Symbolic Knowledge Representation for Remote Sensing

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Abstract

One of the more elusive goals in the field of remote sensing is to develop a completely automated feature extraction and identification system. The output of such a system is usually an annotated map, and thus such a system is often referred to as fully automated computer cartography system. To date only computer assisted cartographic systems have been developed. Human photointerpreters are still required for feature identification and verification. There are many challenging steps along the way to achieving this goal. A mix of digital image analysis techniques and expert systems technology has shown some successes in this area. However one of the biggest stumbling blocks at the moment, is how to represent the knowledge contained in a scene in a compact reliable structure that is compatible with expert systems. This paper outlines this knowledge representation problem, presents an analysis of various image segmentation techniques, discusses the segment attributes required for inferencing and discusses some of the problems associated with this technique.

Introduction

Remotely sensed images contain a wealth of information that can be readily processed by trained human experts, such as photointerpreters. Humans can almost instantaneously identify objects or make some other semantic judgments about an image. Some researchers are using algorithmic techniques to identify and classify cartographic features [Guindon 88]. Other researchers have shown that expert systems can be engineered to perform inferenced reasoning about simple human visual tasks (simple in the human visual system context). [Rao 88]. However, one of the problems that has plagued expert system researchers is how to represent image knowledge in an expert system. This problem is often referred to as the iconic to symbolic gap problem.

In essence the iconic to symbolic gap problem is : How does one convert the spatial, spectral or other knowledge that is stored in an image into a semantical form, that can be processed by an expert system? Typically expert systems store knowledge in a symbolic format. Computerized image processing systems typically store imagery as a large often multi-dimensional matrix of binary numbers. Thus an expert system requires the binary matrix to be converted to a symbolic format, for inference processing.

Many researchers have found that image segmentation has provided meaningful results. Some researchers have used contextual [Stansfield 86] segmenting techniques and others have used non-contextual segmenting techniques [Plunkett 86]. However, once the segments have been determined, then segment attribution can be performed relatively easily. The attributed segment information, can then be passed to the inference engine.

This paper provides an analysis of the concepts and some results of applying various image segmentation techniques to an image and attributing the segments for applying inference rules to perform photogrammetric analysis. The study scene is a geocoded Landsat Thematic Mapper scene of the Ottawa area. A subarea of this image was segmented using several gradient operators. Different thresholds were then used on the segmentation operation. Following segmentation, each segment was attributed with a number of attributes that relate to the segments spectral and spatial properties. These attributes were stored in a flat ASCII file as PROLOG statements and input to an Expert system for analysis.

Methodology

Some authors have indicated that there is a hazy or grey area developing between the image processing and knowledge based processing parts of computer vision systems [Straight 87]. Other authors [Rao 88] have described the differences as low-level vision is the image processing stage and the knowledge based phase is the high level vision stage. Other authors have performed the low-level vision stage manually by humans and then fed this knowledge into the inference engine [Pascucci 87]. Pascucci does however indicate that some research is ongoing to perform some of the low-level vision via computer.

This paper uses the paradigm that the low-level vision is performed by conventional image processing techniques and the high-level vision is performed by expert system techniques. However, the area on which this paper concen-