Applying Augmented Reality to Construction Quality Inspections

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Abstract

The construction industry, like other industries is eagerly investigating novel uses for augmented reality (AR). AR technology is a visual aid that can be used to "annotate" a real-world view with information that is helpful to the observer (Azuma, 1997). This research study examines an approach toward using an AR headset to assist construction inspectors with the task of inspecting the installation of in-situ construction components.

Hypothesis

The researchers hypothesized that the development of a framework of inspection that incorporates AR could improve (in terms of accuracy) the process of construction inspections when compared to more conventional methods of inspection, namely visually observing installed conditions and comparing the results to an interpretation of installation conditions on 2-dimensional paper plans.

Setting & Rationale

The inspection process was tested by observing the installation of embedments. *Embedments* (embeds for short) are used extensively in construction to anchor dissimilar materials in a building together, such as steel to concrete and wood to masonry.

In figure 1, the embed (A) allows for the attachment of the steel joist (B) to the top of the concrete wall (C). The embed (A) is installed in the concrete wall (C) at the time that the wall is being constructed. If the embed (A) is not placed in the correct location within the concrete wall (C) or someone forgets to install it within the concrete wall (C), then the steel joist (B) cannot be correctly installed. This coordination failure usually leads to lost productivity, delayed construction schedules and cost overruns. Therefore, the need for improved quality in this coordination process is highly sought after (Kim & Olsen, 2020).

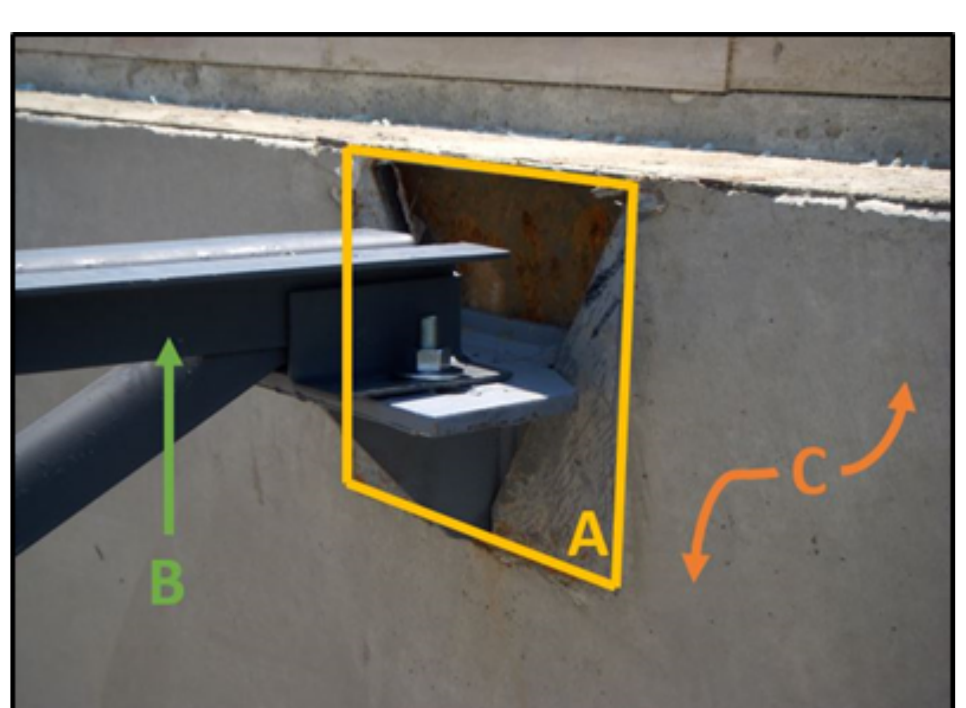

Figure 1. Example of concrete embed with attached steel joist.

Methodology

This research study was designed as a between-groups experiment. Comparison of accuracy was analyzed between the ***AR GROUP*** (figure 2) that used a Microsoft HoloLens to inspect an experiment room of installed embeds while the ***2D GROUP*** (figure 3) used paper plans to interpret the accurate location of the same installed embeds.

