AI-Powered Prescription Reading using Deep Learning

Problem Statement

Manual prescription processing in healthcare is prone to errors, misinterpretation, and inefficiencies. Handwritten prescriptions, varying doctor handwriting styles, and language inconsistencies make it difficult for pharmacists to dispense medications, potentially leading to adverse health effects correctly. An AI-powered system is needed to automate prescription recognition, ensuring accuracy, speed, and efficiency.

Present Market Overview

1. Growth of AI in Healthcare

The global AI in healthcare market is projected to grow at a CAGR of 37.5%, reaching $187.95 billion by 2030. This rapid expansion is fueled by:

- ***Increased Digitalization*** *– More healthcare providers are transitioning to electronic medical records (EMRs) and digital prescriptions to enhance data accessibility and security.*
- ***Rising Demand for Automation*** *– Healthcare organizations are under pressure to reduce errors and improve efficiency, leading to increased adoption of AI-based automation.*

- ***Government Initiatives & Regulations*** *– Many governments are supporting AI integration in healthcare to minimize errors and enhance patient safety (e.g., HIPAA, GDPR compliance).*
- ***Telemedicine & Online Healthcare Services*** *– The growth of telehealth platforms like Practo, 1mg, Teladoc is driving demand for automated prescription recognition.*

2. Market Demand for Prescription Recognition Technology

The prescription recognition system has a broad range of applications across various healthcare segments:

A. Hospitals & Clinics

- *Current Challenge:*
  - *Large hospitals and clinics handle thousands of prescriptions daily.*
  - *Manual processing leads to errors, delays, and inefficiencies in dispensing medicines.*
- *Market Potential:*
  - *AI-driven OCR (Optical Character Recognition) and NLP can significantly reduce medication errors.*
  - *Automated prescription recognition can seamlessly integrate with Electronic Health Record (EHR) systems, improving patient data management.*

B. Pharmacies & Drug Stores

- *Current Challenge:*

- *Pharmacists often struggle with illegible prescriptions, increasing the risk of dispensing incorrect medications.*
- *Manual data entry of prescriptions into pharmacy management systems is time-consuming.*

- *Market Potential:*
    - *AI-based prescription recognition can automate drug identification, dosage interpretation, and digital record-keeping.*
    - *Reduces pharmacist workload, enabling faster service and improving customer satisfaction.*

C. Telemedicine & Online Healthcare Platforms

- *Current Challenge:*
    - *With the rise of online consultations, patients receive prescriptions via PDFs or images, which may not always be structured for digital processing.*
    - *Manual data extraction is inefficient for online pharmacy orders.*
- *Market Potential:*
    - *AI-powered prescription recognition can convert handwritten and digital prescriptions into structured formats, making online medicine ordering seamless and error-free.*
    - *Telehealth platforms can integrate this AI solution to automate medicine recommendations and reminders.*

D. Healthcare Insurance & Regulatory Compliance

- *Current Challenge:*
    - *Insurance companies require accurate prescription records for claims and reimbursements.*
    - *Errors in documentation can cause delays in patient reimbursements.*
- *Market Potential:*
    - *AI-driven solutions can provide structured and verified prescription records, improving insurance claim processing and fraud detection.*
    - *Can assist in ensuring compliance with HIPAA, GDPR, and other medical data privacy laws*.

Who Needs This System?

The AI-Powered Prescription Recognition System is designed to address efficiency, accuracy, and accessibility challenges in prescription processing. It serves multiple stakeholders in the healthcare ecosystem by improving prescription interpretation, reducing manual work, and enhancing patient safety. The following key groups would benefit from this system:

1. Hospitals and Clinics: Reducing Manual Effort and Minimizing Prescription Errors

Current Challenges:

Hospitals and clinics handle hundreds to thousands of prescriptions daily, and manual processing presents several inefficiencies:

- *Handwritten prescriptions are often illegible, leading to misinterpretation by pharmacists and staff.*
- *Doctors' busy schedules lead to rushed handwriting, increasing the risk of medication errors.*
- *Time-consuming manual entry – Nurses, pharmacists, and administrative staff spend valuable time transcribing prescriptions into Electronic Health Record (EHR) systems.*
- *Regulatory Compliance – Hospitals must ensure patient data is accurately recorded and stored securely to meet HIPAA, GDPR, and other healthcare regulations*.

