FPGA Parametric Video Processing Design and Implementation

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ABSTRACT

Video IP project is a parametric FPGA flow that allows raw data obtained from image sensor source to be digitalized, processed using image signal processing algorithms such as the histogram equalization, various filtering types to eliminate noise in the given image, enhanced with enhancement methods and convert the output into one of the desired image formats from either analog or digital formats such as PAL, HDMI, NTSC depending on the project.

INTRODUCTION

The main aim of this project flow is to design the entire process parametrically which allows the flow to be dynamically configurable, depending on the various project uses. To design and implement the components of the project, the project is divided into 3 sub-projects. These 3 parts are as follows:

1- Digital Output Design

2- Analog Output Design

3- Video Processing

OBJECTIVES AND TASKS

DIGITAL OUTPUT DESIGN

Digital output considered in this project is HDMI output. The constraints for HDMI could be given as follows: HDMI uses four channel Transition-minimized differential signaling (TMDS) to transmit and receive the data set of the video. Other important thing about HDMI interface is color spacing. HDMI supports three video pixel formats: RGB 4:4:4, YCbCr 4:4:4 and YCbCr 4:2:2. This determines the depth of the colors in each pixel. Therefore, bit size for each pixel increases if we use full color space. Each TMDS channel of the HDMI 1.3 can support up to 3.4 Gbps so that it would be enough to transmit even 4K full color space video. We can use HDMI 2.0 yet, clock issues arises if we would use it so HDMI 1.3 will be appropriate.

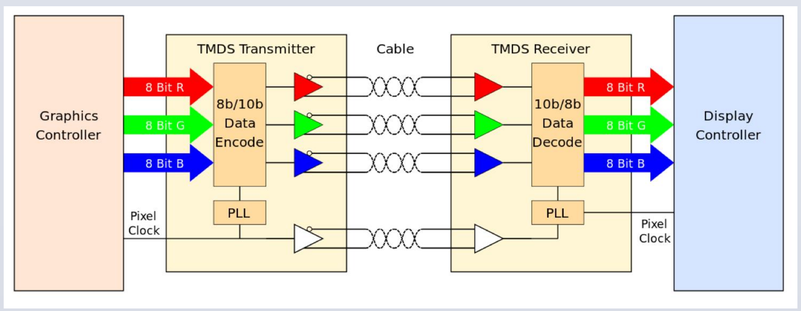


Figure 1: HDMI design scheme

ANALOG OUTPUT DESIGN

NTSC is the video system or standard used in North America and most of South America. In NTSC, 30 frames are transmitted each second. Each frame is made up of 525 individual scan lines. PAL is the predominant video system or standard mostly used in some part of Africa and Europe including Turkey. In PAL, 25 frames are transmitted each second. Each frame is made up of 625 individual scan lines. In both of the formats, interlacing plays an important role to obtain the images in different scan lines.

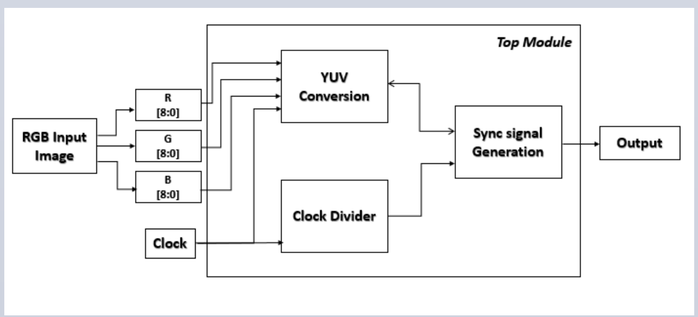


Figure 2: NTSC/PAL RTL design

VIDEO PROCESSING

1. Convolution Based Filtering
2. Noise Suppression
3. Image Restoration

Convolution Based Filtering – Gaussian, Sharpening

-Gaussian filter is a filter whose impulse response is a Gaussian function, is used to blur images and remove detail and noise.

