Metrics-Based Analysis of Latent Fingerprint Image Pre-processing

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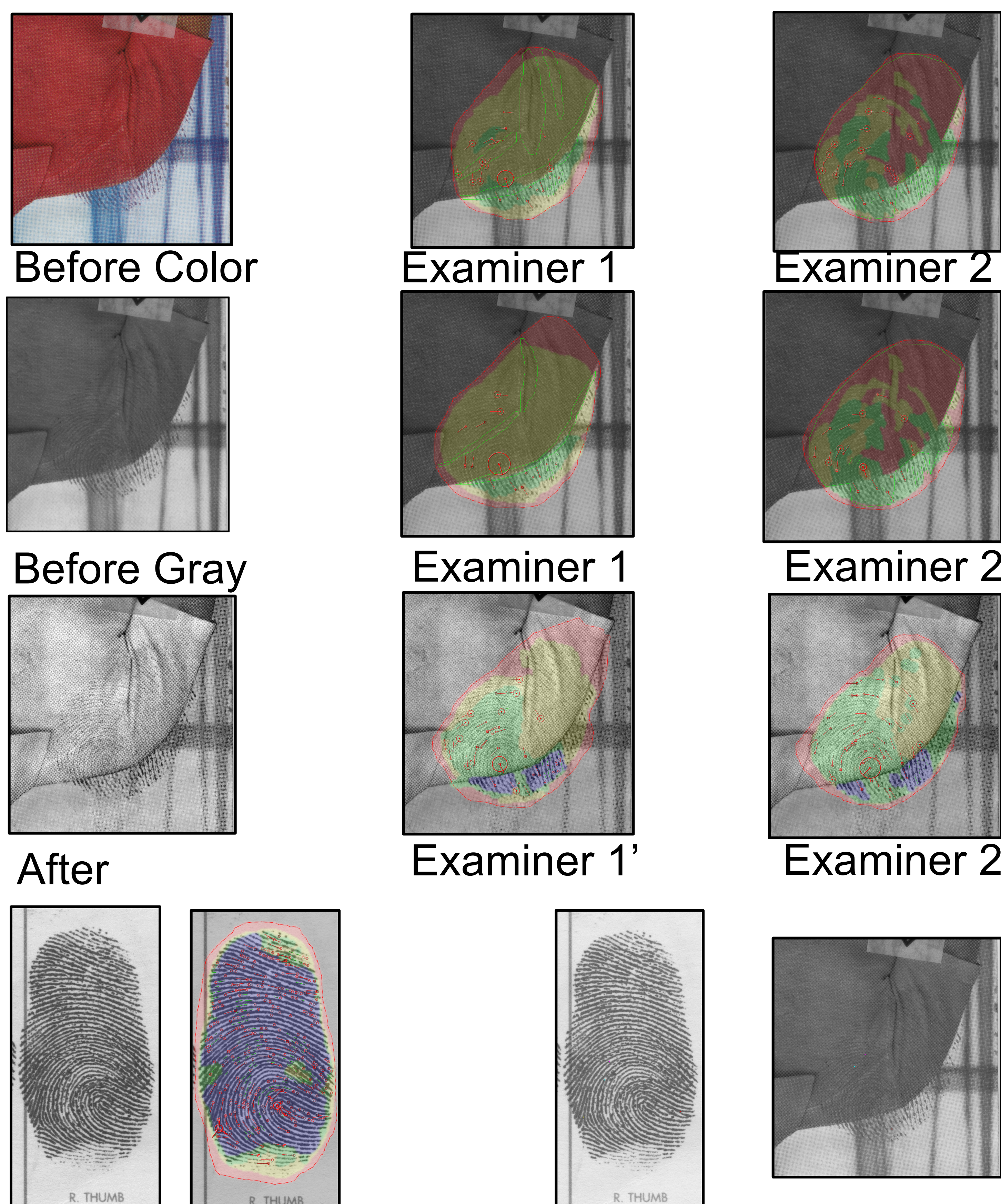
1. What is Preprocessing