2. Pharmacies: Ensuring the Accurate Dispensation of Drugs

Current Challenges:

- *Pharmacists often struggle with poorly written prescriptions, leading to confusion and potential medication errors.*
- *Similar-sounding drug names (e.g., Celebrex vs. Celexa, Hydroxyzine vs. Hydralazine) increase the risk of dispensing the wrong medication.*
- *Incorrect dosage instructions – Misinterpretation can lead to overdosing or underdosing, affecting patient safety.*
- *Manual verification slows down service, resulting in long wait times for customers.*
- *Lack of digital prescription records makes it difficult to track patient medication history.*

3. Healthcare Aggregators: Platforms Like Practo or 1mg Could Benefit from Prescription Digitization

Current Challenges:

- *Online healthcare platforms like Practo, 1mg, Netmeds, and Teladoc enable patients to upload prescriptions for medicine delivery, but:*
  - *Many patients upload unclear or incomplete images, requiring manual verification.*
  - *Processing handwritten prescriptions slows down medicine delivery, leading to customer dissatisfaction.*
  - *Lack of integration with pharmacy systems means that prescriptions must be manually interpreted and entered.*
- *Online pharmacies struggle with fraudulent prescriptions, making it crucial to implement automated verification mechanisms.*

4. Patients: Direct Access to Their Digital Prescriptions for Tracking and Reference

Current Challenges:

- *Paper prescriptions can be lost, damaged, or forgotten, making refills and tracking difficult.*
- *Many patients struggle to read doctors' handwriting, leading to confusion about medication dosage and frequency.*
- *Chronic disease patients (e.g., diabetes, hypertension) require regular prescriptions, but manual tracking is inefficient.*

- *Language barriers – Patients who do not understand the language of their prescription may take medication incorrectly.*

Business Opportunity

The AI-Powered Prescription Recognition System presents a significant business opportunity within the rapidly expanding AI-driven healthcare sector. The global AI in healthcare market is expected to reach $187.95 billion by 2030, with a major portion of this growth attributed to automated document processing technologies, including prescription digitization. The demand for AI-based solutions is driven by regulatory requirements, efficiency improvements, and patient safety initiatives.

1. The Growing Global AI Healthcare Market

Market Growth & Projections

The AI in healthcare market is experiencing rapid expansion due to technological advancements, with key market insights including:

- ***Market Size Projection** – The global AI healthcare market is expected to grow from $11 billion in 2021 to $187.95 billion by 2030, at a CAGR of 37.5%.*
- ***Automation in Healthcare** – A significant portion of this growth is driven by AI applications in document processing, medical imaging, and predictive analytics.*
- ***Prescription Automation Market** – Prescription digitization and AI-powered Optical Character Recognition (OCR) solutions are expected to see a sharp rise in adoption due to:*

    - *Increasing medical errors related to handwritten prescriptions.*
    - *Rising demand for electronic health records (EHRs) in hospitals and clinics.*
    - *Growing popularity of telemedicine and online pharmacies requiring automated prescription verification.*

2. Mandatory Compliance for Healthcare Providers: AI as a Necessity, Not a Luxury

The Problem: High Prescription Error Rates & Regulatory Pressure

- *Medication errors affect millions of patients annually, leading to avoidable hospitalizations and legal risks for healthcare providers.*
- *Handwritten prescriptions account for a significant percentage of these errors due to misinterpretation and illegibility.*
- *Governments and regulatory bodies worldwide are enforcing stricter rules to ensure prescription accuracy, digital record-keeping, and patient safety.*

Target Specifications and Characterization

The AI-Powered Prescription Recognition System is designed to meet the needs of multiple stakeholders in the healthcare ecosystem, ensuring efficiency, accuracy, and compliance in handling medical prescriptions. The system must fulfill specific technical and user requirements to ensure its effectiveness, accessibility, and regulatory adherence.

End Users: Who Will Use This System?

