Face Detection on the GPU

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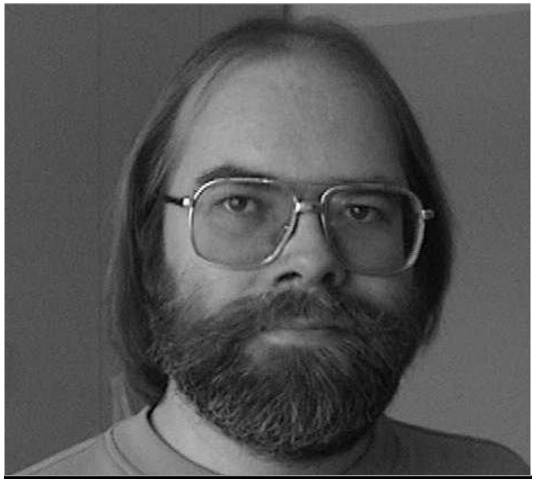
Viola-Jones Object Detection

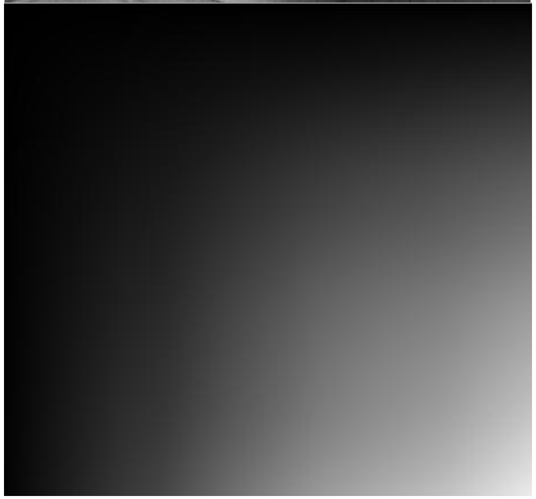
Idea: Use simple rectangular classifiers to rule out things that aren’t faces until you end up with only things that are faces.

