Gamma Filter

Video Processing Circuit on Intel's DE1 SoC FPGA

Cole Maxwell

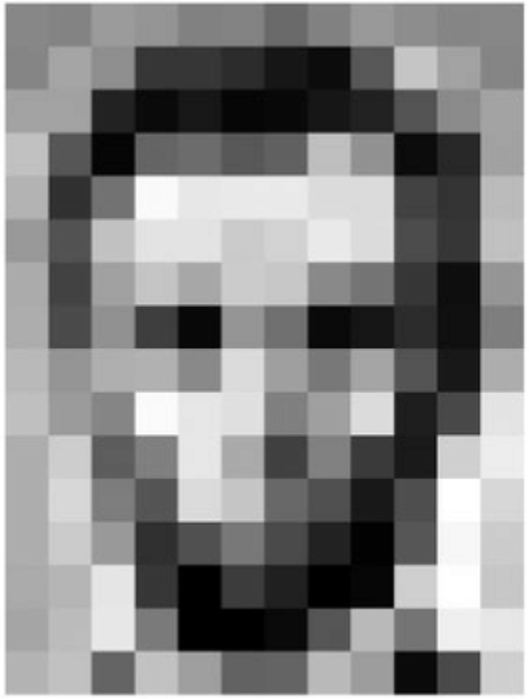
https://github.com/cole-maxwell/Gamma_Filter_DE1_SoC_FPGA

Outline

1. What is a Gamma Filter?
2. Project Overview
3. Demonstration
4. Technical Discussion
5. Questions?

First, what is a computer image?

- 2D array of pixels with ***8-bit intensity values*** ranging from 0 to 255.



157	153	174	168	150	152	129	151	172	161	155	156
155	182	163	74	75	62	33	17	110	210	180	154
180	180	50	14	34	6	10	33	48	106	159	181
206	109	5	124	131	111	120	204	166	15	56	180
194	68	137	251	237	239	239	228	227	87	71	201
172	105	207	233	233	214	220	239	228	98	74	206
188	88	179	209	185	215	211	158	139	75	20	169
189	97	165	84	10	168	134	11	31	62	22	148
199	168	191	193	158	227	178	143	182	106	36	190
205	174	155	252	236	231	149	178	228	43	95	234
190	216	116	149	236	187	86	150	79	38	218	241
190	224	147	108	227	210	127	102	36	101	255	224
190	214	173	66	103	143	96	50	2	109	249	215
187	196	235	75	1	81	47	0	6	217	255	211
183	202	237	145	0	0	12	108	200	138	243	236
195	206	123	207	177	121	123	200	175	13	96	218

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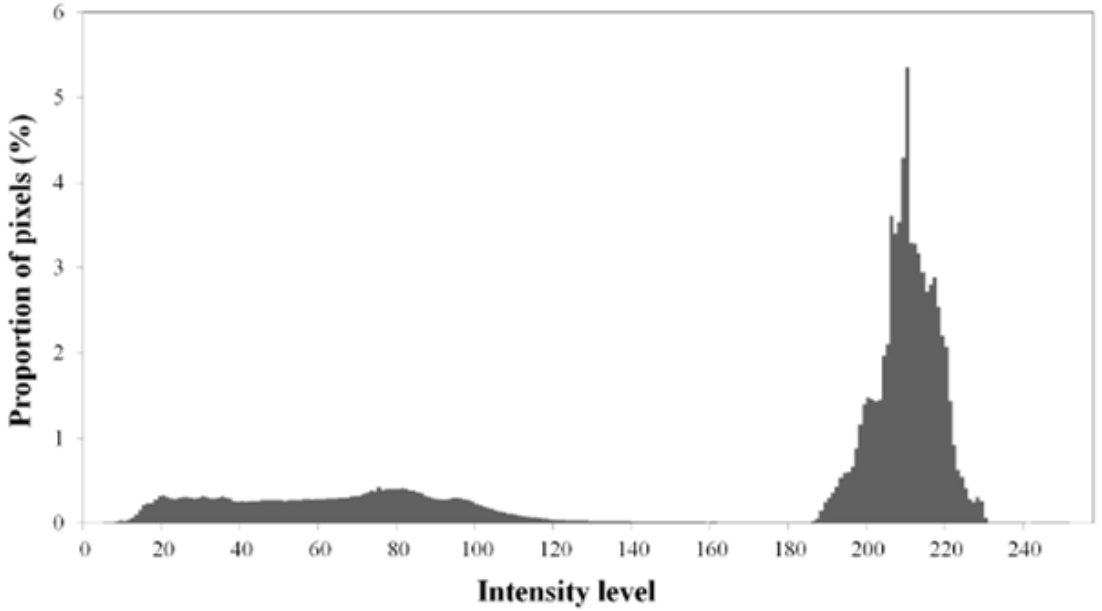
206	109	5	124	131	111	120	204	166	15	56	180
194	68	137	251	237	239	239	228	227	87	71	201
172	105	207	233	233	214	220	239	228	98	74	206
188	88	179	209	185	215	211	158	139	75	20	169
189	97	165	84	10	168	134	11	31	62	22	148
199	168	191	193	158	227	178	143	182	106	36	190
205	174	155	252	236	231	149	178	228	43	95	234
190	216	116	149	236	187	86	150	79	38	218	241
190	224	147	108	227	210	127	102	36	101	255	224
190	214	173	66	103	143	96	50	2	109	249	215
187	196	235	75	1	81	47	0	6	217	255	211
183	202	237	145	0	0	12	108	200	138	243	236
195	206	123	207	177	121	123	200	175	13	96	218

