Analysis of eye tracking during visual inspection of building facades

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0.0198

Question

How can we use eye tracking information to improve visual inspection and augment UAV-based inspection for damage?

Procedure

Participants were asked to inspect two , three –story, steel-framed buildings with masonry infill and veneer in central Pennsylvania using Tobii Glasses 3 wearable eye tracking system.[2]
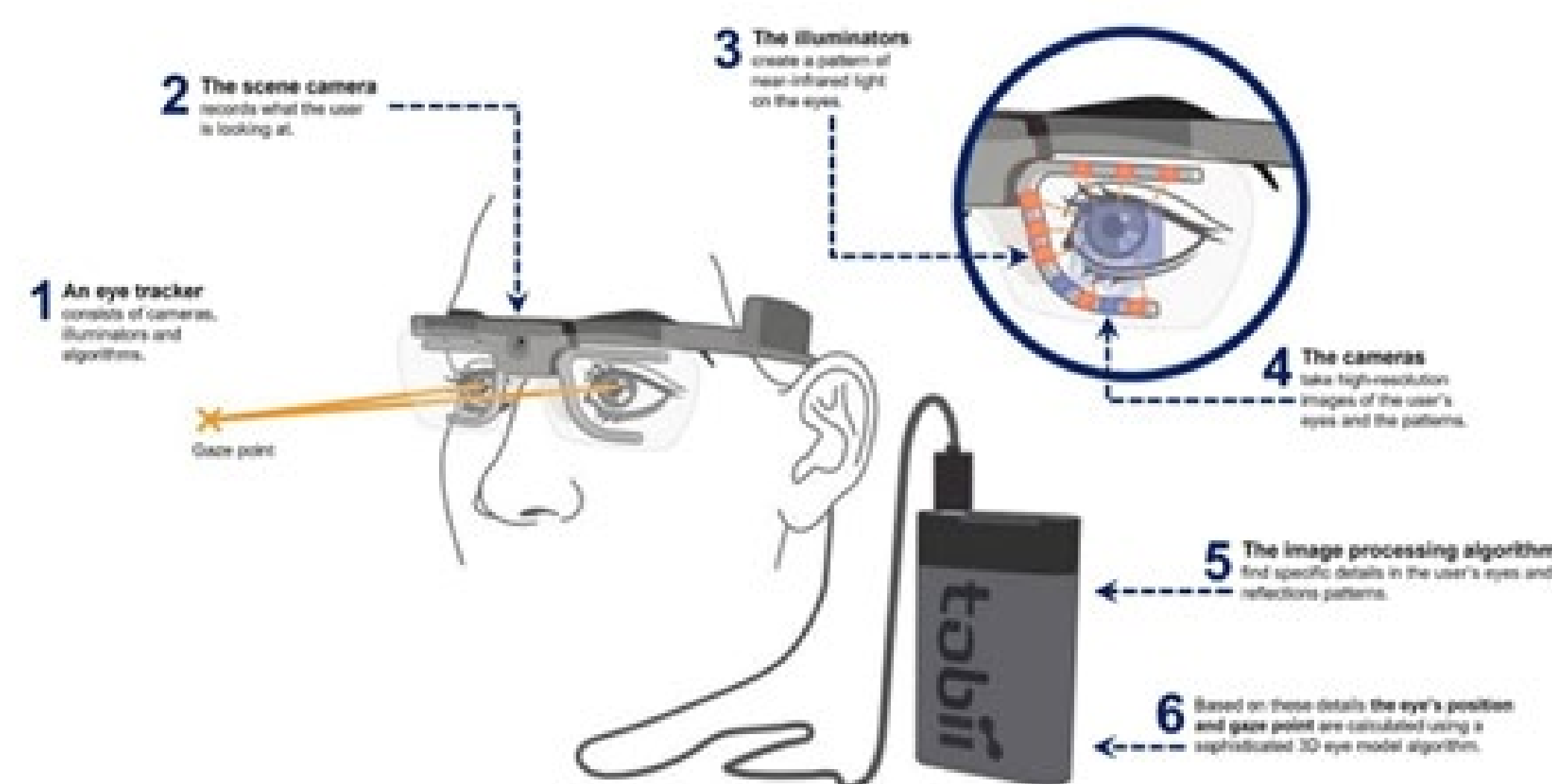

