Transform Optimization for the Lossy Coding of Pathology Whole-Slide Images

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EPSRC Engineering and Physical Sciences Research Council

Data Compression Conference
March 30, 2016

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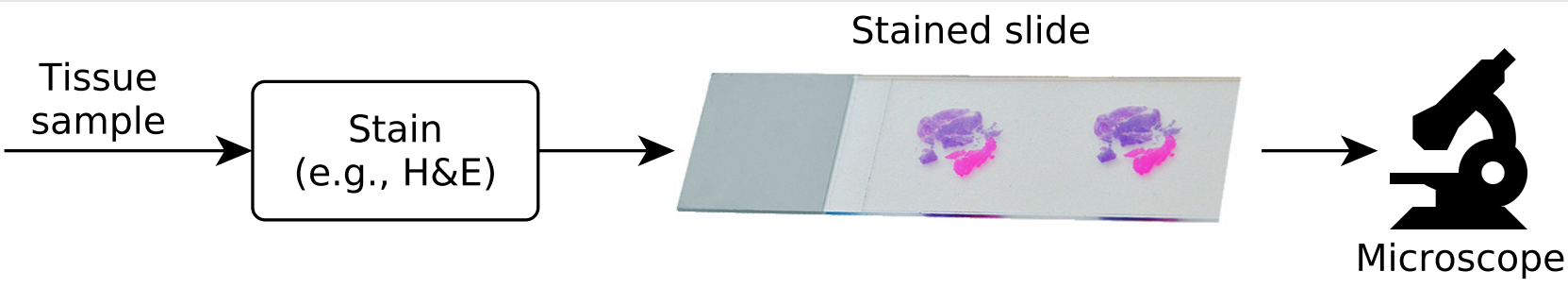
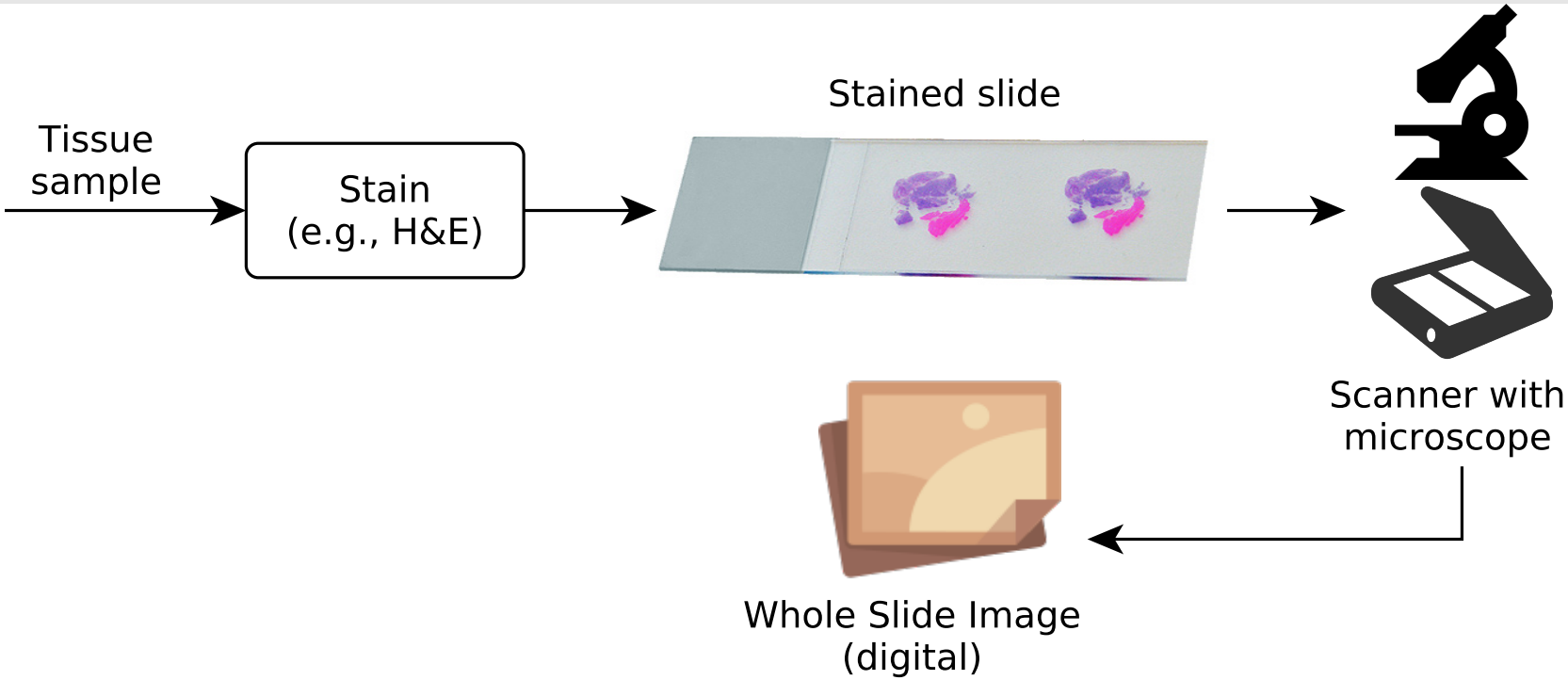
Pathology Workflow

Traditional workflow



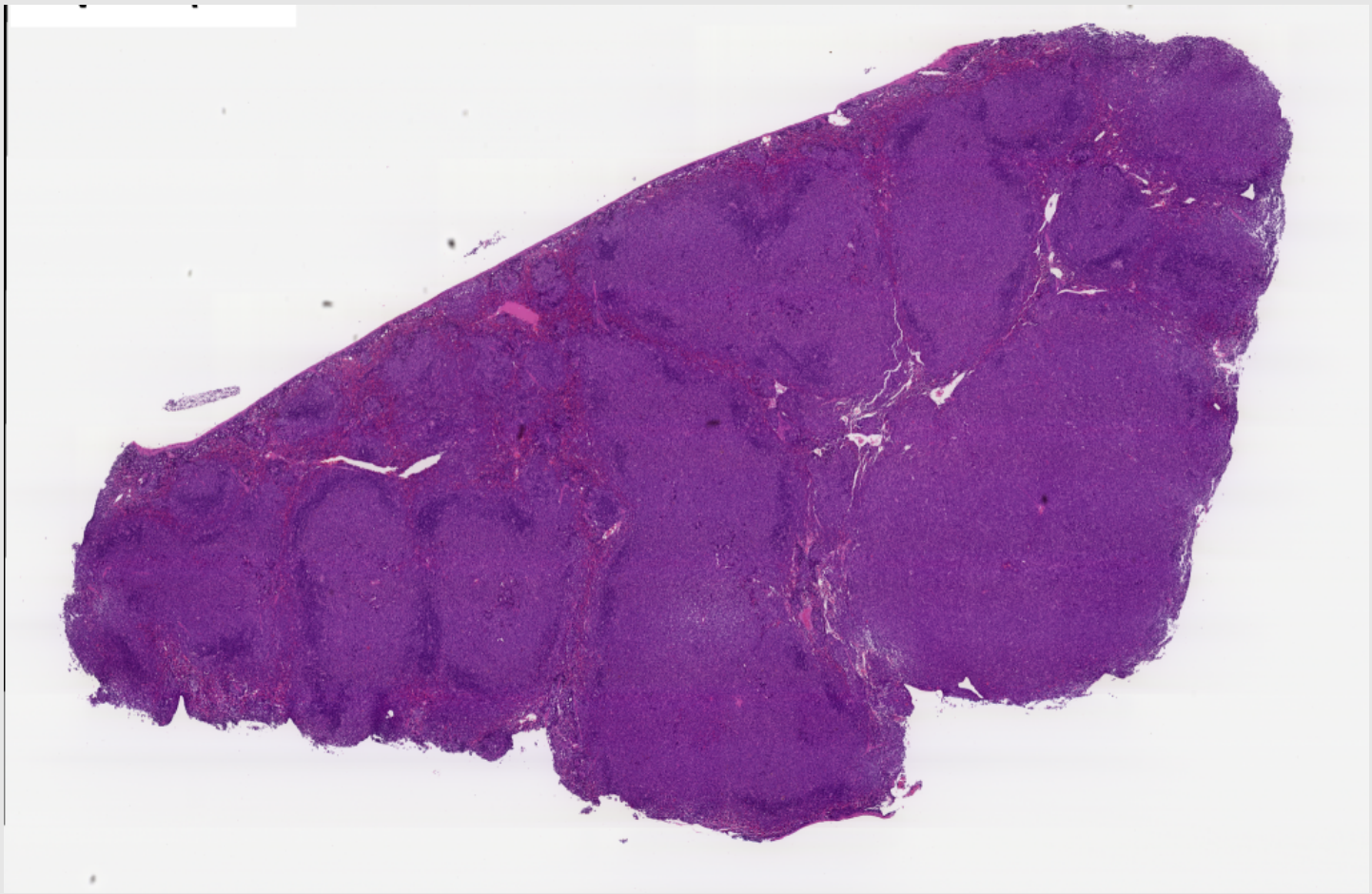
Pathology Workflow

Digital workflow



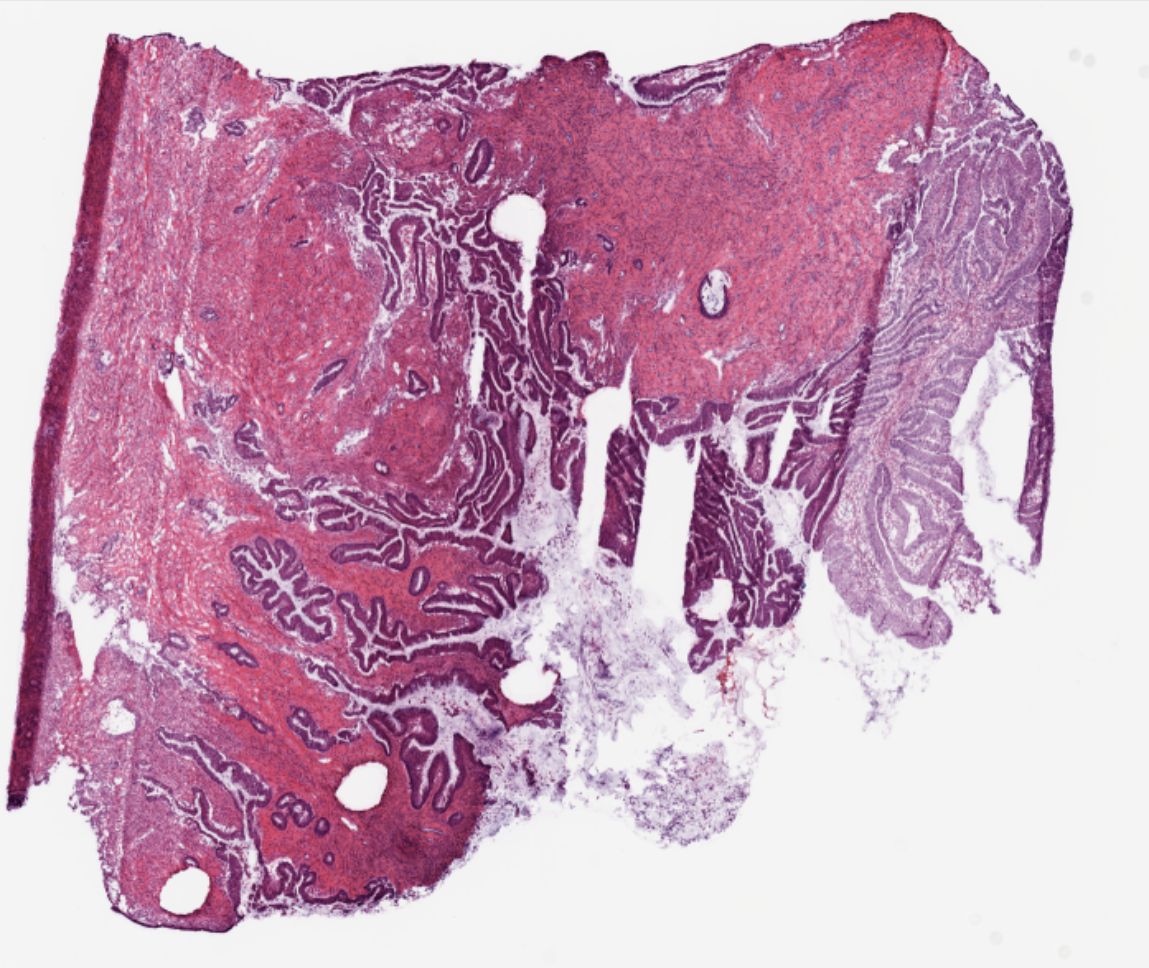
Whole-Slide Images

Sample Pathology WSI (Lymphatic Tissue)



