Flood Damage Assessment

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***Abstract*—The outbreak of floods results into miserable and devastating property loss. This leads to the need of primarily devising a topographical detailed study of the real estate for property evaluation. With an intent to carter to the required precautionary measures arising from the probable aftermath of the floods, the 'Government of Alberta' has proposed to come up with a technical system that estimates the property worth of every accommodation. In order to estimate every residential accommodation, we classify them on basis of the area covered by it and its architectural design that have been provided to us by the 'Alberta Environment and Parks'.**

Keywords—street view images, GIS, contour-extraction, area

I. MOTIVATION

The idea of integration between 'Geographical Earth Science' and 'Image Processing' has always fascinated us. We therefore were motivated to implement the 'Flood Damage Assessment' project which exactly fits the bill. Moreover, we were keen on learning the broad aspects of Google Maps, Remote Imaging and GIS along with image processing techniques to the core.

II. PROBLEM STATEMENT

In order to estimate every residential accommodation, we have to segregate the model functionality such that it caters to two primary requirements. The first branch should be able to compute the area of the property and the second branch should be able to produce the top and street view of the property which should help in demonstrating the property's architectural design. The logical intermediate outcomes of each of the two branches can be collaterally used by the other. These approaches should be then coherently integrated to produce substantial outputs. Based on these two criteria we perform classification of the properties.

III. INTRODUCTION

Through this project we employ a model that is capable of producing the top and the street view of each selected residency by extracting the image data and thus classifying them based on its area using Google Street View, Google Maps, Geographic Information System and Remote Imaging. The business requirements of this project clearly state that we should conduct property evaluation only on the residential properties and evaluating industrial and commercial properties is not within our stated scope. Our primary objectives include extracting complete address, centroid, correct street view, number of levels in an apartment and classifying them on basis of their calculated area of the chosen property. It would be a bonus if we are able to achieve the additional requirements such as calculating the living space, determining whether the property has a basement and whether it is on an elevated ground level. For classification we are following the nomenclature and the classifiers provided to us by the 'Alberta Environment and Parks'.

IV. LITERATURE REVIEW

A. Building Instance Classification Using Street View Images [February 2018] [1]

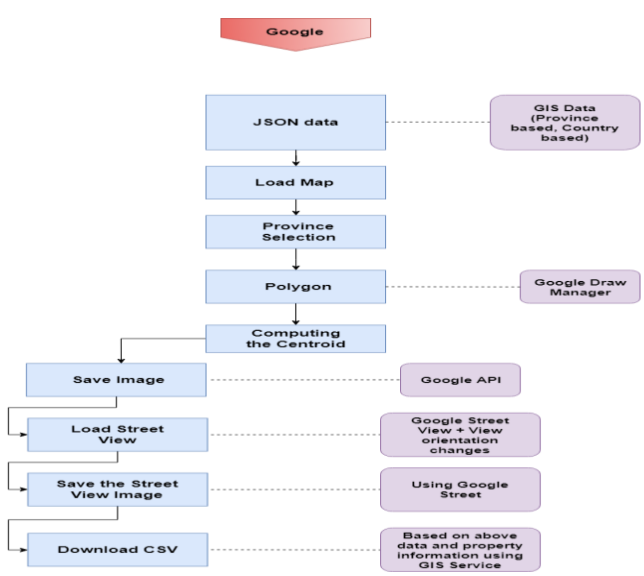
Semantic classification of building information includes transfer from land cover to land use in Earth Observation-data. Their[1] proposed method is based on Convolutional Neural Networks which classify facade structures from Google Street View, in addition to remote sensing images which usually only show roof structures. Geographic information was utilized to mask out individual buildings, and to associate the corresponding street view images. The authors of this paper [1] provide the building footprints which can be associated to street view images via their geographic locations. The correlation of physical indicators such as building volumes, density or alignment has been used to infer the usage of buildings, for example as commercial areas, residential areas or industrial areas. Although we did not use any artificial intelligence parameters such as a neural network to train our model for classification like they did, we however used their [1] approach to some extent for distinguishing the property based on its area. This was also used to identify whether that property has detached garage or basement.

