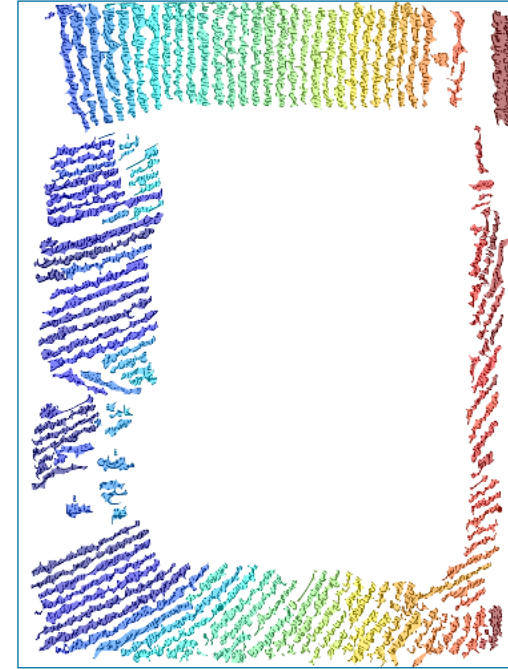
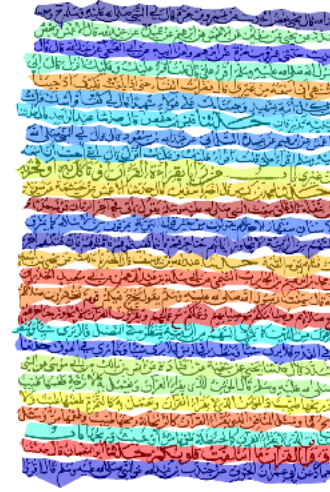


TEXT LINE EXTRACTION USING FULLY CONVOLUTIONAL NETWORK AND ENERGY MINIMIZATION



Annotation by Gunes Cevik

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Input

Lo fondo suo et ambo le pedic
facti eran pietra ei margini dilato
p chio machorsi chel pisso era lid
Tu tueto laltre chio to dimostrate
poscia che noi iramo p la porta
to cui sognare ad nessuno e uetato
Cosa no fui da tuoi ochi scorta
notabile comel presete Ro
che sopra se tuete fia melle amorta
Queste parole fur del duca mio
pehol pregai che milargisse il pusto
diano largito maual digio
Immegol mar siede un quese guasto

Detection

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Baseline

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Blob line

Extraction

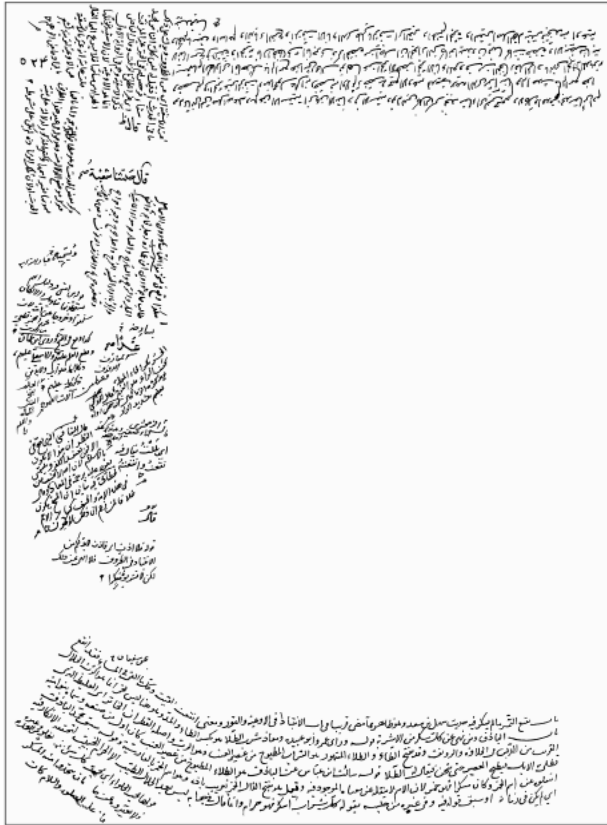
Lo fondo suo et ambo le pedic
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Pixel list

