

Interactive Smoothing of Handwritten Text Images Using a Bilateral Filter

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The Problem

- An increasing number of people are using text images
- Volunteers read text images to index important information
- Many of the images are unreadable due to quality and age of the documents
- Artifacts in the images include background noise and undistinguishable ink strokes

The Problem

Page 6

BURIALS in the Parish of Hope under Dinwiddie in the
County of Hereford in the year One thousand
eight hundred and Eighty.

| No. | Name. | Abode. | When buried. | Age. | By whom the Ceremony was performed. |
|--------|---------------------|--------------------------------|------------------------|------|-------------------------------------|
| No. 40 | Charlotte Dale | Lenninstor. | Feb 12 th | 37 | W. Loyall. |
| No. 41 | William Stafford | Hope (The Home) | April 12 th | 94 | W. Loyall. |
| No. 42 | Edward Gough. | Woodmanton | April 10 th | 76 | W. Loyall. |
| No. 43 | Thomas Smith. | Hill Hole | April 20 th | 100 | W. Andrews |
| No. 44 | Thomas Grafton | Newton. | May 1 st | 67 | W. Andrews. |
| No. 45 | James Goodwin Quinn | The Hill Kempston Park | June 15 th | 64 | W. Andrews |
| No. 46 | John Millichap | The Pigeon House Upper Hill | June 19 th | 10 | W. Andrews |
| No. 47 | Elizabeth Braham | The Valletts Upper Hill | June 29 th | 60 | W. Loyall. |

*from March 4. 1788
buried
old date
to new of
convent*

The Solution

- We improve image visibility by,
- Using a bilateral filter to even out the noise in the background
- Accentuating weak stroke pixels to make them more visible (Laplacian)
- We can apply interactively the algorithm in desired regions
- We adjust the parameters of the algorithm to improve results

The Solution

Page 6

BURIALS in the Parish of *Hope under Dismore* in the County of *Hereford* in the year One thousand eight hundred and *Eighty*.

| Name. | Abode. | When buried. | Age. | By whom the Ceremony was performed. |
|---|--|----------------------------------|------|-------------------------------------|
| <i>W. 40. Charlotte</i> → <i>Leminster.</i> | | <i>Feb 12th 37</i> | | <i>W. Loyatt.</i> |
| <i>No. 41. William Stafford</i> | <i>Hope (The Home)</i> | <i>April 12th 94</i> | | <i>W. Loyatt.</i> |
| <i>No. 42. Edward Gough.</i> | <i>Woodmanton</i> | <i>April 16th 76</i> | | <i>W. Loyatt</i> |
| <i>from March 4. 1788 Lambton Old Oak Trinity convent</i> <i>No. 43. Thomas</i> → <i>Hill Hole</i> | | <i>April 20th 100</i> | | <i>W. Andrews</i> |
| <i>No. 44. Thomas Grafton</i> | <i>Newton.</i> | <i>May 1st 67</i> | | <i>W. Andrews.</i> |
| <i>No. 45. James Gordon</i> | <i>The Mills Lampton Park</i> | <i>June 15th 64</i> | | <i>W. Andrews</i> |
| <i>No. 46. John Mellichamp</i> | <i>The Poplar House Upper Hill</i> | <i>June 19th 10</i> | | <i>W. Andrews</i> |
| <i>No. 47. Elizabeth Badham</i> | <i>The Villetts Upper Hill</i> | <i>June 29th 60</i> | | <i>W. Loyatt</i> |

Before

Page 6

BURIALS in the Parish of *Hope under Dismore* in the County of *Hereford* in the year One thousand eight hundred and *Eighty*.

