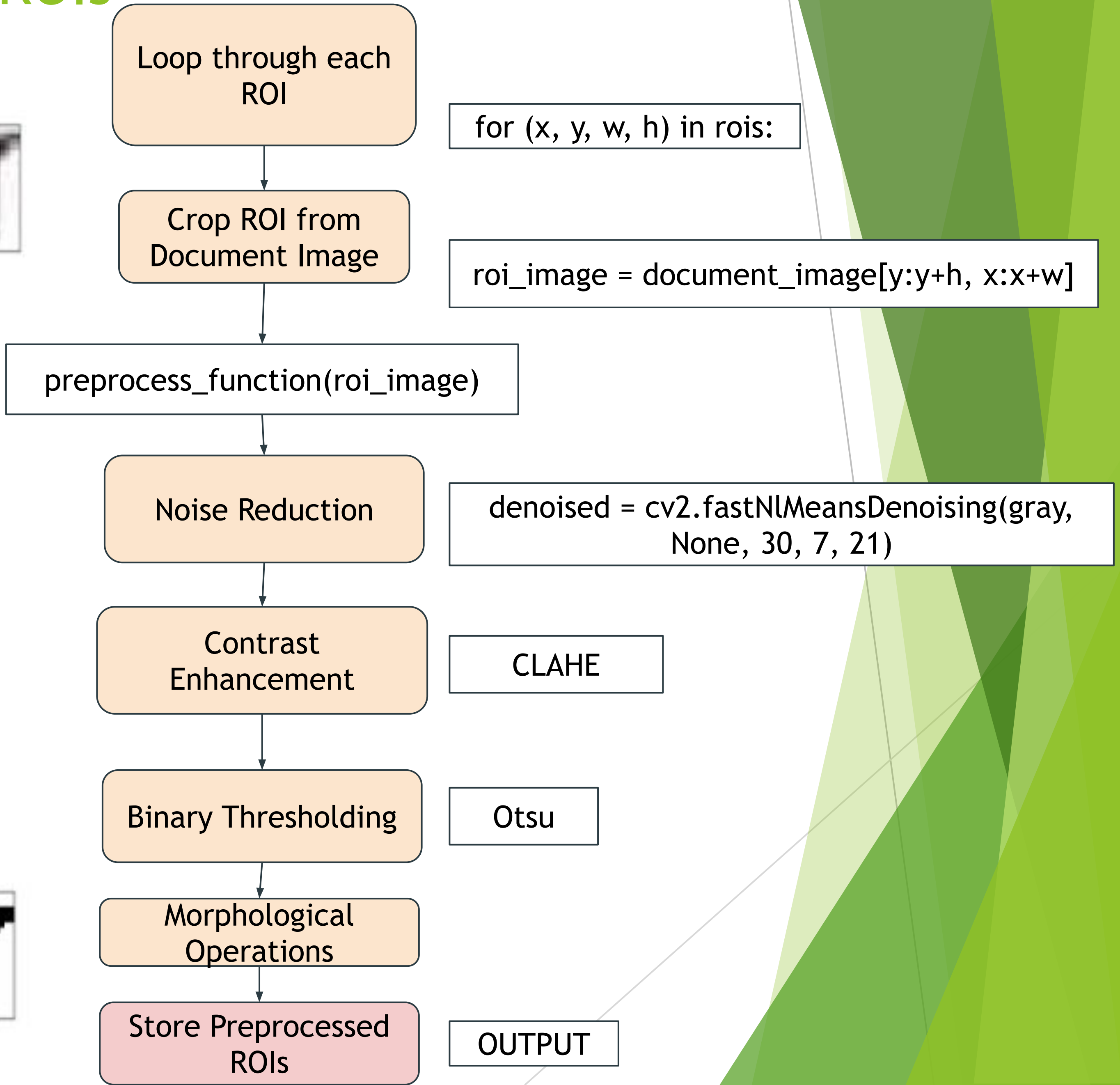
List of extracted ROIs

Output

Each ROI is passed for preprocessing

Preprocessing ROIs





Loop through each ROI

for (x, y, w, h) in rois:

Crop ROI from Document Image

roi_image = document_image[y:y+h, x:x+w]

preprocess_function(roi_image)

Noise Reduction

denoised = cv2.fastNlMeansDenoising(gray, None, 30, 7, 21)

Contrast Enhancement

CLAHE

Binary Thresholding

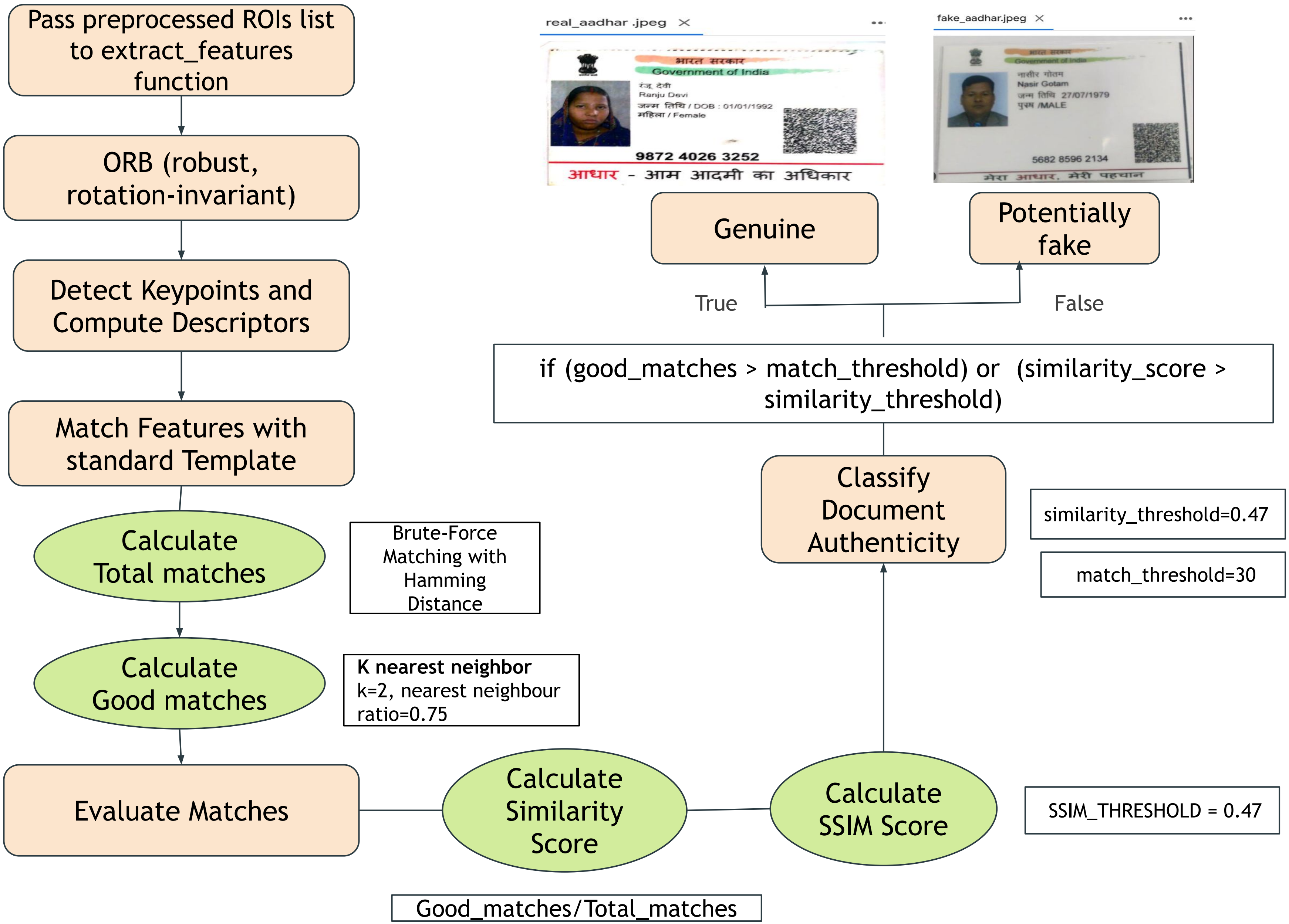
Otsu

Morphological Operations

Store Preprocessed ROIs

OUTPUT

Feature Extraction, Template Matching & Fraud Detection



Pass preprocessed ROIs list to extract_features function

ORB (robust, rotation-invariant)

