Augmented Reality Applied to Tenant Improvement Projects

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Technology keeps on advancing and expanding into different markets, the Construction Industry has adapted these new breakthroughs. The industry has already adapted the concept of 3D Modeling, however with Augmented Reality this takes BIM to the next level. Augmented Reality can assist in numerous attributes within the construction process to help manage the project more efficiently. Given these words, this paper helps to highlight the key factors of Augmented Reality and how it enhances the Tenant Improvement process. This case study helps to highlight the positive returns of this tech, as well as solutions for any challenges that may come with it, through RCI Builders' Dr. Fields T.I. project. Tenant Improvement is extremely detail oriented and focuses more furnishing rather than larger infrastructure like most construction projects. Thus, with the assistance of Augmented Reality Owners, Architects, and Contractors can collectively review and coordinate the design and constructability of the project simply through an Ipad. The research shown in this report discusses how new programs such as Vuforia, EasyAR, and SmartReality APP overlay 3-D models onto the REAL LIFE image of the space being constructed. This in turn minimizes changes made within the project and therefore, saves money and time.

Keywords: Augmented Reality, 3D Model, Detail Orientated, Automatic, Self-Correcting, Coordinate

Introduction

The job of any construction manager once awarded the project is to see that the building is built out in the most efficient and effective way possible. This is achieved in the industry by minimizing cost and ensuring that all moving parts on schedule. It all comes down to time and money, as it does in any other industry. However in the construction industry the management team has the power to to be more proactive and efficiently planning ahead of time, through preconstruction. The process of pre construction consists of clear and transparent communication as well as coordination to ensure all parties are on the same page. Thorough and diligent communication and coordination helps to build a strong pre-construction plan that can be translated and carried through the construction process, to bring success to any project. However, even with a strong pre construction plan, there will unforeseen obstacles and changes throughout the project duration. Changes are inevitable in this industry due to such a diverse group people who work on the project. Everyone involved in the project views certain aspects differently and have different outlooks on designs or solutions. This in turn causes unnecessary costs and delays in schedules increasing costs as well. It is the project manager's duty to coordinate with everyone and communicate effectively with all members throughout the process to minimize these changes. In the Tenant Improvement division of construction, these changes and unforeseen challenges are identified due to its detail oriented focus. Tenant Improvement is

focused more on the furnishing and build out of the interior of a space rather than the infrastructure and exterior like most buildings. The construction of the project becomes more personal as you are delivering the finished and furnished project to the owner. This increases the chance of changes as owners are much more involved and focus on all details of the space built, thus increasing the chance of changes within the project. To add to this most owners in Tenant Improvement projects have little to almost no experience in construction creating more obstacles for the manager, slowing down the process and creating more costs.

Augmented Reality technology brings a solution to this challenging process and brings all teams of the project together. This technology has the power to display the final designs and furnishings of the project to the owner and all other members to unite everyone on the same page. When reviewing the project through the augmented reality it allows changes to be made in real time therefore, cutting time and money throughout the construction process. This paper will discuss the use of this new technology within RCI Builders and how it helped to effectively improve their construction management to increase profits and decrease time. The Fields Medical Office Space will be used as a case study to compliment the benefits of this technology and highlight any solutions to combat any challenges that may occur with this system.

Augmented Reality System Operations

Augmented Reality is the future of virtual reality, as it perfectly combines reality with the virtual world. The technology is produced through the communication between a 2D camera with a 3D model program. In order to implement this process into the construction industry we need to first explain the science of this system and what makes it operate the way it does. Virtual Reality is still effective however does not have that overlay factor with the real world displaying how models would look like in real size. Augmented is more effective than Virtual Reality because of this overlaying factor of computerized designed models into our world. It gives a more real feel mixed with virtual images to really understand how a final product would look in a space, as shown in Figure 1.
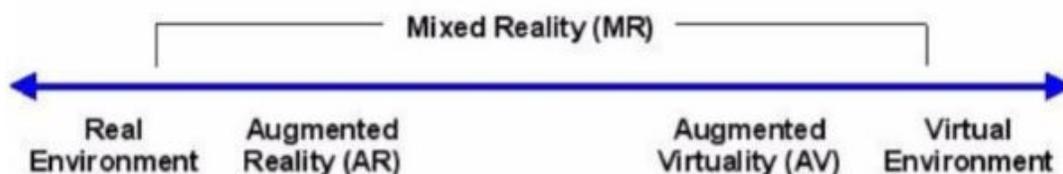

Figure 1: Milgram's Reality-Virtuality Continuum. (Waraporn Viyanon, 2017)