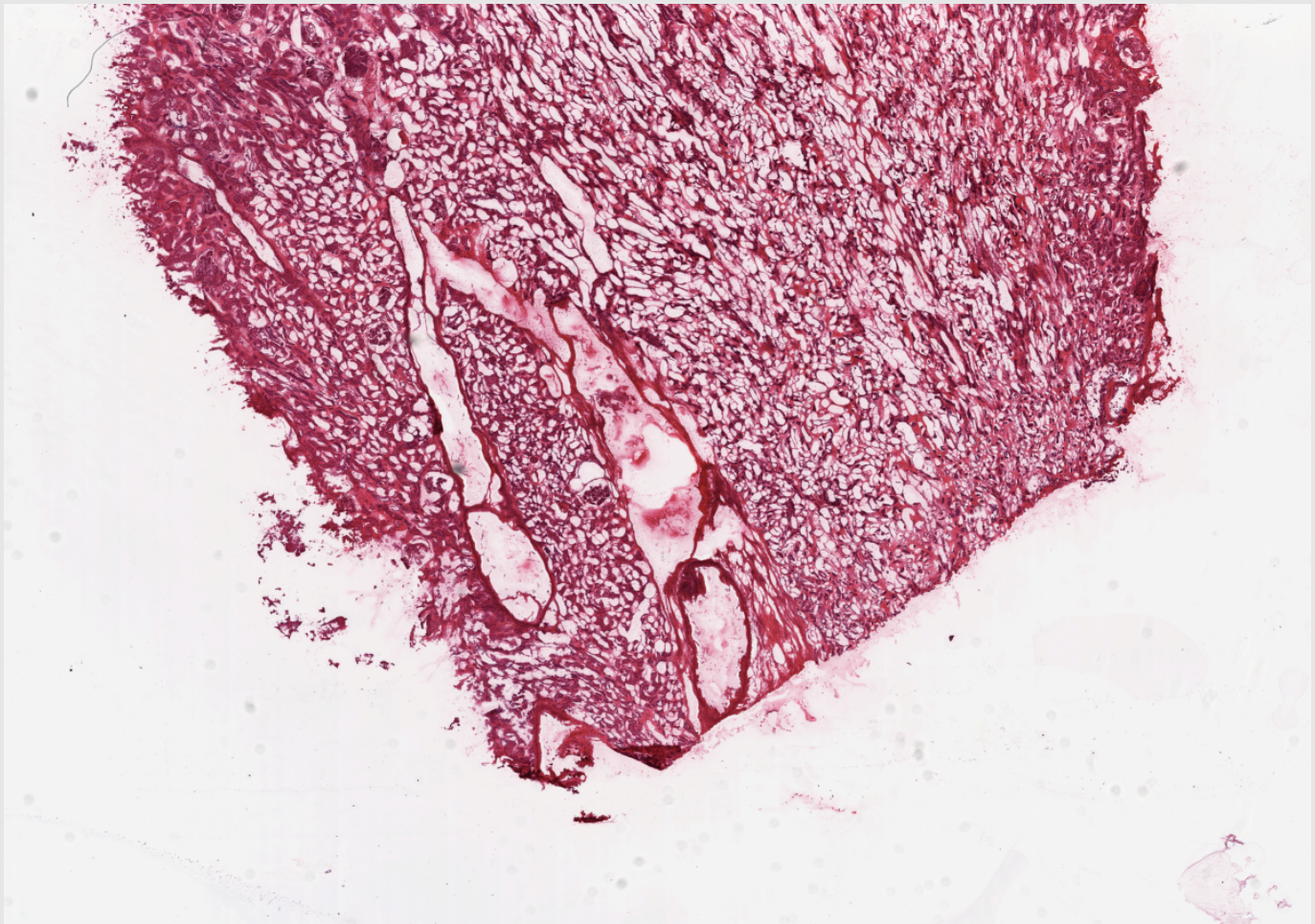
Whole-Slide Images

Sample Pathology WSI (Pancreatic Tissue)



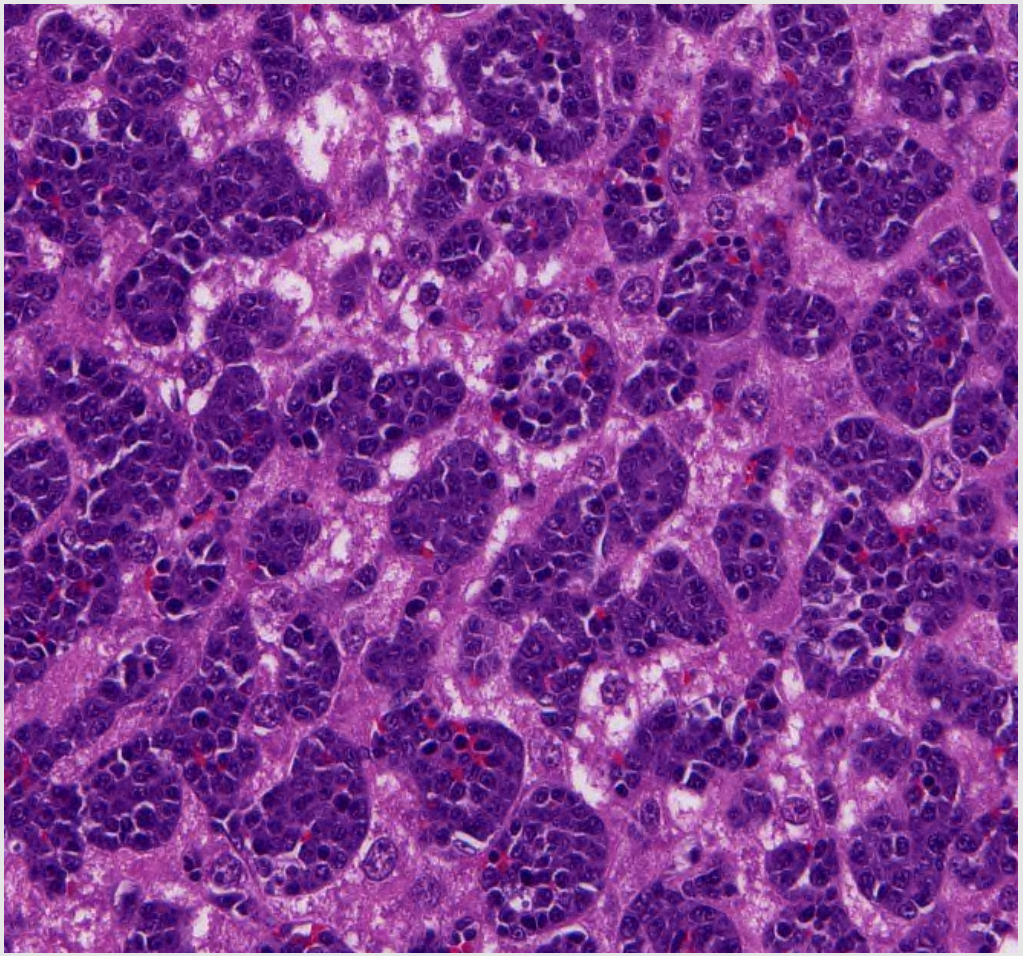
Whole-Slide Images

Sample Pathology WSI (Renal Tissue)



Advantages of Whole-Slide Images

Pathology Image Crop



Advantages over glass:

- More pathologists

$\Rightarrow$ better diagnosis

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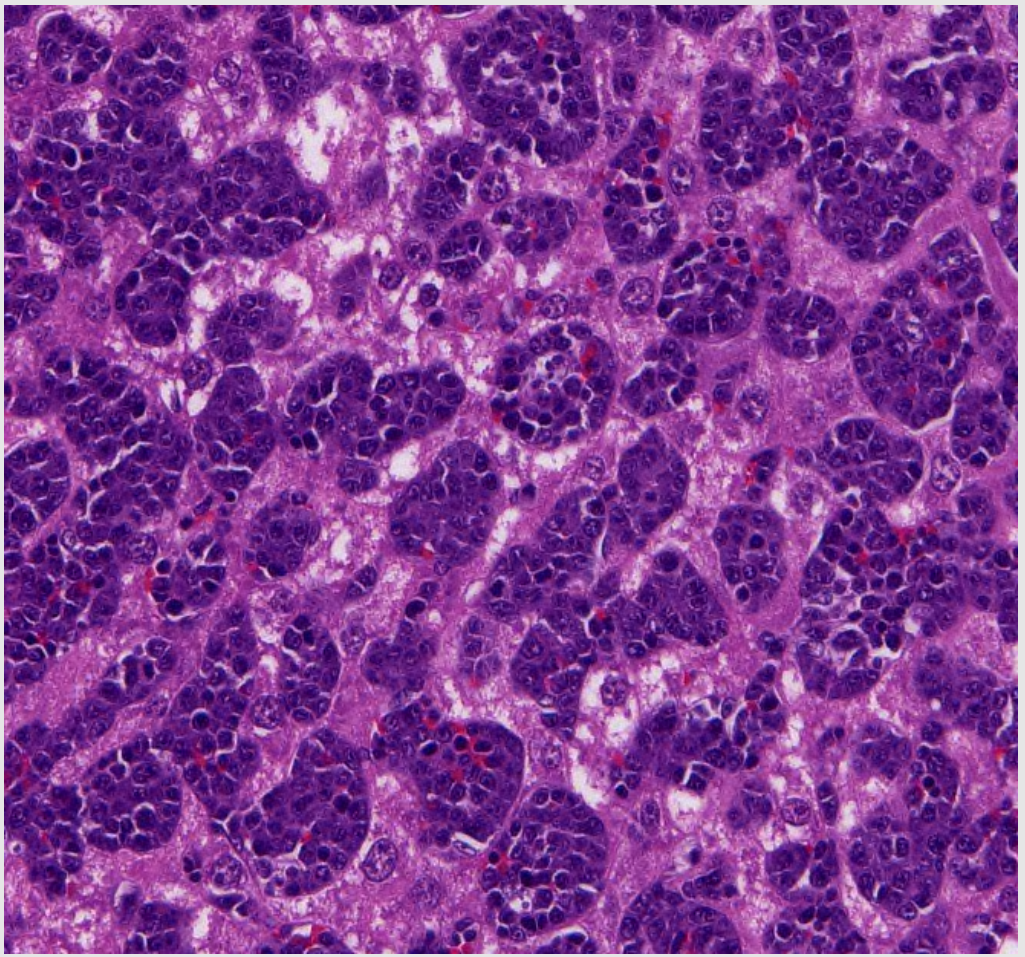

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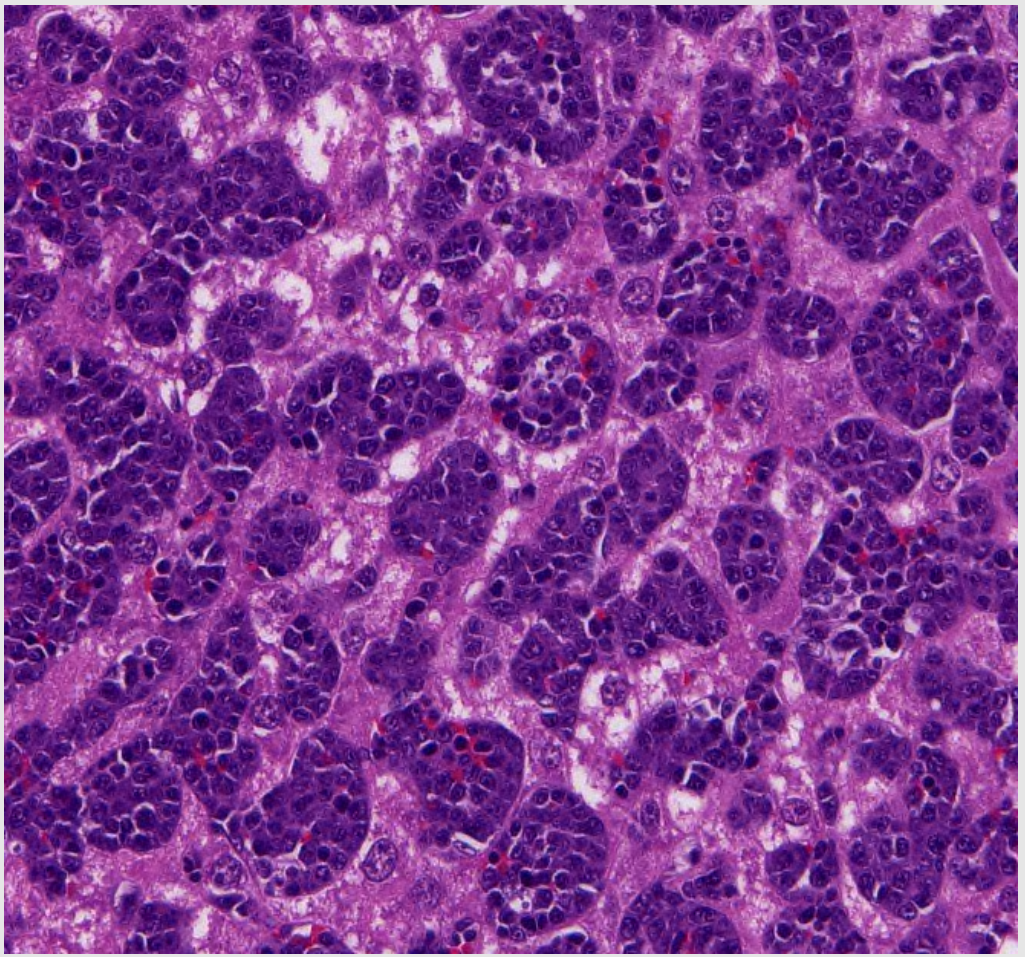