Detect Keypoints and Compute Descriptors

Match Features with standard Template

Calculate Total matches

Brute-Force Matching with Hamming Distance

Calculate Good matches

K nearest neighbor
k=2, nearest neighbour ratio=0.75

Evaluate Matches

Calculate Similarity Score

Good_matches/Total_matches

Calculate SSIM Score

SSIM_THRESHOLD = 0.47

Classify Document Authenticity

similarity_threshold=0.47

match_threshold=30

if (good_matches > match_threshold) or (similarity_score > similarity_threshold)

True

Genuine

real_aadhar .jpeg

भारत सरकार
Government of India
रंजू देवी
Ranju Devi
जन्म तिथि / DOB : 01/01/1992
महिला / Female
9872 4026 3252
आधार - आम आदमी का अधिकार

False

Potentially fake

fake_aadhar.jpeg

भारत सरकार
Government of India
नासीर गोतम
Nasir Gotam
जन्म तिथि 27/07/1979
पुरुष /MALE
5682 8596 2134
मेरा आधार, मेरी पहचान

EXPERIMENTAL RESULTS

Analysis of Document Authenticity through Feature Matching and SSIM Evaluation

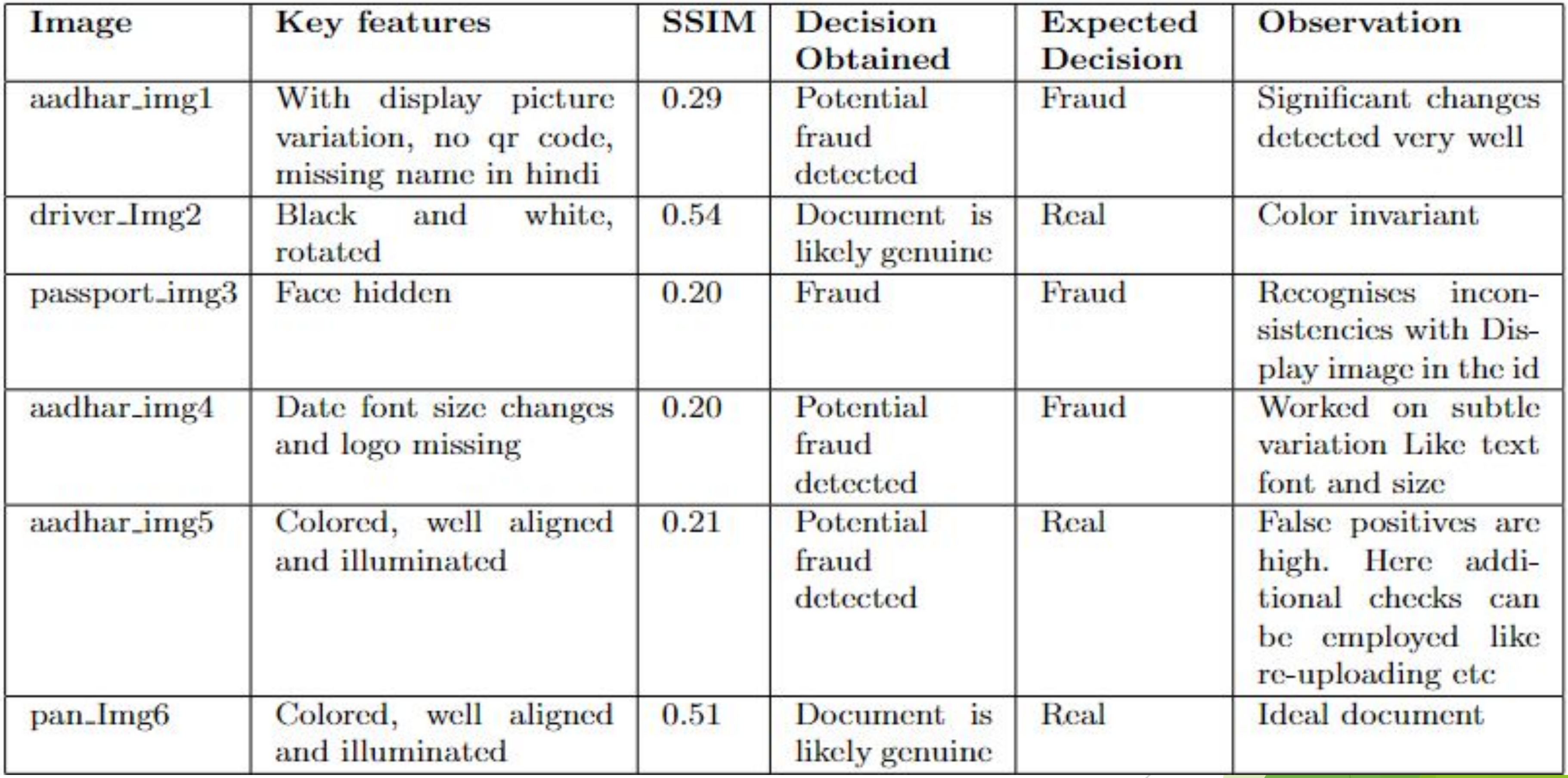


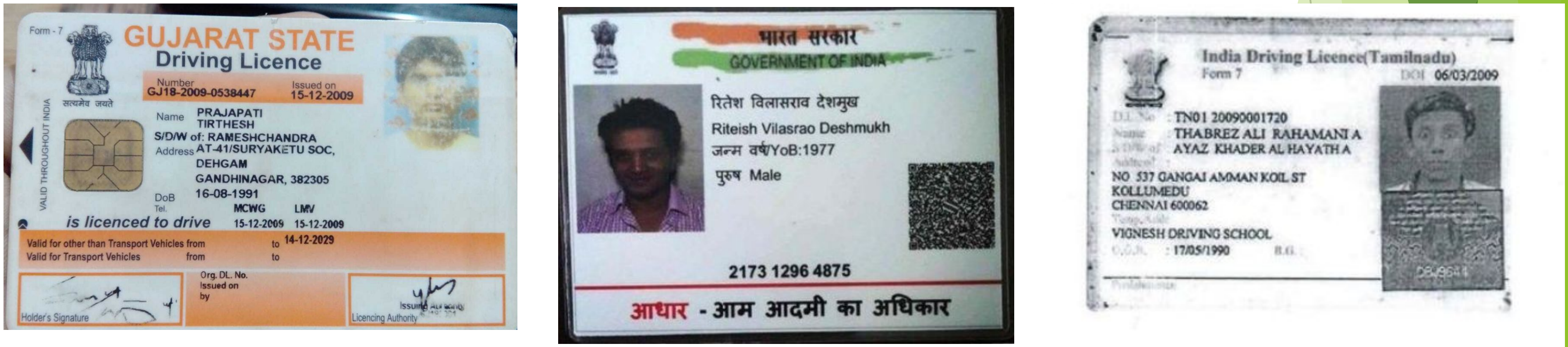
Image	Key features	SSIM	Decision Obtained	Expected Decision	Observation
aadhar_img1	With display picture variation, no qr code, missing name in hindi	0.29	Potential fraud detected	Fraud	Significant changes detected very well
driver_Img2	Black and white, rotated	0.54	Document is likely genuine	Real	Color invariant
passport_img3	Face hidden	0.20	Fraud	Fraud	Recognises inconsistencies with Display image in the id
aadhar_img4	Date font size changes and logo missing	0.20	Potential fraud detected	Fraud	Worked on subtle variation Like text font and size
aadhar_img5	Colored, well aligned and illuminated	0.21	Potential fraud detected	Real	False positives are high. Here additional checks can be employed like re-uploading etc
pan_Img6	Colored, well aligned and illuminated	0.51	Document is likely genuine	Real	Ideal document

III) DOCUMENT CLASSIFICATION

Our model employs a custom CNN architecture particularly designed with convolutional layers progressively increasing in filter count, dropout layers to reduce overfitting, and dense layers to finalize classification. This specialized CNN architecture provides powerful feature extraction, allowing the model to recognize detailed patterns unique to each document format. In parallel, the use of the pre-trained VGG16 model improves feature extraction capabilities, resulting in a more detailed representation of document features.

