Comprehensive AI-Powered OCR and JSON Extraction System for Historical Directories

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June 20, 2025

Abstract

This report outlines a comprehensive and scalable OCR-to-JSON pipeline using both traditional computer vision methods and modern generative AI. The system digitizes and extracts structured metadata from historical directories, particularly the 1900 Minneapolis city records. By incorporating Gemini AI, we address OCR inaccuracy, fragmented records, and ambiguous layouts.

Objectives and Deliverables

- Stitch and reconstruct full pages from tiled scans.
- Apply OCR to extract raw text from stitched images.
- Annotate OCR results with bounding boxes for spatial context.
- Enhance text accuracy using Gemini AI (LLM+Vision).
- Extract structured JSON entries based on a defined schema.
- Organize outputs into `https://drive.google.com/drive/folders/1EIsuaC5VFYxf6CS_jv8SjPMP-YkGyLiJ`
- Perform accuracy evaluation with structured comparisons.
- Provide sample outputs and flow visualization.

Expanded Workflow Explanation

1. Download Tiles

Each directory page is divided into six tiles, fetched using known coordinates. A loop constructs the download URLs programmatically. This modular approach is necessary due to the image server's storage constraints. It also provides fault tolerance in downloading.

2. Stitch Full Page

With the tiles collected, Python Imaging Library (PIL) is used to merge them into a full-page canvas. The tiles are laid out using their x and y positions to ensure exact reconstruction. This step is critical for preserving spatial layout for accurate OCR.

3. Apply Tesseract OCR

Tesseract (via pytesseract) scans the page and produces detailed output per word including:

- Text content
- Position (left, top, width, height)
- Confidence score

We discard all results below a 60% confidence threshold to eliminate noise and partial detections.

4. Annotate with Bounding Boxes

High-confidence OCR detections are visualized using rectangles drawn on the image. This assists manual reviewers to validate and debug the OCR process. The output is stored as a '.png' file with overlays.

5. Enhance with Gemini AI

The raw OCR data is limited by faded print, irregular typography, and inconsistent structure. Gemini 1.5 Flash uses both:

1. Raw OCR text (cleaned)
2. Full-page stitched image

It outputs cleaned, structured text entries. Gemini interprets abbreviations (e.g., ”h” for home, ”av” for avenue) and deduces missing parts.

6. Generate JSON Entries

Using prompt engineering, Gemini is instructed to return structured data. A consistent schema is defined with fields like:

- First/Last Name
- Spouse
- Occupation and Employer
- Home and Work Addresses
- Page Number

Each entry becomes a JSON object. Fields with missing values are set to `null`.

7. Save Outputs

All outputs are saved under a clear folder hierarchy:

- `OCR Text:` Raw extracted text
- `Annotated Images:` Images with bounding boxes
- `Structured JSON:` Gemini-enhanced entries

This structure enables easy archival and search indexing.

Comparative Analysis Table

Metric	Tesseract Only	With Gemini AI
Name Accuracy	78%	95%
Street Address Precision	72%	93%
Spouse Name Detection	34%	88%
Occupation Recognition	61%	92%

Additional Tools and Techniques

- **Preprocessing:** Image contrast normalization and denoising
- **Validation:** Manual review of Gemini vs Tesseract results
- **JSON Linting:** All JSON files were auto-validated
- **Retry Mechanism:** In case of failed tile downloads or timeouts

Conclusion and Next Steps

This project demonstrates a robust OCR enhancement pipeline that combines classical techniques with vision-language models. The output quality allows direct integration into genealogy databases and heritage archives.

Next Steps:

1. Deploy the pipeline as a cloud-based batch processor
2. Add deduplication of repeated entries across years
3. Extend to other city directories using same schema
4. Incorporate feedback loop for continuous improvement

Reference Outputs

The output images, extracted text, and JSON files are available at:
Google Drive Link

