

Evaluation of Method Parameters Affecting Magnetic Flux Measurement of Toners as a Screening Tool for Casework Application

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I N C O R P O R A T E D

FSF Emerging Forensic Scientist Award
Paper Presentation

Overview

- Background
- Research Questions
- Experimental Conditions
- Analytical Methods
- Results and Discussion
- Conclusions

Background

Why Magnetic Flux?

- What is 'Magnetic Flux'?
- Relevance?
- Initial Investigation in 2017 – Assessed
 - Stability of flux fields over time
 - Relationship between toner area and flux
 - Variation in a population

Previous Work

- Initial Investigation - Concluded
 - Magnetic flux is stable over time
 - Relationship between flux and toner area allows for normalization of data
 - Variation present in toner populations allows for discrimination on the basis of flux measurement

Research Questions



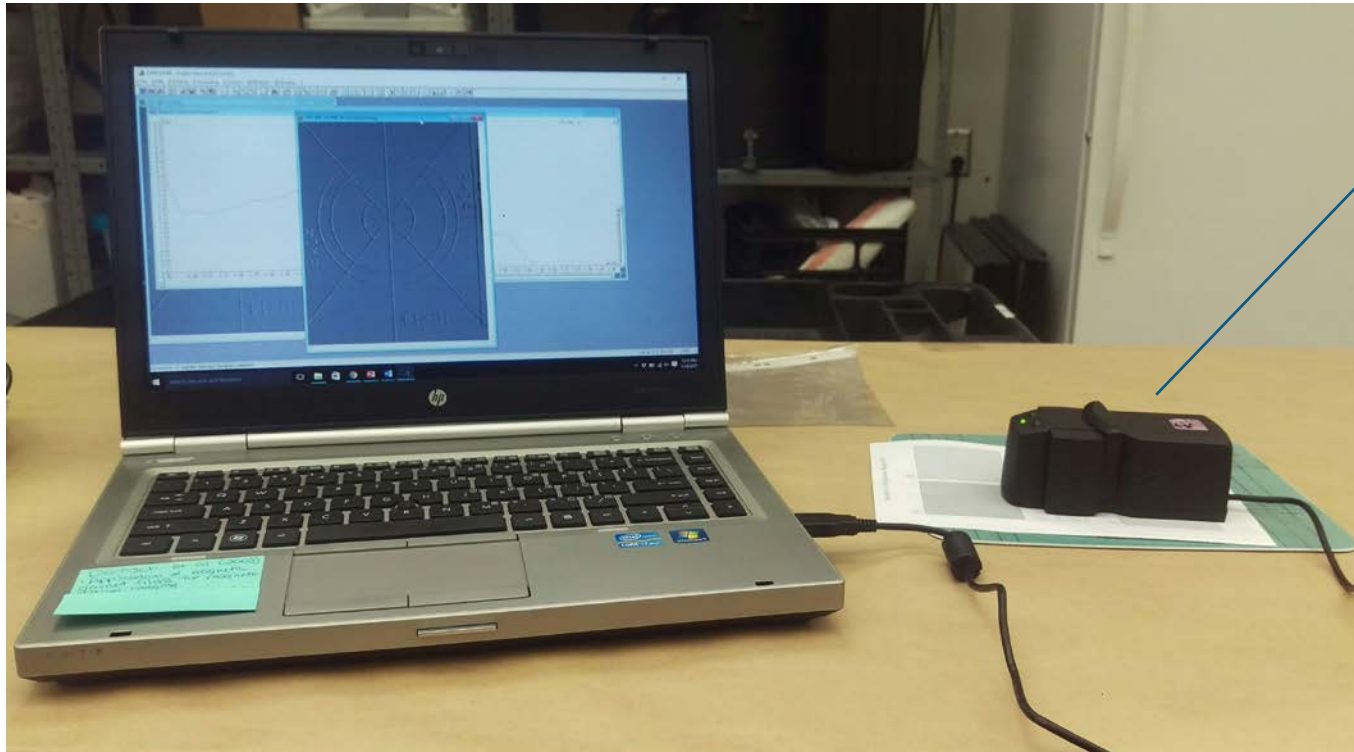
Research Focus

- Evaluation of method reliability
 - Does the area of the sensor occupied affect the precision of magnetic flux measurements?
 - If so, what area of the sensor is optimal to ensure reproducibility?
 - Does the variation of the grey values during area determination have an effect on the precision of area measurements?
 - If so, how can this be controlled to ensure reproducibility of measurements?

