Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

School of Computer Science and Engineering

CSE4019 – Image Processing

3D Model Creation from Building Segmentation of Satellite Images

A project submitted

in partial fulfilment of the requirements for the degree of

Bachelor of Technology (CSE with specialization in Information Security)

By

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Table of Contents

List of Figures

List of Tables

1. Abstract

The project focusses on building 3D models from buildings' segmentation from satellite images. The software built for the project takes an image as input, predicts the segmentation using a machine learning model, followed by a series of image processing techniques to identify the contours and areas of the identified building segments. This information is carried on to create the 3D models.

2. Aim

The aim is to create a project that allows to build 3D models from buildings' segmentation from satellite images.

3. Objective

The objective of the project is to create a software that would identify and build 3D models of buildings from an input image.

The objectives include the following:

1. Creating a CNN based machine learning model to predict the segmentation of buildings in the image
2. Create a flow of image processing steps on the intermediate results to prepare the contour information for the Unity module
3. Create the Unity module which uses this information to create 3D models

4. Literature survey

4.1 [1] Satellite Image Classification for Detecting Unused Landscape using CNN

This paper contributes to the automation of the process of finding vacant land space. A is used in this work. It is a satellite image processing technology that discovers unused land. suggested. As the basis for this study, remote sensing earth photographs are used. dataset in which the pre-processing stage involves image conversion picture conversion to greyscale, compression, and noise removal Segmentation is used to divide a region into useful and unused areas. lands. Local binary feature extraction is used in this case.

Method for identifying edge, flat, and corner surfaces As The many algorithms listed above are utilized in categorization and remote sensing earth image labelling The CNN algorithm is also used. categorization is used, and classification labelling is completed automatically by the use of the CNN algorithm.

4.2 [2] Conjunction and synchronization methods of earth satellite images with local cartographic data

There is a quick summary of interactive maps of the area and various perspectives, including interactive maps with visualization. The most popular services in the area with interactive maps, as well as their types and applications, are considered. The technique for processing satellite photos and then placing them in cartographic services is provided.

Individual project fragments for editing interactive maps for various types of locations are also offered. Orientation problems with greatest precision are discussed using the services OpenStreetMap, Yandex. Maps, and Google Earth, as well as the benefits of using interactive maps for different types of users.

4.3 [3] Satellite Image Analysis: A Review

A great deal of work has been done for satellite image analysis, which includes studies ranging from classification of handcrafted characteristics for high performance computing using satellite imagery The researchers have accomplished a lot. achievement in satellite image analysis However, a systematic review,

It will help researchers to pinpoint the issue and to develop a solution There is a void in this field. An example is given in the preceding chapter. An attempt has been made to offer a comprehensive review of a variety of satellite image processing, classification, and analysis steps databases that are available This chapter will provide impetus for additional study in this subject and will serve as a baseline to investigation into satellite image processing.

5. Proposed Methodology

5.1 High Level Overview

Modules Involved:

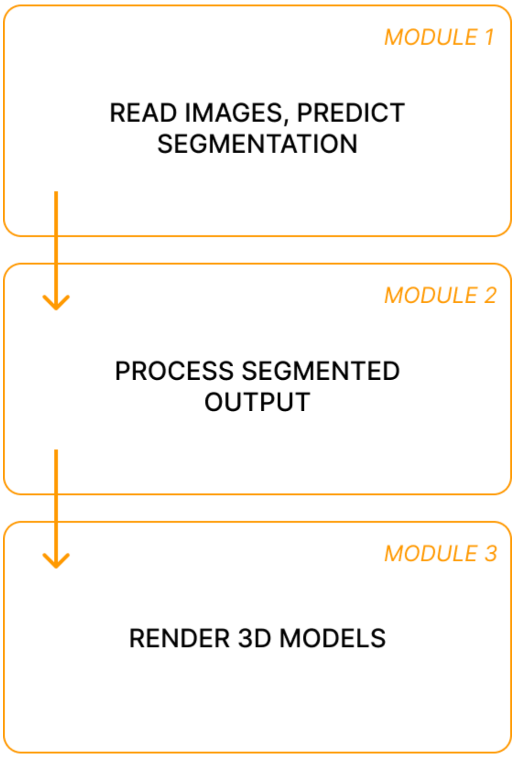

Fig 1 - Modules involved: High Level

5.2 Module Description:

5.2.1 Segmentation Prediction using machine learning model

This module uses a machine learning model to predict the segmentation of buildings in the input image.