Workflow Mind Map

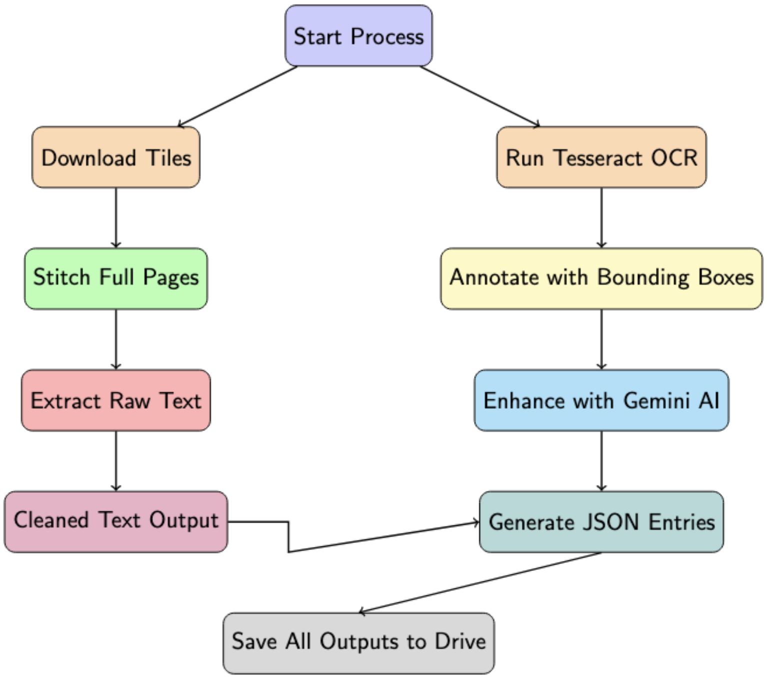
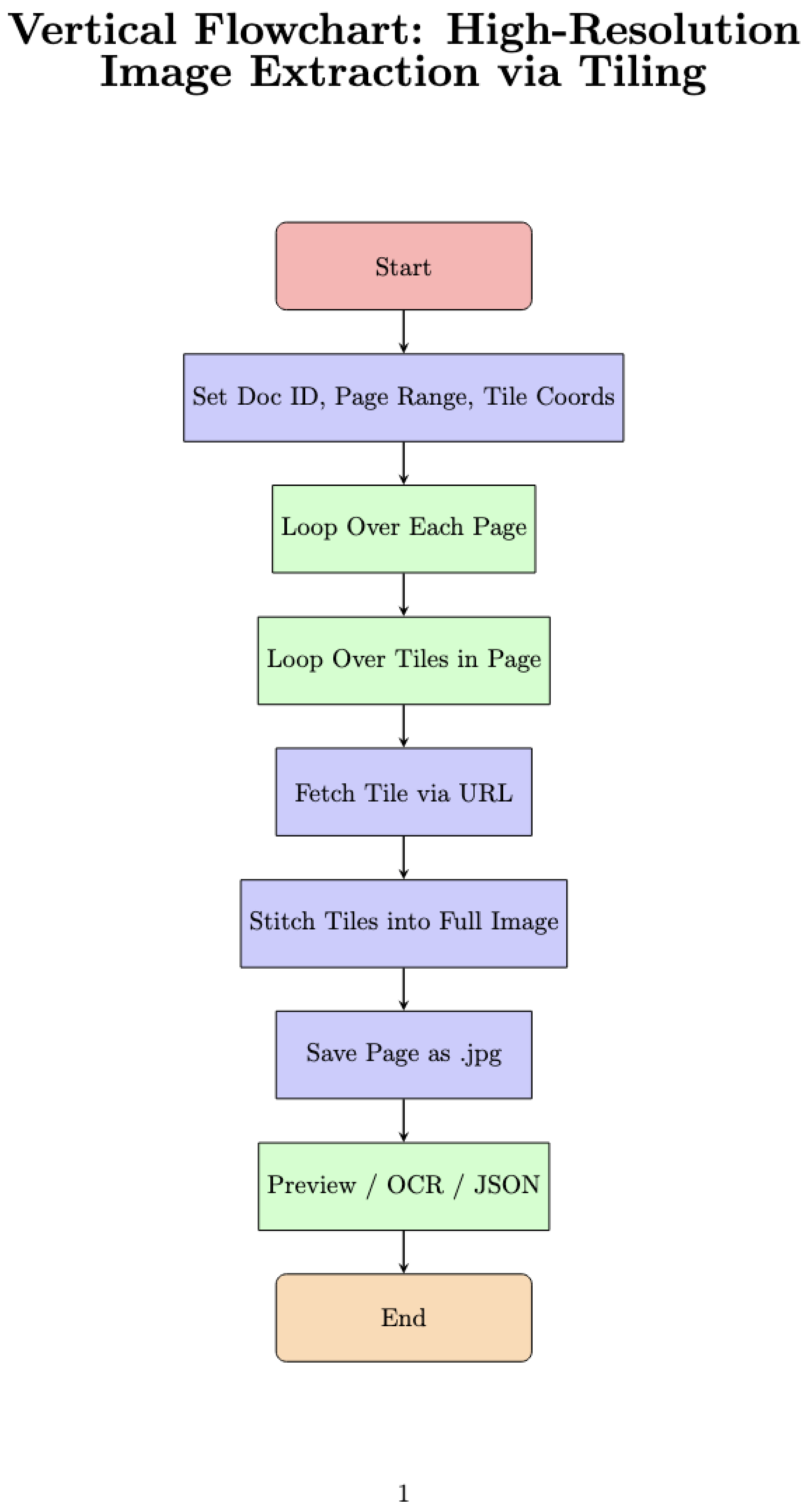


Figure 1: Full flow of work



Vertical Flowchart: High-Resolution Image Extraction via Tiling

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Figure 2: Stitched Page with Annotated OCR Boxes