Experimental Conditions

Instrumentation

- Regula© Magmouse 4197
 - Used for all magnetic flux measurements
 - Positive and negative QC samples were used to monitor for proper instrument function



Samples

- 7 samples
- 3 different sites per sample
 - Sites were selected to provide a range of different areas
- 3 replicate trials
- Conducted in the span of 1 week
 - From July to August 2016
- 63 total measurements

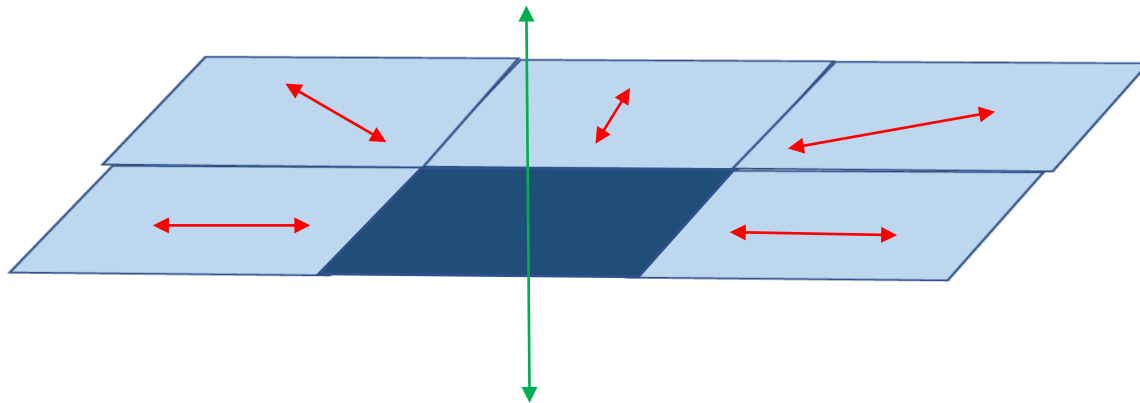
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Key Concept

- Magneto-optical imaging sensor function



Analytical Methods

Test Area Determination

- Performed using Adobe® Photoshop® CC 2015

The scanned original image was overlaid with the image from the Regula® Magmouse 4197