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- Formative scenarios

Challenges of Whole-Slide Images

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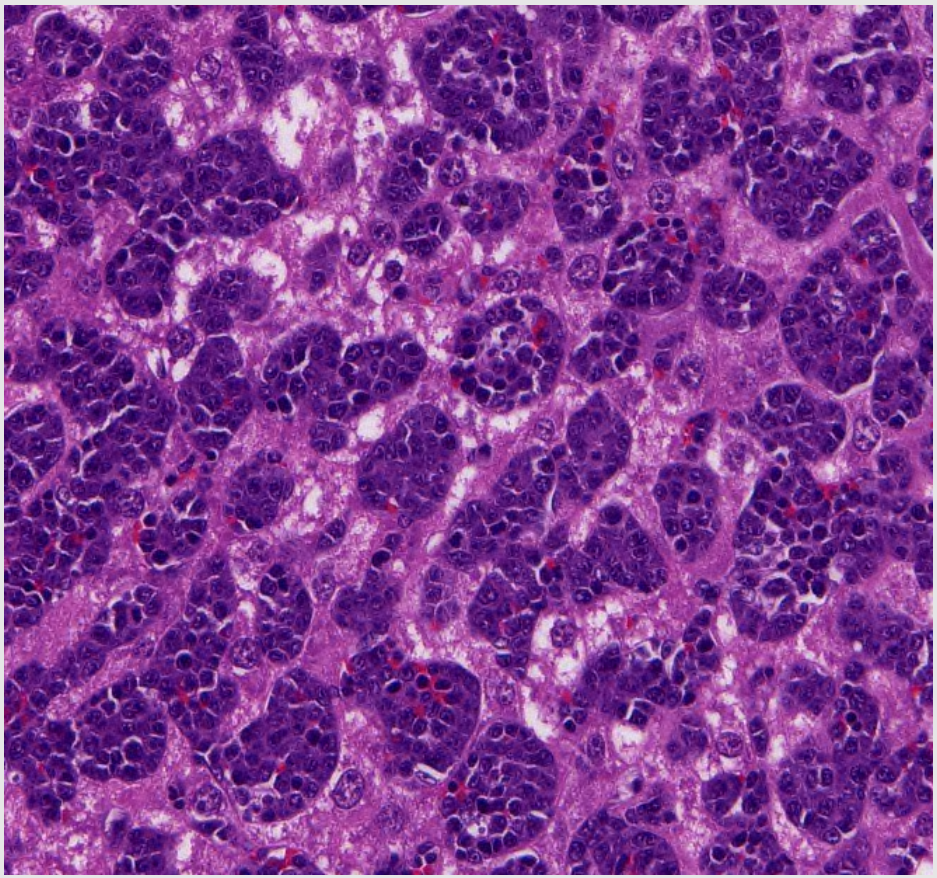

Challenges:

- Huge dimensions
  (>3.5 Gpx)

Challenges of Whole-Slide Images

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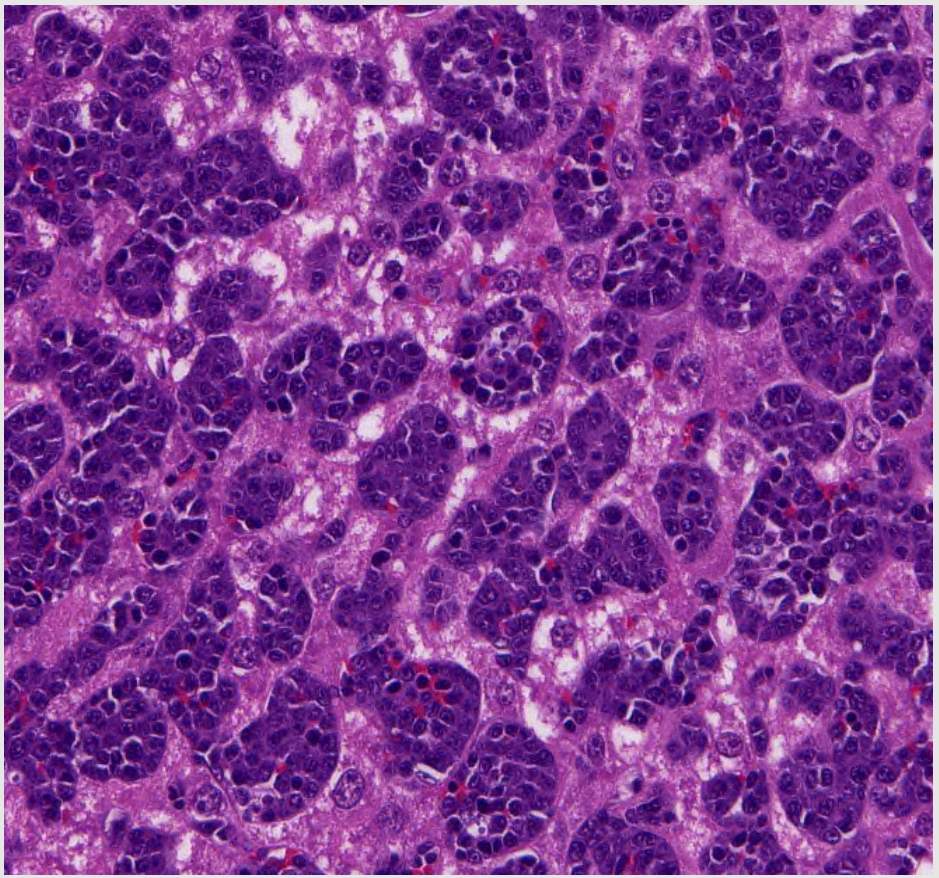

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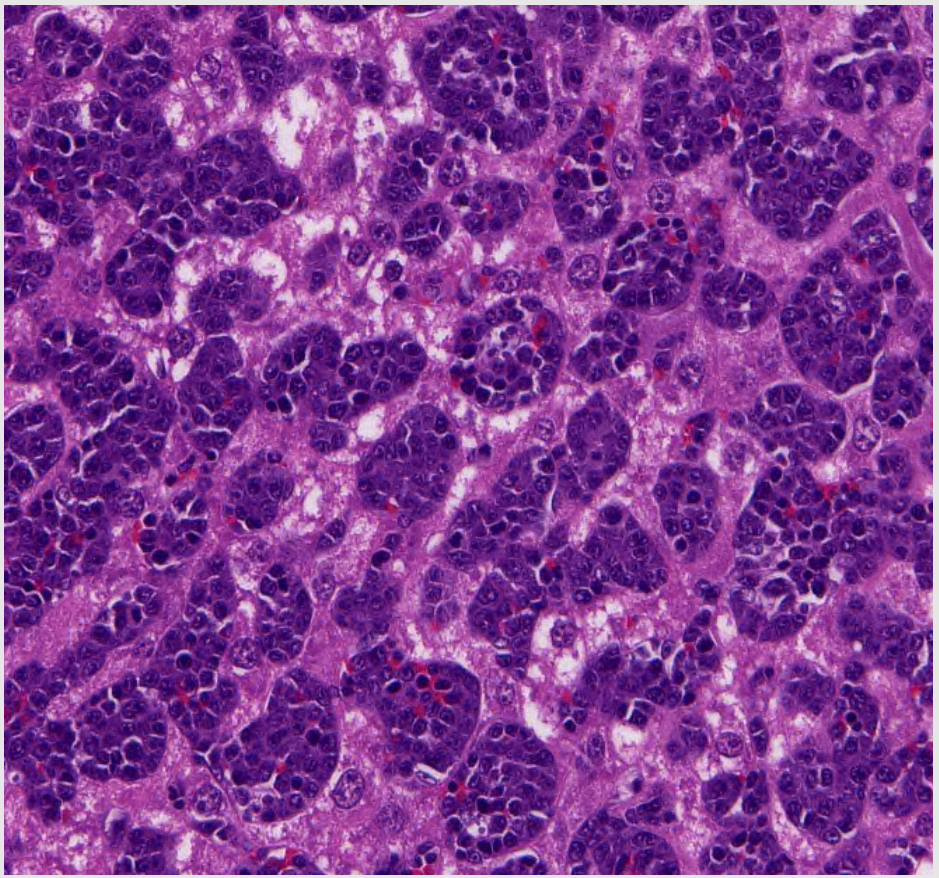

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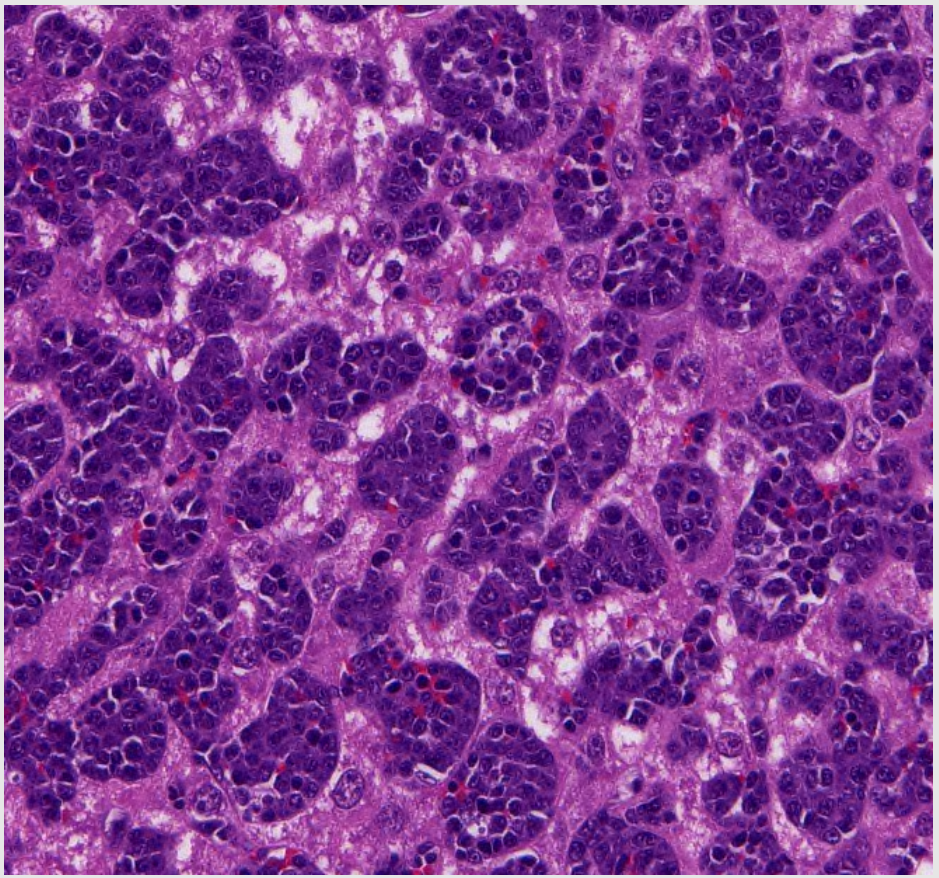

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  - Transmission
  - Visualization

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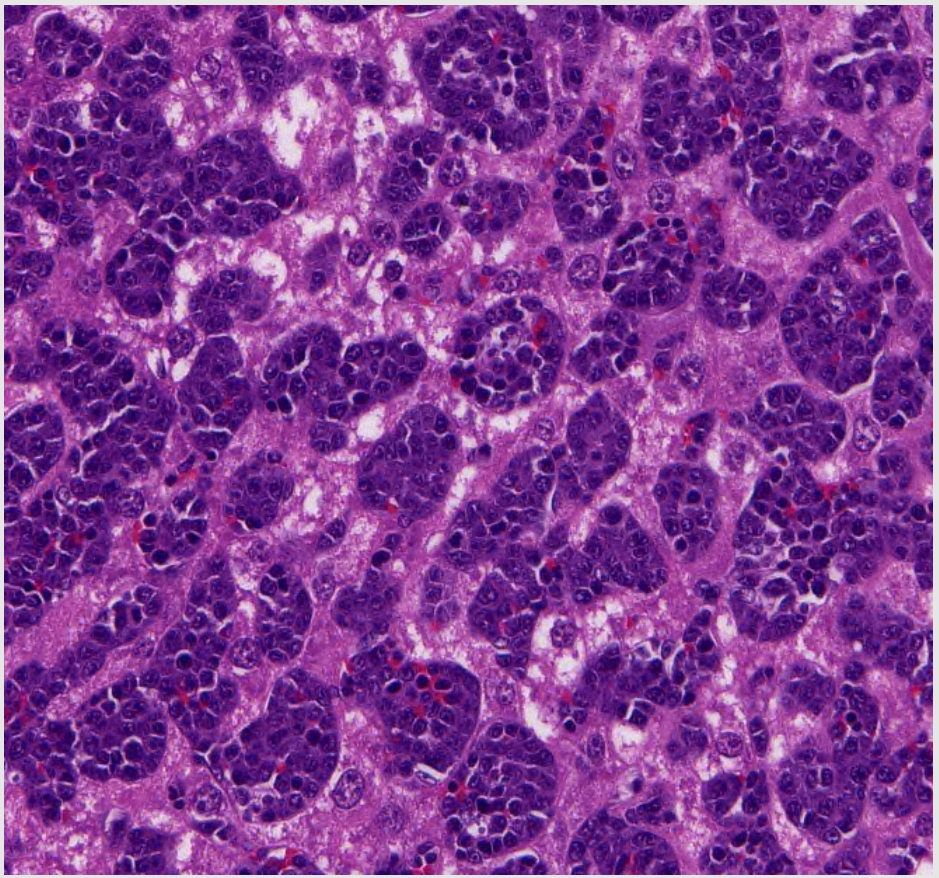

