เทคนิคการเชื่อมต่อภาพถ่ายดิจิตอลพยาธิวิทยาในรูปแบบภาพพาโนรามา

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Outline

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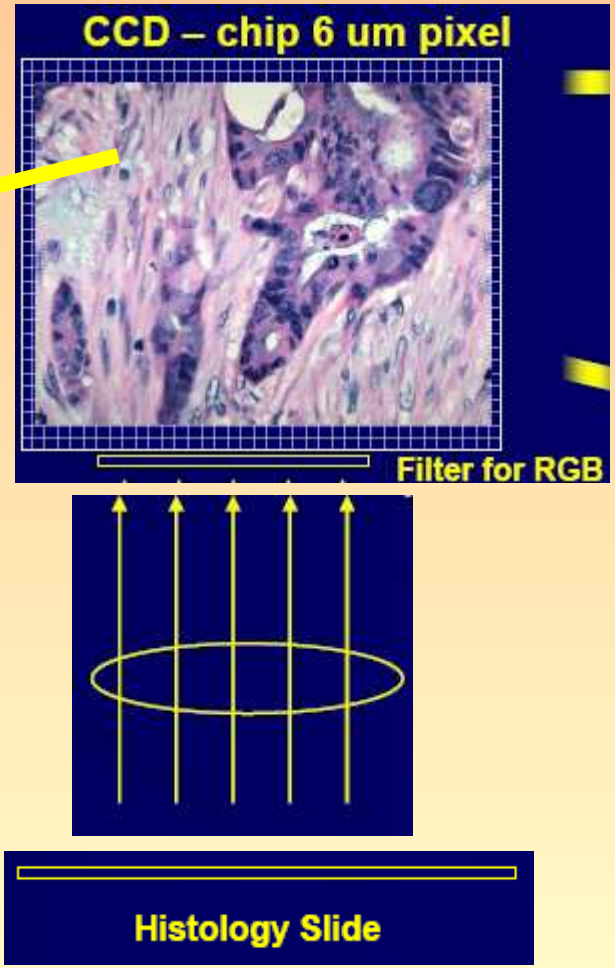
Introduction

Digital Slide/ Digital Pathology

- Converting entire glass microscope slides to high resolution, whole-slide digital images
- Advantages:
  - view via computer monitor
  - view across a network, including the Internet
  - using specialized viewing software that provides more timely and accurate information compared with traditional methods
  - decision support, digital slide conferencing, proficiency testing, and quality assurance

