FPGA design of a camera control system for road traffic monitoring

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Abstract—Video surveillance and monitoring more than a decade now remains a big challenge. Today is becoming more and more vital due to rapid development of hardware equipments as well as the software methods that support intelligent monitoring and analytics. This paper proposes the architecture of a FPGA design of a camera controller for surveillance that could be applied for road traffic monitoring and image data management purposes. The proposed system could deal with real-time monitoring of persistent and transient objects within the specific environment of a motorway or crossroad, taking input from a camera. Functional models were synthesized in VHDL. The design and simulations analysis were carried out within Quartus II Altera software package while further analysis was also performed with ModelSim. The functional performance and operation of the proposed design was evaluated based on such simulations and analysis.

Keywords—monitoring; camera controller; FPGA design; simulations

I. INTRODUCTION

Video surveillance systems that use analog CCTV cameras and interfaces as the basis are not easily expandable, and have low video resolution with little or no signal processing. However, next generation of video surveillance systems with digital LAN cameras, that support complex image processing, and video-over-IP routing are more intelligent and allow further scalability and flexibility [6], [7], [8]. In this direction, programmable modules, with or without embedded DSP blocks, with memory blocks, several interfaces, and other units, fulfill the new contemporary system requirements [5], [12].

Today several systems are designed on the same chip, based on a Field Programmable Gate Array (FPGA), for intelligent and fast data processing and miniaturization of the system. Particularly, in modern surveillance systems, FPGA-based intelligent controllers play an important role in improving the performance of the camera control system [2], [3], [4], [16], [19].

The purpose of this paper is to present first results of an ongoing research project on the implementation of a smart camera control system for traffic surveillance based on a FPGA. The problem of providing automated vision surveillance on an efficient way that last years has been intensively examined [10], [11], [13]. Today there is a rapid development of such systems towards intelligent control units [1], [9], [15] and several algorithms have been proposed towards this direction [14], [17].

In this research, the system proposed captures a video stream, computes traffic information and performs on chip video analytics and finally transfers the video stream and the traffic information to a host PC in order to be generated further alarm signals and events to be triggered according to various traffic situations. The objective of the paper is to describe the design of an intelligent surveillance system within an academic environment for traffic monitoring purposes. The proposed architecture incorporates a camera controller that **obtains traffic images and performs analytics. It performs** contour identification, axis specification, axis shift, percent zoom, smooth, etc., as well as facilities for mathematical and statistical analysis of the numerical data (pedestrians, cars, etc.), such as: densities, deviations, aggregates, etc.

In section II is described the design methodology followed and the goals aimed to be achieved. In section III the system architecture is detailed and section IV discusses the simulations carried towards the evaluation of system's functionality. Finally, section V presents a brief discussion and conclusions on the proposed system.

II. DESIGN METHODOLOGY AND GOALS

A. Design Approach

The overall design of the IP surveillance camera controller is to be implemented as a complete system on a chip using a FPGA device. An FPGA-based architecture is quite flexible **and customizable, to such extend that easily allows a system** architecture to be enhanced and modified according to various system specifications and requirements. Thus FPGA architectures are easily reconfigurable.

In addition, in our case study of remote traffic monitoring would be possible to add custom video processing software in real time (video analytics) and system upgrades (i.e. a new