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⇒ **Compression: natural approach**

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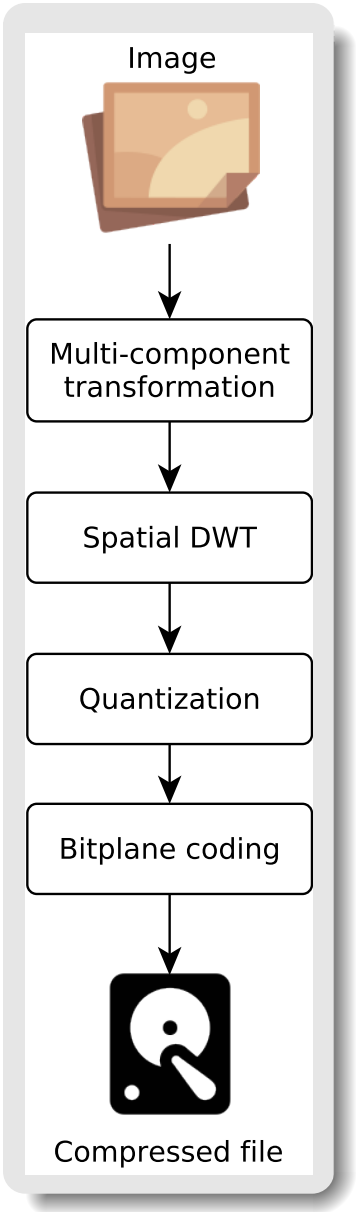
Multi-Component Transforms (MCTs)



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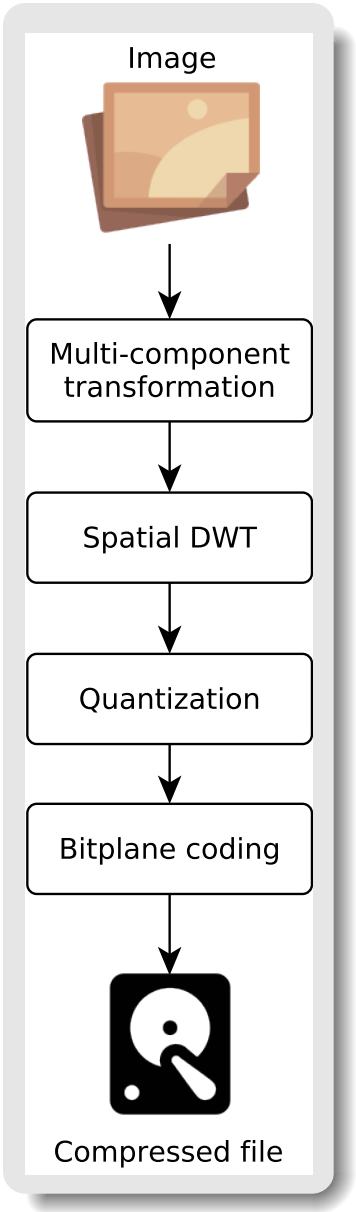

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- Lymphatic: 0.9823
- Pancreatic: 0.8718
- Renal: 0.9524

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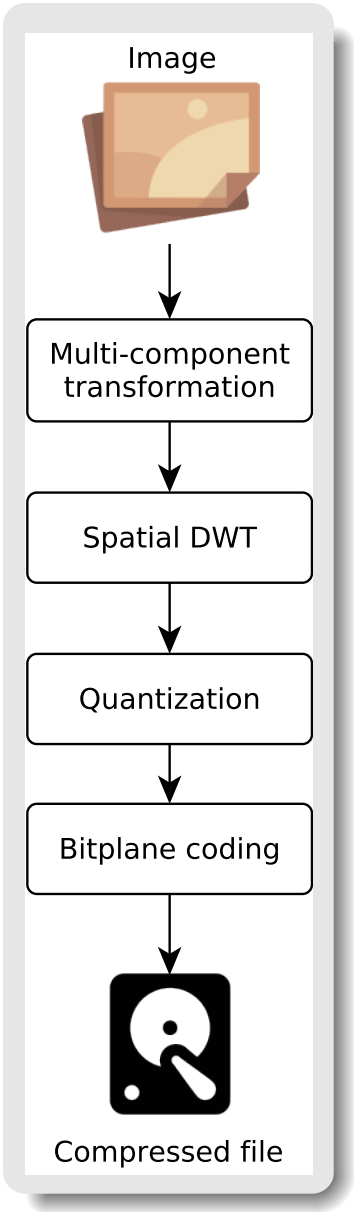

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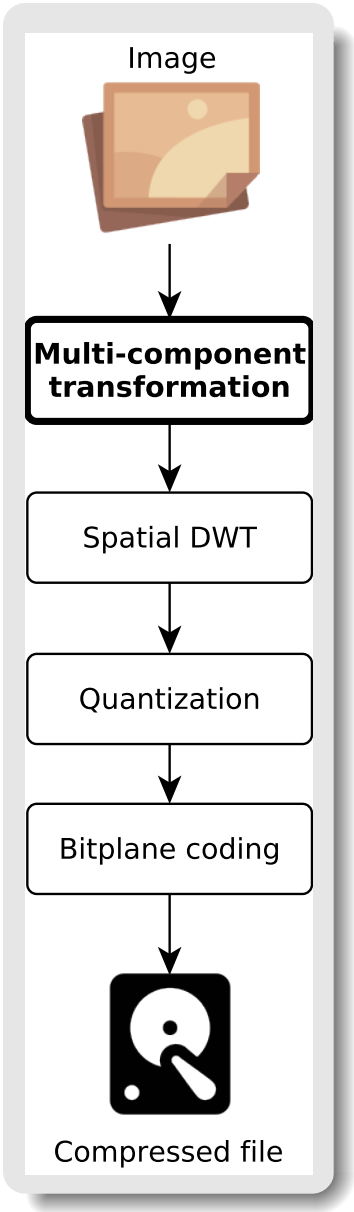

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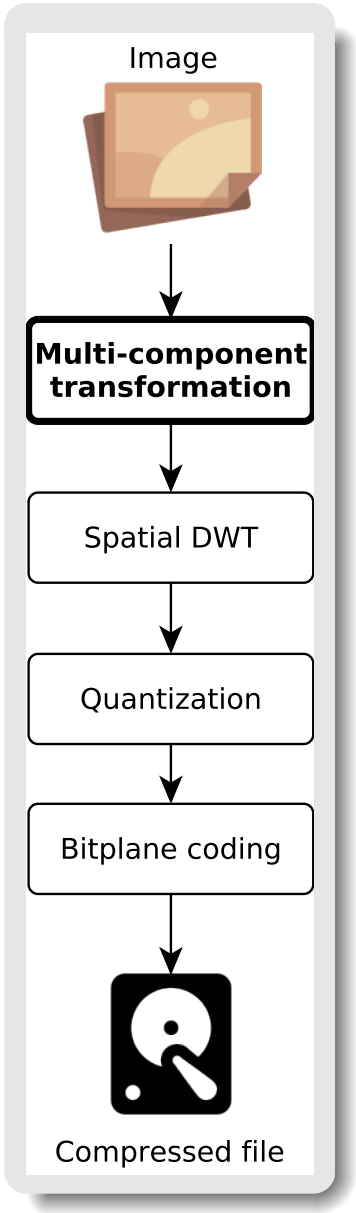

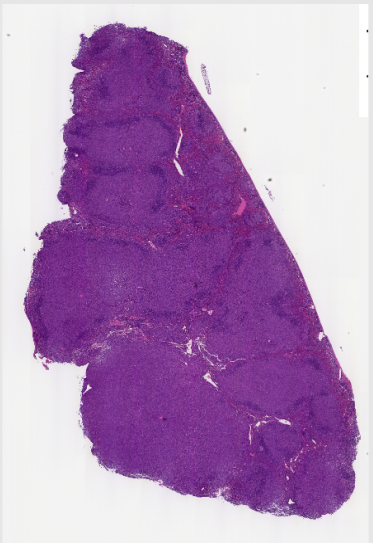

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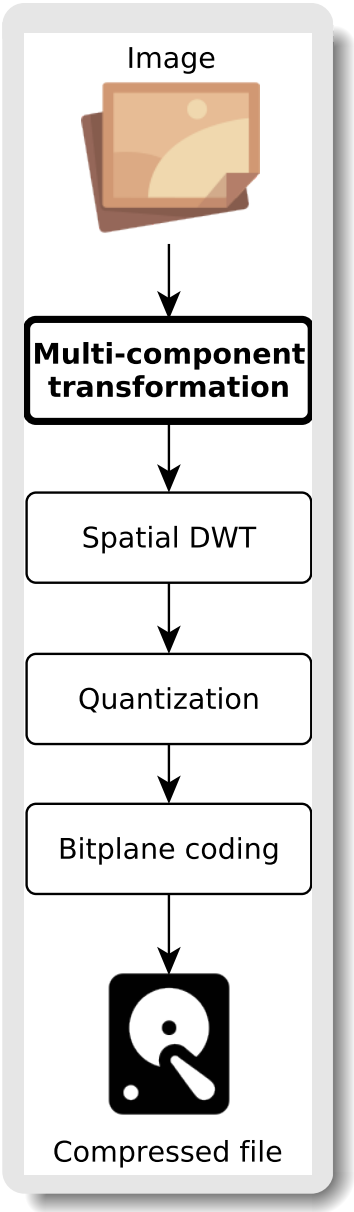

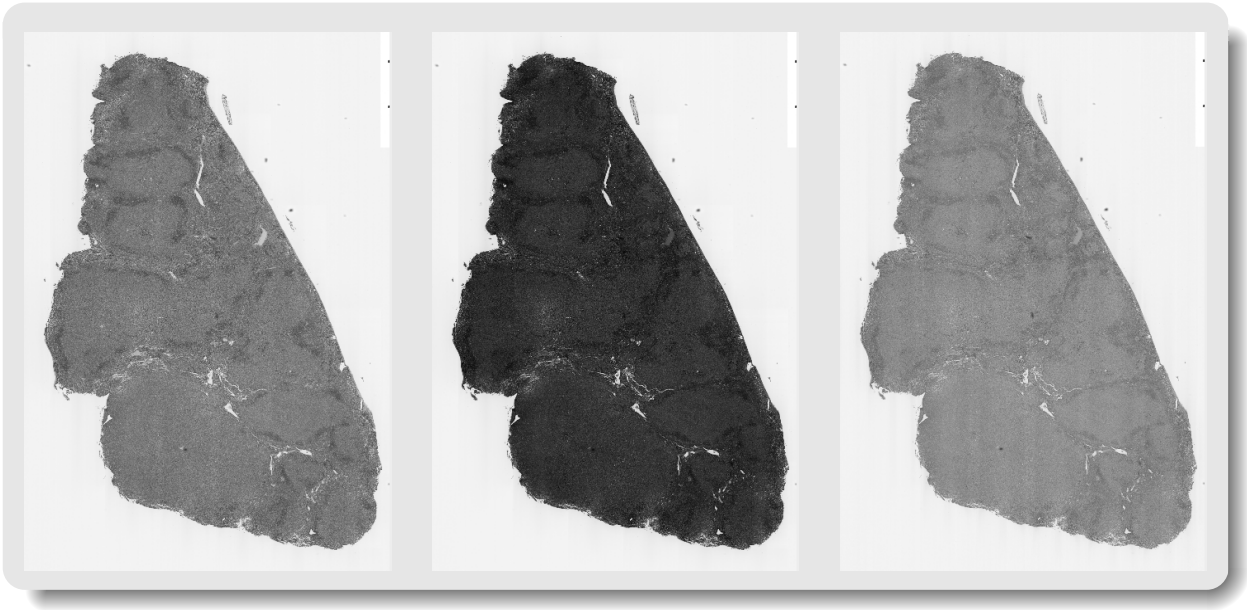

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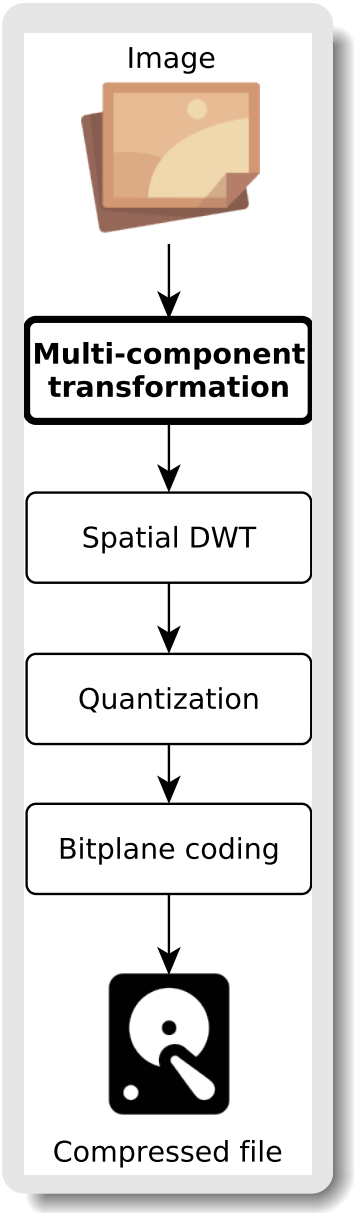

