An embedded system for an eye-detection sensor

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Abstract

Real-time eye detection is important for many HCI applications, including eye-gaze tracking, autostereoscopic displays, video conferencing, face detection, and recognition. Current commercial and research systems use software implementation and require a dedicated computer for the image-processing task—a large, expensive, and complicated-to-use solution. In order to make eye-gaze tracking ubiquitous, the system complexity, size, and price must be substantially reduced. This paper presents a hardware-based embedded system for eye detection, implemented using simple logic gates, with no CPU and no addressable frame buffers. The image-processing algorithm was redesigned to enable highly parallel, single-pass image-processing implementation. A prototype system uses a CMOS digital imaging sensor and an FPGA for the image processing. It processes $640 \times 480$ progressive scan frames at a 60 fps rate, and outputs a compact list of sub-pixel accurate $(x, y)$ eyes coordinates via USB communication. Experimentation with detection of human eyes and synthetic targets are reported. This new logic design,
operating at the sensor’s pixel clock, is suitable for single-chip eye detection and eye-gaze tracking sensors, thus making an important step towards mass production, low cost systems.

**Keywords:** Eye detection; Eye-gaze tracking; Real-time image processing; FPGA-based image processing; Embedded systems design