Latent fingerprint examiner edits image for readability
- Photoshop or customized software
- Principle: preprocessing should not add or remove minutiae.
- Few guidelines/standards

2. Objective

Analyze the effect that preprocessing has on latent image quality using objective fingerprint quality metrics

3. Database

Before Color | Examiner 1 | Examiner 2

Before Gray | Examiner 1 | Examiner 2

After | Examiner 1' | Examiner 2'

Card image and its markup | Benchmark Latent and Card

4. Good, Bad, Ugly Rating

GBU is a subjective rating given by latent examiners.

Ugly | Bad | Good

Quality Maps
- Created by examiners in ULW software
- Markup file contains matrix of sampling points (SP's)
- SP is an integer in [0,5]
- SP corresponds to 8 by 8 pixels in original image

Color:	Code:	Confidence in:
(black)	0	None
(red)	1	Level 1 detail
(yellow)	2	Level 1-2 detail
(green)	3	Level 2 detail
(dark blue)	4	Level 2-3 detail
(light blue)	5	Level 3 detail

5. Evaluation Metrics

Minutiae Count
- Number of minutiae

**Quality Map Threshold Minutiae Count**
- Number of minutiae in an area of quality 3 or greater

Overall Clarity metrics proposed by Noblis
- Total area, Contiguous area (OpenClose), Largest contiguous area

Overall Clarity from	to	Value	Description	Calculation
0		No value	Reserved for completely blank image	If $GrayscaleRange = 0$ then $OC = 0$ else
1			Unusable: No ridge information	If $TotalArea(1) = 0$ then $OC = 1$ else
2	9		Unusable: No usable ridge flow	If $OvConsist(2) = 0$ then $OC = \min\left[\left(\frac{TotalArea(1)}{0.7}\right)*7 + 2, 9\right]$ else
10	19	Exclusion only	Only ridge flow can be used	If $OvConsist(3,4) \leq 0.01$ then $OC = \min\left[\left(\frac{OvConsist(2)}{0.7}\right)*9 + 10, 19\right]$ else
20	99	Of value for comparison	Continuous value ranging from very difficult to ideal	If $OvConsist(3,4) \leq 0.1$ then $OC = \left(\frac{OvConsist(3,4)-0.01}{0.09}\right)*20 + 20$ else
				If $OvConsist(3,4) \leq 0.2$ then $OC = \left(\frac{OvConsist(3,4)-0.1}{0.1}\right)*20 + 40$ else
				If $OvConsist(3,4) \leq 0.4$ then $OC = \left(\frac{OvConsist(3,4)-0.2}{0.2}\right)*20 + 60$ else
				If $OvConsist(3,4) \leq 0.1$ then $OC = \left(\frac{OvConsist(3,4)-0.4}{0.3}\right)*10 + 80$ else
				If $OvConsist(4) \leq 0.1$ then $OC = \left(\frac{OvConsist(3,4)-0.7}{0.8}\right)*5 + 90,95$ else
				If $OvConsist(4) > 0.1$ then $OC = \min\left[\left(\frac{OvConsist(3,4)-0.7}{0.8}\right)*9 + 90,99\right]$

