Generating Building Drawings using Photogrammetry and Deep Learning

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Table of Contents

Introduction

- In cases involving old structures, it is difficult to obtain precise measurements employing traditional methods.Therefore,a computer-aided approach is needed to efficiently produce these drawings.
- This research introduces a method that uses image-processing techniques like photogrammetry and deep learning to generate building drawings, significantly reducing both time and cost compared to traditional approaches.

Motivation

- The growing need for quick and affordable solutions in architectural design drives the demand for innovative methods that can benefit architects, urban planners, and researchers by reducing time and financial barriers.
- This research proposes a novel approach to address these limitations, offering a more accessible and efficient method for generating building drawings.

Problem Statement

- The research, ”Generating Building Drawings using Photogrammetry and Deep Learning ,” addresses the challenge of creating accurate building drawings, particularly for old buildings. These limitations highlight the need for automated and cost-effective solutions.
- **Gaps:** Though there are software tools to obtain 3D models using various scanning techniques, there isn’t any existing model that provides the elevation drawing of the building in DXF format.

Objectives

- To develop a computationally efficient and simple method for producing accurate architectural drawings in a desired format that can be viewed and edited in CAD software.
- To generate accurate drawings without the use of complex LiDAR and laser-based systems.

Related Work - 1

Name	H/W Used	S/W Used	Technology Used	Result
Documentation of architectural scenes using a hierarchical method (2010)	8 MP point and shoot camera	Custom Model	Harris Corner Detector, SFM, RANSAC, CAM-PLAN	3D model of Anna University created using 100 photos on 8 MP camera; part of software contains text data.

Related Work - 2

Name	H/W Used	S/W Used	Technology Used	Result
Architectural Photogrammetry: A low-cost image acquisition method in documenting built environment (2021)	Canon DSLR D60, DJI Phantom 4	Lightroom, ContextCapture	Point Cloud Generation	3D model of SEWU temple created; results were compared to laser-scanned model and found to be a good enough solution.

Related Work - 3

Name	H/W Used	S/W Used	Technology Used	Result
Quality enhancement in Digital Twin production of complex architectures with integrated use of terrestrial and aerial images (2023)	Nikon D300, DJI Phantom 4, CHC i80 GNSS, Geomax Zoom25	Lightroom, ContextCapture	Point Cloud Generation	3D point cloud model of Gebze Technical University Geomatics Engineering Building, along with roof.

Related Work - 4

Name	H/W Used	S/W Used	Technology Used	Result
3D modeling of cultural heritage with point cloud generation by integrating UAV and terrestrial photogrammetry techniques (2023)	Canon EOS600D, DJI Zenmuse P1, Topcon HiPer Sr GPS, Topcon GPT-3500	Agisoft Metashape	Structure from Motion	3D model of Yildiz Technical University Guest House building; 53 aerial photos and 521 ground photos used.

Related Work - 5

Name	**H/W Used**	**S/W Used**	**Technology Used**	**Result**
3D Modeling of Sanggrahan Temple using UAV imagery and terrestrial photogrammetry method (2023)	Nikon D300 DSLR 24MP, DJI Phantom 4, 20MP	N/A	Structure From Motion	Dense point cloud model, mesh model, and textured model made of Sanggrahan Temple.

Methodology - Approach 1

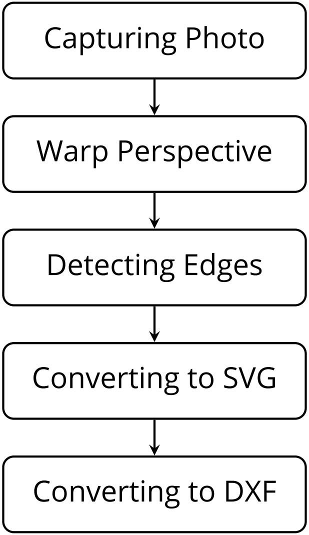

Figure 1: Flowchart of Approach 1

Methodology - Approach 1

- A single image is captured of the front view of building.
- Orthographic projection is obtained using the warp perspective function from OpenCV python library.
- Canny edge detector is applied to this contour image after converting it to grayscale.
- The resulting image is converted into a SVG file using the svgwrite Python library.
- This SVG image is then converted to a DXF file using the INKSCAPE application.

