

GPGPU @ HPL(ISRAEL)

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January 2011



HP LABS - ISRAEL

- Established on 1994, by Abraham Lempel
- Based in the Technion
- High impact research themes addressing the next technology challenges and opportunities
- Working hand in hand with HP divisions in Israel - HP-Indigo, HP-Scitex, HPSW (formerly Mercury)
- My background



PAST PROJECTS

- Automatic Image Enhancement on a GPU
 - Old project, remained a POC
- Video Enhancement
 - Full duplex, real-time video enhancement
 - Integrated into an HP telepresence solution (HALO)
- Several research projects



PRINT DEFECT DETECTION ON A GPU

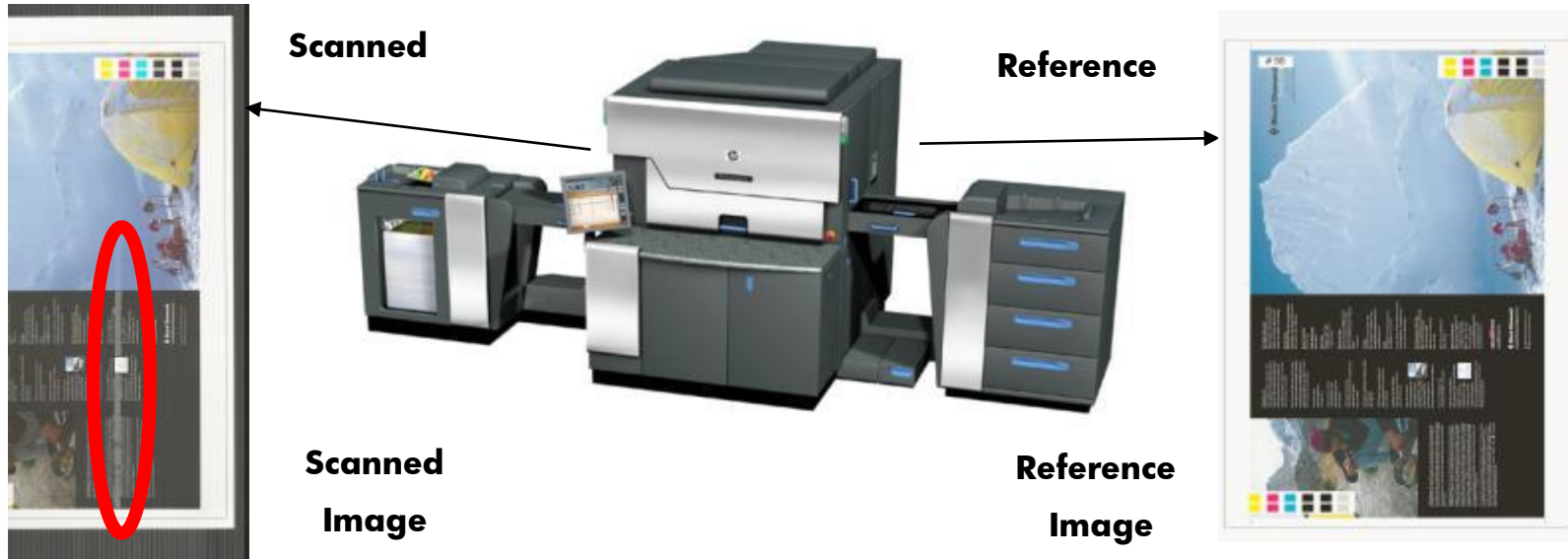
Lab-wide effort



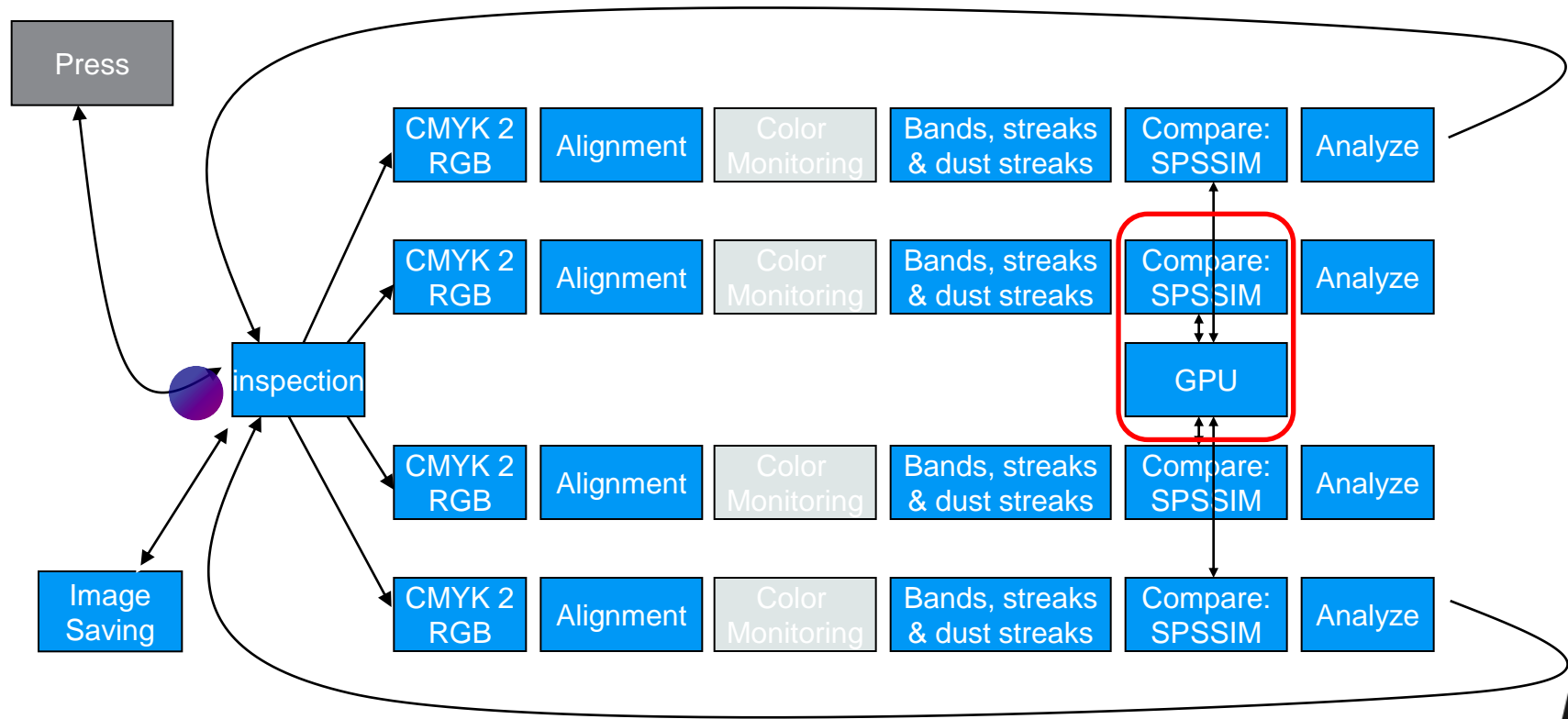
THE CHALLENGE

Allow print-inspection coping with print-speed VDP input

Compare two images from different acquisition device



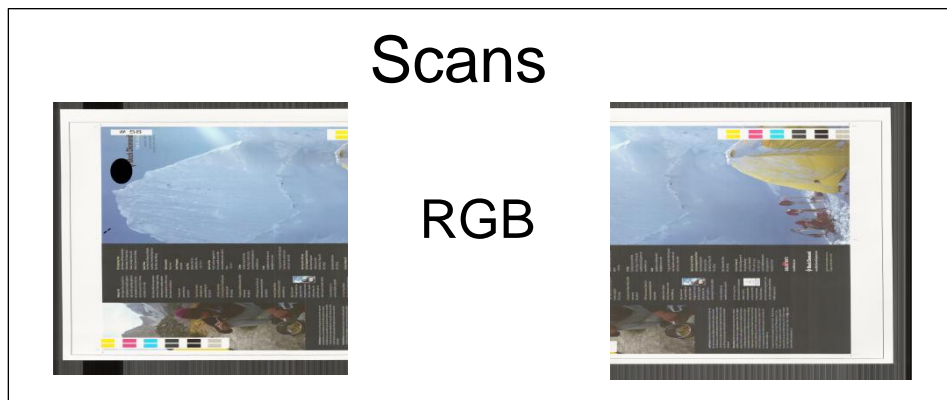
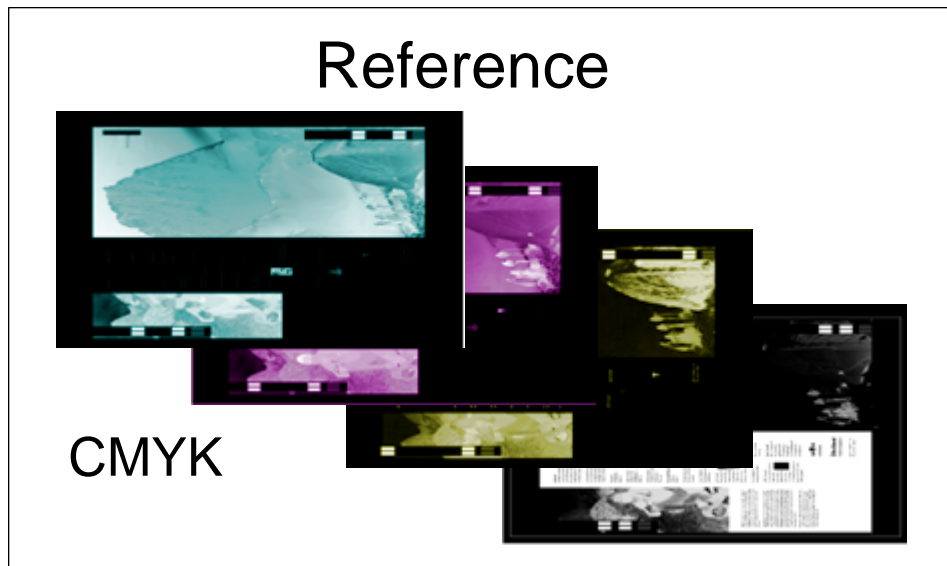
INSPECTION: HIGH LEVEL COMPONENTS