Fig. 1. Working principle of Tobii Pro Glasses 3 wearable eye tracking system

Buildings have minor cracks, surface stains, biological growth, weathered stone, etc.[2]

Participant gaze patterns were recorded for the metrics of number and duration of fixations as well as number and during of visits.[2]
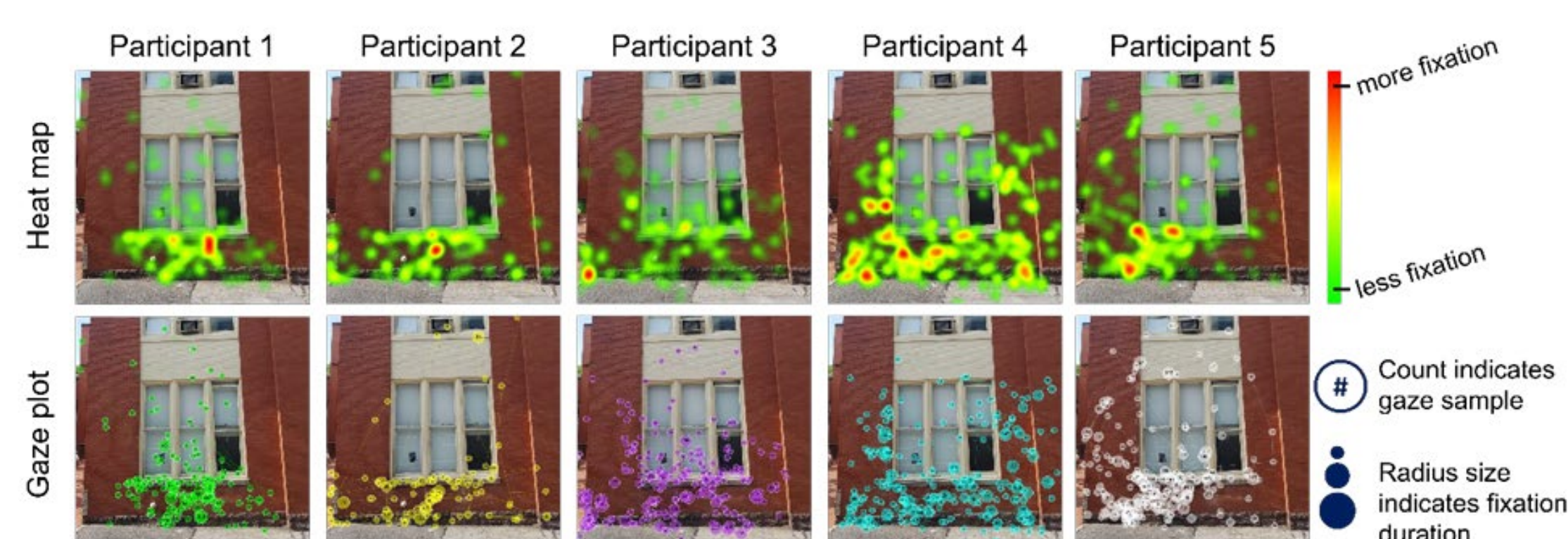
Data Visualization

Fig. 2. Heat maps and gaze plots for different participants for building 1.[2]

Fig. 3. Area of interest (AOI) labeling on visual stimuli.

Damaged areas are labeled and outlined.

Data Analysis

Data were standardized per area unit (cm^2) for all seven AOI's.

A repeated-measures ANOVA test was attempted with AOI's and surrounding areas. Normal distribution assumptions failed for both biological growth and crack AOI's.

Fig. 4. Normal QQ plot to test for normality of duration of fixation.

Analysis of surrounding vs damaged areas:

Hypotheses for a one-tailed, upper tail, paired t-test:

- $H_0: \mu_{difference} = 0$
- $H_A: \mu_{difference} > 0$

The conditions were met for number and duration of fixations, duration of visit, and time per fixation.