The system caters to four primary user groups, each with distinct needs and use cases:

1. Pharmacists (Retail & Hospital Pharmacies)

Use Case:

- *Pharmacists receive and process prescriptions daily, often dealing with handwritten and unclear prescriptions.*
- *They are responsible for dispensing the correct medication, dosage, and instructions.*
- *Manual verification of prescriptions is time-consuming and prone to errors.*

2. Hospital Staff (Doctors, Nurses, and Administrative Personnel)

Use Case:

- *Doctors write prescriptions for patients, often by hand.*
- *Nurses and administrative staff manually enter prescription details into Electronic Health Record (EHR) systems.*
- *Misinterpretation of handwritten prescriptions can lead to serious medical errors*

3. Patients (Consumers Using Mobile Apps or Digital Health Platforms)

Use Case:

- *Many patients struggle to read handwritten prescriptions, leading to medication errors.*
- *Paper prescriptions can be lost, damaged, or difficult to store.*
- *Chronic disease patients (e.g., diabetes, hypertension) require regular medication tracking.*

4. Third-Party Healthcare Apps (Telemedicine, Online Pharmacies, and Health Aggregators)

Use Case:

- *Platforms like Practo, 1mg, Netmeds, Teladoc handle thousands of prescription uploads daily.*
- *Many prescriptions are in image format, requiring manual verification before processing orders.*
- *Fraudulent or unclear prescriptions cause delays in medicine delivery.*

Key Customer Needs & System Requirements

The AI-Powered Prescription Recognition System must meet the following technical specifications and performance benchmarks to ensure optimal usability and efficiency:

1. High Accuracy in Drug Name Recognition (>95%)

Why It Matters:

- *Medical errors due to incorrect drug identification can be life-threatening.*
- *Many drugs have similar names (e.g., Zantac vs. Zyrtec, Celebrex vs. Celexa).*
- *Pharmacists and doctors require near-perfect accuracy to ensure safe medication dispensing.*

2. User-Friendly Mobile App or Desktop Platform for Easy Accessibility

Why It Matters:

- *Doctors, pharmacists, and patients need an easy-to-use platform to scan, review, and manage prescriptions.*
- *The system must cater to different user groups, from hospital professionals to elderly patients.*

3. Speedy Processing (Recognition Time < 5 Seconds)

Why It Matters:

- *Hospitals and pharmacies process thousands of prescriptions daily; any delay affects efficiency.*
- *Patients expect quick verification for online medicine orders.*

4. Ability to Recognize Multilingual Prescriptions (for International Markets)

Why It Matters:

- *Global hospitals and pharmacies handle prescriptions in multiple languages.*
- *Patients may not understand prescriptions written in a foreign language, leading to misuse.*

5. Ensuring Data Privacy and Compliance with HIPAA and Other Regulations

Why It Matters:

- *Prescription data contains sensitive patient information; failure to protect it could result in legal penalties.*
- *Regulatory bodies like HIPAA (US), GDPR (Europe), and the Indian Digital Health Act mandate strict data protection policies.*

External Search

Research Papers: Foundations of Prescription Recognition

1. Dhar et al. (2021) – Prescription Text Classification

Objective:

This study focused on classifying and extracting information from medical prescriptions using machine learning and deep learning techniques.

Key Findings:

- *Prescription text contains structured (drug names, dosages) and unstructured (handwritten notes) information.*
- *OCR combined with NLP models significantly improves text recognition accuracy.*
- *Context-aware AI models help in distinguishing similar-looking drug names to prevent misclassification.*

2. Fajardo et al. (2019) – Doctor Cursive Handwriting Recognition

Objective:

This research focused on improving OCR models to recognize cursive handwriting in medical prescriptions.

Key Findings:

- *Traditional OCR struggles with cursive handwriting, requiring deep learning-based handwriting recognition.*
- *CNN-based models showed improved accuracy in identifying handwritten drug names.*
- *Noise removal and image preprocessing significantly enhance text recognition.*

Technologies & Libraries: AI Tools for Prescription Recognition

1. OCR Tools for Text Extraction

OCR (Optical Character Recognition) converts handwritten or printed prescription images into machine-readable text.

(A) Google Tesseract OCR

- *An open-source OCR engine developed by Google.*
- *Strengths:*
- *1) Works well with printed text.*
  2) Supports multiple languages.

(B) *PaddleOCR*

- *A deep learning-based OCR tool with superior handwriting recognition capabilities.*
- *Strengths:*

  1) More accurate in recognizing handwritten text compared to Tesseract.

  2) Supports real-time recognition.

2. *Deep Learning Models for Handwriting Recognition*

OCR alone is insufficient for high-accuracy recognition of complex handwriting. Deep learning models enhance performance.