6. Experiment Results

Overall Clarity Relative Change
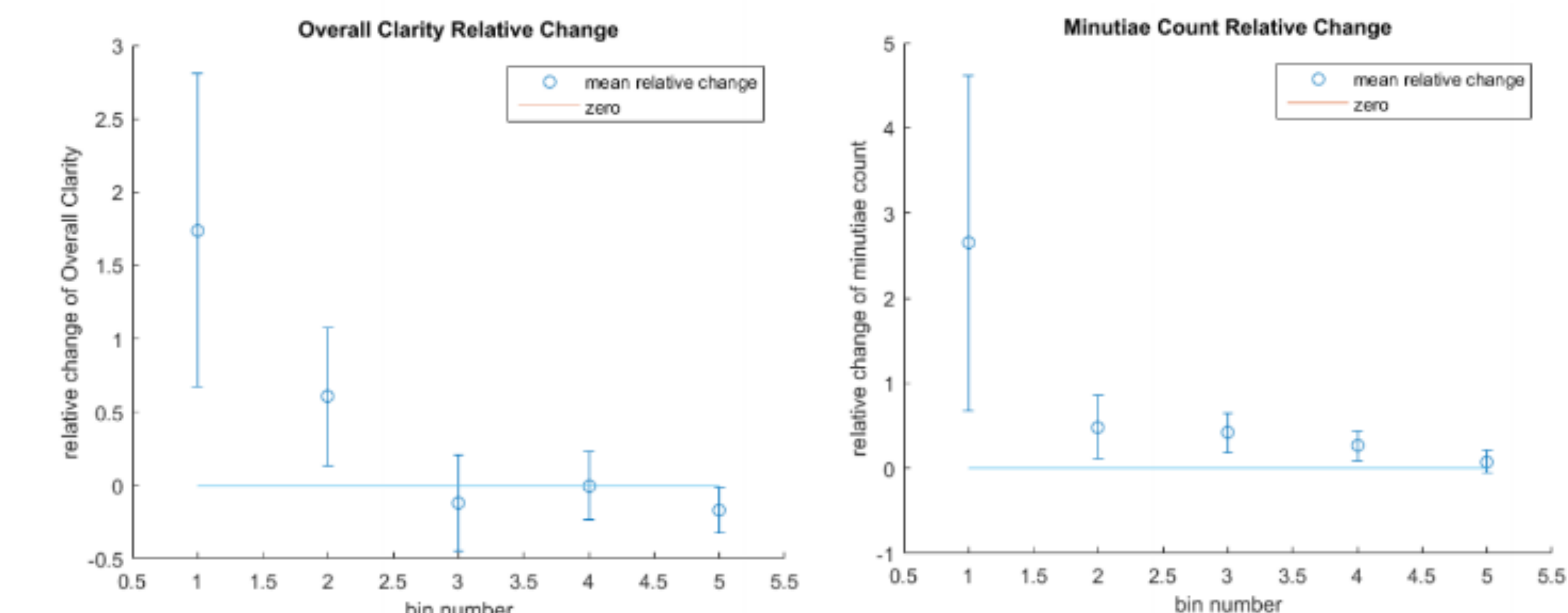
	Before		After		
GBU	$\bar{x}$	n	$\bar{x}$	n	t-test p-value
All	45.26	77	47.04	77	0.693
Good	73.75	23	60.85	44	0.0167
Bad	41.72	27	30.86	23	0.0652
Ugly	24.53	27	23.5	10	0.886

Minutiae Count Relative Change

	Before		After		
GBU	$\bar{x}$	n	$\bar{x}$	n	t-test p-value
All	30.57	77	42.49	77	.000348
Good	48.09	23	55.77	44	.0410
Bad	31.0	27	25.26	23	.105
Ugly	15.22	27	23.7	10	.223