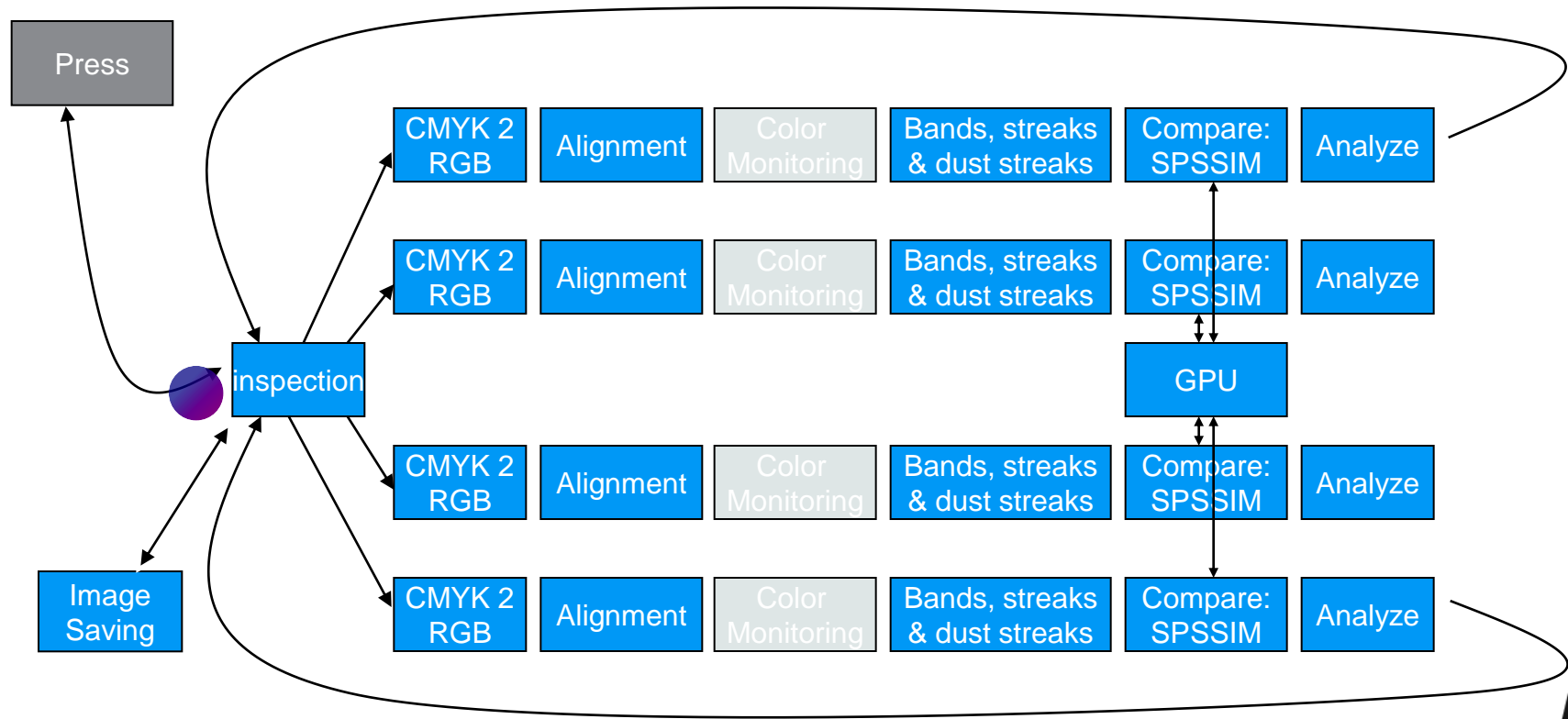
INPUT IMAGES



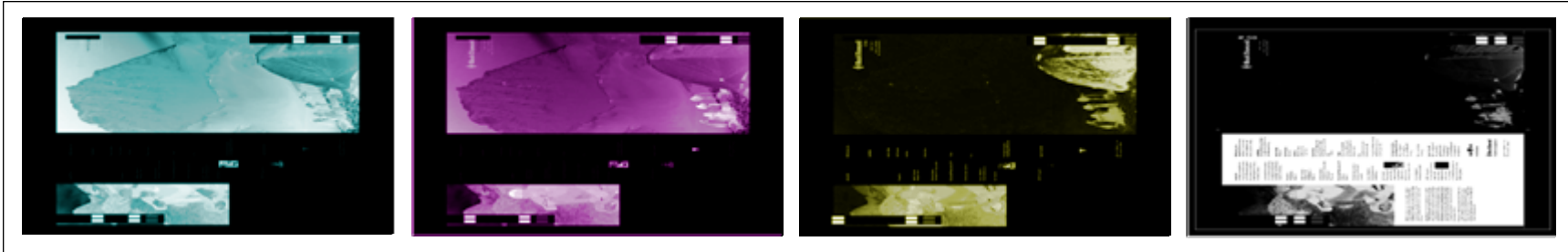
The Job



INSPECTION: HIGH LEVEL COMPONENTS



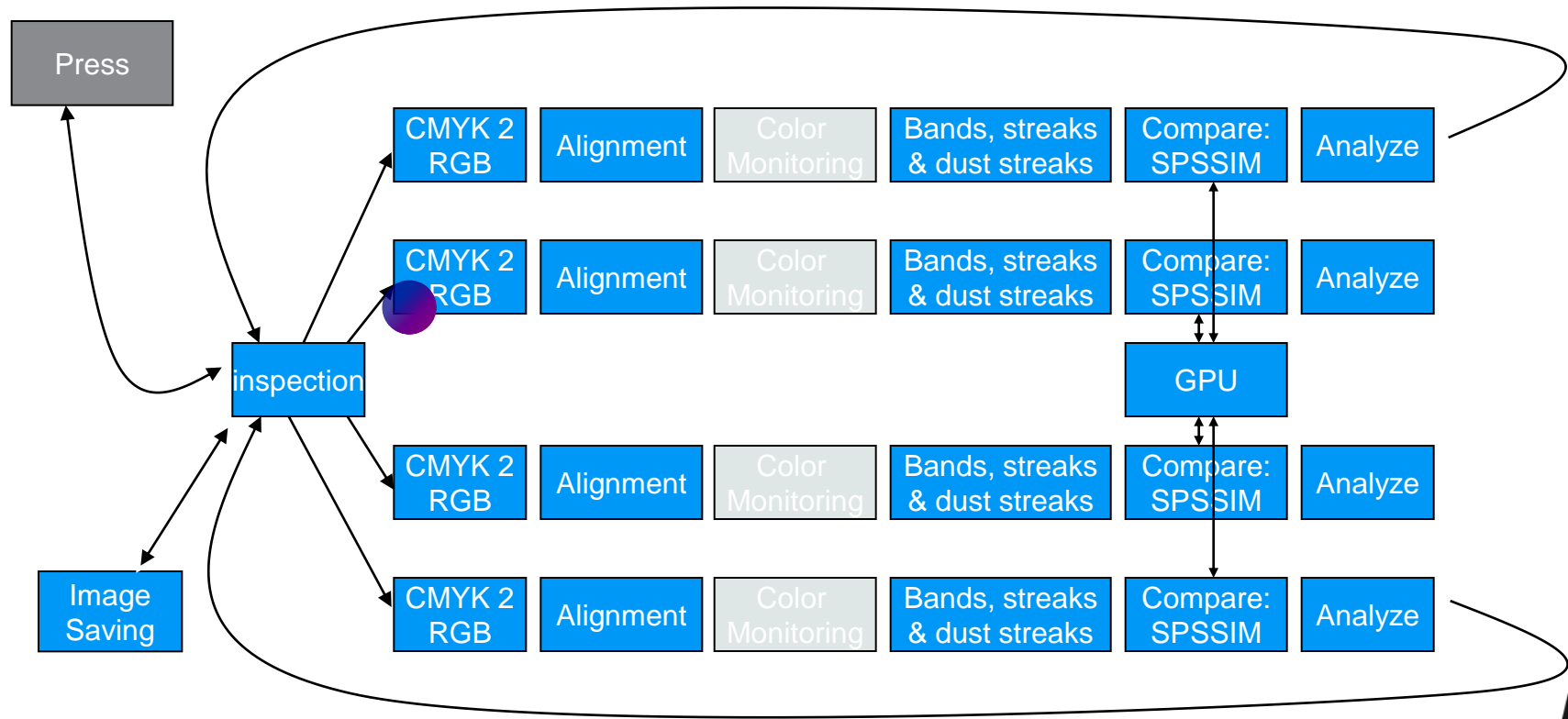
CMYK TO RGB



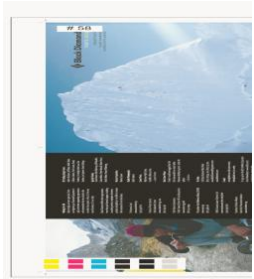
Conversion
table



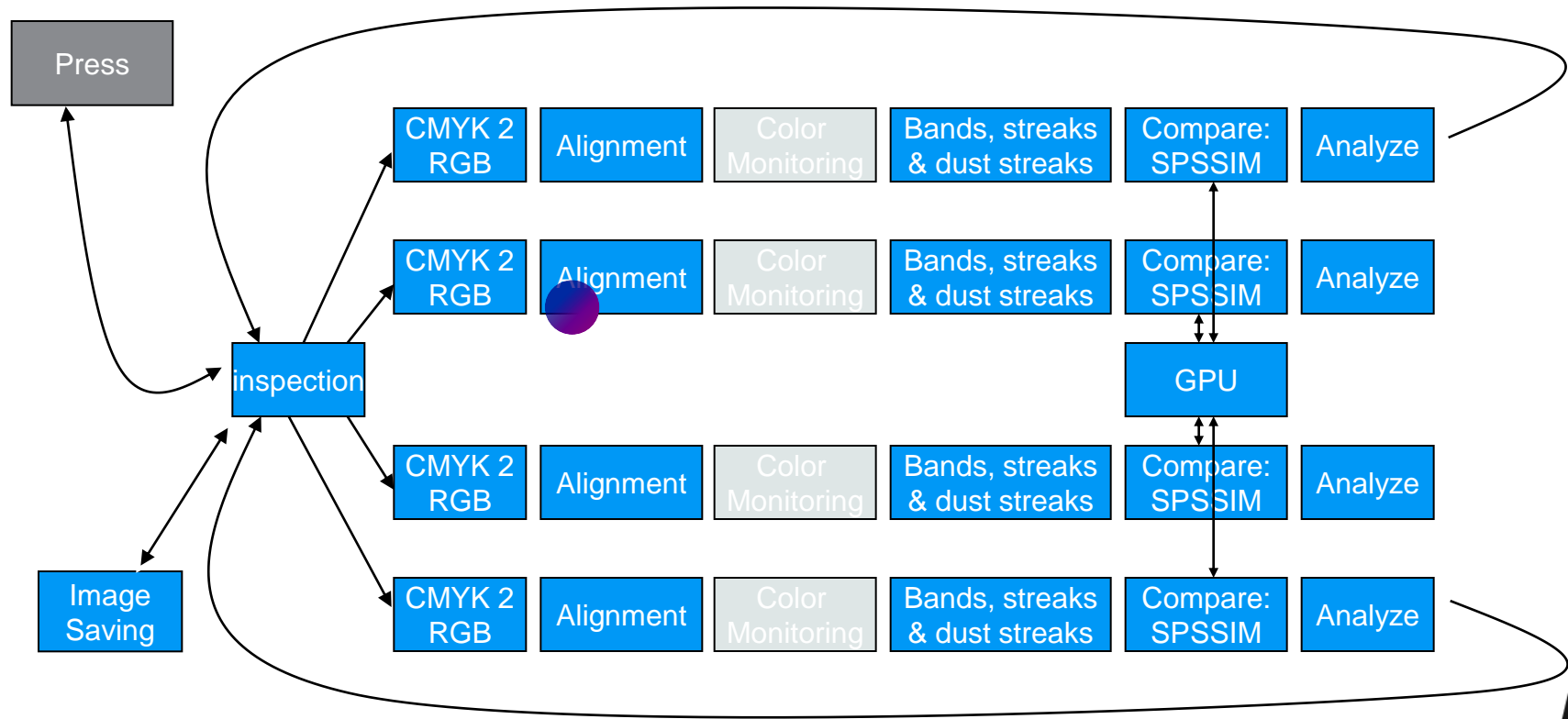