Dataset Overview :

Document Type	Aadhar Card	Pan Card	Driving License	Voter Id	Passport
No. of Documents	129	45	64	76	37



Form - 7
GUJARAT STATE
Driving Licence
सत्यमेव जयते
VALID THROUGHOUT INDIA
Number GJ18-2009-0538447
Issued on 15-12-2009
Name PRAJAPATI TIRTHESH
S/D/W of: RAMESHCHANDRA
Address AT-41/SURYAKETU SOC,
DEHGAM
GANDHINAGAR, 382305
DoB 16-08-1991
Tel.
is licenced to drive MCWG 15-12-2009 LMV 15-12-2009
Valid for other than Transport Vehicles from to 14-12-2029
Valid for Transport Vehicles from to
Holder's Signature
Org. DL. No.
Issued on
by
Issuing Authority
Licencing Authority

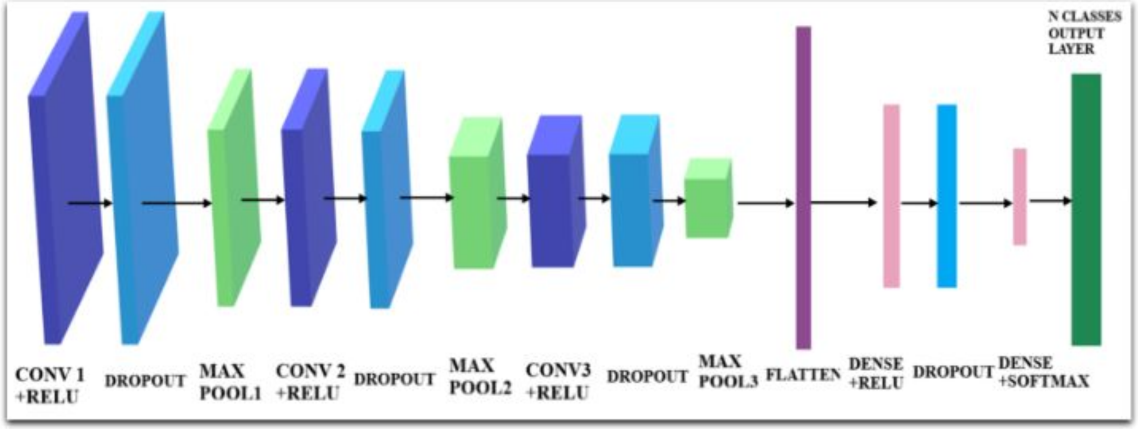
भारत सरकार
GOVERNMENT OF INDIA
रितेश विलासराव देशमुख
Riteish Vilasrao Deshmukh
जन्म वर्ष/YoB:1977
पुरुष Male
2173 1296 4875
आधार - आम आदमी का अधिकार

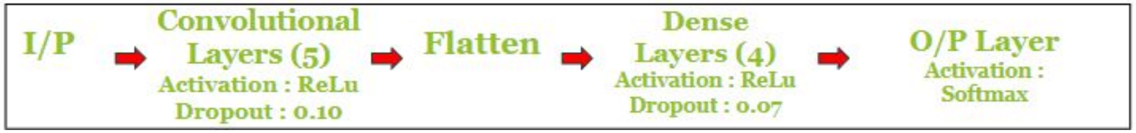
India Driving Licence(Tamilnadu)
Form 7
DOI 06/03/2009
: TN01 20090001720
: THABREZ ALI RAHAMANI A
AYAZ KHADER AL HAYATH A
NO 537 GANGAI AMMAN KOIL ST
KOLLUMEDU
CHENNAI 600062
VIGNESH DRIVING SCHOOL
: 17/05/1990

Few images from Training set

Proposed Classification Model

CNN Model Layers



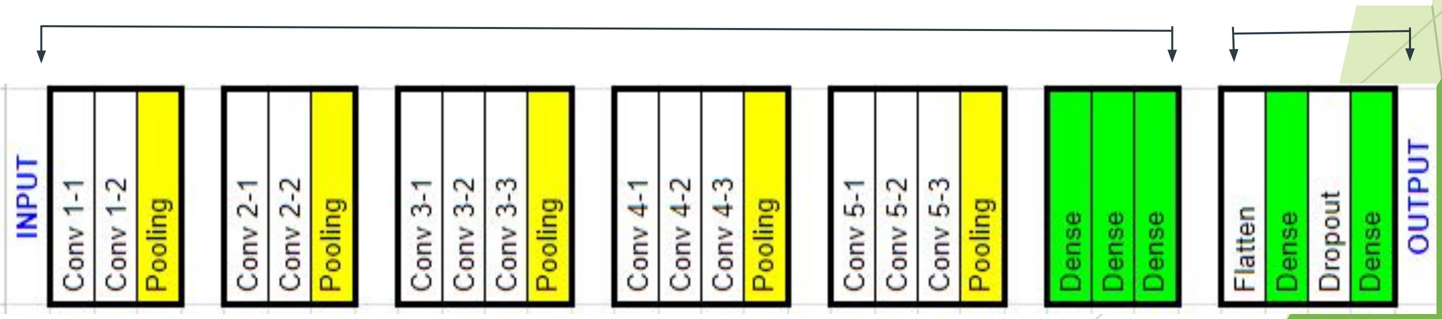


I/P → Convolutional Layers (5) Activation : ReLu Dropout : 0.10 → Flatten → Dense Layers (4) Activation : ReLu Dropout : 0.07 → O/P Layer Activation : Softmax