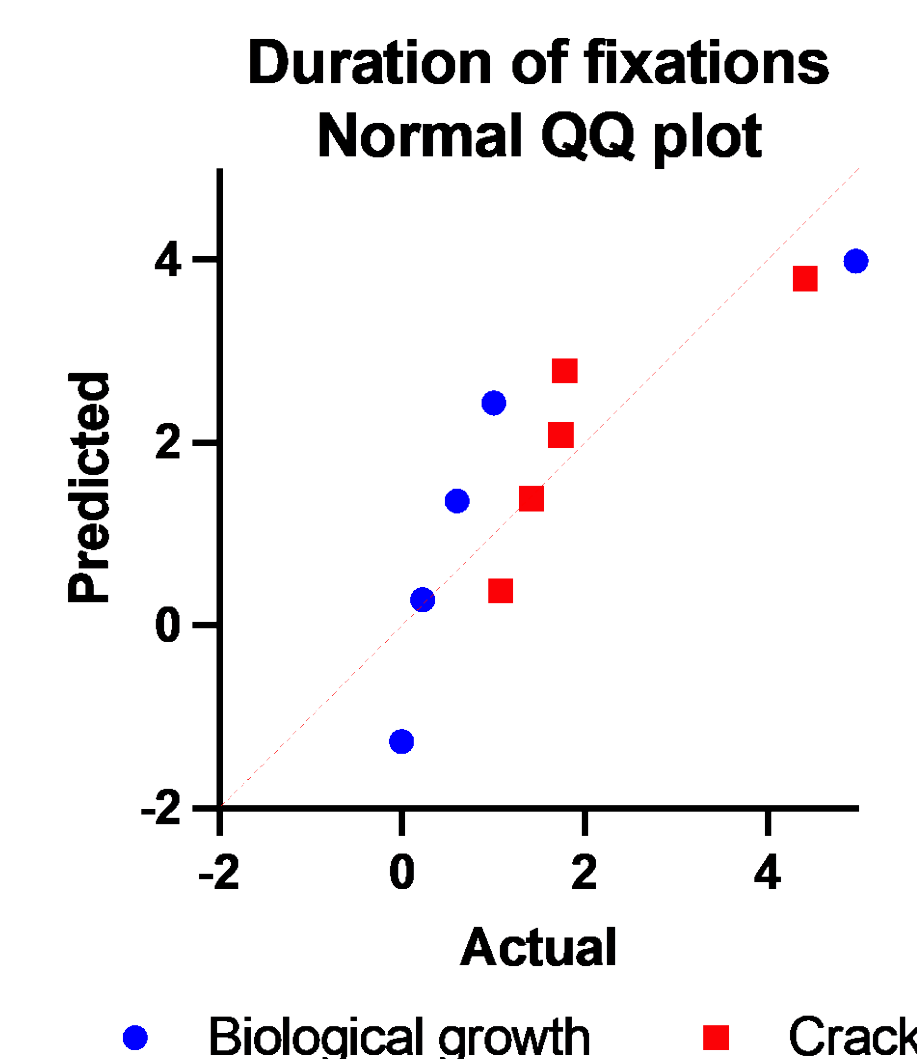Therefore, a paired t - test can be conducted on