B. Semantic Segmentation based Building Extraction Method using Multi-Source GIS Map Datasets and Satellite Imagery [January 2018][2]

The authors of this paper [2] used a semantic segmentation and ensemble learning based building extraction method which uses multiple data sources. These data sources also include LiDAR and OpenStreetMap datasets for accessing earth observation data.. They have used a data fusion method for combining the multispectral satellite image datasets with several public GIS map datasets using deep learning methods for data extraction. Although we are not using deep learning methods, we took an inspiration from this approach [2] to integrate remote imaging and GIS such that the images obtained from each of the sources are placed over each other in pixels per meter scale which in turn are utilized for finding the area of the property.

V. Project Workflow

Using HTML, we fetch the images and then we apply image processing techniques on these collected images to get desirable outputs. Since we cannot hit the GIS more than that of the restricted number of hits being set, we save the country and province data in json format to overcome this shortcoming. We suggest the user to enter the province from the provided drop-down list. To load this province the saved json data is now being used. Following this the user will zoom in and will draw a polygon over the accommodation he wishes to choose. For drawing this polygon, we have used the Google Draw Manager plugin which allows one to draw polygons over Google Maps. Now we implement a logic to compute the centroid of the polygon, rectangle in our case. We will use the centroid coordinates to get its exact address as the coordinates are nothing but the latitude and longitude details of the chosen property. Now the user will save this image with the property encapsulated in the drawn polygon by hitting the button that is provided. The two URLs that are being generated and saved contain two images: one without the bounding box and another with the box. For the second part of the project, we load the street view of the chosen location where the centroid is and change the orientation of the street view to exactly face the property. The user should then hit the save street view button to save the street view image. Then, in a csv file we save all the computed details such as the centroid's latitude and longitude, complete address of the place, the two images from the top view one with and other without the bounding box, and the meter per pixel of google earth details required for calculating the area and the street view image. Lastly the hyperlink to create the csv file will be downloaded for retrieving this information.



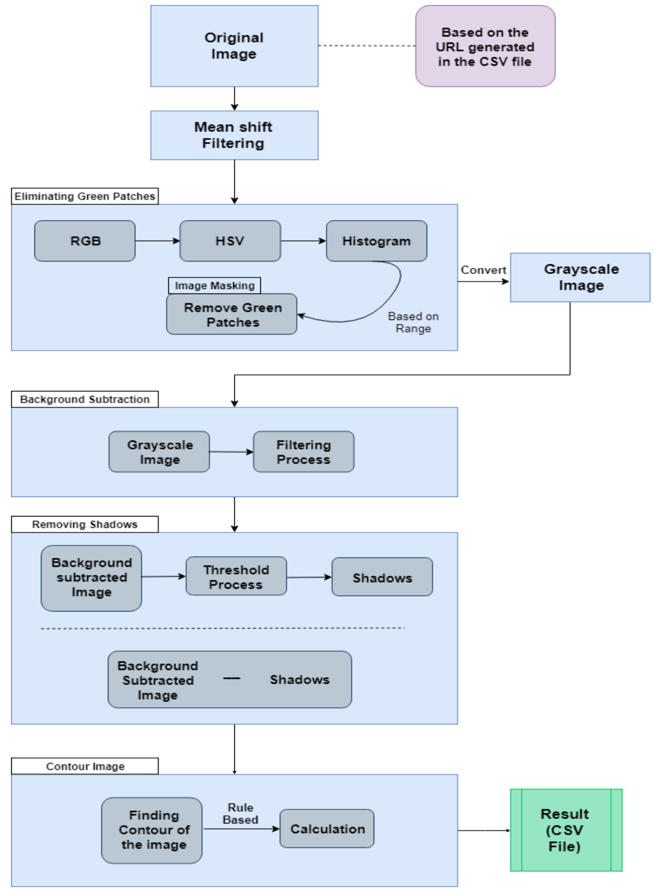


Fig. 1. Workflow and Construction

VI. Image Processing Techniques

Primarily Python will download the jpeg images from the links in csv file on its initiation.

A. *Mean Shift Filtering*

We basically get a Spatial Temporal Graph with lot of data and color variants. We therefore smoothen the image using mean shift filtering.