Reference: ***(III)***

Intensity Histogram

- Displays the number of times each *intensity value* appears in the image.



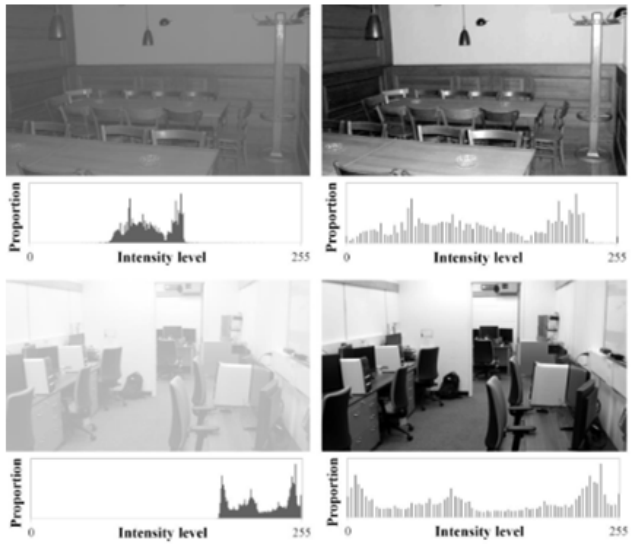
Reference: ***(I)***

Image Filtering

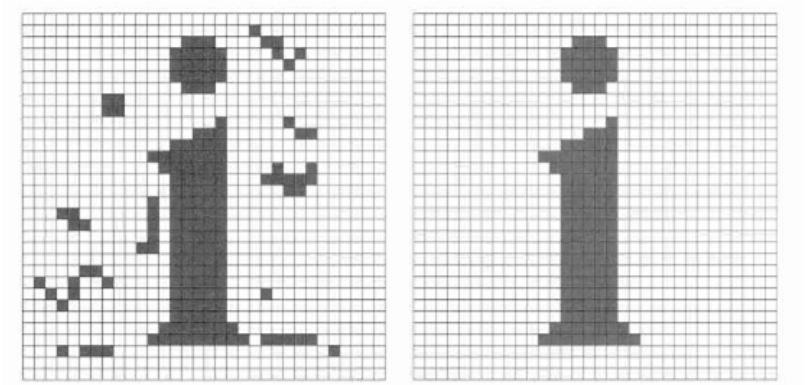
- Transforming the intensity values of each pixel in an image is a common technique that can make the image easier for a human to see or better for an algorithm to process.

- There are many types of image filters for different applications, many of them based on *convolution*.