(A) CNN (Convolutional Neural Networks)

- *Used for image recognition tasks, including handwritten text extraction.*
- *Why CNN?*

  1) Excels in detecting handwriting strokes and patterns.

  2) Used in previous research (Fajardo et al., 2019) for prescription digitization.

(B) Transformer Models (TrOCR, Donut)

- *Modern deep learning models specifically designed for OCR tasks.*
- *TrOCR (Transformer OCR) – Developed by Microsoft*

  1) Pretrained on handwritten text datasets.

  2) Works well with cursive and non-standard handwriting styles.
- *Donut (Document Understanding Transformer)*

  1) Excels in extracting structured information from unstructured medical text.

3. NLP Tools for Understanding Prescription Text

Once the text is extracted from prescriptions, ***Natural Language Processing (NLP) is used to understand drug names, dosages, and instructions****.*

(A) SpaCy

- *Fast and efficient NLP library for extracting structured data.*
- *Use Case:*

  1) Identifies drug names and medical terminology from prescriptions.

(B) BERT (Bidirectional Encoder Representations from Transformers)

- *State-of-the-art NLP model for contextual text understanding.*
- *Use Case:*

  1) Helps in resolving ambiguities in drug names and dosages.

(C) MedSpaCy

- *A healthcare-specific NLP tool that integrates with medical data.*
- *Use Case:*

  1) Identifies disease names, symptoms, and prescription instructions.

Final Product Prototype

Schematic Diagram:

1. ***Input: Image of the Prescription (via camera or upload)***
    - ***What Happens***: *The process begins when the user either takes a picture of a handwritten prescription or uploads an image of the prescription.*
    - ***How It Works***: *Users can use their mobile device or web application interface to capture an image of the prescription or upload a scanned version.*
    - ***Challenges***: *Handwritten prescriptions can vary widely in terms of legibility, handwriting style, and clarity. The system must be able to handle low-quality images, tilted orientations, and lighting issues.*

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2. ***Data Preprocessing: Removes Noise, Adjusts Brightness, and Segments Text***
    - ***What Happens***: *Once the image is captured or uploaded, the system begins to preprocess the image to improve its quality before passing it to the OCR and recognition system.*
    - ***How It Works***:
        - ***Noise Removal***: *The image may contain unwanted artifacts (like smudges, background noise, or irrelevant marks) that need to be removed to make the handwriting clearer.*

        - ***Brightness Adjustment****: Sometimes, images might be too dark or overexposed. The system adjusts the brightness and contrast to optimize the clarity of the text.*
        - ***Text Segmentation****: The image is divided into smaller, logical sections (e.g., separating the prescription name, patient information, drug names, and instructions). This segmentation helps the system better process the text.*
    - ***Challenges****: Ensuring that the image preprocessing works across different lighting conditions, angles, and image qualities. This step is crucial for the system to successfully recognize handwritten characters.*

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3. ***OCR and CNN: Recognizes Handwritten Text (Drug Names, Dosages, Frequencies)***
    - ***What Happens****: The preprocessed image is now ready for Optical Character Recognition (OCR) to detect and extract text from the image.*
    - ***How It Works****:*
        - ***OCR Technology****: OCR uses pattern recognition and machine learning techniques to convert the visual information in the image into machine-readable text. It reads the characters (numbers and letters) and tries to form words, phrases, and sentences based on the handwriting.*
        - ***Convolutional Neural Networks (CNN)****: CNNs are deep learning models designed for image recognition*

tasks. The OCR system is enhanced by CNNs, which help to classify and recognize the characters in the image, even if the handwriting is difficult or inconsistent. CNNs excel at recognizing patterns and features in images, which improves the accuracy of the OCR system, especially for handwriting.

    - *The system specifically looks for **drug names**, **dosages**, and **frequencies** to ensure that the prescription details are extracted correctly. For example, it might detect "Amoxicillin 500mg" or "Take 2 tablets daily."*

  - ***Challenges**: Handwriting variation, unclear or overlapping text, and inconsistencies in spelling can make it difficult for the OCR to recognize the text accurately. The integration of CNNs helps improve recognition of complex and irregular handwriting.*

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4. *NLP Analysis: Extracts Key Information and Categorizes It into Drugs, Dosages, and Instructions*

