Development of the Image Processing System Based on Hardware/Software Co-Design

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ABSTRACT

Thresholding is widely used for image processing. Since each object has its own distinct gray-level distribution, an appropriate threshold is required to extract the objects from their background effectively. But the existing methods are quite complex, time-consuming, and hard to implement on the hardware efficiently. To overcome the inefficiency of the existing methods, this study proposes an algorithm called HGEM (Histogram-based Gaussian Estimation Method), and implements the Sobel edge detector on a Xilinx Virtex-4 (XC4VLX25) FPGA. Synthesized report shows that the proposed architecture on FPGA can run at a speed of 193.9 MHz, which is equivalent to a theoretical frame rate of 1,479 frames per second with gray-level images of 256×256 pixels. This result confirms that the proposed architecture on FPGA can easily achieve the requirements for a real-time image processing system. But for many different applications, bilevel threshold is often not enough for objects extracted from their background. Thus multilevel threshold selection is necessitated for such applications. The Otsu ’ s method can be easily extended from bilevel to multilevel threshold selection, but the computation complexity of the Otsu ’ s method exponentially increases with the increase in the class number of an image. To improve the inefficiency of the Otsu ’ s method, this study proposes an algorithm called TSMO method (Two-Stage Multithreshold Otsu method), which is based on the Otsu ’ s method by maximizing the between-class variance. The TSMO method first divides the histogram into several groups with certain gray levels, and completes the number of cumulative pixels and the mean for each group statistically. Then the Otsu ’ s method can be applied to find the groups with the maximal between-class variances. Hence, the optimal thresholds can be found in those groups by applying Otsu ’ s method again in a similar fashion. The results show that when the TSMO method with 32 group numbers (TSMO-32) is applied, the error relative to the Otsu ’ s method is less than 1%, but the performance of the TSMO-32 method can achieve more than 100,000 times compared to the Otsu ’ s method with five thresholds.

Keywords : Edge detection ; Otsu ; HGEM ; TSMO ; FPGA

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