ABSTRACT

Nowadays in computer vision applications, image segmentation is an important and required task. Segmentation subdivides an image into its constituent regions or objects by grouping the pixels that have similar attributes together for further analysis. Edge detection, which is a well developed field in segmentation, is an important step in feature extraction and supervision tasks like texture analysis, pattern recognition, machine vision, motion detection etc. Edges are the pre-dominant elements of an image and are mainly used to analyze the images. The performance of edge detection results has an effect on further processing like object recognition and object classification etc.

Satellite image analysis is a major research area in remote sensing applications. Processing of satellite images helps to update geography information. One of the uses of processing the satellite images is extracting objects for various purposes whether the objects are natural (mountain, desert, lake, etc.), artificial or man-made (roads, places, electricity lines, etc). Processing and interpreting these images on specific features are in great demand for real time applications.

Edge segmentation of satellite images has different scientific and need based applications in the field of agriculture, geology, forestry, biodiversity conservation, regional planning, education, intelligence and warfare. Automatic detection of road networks from the satellite and aerial images is the most demanded research area in satellite image processing, and it is utilized for various remote sensing applications. Roads are the backbone and essential modes of transportation. They provide many different supports to human civilization. Manual updating of Geographic Information System (GIS) database is expensive, tedious process, and also there is a possibility of mistake. Therefore, automatic method is needed to extract the road network in robust manner. Road data allow GIS applications to assist in variety of services such as
route planning, health-care accessibility planning, satellite navigation, land cover classification, and infrastructure management. For real time application, hardware implementation of image edge detection and road network extraction is desirable one. Field Programmable Gate Array (FPGA) has become a useful hardware realization tool for real-time image processing because of its advantages of high calculation speed and parallel processing.

The aim of this thesis is to realize the FPGA architectures for edge detection on general, and satellite images and road network segmentation from satellite images using morphological operator and Simplified Gabor Wavelet. This thesis includes four modules of image segmentation algorithms and their FPGA realization.

First work describes the FPGA architecture for image edge detection by using Multi Structure Element (MSE) based morphological operator and its performance analysis. The performance of morphological operator is based on size and shape of Structure Element (SE). Single Structure Element (SSE) is sensitive to only one direction of edges. In order to detect all the edges in an image, four structure elements are used to detect the edges in this work. This method is also applied on various levels of noise induced images.

FPGA architecture is proposed for this edge detection algorithm. The proposed FPGA architecture is simulated using Verilog and synthesized using Xilinx ISE simulator. The Spartan 3, 3S400TQ144-4 device is used to implement this architecture. Evaluation of this work is based on synthesis and timing report and it is obtained from ISE 10.1. To test the performance, the design is implemented on FPGA to analyze the resource utilization. The performance measures such as Figure of Merit (FOM) and Peak Signal to Noise Ratio (PSNR) are evaluated for both the implementations in PC (Personal Computer) using Matlab and in FPGA by using Verilog and the results are compared with other methods.
Second work is the extraction of boundary and centerline of road network from satellite images using MSE based morphological operators and its hardware implementation using FPGA. This method includes the steps such as segmentation of approximated road regions using adaptive global threshold method and trivial opening to extract road pixels from segmented region. MSE Morphological based edge detection is applied to detect the boundary of the road network. Thinning is applied to detect the centerline of the road network. This method is also applied on noisy images which are contaminated by various levels of noises. This morphological based road network extraction is implemented in FPGA using Verilog. The Spartan 3, 3S400TQ144-4 device is used to implement this architecture. The system is evaluated based on synthesis and timing report, and resource utilization. The performance measures such as Completeness, Correctness, and Quality are evaluated for both the implementations in PC using Matlab and in FPGA using Verilog and the results are compared with other methods.

Third module is the implementation of image edge detection using Simplified Gabor Wavelet (SGW) and its FPGA realization. This algorithm is applied on both general images and satellite images. Gabor Wavelet (GW) is commonly used for extracting local features for various applications. The computation cost is high for GW based edge extraction methods. In order to reduce the computation cost, SGW is proposed in this work. The performance of the method is also examined by noisy images at various noise levels. FPGA architecture is proposed to implement the edge detection method using SGW. This FPGA architecture is simulated using Verilog, synthesized using Xilinx ISE and implemented in Spartan 3, 3S400TQ144-4 device. The performance of the edge detector is proved by both qualitative and quantitative measures. The quantitative measures such as FOM and PSNR are measured for both FPGA and PC based implementations and are compared with other works.
The final work is the realization of FPGA architecture for the extraction of boundary and centerline of the road network from satellite images using Simplified Gabor Wavelet. The methodology of this work is that the road regions are extracted using connected component approach. The SGW based edge detection is applied on this image to extract the road boundary. Morphological closing and thinning operations are applied to detect the centerline of the road network. The performance of this method is also analyzed on noisy images at various noise levels. FPGA architecture is proposed to implement the road network extraction method using SGW. This FPGA architecture is simulated using Verilog, synthesized using Xilinx ISE and implemented in Spartan 3, 3S400TQ144-4 device. The performance of the system is proved using the measures such as Completeness, Correctness, and Quality for both the implementations in PC using Matlab and in FPGA using Verilog and the results are compared with other methods.