those Metrics but not for the number of visits.
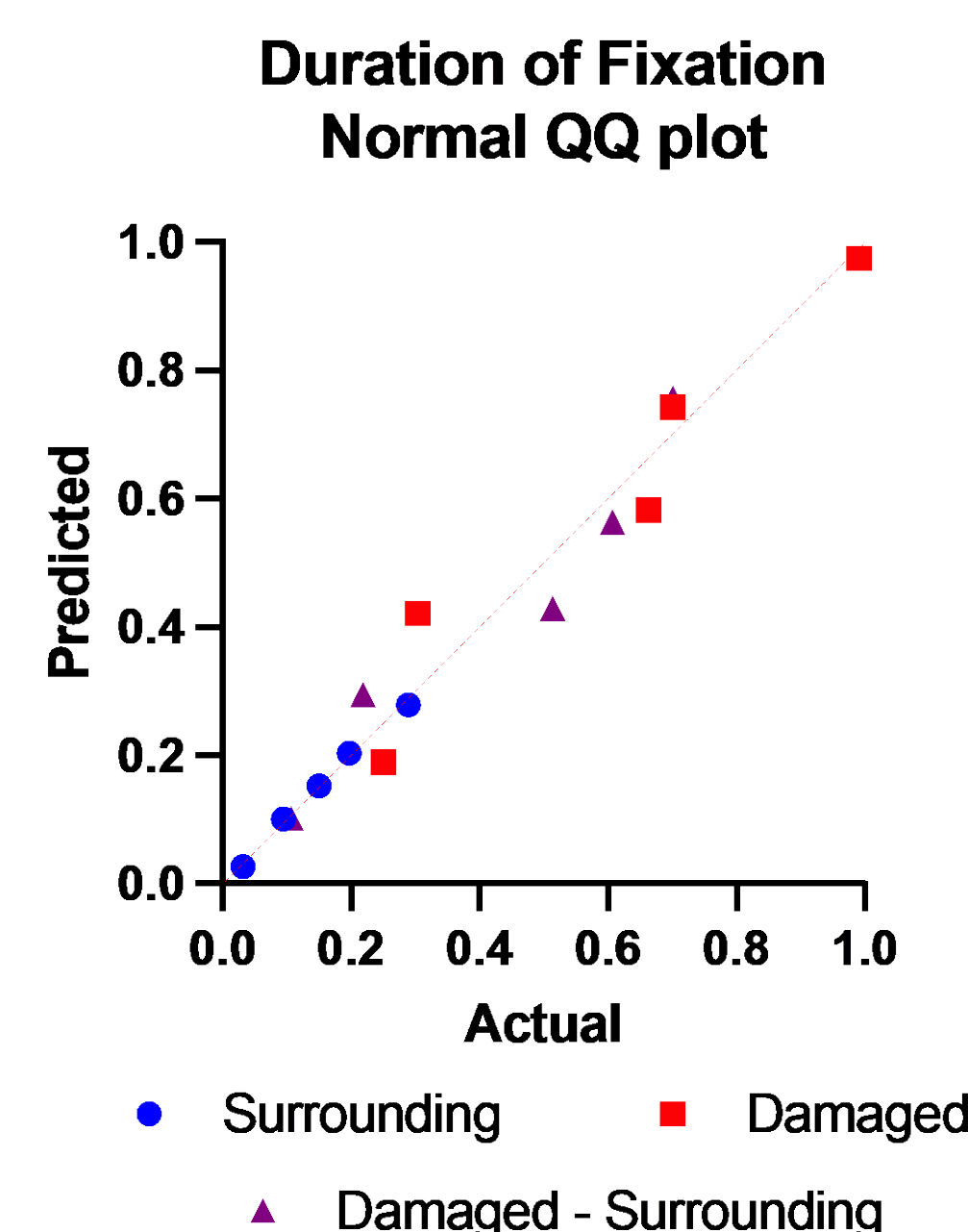

