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Implementation of Face and Eye Tracking System Using High Level Synthesis

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Abstract: This Proposed system is developed by implementing an algorithm proposed by Viola-Jones for face and eye detection and tracking. By monitoring various features of face and eye, attention of person can be estimated. Given system uses Vivado High Level Synthesis (HLS) for implementing Viola-Jones algorithm. Here, Xilinx Zynq-7000 SoC series is used as hardware platform, processing platform. OpenCV libraries which gives optimum real time image processing, is used to obtain required application. Viola-Jones uses Haar cascade classifier which classifies different face inclination of person and system estimates whether a person is attentive or not. This system is running on the ARM Cortex-A9 dual core processor of the Zynq-7000 SoC and with Vivado HLS along with OpenCV libraries, and the results show that the system performs satisfactorily when a face is not inclined. However, if face is inclined at certain angle, system stops detection and tracking of face and eyes.

Keywords: Vivado HLS, Viola-Jones algorithm, OpenCV libraries, Xilinx Zynq-7000 SoC.

I. INTRODUCTION

Computer vision has many applications in which acquiring, processing, analysing real time data takes place and this data is nothing but the input images taken of any particular object. The main objective of computer vision is to model, replicate, and more importantly exceed human vision using computer software and hardware at various levels. Here, basic process is acquiring image and processed it for various features extraction (edge, corner detection). One such application of computer vision lies in tracking of face and eye of a person. Face and eye tracking has many application which include attention detection, in security system, human computer interaction and also eye diagnosis.

OpenCV libraries are utilised mainly for real time image processing. It has many applications e.g. motion tracking object recognition etc. Here, haar cascade classifier of viola-jones algorithm is used for face and eye tracking. OpenCV source code calls the classifier which classifies different features of face and eye and thus required application is achieved.

The major parts of the face and eye tracking system are (1) imaging, (2) hardware platform, and (3) the intelligent software. In the proposed system we use camera for imaging through which images of persons face will be taken and fed through the hardware and various image processing operation is done.

The system is developed on all programmable SoC Zynq-7000 series is used as a hardware platform for a proposed system. Camera which used for image acquisition is connected to board. ZedBoard is a Zynq-7000 series family member can be used as hardware platform and features of this board is a complete development kit for designers interested in exploring design using the Xilinx: Zynq™-7000 All Programmable SoC. The board contains all the necessary interfaces and supporting functions to enable a wide range of applications.

II. PREVIOUS WORK

There are many systems have been developed with the application of face and eye detection and tracking. One such system is to monitor the driver while driving the vehicle. In [1], driver eyes on the road or off the road have been estimated by eye gaze tracking of driver and thus system comes to know that whether driver's attention is on road or not. Similar approach is given in [2], [3] in which different algorithm for real time eye detection and face detection has been implemented on system such that they can estimates drowsiness of driver by estimating various facial and eye features e.g. yawning, eye blink rate etc and in [4], face detection carried out depending upon motion of face. There is another such implementation [5] of attention detection of driver developed on system on chip Zynq platform.

There has been different studies performed and different algorithms have been proposed on eye gaze tracking and face detection. In [6], method has been given which concentrates on visible-imaging and here an approach has presented to the eye gaze tracking using a web camera in a desktop environment. Various algorithms has certain methodology for such application; in [7] different face and eye detection models have been categorised and different algorithm for them has examined.

OpenCV i.e. Open source Computer Vision libraries have been gaining its importance in real time image processing as it gives more promising results than other methods. There are many application developed with the help of OpenCV libraries such in [8] which shows image encryption by handling image and processing on it through IplImage data structure, in [9] design and implementation of face recognition has given. In the given system we are using same library function to develop required application.

P. Viola and M. Jones has proposed and developed an algorithm which can recognize and classifies different face

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and their inclination with the help of different features of the face. It gives rapid image processing and high detection rates. Here haar cascade classifier is used to classify the faces and it differentiate from background based on Adaboost algorithm which mainly involves training of the classifiers given in [10], [11] with large set of image data based on various facial features and then implement that classifier for face detection. In [12], another approach for face detection and tracking is given which is based on Adaboost algorithm and also there is another algorithm called camshaft algorithm is utilised for the given application.

