Generating a Map from a Linguistic Description

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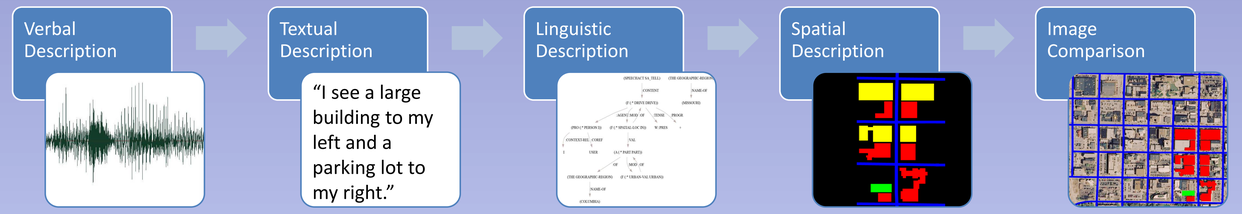
Abstract

In the field of geospatial intelligence, it is desirable to be able to identify objects in a satellite image. Doing so allows for many useful applications, such as the ability to determine a position in space based on a linguistic description of the area. This project explores the task of placing objects in a sketch to match what is found in satellite imagery. Given a linguistic description of an area, the spatial locations of objects are determined through processes such as the histogram of forces and iterative optimization. This sketch is then compared to existing data to find the best match. The focus of this project is the generation of data for use by the sketching system. This includes hand-segmenting satellite imagery and producing linguistic descriptions of real world environments.

Background

This project encompasses a variety of fields. In the process of converting a verbal description into a real world location, we must consider speech recognition, deep-language understanding, spatial reasoning, and geospatial image matching. While much research can be devoted to any of these fields, this project aims to provide a broad overview of the techniques required to match a real world image to a verbal description. The primary focus is on generating a spatial sketch from a linguistic description and obtaining accurate segmentation results from high resolution satellite images. Currently our focus is restricted to an urban environment, as the methods for urban and rural areas can differ greatly.

The process of building a sketch starts with the decomposition of a sentence into structures and their relative locations. The structures are then placed into the sketch one by one using a best fit algorithm. The resulting sketch can then be compared to a database of known satellite imagery to find the closest match. This requires that satellite images be segmented accurately and completely.



Histogram of Forces

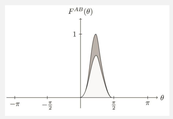
To place a set of objects into a sketch, we must first have an understanding of their spatial relationship. This can be accomplished with the histogram of forces. This method produces a histogram with the most probable direction one object is from another.


Handling points


Handling segments


Handling longitudinal sections


Handling directions


Resulting histogram

For every angle θ, a set of parallel lines is drawn across the two objects and the lengths for which each line is inside each object is measured. The histogram represents the amount that one object is angle θ from the other.

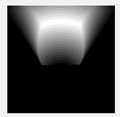
Linguistic Descriptions

A sentence can be broken into atomic elements using a natural language parser. From these elements, we can determine physical structures and their relative locations. This information can be used to build an approximate sketch of the area. As an example, consider placing the MU columns with respect to Jesse Hall from the sentence "The columns are in front of and somewhat close to Jesse Hall."


Jesse Hall and the Columns


A silhouette of Jesse Hall


The search area "in front of"


Distance information, "somewhat close"

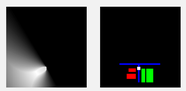
Building a Sketch

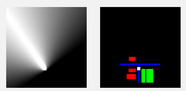
Once a sentence is broken into structures and spatial relationships, each object can be added to the sketch. This is done by computing a fuzzy region template for each new object and comparing the new object's placement to other objects using the histogram of forces. To demonstrate this method, we will develop a sketch from a set of descriptive sentences.

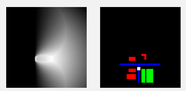

"There is a somewhat long, thin rectangular shaped parking lot that extends forward relative to me."

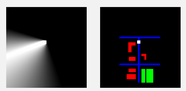

"To the immediate right of that parking lot is a parking garage."


"I see a moderately small rectangular building close to me that is mostly to my left but partially forward."


"Travelling to a 4-way intersection, there is a small rectangular building close to me on my left that extends behind me."


"There is another small rectangular building across the street that is mostly to the front of me, but somewhat to the left."


"A short distance to the right of that building is a small L-shaped office."


"Travelling to another 4-way intersection, there is a large L-shaped restaurant that extends to the rear."

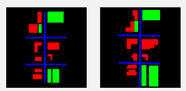
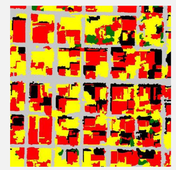

Final sketch with additional objects on left with real world ground truth on right

Image Segmentation

An image from a satellite typically consists of several spectral bands of information. These may include frequencies beyond visible light such as infrared and ultraviolet. Using this information, it is possible through analysis to group pixels that share similar characteristics. This results in clusters of pixels that tend to represent physical features in the image, such as buildings, roads, parking lots, and vegetation. The segmentation of an image can be done either by hand or automatically. Although automated segmentation accuracy has increased dramatically over the past few years, hand segmentation still is far more reliable.


Automated segmentation of downtown Columbia, MO


Hand segmentation of downtown Pensacola, FL

Conclusion

Although much work is still required to fully automate the process of generating a sketch from a linguistic description, much progress has been made. Future research will focus on more accurate placement of objects into sketches and greater reliability in automated image segmentation systems.

Acknowledgements & References

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A. K. Shackelford and C. H. Davis, "A hierarchical fuzzy classification approach for high-resolution multispectral data over urban areas," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 41, pp. 1920–1932, 2003.