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SEAM CARVING FOR TEXT LINE EXTRACTION ON GRAYSCALE HISTORICAL MANUSCRIPTS

Abstract

We propose a novel algorithm for automatic text line extraction on grayscale manuscripts without prior binarization. Our method is based on constrained seam carving to compute separating seams between consecutive text lines. Extensive experimental evaluations on diverse manuscripts show that we improve upon the state-of-the-art for grayscale text line extraction.

Why no prior binarization?

With binarization

Without binarization

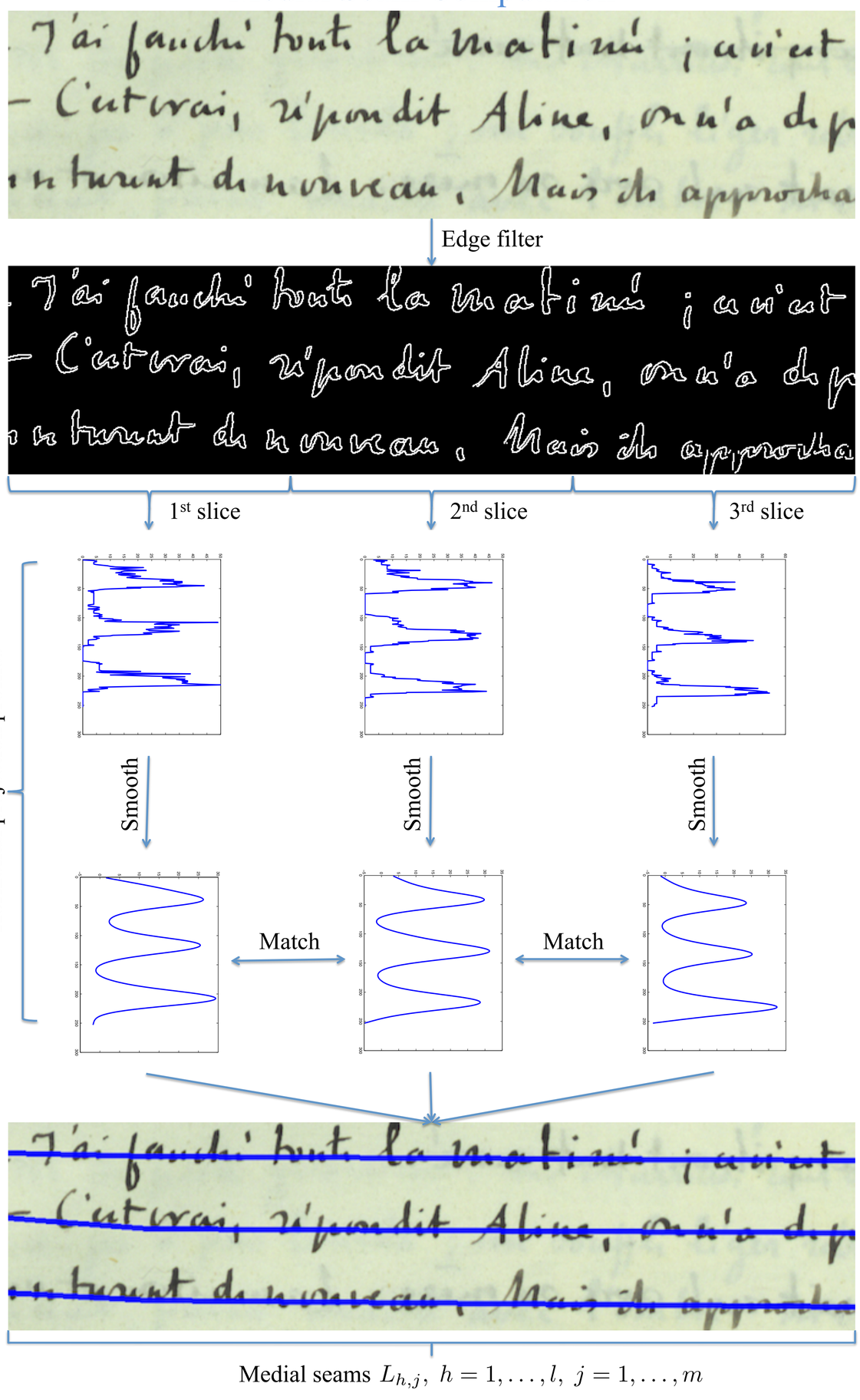
Due to the low quality of the manuscript, the binarization method results in extensive information loss. Any algorithm based on binary input is non-applicable.

Our Approach

Our algorithm takes as input a grayscale image $\mathbf{I} \in \mathbb{R}^{n \times m}$. It consists of two steps:

1) Medial seam computation using a projection profile matching approach similar to [3].
2) Separating seam computation using a modification of the seam carving procedure [4].

