Project Proposal:
Preprocessing of Satellite Imagery

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Background

Satellite imagery poses an interesting set of unique challenges for computer vision work. The biggest challenge with satellite imagery is with the ethical issues of privacy, due to this there are legal regulations that limit the image resolution of satellite photos. Currently the regulation is 25-centimetre resolution for grayscale images and 1-metre for color images [1]. This was updated from a previous 50-centimetre regulation as commercial companies pushed for higher resolution but this sparked issue of privacy concerns amongst civilians. This creates a very interesting issue; how do companies continue to offer better quality satellite image processing techniques without creating privacy concerns for citizens.

Problem

Edge detection is a critical component in image analysis, for satellite imaging this technique is used for building mapping, road mapping, and vehicle location. The results of Canny edge detection are dependant on having good quality images to produce better results. Satellite images have poor resolution, have object shadows, and low contrast edges which result in edge detection being often unsatisfactory [2]. As a result, Deep Learning based algorithms have started to become more prevalent in satellite imagery edge detection processing. One such example is the Holistically-Nested Edge Detection (HED) algorithm which uses convolutional neural networks to process edges [4]. However, Deep Learning training and testing is computationally intensive, and requires very robust datasets to get decent results in a variety of situations. Satellite imagery again poses a unique problem of having large variations in what could be captured, such as deserts, forests, coast lines, highways, farmlands, and city centres to name a few. Curating and then training such a large and varying dataset would take a very long time and would require a lot of computation time.

As a result, currently there are two prevalent methods, but both have issues with their use. Deep Learning has intrinsic issues that occur simply because Machine Learning is computationally intensive and training dependant. In contrast, Canny edge detection and classical computer vision approaches face extrinsic factors that limit the overall performance of the edge detector. If these extrinsic factors can be resolved, then Canny edge detection may result in more consistent and higher quality edge detected images. To help alleviate these issues, the proposed solution is to use classic computer vision preprocessing techniques to increase image quality and help produce more accurate edge detections. This is also a beneficial solution for the social issue mentioned earlier, preprocessing can help produce better outcomes without the need to increase resolution quality which may have privacy issues associated with it.

Proposed Approach

This project will focus on helping to alleviate the following issues within satellite images; poor image resolution, image noise, light variations, image shadows, and over capturing of less significant edges. For poor image resolution, kernels will be applied to smooth across the images so that deviations are not as intense. Image noise will be reduced by applying median blurs to remove small image discrepancies that should not be picked up by the edge detector. Light variation is another issue that causes unique problems for satellite images, since these images depend on natural light, the variations can vary, and certain subsets may have issues with reflections. As an example, an image of a coastline near sunrise will have very intense lights and lots of reflection, whereas a desert at dusk will have very low lights. These two images are both very likely to be captured by a satellite but require polar opposite approaches in how preprocessing steps for contrast and light need to be applied. Being able to differentiate between these types of images and how they are preprocessed will be a significant step in ensuring consistent results. Image shadows can also be prevalent in many images and may produce pseudo edges that are not actually real. Using median blurs as well as thresholding, some of these shadows can be greatly reduced. Finally, for less significant edges, Canny edge detection produces additional “edges” which are not accurate and so by increasing the deviation of the detector these excess lines may be reduced.

It may not be useful to apply all these techniques and often certain subsets of images with certain common properties may benefit from a specific group of preprocessing. To handle this, when doing the preprocessing, there will be an analysis to determine if certain properties hold true, and if they do then to apply certain preprocessing techniques. For example, if an image has very high color values, it may mean that the image requires contrasting to help differentiate between the lines. Along with this, multiple versions of the Canny edge detection may be run on various versions of the image with different subsets of preprocessing, and the edges which are most prevalent amongst the different variations will be considered to be the more significant edges and the combined edge detection map may be closer to that of ground truth. For this project, the dataset being used will be the 19-class Satellite Scene dataset as the source of input images [5].

Project Outcome

Throughout this experiment, the images will be compared against the Canny edge detection of the original image, as well as against HED algorithm [3]. By doing this, the goal is to demonstrate that overall preprocessing the image will consistently produce better results then running Canny on original images. With respect to HED the goal is that the preprocessed version will produce comparable outputs to that of the HED, and that in some cases using Canny will have more robust results for pictures that were most likely not seen by the Deep Learning training set. These outcomes would imply that using a classical approach may offer better results over a larger range of images even though some images within the HED set will be of higher quality, and that specialized preprocessing should result in a better net result in most if not all cases against the original image. This would be a beneficial result as it would mean there is more useful information that can be extracted from current satellite images without the need to produce computationally intensive learning networks or result to higher quality images which pose privacy issues.

References

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