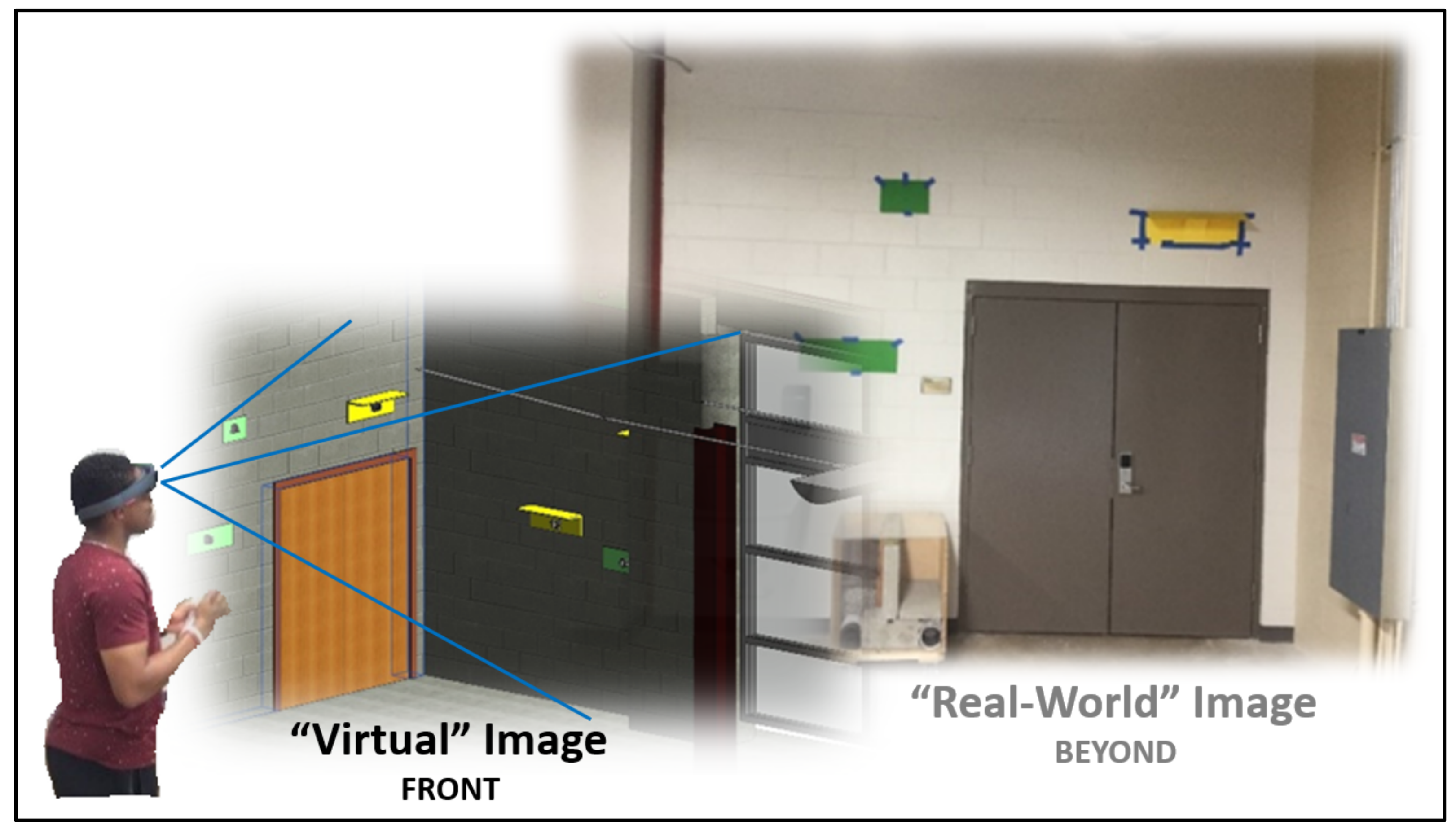

Figure 2. ***AR GROUP*** method of inspection.