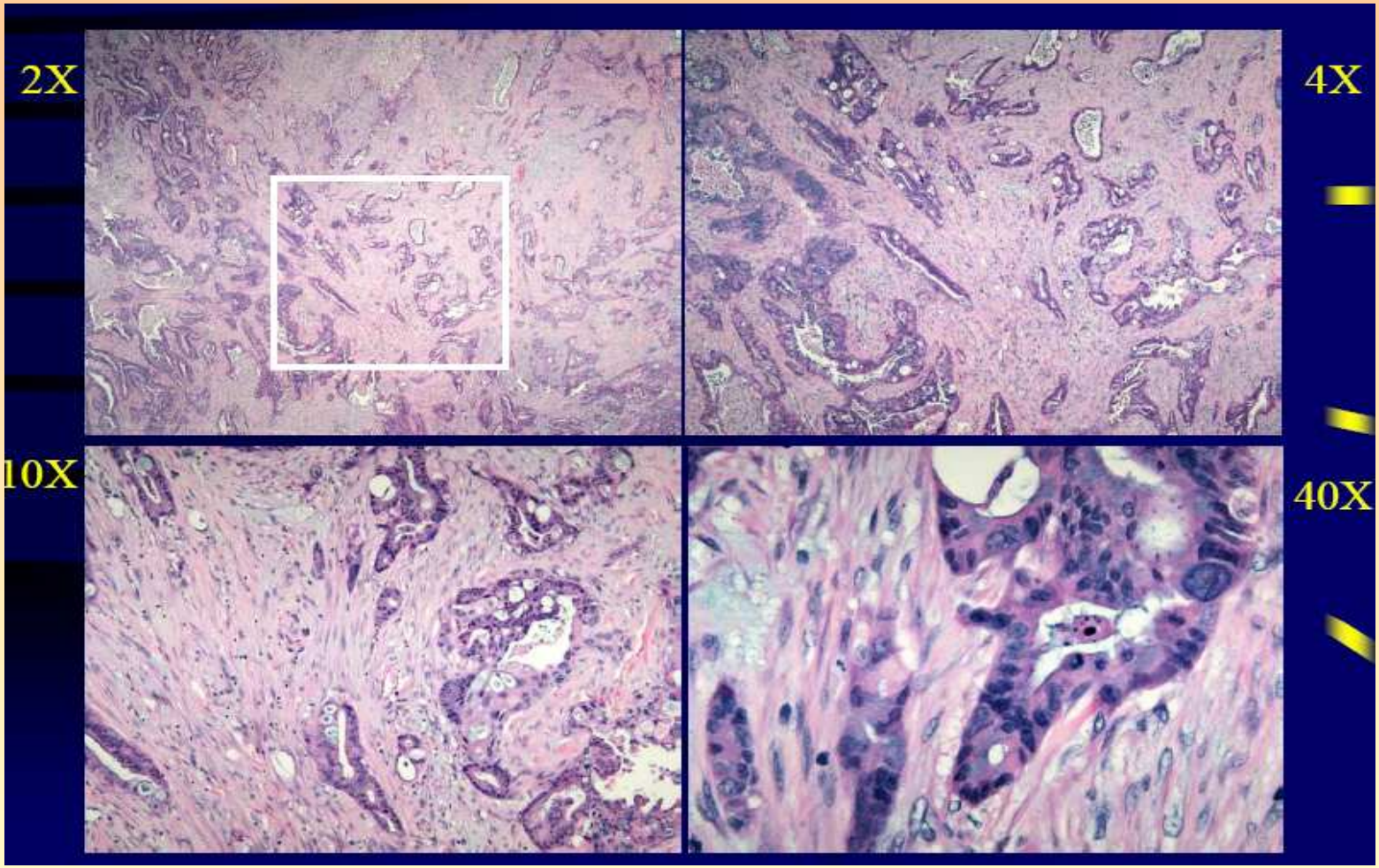
Introduction

System Setup



Feldman, Digital microscopy:new paradigm's for teaching microscopic anatomy and pathology

Introduction



Feldman, Digital microscopy:new paradigm's for teaching microscopic anatomy and pathology

Introduction

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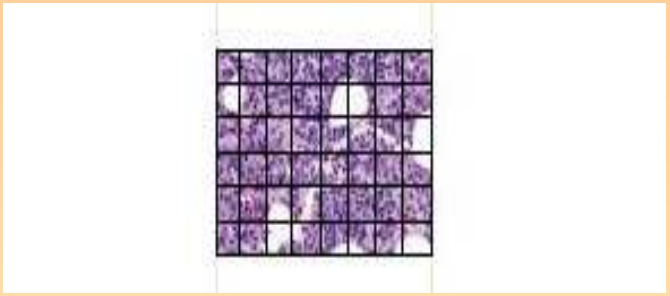
How the sample slides captured ?

- Tiling
  - Manually take pictures and assemble them with “Image Stitching” algorithm
  - Robotic tiling
    - Microbrightfield (http://www.microbrightfield.com/)
    - Bacus (http://www.bacuslabs.com/)
  - Striping: scanner works like fax and scans a stripe (width of scanning element) at very high resolution
    - Aperio Scanscope (http://www.aperio.com/home.asp)

Image Stitching

Digital Slide Stitching



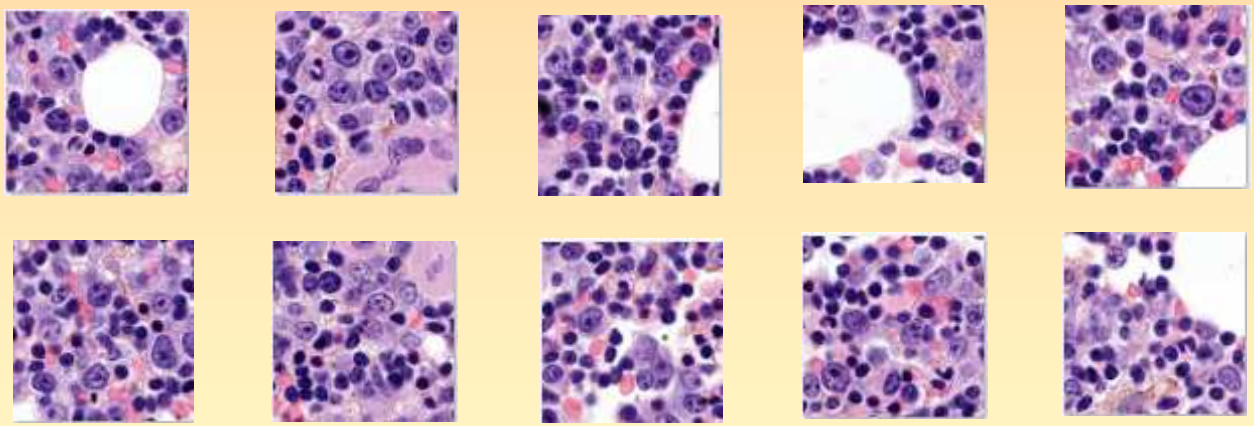


Image Stitching

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Process of image stitching: three steps

1. Image Registration

multi-images are compared to find the translations that can be used for the alignment of images

