Augmented Reality on FPGA

Realtime Object Recognition and Image Processing

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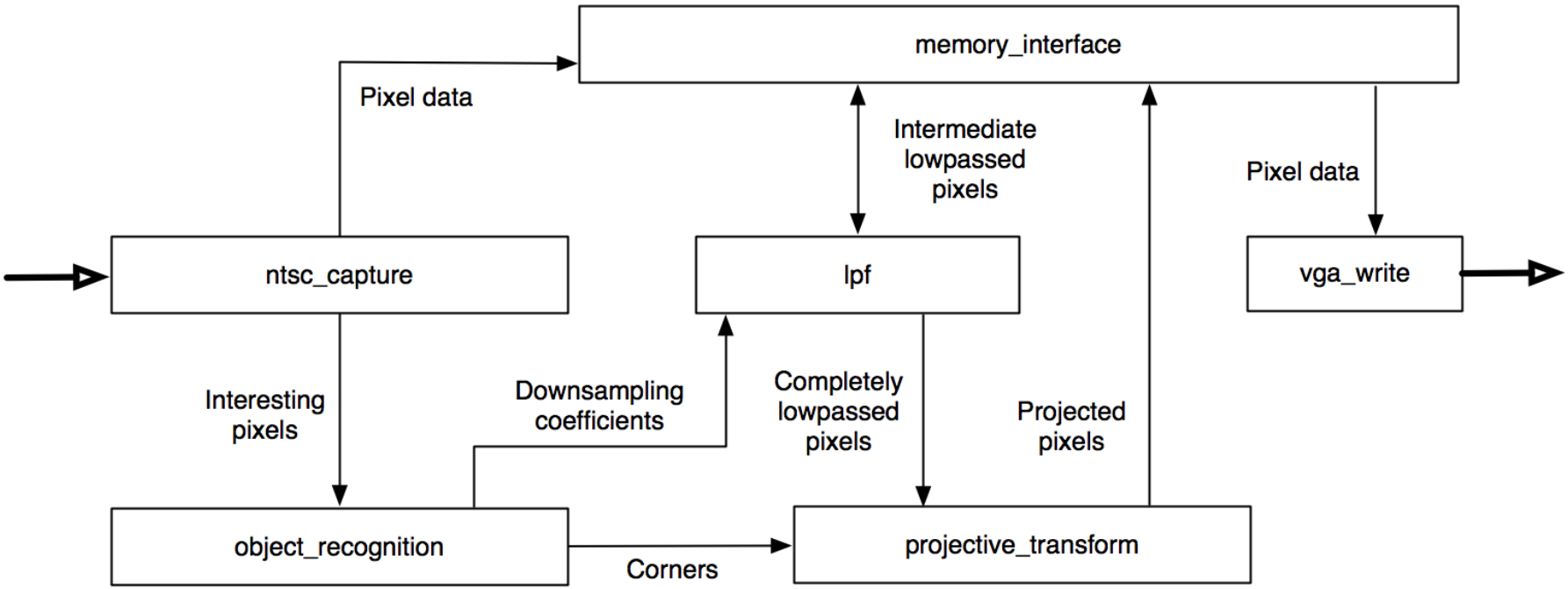
Introduction

Overlay a digital image on a physical object in realtime.

example image

top-level overview



projective_transform

object_recognition

`LPF`: its purpose

- `projective_transform` → aliasing

graphic showing normal signal

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graphic aliases

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- Aliasing reduces the quality of an image

zoom in on aliased pixels

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- Lowpass filtering prevents aliasing

picture depicting lowpass filter in 2D

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picture of original picture

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picture of other image

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picture of original phase with other's magnitude

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- Parks-McClellan: reasonable accuracy, symmetric, easily calculable

frequency response of Parks-McClellan filter

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- FIR PM filter reduces mem. acceses to 1.5/pixel

LPF: the algorithm

1. Given an arbitrary image & skewing coefficients M_x & M_y.

graphic showing the interface between object_recognition and LPF
image
magnitude fourier plot of image

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2. Fetch a filter with cutoff $\frac{\pi}{M_y}$.

magnitude plot of image
magnitude plot of filter with cutoff pi/2

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3. Filter each column and store in memory.

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magnitude plot of filter with cutoff pi/2
magnitude fourier plot of filtered

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3. Filter each column and store in memory.
4. Fetch a filter with cutoff $\frac{\pi}{M_x}$.

magnitude plot of filtered image
magnitude plot of filter with curoff pi/4

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2. Fetch a filter with cutoff $\frac{\pi}{M_y}$.
3. Filter each column and store in memory.
4. Fetch a filter with cutoff $\frac{\pi}{M_x}$.
5. Filter each row and output to `projective_transform`.

magnitude plot of filtered image
mangitude plot of filter with cutoff pi/5
magnitude plot of output

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2. Fetch a filter with cutoff $\frac{\pi}{M_y}$.
3. Filter each column and store in memory.
4. Fetch a filter with cutoff $\frac{\pi}{M_x}$.
5. Filter each row and output to `projective_transform`.
6. Repeat this process every refresh cycle.

magnitude plot of original
magnitude plot of filter
magnitude plot of output

memory_interface

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  $640 \cdot 480 \cdot 24$ bits ≈ 0.88MiB

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- Let's store store 18 bits per pixel or 2 per address

`memory_interface`: operation

1.

system io: `ntsc_capture`

system io: vga_write

timeline