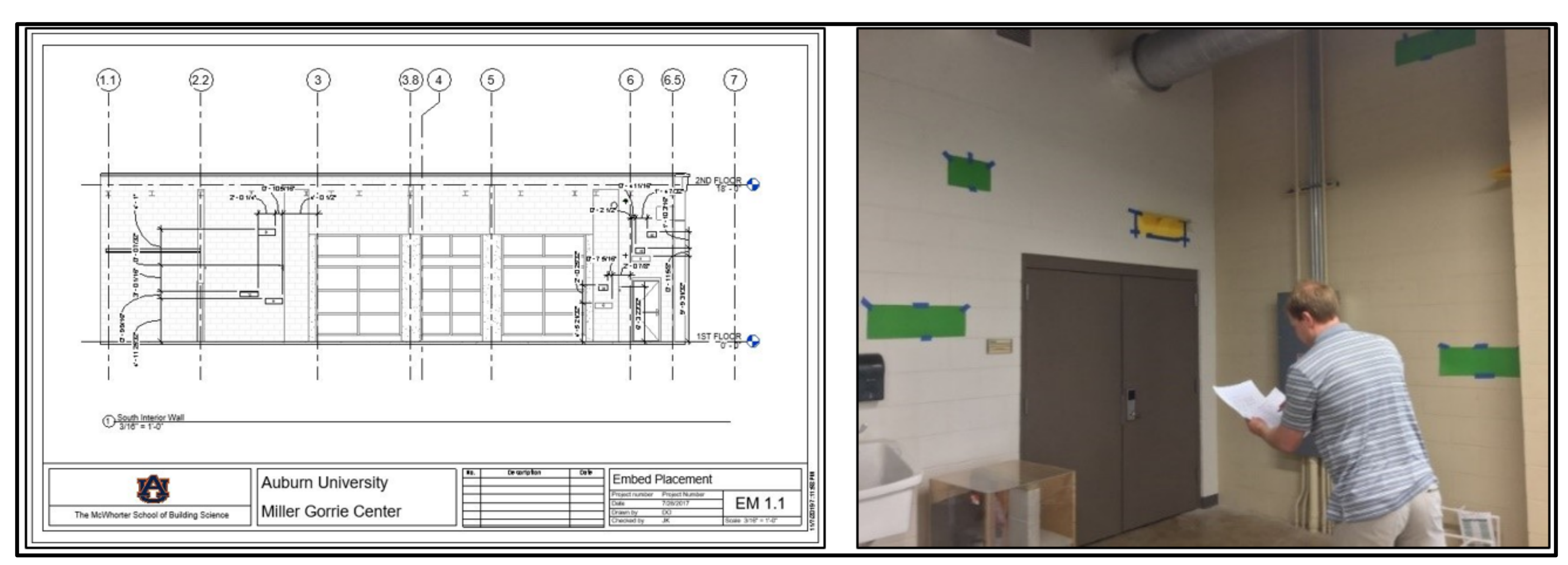

Figure 3. ***2D GROUP*** method of inspection.

Data & Results

A total of 46 student inspectors participated in the study (n=46). 21 of the students used the AR method and 25 of the students used the 2D paper plans.

The researchers analyzed the error frequencies for each embed placed in the experiment space and calculated an average accuracy for each method. The AR method resulted in 90.2 points out of a possible perfect score of 100 while the 2D plan method resulted in 86.4 points. A t-Test calculation resulted in p=0.0342029 ($p\leq0.05$) assuming Confidence Interval of 95% (CI=95%), significantly favoring the AR method of inspection.

Discussion

The weak significance resulting from the difference between the average accuracy scores for both method leads to a conclusion that is somewhat indeterminant. However, while conducting the experiment, some valuable findings were discovered that could redirect a continuation of this research study.

Visibility

There were two embeds installed in a manner that made them harder to identify for both inspection methods. The embeds were installed turned on end so that only a narrow profile was visible to the inspector. This is a common condition on observed construction projects and so it was included in this study to mimic real-world conditions (see figure 4). The data indicated that the ***AR GROUP*** was successful in recognizing this condition more often than the ***2D GROUP***.