2. Image Merging

images are merged together to form a single image

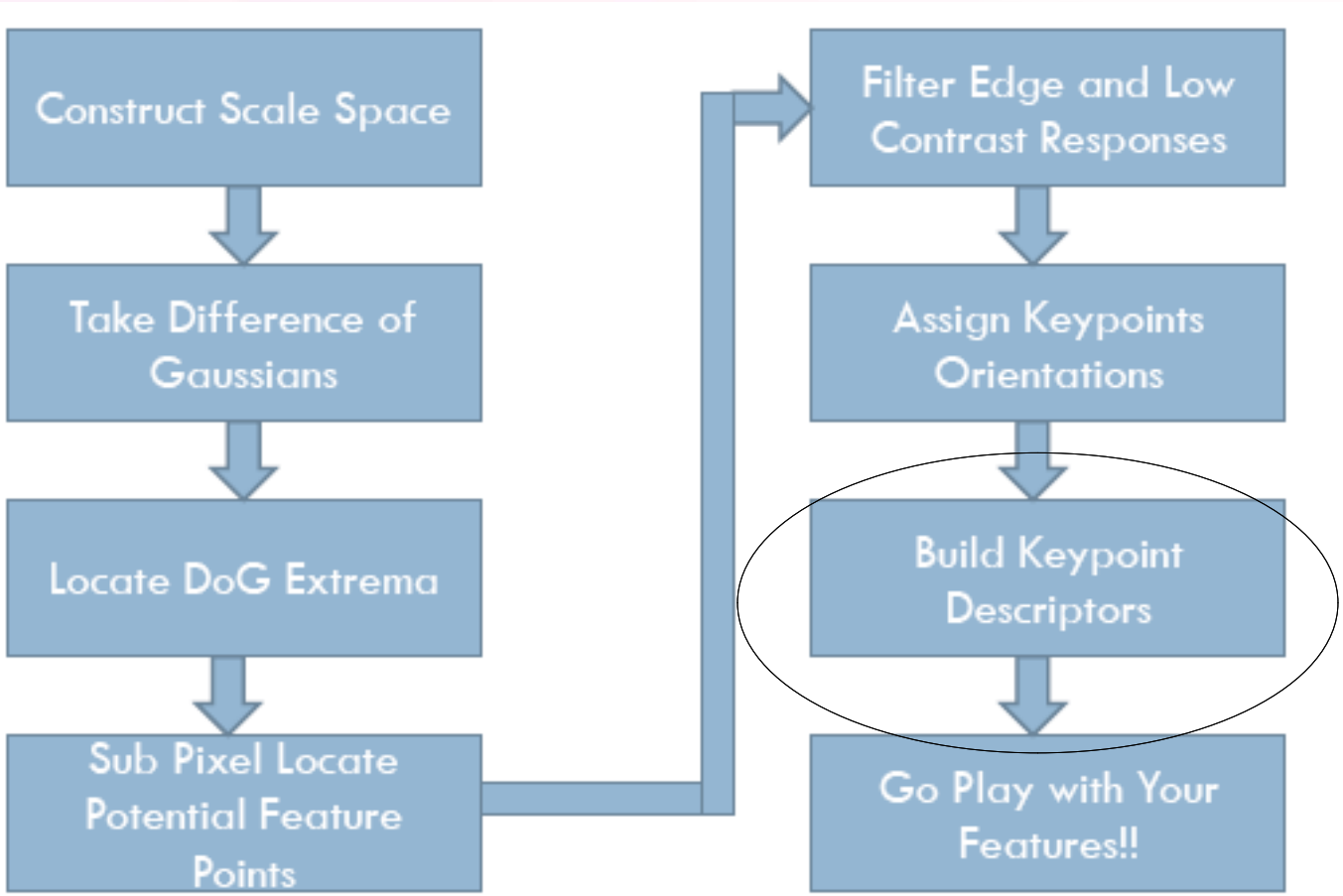
3. Image Blending

eliminate undesirable intensity discrepancies and improve visual quality of the composite image

Popular technique

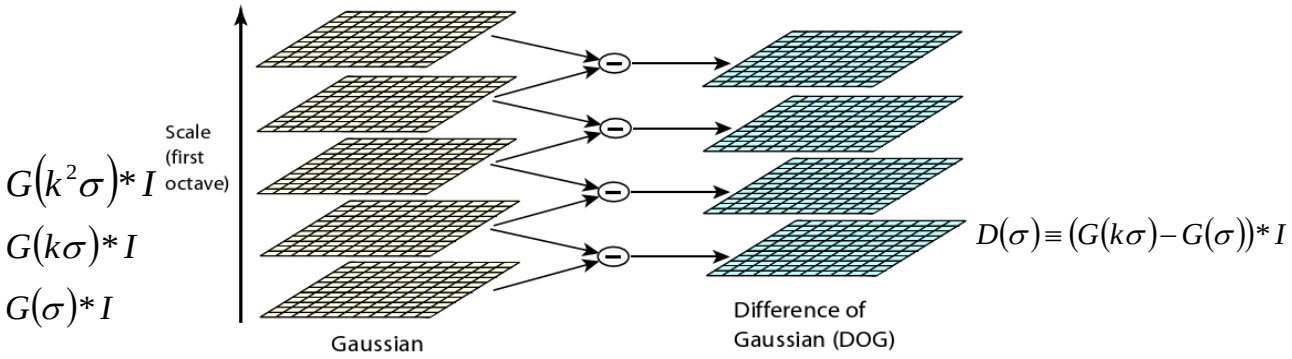
- use scale-invariant feature transform (SIFT) algorithm [Lowe, 2004] for extraction of feature for the registration of two images
- blending algorithms options: linear blending and multi-band blending (pyramid-based)

