Ran2Dev OCR Project Summary

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Ran2Dev: Converting Ranjana Lipi to Devanagari Script (Without Modifiers)

Project Summary Document

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Project Overview

Ran2Dev is a machine learning-based Optical Character Recognition (OCR) system that converts Ranjana Lipi, an ancient Newar script, into Devanagari script. This project was initiated to preserve historical Newar manuscripts and provide accessibility through digitization. The solution lies within the domains of Computer Vision and Natural Language Processing, where OCR and character-level recognition are key components. The system primarily focuses on recognizing Ranjana characters without modifiers.

History and Importance of Ranjana Lipi

Ranjana Lipi originated in the 7th century and was historically used for writing in Nepal Bhasa, Sanskrit, and Pali. It features 36 consonants, 16 vowels, and 10 numerals. Despite its artistic elegance and cultural relevance in Buddhism and Hinduism, its usage declined under the suppression of the Rana regime. The script continued in religious contexts and experienced revival efforts post-1951. Ranjana Lipi holds cultural significance and has been officially recognized in Nepal's Bagmati Province since 2024.

Models Used and Architecture

Two models were implemented and tested for character recognition. The first, LeNet-5, is a classical

convolutional neural network consisting of 2 convolutional layers, 2 pooling layers, and 3 fully connected layers. It accepts 32x32 grayscale images and achieved an accuracy of 99.10%. The second, Ran2Dev, is a custom-designed CNN with 3 convolutional layers, max and average pooling, and 3 dense layers, optimized for 64x64 grayscale input. It achieved a higher accuracy of 99.74%. Both models were trained using backpropagation and evaluated with precision, recall, and F1 score metrics.

Preprocessing Techniques

To improve model performance, images are preprocessed through grayscale conversion, aspect ratio scaling, normalization, and binarization using Otsu's Thresholding and Binary Inversion. Gaussian Blur is applied to remove noise. These steps ensure cleaner and more consistent input for character recognition, especially for handwritten texts that may vary in intensity or contain noise.

Questions and Answers

1. Who developed the Ran2Dev project?

The project was developed by Nekesh Koju, Nischal Baidar, Sarif Tachamo, and Surag Basukala, students of Khwopa Engineering College under the supervision of Er. Shree Ram Khaitu.

2. What is Ranjana Lipi and why is it important?

Ranjana Lipi is a traditional Newar script known for its artistic structure. It has historical significance in religious and literary contexts and was used extensively before the 20th century. Its preservation is vital for safeguarding Newar heritage.

3. How does the OCR system work?

The system takes a scanned or handwritten image in Ranjana Lipi, preprocesses it, and uses a trained CNN model to recognize characters. The recognized characters are mapped to their Devanagari equivalents.

4. What models are compared in the project?

LeNet-5 and a custom model named Ran2Dev were used. Ran2Dev outperformed LeNet-5 in terms of

accuracy and precision.

5. What preprocessing steps are used?

Images undergo grayscale conversion, aspect ratio scaling, normalization, binarization using Otsu thresholding, binary inversion, and Gaussian blur filtering.

6. How was the dataset prepared?

The dataset was collected from manuscripts, online sources, and institutional resources. It includes labeled images segmented for character-level recognition.

7. What is the real-world use of this system?

This system helps preserve and digitize ancient Newar texts, making them accessible for scholars, cultural institutions, and the visually impaired.

8. Can it recognize full words or sentences?

The system currently focuses on characters and words without modifiers. Full sentence recognition and modifier support are planned for future enhancements.

9. What tools were used?

TensorFlow, Keras, OpenCV, Flask, and MLFlow were used in model building, preprocessing, deployment, and monitoring.

10. Is there a mobile version?

A mobile app is under development using TensorFlow Lite for on-device inference.

11. How is the model evaluated?

The models are evaluated using accuracy, precision, recall, F1 score, ROC curves, and confusion matrices.

12. What are the future enhancements?

Plans include modifier support, improved UI, mobile deployment, rotational and distortion handling, and

larger dataset integration.

System Design & Implementation

The project follows a modular architecture. The frontend lets users upload Ranjana script images. The backend, built with Flask, processes the image, selects the appropriate model (LeNet-5 or Ran2Dev), performs prediction, and returns the result. The prediction pipeline involves preprocessing, model inference, and character-to-Devanagari mapping. A use case and data flow diagram supports the development and explanation of the system.

Conclusion

Ran2Dev provides a valuable solution to the problem of Ranjana Lipi recognition and conversion. By leveraging CNNs, this system not only achieves high accuracy but also offers a path for reviving and digitizing ancient scripts. With future enhancements, it aims to support more complex recognition tasks and broaden its accessibility through mobile platforms.

Expanded Scope and Applications

The Ran2Dev project has a wide array of applications beyond simple text recognition. It plays a crucial role in digitizing cultural heritage, especially endangered scripts. It provides a valuable tool for linguists, researchers, and cultural institutions to access ancient Newar manuscripts more easily. The system is also designed to be scalable and adaptable, allowing for extension into recognizing full sentences and incorporating modifiers in future versions. Potential users include historians, language ...

Limitations of the Current System

Despite its high accuracy, the current version of Ran2Dev has some limitations. It only supports character

recognition without modifiers, limiting its usage to basic text structures. The OCR is also sensitive to input quality; poorly aligned, smudged, or distorted characters may reduce accuracy. Additionally, the model has only been trained on a specific dataset size and diversity; therefore, its performance may vary with different handwriting styles. Future work is required to make the model more robust...

Real-world Use Cases

Ran2Dev can be integrated into museum archives for digitizing and cataloging ancient scripts. Schools and educational institutions can use the system to teach students about historical writing systems. Scholars and language preservationists can benefit from easier access to scanned texts and automatic conversions for study. The system is also intended to support visually impaired users by converting hard-to-read script into accessible text formats via screen readers.

Technologies and Frameworks Used

- TensorFlow and Keras: For building and training the neural network models (LeNet-5 and Ran2Dev).
- OpenCV: For image preprocessing, such as resizing, grayscale conversion, and thresholding.
- Flask: Used to build a web API that accepts user inputs and returns predictions.
- MLFlow: For tracking and visualizing model performance across training sessions.
- Streamlit (Future): Planned for creating interactive demo dashboards.
- TensorFlow Lite: Used for converting models into mobile-compatible formats.

Future Enhancements in Detail

To make the system more comprehensive and accessible, the following enhancements are planned:

- Modifier and Ligature Support: Extend OCR capabilities to support compound characters and linguistic modifiers in Ranjana script.
- Cross-Script Support: Enable recognition of other Newar scripts like Bhujinmol and Golmol.
- Enhanced Segmentation: Improve handling of full words and sentence-level predictions.

- Robust Error Correction: Integrate contextual grammar models for refining recognition accuracy.
- Offline Mobile Application: Use TensorFlow Lite for Android apps that can run offline without heavy computation.
- Community Input: Enable community-submitted samples to help build a larger, more diverse dataset.

Why This Project Matters

Languages and scripts are vessels of culture and identity. The decline of Ranjana Lipi means a gradual erosion of Newar cultural heritage. This project represents a technological effort to fight this decline. By converting Ranjana script into digital, editable Devanagari text, we preserve ancient knowledge and help reintroduce this beautiful script into daily life, academic research, and spiritual practices. Ran2Dev is more than a tech projectits a cultural preservation initiative.