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Eighth International Conference on Road Traffic Monitoring and Control, 23-25 April 1996 ,1996 *Journal of Transportation and Statistics* ,2002 **Advanced Video-Based Surveillance Systems** Carlo S. Regazzoni,Gianni Fabri,Gianni Vernazza,2012-12-06 Advanced Video Based Surveillance Systems presents second generation surveillance systems that automatically process large sets of signals for performance monitoring tasks Included is coverage of different architecture designs customization of surveillance architecture for end users advances in the processing of imaging sequences security systems sensors and remote monitoring projects Examples are provided of surveillance applications in highway traffic control subway stations wireless communications and other areas This work will be of interest to researchers in image processing computer vision digital signal processing and telecommunications Highway Maintenance Handbook Ken Atkinson,1997-04-10 This handbook deals with the ongoing task of maintaining Britain s network of roads in a safe and satisfactory condition It provides a commentary on a range of maintenance areas and analyzes both concrete and bituminous carriageways highlighting the advantages or problems of each Intelligent Vehicle Technologies Ljubo Vlacic,Michel Parent,Fumio Harashima,2001 Intelligent Vehicle Technologies covers the growing field of intelligent technologies from intelligent control systems to intelligent sensors Systems such as in car navigation devices and cruise control are already being introduced into modern vehicles but manufacturers are now racing to develop systems such as smart cruise control on vehicle driver information systems collision avoidance systems vision enhancement and roadworthiness diagnostics systems aimed specifically at the automotive industry packed with practical examples and applications in depth treatment written in a text book style rather than a theoretical specialist text style Sensors and Their Applications VIII, Proceedings of the eighth conference on Sensors and their Applications, held in Glasgow, UK, 7-10 September 1997 A. T. Augousti,Neil White,1997-01-01 Sensors and Their Applications VIII provides a valuable forum for individuals from all over the world working in all areas of sensors to meet and discuss the developments and applications of transducers and sensor systems The strength of the sensor community in the UK reinforces the importance of this volume as a valuable reference for all workers in the field *Proceedings of the International Conference on Applications of Machine Intelligence and Data Analytics (ICAMIDA 2022)* Sharvari Tamane,Suddhasheel Ghosh,Sonal Deshmukh,2023-05-01 This is an open access book As on date huge volumes of data are being generated through sensors satellites and simulators Modern research on data analytics and its applications reveal that several algorithms are being designed and developed to process these datasets either through the use of sequential and parallel processes In the current scenario of Industry 4 0 data analytics artificial intelligence and machine learning are being used to support decisions in space and time Further the availability of Graphical Processing Units GPUs and Tensor Processing Units TPUs have enabled to processing of these datasets Some of the applications of Artificial Intelligence Machine Learning and Data Analytics are in the domains of Agriculture Climate Change Disaster Prediction

Automation in Manufacturing Intelligent Transportation Systems Health Care Retail Stock Market Fashion Design etc The international conference on Applications of Machine Intelligence and Data Analytics aims to bring together faculty members researchers scientists and industry people on a common platform to exchange ideas algorithms knowledge based on processing hardware and their respective application programming interfaces APIs **Eighth International Conference on Road Traffic Monitoring and Control, 23-25 April 1996** ,1996 **Equilibrium and Advanced Transportation Modelling** P. Marcotte,Sang Nguyen,2013-06-29 Each chapter in Equilibrium and Advanced Transportation Modelling develops a topic from basic concepts to the state of the art and beyond All chapters relate to aspects of network equilibrium Chapter One advocates the use of simulation models for the representation of traffic flow movements at the microscopic level Chapter Two presents travel demand systems for generating trip matrices from activity based models taking into account the entire daily schedule of network users Chapter Three examines equilibrium strategic choices adopted by the passengers of a congested transit system carefully addressing line selection at boarding and transfer nodes Chapter Four provides a critical appraisal of the traditional process that consists in sequentially performing the tasks of trip generation trip distribution mode split and assignment and its impact on the practice of transportation planning Chapter Five gives an insightful overview of stochastic assignment models both in the static and dynamic cases Chapters Six and Seven investigate the setting of tolls to improve traffic flow conditions in a congested transportation network Chapter Eight provides a unifying framework for the analysis of multicriteria assignment models In this chapter available algorithms are summarized and an econometric perspective on the estimation of heterogeneous preferences is given Chapter Nine surveys the use of hyperpaths in operations research and proposes a new paradigm of equilibrium in a capacitated network with an application to transit assignment Chapter Ten analyzes the transient states of a system moving towards equilibrium using the mathematical framework of projected dynamical systems Chapter Eleven discusses an in depth survey of algorithms for solving shortest path problems which are pervasive to any equilibrium algorithm The chapter devotes special attention to the computation of dynamic shortest paths and to shortest hyperpaths The final chapter considers operations research tools for reducing traffic congestion in particular introducing an algorithm for solving a signal setting problem formulated as a bilevel program **Electronic Systems and Intelligent Computing** Pradeep Kumar Mallick,Preetisudha Meher,Alak Majumder,Santos Kumar Das,2020-09-22 This book presents selected high quality research papers from the International Conference on Electronic Systems and Intelligent Computing ESIC 2020 held at NIT Yupia Arunachal Pradesh India on 2 4 March 2020 Discussing the latest challenges and solutions in the field of smart computing cyber physical systems and intelligent technologies it includes papers based on original theoretical practical and experimental simulations developments applications measurements and testing The applications and solutions featured provide valuable reference material for future product development *International Encyclopedia of Transportation* ,2021-05-13 In an increasingly globalised world

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