B. *Eliminating The Green Pastures using Subtraction*

We do not need the greenery in the image, however, we cannot directly eliminate it from an RGB image. We therefore first convert the RGB image to an HSV image and get the histogram of the converted image. Upon getting the histogram we choose green from the range of colors and create a new image mask with only the green shade. We then subtract this green mask from the original image where we replace every green pixel with a white pixel. After doing this we convert the image with the green color being removed to its grayscale equivalent. This image is compared to the grayscale equivalent of the image with the building encapsulated in a bounding box, such that only the area embedded inside the polygon is retained and everything outside is replaced with white pixels.

C. *Eliminating unwanted data by Background Subtraction*

The grayscale image with the green color being removed is compared to the grayscale equivalent of the image with the building encapsulated in a bounding box and background subtraction is performed such that only the area embedded inside the polygon is retained and everything outside is replaced by white pixels.

D. *Elimination of Shadows using Subtraction*

The shadows of the properties in a grayscale image will be in the darker color variant of gray. However, this needs to be deleted to avoid miscalculation of area of every property. We do so by setting up a threshold value. We obtain the histogram of this grayscale image and then we select dark gray from the image. We will now create a new image with a dark gray mask and then we will subtract this from the original grayscale image to get a grayscale image which will retain the properties without their shadows.

E. *Contour Extraction*

By applying contour extraction, we will take out two big contours from the image. From this it is obvious that the larger out of the two would be the building or the house and the smaller one will be a detached garage. However, while performing contour extraction sometimes the biggest contour is the image itself therefore, we set up a condition wherein if the biggest contour is occupying more than 80% of the image size then that contour will be discarded. Also, there are chances of the smaller out of the two contours of being too small for it to be concluded as a garage, so much that not even a car can fit into it. Therefore, we set a condition wherein if it is smaller than a preset area it will be discarded. We consider the second biggest contour in the image as a garage only if it is reasonably big. Using the length and breadth of these contours the area of the property and the detached garage is calculated.

We then calculate the living space by subtracting the garage area from the total area if a property has an attached garage. We subtract forty-one square meters from the total area as specified in the document provided to us by the 'Alberta Environment and Parks'. After applying all these image processing techniques, we classify the properties and save them in a csv file.

VII. Performance And Accuracy of our Model over its Predecessors

Since there aren't too many projects which are similar to the one that we worked on, we do not have ample comparison data analysis. Also, form the chosen few those were first being implemented [1 and 2] used Artificial Intelligence neural network models to train their system for classification. However, we were able to achieve this purely using Image Processing techniques which was a challenge.

Since we do not have any previous model to compare with, we are comparing our calculated area to the area obtained from the google maps which serves as a ground truth. We are demonstrating the accuracy results as under:

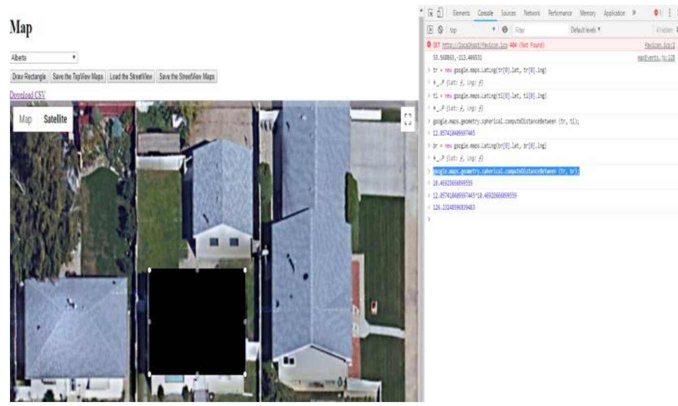


Fig. 2. Area computed by Google Maps is 126.23 square meters

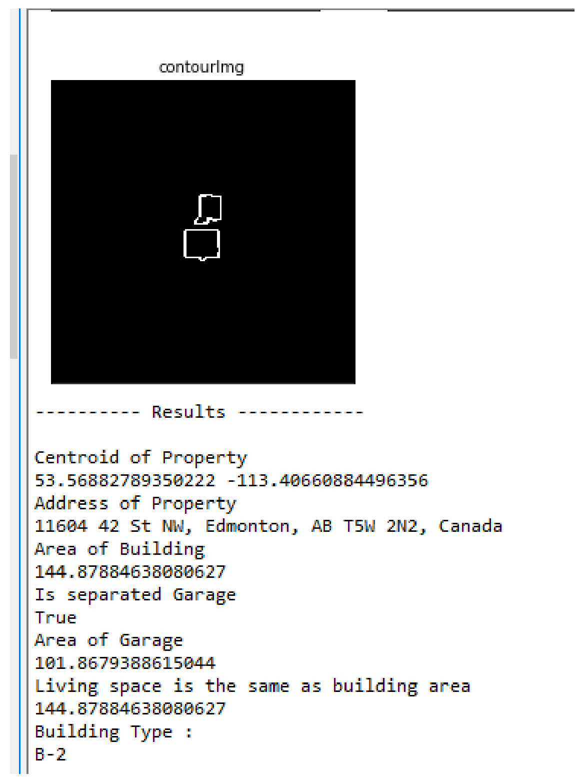


Fig. 3. Area computed by us using Image Processing is 144.87 square meters

There is an approximate difference of eighteen square meters between the area retrieved using google maps (Fig. 2) and the area that is being calculated by us (Fig. 3).

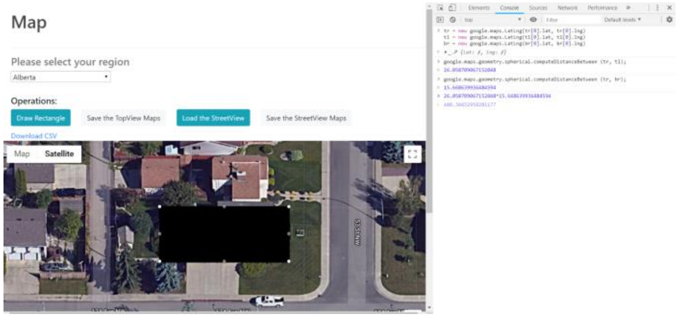


Fig. 4. Area computed by Google Maps is 408.30 square meters

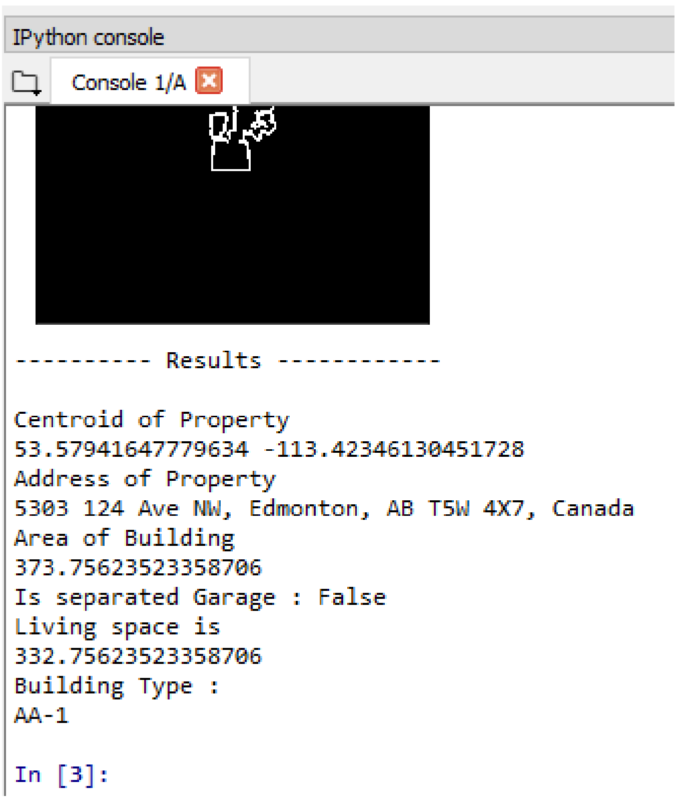


Fig. 5. Area computed by us using Image Processing is 373.76 square meters

There is an approximate difference of thirt-four square meters between the area retrieved using google maps (Fig. 4) and the area that is being calculated by us (Fig. 5).

