

Human-centered Readability Enhancement of Degraded Historical Text Images



Recovering obscured text from hidden fragments or palimpsests requires specialized imaging modalities, such as multispectral imaging (MSI) and hyperspectral imaging (HSI), as well as post-processing techniques. However, current approaches often fail to produce text that is readily readable by non-experts, limiting the public accessibility of these cultural heritage artifacts. The main goal of this work is to incorporate human perception of readability into the text recovery process for degraded historical documents.

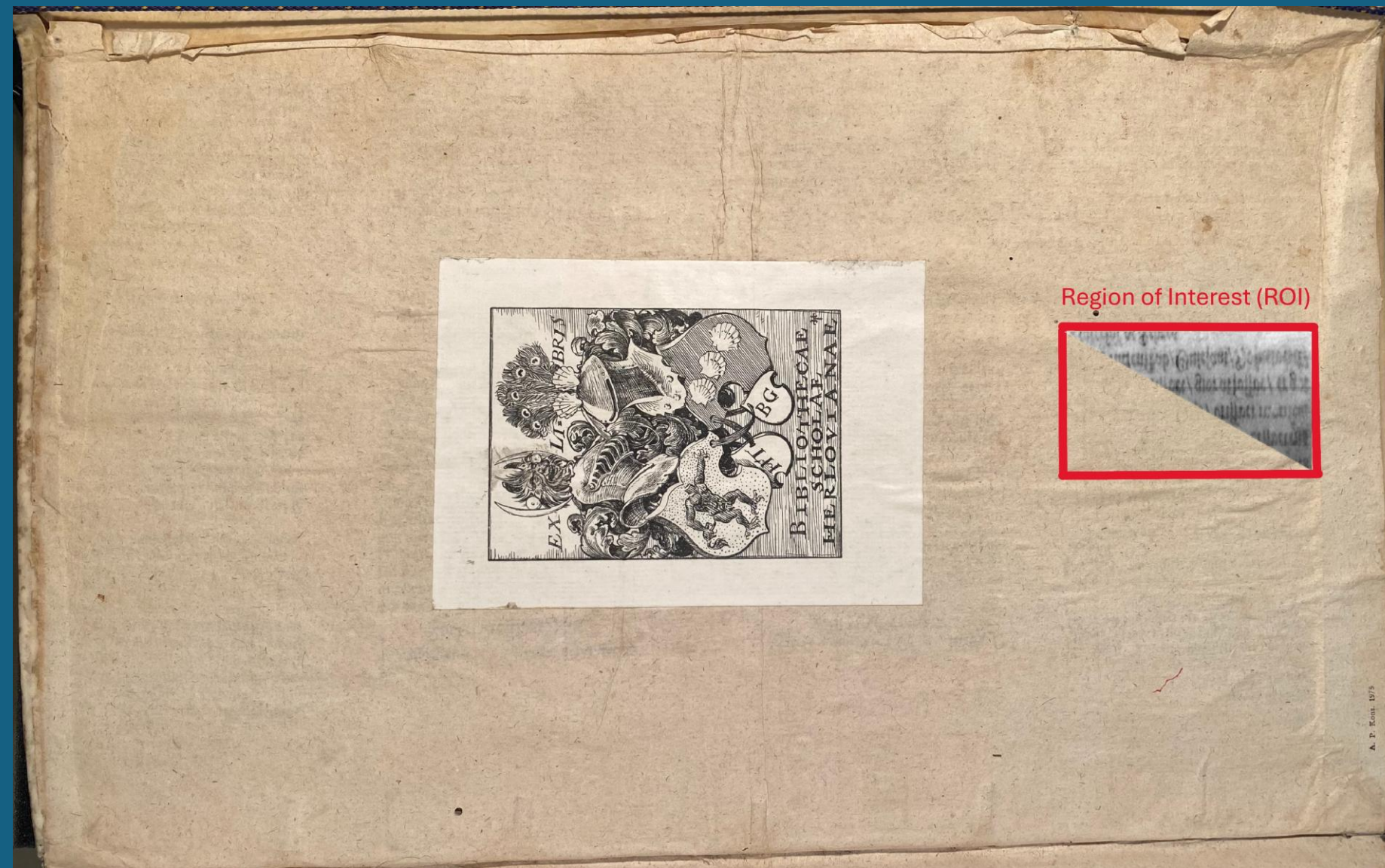


Fig. 1: Example of hidden fragments within book bindings. Herlufsholm 24.1, Special Collections at SDUB



Fig. 2: Example of hidden undertext on palimpsests. Codex XL (38), Biblioteca Capitolare of Verona.

