ECE 492 - Computer Engineering Design Project

Simple Digital Camera with On-board/Web Editor

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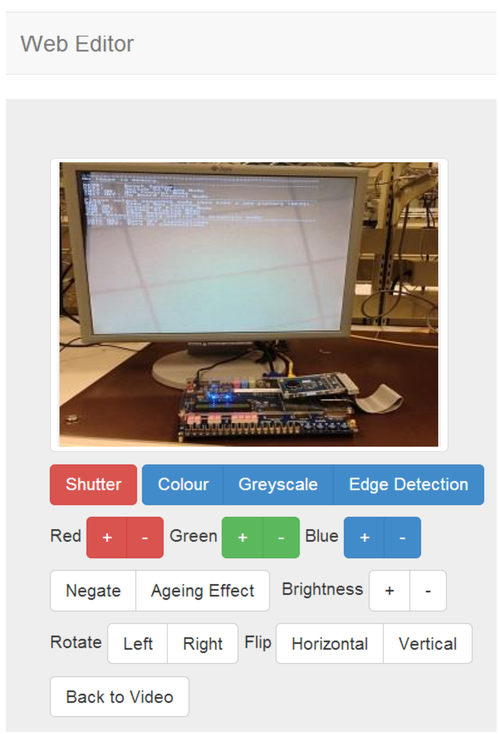
Introduction

The goal of this project is to implement a simple digital camera with on-board and web-based image processing system. The major components include a Terasic D5M serial camera, a frame buffer and web server on the Altera DE2 board, and a VGA monitor for displaying the images.



Web Editor

The Ethernet Controller (DM9000A) is interfaced on DE2 board. A web server have been flashed in the system to host a web page accessible by computers and other mobile devices such as smartphones. The web page allows the user to apply different image process operations, and the system will response in real time.

Camera

Terasic D5M camera supports Bayer Pattern color output on both Continuous Video Mode and Snapshot mode.

The original resolution 2592x1944 pixels was cut to 320x240. The color format was transformed to 16-bit RGB565, and then saved to pixel buffer.

Pixel Buffer

Frame output from the camera will be stored in SRAM. Image processor in software will read and modify the image via a byte array when user choose an image operation through on-board or web-editor interface. The modified image will be written it back to SRAM.

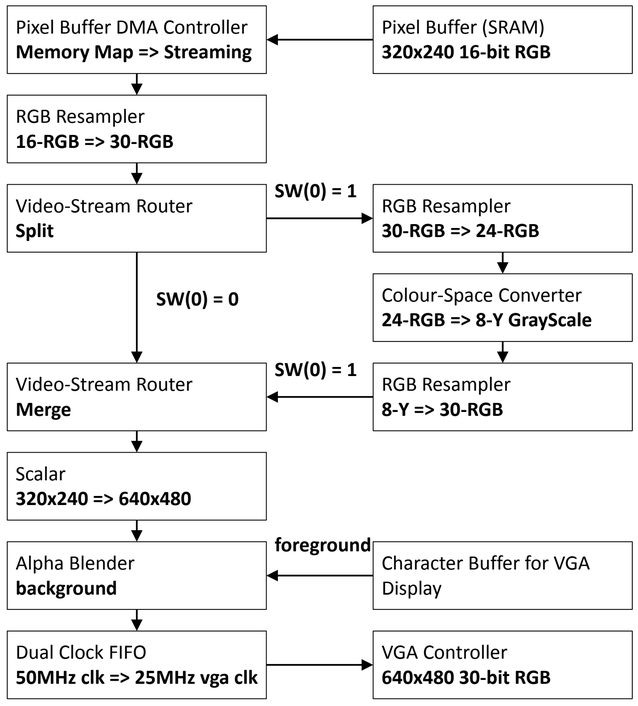


Image Operations

A series of pixel based image processing operations are available on Color mode and Grayscale mode:

- ❑ Color Negation — *buffer[pixel] = 0xFF – buffer[pixel]*
- ❑ Brightness Adjustment — *buffer[pixel(R,G,B)] = buffer[pixel(R,G,B)] +/– Brightness Step Size*
- ❑ Clockwise Rotation — *rotated index = 2*(320 *(320 – ((index/2) mod x) – 1) + row number)*
- ❑ Counter Clockwise Rotation — *rotated index = 2*((1 + ((index/2) mod 320))* 320 – (1+row number))*
- ❑ Horizontal Reflection — *reflected index = 2*(320* row number + (320 – ((index/2) mod 320) – 1))*
- ❑ Vertical Reflection: — *reflected index = 2*(320*320 – 320 – (row number * 320) + ((index/2) mod 320))*
- ❑ Color filters — *buffer[pixel(R/G/B)] = buffer[pixel(R/G/B)] +/– Filter Step Size*
- ❑ Ageing Effect — *pixel(R)=pixel(R)+0x03; pixel(G)=pixel(G)+0x02; pixel(B)=pixel(B)–0x03*

Where *index* above refers to the pixel index stored in the image buffer which is array of bytes.

In video streaming mode, the system can also perform Color to Grayscale conversion and Edge Detection when Grayscale mode is active.

Streaming

The process of streaming image/video data from pixel buffer to VGA screen involves a complex architecture of Altera University Program IP cores. Figure on the left gives a simplified design idea.

The frame data gets through processes of scaling, reformatting, merging with characters, and a logic routing to components that performs grayscale conversion and edge detection.

Testing

- ❑ Software testing is done by generating a picture with some color patterns in it, and then performing the processing operations.
- ❑ Hardware testing consists of integrating all the system components and DE2 board. Real images are taken from camera and are shown in VGA monitor to verify the system is working properly.
- ❑ Integration tests combine all the software components and hardware components, and apply processing operations on the real images.

Potential Improvements

1. The prototype uses Ethernet with a router as the communication media between the board and the mobile devices. This can be further improved by replacing Ethernet with a Wi-Fi module.
2. The current version of the on-board editor only has instructions printed out as plain text. A simple GUI for the on-board editor could be made for better user experience.