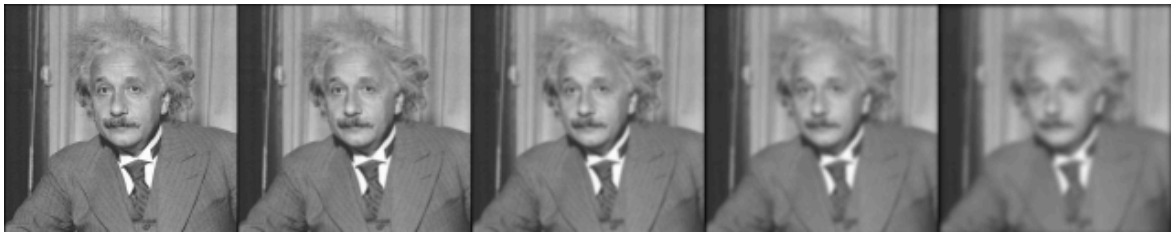
Overview of SIFT algorithm



D.Lowe. “Distinctive Image Features from Scale-Invariant Keypoints”. IJCV 2004

Difference of Gaussian





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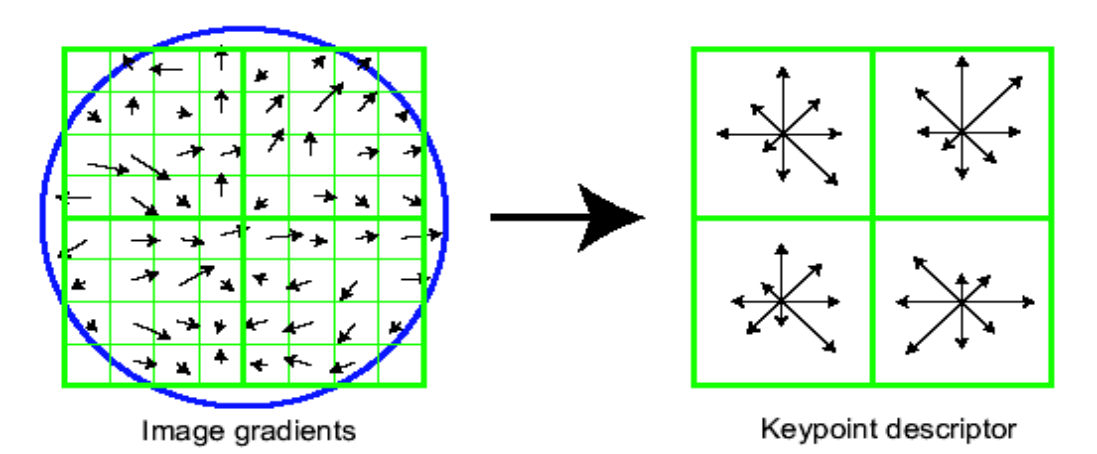
Keypoint Descriptors

- Determine scale (by maximizing DoG in scale and in space), local orientation as the dominant gradient direction. Use this scale and orientation to make all further computations invariant to scale and rotation.
- Compute gradient orientation histograms of several small windows (128 values for each point)
- Normalize the descriptor to make it invariant to intensity change