Fig. 5. Normal QQ plot to test for normality of duration of fixation for each AOI and the difference between them.

Conclusion

Based on our p-value ($p = 0.01$), we reject the null hypothesis.

There appears to be a statistically significant difference between the means of the surrounding area and the means of the damaged areas for all metrics.

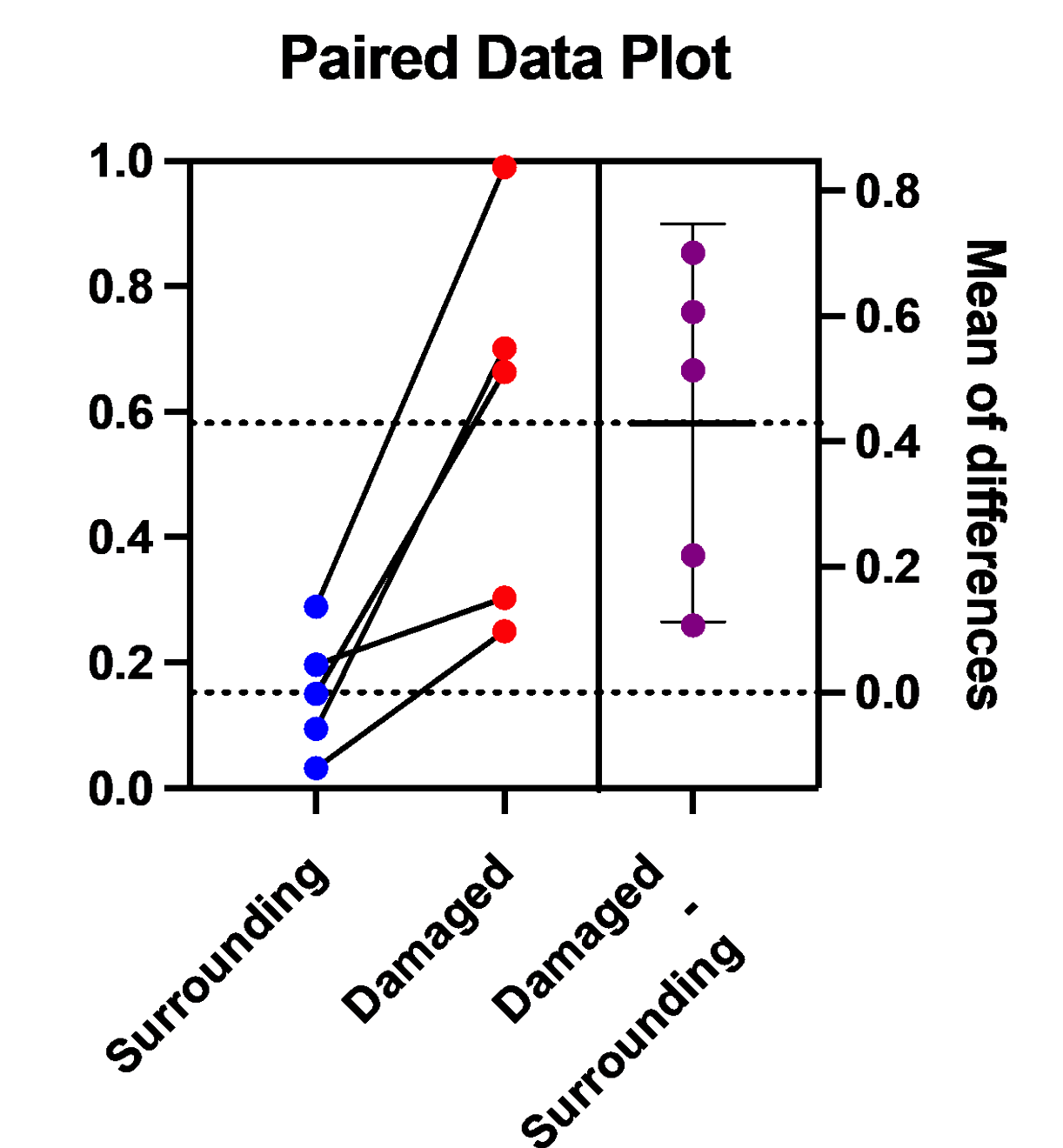On average, inspectors were more focused on damaged areas than they were non-damaged areas.

Fig. 6 Plot comparing differences between paired data

Future Considerations

For this research:
With the sample size being so small (n = 5), drawing conclusions are difficult. An expansion of the study will increase the power and effect of the test.[1,3]

Re-expression of data could make the distribution appear more normally distributed with a larger sample size.[1,3]

For classroom research:
The techniques used for data gathering could be used with various bio-metrics to quantitatively analyze typically qualitative observations. (Is yellow a calming color? What characteristics of a classroom are distractors for students with ADD/ADHD?)

References

[1] de Winter, J. C .F. "Using the Student's 't'-Test with Extremely Small Sample Sizes." *Practical Assessment, Research & Evaluation*, Center for Educational Assessment. 813 North Pleasant Street, Amherst, MA 01002. e-Mail: Pare@Umass.edu; Tel: 413-577-2180; Web Site: Https://Scholarworks.umass.edu/Pare, 31 July 2013, https://eric.ed.gov/?id=EJ1015748.

[2] Saleem, Muhammad Rakeh & Straus, A. & Napolitano, Rebecca. (2021). INTERPRETATION OF HISTORIC STRUCTURE FOR NON-INVASIVE ASSESSMENT USING EYE TRACKING. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. XLVI-M-1-2021. 653-660. 10.5194/isprs-archives-XLVI-M-1-2021-653-2021.

[3] Morgan, Charity J. "Use of Proper Statistical Techniques for Research Studies with Small Samples." *American Journal of Physiology-Lung Cellular and Molecular Physiology*, vol. 313, no. 5, 2017, https://doi.org/10.1152/ajplung.00238.2017.