  - ***What Happens**: After OCR has identified the text, the system uses Natural Language Processing (NLP) to analyze and extract meaningful information from the recognized words.*
  - ***How It Works**:*
    - ***NLP Techniques**: NLP helps the system understand the structure and context of the prescription text. It analyzes the recognized words and categorizes them into different groups:*

        - ***Drugs***: *Identifies drug names (e.g., Amoxicillin, Ibuprofen).*
        - ***Dosages***: *Recognizes numeric values associated with dosages (e.g., 500mg, 10ml).*
        - ***Frequency/Instructions***: *Identifies the dosage frequency and additional instructions (e.g., "Take 2 tablets daily," "Apply twice a day").*
    - *The NLP system uses a combination of dictionaries, pre-trained models, and context-aware algorithms to ensure the extracted information is correctly categorized and structured.*
  - ***Challenges***: *Handwritten text can include non-standard abbreviations, mis-spellings, or unique instructions. The NLP model must be able to interpret these variations to categorize the information correctly.*

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5. ***Output: Digital Version of the Prescription Displayed on the App or Dashboard***
   - ***What Happens***: *After the key information has been extracted and categorized, the system generates a digital version of the prescription, which is displayed on the app or web dashboard.*
   - ***How It Works***:
     - *The app presents the prescription details in a structured, readable format. Users can view the drug names, dosages, frequencies, and instructions in an easily editable format.*

        - ***Actionable Output***: *The digital prescription can be saved, shared with pharmacies, or integrated into electronic health records (EHR) systems. This reduces the need for manual transcription and minimizes the chance of errors.*
    - ***Challenges***: *The system must ensure that all extracted data is correctly formatted and displayed clearly to users. Any errors in extraction could affect the legibility and reliability of the digital prescription.*

Key Features of the Product:

- ***Accuracy***: *The combined use of OCR, CNN, and NLP ensures high accuracy in recognizing handwritten text, even with challenging handwriting styles.*
- ***User-Friendly Interface***: *The mobile or web-based app provides a simple, easy-to-navigate interface that allows users to upload, process, and view prescriptions quickly.*
- ***Integration with Healthcare Systems***: *The final digital prescription can be shared directly with pharmacies or integrated into electronic health records for a more efficient workflow.*
- ***Security and Compliance***: *The system should comply with healthcare data regulations (e.g., HIPAA, GDPR) to ensure that patient data is protected and handled securely.*

Product Details

How it Works

The core functionality of the product revolves around processing images of handwritten prescriptions, extracting meaningful data, and displaying it in a structured format. Below are the steps involved:

Step 1: Mobile App Takes Prescription Image

- ***User Input****: The user (doctor, pharmacist, or patient) takes a photo of a handwritten prescription using their mobile phone or uploads an image of the prescription onto the app.*
- ***Image Quality Considerations****: The app must handle variations in image quality, lighting, and orientation of the image to ensure the next steps work correctly. It will also offer preprocessing options like rotating, adjusting brightness, or cropping for clearer images.*

Step 2: OCR Converts Text to Machine-Readable Format

- ***OCR Technology****: Optical Character Recognition (OCR) is applied to the image to detect and convert any text into a machine-readable format.*
- ***Process****: The image is processed by the OCR engine to recognize the characters (letters, numbers, etc.) on the prescription. OCR software like* ***Tesseract*** *can identify the characters in the image based on their patterns and produce a digital version of the text.*
- ***Challenges****: Handwritten text can be difficult to recognize due to different styles, slanting, and unclear handwriting. The OCR system needs to handle variations in handwriting, background noise, and potential distortions.*

Step 3: NLP Extracts Drug Details

- ***NLP Process****: After the OCR step, Natural Language Processing (NLP) algorithms are used to analyze the recognized text and extract useful medical information.*
- ***Extraction Goals****:*

- ***Drug Names**: The system identifies and categorizes drug names, e.g., "Amoxicillin," "Aspirin."*
- ***Dosages**: Dosage information such as "500mg," "10ml" is detected.*
- ***Instructions**: The NLP models will extract instructions like "Take 2 tablets daily" or "Apply twice a day."*

- ***NLP Models**: Models like **SpaCy**, **BERT**, or custom-trained models on medical text will be used to identify and categorize medical terms accurately.*
- ***Context Understanding**: NLP helps to distinguish between similar terms, such as recognizing "mg" as milligrams or "ml" as milliliters, and also helps deal with abbreviations like "Tab" (Tablet) or "Gm" (Grams).*