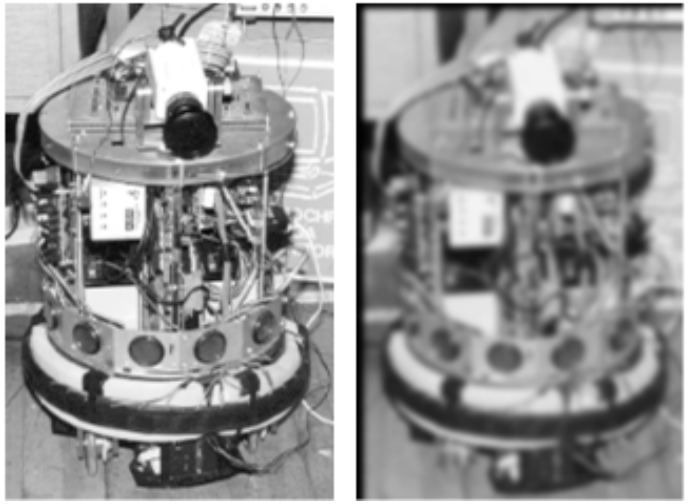
Linear Histogram Scaling



Size Filter



Gaussian Filter

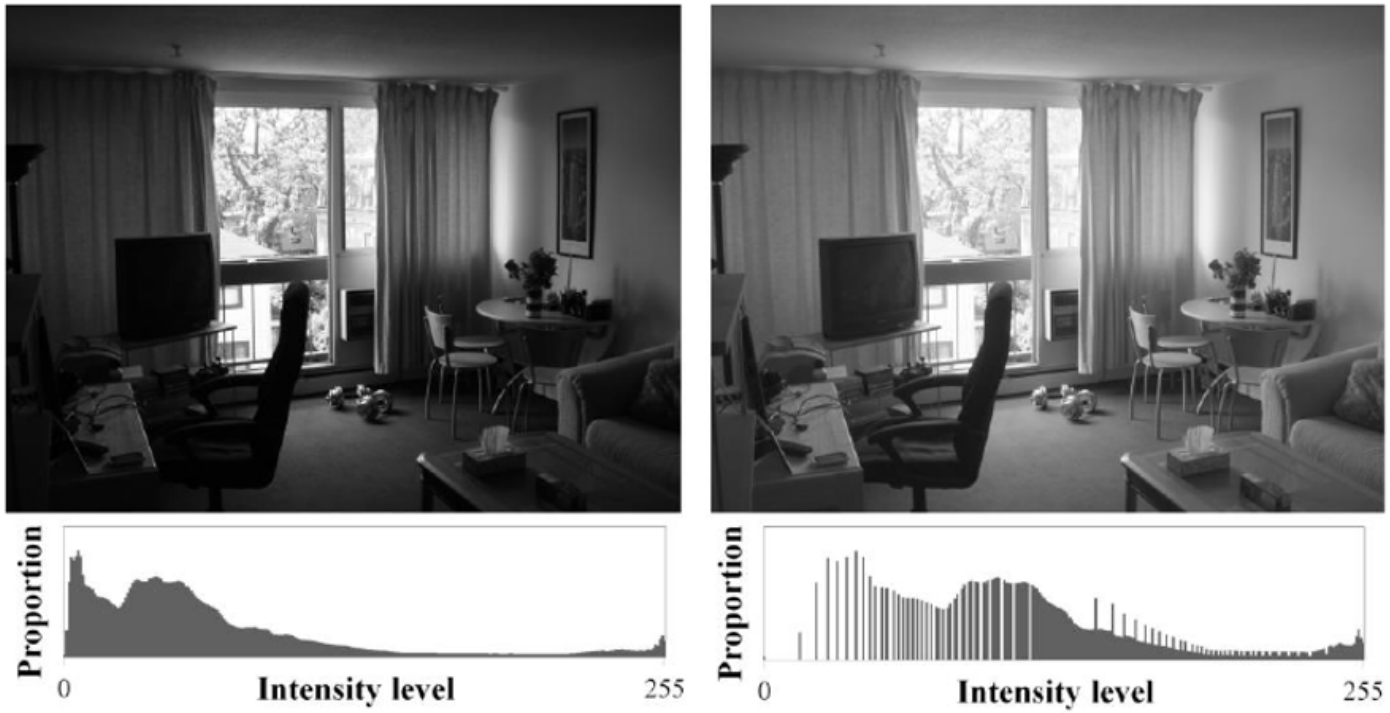


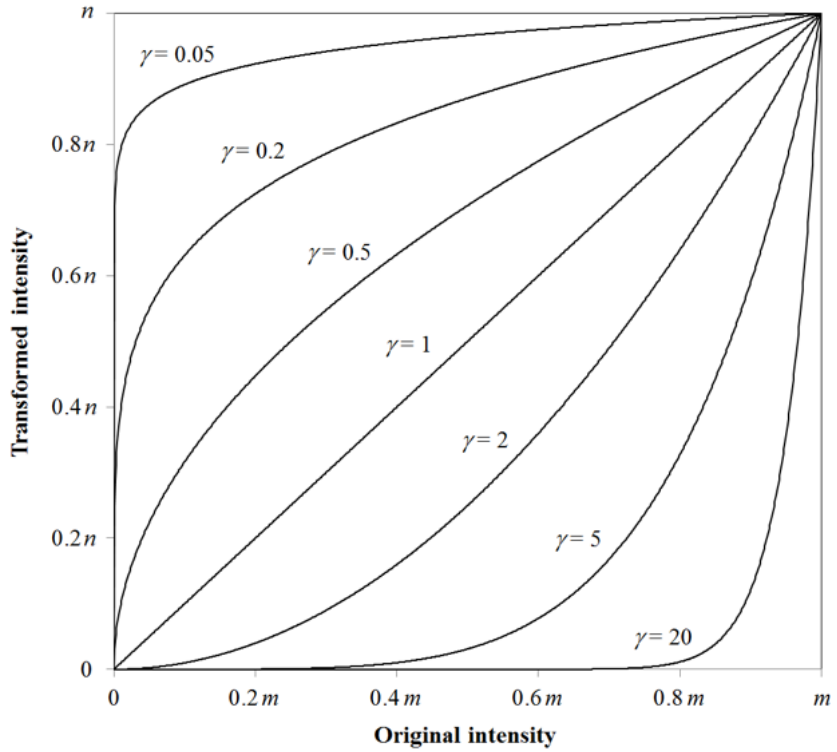
Reference: ***(1)***

Gamma Filter

- Image histograms that *skew high* or *skew low* can lack contrast.
- A gamma filter *remaps* intensity values to increase visibility.