With the Zynq-7000 All Programmable SoC, Xilinx is fielding a platform implementation of ARM Cortex- A9 processor that suits the vast majority of embedded applications. As given in [13], the Zynq SoC offers many advantages over ASIC, ASSP and even ASSP+FPGA combos as a silicon platform. In comparison to other hardware implementations of the ARM processing system, the Zynq SoC has the best feature set in terms of NRE, flexibility, differentiation, productivity/time-to-market, lowest cost of derivatives and best overall risk mitigation. Another approach in [14], [15], analyzes Zynq-7000 AP SoC from the perspective of an evolvable hardware designer as it has more, also [16] and [17] is useful for understanding basic Vivado HLS designing methodology.

Additional to this, in proposed system target platform is a Zynq-7000 SoC which enables us to easily migrate from software only solution to a hardware/software co-design in future works.

III.METHODOLOGY

Many techniques have been developed for face and eye detection tracking. Here, basically person is monitored for with the help for capturing his face images to determine its various features and to know whether he is being attentive or not. Along with camera, there is a hardware platform for computation and software which performs the basic algorithm for eye and face monitoring. Following is description about overall system design and the algorithm implemented for attention detection.

A. Zynq Platform

Proposed system uses hardware/software co-design approach which is developed using All Programmable System on chip (APSoC) Zynq platform. Zynq provides an even more ideal platform for implementing flexible SoCs: Xilinx markets the device as an 'All-Programmable SoC' (APSoC), which perfectly captures its capabilities.

Fig. 1 shows the simplified model for Zynq architecture. Note that Zynq comprises two main parts: a Processing System (**PS**) formed around a dual-core ARM Cortex-A9 processor, and Programmable Logic (**PL**), which is equivalent to that of an FPGA. It also features integrated memory, a variety of peripherals, and high-speed communications interfaces.

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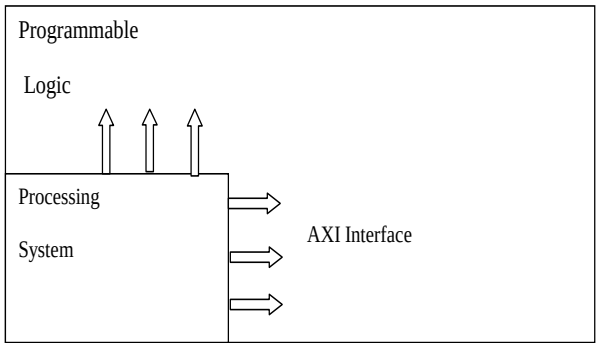

Fig.1 A simplified model of the Zynq architecture

It also features integrated memory, a variety of peripherals, and high-speed communications interfaces.

The PL section is ideal for implementing high-speed logic, arithmetic and data flow subsystems, while the PS supports software routines and/or operating systems, meaning that the overall functionality of any designed system can be appropriately partitioned between hardware and software. In this platform, links between the PL and PS are made using industry standard called as Advanced eXtensible Interface (AXI) connections.

B. Vivado HLS Design flow

Vivado Design Suite is a software suite produced by Xilinx for synthesis and analysis of different HDL designs, with additional features for system-on-chip development and high-level synthesis which gives it more efficiency than Xilinx ISE. Vivado HLS is a part of Vivado Design Suite and this enables developers to synthesize (compile) their designs, perform timing analysis, examine RTL diagrams, simulate a design's reaction to different stimuli, and configure the target device i.e. Zynq platform with the programmer.

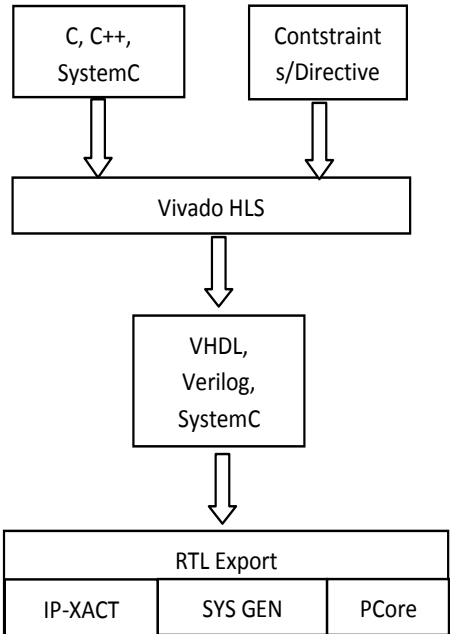

Fig.2 Vivado HLS Design Flow

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Vivado is a design environment for FPGA products from Xilinx, and is tightly-coupled to the architecture of such chips, and cannot be used with FPGA products from other vendors.