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SIFT keypoints

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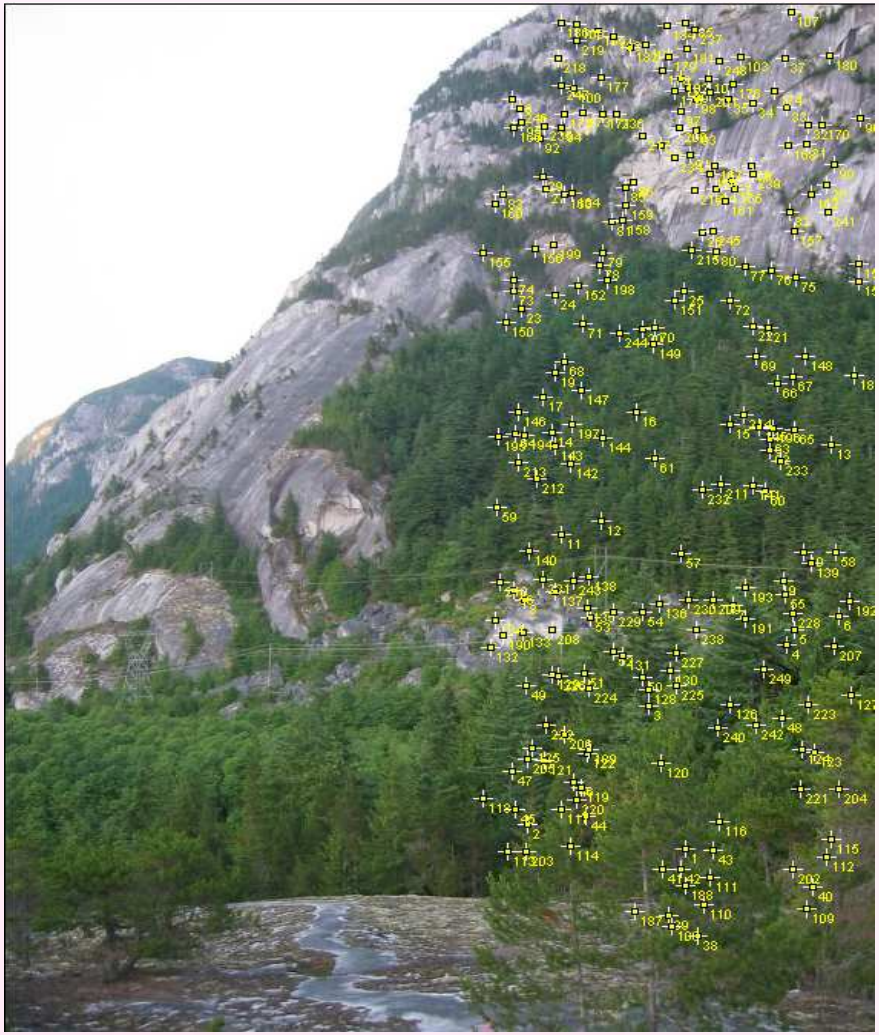
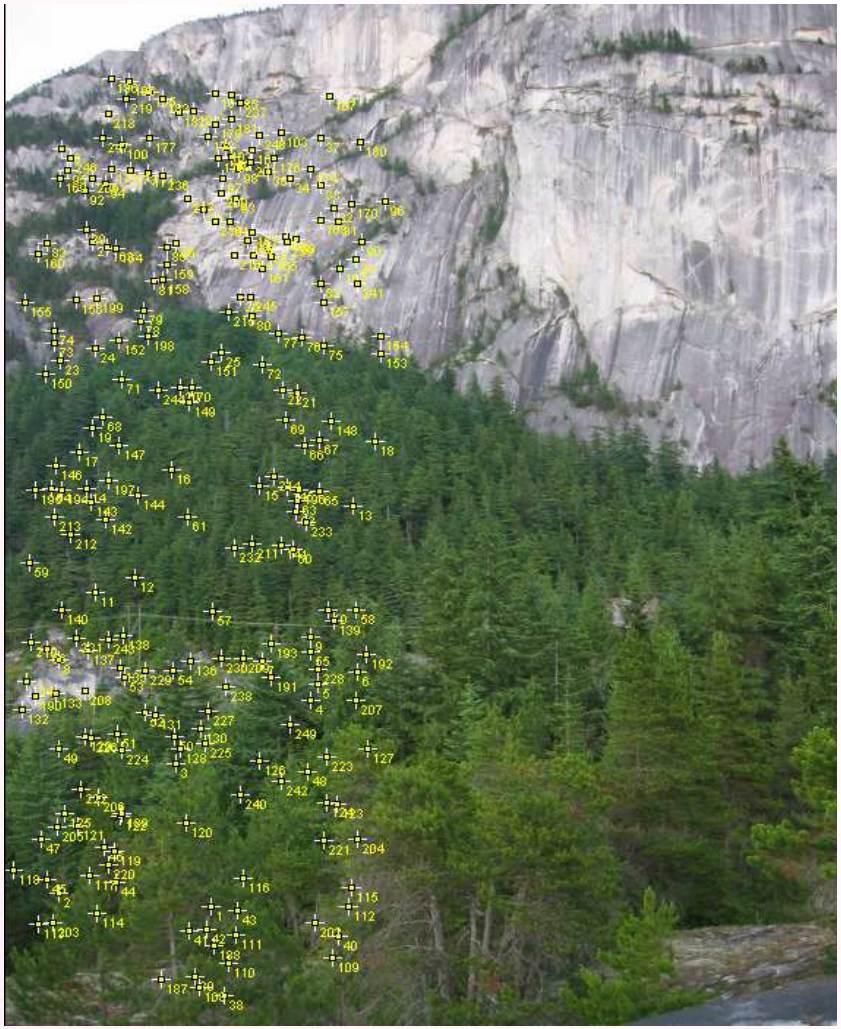
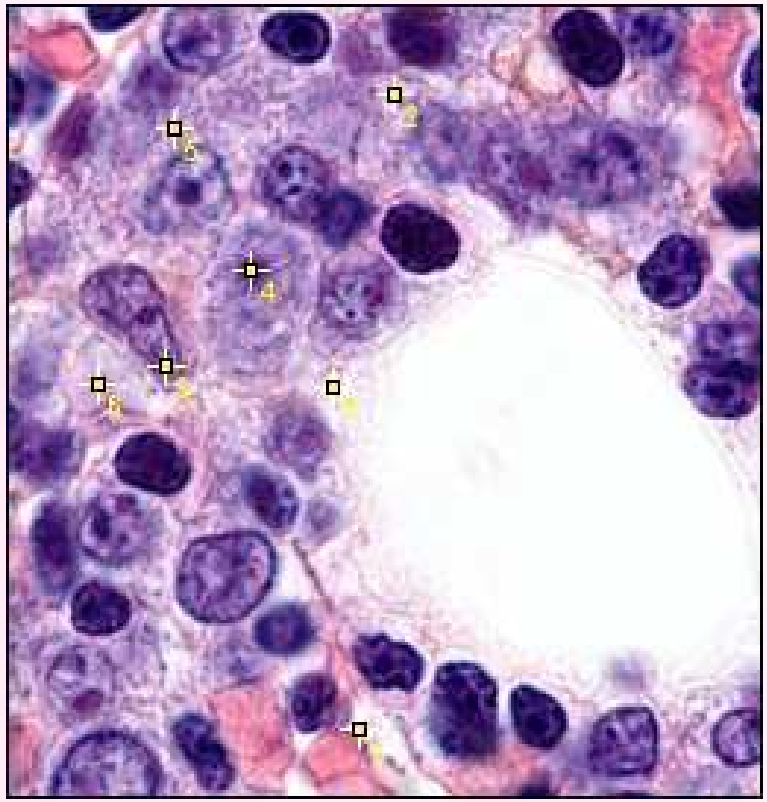
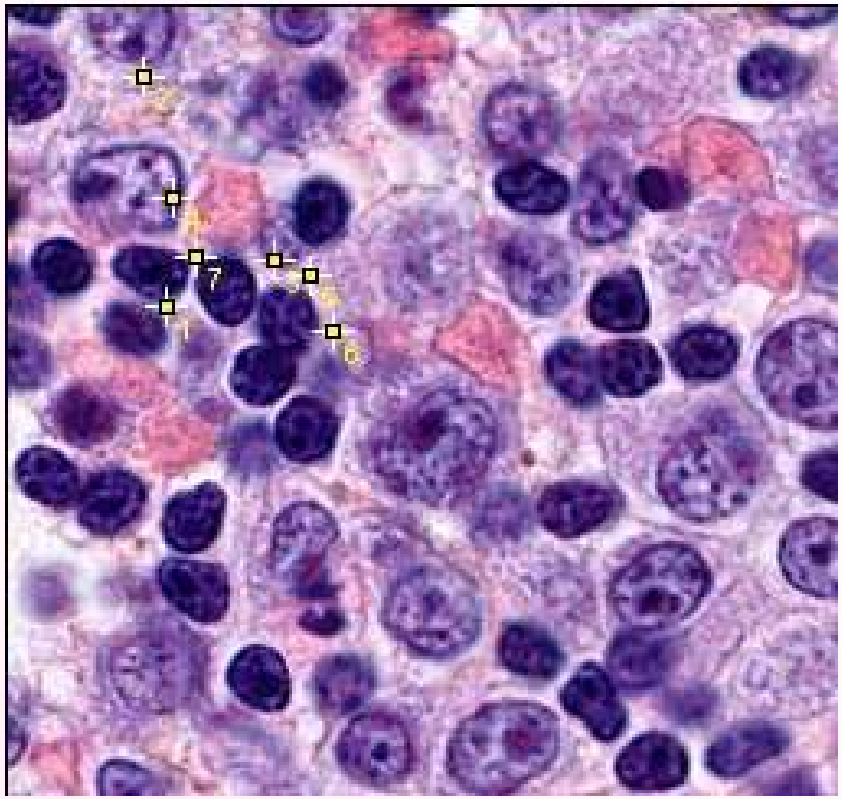