Methodology - Approach 2

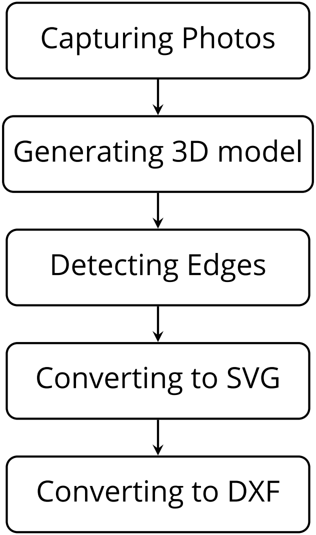

Figure 2: Flowchart of approach 2

Methodology - Approach 2

- Around 100-150 photos taken with more than 80% overlap.
- Photos are taken at varying height and from different angles.
- Here Agisoft metashape is used for generating 3d model.
- A custom edge detecion pipeline is used for quality edge detection.
- Image processing and Conversion is done using Python and its various libraries.
- Click here to see Application

Methodology - Approach 2 Edge Detection

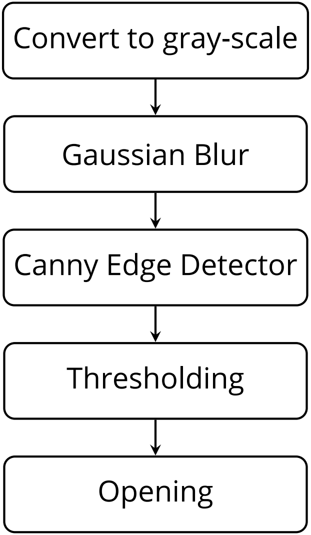

Figure 3: Flowchart of Custom Edge Detection Pipeline

Methodology - Approach 2 Edge Detection

- Converting to grayscale to reduce complexity and increase accuracy of edge detection algo.
- Gaussain blur reduces noise resulting in sharp and clear edges.
- Thresholding is used to convert image to binary further reducing noise.
- Opening reduces noise and remove small edges keeping meaningful data and increasing accuracy.
- Here opencv and numpy are used for image processing tools and for working with array respectively.

Methodology - Approach 2 Obtaining Projection

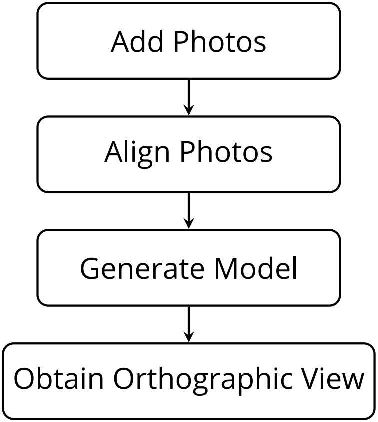

Figure 4: Flowchart of Obtaining Orthographic Projection

Methodology - Approach 2 Obtaining Projection

- Generation of 3d model is done in Agisoft Metashape which is a professional photogrammetry software.
- The quality of generates model depends on the quality and quantity of photos used.
- The textured view of model provide realistic view of model.
- 3d model is used obtain the orthographic view,this orthographic view image is further processed to get the drawing of building.

Methodology - Improvements Made in Approach 2

- 3D Modelling instead of Warp perspective.
- Custom Edge Detection Pipeline
- EZDXF Python library instead of INKSCAPE

Methodology - Approach 3

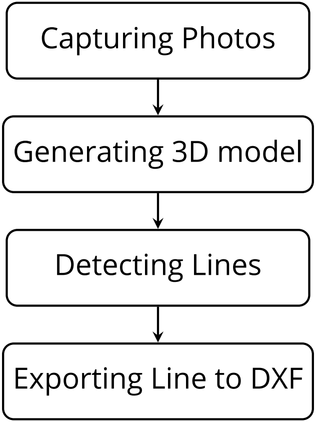

Figure 5: Flowchart of approach 3

Methodology - Approach 3

- This builds upon the previous approach, and all the steps remain the same for obtaining the orthographic projection of the building using a 3D model built in METASHAPE.
- Once the orthographic view image is obtained, it is processed using the Line Segment Detector (LSD) function from the OpenCV library.
- The LSD (Line Segment Detector) in OpenCV is based on the LSD algorithm developed by Rafael Grompone von Gioi et al. in 2012
- The LSD function extracts a NumPy array of detected line segments, where each entry consists of four values representing the segment's start and end coordinates.
- This output array is then utilized to generate the DXF file.