Furthermore, this system works because the camera has the ability to communicate with the model program. This is the most crucial process in the Augmented Reality system. This step is what takes this new system to the next level from Virtual Reality. The information that is registered by the camera is translated through the lens as information and coding that has the ability to change the model itself in real time. The process takes only seconds to register and correct the model with the new information. Looking at Figure 1 below you can view how the system travels from camera to model.
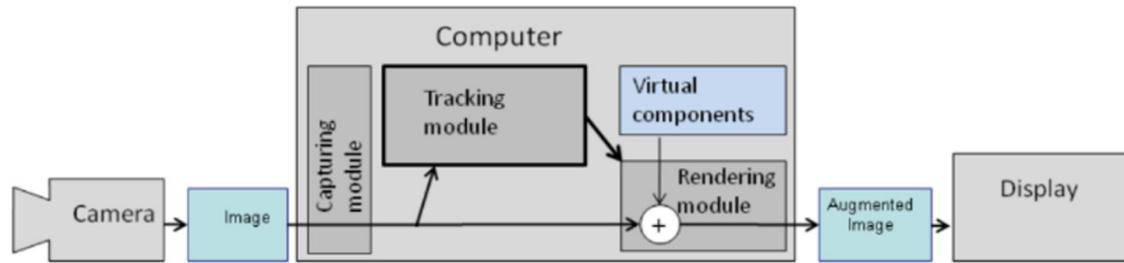
Figure 2: Flowchart for a Augmented Reality System. (Waraporn Viyanon, 2017)

Referencing Figure 2 you can see how the image travels through the capturing module in the camera, however the next destination is the important factor. The Tracking Module is what creates the log of changes and updates the program model. The rendered module combines the virtual components that are coded and designed in the modeling program and are edited with the images picked up, within the tracking module. The virtual components use GPS location programed in order to place the model in the correct position. Once viewing through the camera and directed at the correct location you can view the rendered building or rendered furnishings. When programing and designing the model itis important to use real length, sizing, colors, as well as depth in order to get a very accurate render which is then displayed into the real world.

Now that we know the science behind this amazing system, we look towards how this can be beneficial in the Tenant Improvement industry. In order to coordinate the design and vision of the space being constructed all members need to have a good understanding of the model created. For many members with little to no experience in the construction process it can be hard to visualize the plans in real life, or even understand how the model is scaled or relates to real life. However, with the power of Augmented Reality it brings the virtual and 2D plans to reality and helps to convey the final design in a way that owners, architects and contractors can all coordinate and understand.
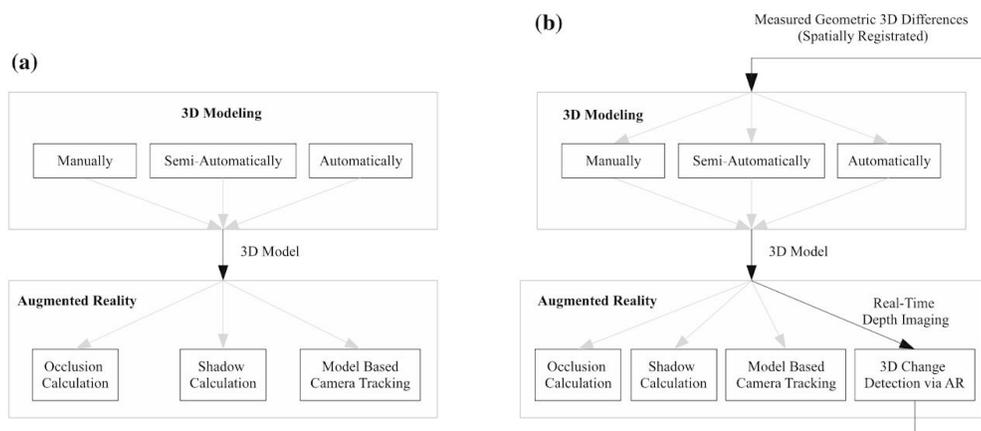

Figure 3: Conventional Framework vs. Proposed Framework. (Khan, Svenja 2011)

As shown above we can see the difference between a regular 3D virtual model to a Augmented Reality model, where the key difference is real-time depth imaging. Augmented Reality has 6 dimensions, due 3 dimensions in the real life image, then 3 dimensions for the modeled program being overlayed. Together these 6 dimensions can bring improvements in Tenant Improvement because of how detail oriented the specific industry is. This new proposed framework can bring inexperienced owners and coordinate with contractors as well as architects together and update plans in real time.