The machine learning model is trained using a dataset obtained from Kaggle.

PARAMETERS	VALUES
BLOCK_COUNT	1
EDGE_CROP	16
BASE_DEPTH	16
SPATIAL_DROPOUT	0.25
GAUSSIAN_NOISE	0.1
BATCH_SIZE	24

Table 1 - Image parameters for dataset

5.2.1.1 Model Training

PARAMETERS	VALUES
LOSS	-0.3901
DICE_COEF	0.4719
BINARY_ACCURACY	0.7219
TRUE_POSITIVE_RATE	0.6625
VAL_LOSS	-0.4025
VAL_DICE_COEF	0.4941
VAL_BINARY_ACCURACY	0.7501
VAL_TRUE_POSITIVE_RATE	0.6101

Table 2 - Parameters for model training

5.2.1.2 Model Summary

Layer (type)	Output Shape	Param #	Connected to
RGB_Input (InputLa yer)	(None, 300, 300, 3)	0	-
gaussian_noise_1 (G aussianNoise)	(None, 300, 300, 3)	0	RGB_Input[0][0]
batch_normalization _1 (BatchNor)	(None, 300, 300, 3)	12	gaussian_noise_1[0] [0]
conv2d_1 (Conv2D)	(None, 300, 300, 8)	216	batch_normalization _1[0][0]
batch_normalization _2 (BatchNor)	(None, 300, 300, 8)	32	conv2d_1[0][0]
activation_1 (Activat ion)	(None, 300, 300, 8)	0	batch_normalization _2[0][0]
conv2d_2 (Conv2D)	(None, 300, 300, 8)	576	activation_1[0][0]
batch_normalization _3 (BatchNor)	(None, 300, 300, 8)	32	conv2d_2[0][0]
activation_2 (Activat ion)	(None, 300, 300, 8)	0	batch_normalization _3[0][0]
conv2d_3 (Conv2D)	(None, 300, 300, 1 6)	1152	activation_2[0][0]
batch_normalization _4 (BatchNor)	(None, 300, 300, 1 6)	64	conv2d_3[0][0]

activation_3 (Activation)	(None, 300, 300, 16)	0	batch_normalization_4[0][0]
conv2d_4 (Conv2D) x 6	(None, 300, 300, 16)	2304	activation_3[0][0]
concatenate_1 (Concatenate)	(None, 300, 300, 99)	0	batch_normalization_1[0][0]
spatial_dropout2d_1 (SpatialDro)	(None, 300, 300, 99)	0	concatenate_1[0][0]
batch_normalization_5 (BatchNor)	(None, 300, 300, 99)	396	spatial_dropout2d_1[0][0]
activation_4 (Activation)	(None, 300, 300, 99)	0	batch_normalization_5[0][0]
conv2d_10 (Conv2D)	(None, 300, 300, 32)	28512	activation_4[0][0]
batch_normalization_6 (BatchNor)	(None, 300, 300, 32)	128	conv2d_10[0][0]
activation_5 (Activation)	(None, 300, 300, 32)	0	batch_normalization_6[0][0]
conv2d_11 (Conv2D)	(None, 300, 300, 1)	33	activation_5[0][0]
cropping2d_1 (Cropping2D)	(None, 268, 268, 1)	0	conv2d_11[0][0]
zero_padding2d_1 (ZeroPadding2D)	(None, 300, 300, 1)	0	cropping2d_1[0][0]

Table 3 – CNN Model Summary

Total params: 44,977

Trainable params: 44,645

Non-trainable params: 332

5.2.1.3 Dataset

Link: https://www.kaggle.com/code/kmader/segmenting-buildings-in-satellite-images/data

Total number of images: 281,000

5.2.2 Image processing on Segmentation

The segmented intermediate output image is processed through the following image processing steps, as follows:

i. Bilateral Filter
ii. Color space transformation from BGR to GRAY
iii. Dilation
iv. Erosion
v. Canny Edge Detection
vi. Contour Detection

The bilateral filter is a non-linear, smoothing filter, that preserves edges in the image. The intensity of each pixel is replaced with the weighted average of the intensity values of the nearby pixels.

The ***cv2.bilateralFilter()*** is used for the above operation

The color space is converted from BGR to GRAY. The ***cv2.cvtColor()*** function is used for this operation.