VGG16 Model Layers

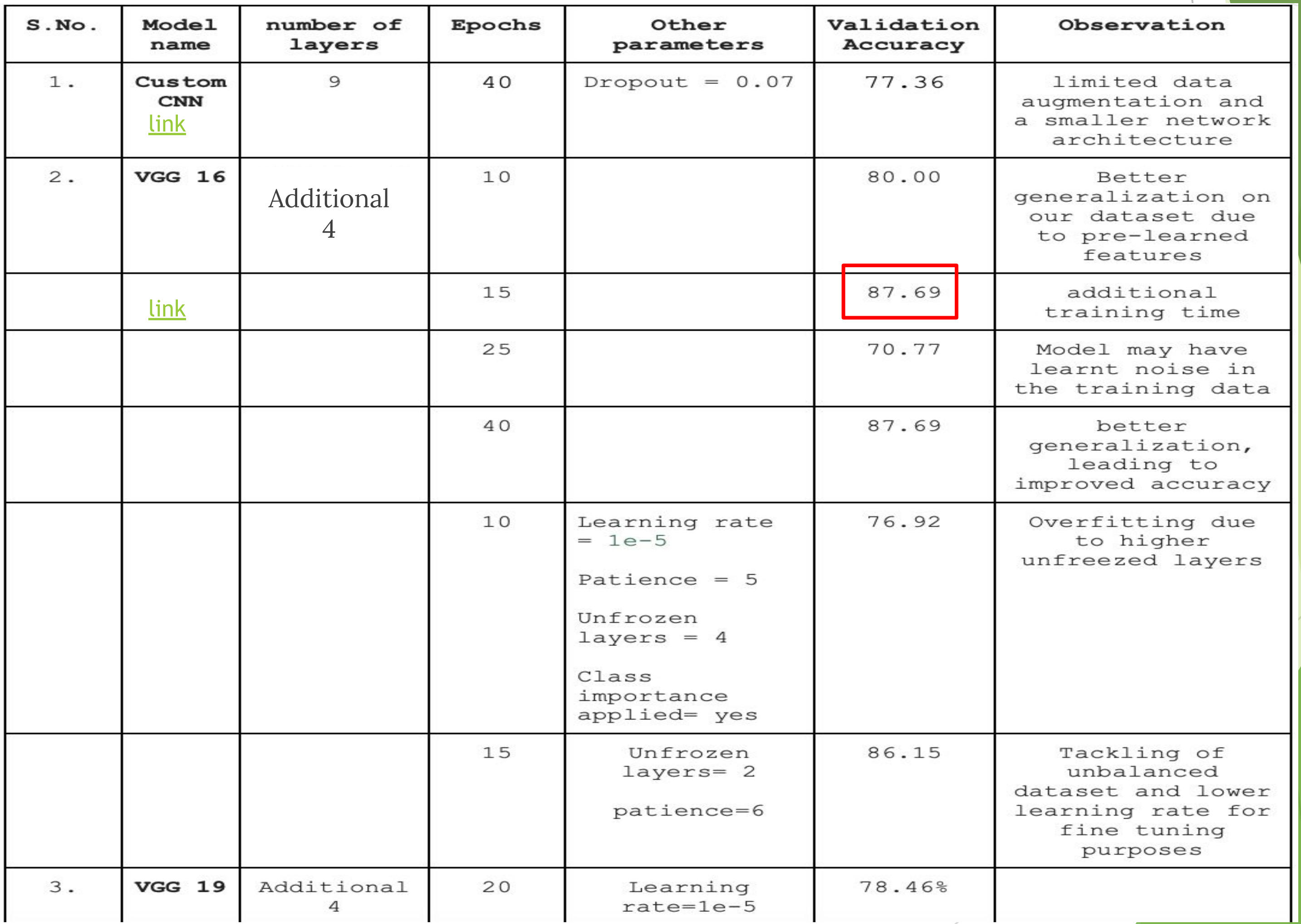
VGG16

Additional layers



EXPERIMENTAL RESULTS

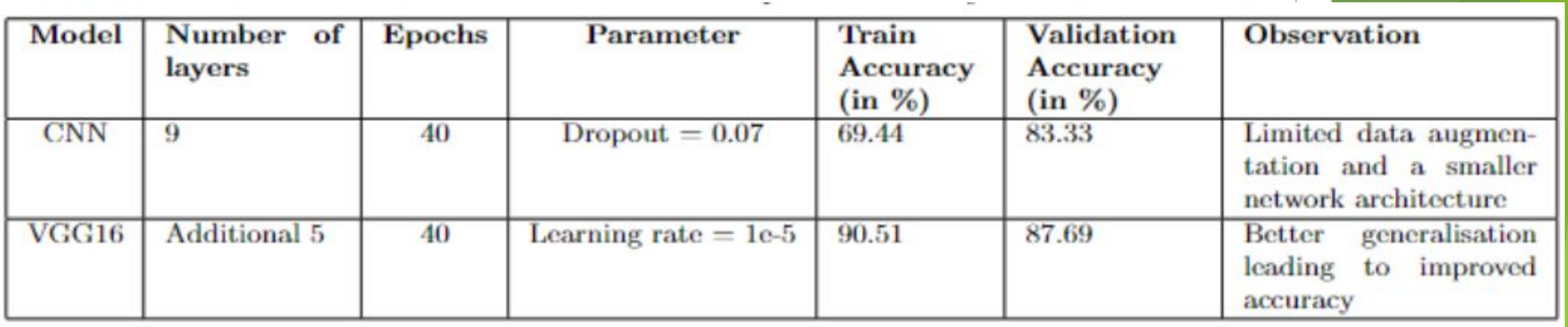
Custom CNN model results with hyperparameter tuning



S.No.	Model name	number of layers	Epochs	Other parameters	Validation Accuracy	Observation
1.	**Custom CNN** link	9	40	Dropout = 0.07	77.36	limited data augmentation and a smaller network architecture
2.	**VGG 16**	Additional 4	10		80.00	Better generalization on our dataset due to pre-learned features
	link		15		87.69	additional training time
			25		70.77	Model may have learnt noise in the training data
			40		87.69	better generalization, leading to improved accuracy
			10	Learning rate = 1e-5 Patience = 5 Unfrozen layers = 4 Class importance applied= yes	76.92	Overfitting due to higher unfreezed layers
			15	Unfrozen layers= 2 patience=6	86.15	Tackling of unbalanced dataset and lower learning rate for fine tuning purposes
3.	**VGG 19**	Additional 4	20	Learning rate=1e-5	78.46%	

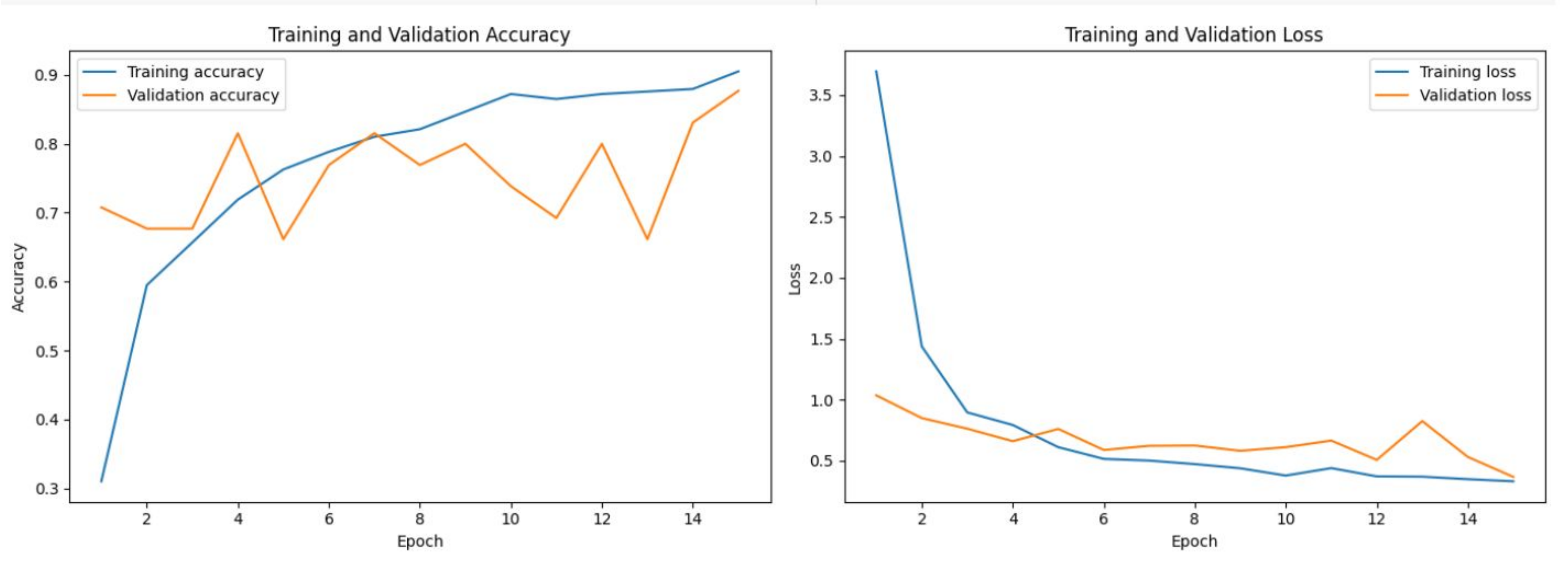
EXPERIMENTAL RESULTS

Comparative Analysis of CNN and VGG16 model



Model	Number of layers	Epochs	Parameter	Train Accuracy (in %)	Validation Accuracy (in %)	Observation
CNN	9	40	Dropout = 0.07	69.44	83.33	Limited data augmentation and a smaller network architecture
VGG16	Additional 5	40	Learning rate = 1e-5	90.51	87.69	Better generalisation leading to improved accuracy

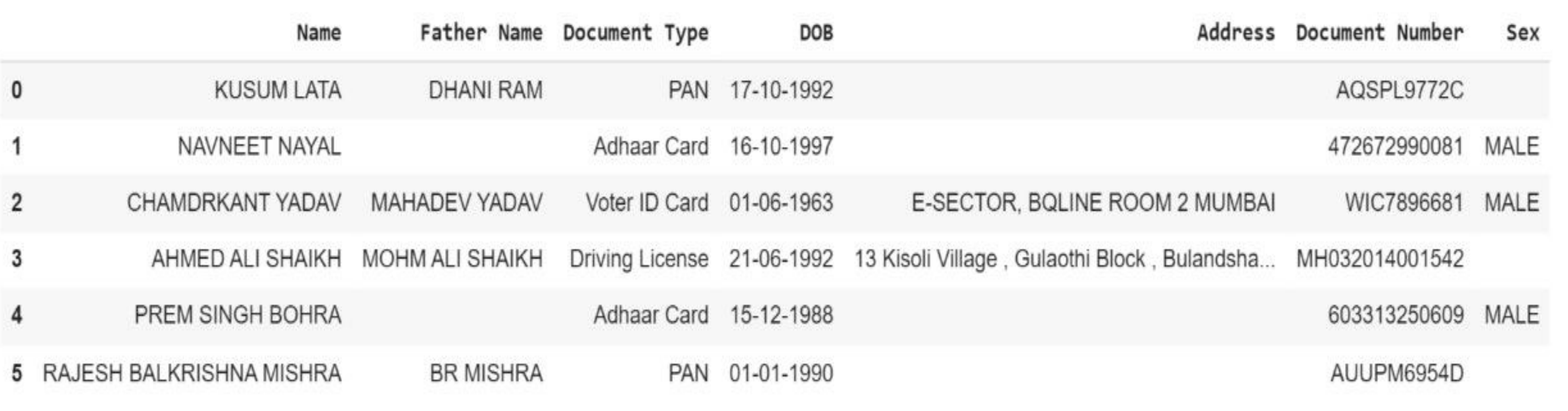
Accuracy and loss graph for finalised VGG16 model



Information Extraction Model (OCR)

- Applied OCR for text extraction from scanned documents.
- Conducted image processing, text extraction, and cleaning.
- Extracted information using keywords from the cleaned text.
- Saved extracted data into a downloadable Excel file.