Augmented Reality Tenant Improvement

Tenant Improvement consists of taking an existing space, stripping it down to its shell, then implementing your design to provide a new usable space for the tenant. This immediately creates numerous challenges because of the vast amount of members that give input to the finishing and final functionality of the design. To dig even deeper as the construction process moves forward and begins, to everything is built exactly to plan as in any project. As well as owners and architects change plans constantly and designs because the project becomes so personally invested to see the final product exactly how they want it. Tenant Improvement is more detail and finish product focused, causing the project to be prolonged until all the specs are met.

Augmented Reality can be implemented perfectly to help combat these challenges in design that occur throughout the process. With this new developed imaging system changes can be minimized to help keep the project running smooth, under budget, and right on time. RCI Builders used this system on their medical office space to help coordinate between the owner, designers, as well as contractors. They believed that this system would help bring some light to the construction process and how the design will come together before they even start building. Next we will look more into depth of how this system was used by RCI and all the benefits that were incorporated.

Methodology

For this case study in order to get the best data and understand the pros and cons of the implementation of Augmented Reality, qualitative research is the best practice. The data was collected primarily through interviews and discussions on the practice of this system throughout the construction process. I spoke to the Project Executive, Project Manager of the tenant improvement project. The interview covered the process of acquiring and setting up the technology, presenting and explaining the system to the owner, the coordination process with the use of this system, lastly if it was beneficial and if they would do it again. The interview was done after the completion of the project therefore, I was able to collect a complete results from this project and all the benefits and challenges.

The objectives of this case study are;
1. Discuss the major benefits of using Augmented Reality on the Tenant Improvement Project.
2. What are some challenges that came with this technology, and possible solutions for this.
3. Why Augmented Reality is the best tool for coordination between various teams and members on a project.
4. What are ways to expand this technology for the future.

Case Study

RCI Builders implemented Augmented Reality for the first time on the Fields Medical Office Space. The project was located in Thousand Oaks, California and was about 2,5000 square feet. The space prior to the construction was an older and very outdated medical office space. The equipment and layout was not efficient at all, and continued to detract from business. They had to cancel multiple appointments and the layout and technology they had at the time was not working properly. The owners AH Rolling Oaks LLC hired Tom Oswalt Architects to help produce and implement a more fluid and efficient layout with improved equipment. RCI Builders thought that for this project to give the tenants really a feel for the right layout and design of their workplace they would utilize Augmented Reality.

Project Specifications

The following are the key details for this case study project:
- Project Size: 2,5000 Square Feet, Single Story Medical Office Space Improvement
- Existing building is to remain untouched, only construct from shell to furnish.
- Build-out entire facility and install all furnishings including medical equipment.
- Total Cost: $1.2 MM
- Total Duration: 18 months

RCI Builders main goal was to construct and furnish the ideal medical office space for AH Rolling Oaks LLC, with the latest and best equipment as efficient layout.

Discussion and Results

The following explains the findings from the interviews with the Project Exec and Project Manager on the Fields Medical Office Space. It touches on the goals of implementing the Augmented Reality system and focuses on the benefits of this system. In addition, it also covers challenges that were found and what solutions were used to combat these problems.

Goals to Obtain from Implementing Augmented Reality

1. Increase Clientele: As RCI continued to grow an expand their Tenant Improvement sector they needed something to help attract clients. They wanted to expand and be better by the competition, so they implemented a system that no one in their market area was using. They quickly found that most people doing Tenant Improvement have little to no experience in construction. With the implementation of Augmented Reality it helps to advance their clients design and input in the design and coordinate the construction process more effectively and efficiently.

2. Minimize Changes in the Project: This was the main goal for the utilization of Augmented Reality. As mentioned before owners of these buildings get very invested in their product and want to ensure the final products resembles their vision. With this technology they can show the clients and designers exactly how the space will look as if it is fully constructed and furnished. With this technology clients and designers can

edit and adjust sizes, colors, positioning, and depths of all aspects of the project. In turn this helps to lower changes made keeping the project o schedule and under budget.

3. Cost Efficiency: The utilization of this technology allows all members of the project stay more cost effective throughout the duration of the project. The owners, can make decisions more effectively and diligently and save money. The architects can save money by not having to redesign the building and waste time and money on any additions of the building. In addition, the contractors can save money by allowing the owners and architects be completely final with the designs and furnishings. This lowers any rework that would have to be done and minimize the amount of material that has to be bought.

4. Improve Coordination: Augmented Reality allows all members of the project team to coordinate and communicate more effectively and efficiently. The technology allows the clients and designers to view the exact design and be completely transparent with what the final product will look like. This helps to convey ideas and systems in a more universal way that everyone can understand be on the same page.

Benefits of Augmented Reality in Tenant Improvement

The use of Augmented Reality is a relatively new system and not used most majority of the construction industry. The key benefits of implementing this system is increase cost savings, enhance clash detection, construct the highest quality design.