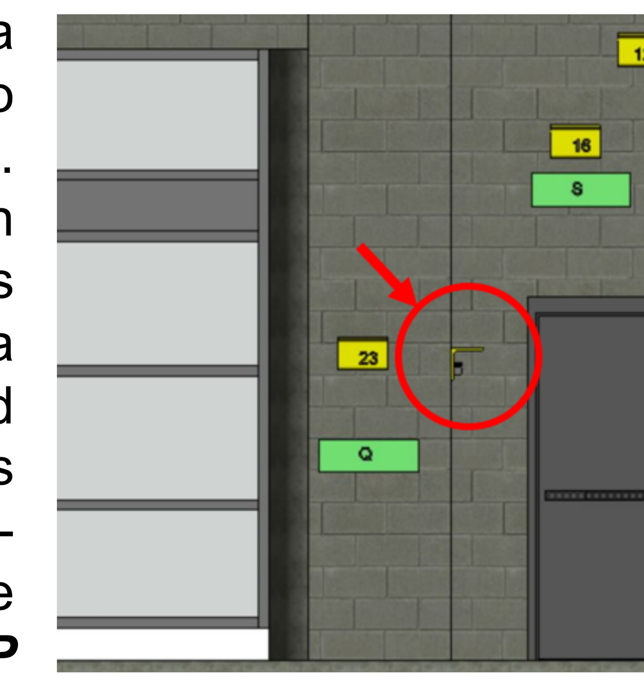

Figure 4. Embed installed with only a narrow profile visible.

Image Drift

Another issue concerned image drift. This is an unlocking of the virtual image from its connectedness with the real-world view (Azuma, 1997). When this happens, the equipment must be recalibrated to connect the virtual and real-world views together in order to continue the inspection.

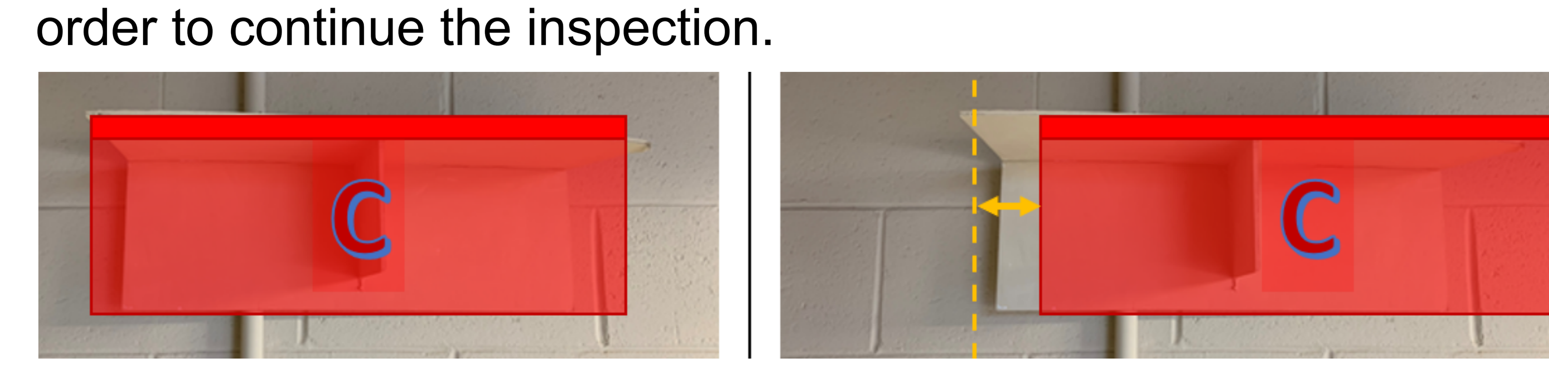

Figure 5. Correctly aligned image (left) and image drift (right).

Conclusion

As mentioned, the results were weakly significant, yet with the additional findings presented above, a continuation of this research study may result in more robust result.

The motivation for this study is encouraged by the need to improve this inspection process, among other similar inspection processes with an ultimate desire to have a direct impact on the quality, cost, safety and timely delivery of a newly constructed project.