VIII. Challenges Faced

- We experienced that an image beyond the size 640 *640 cannot be saved. We can download image only in maximum size format. The zooming value for street view is set to one which is minimal. Therefore, we programmed in such a way that if we want a street view image of the entire tall building then we then we would at least get an image covering the entire height of the building.
- It was a challenging task to obtain the images from google maps. It was then fixed with a lot of processing and improvising.
- The existence of shadows in the grayscale image resulted into a lot of ambiguity thereby resulting into miscalculation of area as it was also taking the shadows into account. We however have now fixed this problem using subtraction.
- Whenever we would want only the image of the property the green patches surrounding it would also come into picture. We resolved this issue by subtraction.
- We faced a lot of issues while creating a bounding box for just one property without including its adjacent properties. Earlier with the use of place marker a bounding box would be generated with the adjacent properties as well. We now have fixed this issue by using draw tool from Google Draw Manager API.
- One of the major challenges we faced was the orientation of the centroid which would face anywhere in the street view chosen. We have now fixed this by adjusting the centroid to only face the property.
- While Contour Extraction we realized that at times we were getting the entire image as the biggest contour which led to unnecessary confusion. We fixed this by imposing a condition wherein if the contour size exceeds eighty percent of the original image it would be discarded.
- We spent a considerable amount of time on Map Box API which looked promising because it provided 3D representation with height, width, breadth of the property that would have given the area of the property. However irrespective of what location is chosen, the image would include the other accommodations as well. So, we did not go ahead with this approach.

IX. Limitations

- The presence of the fence in front of the property chops the image into half and we do not get a proper street view of that property in this case.
- Google Street Manager may produce the back or the front of the property. If the back of the property is produced, then there are chances of it being a garage which is not the desired output that we are looking for.
- If the property in question is a tall building, then the street view of the property will include the entire height of the building. However, this may necessarily not be from the front.

X. Future Scope

We are certain to determine the number of layers in an apartment, whether the property is constructed on an elevated ground level and if it has a basement in near future. While implementing this project we found out about Open Street View API which looked promising for achieving these remaining requirements. This can be used to find the number of storeys and the presence of basement. However, we had to drop this approach as it had a limited access and is a paid service otherwise. We may consider this approach in future though.