Dilation operation is performed to expand the image pixels, and adds pixels in the object boundaries. The ***cv2.dilate()*** function is used for this operation.

Erosion operation is performed to remove the image pixels, and removes pixels from the object boundaries. The ***cv2.erode()*** function is used for this operation.

Canny Edge detection is a multi-stage algorithm to detect a range of edges in images. The ***cv2.Canny()*** function is used for this operation.

Contours are curves joining all continuous points having the same color and intensity. Detecting these is termed contour detection. The ***cv2.findContours()*** and ***cv2.contourArea()*** function is used for this operation, and returning the area of the identified contours.

5.2.3 Render 3D models

The information regarding the contours and the areas of the identified contours are used to render the 3D models. The information is stored in the local storage of the web browser, which is read from the jslib plugin file, which is used to communicate with the browser from the WebGL block.

Once the values are read, the Generator file would create 3D block prefabs of appropriate area as returned by the segmented outputs stored locally in the browser.

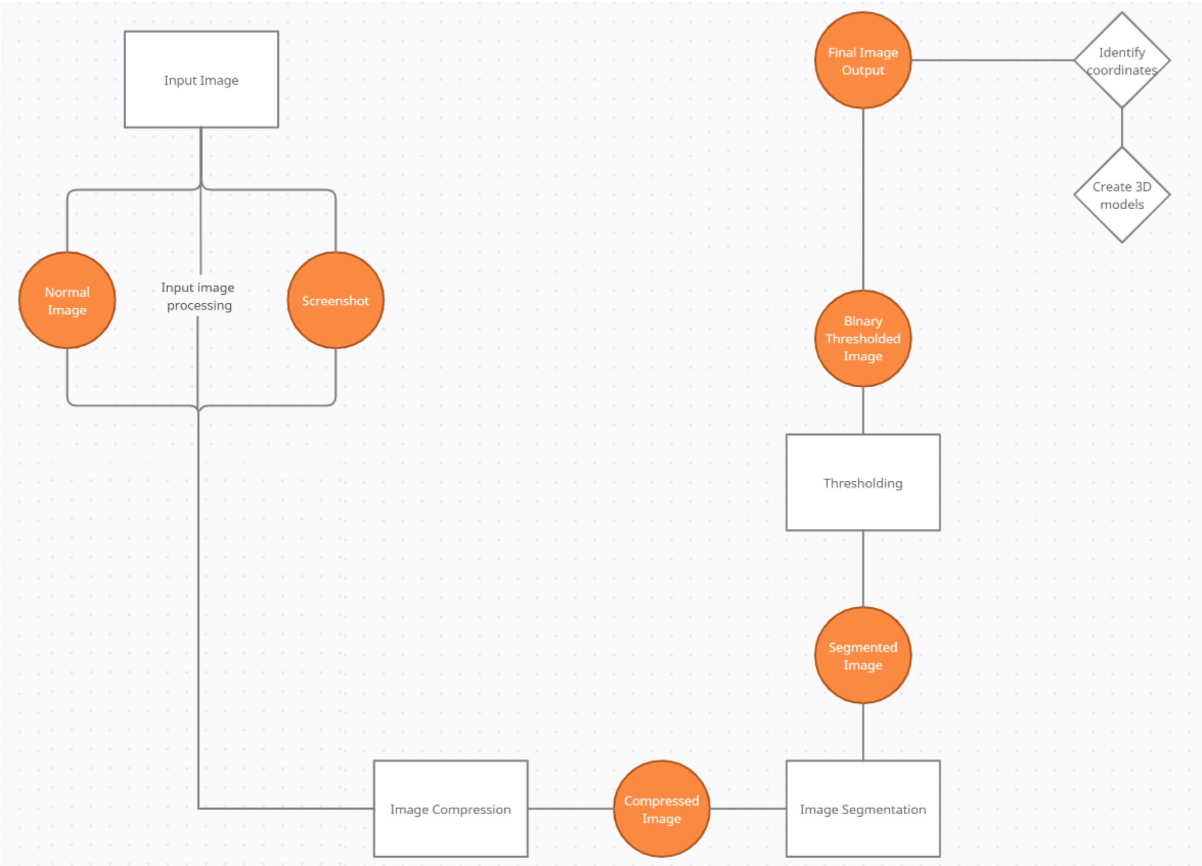

Fig 2 - Module 2: Process segmented output

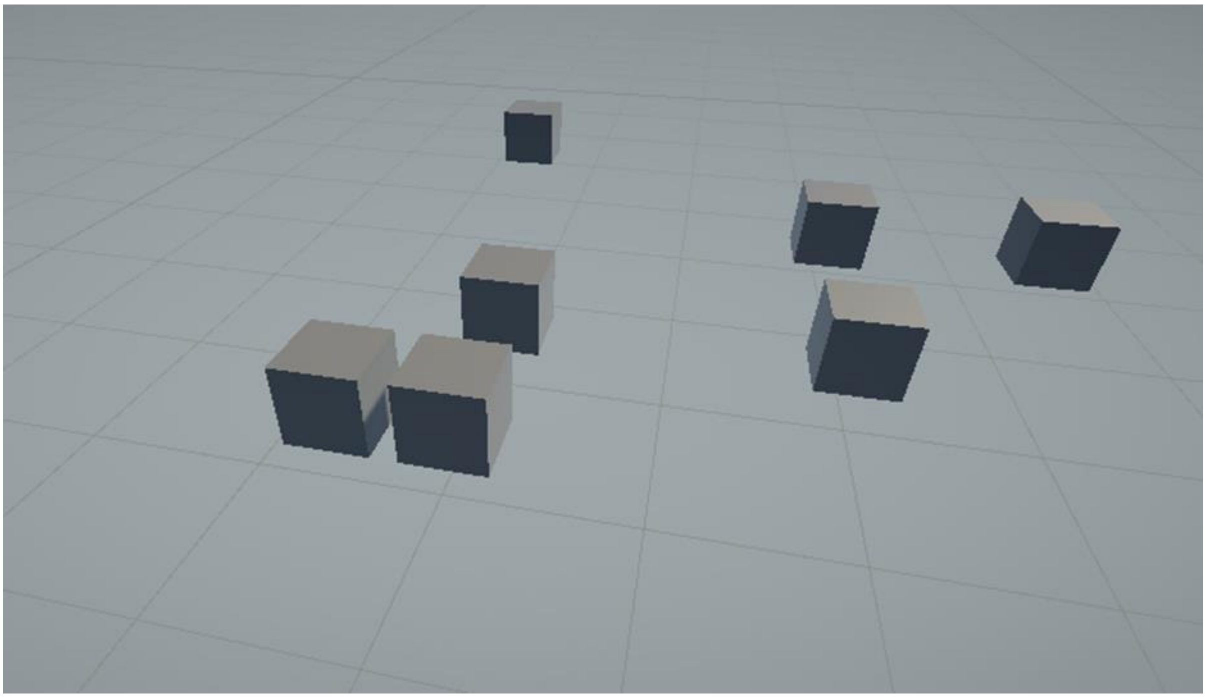

Fig 3 - Module 3: Rendered 3D models of the identified segmented buildings