Enhancing the readability by optimizing the principal components combination based on Shannon entropy, RMS contrast, and edge intensity is the first step forward. These image quality metrics have shown strong correlation with human legibility.

	SRC - all areas				
RMS contrast	0.42	0.42	0.39	0.35	0.35
entropy	0.36	0.38	0.36	0.34	0.35
edge intensity	0.33	0.36	0.37	0.38	0.41
Neumann & Matas [36]	0.37	0.44	0.49	0.51	0.49
EAST [54]	0.14	0.28	0.42	0.54	0.61
TextBoxes [29]	0.17	0.23	0.27	0.34	0.4
Grüning et al. [17] (lines)	0.36	0.41	0.45	0.48	0.48
Grüning et al. [17] (regions)	0.42	0.44	0.47	0.49	0.49
BRISQUE [35] (default)	0.095	0.15	0.16	0.19	0.21
BRISQUE [35] (trained)	0.31	0.43	0.44	0.41	0.37
Shahkolaei et al. [43] (default)	0.044	0.012	-0.02	-0.057	-0.12
Shahkolaei et al. [43] (trained)	0.23	0.42	0.6	0.63	0.54
CNN regression	0.68	0.69	0.7	0.71	0.71
	45	90	180	360	720
	window size				

Fig. 3: Spearman rank correlation coefficients between tested methods and ground truth (From Brenner et al. 2021)



Fig. 4: Optimal principal component combination for maximum b) entropy, c) contrast, and d) edge intensity compared to a) the most readable principal component



Separation of overlapping characters can help with reading the undertext and overtext on palimpsests. Here, we used a Capsule Network to label the overlapping Greek characters. We compared the performance of Capsule Network with the performance of human readers. The human performance establishes the baseline for this task.

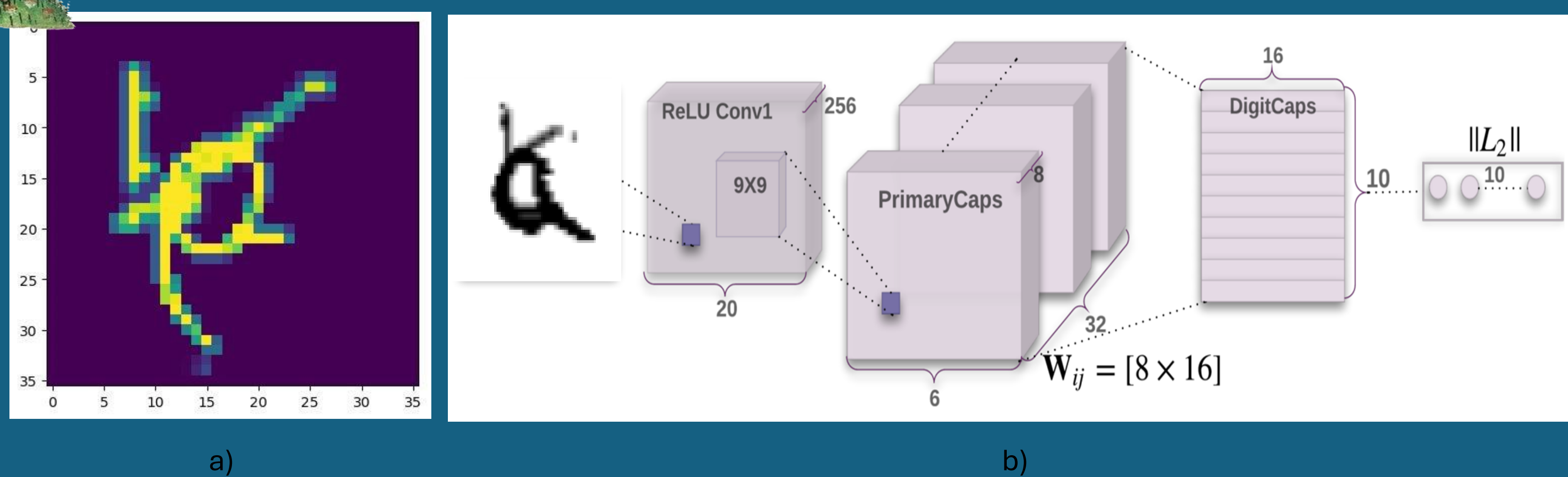


Fig. 5: a) Synthetic overlapped Greek characters and b) the Capsule Network used for labeling

Model	People (overall)	Experts	Fluent in Greek
80%	67%	66%	60%

Table 2: Performance of Caps. Net compared to the human participants (overall)

References:
Brenner, S, et al. Estimating human legibility in historic manuscript images-a baseline. International Conference on Document Analysis and Recognition 2021 Sep 2 (pp. 492-506).
Pourahmadi B, et al. Challenges in Revealing Readable Text from Fragments Hidden in Book Bindings: A Case Study from the Herlufsholm Collection. In International Conference on Document Analysis and Recognition 2025 Sep 16 (pp. 493-508).