XI. RESULTS

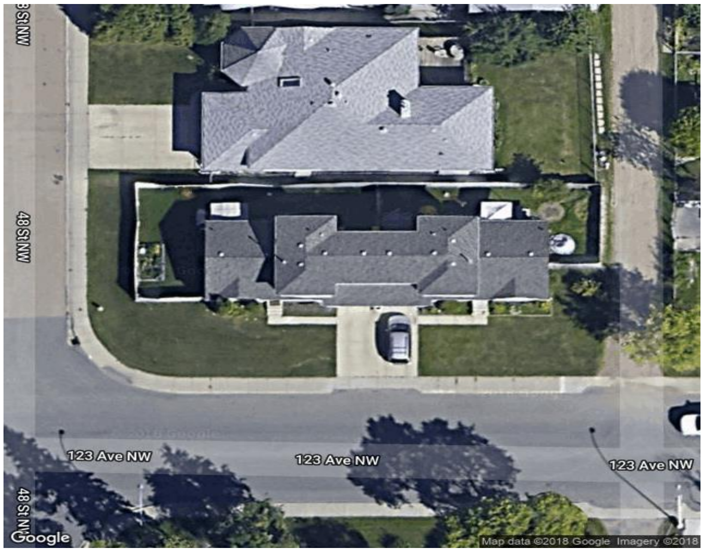


Fig. 1. Earth Image

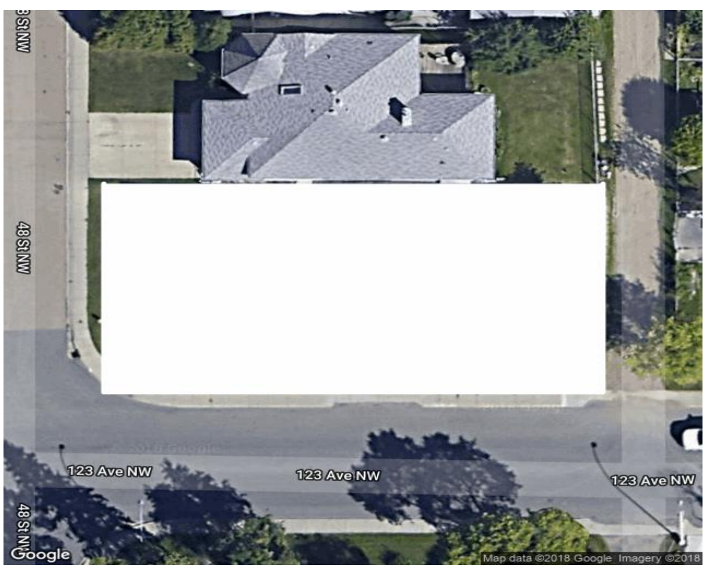


Fig. 2. Earth Image with bounded Box

Fig. 3. Street View Image of the single chosen property

Fig. 3. Mean Shifted Earth Image

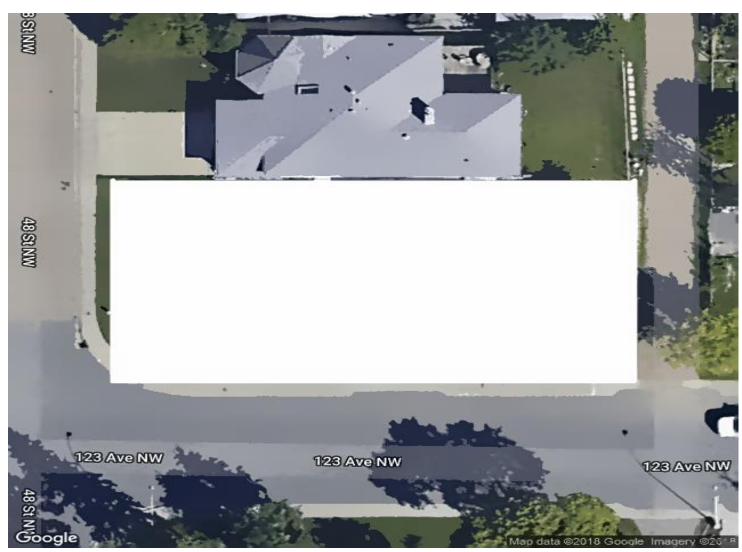


Fig. 4. Applying Mean Shift on Earth Bounded Image

Fig. 5. Mean Shift Filter on Street View Image of the single chosen property

Fig. 6. Gray Scale of Mean Shifted Earth Image with greenary removed

Fig. 6Gray Scale of Mean shifted Earth image with bounding box

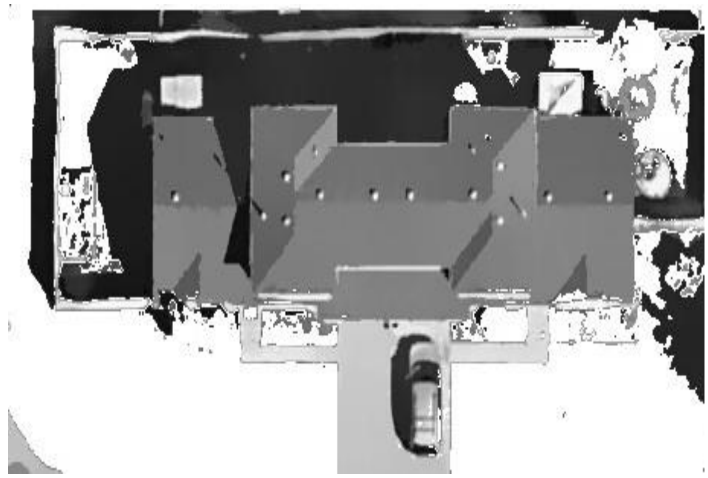


Fig. 6. Background Subtracted Image

Fig. 7. Background Subtracted Image with shadow components

Fig. 8. Background Subtracted Image of the components without the shadow

XII. Conclusion

Working with topographical aspects such as Remote Imaging, GIS, Google Street View is vague and convoluted which demanded rigorous brainstorming. However, it was challenging and worthwhile to work on this project as we were able to explore various Image Processing techniques and also learnt the various aspects of Google Maps, Remote Imaging and GIS.

ACKNOWLEDGMENT

We are thankful to the ‘Alberta Environments and Parks’ for providing us with the nomenclature and criteria for classification based on the property area. The consent criteria documentation provided by them is confidential and this can only be shared based on approval. We are grateful to the ‘Government of Alberta’ for proposing this project, and to Dr. Irene Cheng and Dr. Amirhossein Firouzmanesh for guiding us throughout the project.

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