Text extraction using Tesseract OCR engine. link

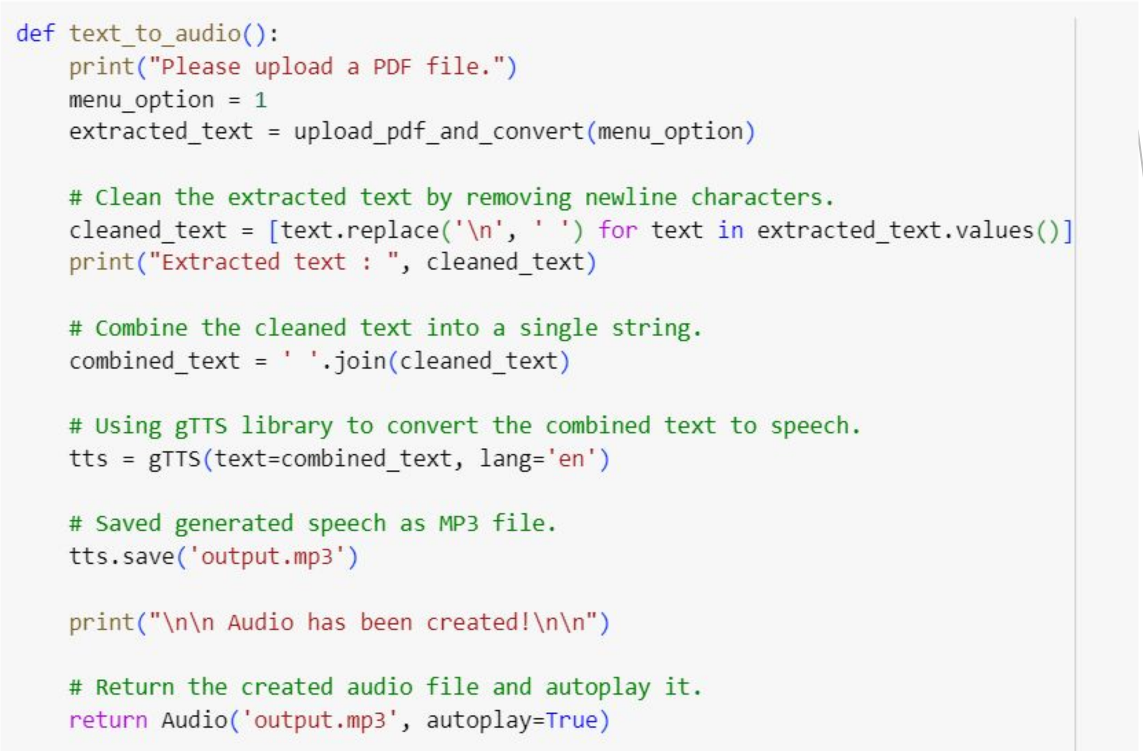


	Name	Father Name	Document Type	DOB	Address	Document Number	Sex
0	KUSUM LATA	DHANI RAM	PAN	17-10-1992		AQSPL9772C	
1	NAVNEET NAYAL		Adhaar Card	16-10-1997		472672990081	MALE
2	CHAMDRKANT YADAV	MAHADEV YADAV	Voter ID Card	01-06-1963	E-SECTOR, BQLINE ROOM 2 MUMBAI	WIC7896681	MALE
3	AHMED ALI SHAIKH	MOHM ALI SHAIKH	Driving License	21-06-1992	13 Kisoli Village , Gulaothi Block , Bulandsha...	MH032014001542	
4	PREM SINGH BOHRA		Adhaar Card	15-12-1988		603313250609	MALE
5	RAJESH BALKRISHNA MISHRA	BR MISHRA	PAN	01-01-1990		AUUPM6954D	

IV) READ ALOUD

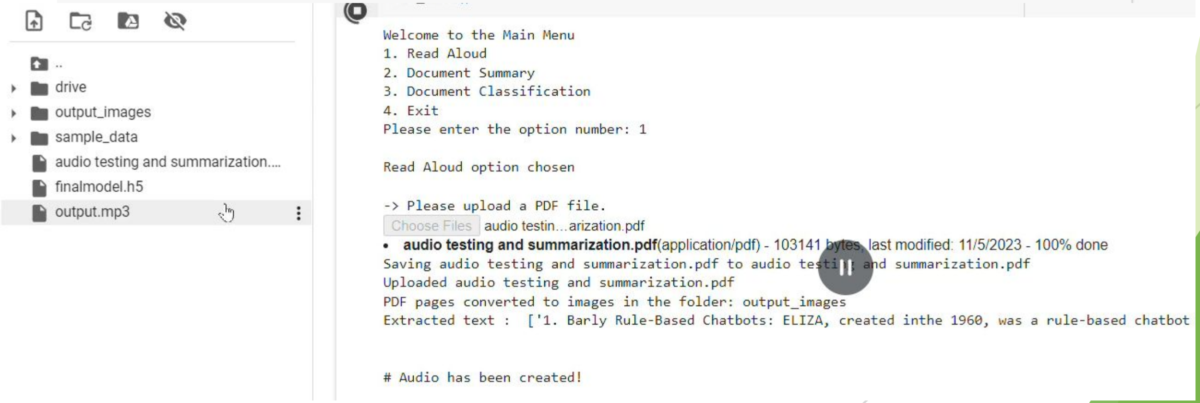
Converts uploaded text into speech using the gTTS library.

Code Snippet



```python
def text_to_audio():
    print("Please upload a PDF file.")
    menu_option = 1
    extracted_text = upload_pdf_and_convert(menu_option)

    # Clean the extracted text by removing newline characters.
    cleaned_text = [text.replace('\n', ' ') for text in extracted_text.values()]
    print("Extracted text : ", cleaned_text)

    # Combine the cleaned text into a single string.
    combined_text = ' '.join(cleaned_text)

    # Using gTTS library to convert the combined text to speech.
    tts = gTTS(text=combined_text, lang='en')

    # Saved generated speech as MP3 file.
    tts.save('output.mp3')

    print("\n\n Audio has been created!\n\n")

    # Return the created audio file and autoplay it.
    return Audio('output.mp3', autoplay=True)
```

Output

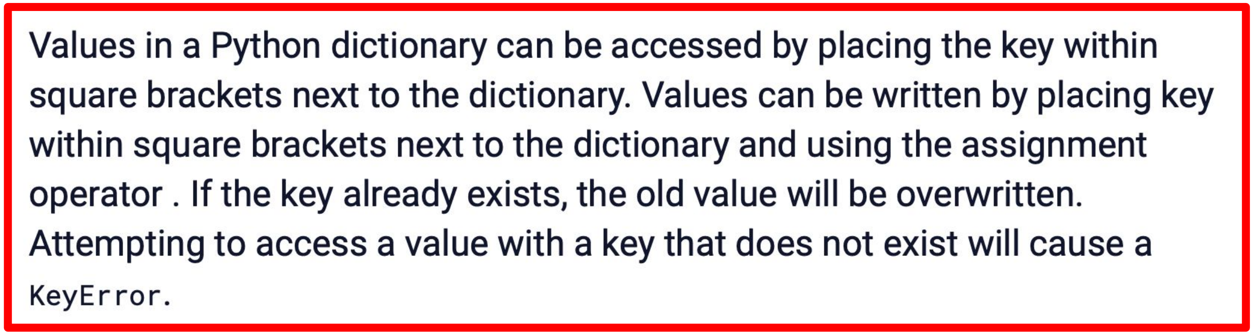


```
Welcome to the Main Menu
1. Read Aloud
2. Document Summary
3. Document Classification
4. Exit
Please enter the option number: 1

Read Aloud option chosen

-> Please upload a PDF file.
Choose Files audio testin...arization.pdf
• audio testing and summarization.pdf(application/pdf) - 103141 bytes, last modified: 11/5/2023 - 100% done
Saving audio testing and summarization.pdf to audio testing and summarization.pdf
Uploaded audio testing and summarization.pdf
PDF pages converted to images in the folder: output_images
Extracted text :  ['1. Barly Rule-Based Chatbots: ELIZA, created inthe 1960, was a rule-based chatbot


# Audio has been created!
```

V) PARAPHRASING

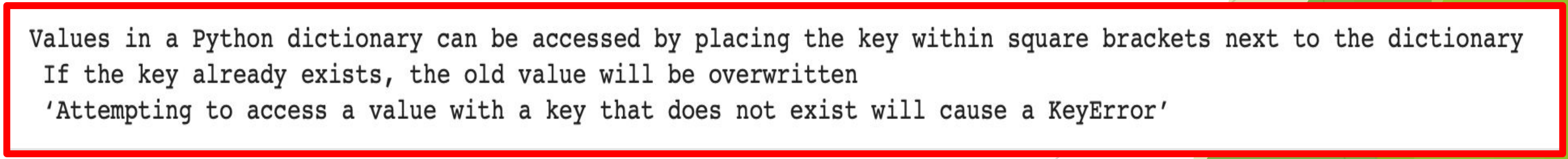
- The work leverages the BART model from the transformers library to paraphrase text extracted from a PDF. It begins by importing necessary components and utilizing a function that splits a given text into smaller, manageable chunks.
- This is followed by the loading a pre-trained BART model and tokenizer, chunks the input text, and then paraphrases each chunk individually. The chunks are then recombined into a single paraphrased text.