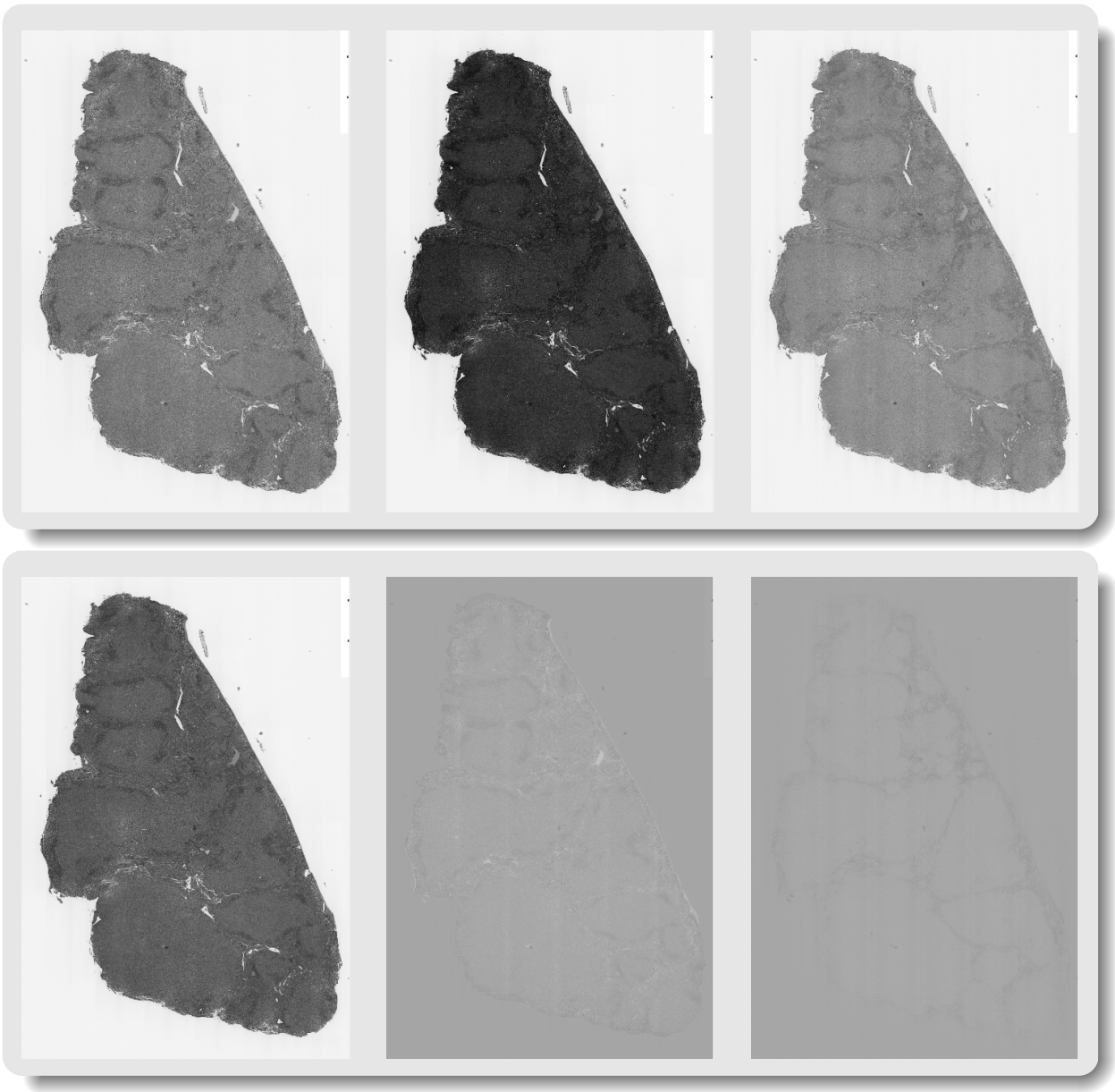

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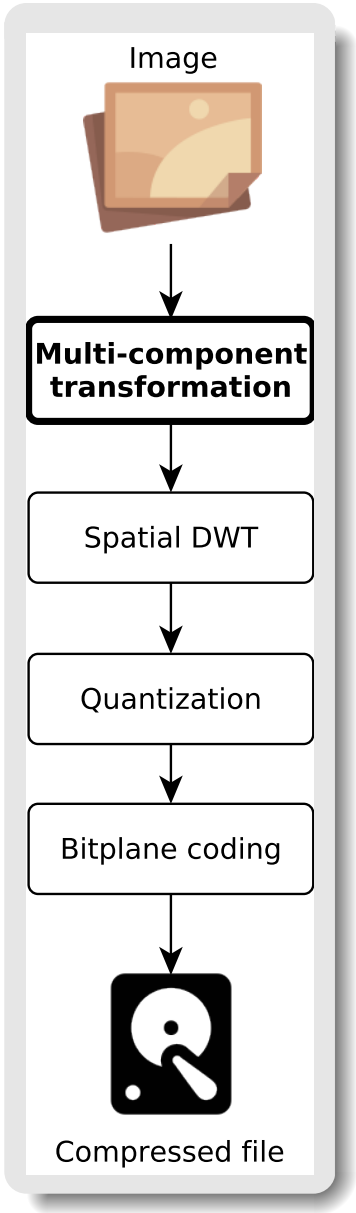
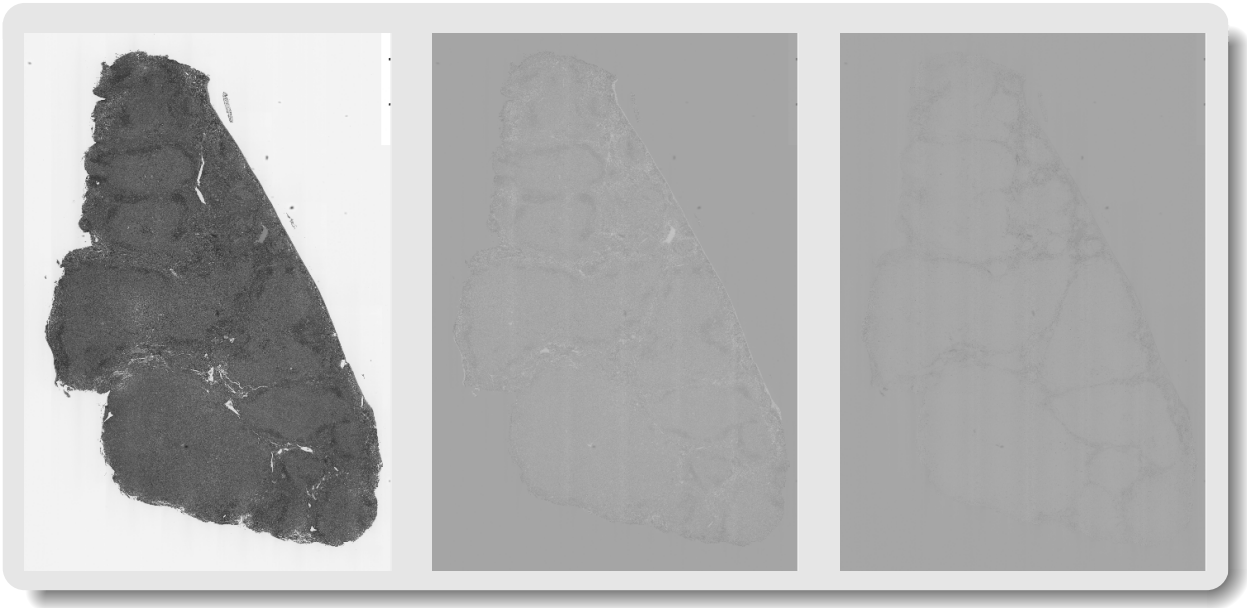


Advantages:

- decorrelate components
- compact energy

$\Rightarrow$ enhance compression



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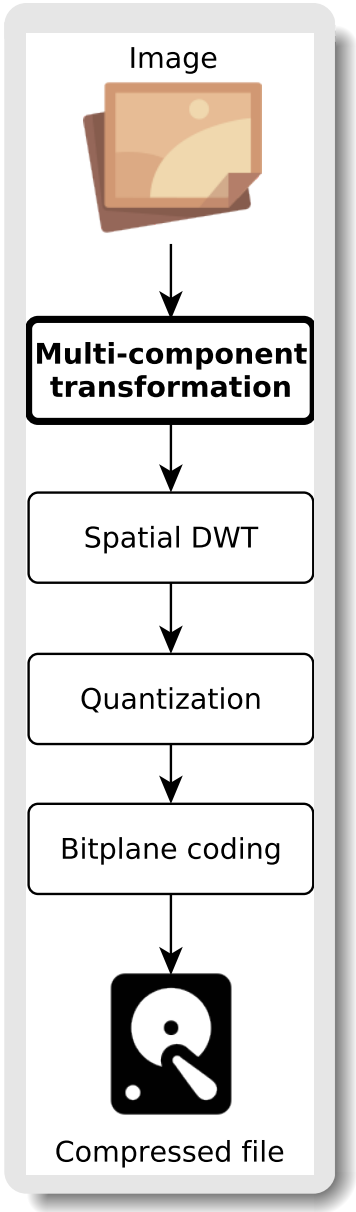

Focus on **linear** MCTs:

$$\begin{pmatrix} u_i \\ v_i \\ w_i \end{pmatrix} = \mathbf{M} \begin{pmatrix} r_i \\ g_i \\ b_i \end{pmatrix} \quad \forall \text{ pixel } (r_i, g_i, b_i),$$

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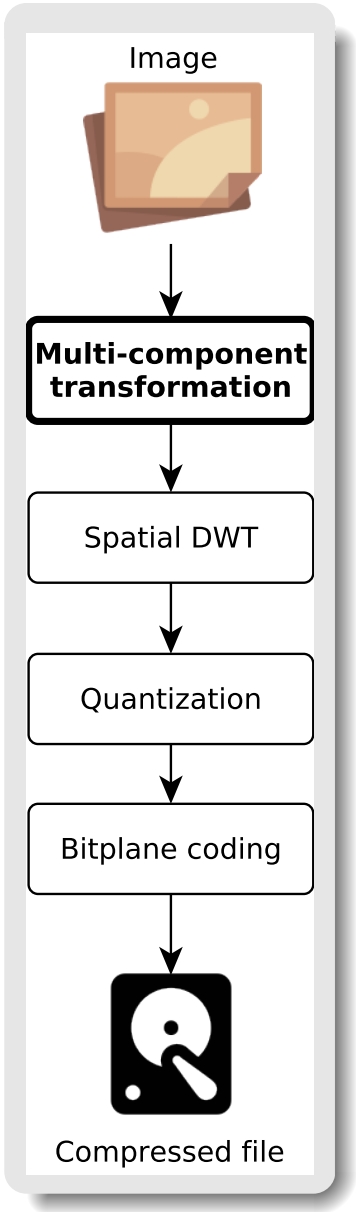

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where

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Contents

Static MCTs

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- Neglect compressor details:
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Our approach

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$$\underset{MCT}{\text{argmin}} \ \textsc{EvaluateMSE}(MCT)$$