Methodology - Improvements made in Approach 3

- OpenCV's line segment detector instead of an edge detection pipeline.
- Directly plotting the lines in the output.

Methodology - Approach 4

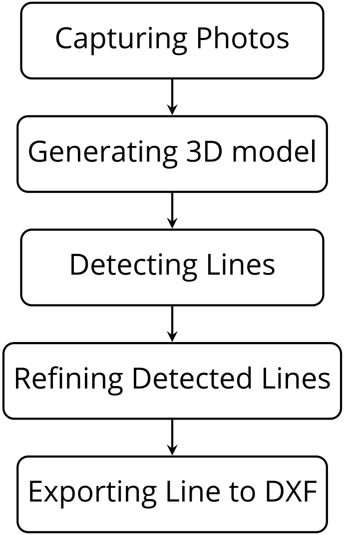

Figure 6: Flowchart of approach 4

Methodology - Approach 4

- This builds upon the previous approach, and all the steps remain the same for obtaining the orthographic projection of the building using a 3D model built in METASHAPE.
- Once the orthographic view image is obtained, it is processed using DeepLSD.
- DeepLSD (Deep Learned Line Segment Detector) is a deep learning-based line segment detector that improves upon traditional methods like LSD by leveraging neural networks for more robust and accurate line detection.
- DeepLSD provides an array of detected lines, similar to OpenCV's LSD.
- This output array is then refined using custom functions to improve line accuracy and continuity before generating the DXF file.

Methodology - Approach 4 Refining Lines

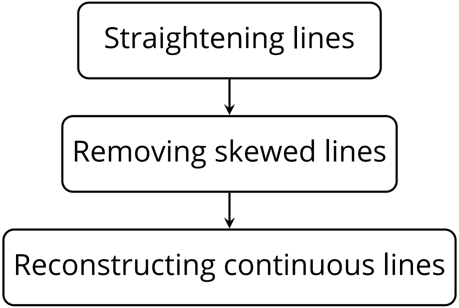

Figure 7: Flowchart of Lines Refinement.

Methodology - Approach 4 Refining Lines

- Small angular deviations are corrected using numerical adjustments on the line endpoints.
- Lines that do not conform to 0° or 90° orientations are identified and filtered out.This step helps eliminate unnecessary diagonal or misaligned segments.
- Small, fragmented line segments that align with each other are merged into longer, continuous lines.

Methodology - Improvements made in Approach 4

- DeepLSD instead of OpenCV's LSD.
- Custom Functions for Line Refinement.

Results and Analysis

Figure 8: Result of Approach 1

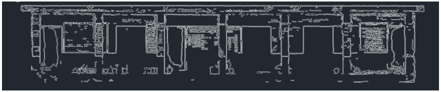

Figure 9: Result of Approach 2

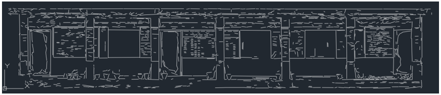

Figure 10: Result of Approach 3

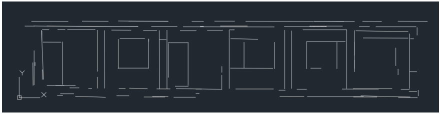

Figure 11: Result of Approach 4

Results and Analysis

- The proposed model is able to generate elevation drawings of buildings in DXF format.
- These generated drawings can be easily scaled within CAD software to accurately represent the building's measurements.
- A robust Line Segment Detector enhanced with refining methods extracts detailed contour information from the image, while effectively filtering out noise.

Results and Analysis-Comparison

Approach	Obtaining Projection	Edge/Line Detection	DXF Creation
Approach 1	Warp Perspective	Canny Detector	Svgwrite and Inkscape
Approach 2	3D model	Custom Edge Detector	Svgwrite and Ezdxf
Approach 3	3D model	OpenCV LSD	Ezdxf
Approach 4	3D model	DeepLSD+Refining	Ezdxf

Table: Comparison of Different Approaches

Conclusion

- The proposed model is capable of generating building drawings with the desired accuracy while maintaining minimal computational requirements.
- This model offers a cost-effective solution for building documentation, requiring only a fraction of the cost compared to traditional methods.

References

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