A High Speed, run time reconfigurable image acquisition processor for a Missile Approach Warning System

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ABSTRACT

High frame rate video capture and image processing is an important capability for applications in defense and homeland security where incoming missiles must be detected in very short time frames. Camera systems that operate in the domain can benefit from hardware zooming. This refers to the situation where the camera is capable of changing its frame rate and frame pixel count in real time to capture objects of interest. In a searching mode the full frame is used at a lower frame rate whilst once an object is detected the camera reduces its field of view and increases the frame rate. This paper describes a reconfigurable computing based frame acquisition and processing system together with a reconfigurable test pattern generator that demonstrates the feasibility of this technique for high frame rate application in excess of 400 frames per second. The design is part of a larger ship borne Missile approach warning systems (MAWS) that will use run time reconfiguration in the tracking and detection algorithms.

1. INTRODUCTION

This paper discusses a component of missile approach warning system (MAWS) based entirely on reconfigurable computing. A classical MAWS consists of 2 core components, namely an image acquisition component, an object detection and tracking component. MAWS has very high computation requirement [7] because it has typically has less than 5 seconds to image a possible threat, decide that the object is a real threat and deploy a counter measure. In this paper we focus on the first components of MAWS and in particular a flexible design makes best use of an adaptive camera whose frame rate and frame pixel count can be varied in real time. The original MAWS achieved a frame rate of 120 frames/ sec with a fixed frame pixel count. In the new prototype the camera is directly connected to the FPGA thus bypassing the slow PCI buss. The new MAWS prototype achieves a much higher frame rate and provides run time reconfigurability.

2. RUN TIME RECONFIGURABILITY

One of the special requirements of the image acquisition system is run time reconfigurability. Run time reconfigurability requires dynamic reconfiguration. Dynamic reconfiguration refers to the ability to reconfigure the processing hardware to adapt to changing user data needs.

This is of great importance to missile approach warning systems. In these systems, it is essential to develop the caliber to dynamically adjust the system based on changing user requirements. For instance, the frame zoom/ enlarge/ minimize functions should instantiate special processes within the system to accommodate the demand for more or less resources based on the situation at hand.

3. NEW MAWS PROTOTYPE

The new prototype is shown in Figure 1. In this design the camera is directly connected to the image acquisition system. The new solution is also different in that it aims to capture frames with varying frame rates and sizes.

The image acquisition system, which is implemented on the FPGA, acquires images from the camera. The camera has a varying frame size and rate. As the frame size and rate changes, the image acquisition system dynamically changes the system configuration, such as memory allocation and frame capture rate. This is because frame size and frame rate are inversely proportional. For instance, as the camera zooms, the frame size drops while the frame rate increases.

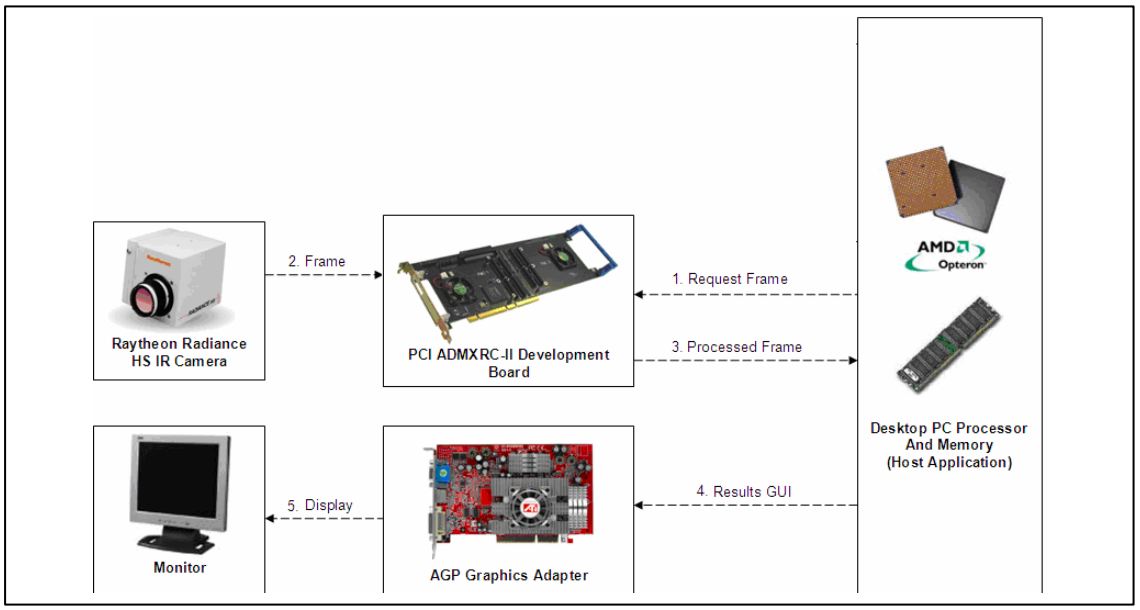

Figure 1: New processing chain of MAWS

4. RESULTS

The primary goal of this design was to develop a high speed, run time reconfigurable image acquisition processor. The newly developed system successfully met both the requirements. The system was tested extensively and the results of the tests are tabulated below. The system was tested using the test pattern generator. For the standard settings, where the frame rate is 45MHz and the pixels per frame is 32768, it took on average of 1.19 milliseconds to capture, store and display a frame to screen for the test pattern generator. This translates to an output of 840 frames per second. The previous solution took 7.9 milliseconds to display one frame [4].

Furthermore, the image acquisition system was tested for reconfigurability. While the system was running, the frame rate was varied, the frame size was varied and the camera was replaced with the test pattern generator. The results of the tests are tabulated below. The test pattern generator had the functionality to test the image acquisition processor for varying frame rates and pixel counts.

Results table 1: Standard setting (Fixed pixel count)

Image acquisition processor	Frame Rate	Pixel count	Time/ frame (msec)	Frames/ Second
New model	45MHz	32768	1.19	840
Old model	45MHz	32768	7.9	126

Data acquisition processor	Frame Rate	Pixel count	Time/ frame (msec)	Frames/ Second
New model	45MHz	65536	2.38	420
Old model	45MHz	NA	NA	NA

Results table 2: Variable Pixel Count (pixel count)

Frame Rate	Pixel Count	Time/ frame (msec) New model	Time/frame (msec) Old model
100MHz	65536	4.76	NA
75MHz	65536	4.165	NA
50MHz	65536	2.38	NA

Results table 3: Variable Frame Rate (pixel count)

5. CONCLUSION

This research project has been successful in developing single-card reconfigurable image acquisition architecture for missile approach warning systems. The image acquisition has been demonstrated in real time has have provided significantly higher performance.

This is a significant achievement, as the removal of the bottleneck enables the MAWS to operate at a much higher capacity.

6. REFERENCES

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