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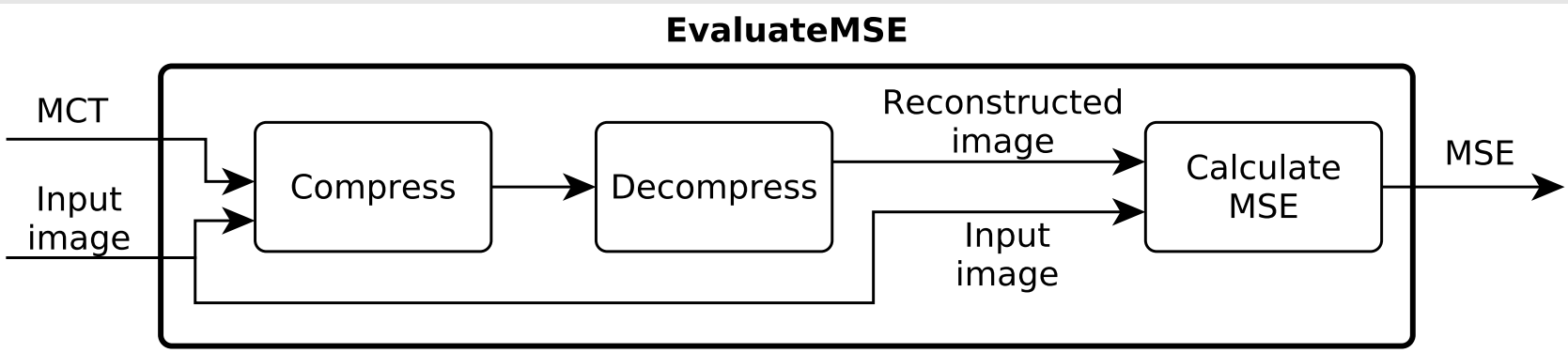
$$\underset{MCT}{\operatorname{argmin}} \ \textsc{EvaluateMSE}(MCT)$$

Cost function



MCT Optimization

Analytical EvaluateMSE: intractable

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Decisions

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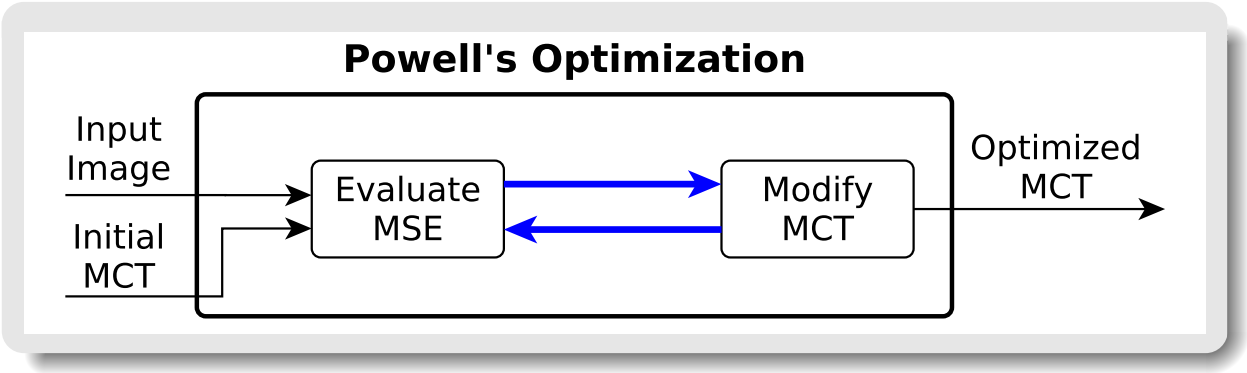

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- ✓ Optimization algorithm
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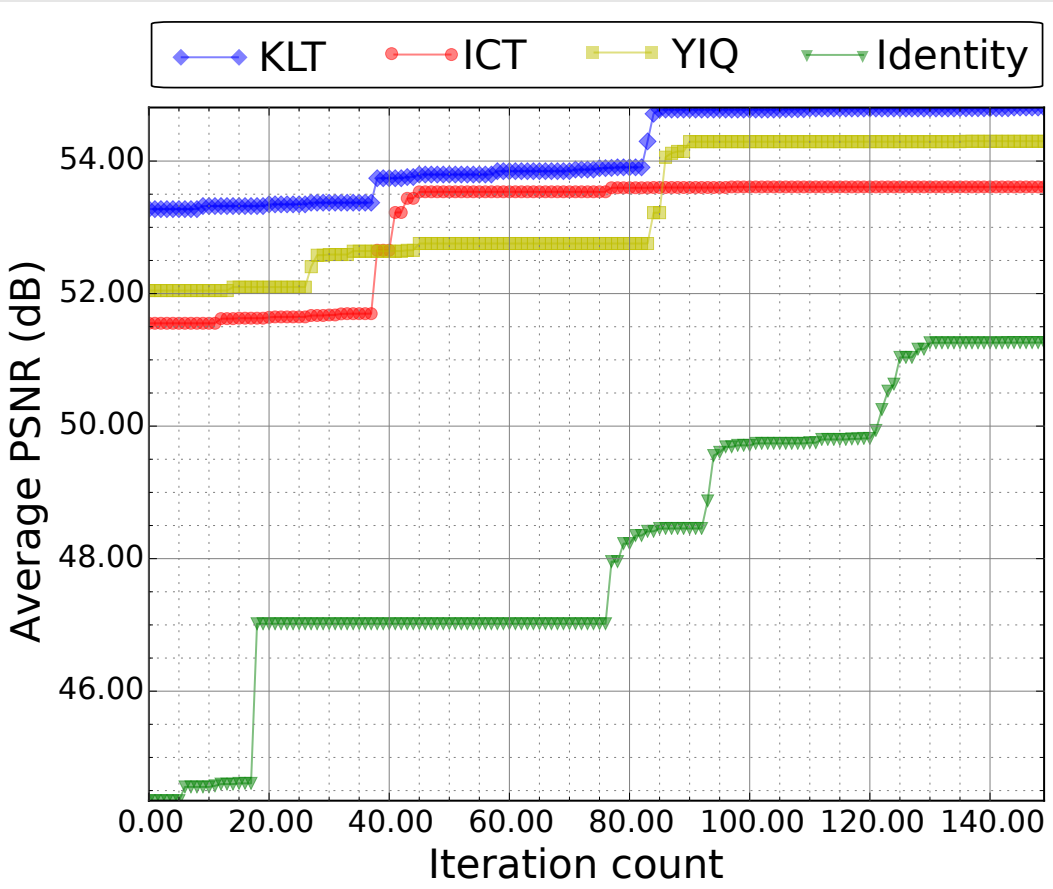
PSNR Evolution (4 candidates)



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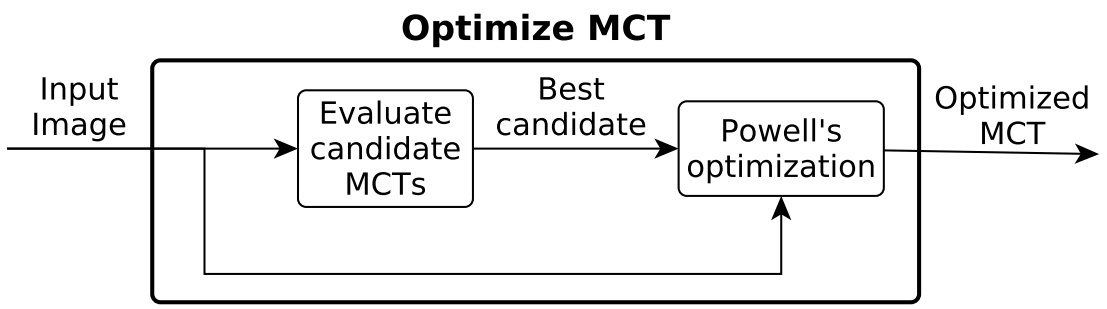
Proposed Algorithm



1. Evaluate N candidates
2. Optimize best candidate

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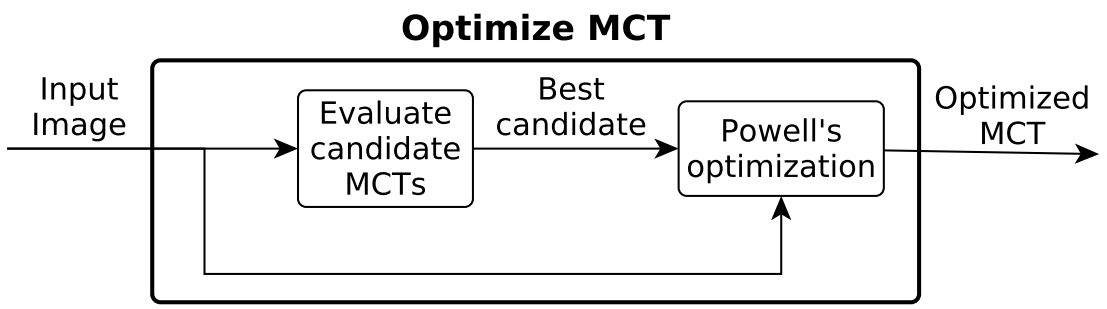

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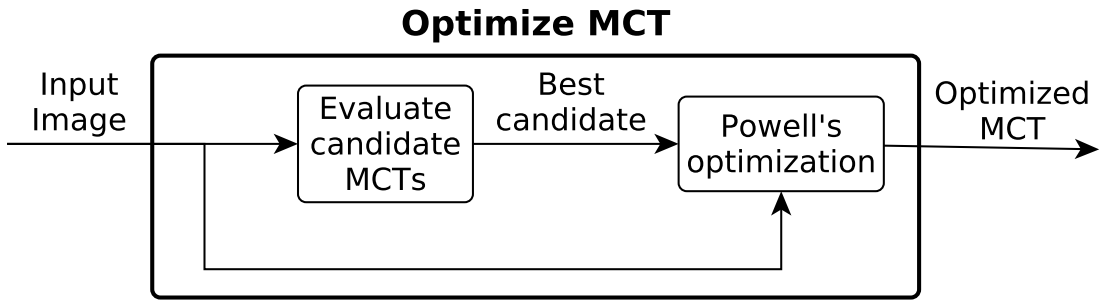

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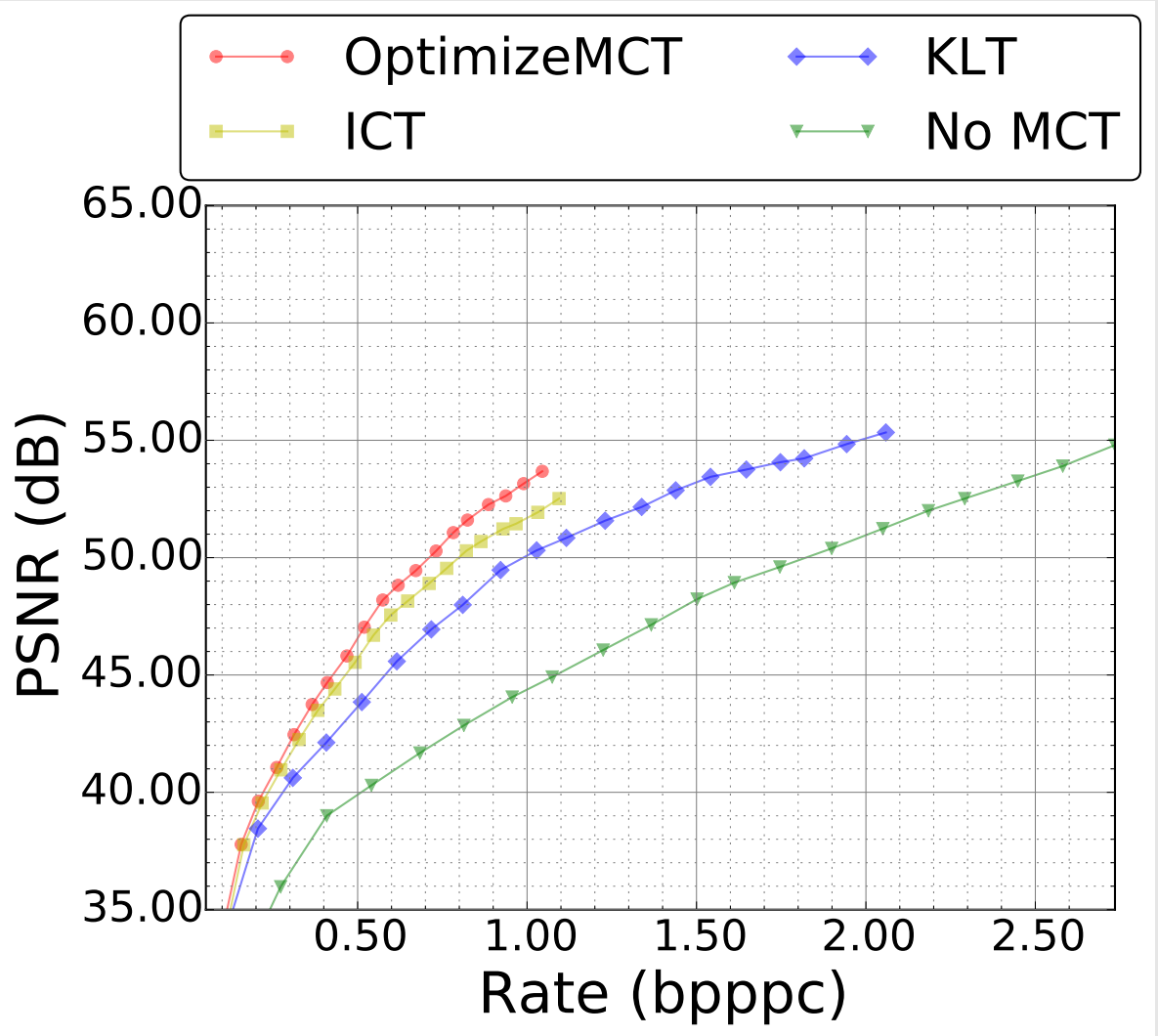
   Limit to 250–300 iterations