Step 4: Display Output

- ***Final Display**: Once the text is recognized and analyzed, the app will display a structured digital version of the prescription, showing the extracted information in an organized way. It could appear as:*
  - ***Drug Name**: Amoxicillin*
  - ***Dosage**: 500mg*
  - ***Instructions**: Take 2 tablets daily*
- ***User Interface**: The output will be shown on the app dashboard or web portal, where users can further edit, save, or share the prescription with pharmacies or other healthcare systems.*
- ***Integration**: The digital prescription may be exported in different formats (e.g., PDF, JSON) for further use, such as sending to pharmacies or integrating with hospital records.*

Data Sources

To ensure the app works efficiently and accurately, it needs to be trained on high-quality data sources:

- ***Hospital Prescriptions****: The primary data source would be real hospital prescriptions. This data will be used to train the OCR and NLP models to recognize common handwriting styles, medical terminology, drug names, dosages, and frequencies.*
    - ***Data Privacy****: Since this involves sensitive patient data, it's crucial to ensure that all data sources comply with privacy regulations such as* ***HIPAA*** *(Health Insurance Portability and Accountability Act) in the U.S. or* ***GDPR*** *(General Data Protection Regulation) in Europe. Anonymization techniques and secure storage should be employed.*
- ***Crowdsourced Handwritten Datasets****: To further train and improve the system, the app could leverage publicly available or crowdsourced handwritten datasets. These datasets, which might contain various handwriting styles, would be critical in making the system more robust.*
    - ***Privacy Compliance****: Datasets used for crowdsourcing would also need to be compliant with* privacy regulations, ensuring that any personal information is either anonymized or removed.

Algorithms/Frameworks

The AI system for prescription recognition and data extraction relies on multiple algorithms and frameworks. The most important ones are:

- ***Convolutional Neural Networks (CNNs)****:*
    - ***Use****: CNNs are a type of deep learning model used primarily for image-related tasks, such as object detection and*

classification. In the case of this app, CNNs will be used to help with the OCR process, especially in recognizing and classifying different parts of the prescription image, such as distinguishing text from background noise.

  - ***Benefit**: CNNs excel in analyzing images and recognizing patterns, which is essential for accurate handwriting recognition.*
- ***Recurrent Neural Networks (RNNs)**:*
  - ***Use**: RNNs are typically used for tasks that involve sequential data, like text processing. They are particularly useful for recognizing handwritten characters and words that are structured in sequences (i.e., a prescription's name, dosage, and frequency).*
  - ***Benefit**: RNNs can maintain memory across sequences, allowing the model to handle the structure of handwriting more effectively.*
- ***Tesseract OCR**:*
  - ***Use**: Tesseract is one of the most widely used open-source OCR engines. It can extract text from images and is highly customizable for different languages and fonts.*
  - ***Benefit**: Tesseract is efficient at converting printed or handwritten text into machine-readable form, especially with some fine-tuning for challenging handwriting.*
- ***SpaCy**:*
  - ***Use**: SpaCy is a popular open-source NLP library for advanced natural language processing tasks. It can be used to parse the extracted text, identify entities (such as drug names and dosages), and categorize them.*
  - ***Benefit**: SpaCy's ability to process large volumes of text quickly and accurately makes it ideal for this application.*

- ***BERT (Bidirectional Encoder Representations from Transformers)***:
    - ***Use***: *BERT is a pre-trained transformer model for NLP tasks. It can be fine-tuned to recognize and categorize complex medical information (e.g., drug names, dosages, and instructions).*
    - ***Benefit***: *BERT's understanding of context in text makes it very powerful for tasks like named entity recognition, which is crucial for accurately extracting drug details from prescriptions.*