Actual text



Values in a Python dictionary can be accessed by placing the key within square brackets next to the dictionary. Values can be written by placing key within square brackets next to the dictionary and using the assignment operator . If the key already exists, the old value will be overwritten. Attempting to access a value with a key that does not exist will cause a `KeyError`.

Paraphrased text `BLEU Score: 0.6408`

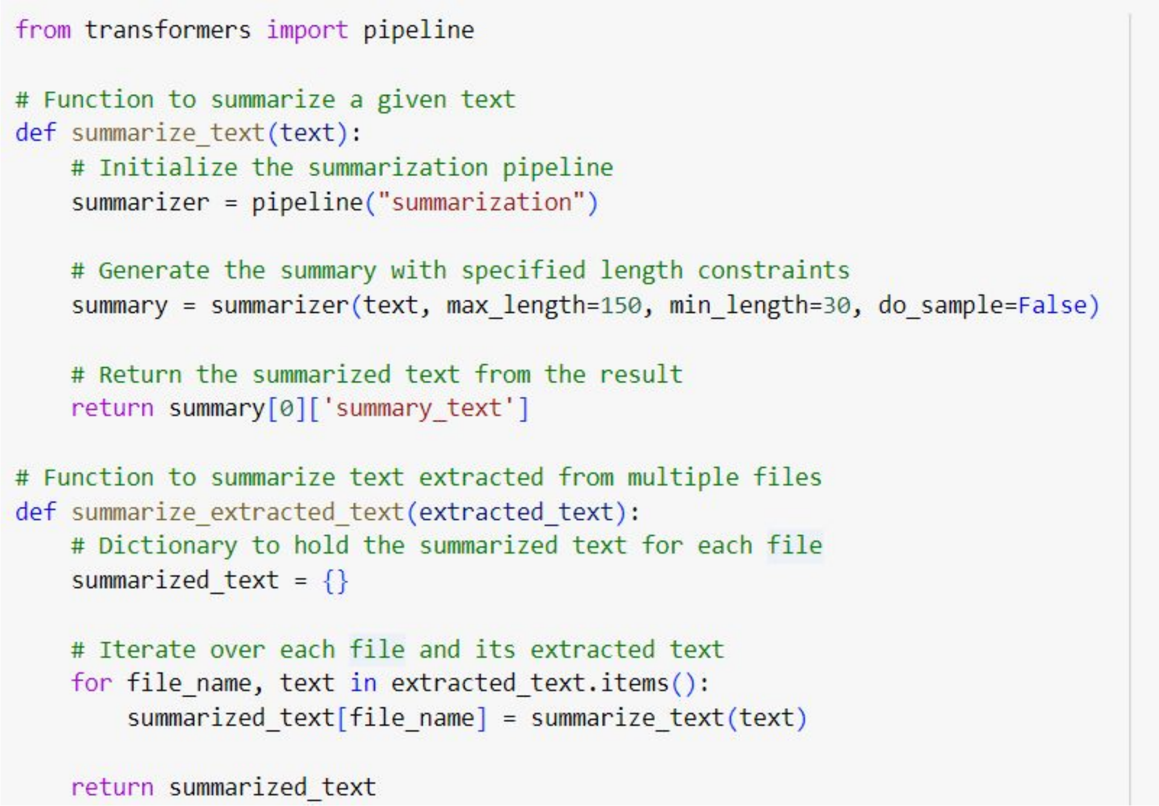


```
Values in a Python dictionary can be accessed by placing the key within square brackets next to the dictionary
 If the key already exists, the old value will be overwritten
 'Attempting to access a value with a key that does not exist will cause a KeyError'
```

VI) SUMMARISATION

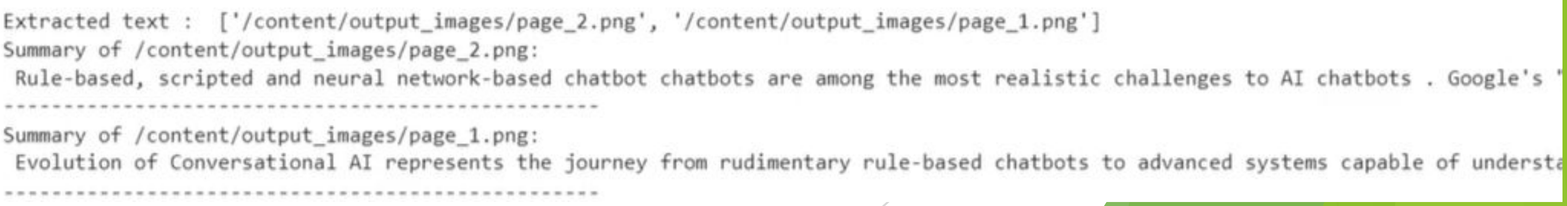
Document summarization condenses text into concise summaries, facilitating quick understanding and information extraction.

Code Snippet



```
from transformers import pipeline

# Function to summarize a given text
def summarize_text(text):
    # Initialize the summarization pipeline
    summarizer = pipeline("summarization")

    # Generate the summary with specified length constraints
    summary = summarizer(text, max_length=150, min_length=30, do_sample=False)

    # Return the summarized text from the result
    return summary[0]['summary_text']

# Function to summarize text extracted from multiple files
def summarize_extracted_text(extracted_text):
    # Dictionary to hold the summarized text for each file
    summarized_text = {}

    # Iterate over each file and its extracted text
    for file_name, text in extracted_text.items():
        summarized_text[file_name] = summarize_text(text)

    return summarized_text
```

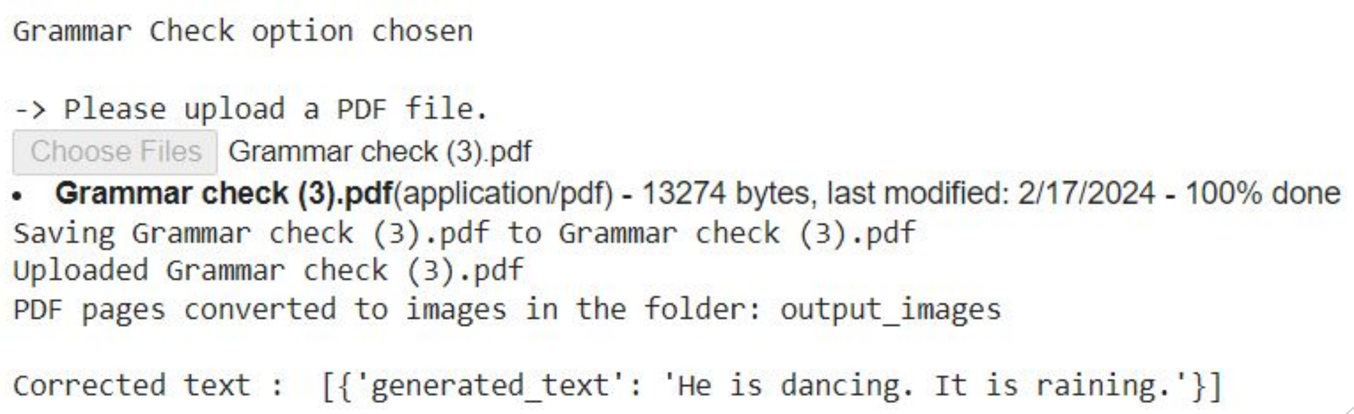
Output



```
Extracted text :  ['/content/output_images/page_2.png', '/content/output_images/page_1.png']
Summary of /content/output_images/page_2.png:
 Rule-based, scripted and neural network-based chatbot chatbots are among the most realistic challenges to AI chatbots . Google's '
--------------------------------------------------
Summary of /content/output_images/page_1.png:
 Evolution of Conversational AI represents the journey from rudimentary rule-based chatbots to advanced systems capable of understa
--------------------------------------------------
```