Integral Images

Integral images reduce memory lookups of classifiers



Pre-compute areas by summing all pixels *above* and *left* of the given pixel

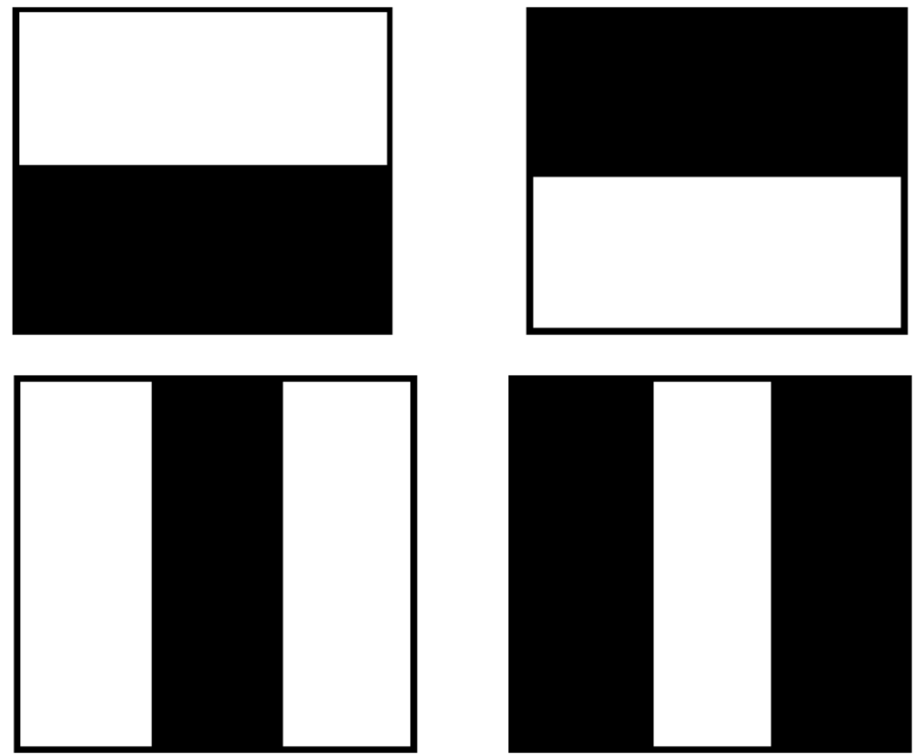


Classifiers

Simple rectangular classifiers

Fit value = white area – black area

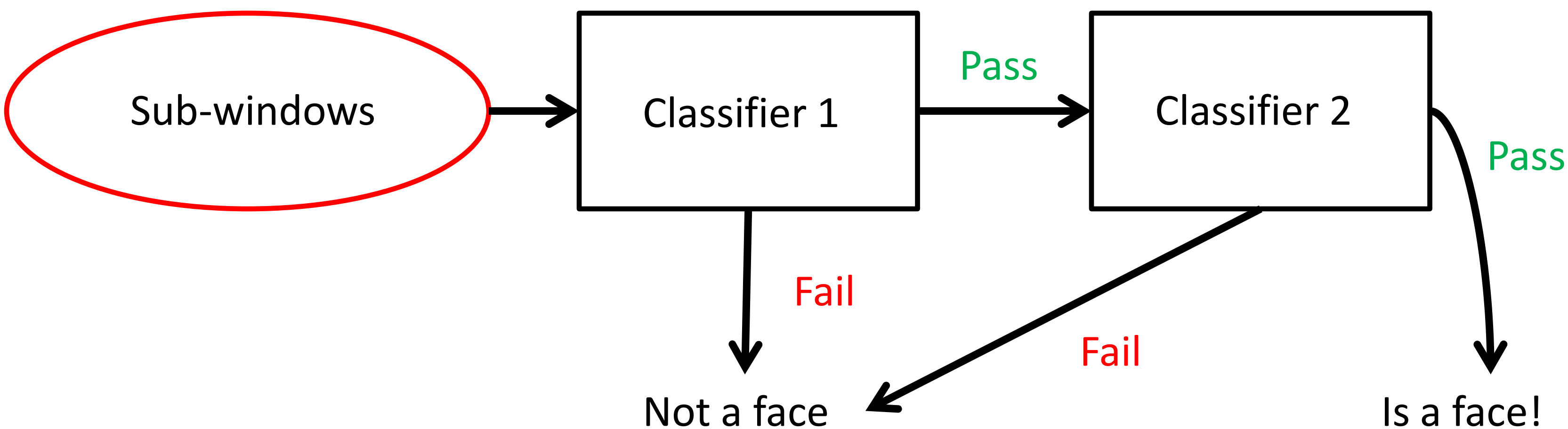
Find fit value at many different image locations



Cascading Classifiers

Have each classifier remove all of the failures from the input data for the next classifier

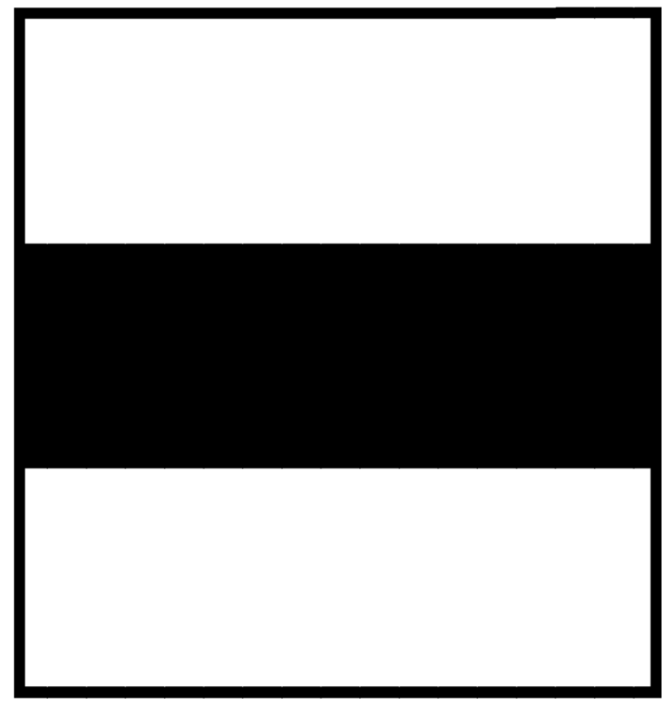
Anything left at the end is a face



Glasses Classifier

One extra classifier to determine whether the faces detected have glasses on or not