Code Implementation/Validation

```
!pip install pytesseract
!sudo apt install tesseract-ocr
```

```
import cv2
import numpy as np
import pytesseract
from keras.models import Sequential
from keras.layers import Conv2D, LSTM, Dense, MaxPooling2D, Flatten
import spacy
```

```
def preprocess_image(image="/content/IMG-20241019-WA0004.jpg"):
    img = cv2.imread("/content/IMG-20241019-WA0004.jpg")
    img = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
    img = cv2.GaussianBlur(img, (5,5), 0)
    img = cv2.resize(img, (128, 128))
    _, img = cv2.threshold(img, 0, 255, cv2.THRESH_BINARY + cv2.THRESH_OT
    return img
```


```
def preprocess_image(image="/content/IMG-20241019-WA0004.jpg"):
    img = cv2.imread("/content/IMG-20241019-WA0004.jpg")
    img = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
    img = cv2.GaussianBlur(img, (5,5), 0)
    img = cv2.resize(img, (128, 128))
    _, img = cv2.threshold(img, 0, 255, cv2.THRESH_BINARY + cv2.THRESH_OT
    return img
```

```python
def preprocess_image(img_path="/content/IMG-20241019-WA0006.jpg"):
    img = cv2.imread(img_path)
    img = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
    img = cv2.GaussianBlur(img, (5, 5), 0)
    img = cv2.resize(img, (128, 128))
    _, img = cv2.threshold(img, 0, 255, cv2.THRESH_BINARY + cv2.THRESH_OTSU)
    return img
```

```python
def build_cnn_model():
    model = Sequential()
    model.add(Conv2D(32, (3,3), activation='relu', input_shape=(128, 128, 1)))
    model.add(MaxPooling2D(pool_size=(2, 2)))
    model.add(Conv2D(64, (3,3), activation='relu'))
    model.add(MaxPooling2D(pool_size=(2, 2)))
    model.add(Flatten())
    model.add(Dense(256, activation='relu'))
    model.add(Dense(26, activation='softmax'))  # Assuming 26 characters (A-Z)
    model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accurac
    return model
```

```python
def ocr_tesseract(image):
    text = pytesseract.image_to_string(image)
    return text
```

```python
def extract_entities(text):
    nlp = spacy.load("en_core_sci_md")  # Use BioBERT for better medical term extracti
    doc = nlp(text)
    for ent in doc.ents:
        print(f"Entity: {ent.text}, Label: {ent.label_}")
```

```python
def process_prescription(image_path):
    # Step 1: Preprocess the image
    image = preprocess_image(image_path)

    # Step 2: Perform OCR
    text = ocr_tesseract(image)

    # Step 3: Extract medical entities using NLP
    extract_entities(text)

    return text
```

```python
import os
import xml.etree.ElementTree as ET
import cv2

# Function to read XML annotations and extract bounding box data
def parse_annotation(xml_file):
    tree = ET.parse(xml_file)
    root = tree.getroot()

    words = []
    bboxes = []

    for obj in root.findall('object'):
        word = obj.find('name').text  # Get the word label
        bndbox = obj.find('bndbox')

        # Get bounding box coordinates
        xmin = int(bndbox.find('xmin').text)
        ymin = int(bndbox.find('ymin').text)
        xmax = int(bndbox.find('xmax').text)
        ymax = int(bndbox.find('ymax').text)

        # Store word and its bounding box
        words.append(word)
        bboxes.append((xmin, ymin, xmax, ymax))

    return words, bboxes

# Function to draw bounding boxes on the image
def draw_bboxes(image_path, words, bboxes):
    image = cv2.imread(image_path)

    for i, bbox in enumerate(bboxes):
        xmin, ymin, xmax, ymax = bbox
        word = words[i]

        # Draw bounding box
        cv2.rectangle(image, (xmin, ymin), (xmax, ymax), (0, 255, 0), 2)

        # Put the label (word) near the bounding box
        cv2.putText(image, word, (xmin, ymin - 10), cv2.FONT_HERSHEY_SIMPLEX, 0.6, (0, 255, 0), 2)

    # Display the image with bounding boxes
    cv2.imshow("Labeled Image", image)
    cv2.waitKey(0)
    cv2.destroyAllWindows()

# Example usage
if __name__ == "__main__":
    # Path to your image and its corresponding annotation file
    image_path = 'prescription_image.jpg'
    annotation_path = 'prescription_image.xml'

    # Parse the XML file to get word labels and bounding boxes
    words, bboxes = parse_annotation(annotation_path)

    # Draw the bounding boxes on the image and display
    draw_bboxes(image_path, words, bboxes)
```

Conclusion:

This AI-powered prescription scanning and management system is a powerful tool that leverages advanced AI models, NLP, and OCR to improve the accuracy and efficiency of converting handwritten prescriptions into digital formats. By combining cutting-edge technologies, a skilled team, and clear processes, this product is poised to streamline healthcare workflows, reduce transcription errors, and improve patient outcomes.