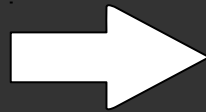
| Name. | Abode. | When buried. | Age. | By whom the Ceremony was performed. |
|---|--|----------------------------------|------|-------------------------------------|
| <i>W. 40. Charlotte Dale</i> | <i>Leminster.</i> | <i>Feb 12th 37</i> | | <i>W. Loyatt.</i> |
| <i>No. 41. William Stafford</i> | <i>Hope (The Home)</i> | <i>April 12th 94</i> | | <i>W. Loyatt.</i> |
| <i>No. 42. Edward Gough.</i> | <i>Woodmanton</i> | <i>April 16th 76</i> | | <i>W. Loyatt</i> |
| <i>from March 4. 1788 Lambton Old Oak Trinity convent</i> <i>No. 43. Thomas Smith.</i> | <i>Hill Hole</i> | <i>April 20th 100</i> | | <i>W. Andrews</i> |
| <i>No. 44. Thomas Grafton</i> | <i>Newton.</i> | <i>May 1st 67</i> | | <i>W. Andrews.</i> |
| <i>No. 45. James Gordon</i> | <i>The Mills Lampton Park</i> | <i>June 15th 64</i> | | <i>W. Andrews</i> |
| <i>No. 46. John Mellichamp</i> | <i>The Poplar House Upper Hill</i> | <i>June 19th 10</i> | | <i>W. Andrews</i> |
| <i>No. 47. Elizabeth Badham</i> | <i>The Villetts Upper Hill</i> | <i>June 29th 60</i> | | <i>W. Loyatt</i> |

After

Background

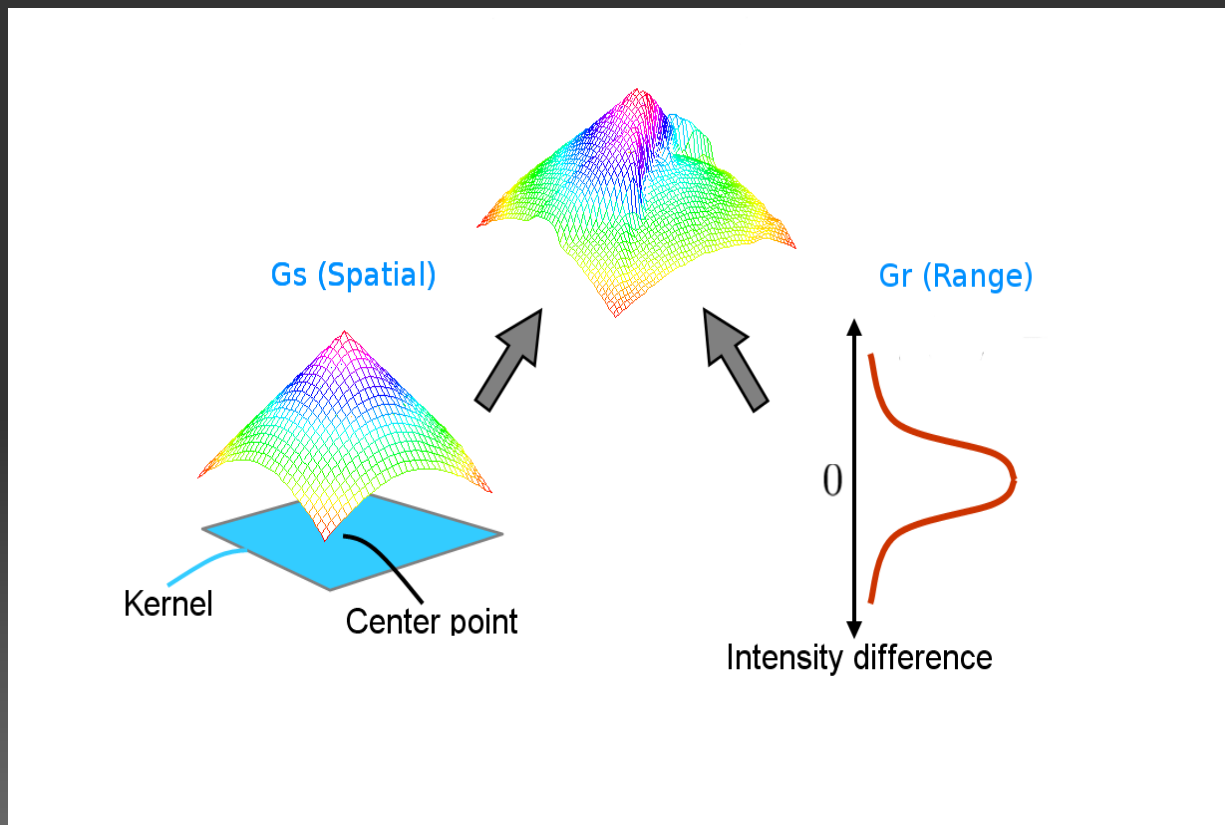
Bilateral Filter (Tomasi et al.1998)