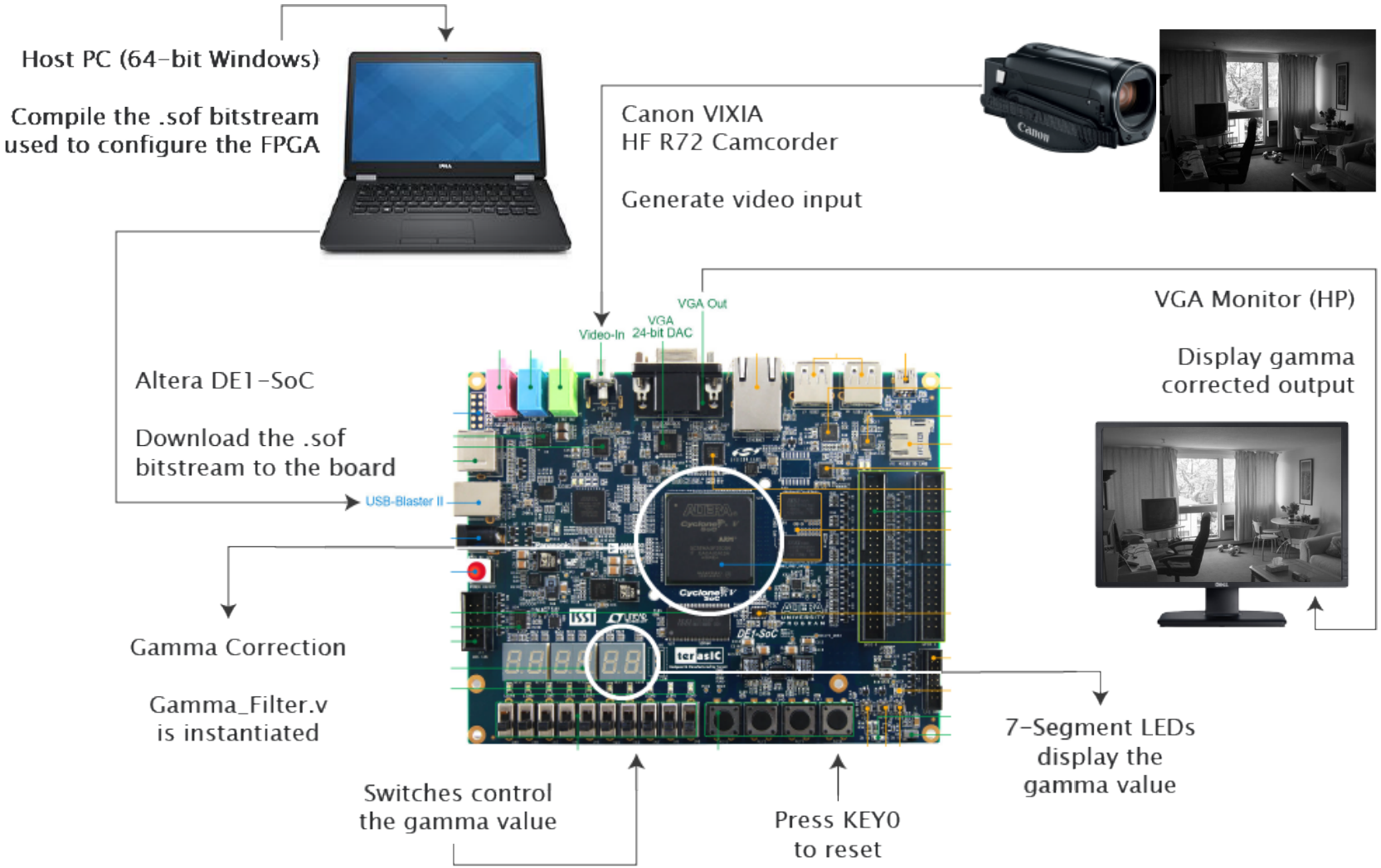
$$I' = 255(I/255)^{\gamma}$$





Reference: ***(II)***

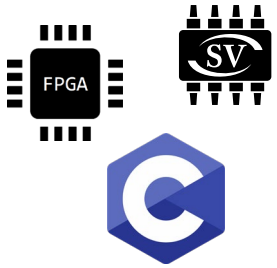
Hardware Setup



Reference: ***(IV, VI)***

Software Setup

C, Verilog & SystemVerilog



Generate_Gamma_Values.c

Gamma_Correct_TB.v

DE1_Gamma_Filer.v