INSPECTION: HIGH LEVEL COMPONENTS



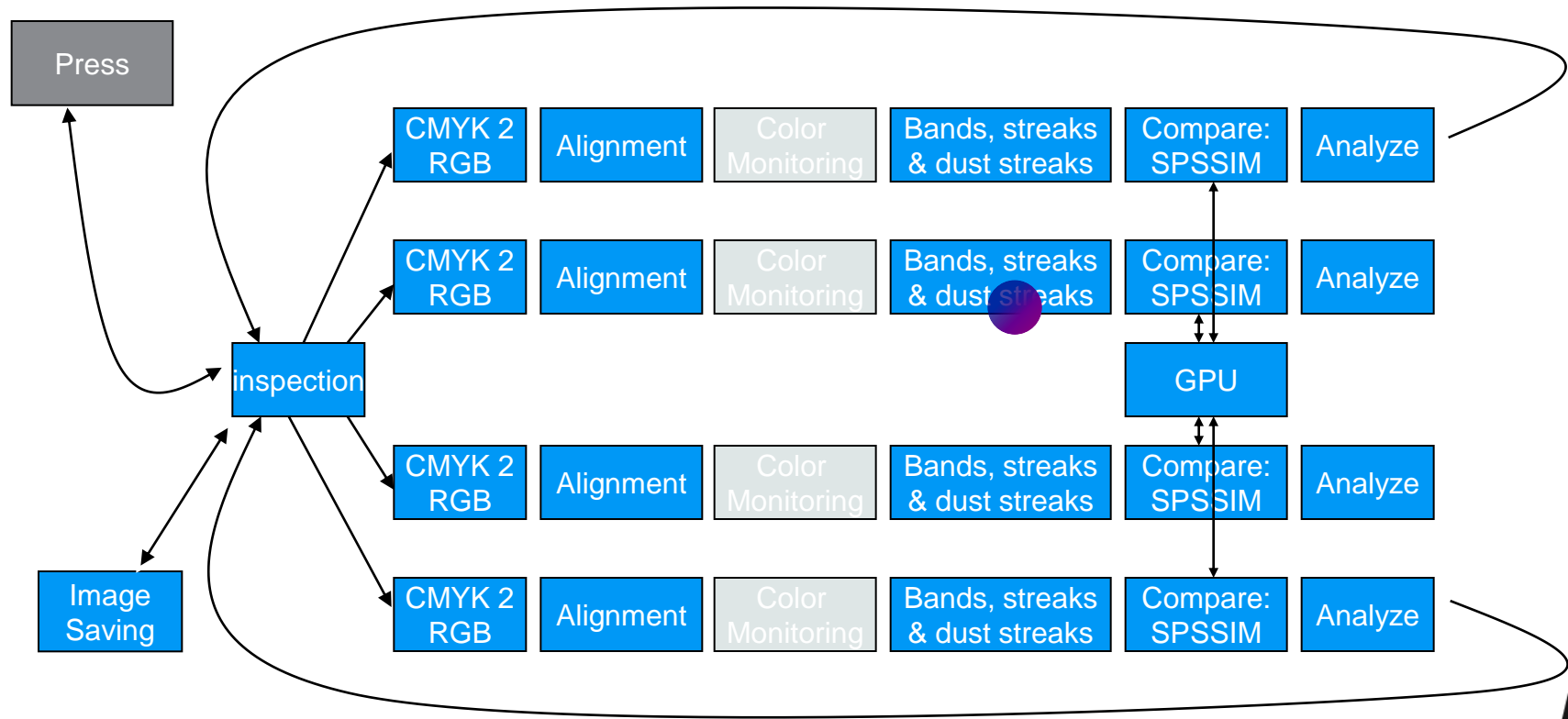
ALIGNMENT



INSPECTION: HIGH LEVEL COMPONENTS



INSPECTION: HIGH LEVEL COMPONENTS



GOAL

Define a similarity measure that respects human preferences

Digital reference



Scanned image



SSIM MEASURE

SSIM (Structure SIMilarity measure) –