VII) GRAMMAR CHECK

- The Grammar Check feature leverages Natural Language Processing (NLP) techniques to ensure accurate and context-aware text corrections. It begins with extracting text from PDF documents using the `upload_pdf_and_convert` function.
- Next, a transformer-based model from Hugging Face's Transformers library, specifically the `pszemraj/flan-t5-large-grammar-synthesis`model, is used for grammar correction. The model, initialized via the `pipeline` function, processes the input text and generates a grammatically corrected version, which is retrieved through `results[0]['generated_text']`.



```
Grammar Check option chosen

-> Please upload a PDF file.
Choose Files  Grammar check (3).pdf
•  Grammar check (3).pdf(application/pdf) - 13274 bytes, last modified: 2/17/2024 - 100% done
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Corrected text :  [{'generated_text': 'He is dancing. It is raining.'}]
```
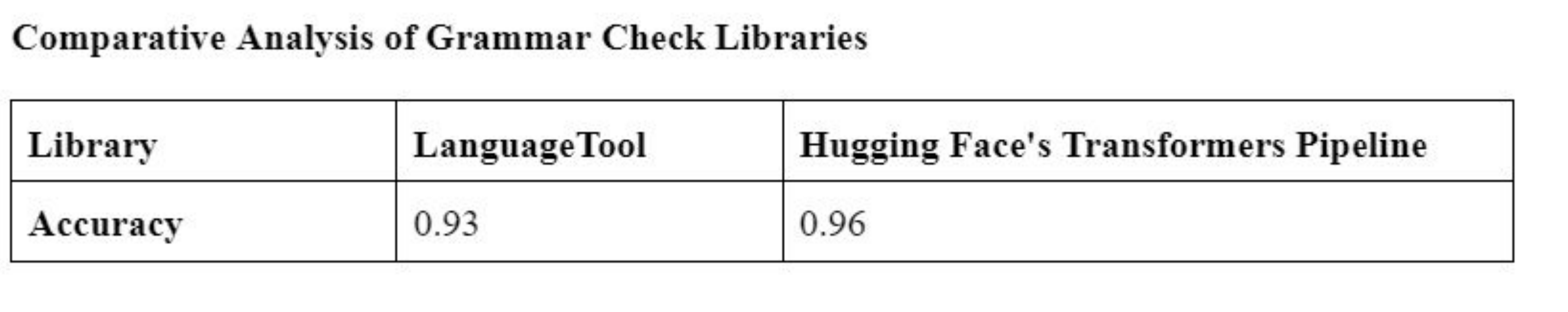

Original: I is dancing. It are raining.

EXPERIMENTAL RESULTS



Comparative Analysis of Grammar Check Libraries

Library	LanguageTool	Hugging Face's Transformers Pipeline
Accuracy	0.93	0.96

CONCLUSION AND FUTURE WORK

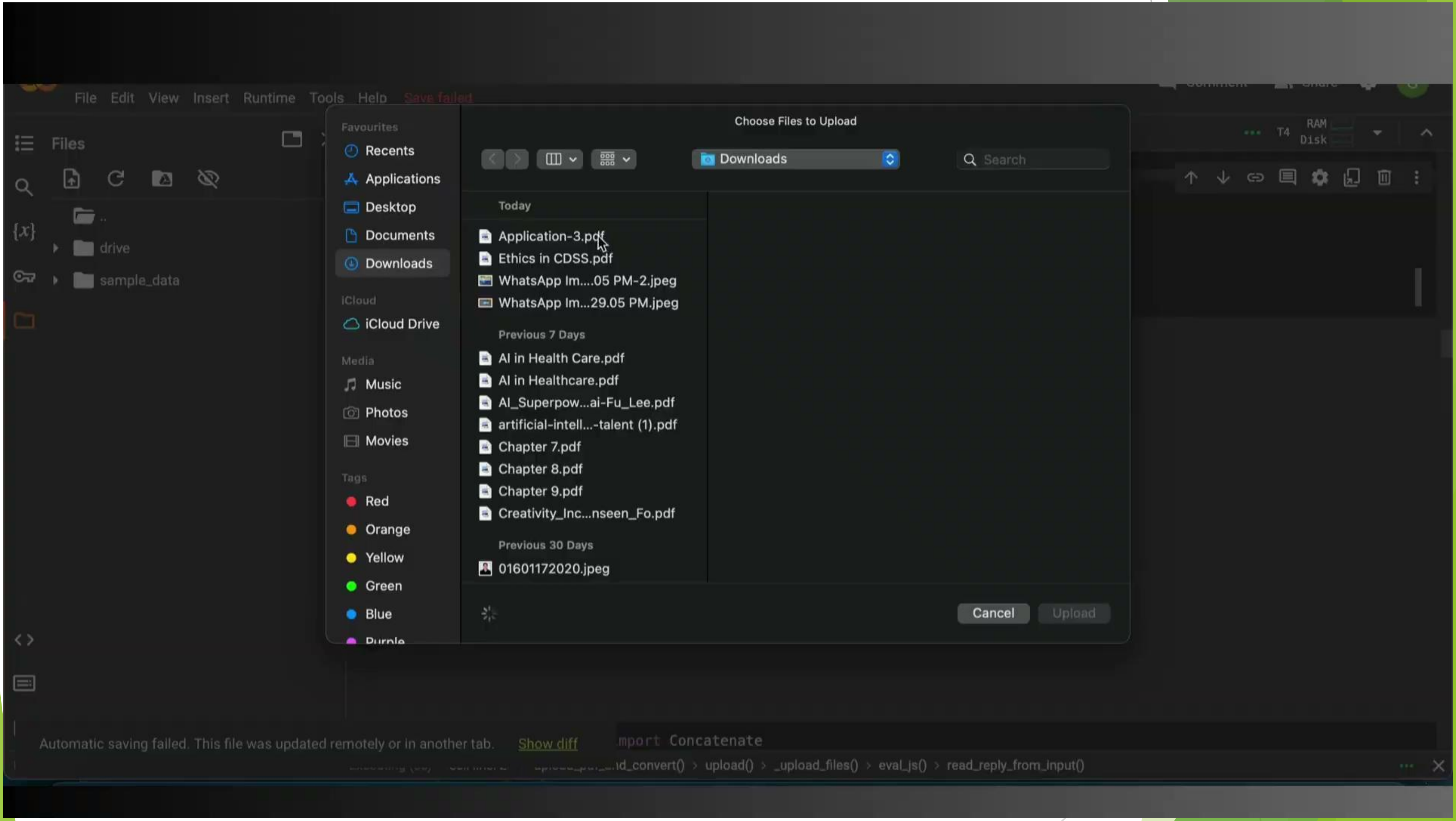
- Different CNN designs have been evaluated and each displayed unique performance traits. Our custom CNN, with only minimal data enhancement, struck a compromise between efficiency and intricacy. Additional layers improved the ability to generalize performance of VGG16.

- Furthermore, our interactive Q&A system yielded reliable outcomes with high confidence levels.

- To ascertain document genuineness with most possible accuracy, we have fused up-to-date image processing techniques with the established techniques of comparing template shapes. Our project to develop AI-powered document intelligence has made certain that its templates are matched, answering interactive questions and document classification.

- Subsequent development stages of AI-driven document intelligence will major on enhancing the accuracy levels of our models by training them on wider data sets as well as applying more advanced classifiers.