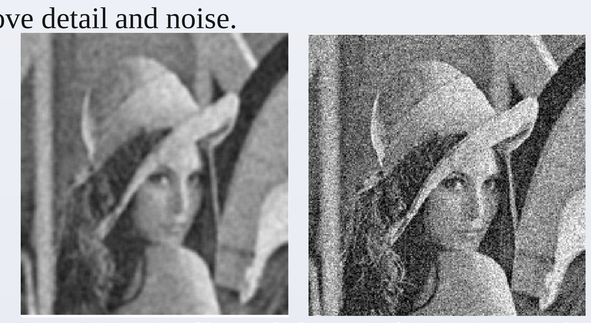


Figure 3: Gaussian filter applied image(Left), Noisy image(right)

Sharpening aims at producing an enhanced image by increasing the contrast of the given image along edges, without adding too much noise within homogeneous regions in the image.

Figure 4: Original image(left), Noisy image(middle), Sharpening filter applied image(right)

Median filtering is a nonlinear method for noise suppression. The main pass a window over the pixels, calling the corresponding pixels from the BRAM, sorting them, and finding their median.

Figure 5: Noisy image(left), Median filter applied image(right)

Image Restoration:

Image Restoration is the operation of taking a corrupt/noisy image and estimating the clean, original image. Corruption may come in many forms such as motion blur, noise and camera mis-focus.

In this core, both inverse and Wiener filter were implemented :

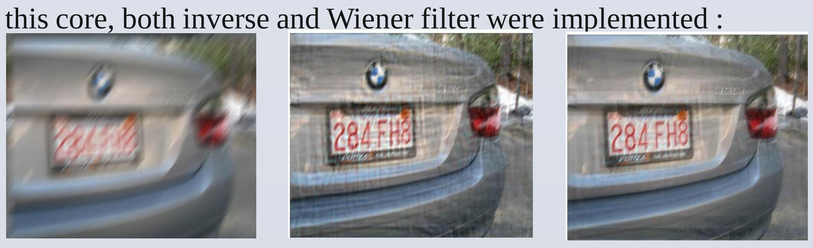
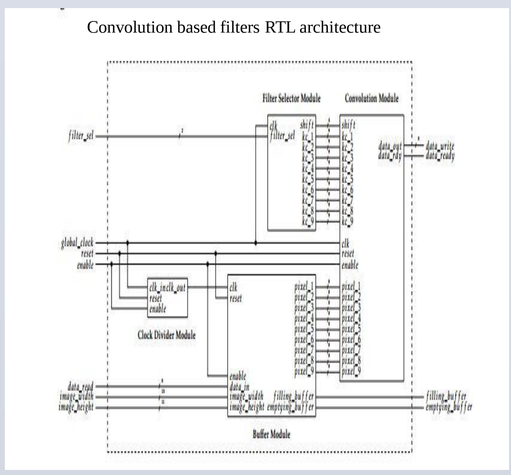
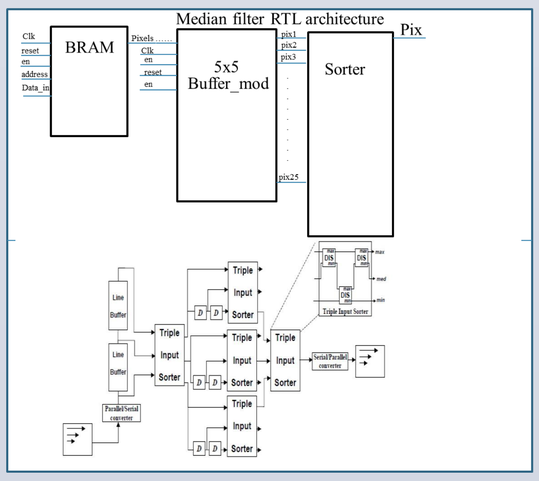


Figure 6 : motional blurred image(left), inverse filter applied with length estimated as 30 and angle as 45 (middle), Wiener filter applied image(right)





CONCLUSION

- The noise that might interfere has different forms, each one of them requires a specific filter type to be gone.
- The parametricity can not be applied in all applications due to FPGA restrictions and the difficulty of designing floating point systems.
- This project is still in progress, the team is still working on synthesizing the remaining hardware since the project is expected to be completed by the end of this semester.

REFERENCES

- Rekleitis, I.M., 1995. Visual motion estimation based on motion blur interpretation. Master's Thesis, School of Computer Science, McGill University, Montreal, Quebec, Canada.
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