Experimental Results

Rate-distortion results (lymphatic)



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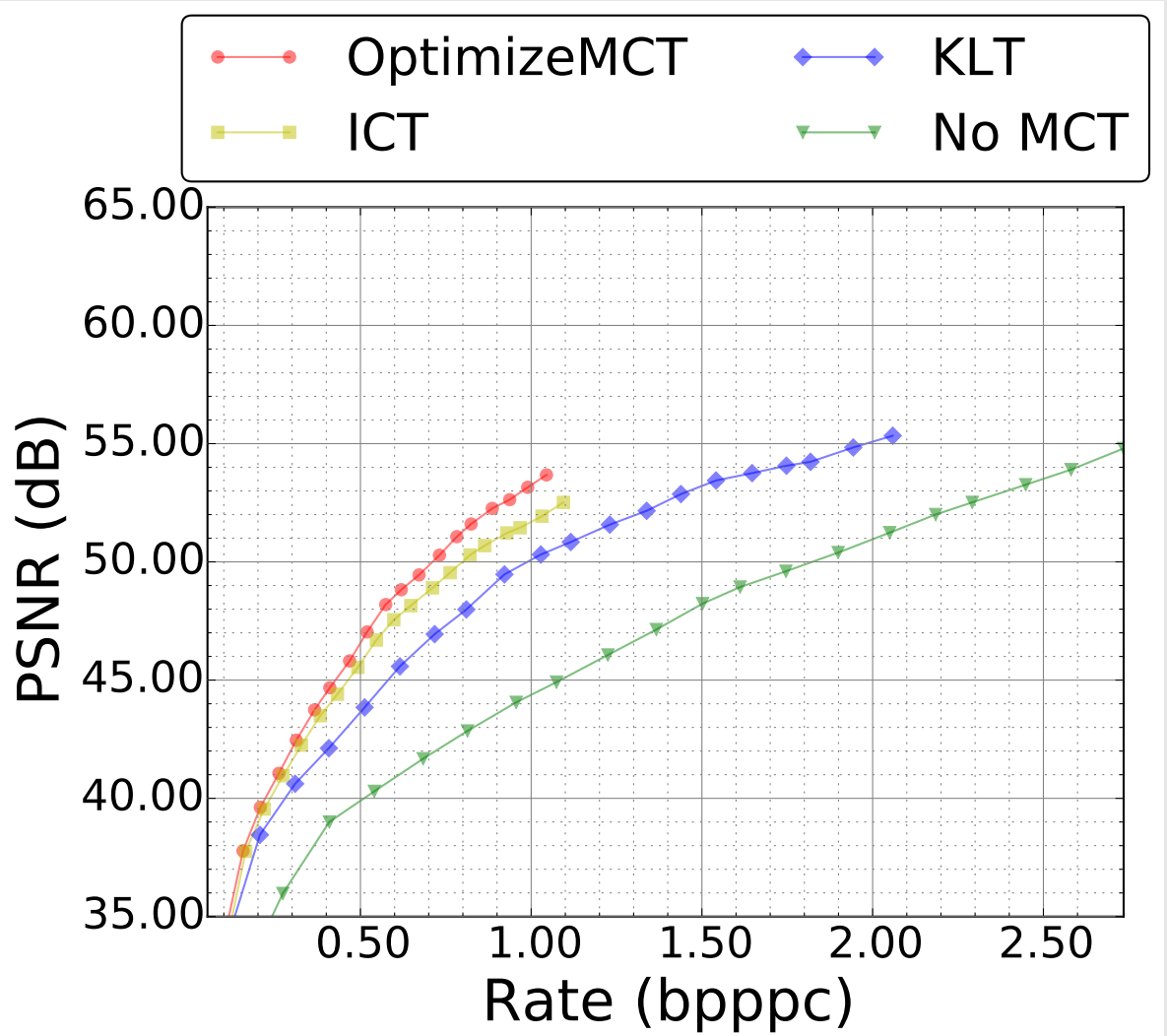

Improvements:

- all bitrates

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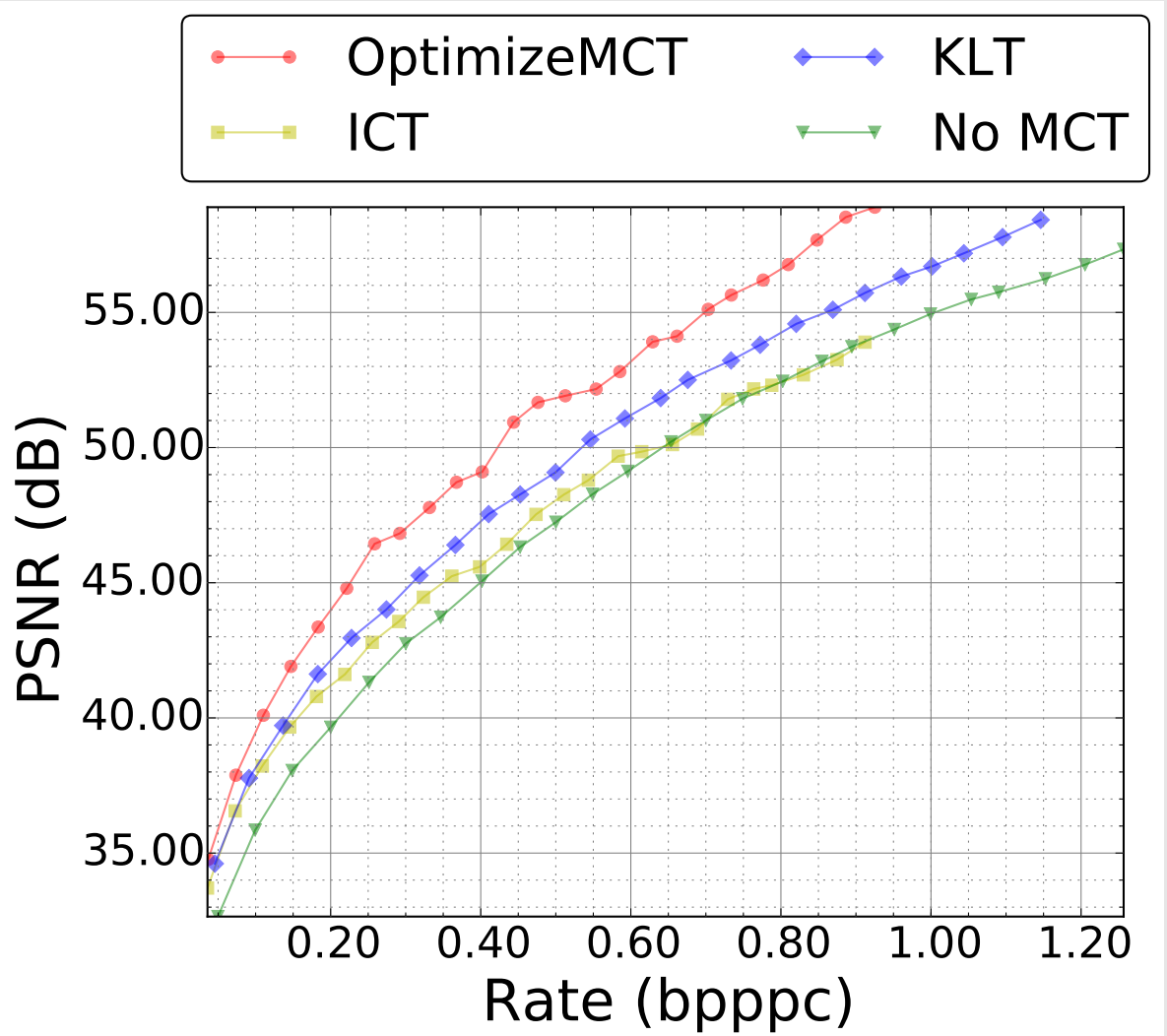
Rate-distortion results (pancreatic)



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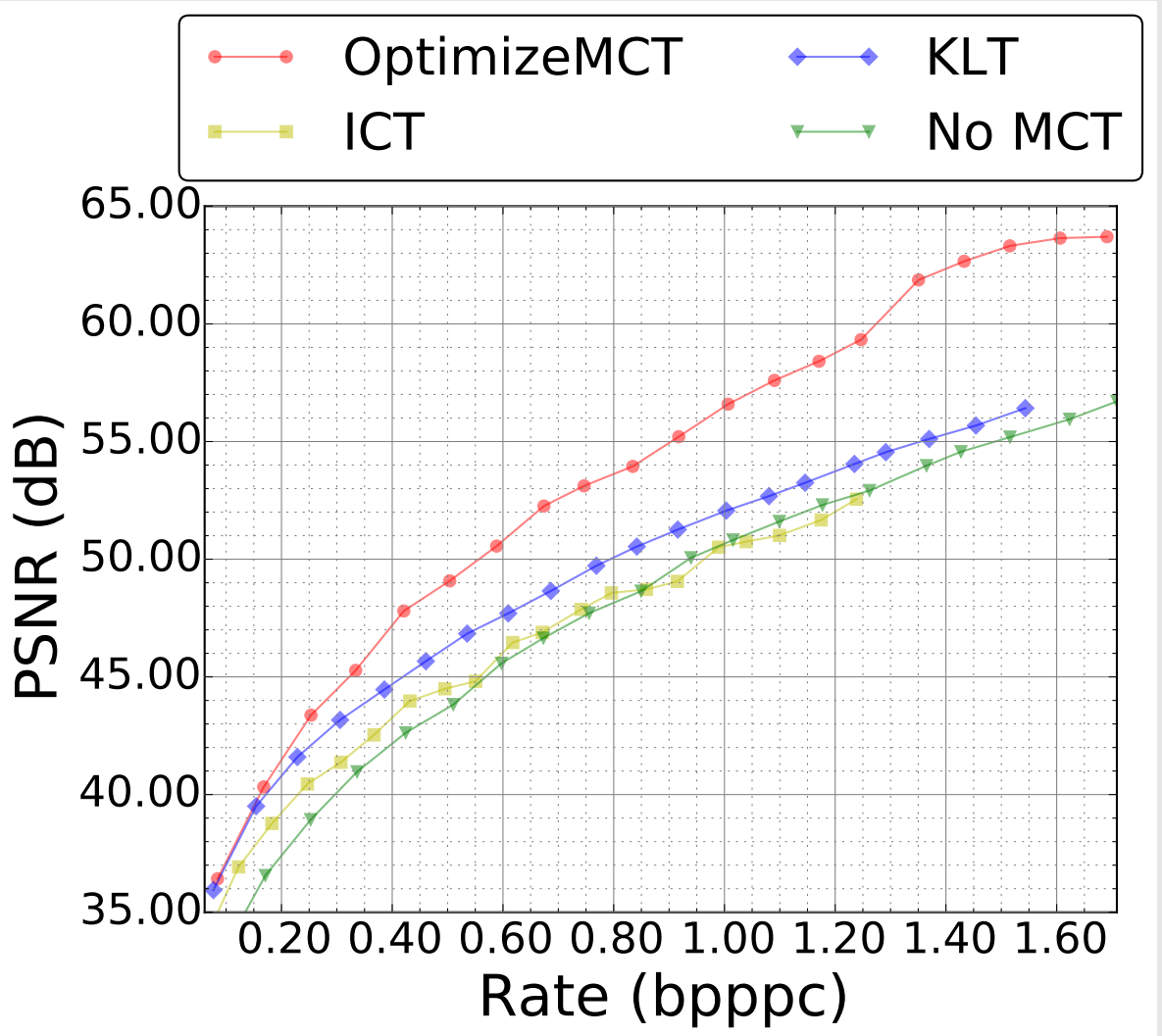
Rate-distortion results (renal)



Improvements:

- all bitrates
- different WSI types

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Average reconstructed PSNR (dB)

Images	Target bitrate	No MCT	ICT	KLT	OST	Optimize MCT
All (23)	0.54					

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Images	Target bitrate	No MCT	ICT	KLT	OST	Optimize MCT
All (23)	0.54	44.42	46.62	46.76	47.16	**49.61**

- Avg. improvement vs KLT: 2.85 dB
- Improvement vs KLT up to: 5 dB

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Average reconstructed PSNR (dB)

Images	Target bitrate	No MCT	ICT	KLT	OST	Optimize MCT
All (23)	0.54	44.42	46.62	46.76	47.16	**49.61**
Lymphatic (6)	0.58	41.56	46.14	44.74	45.81	**47.38**
Renal (7)	0.42	44.74	47.41	47.39	48.02	**49.64**
Pancreatic (10)	0.68	46.43	45.91	47.59	47.10	**51.49**

