Ink-Bleed Reduction Using Functional Minimization

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Introduction

Ink-bleed problem

• Ink seeps through a paper document and interferes with the text written on the opposite side

Previous approaches

• Methods based on wavelet, MRF, blind signal separation, diffusion model etc, usually involving a set of parameters to be adjusted or estimated based on prior assumptions

• classification methods need user-supplied markup as training data, either requiring sufficient markup or resorting to directed assistance for iterative marking up, but independent of parameters

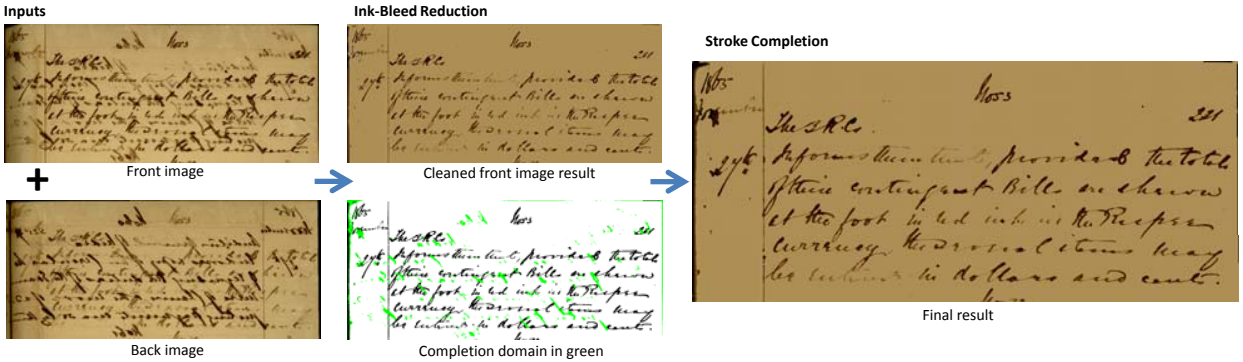
Our approach

• Ink-bleed removal by a modified Chan-Vese active contour model, taking into account the information from both recto and verso image

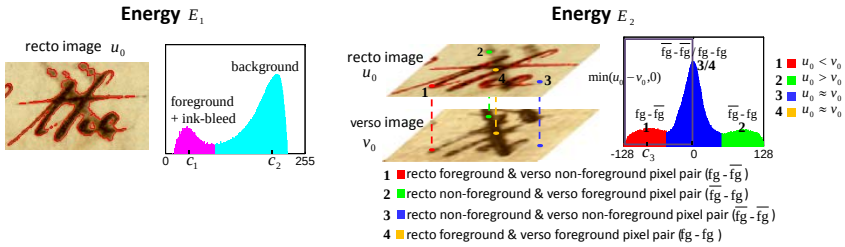
• Functional minimization for completing broken strokes that arise when strong ink-bleed overlaps the foreground strokes

• Interactive tool to improve the results over local regions, for documents with non-uniform characteristics

Workflow



Ink-Bleed Reduction Algorithm



Result of Individual and Combined Energies

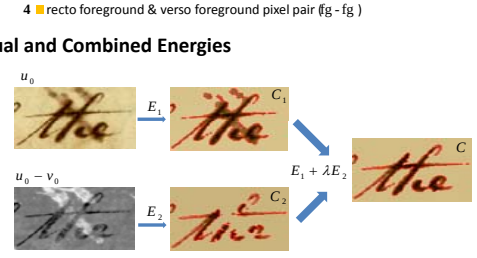
• Minimize E_1 to remove the background, but the ink-bleed cannot be discriminated from the foreground

• Minimize E_2 to extract the fg - $\overline{\text{fg}}$ pixel pairs, but the both-foreground pixel pairs are removed

• Minimize the combined energy functional

$E = length\ (C) + E_1 + \lambda E_2$

to generate the desired result, where λ is a user defined parameter for controlling the balance between energy E_1 and E_2



Stroke Completion

• When ink-bleed is severe, the parameter λ needs to be increased considerably, resulting in the broken strokes

• Perform statistical significance testing to determine the domain in need of completion

• Use modified Cahn-Hilliard functional to inpaint the broken stroke in the completion domain

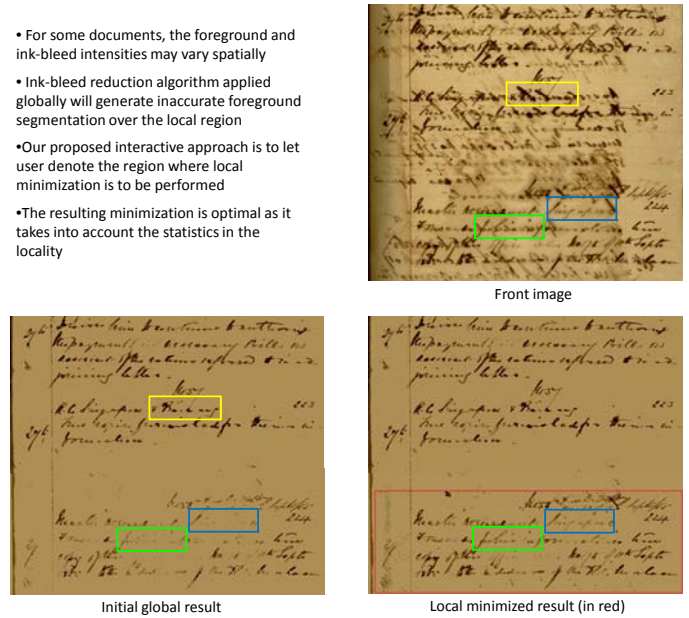
Extension for Interactive Approach

• For some documents, the foreground and ink-bleed intensities may vary spatially

• Ink-bleed reduction algorithm applied globally will generate inaccurate foreground segmentation over the local region

•Our proposed interactive approach is to let user denote the region where local minimization is to be performed

•The resulting minimization is optimal as it takes into account the statistics in the locality



Experimental Results