Medial Seam Computation



Medial seams $L_{h,j},\ h = 1, \ldots, l,\ j = 1, \ldots, m$

Separating Seam Computation

Compute minimum-energy horizontal seams on the gradient image $\mathbf{E}$:

- Horizontal seam definition:

$$\mathbf{s}_h = \{\mathbf{s}_{h,j}\}_{j=1}^{m} = \{(y_h(j), j)\}_{j=1}^{m}, \quad |y_h(j) - y_h(j-1)| \leq 1,$$
$$y_h(j) = L_{h,j}, \ldots, L_{h+1,j}, \quad y_h : [1, \ldots, m] \rightarrow [L_{h,j}, \ldots, L_{h+1,j}]$$

- Seam computation with DP [4]:

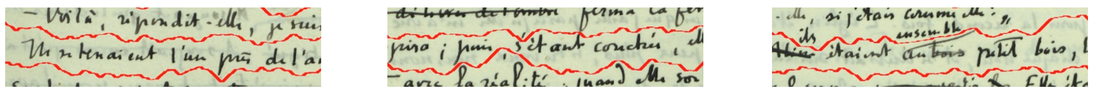
1. Cumulative minimum energy computation:

$$M_{y_h(j),1} = E_{y_h(j),1}, \quad M_{y_h(j),j} = E_{y_h(j),j} + \min \begin{cases} M_{y_h(j)-1,j-1} \\ M_{y_h(j),j-1} \\ M_{y_h(j)+1,j-1} \end{cases}$$

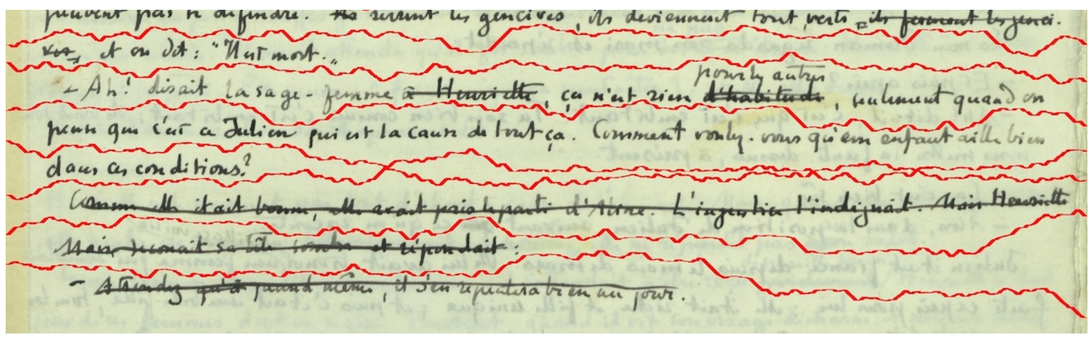
2. Traverse $\mathbf{M}$ backwards for optimal seam generation.

Results

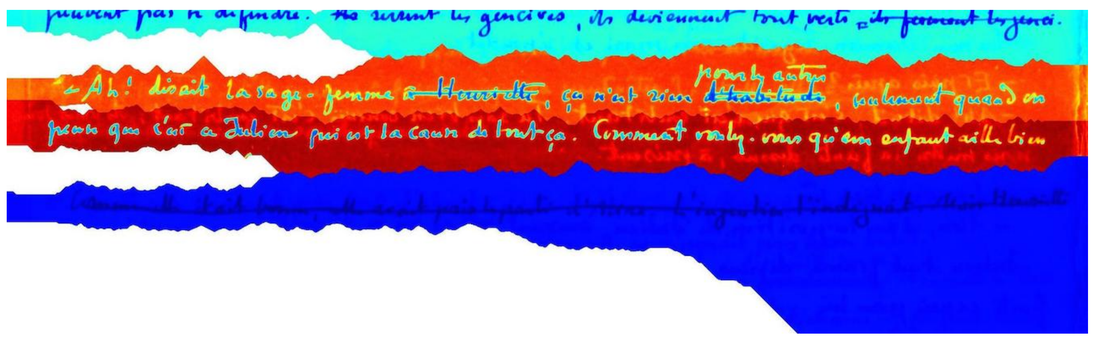
We distinguish three seam types:



Type I seams, perfect. Type II seams, letter cuts. Type III seams, wrong words.



Seams with our approach.



Seams with the state-of-the-art [2].

	Seam Type					
Collection	**I**		**II**		**III**	
	Ours	[2]	Ours	[2]	Ours	[2]
Al-Majid-2	**98.2**%	69.9%	**1.8**%	26.4%	**0**%	3.7%
Wadod-2	**78**%	21.5%	**21.5**%	45.6%	**0.5**%	**0.5**%
AUB-2	**92**%	53.9%	**8**%	43.4%	**0**%	2.7%

Table I. Seam type comparison with the state-of-the-art [2].

	Accuracy	
Collection	**Ours**	**[2]**
Al-Majid-1	**99.30**%	97.59%
Al-Majid-2	**99.97**%	98.19%
Wadod-1	**99.04**%	98.35%
Wadod-2	**99.87**%	97.53%
AUB-1	**99.75**%	98.05%
AUB-2	**99.97**%	96.15%
Thomas Jefferson	**97.75**%	95.21%

Table II. Automatic comparison with the state-of-the-art [2].

Acknowledgments

We thank Abedelkadir Asi for providing us the results of [2]. We also thank the Bibliothèque Cantonale et Universitaire de Lausanne for providing us with the manuscript pages of Aline.

References

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[3] M. Liwicki, E. Indermühle, and H. Bunke, "On-line Handwritten Text Line Detection Using Dynamic Programming," ICDAR 2007.
[4] S. Avidan and A. Shamir, "Seam Carving for Content-Aware Image Resizing," SIGGRAPH 2007.

More information: http://ivrg.epfl.ch/research/handwriting_recognition/text_line_extraction