Design of an FPGA-Based Smart Camera and its Application Towards Object Tracking

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Abstract

Smart cameras and hardware image processing are not new concepts, yet despite the fact both have existed several decades, not much literature has been presented on the design and development process of hardware based smart cameras. This thesis will examine and demonstrate the principles needed to develop a smart camera on hardware, based on the experiences from developing an FPGA-based smart camera. The smart camera is applied on a Terasic DE0 FPGA development board, using Terasic's 5 megapixel GPIO camera. The algorithm operates at 120 frames per second at a resolution of 640x480 by utilising a modular streaming approach. Two case studies will be explored in order to demonstrate the development techniques established in this thesis.

The first case study will develop the global vision system for a robot soccer implementation. The algorithm will identify and calculate the positions and orientations of each robot and the ball. Like many robot soccer implementations each robot has colour patches on top to identify each robot and aid finding its orientation. The ball is comprised of a single solid colour that is completely distinct from the colour patches. Due to the presence of uneven light levels a YUV-like colour space labelled YC_1C_2 is used in order to make the colour values more light invariant. The colours are then classified using a connected components algorithm to segment the colour patches. The shapes of the classified patches are then used to identify the individual robots, and a CORDIC function is used to calculate the orientation.

The second case study will investigate an improved colour segmentation design. A new HSY colour space is developed by remapping the Cartesian coordinate system from the YC_1C_2 to a polar coordinate system. This provides improved colour segmentation results by allowing for variations in colour value caused by uneven light patterns and changing light levels.

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Table of Contents

List of Figures

List of Tables