Quality Map Threshold Minutiae Count Relative Change
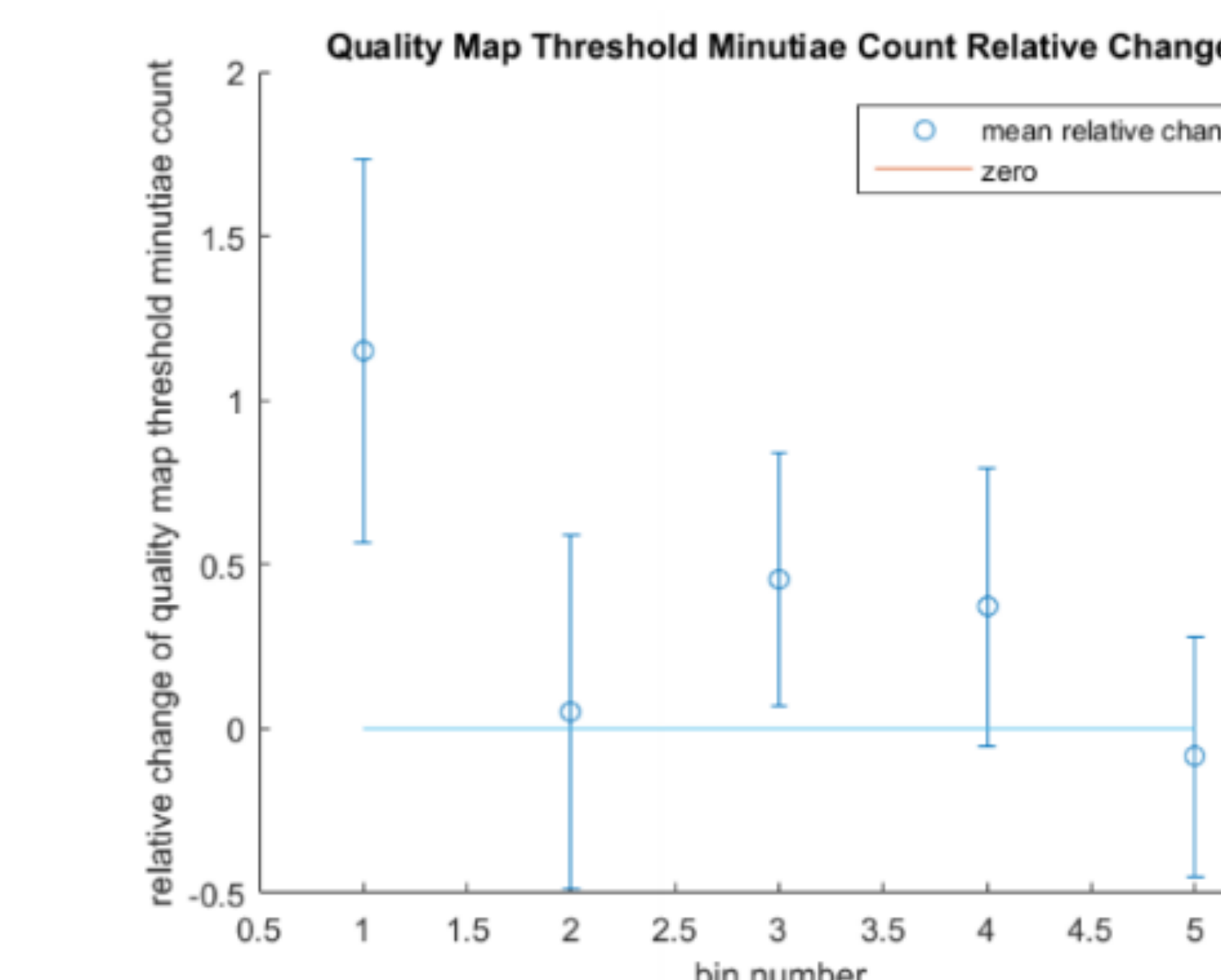
	Before		After		
GBU	$\bar{x}$	n	$\bar{x}$	n	t-test p-value
All	19.49	77	26.96	77	.0175
Good	36.09	23	39.48	44	0.390
Bad	17.37	27	10.09	23	0.0177
Ugly	7.48	27	10.7	10	0.585

Though preprocessed images typically have higher quality, there is a possibility that certain scenarios exist where the before image should be weighted more.

7. Future/Ongoing Work

- Before and after direct comparison, based on quality map and minutiae respectively.
- Before and after minutiae comparison by card markup GT: rotation alignment, minutiae correspondence, etc.
- Experiments with various quality metrics.

8. Disclaimer