- Smooths regions while preserving edges



Background - Bilateral Filter

- It uses 2 weighting functions
- G_s = spatial normal distribution
- G_r = range (color) normal distribution



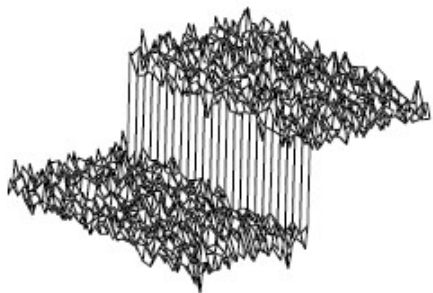
Background - Bilateral Filter

We combine the two weighing functions and we have:

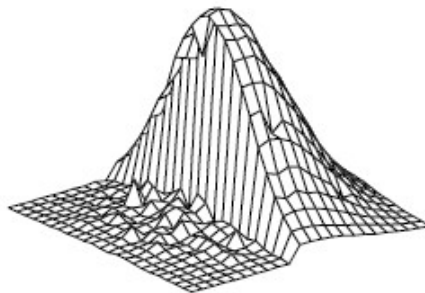
$$I_p' = \sum G_s(|p - q|) G_r(|I_p - I_q|) I_q / W_p$$

where

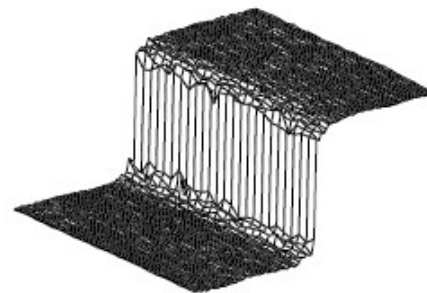
$$W_p = \sum G_s(|p - q|) G_r(|I_p - I_q|)$$



(a)



(b)



(c)

Background

Laplacian Filter

- Calculates the 2nd derivative of the image (edge detection)

| | | | | | | |
|----|----|----|--|----|----|----|
| 0 | -1 | 0 | | -1 | -1 | -1 |
| -1 | 4 | -1 | | -1 | 8 | -1 |
| 0 | -1 | 0 | | -1 | -1 | -1 |

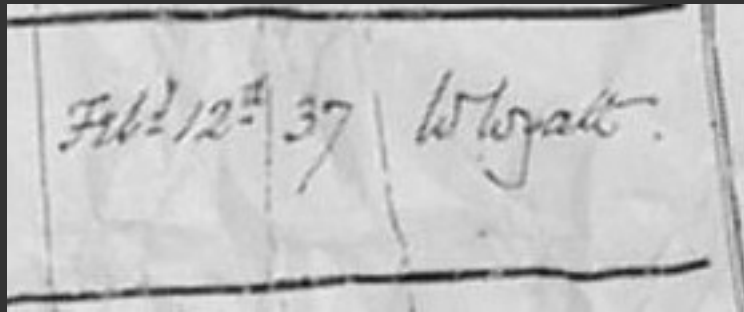
- We combine it with the bilateral filter to augment soft strokes