Gamma_Correct.v

SEG7_LED.v

…

Quartus Prime Lite 18.1

Project File:
DE1_Gamma_Filter.qpf

Analysis &
Synthesis

Compilation &
Debugging

ModelSim

RTL Simulation with
Gamma_Correct_TB.v &
Gamma_Correct.v

Waveform Viewer

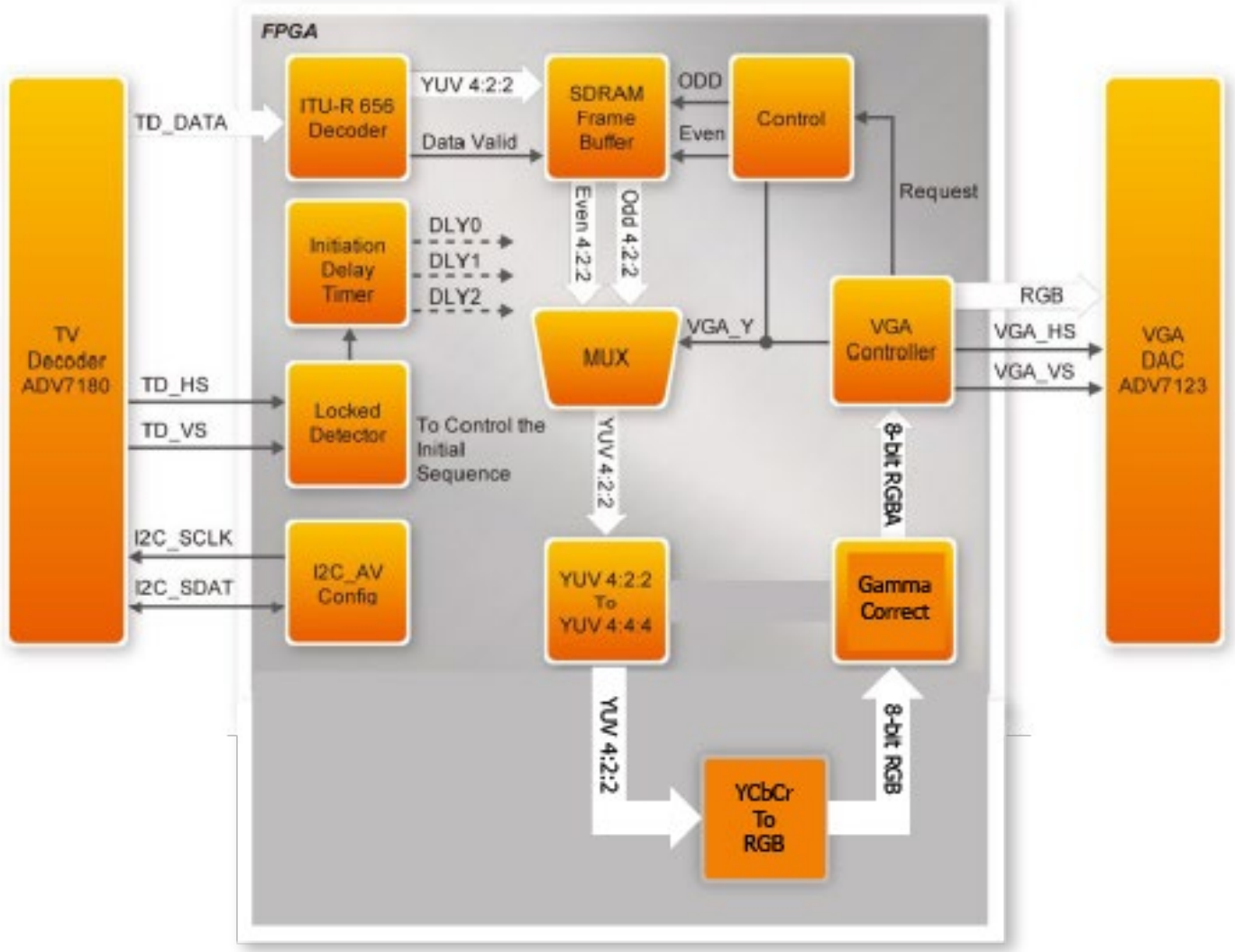
Programmer (Quartus Prime 18.1)