DEMO VIDEO



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...d_convert() › upload() › _upload_files() › eval_js() › read_reply_from_input()

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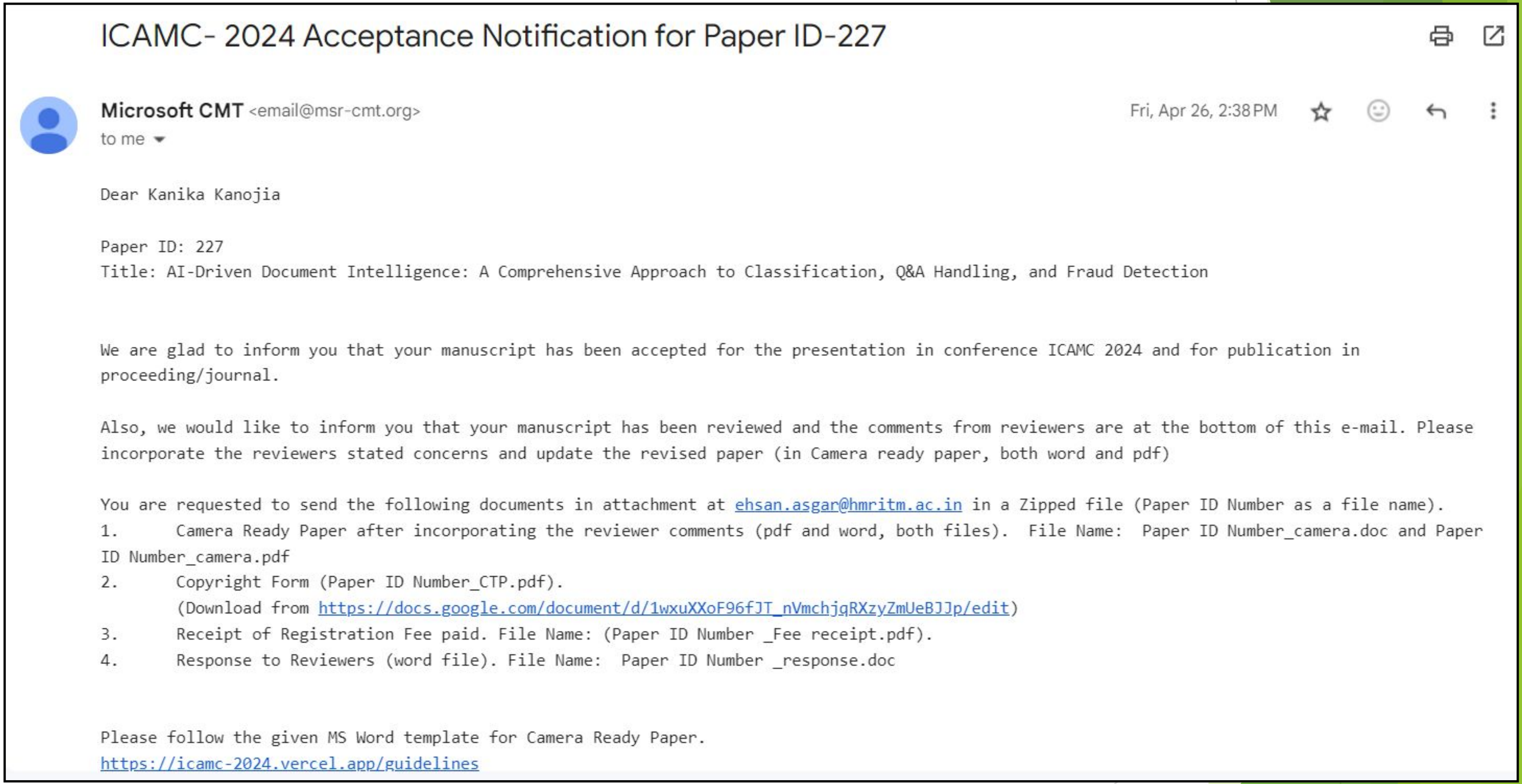
ACCEPTANCE LETTER



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RESEARCH PAPER (link)

AI-Driven Document Intelligence: A Comprehensive Approach to Classification, Q&A Handling, and Fraud Detection

Sonanshi Goel[1], Shambhavi Rai[1], Princy Singhal[1], Mehak Aggarwal[1], Kanika Kanojia[1], *Ritika Kumari[1,2], Poonam Bansal[1]

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Abstract

With the growth in dependency of electronic verification systems used both by government and private organizations, there has been an increase in usage of digitized manuscripts. This demands for user friendly and efficient document interaction tools. Optimisation of the document management process has become AI driven with features like identity document classification, authenticity checking algorithms and interactive question answering. If we effectively identify the document type, we can streamline workflows and enable secure verification processes.The project employs Deep Learning techniques to classify documents like PAN cards, Aadhar cards etc. Also we employ a Similar Document Template Matching Algorithm which can seamlessly extract features, match the template with a real document and thereby detect fraud. Additionally LLMs have been leveraged to enable interactive question answering over documents. Experimental findings in our study showed the effectiveness of our work in improving efficiency, accuracy and usability in document management.

Keywords: CNNs for Document classification, LLMs for Question Answering, Langchain, Similar Document Template Matching Algorithm, VGG16, Fraud Detection,ORB

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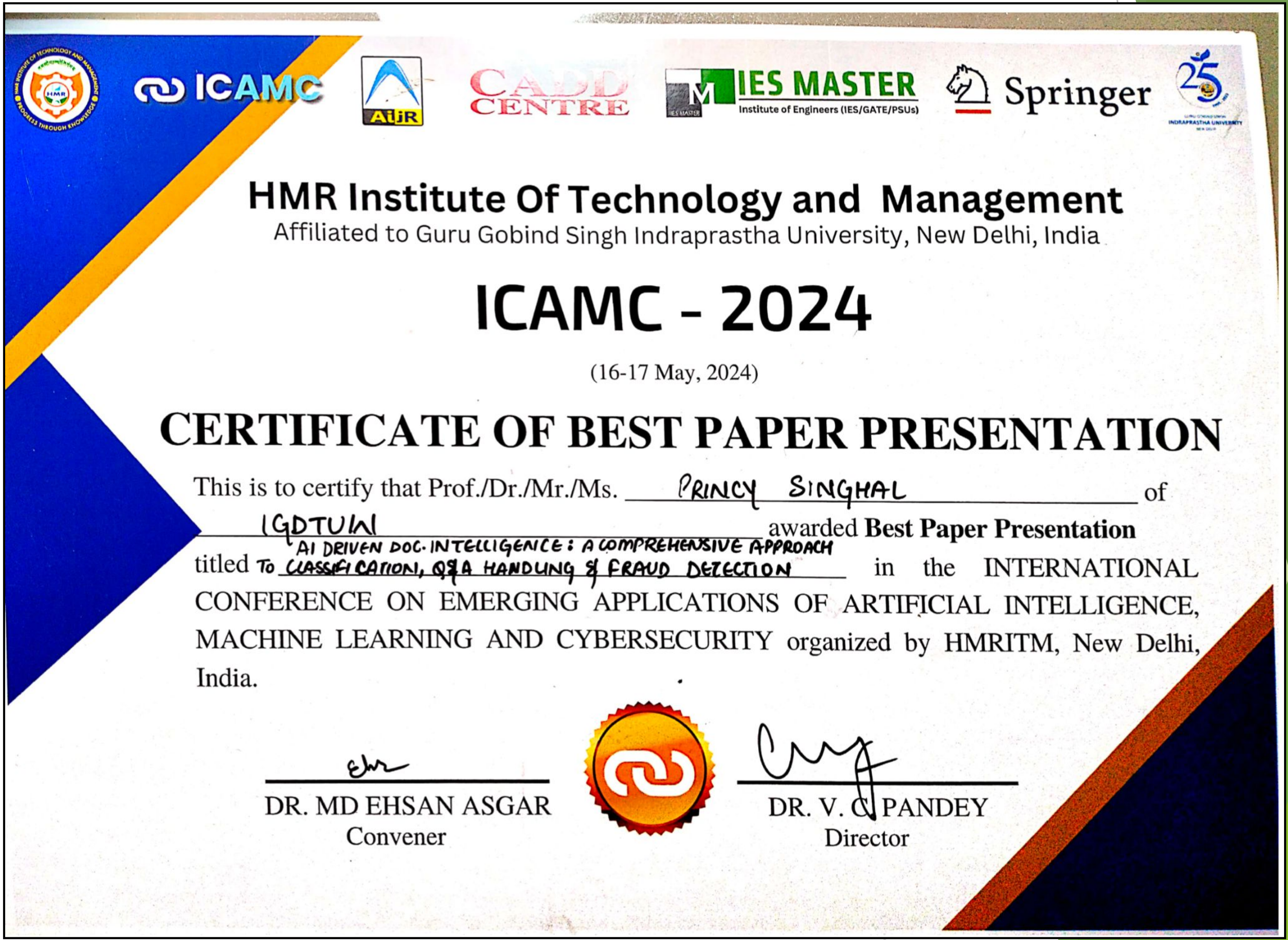

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