SIFT keypoints





Implemented Methodology

Image Registration

Assumption: all transformations between overlapping tiles to be “Translation”

- Translation shift is computed from inverse Fourier transform of the “Phase Correlation Matrix”

$$f_1(x, y) = f_2(x - x_0, y - y_0) \quad (1)$$

$$F_2(\omega_x, \omega_y) = e^{-j(\omega_x x_0, \omega_y x_0)} F_1(\omega_x, \omega_y) \quad (2)$$

Normalized Cross-power spectrum

$$\frac{F_1^*(\omega_x, \omega_y) F_2^*(\omega_x, \omega_y)}{|F_1^*(\omega_x, \omega_y) F_2^*(\omega_x, \omega_y)|} = e^{-j(\omega_x x_0 + \omega_y x_0)} \quad (3)$$

Implemented Methodology

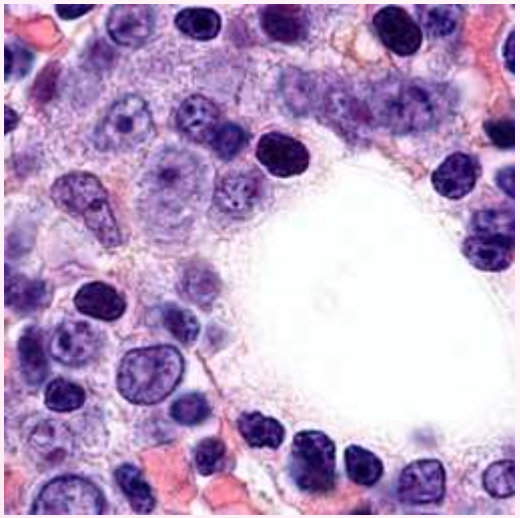
From Normalized Cross-power spectrum, find several peaks marking different translations with high correlation using Global Optimized Registration

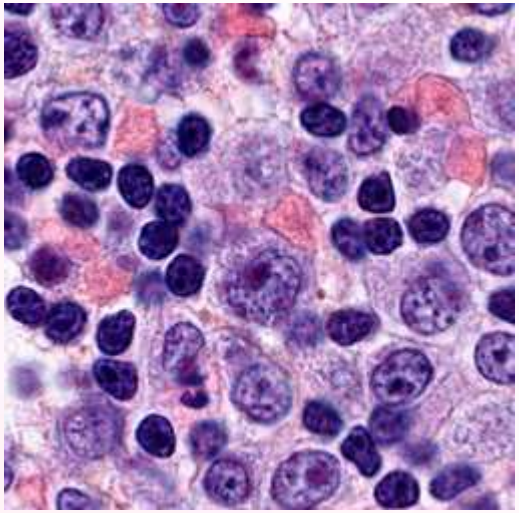
$$\begin{bmatrix} \mu_1 \mathrm{I} \\ 0 \\ 0 \\ 0 \\ \vdots \end{bmatrix} = \begin{bmatrix} \mu_1 \mathrm{I} & 0 & 0 & \cdots & 0 \\ \mu_2 \mathrm{A}_{21} & -\mu_2 \mathrm{I} & 0 & \cdots & 0 \\ 0 & \mu_3 \mathrm{A}_{32} & -\mu_3 \mathrm{I} & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots \end{bmatrix} \begin{bmatrix} \mathrm{P}_1 \\ \mathrm{P}_2 \\ \mathrm{P}_3 \\ \vdots \\ \mathrm{P}_n \end{bmatrix}$$