Overly simple but just a small extension of the algorithm



Opportunities for Parallelism

Different scales

Evaluate identifier at different sizes

Different sub-windows

Many different sub-windows per image at different offsets and different scales

Different identifiers

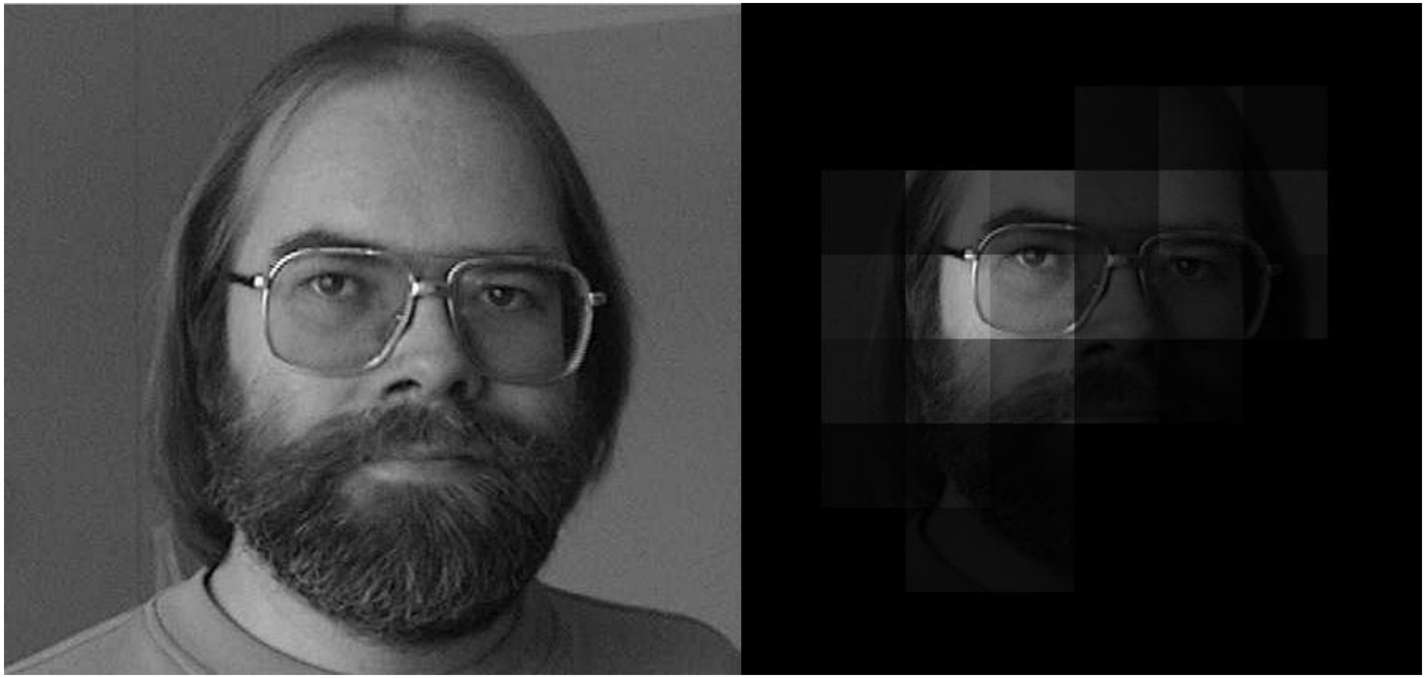
We only use a single identifier per stage and cascade them so this one cannot be used in our implementation

Results

Execution times:

Face detection – 0.20334 s

Glasses detection (after face detection) – 0.004104 s



Lessons Learned

Integral images on GPU vs. CPU

Occupancy based on scale

Issues with memory coalescing

Cascade versus non-cascade on GPU

Computing Integral Images

Parallel approach (GPU):

- compute all pixels above (column scan)
- then add the column scan values of each location to the left (row scan)

Serial approach (CPU):

- Just iterate through from top left down to bottom right and add the neighbors

Results: CPU wins (0.000709s vs. 0.005148s)

Occupancy Based on Scale

Different scales of identifiers equals more concurrent threads that can be run

Each thread only using ~10 registers so no local memory issues

Optimal thread count (based on CUDA calculator): 128 threads per block

Memory Coalescing

Classifier memory accesses are not regular

Each classifier skips several pixels as it is scanned across the image

Issue: How to make these sparse but predictable memory accesses coalesce?

Cascade versus Non-Cascade

On CPU, cascading removes a ton of work and is a net win

On GPU, parallel units can do the extra work that makes cascading lose some of its advantage

- Removing the bad sub-windows also takes GPU time (scan)

Questions