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Bounding polygon

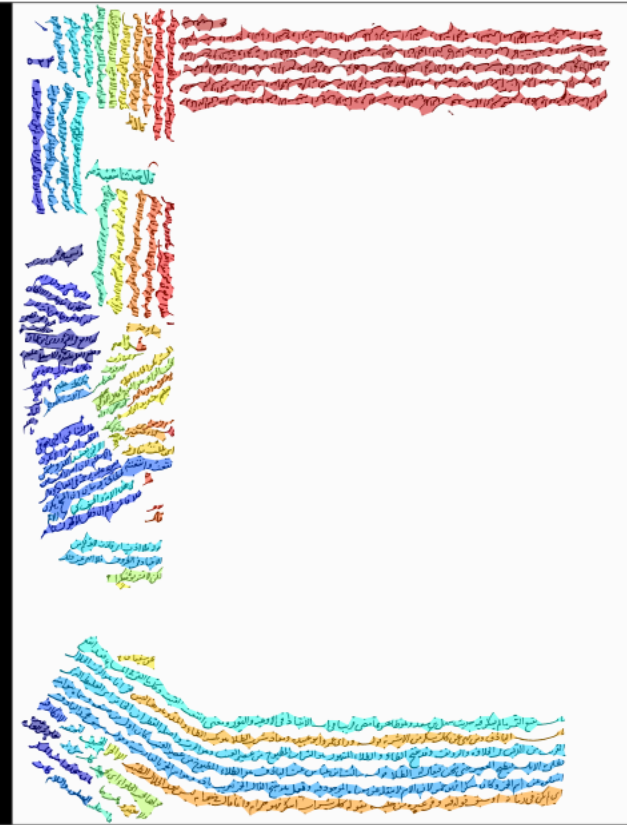
Input



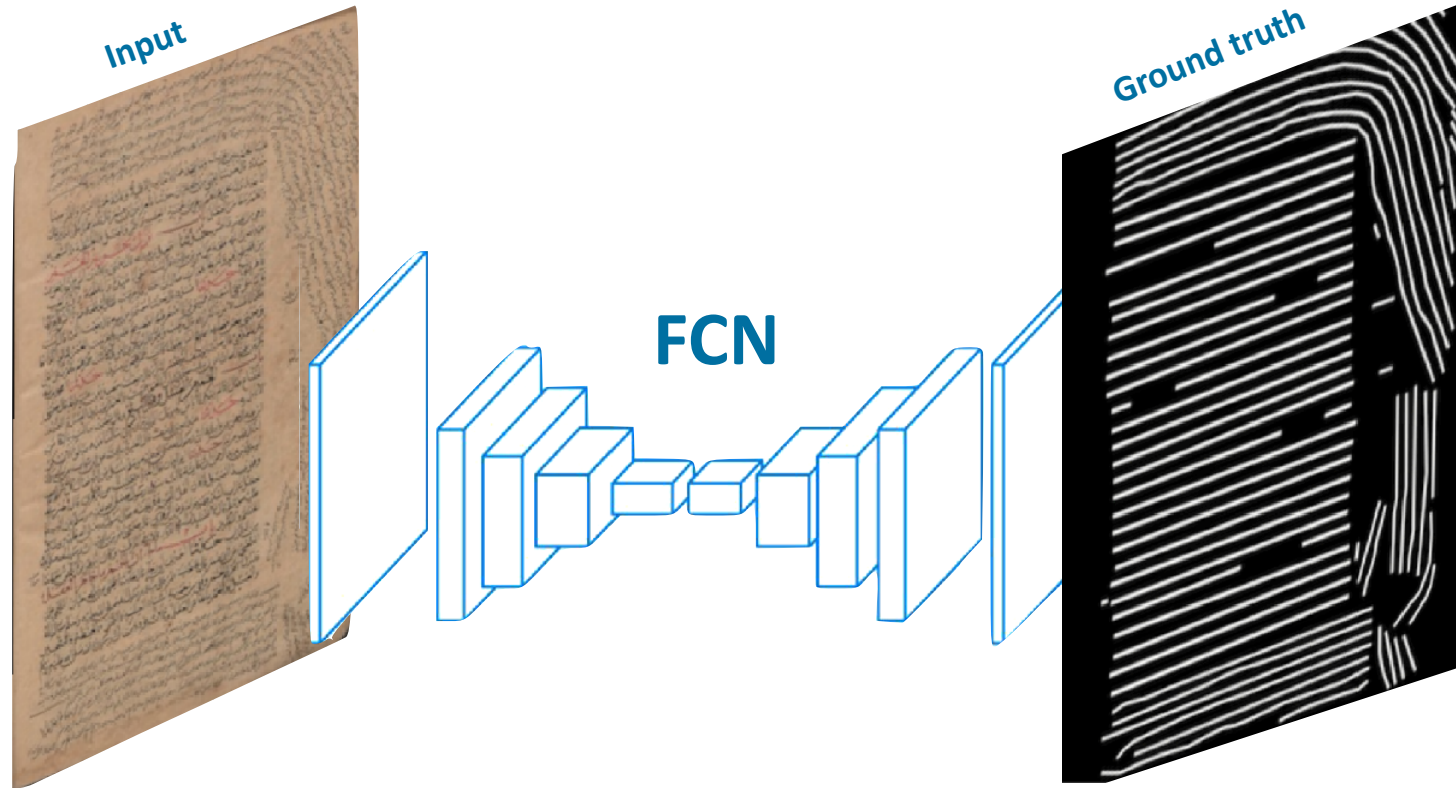
Text line detection using FCN



Text line extraction using EM



Text line detection using FCN



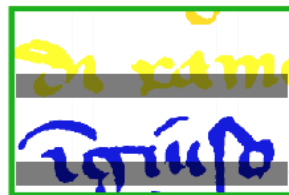
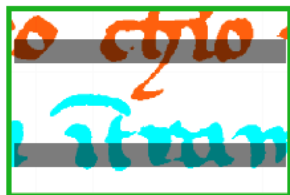
Text line extraction using energy minimization

$$E(f) = \sum_{e \in \mathcal{E}, l_e \in \mathcal{L}} \overset{\text{Data cost}}{D(e, l_e)} + \sum_{\{e, e'\} \in \mathcal{N}} \overset{\text{Smoothness cost}}{\frac{1}{e^{d_n(e, e')}}} \cdot \delta(l_e \neq l_{e'})$$

- \mathcal{L} = Set of binary blob lines
- \mathcal{E} = Set of binary elements
- \mathcal{N} = Set of nearest element pairs
- D = Cost of assigning element e to label l_e
- d_n = Profit of assigning neighbour elements to different labels
- δ = Indicator function = 1 when neighbour elements have different labels