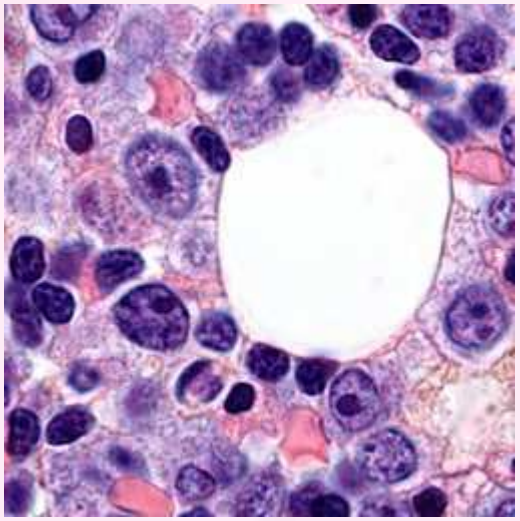
Image Blending:

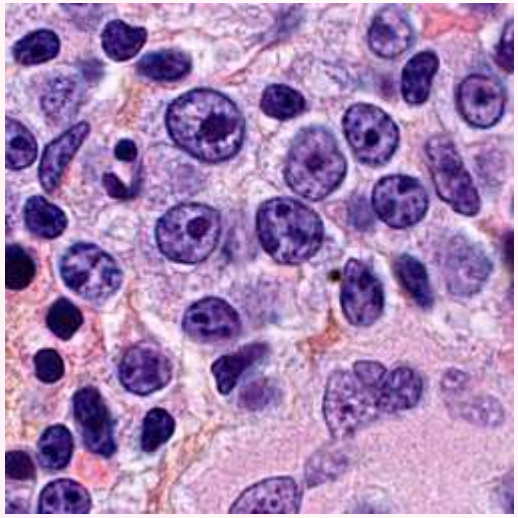
Compensate the shading and intensity differences between the tiles by applying weighting factor.

