CS 405 Project Update

Remote Sensing Analysis with CNNs

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A report submitted for the undergraduate section.

Figure 1: Semantic Segmentation on Satellite Imagery.

1 Introduction

For my project, I want to focus on implementing semantic segmentation on satellite images. Semantic segmentation is the process of dividing an image up into meaningful sections. The purpose of this is for a computer or human to be able to look at an image in a more useful way. This can be a very useful thing when applied to remote sensing [4]. Image segmentation can be used to break up and classify geographical features in satellite images. Figure 1 shows semantic segmentation being used to outline building foundations. The ability to segment these images can be very insightful. This analysis on remote sensing is applicable to change detection, urban planning, emergency management, and much more.

2 Previous Research

Over the years, there have been many different methods used to try and solve this issue. One of the simplest methods used to segment images is known as thresholding. Thresholding involves replacing a pixel in an image with a black pixel if its intensity is smaller than a fixed constant, and replacing it with a white pixel if otherwise. This creates a binary image. This can be used to accentuate the edges in an image to easily segment it. [1]

Another method used is clustering using the K-means algorithm. Clustering works by first picking K cluster centers. Each pixel in the image is then assigned to the cluster that is closest. Then the cluster centers are readjusted by averaging the pixels in the cluster. The last two steps are then repeated until pixels no longer switch the cluster that they are assigned. All set of pixels assigned to a cluster represent a segmented part of the image. [1]

A third method that has several different variations is graph partitioning. The general idea behind this technique involves modeling the image as a weighted graph. A certain algorithm used to model 'good' clusters. The graph is then partitioned based off of these clusters. [1].

3 Proposed Solution

The algorithm I want to apply to the remote sensing analysis is a Convolutional Neural Network (CNN). The CNN is based off of how the visual cortex in certain animals such as cats and monkeys. The first paper to propose the idea of using this mechanism on images with a computer is titled "Neocognitron: A Self-organizing Neural Network Model for a Mechanism of Pattern Recognition Unaffected by Shift of Position" by Kunihiko Fukushima [2]. One thing that needs to be considered during the project is processing power. CNNs can require a lot of processing power and many projects use multiple computers for it [3]

The algorithm takes an input of a matrix. The matrix represents the image that is being analyzed, where each number in the matrix represents a pixel. Smaller matrices that represent certain features of the object you are searching for are run over the main image matrix. At each position, matrix multiplication and averaging is done to determine a value that represents how much the feature matches the section of the image. This small matrix is run over the entire image, determining the value of feature matching for every position of the image. After going over the entire image, a new matrix of all of the feature matching values will be created. Several different features will be run over the main image, creating several of these matrices. This entire process is call convolution [5]. The convolution step is shown in figure 2.

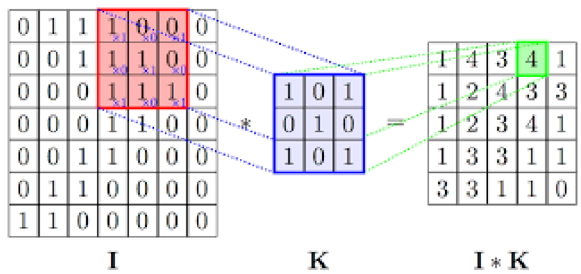

Figure 2: Convolution Operation

After convolution, an operation called max pooling is done to each of the convoluted matrices. Max pooling is a method of simplifying a convoluted image by splitting it up into blocks of pixels and choosing the largest value to represent the entire group. Each maximum is put into a new matrix. This simplifies the image even more and makes it easier to analyze. Figure 3 demonstrates max pooling on a smaller sample. Figure 4 shows what we have done to the image so far.

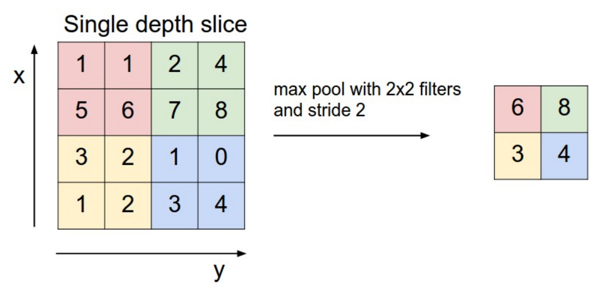

Figure 3: Max Pooling Operation

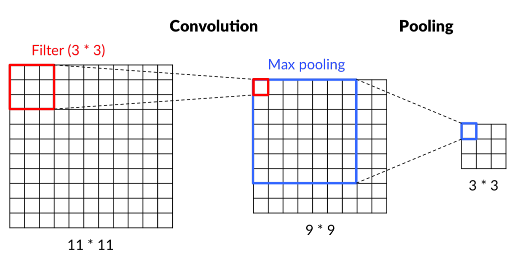

Figure 4: Convolution with Max Pooling

A third operation applied to the matrices that have been edited is normalization. Normalization is done by flipping all of the negative values in the matrices to zeros.

All three of the operations can be done on the matrices multiple times depending on several variables related to the image. Once all of these operations have been done to the point that the image has been flattened out into a satisfactory amount of small matrices, The matrices can then be used as the input nodes to the neural network. The neural network will end with several output nodes that represent the different classes we will be looking for. We will then know what pixels correspond to which classes. This is how I plan on determining what parts of the image are classified as buildings. Figure 5 shows the entire network laid out.

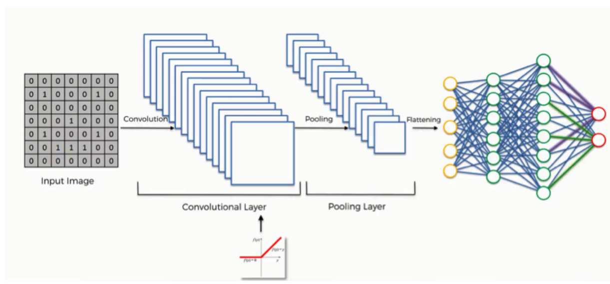

Figure 5: The entire Convolutional Neural Network

PEAS	Your Approach
Performance Measurement	Percentage of objects correctly classified
Environment	Satellite Images
Actions	Classifies/colors segments
Sensors	Image pixels

Table 1: The PEAS description for Remote Sensing Analysis with CNNs

4 Project Goals

My main goal for this project is to have my CNN classify my images with relatively high success (better than 70%). My initial goal is to be able to pick out one category with a high success rate such as building. If things are working out better than expected, then I would like to implement more categories in the images and see how far I can go.

References

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[2] Kunihiko Fukushima. Neocognitron: A self-organizing neural network model for a mechanism of pattern recognition unaffected by shift of position. *Biological Cybernetics*, 36:193–202, 1980.

[3] Alex Krizhevsky, Ilya Sutskever, and Geoffrey E Hinton. Imagenet classification with deep convolutional neural networks. In F. Pereira, C. J. C. Burges, L. Bottou, and K. Q. Weinberger, editors, *Advances in Neural Information Processing Systems 25*, pages 1097–1105. Curran Associates, Inc., 2012.

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[5] Steve Lawrence, C. Lee Giles, Ah Chung Tsoi, and Andrew D. Back. Face recognition: A convolutional neural-network approach. *IEEE Transactions on Neural Networks*, 8, 1997.