State-of-the-art image measure that reflects human perception

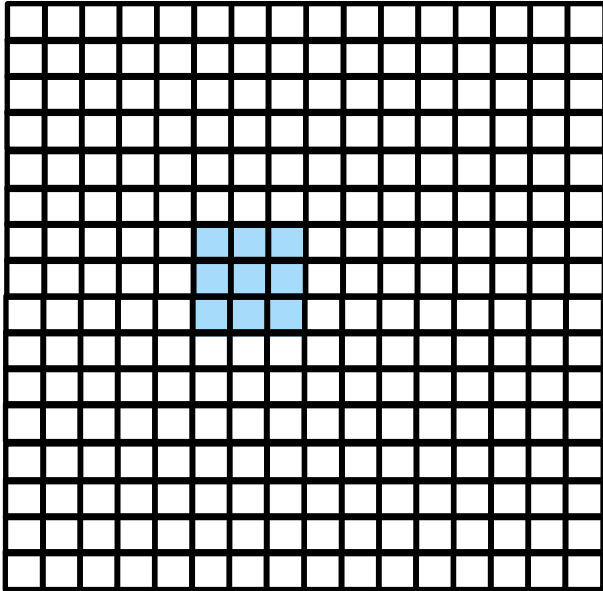
$$\text{SSIM}(\mathbf{x}, \mathbf{y}) = l(\mathbf{x}, \mathbf{y}) \cdot c(\mathbf{x}, \mathbf{y}) \cdot s(\mathbf{x}, \mathbf{y})$$

Diagram illustrating the components of the SSIM measure:

- luminance** (indicated by a red arrow pointing to the first term): $\frac{2\mu_x \mu_y}{\mu_x^2 + \mu_y^2}$
- contrast** (indicated by a red arrow pointing to the second term): $\frac{2\sigma_x \sigma_y}{\sigma_x^2 + \sigma_y^2}$
- structure** (indicated by a red arrow pointing to the third term): $\frac{\sigma_{xy}}{\sigma_x \sigma_y}$