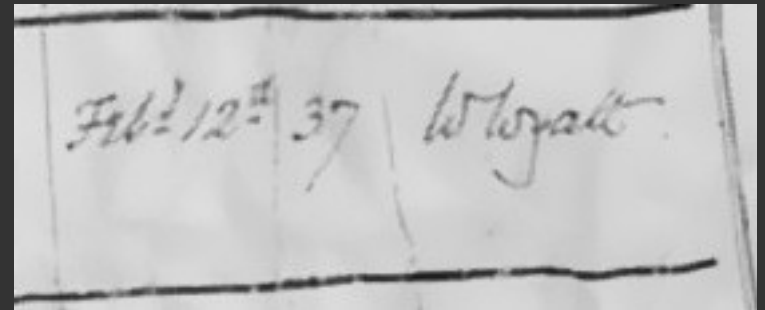
Our Algorithm

- We identify if the mouse is over an edge (ink stroke)
 - The Laplacian filter gives us zero crossings
- We apply the bilateral filter on `mouse_down` and `mouse_move` events
- If we are over an edge, we darken the stroke
- Otherwise, we make the background lighter

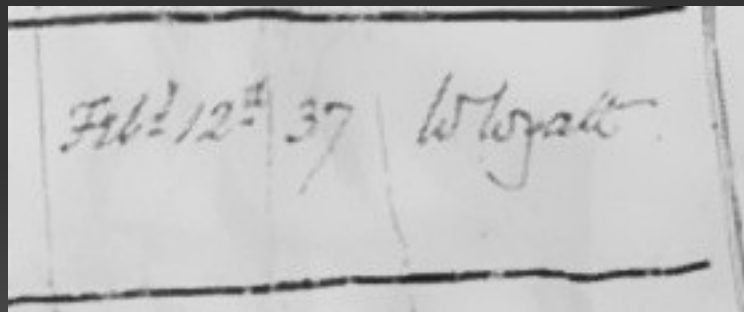
Results



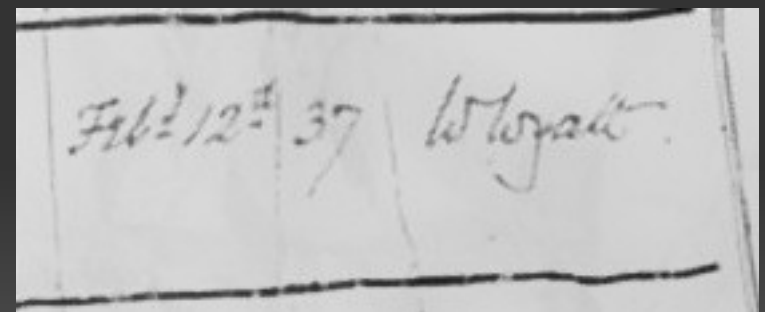
Original Image



Result ($G_r = 3$, $G_s = 5$)

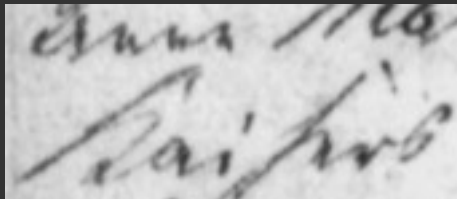


Result ($G_r = 3$, $G_s = 10$)

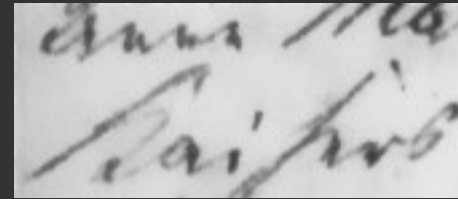


Result ($G_r = 3$, $G_s = 15$)

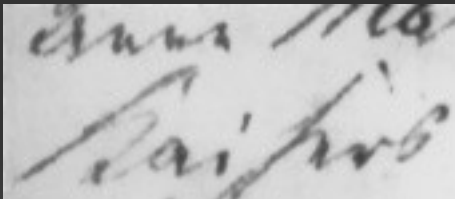
Results



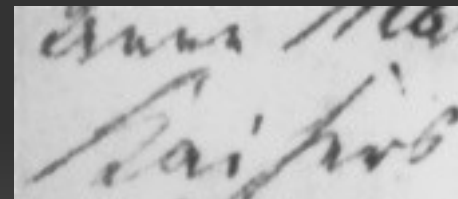
Original Image



Result ($G_r = 3$, $G_s = 5$)