Fig. 2 shows the simple design flow for Vivado HLS which includes various parts which are involved in different HDL implementation. The Vivado HLS compiler enables C, C++ and SystemC programs to be directly targeted into Xilinx devices without creating any RTL design. Given C, C++ and SystemC program are firstly gone through simulation process and after that given designed is synthesized along with different constrained and directives. With the help of constraints and directive, overall functioning, efficiency of programs can be improved.

After synthesis, if no error present in the program, then next step is to create HDL implementation and this is done by C/RTL co-simulation option which is available in Vivado HLS. After creating HDL wrapper, next part of the design is to transform resulted HDL code to RTL design which is done through IP core generation or system generator, thus obtaining required RTL design of available C, C++, SystemC program.

IV. RESULTS

Results have been obtained regarding various face and eye position.Viola-Jones algorithm along with OpenCV libraries when implemented with vivado hls, it gives results as shown in the figure 3 and figure 4. These figures show results of the simulation process involved in the high level synthesis of opencv library function for face and eye detection and tracking.

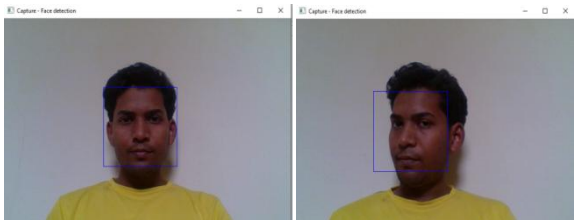

fig. A fig.B

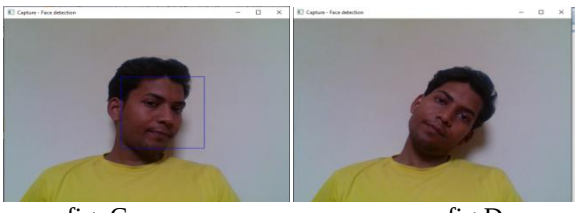

fig. C fig.D

Fig. 3 Face detection and tracking at various face position

Fig.3 shows the results which involve face detection and face tracking. Here, results are obtained with respect to various face position, inclination and at certain tilt angle of face. In this figure, fig. A, fig. B and fig. C gives the required results of face detection and tracking while fig. D does not detect face which shows that when face is tilted beyond certain angle, given system failed to give required results so this is important part of this system as this application can be used in attention detection of driver as given in [4], such that if he sleeps while driving his face tilted can be detected by given system and any chances of accident can be reduced.

Fig.4 shows results of eye detection and tracking which shows the detection and tracking of eye at various positions and tilt angle of face. Here, fig. A gives optimum results as system able to detect and track both eyes and for such position; we get required results for real time.

When eyes are moved from direct site of camera, detection and tracking rate gets reduced and at certain position, like shown in fig. B and fig. C, system unable to detect both eyes and at such points, tracking of eyes gets stopped.

fig. A fig.B

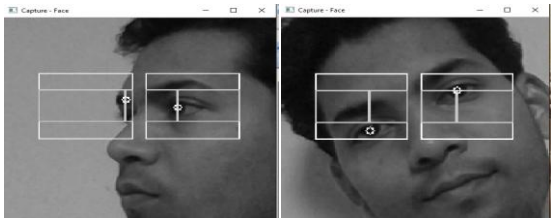

fig.C fig.D

Fig.4 Eye detection and tracking at various face position

Similar situation occurs when face gets tilted at certain angle as shown in fig. D. Here also eye tracking rate reduced when face starts tilting and after some limit system will not be able to track eyes and stops execution of given algorithm. This property can also be used as a metric of attention detection.

Vivado HLS effectively used the OpenCV libraries and perform operation of face and eye detection and tracking with viola-jones algorithm in which harr cascade classifier is first trained with the help of large set of data and then it is implemented for given application. Here, in proposed system classifier was already available and it is then called with OpenCV library functions during simulation process involved in Vivado HLS.

Both figures (Fig.3 and Fig.4) are inter-related as tracking of face and eye is going on simultaneously. These two has many potential applications in computer vision: it can help the disabled person to control the computer effectively just by his eye movement, the integration of user's gaze and face information can improve the security of the existing access control systems.

V. CONCLUSION

Proposed system uses an OpenCV library functions which gives more promising and real time results in image processing and when it is used along with Vivado HLS, it shows the alternative method for implementing given face

and detection application which definitely proved that there is better scope for implementing such a complex image processing application in high level synthesis. Given systems will not gives accurate results when the light intensity in a room is not sufficient to capture images also if person is wearing any spectacles will resist eye detection and tracking.

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