The two images were normalized and aligned



The scanned image was cropped to the dimensions of the instrument image

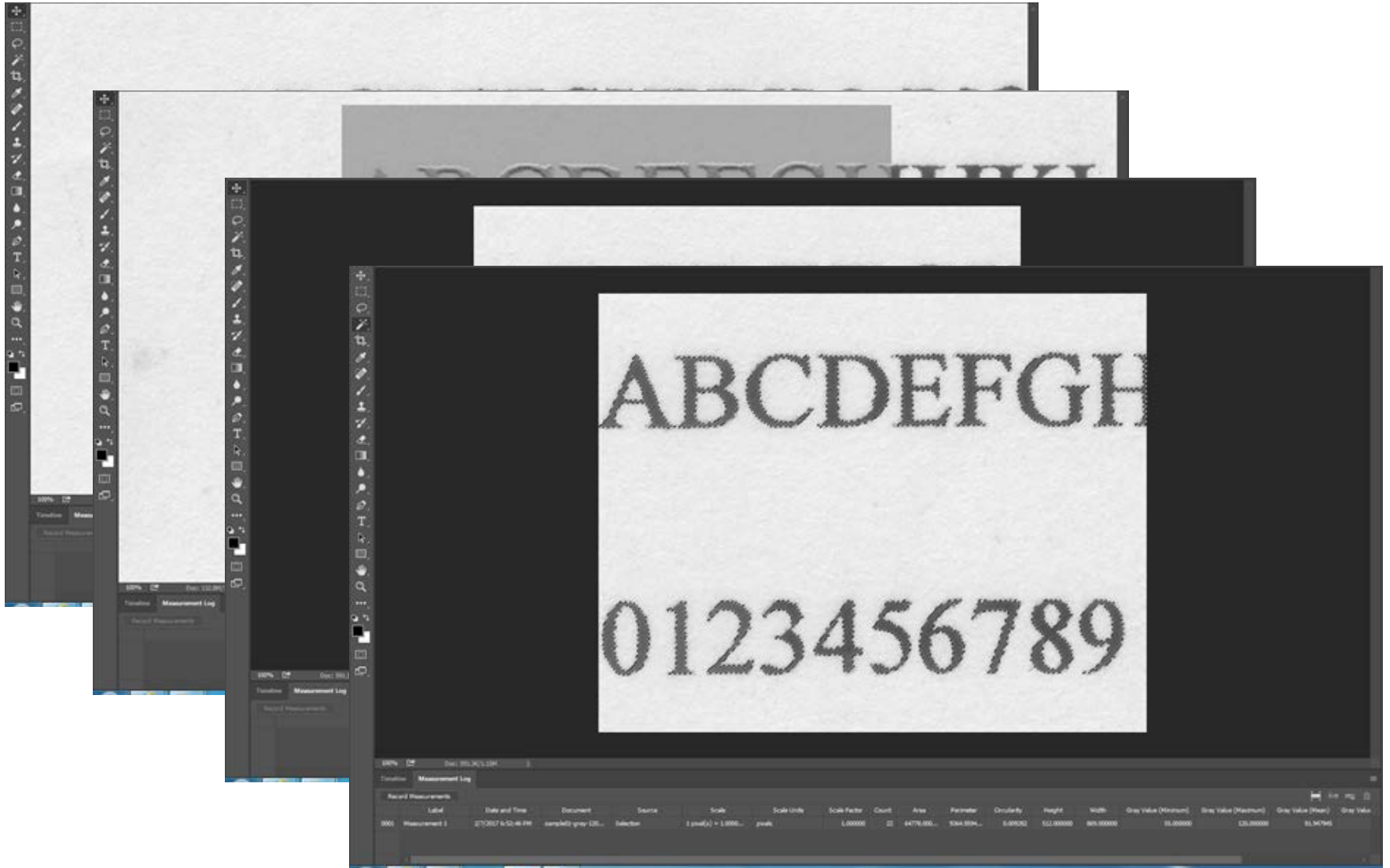


Pixel values representative of the toner were selected and measured



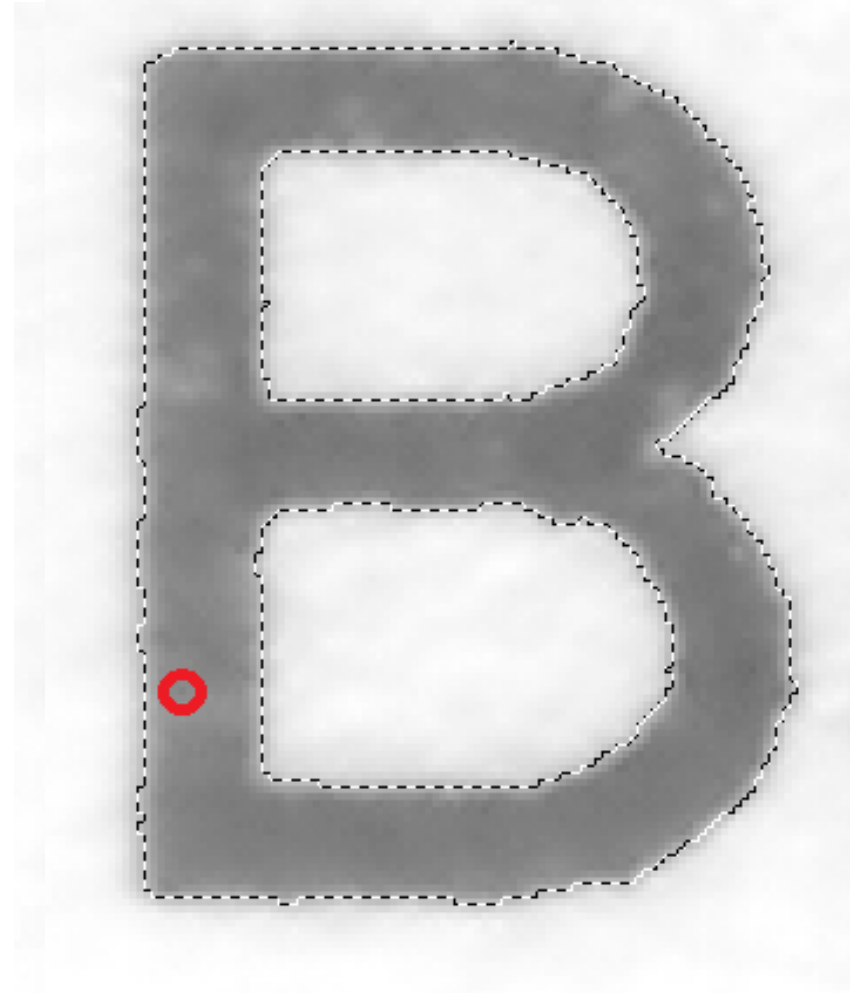
A formula was applied to convert the area in pixels to the area in mm²

Walkthrough



Key Concept

- Pixel selection using the magic wand tool



Results and Discussion

Sample Area Optimization

- Sample area can vary without impacting precision of results
- Precision is increased when sample area does not intersect with the margins of the sensor

Sample B			
Area Size	Intersect	Mean Flux/mm ²	SD
Small	N	0.73	0.03
Medium	Y	0.59	0.05
Large	Y	0.66	0.05
Welch p-value			0.096

Sample D			
Area Size	Intersect	Mean Flux/mm ²	SD
Small	Y	0.29	0.02
Medium	N	0.26	0.03
Large	N	0.30	0.01
Welch p-value			0.116

Sample C			
Area Size	Intersect	Mean Flux/mm ²	SD
Small	N	0.38	0.02
Medium	Y	0.39	0.03
Large	Y	0.42	0.03
Welch p-value			0.156

Sample Area Optimization

- If text must intersect sensor for placement, large test areas are preferred
- Impact of peripheral pixel distortion on overall flux calculation is minimized

Sample A			
Area Size	Intersect	Mean Flux/mm ²	SD
Small	N	0.61	0.05
Medium	Y	0.55	0.04
Large	Y	0.52	0.03
Welch p-value			0.080

Sample F			
Area Size	Intersect	Mean Flux/mm ²	SD
Small	Y	0.25	0.01
Medium	Y	0.25	0.02
Large	Y	0.29	0.002
Welch p-value			0.052

Sample G			
Area Size	Intersect	Mean Flux/mm ²	SD
Small	Y	0.70	0.05
Medium	Y	0.77	0.02
Large	Y	0.79	0.01
Welch p-value			0.065

Pixel Selection Optimization

- In 2017 investigation, pixel selection was not a controlled factor
 - Was identified at that time as a potential source of uncertainty
- Pixel selection process was optimized by:
 - Repeating the area determination for a sample under different conditions
 - mean grey value +/- 1
 - mean grey value +/- 0.5
 - mean grey value +/- 0.25

Conclusions

Conclusions

- Text area can vary as long as intersections with the sensor periphery are minimized
- If contact with the sensor periphery cannot be avoided, analysis of large text areas minimizes the effect of distortion on the calculation of the flux
- Changes in the mean grey value can affect the precision of results
- This type of error can be prevented through standard methodology which limits the SD of the mean grey value to 0.5

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Questions

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