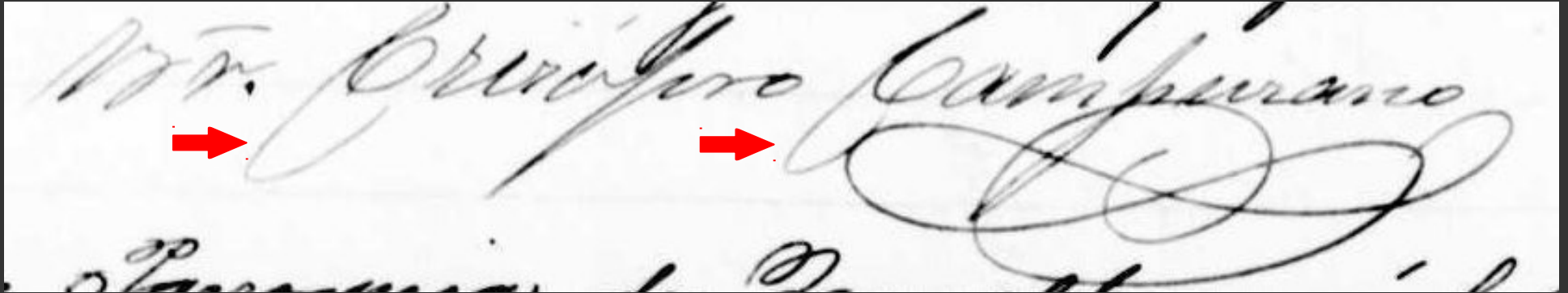


Result ($G_r = 3$, $G_s = 10$)

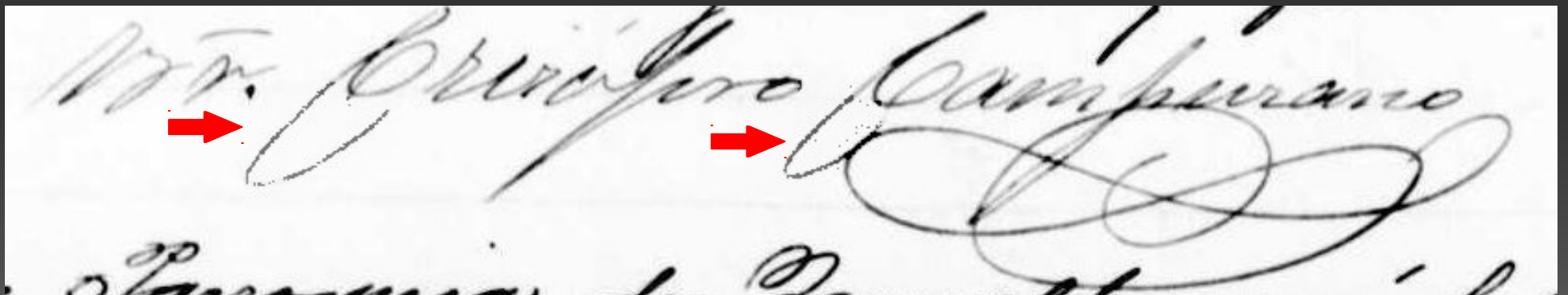


Result ($G_r = 3$, $G_s = 15$)

Results



Original Image



Result - Accentuated Strokes

Conclusion

- We applied the Bilateral filter and Laplacian to solve the problem of low quality text images
- Results are promising and indicate that;
- Bilateral filter is robust and smooths text images without losing important pixels
- Edge enhancement can make faint text more readable

Further Work

- Improve identifying the edges better, using a better edge detector.
- Automatically select the parameters to work with the bilateral and laplacian filters.
- Use the bilateral filter for text segmentation of old document images.

Questions?