- Avg. improvement vs KLT: 2.85 dB
- Improvement vs KLT up to: 5 dB

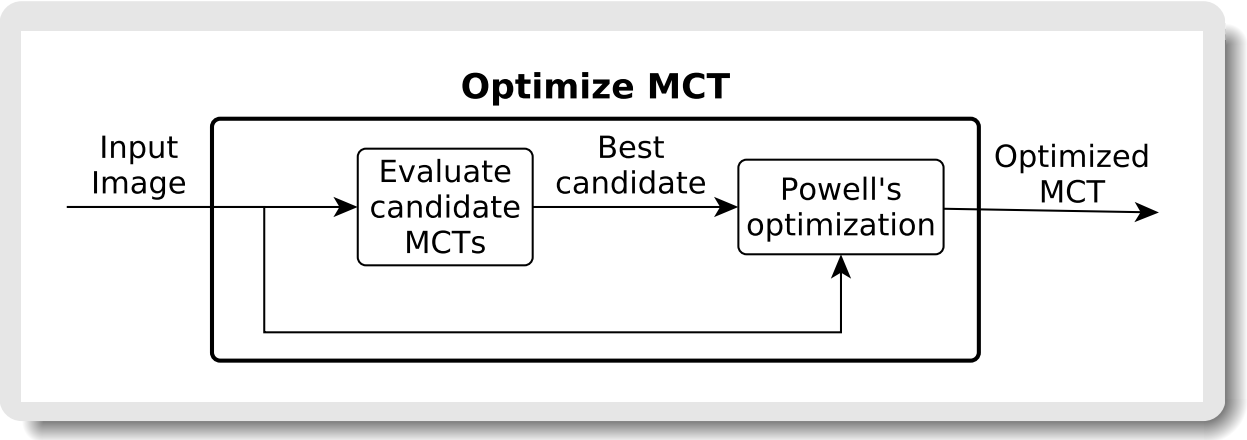
Experimental Results

Average reconstructed PSNR (dB)

Images	Target bitrate	No MCT	ICT	KLT	OST	Optimize MCT
All (23)	0.54	44.42	46.62	46.76	47.16	**49.61**
Lymphatic (6)	0.58	41.56	46.14	44.74	45.81	**47.38**
Renal (7)	0.42	44.74	47.41	47.39	48.02	**49.64**
Pancreatic (10)	0.68	46.43	45.91	47.59	47.10	**51.49**

- Avg. improvement vs KLT: 2.85 dB
- Improvement vs KLT up to: 5 dB
- Improvements for all images

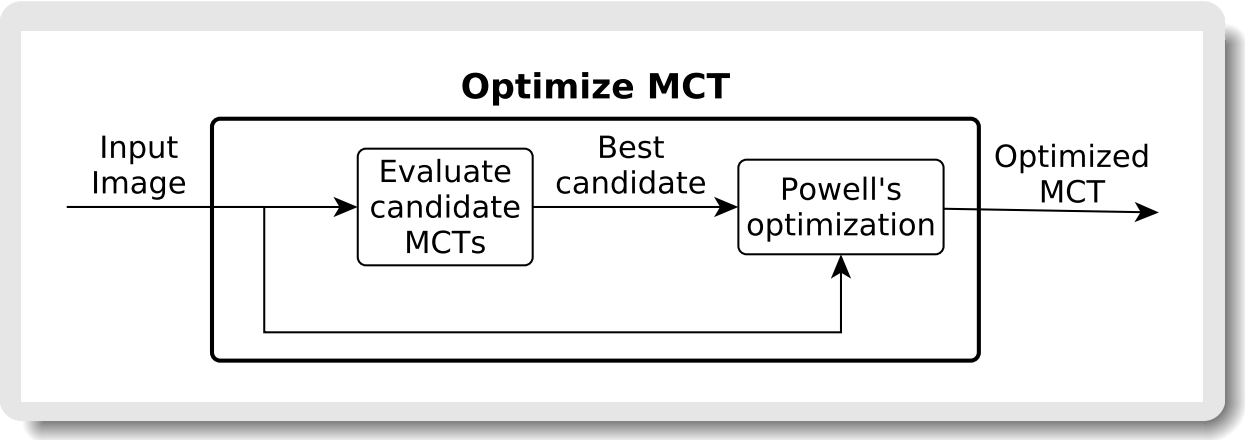
Conclusions & Future Work



Conclusions:

- Traditional MCTs: suboptimal for WSIs

Conclusions & Future Work



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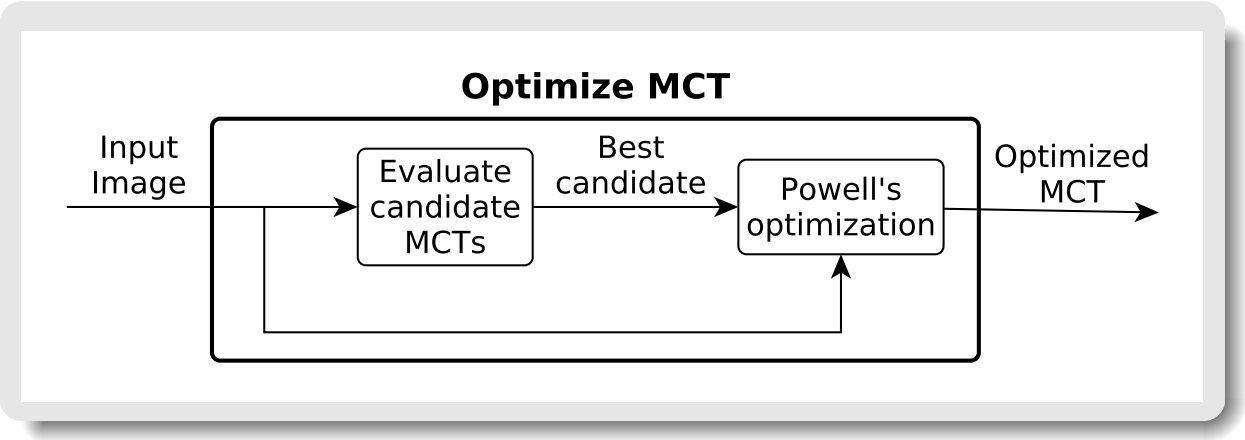

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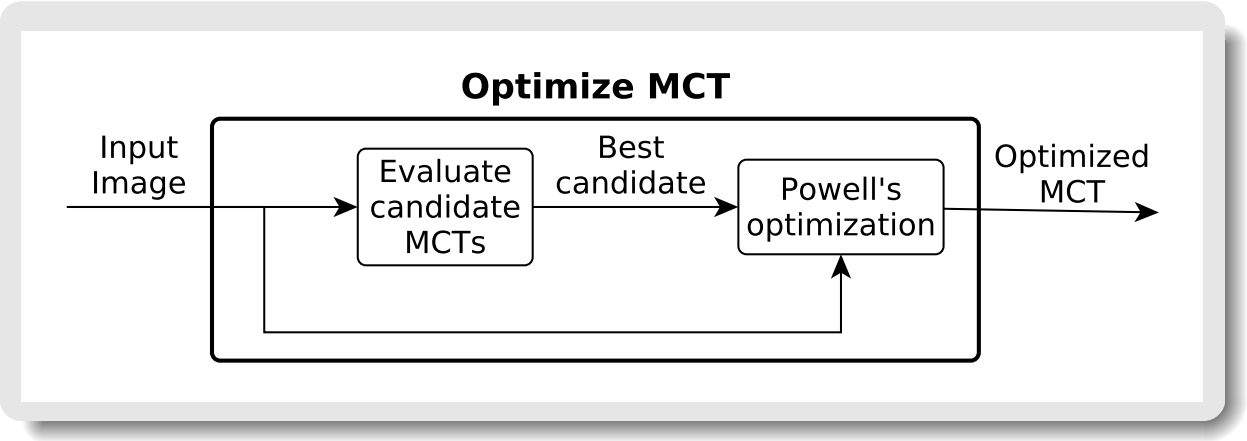
  - Several tissue types

Conclusions & Future Work



Conclusions:

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Future work:

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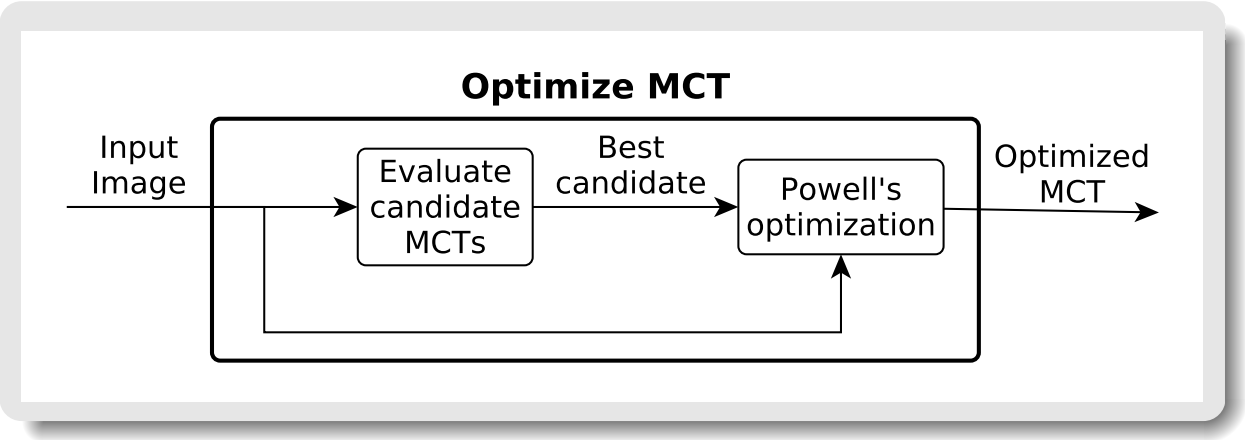
  - Current: 120 min
  - Scan: 1–3 min

Conclusions & Future Work



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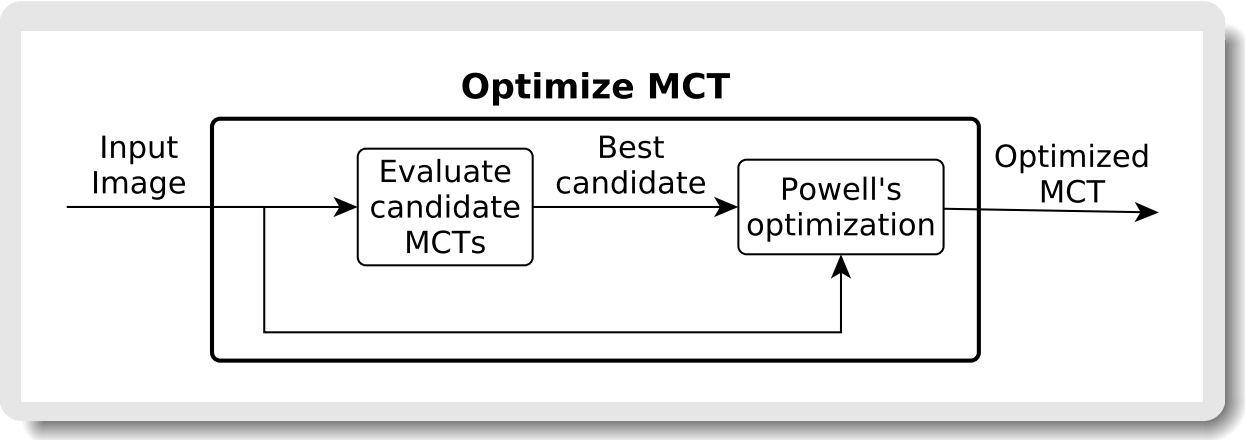

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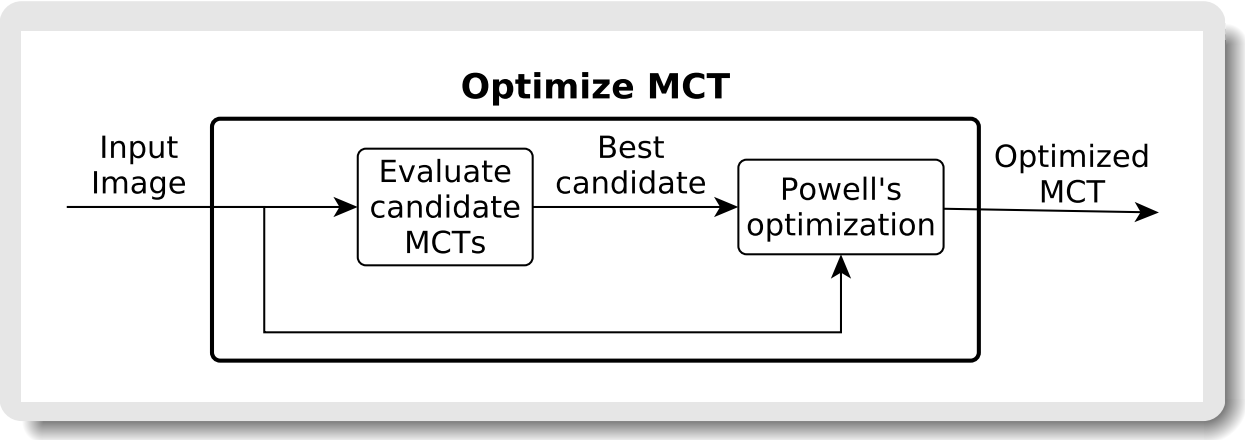

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