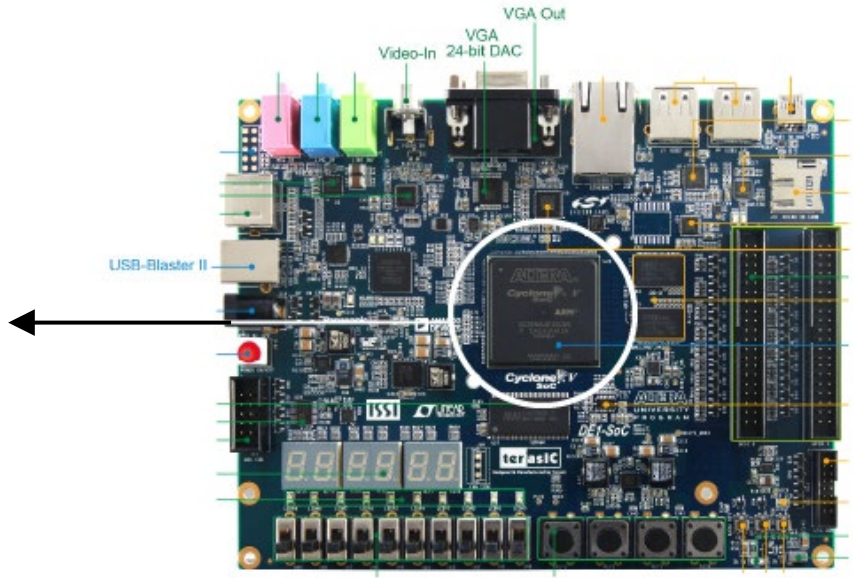
Hardware Detection
& Setup

Download the
DE1_Gamma_Filter.sof
bitstream to the board

Demonstration

FPGA Block Diagram





*Reference: **(V)***

Verilog Module Structure

Questions

References

(I) Pomplun, Marc. Computer Science 675: Computer Vision. Fall 2019, University of Massachusetts Boston. Class Lecture 4: Thresholding, Component Labelling, Size Filter.

(II) Pomplun, Marc. Computer Science 675: Computer Vision. Fall 2019, University of Massachusetts Boston. Class lecture 5: Compactness, Intensity, and Gamma.

(III) ResearchGate: https://www.researchgate.net/figure/Pixel-Data-Diagram-of-Abraham-Lincoln-166_fig4_337402608

(IV) Terasic Technologies Inc. 2003-2013, DE1-SoC Getting Started Guide, April 11, 2019

(V) Terasic Technologies Inc. 2003-2013, DE1-SoC User Manual, April 11, 2019

(VI) Canon, HF R72/R70, HD Camcorder Instruction Manual, PUB. DIE-0468-000