Input test data

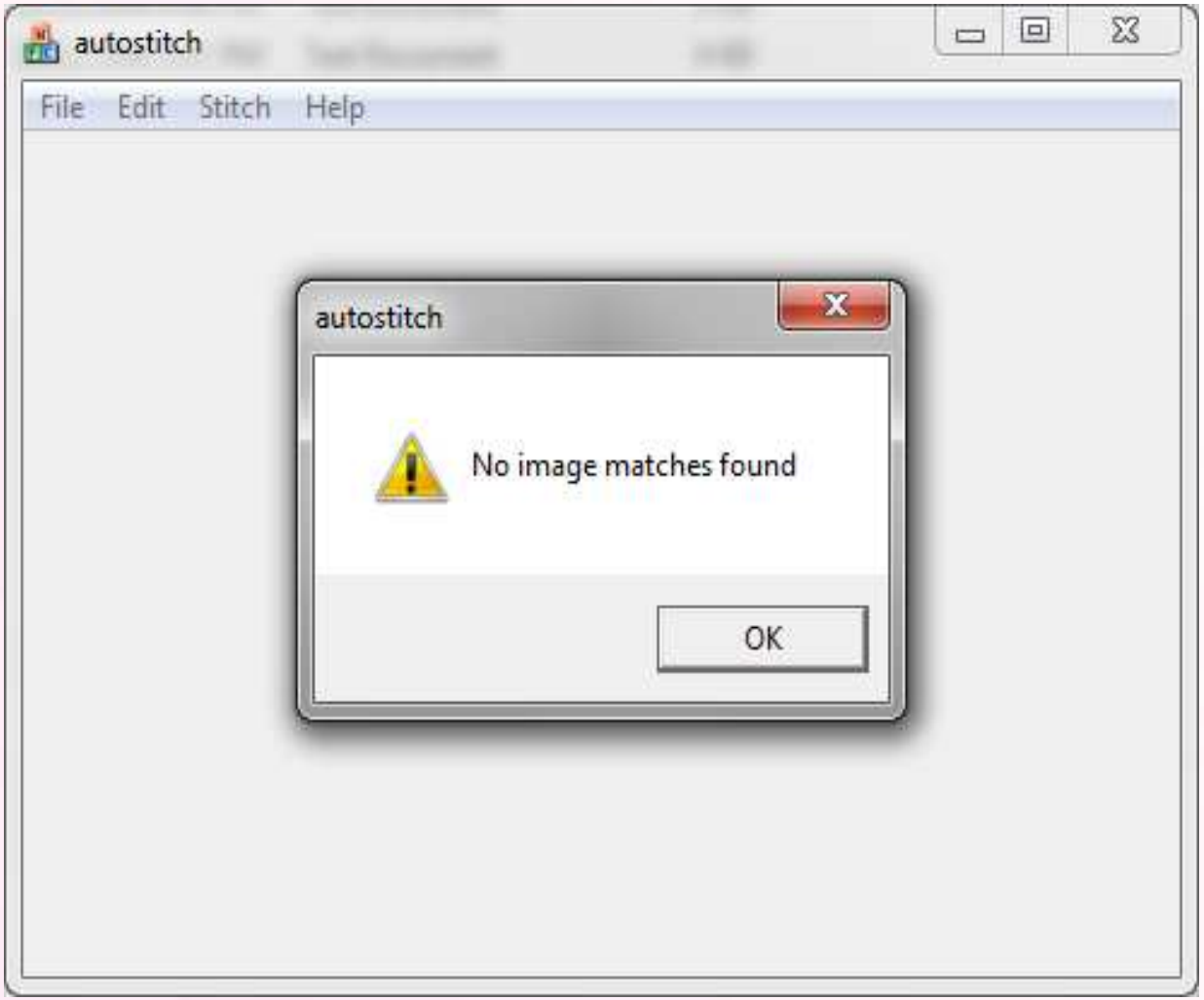




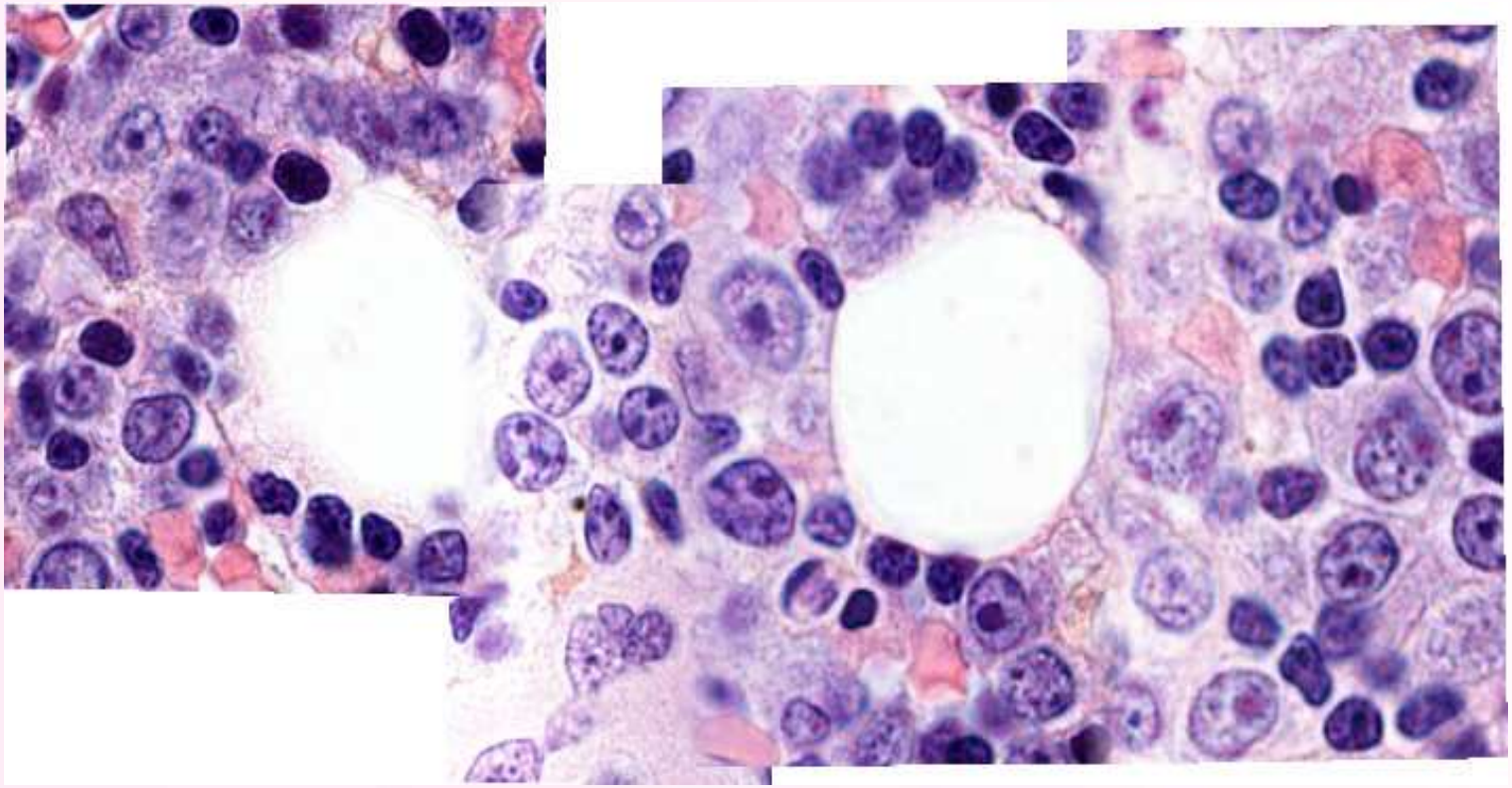




Result using Autostitch



Result using PhotoStitch (Canon)



Result – Implemented Methodology