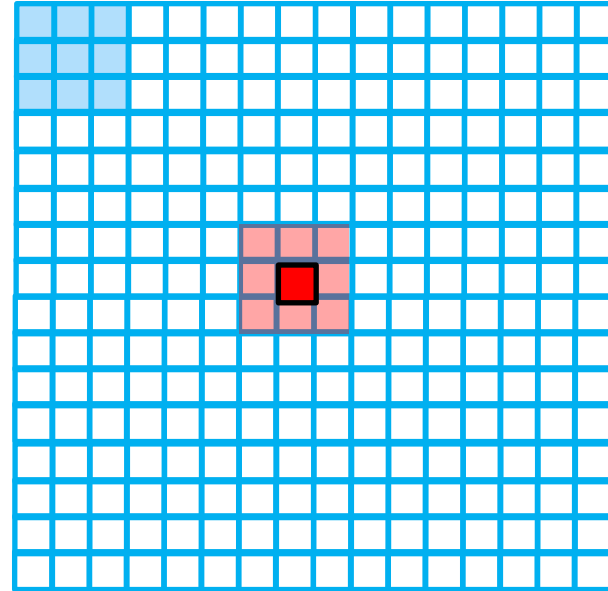
BLOCK SSIM

Scanned Image



11

Reference Image

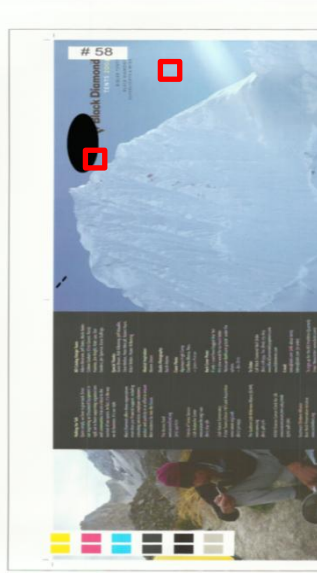


11

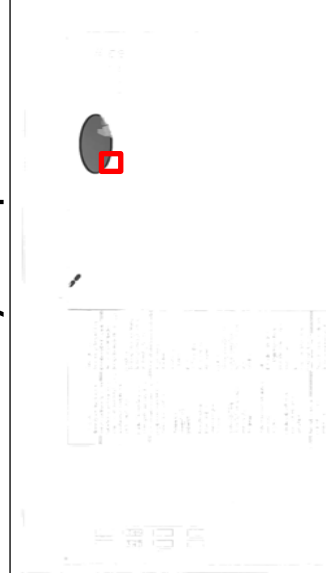
max ssim grade < threshold (with an early break)

SIMILARITY MAP

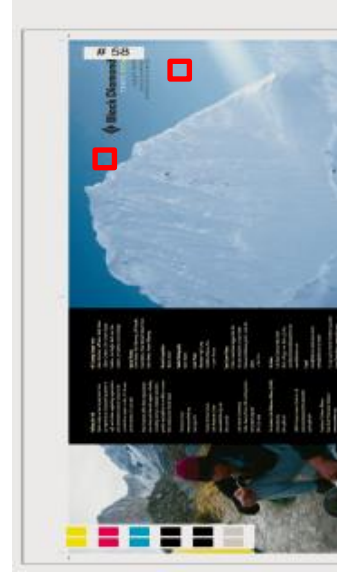
scan



similarity map



reference



REQUIRED PERFORMANCE

– Per pixel

- Compute SSIM (mean, variance, covariance) for 3X3 block with an 11X11 search neighborhood.

– Performance

- Data size : $2_{\text{Mpixel/frame}} \times 3_{\text{rgb}} \times 4_{\text{pipelines}} = 24_{\text{MB/Sec}}$
- 4 pipes share the GPU

– Real time : each pipe stage should complete with in 1_{Sec}