Smoothness cost from Gestalt principles

Correct segmentations
with smoothness cost

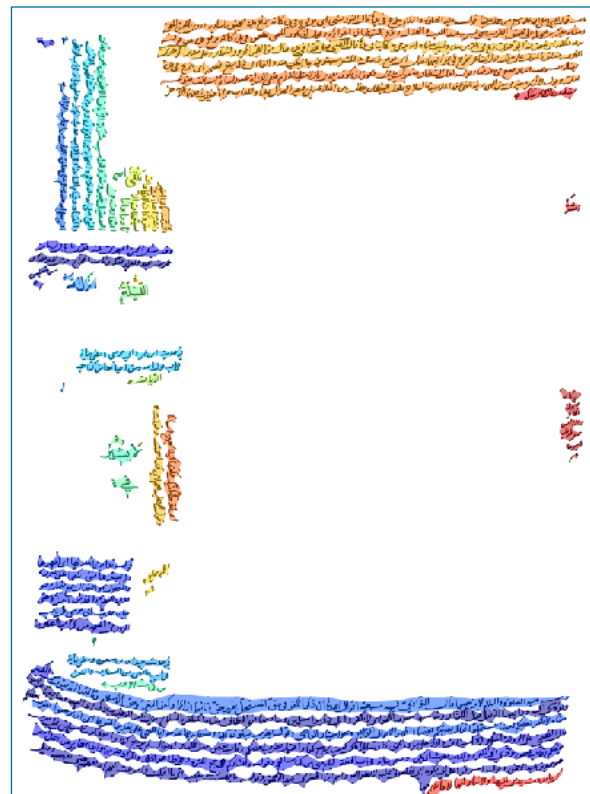


Wrong segmentations
without smoothness cost



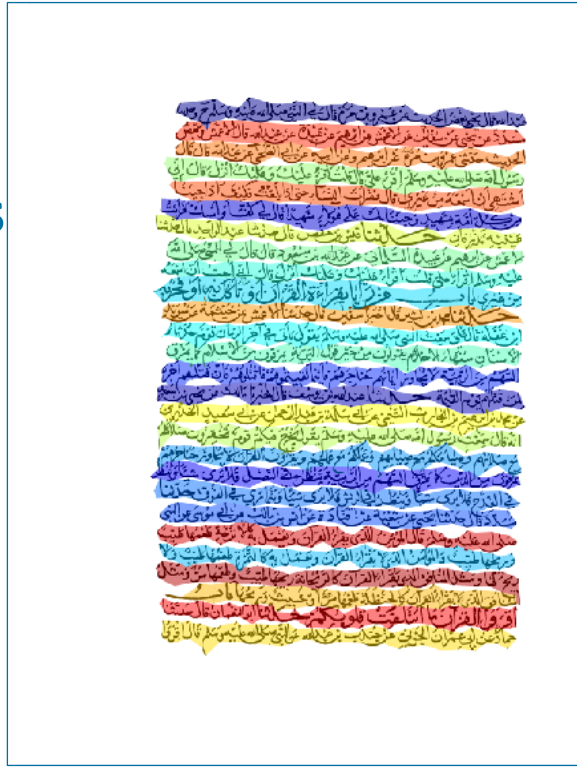
VML-MOC dataset text line extraction results

	LineIU	PixelIU
FCN+EM	35.12	60.97
Cohen et al	60.99	80.96



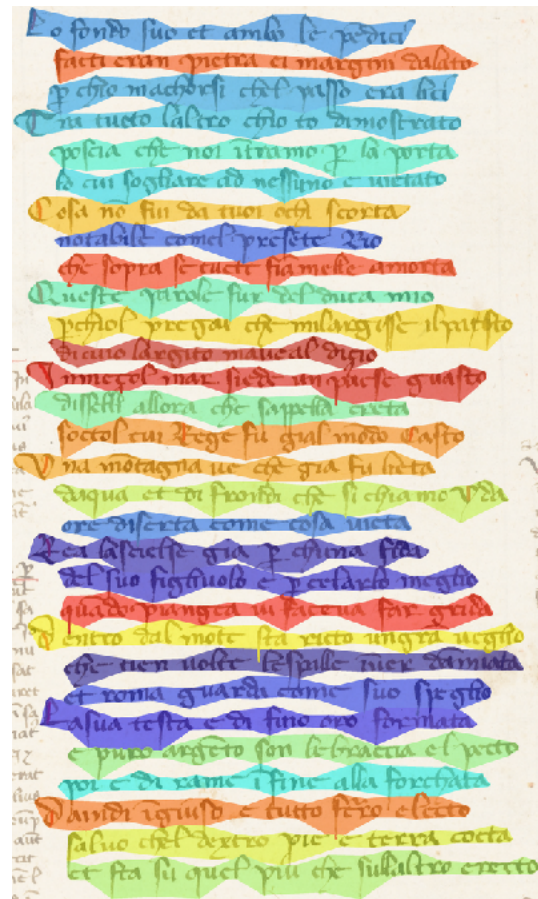
VML-AHTE dataset text line extraction results

	LineIU	PixelIU
FCN+EM	94.52	90.01
Mask-RCNN	93.08	86.97



DIVA dataset text line extraction results

	LineIU	PixelIU
FCN+EM	99.22	97.54
System9+4.1	97.86	97.05



Conclusion

- A Fully Convolutional Network (FCN) can detect text lines without assuming any text line orientation, font type and font size.
- Energy Minimization (EM) can extract text lines without assuming any text line orientation, font type and font size.
- We proposed to use FCN+EM combination for assumption free segmentation of text lines.
- The proposed method can segment multiply oriented and curved text lines with a performance far below a learning-free algorithm.
- The proposed method achieves superior performance in segmenting crowded and touching text lines.