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	ρ and π	ϵ and π
Model	Correct	Half correct
People	81.25%	33.33%

Table 1: Performance of Caps. Net, compared to the human participants in identifying the overlapping characters (selected samples)

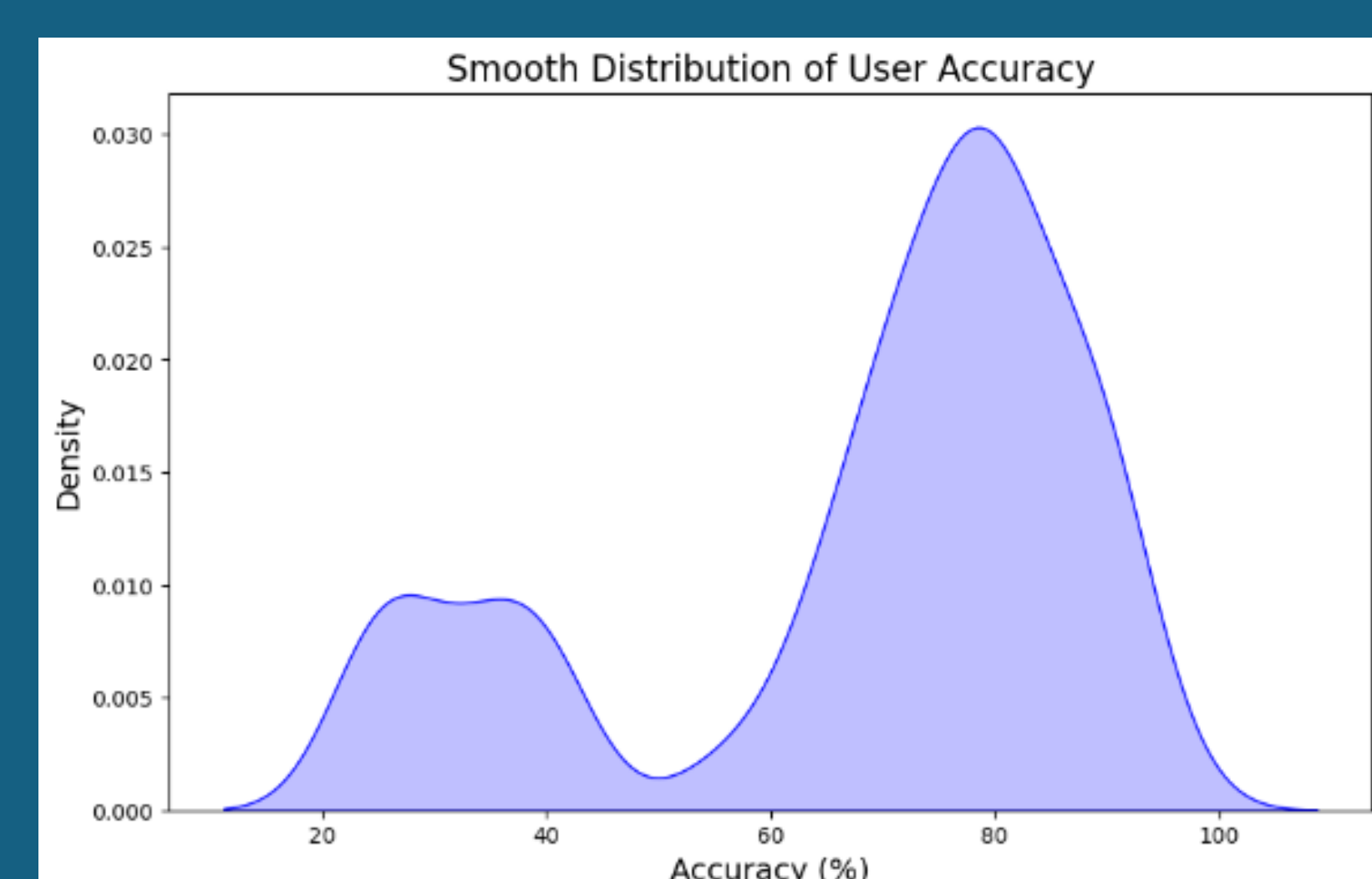


Fig. 6: Probability density distribution of different accuracy levels