- Original implementation with OpenCV
 - single threaded, not optimized
 - ~30 seconds/frame



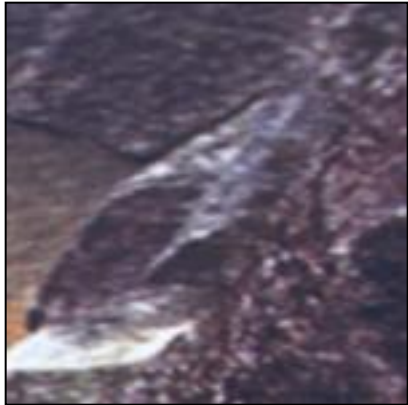
GPU DETAILS

- Implemented in CUDA
- An Nvidia quadro 3700 (upgraded recently)
- The card is shared (GUI)
- GPU code
 - Not fully optimized
 - we stopped on 0.25 sec/frame
 - Shared memory would improve results
 - Heavy use of templates to keep a single kernel for all cases
 - Issues with multithreaded access.



SPSSIM - RESULTS

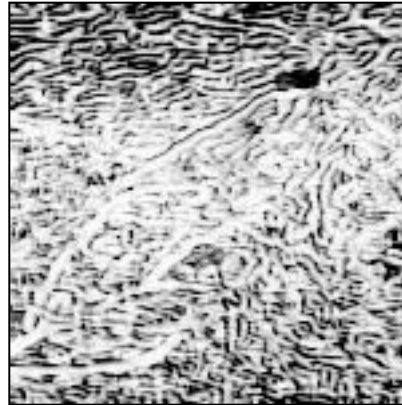
Reference



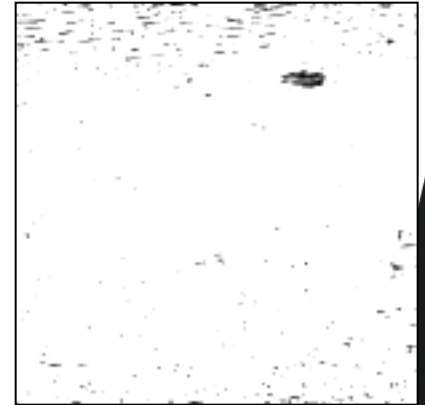
Scan



SSIM



SPSSIM



GPUS IN THE FUTURE ?

- Getting compute intensity becoming cheap
- How do we program GPUs ?

Ease of programming