The image input is taken, followed by compression. The compressed image is fed into a trained machine learning model. The machine learning model predicts the accurate segmentation for the buildings in the image. The segmentation is preformed followed by a thresholding operation. The threshold output is further processed in the following order.

vii. Bilateral Filter
viii. Color space transformation from BGR to GRAY
ix. Dilation
x. Erosion
xi. Canny Edge Detection
xii. Contour Detection

The output yields the image with contours marked as well as the areas of each identified contour. This information is now passed to the Unity module. The Unity module creates 3D blocks of the respective areas as returned by the previous module.

6. Results

The web application renders a 3D model of the segmented buildings in the input image

7. References

1] Akshay, S., Mytravarun, T. K., Manohar, N., & Pranav, M. A. (2020, July). Satellite image classification for detecting unused landscape using CNN. In 2020 International Conference on Electronics and Sustainable Communication Systems (ICESC) (pp. 215-222). IEEE.

[2] Dymkova, S. S. (2020, March). Conjunction and synchronization methods of earth satellite images with local cartographic data. In 2020 Systems of Signals Generating and Processing in the Field of on Board Communications (pp. 1-7). IEEE.

[3] Babbar, J., & Rathee, N. (2019, February). Satellite image analysis: A review. In 2019 IEEE International Conference on Electrical, Computer and Communication Technologies (ICECCT) (pp. 1-6). IEEE.

8. Code

Link: https://github.com/PranavPrakasan07/Map-Build