Cost Savings can be easily achieved with this system as changes are minimized. With this system implemented everyone on the project can be united under the same design and move forward without making drastic changes. This system allows clients and designers to view the current image of the space and overlay with the virtual models. This in depth model shows the final furnishing and design of the office space and allowing all members to make changes before they construct it. This will help save time which in turn saves money for all members of the project. In turn, this helps minimizes rework and increases in pricing by ensuring that this is the equipment and layout that everyone wants.

Next, Augmented Reality helps to enhance the clash detection by planning the equipment and systems earlier on. In this particular case study the medical office has a lot equipment. The numerous amounts of mechanical, electrical, plumbing, and now medical equipment systems create a very difficult and crowded project. However, with this technology you can visualize how the different systems navigate and are set up in the building. This technology does not have to be only for aesthetics but can be utilized for MEP systems as well. Coordination between the different subcontractors can coordinate with the engineers and ensure that not systems will clash. This is more effective than virtual reality as you can design in it real size and overlay in the existing location, to ensure that everything fits and can be constructed correctly. This can be translated into any other type of division as construction not only tenant improvement. This helps to minimize clashes which helps keep any lower costs lower.

Lastly, this new system can be used most effectively for ensuring that the building is built to the highest quality and to the owner's exact vision. The architect and owner can view their plans and ensure that what they are building is exactly what they want. This helps to lower re-work and stop any unnecessary work. They can also test multiple floor plans and interior designs and do cost analysis on each. This helps to understand the different patterns and color schemes to ensure that the tenant builds out their vision.

Challenges with Augmented Reality

Augmented Reality does have a vast amount of benefits, however it does come with numerous challenges as well. This is a common theme with any new technology or system used in the industry. The main challenge with this system is the learning curve to learn the software and learn how to model a program to implement into the augmented reality. Programs such as Vuforia, EasyAR, and SmartReality APP do have easy and user friendly interfaces. As shown in the chart below, out of a sample of 100 people SmartReality APP concluded the following results.

Usability score

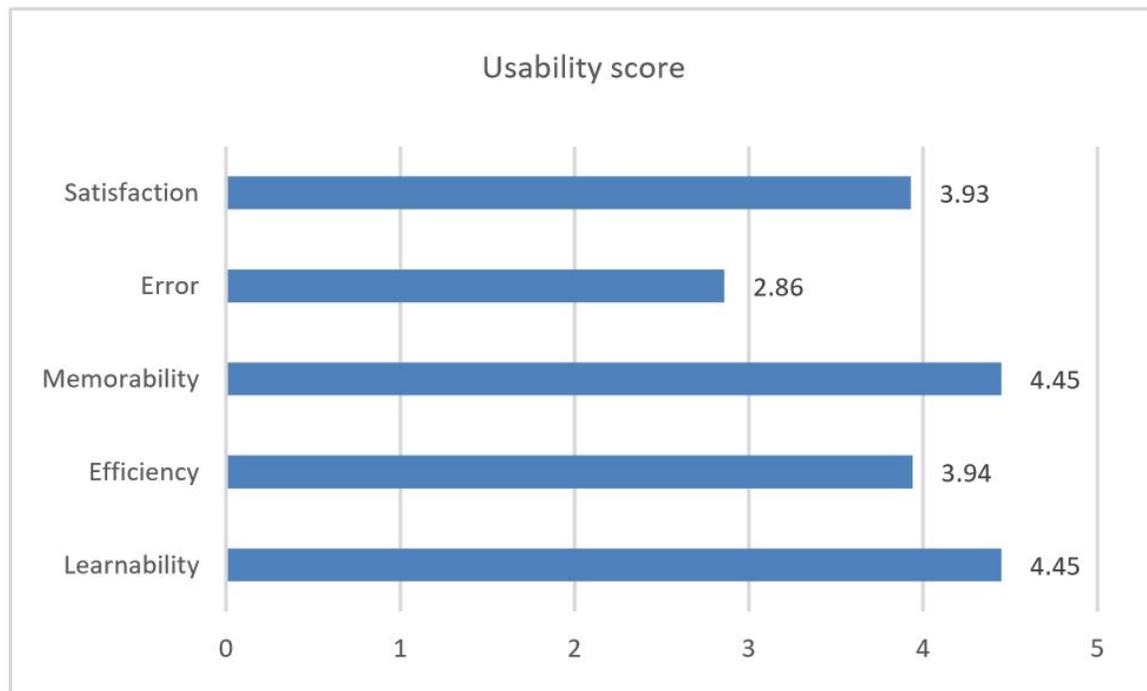|	Value
Satisfaction	3.93
Error	2.86
Memorability	4.45
Efficiency	3.94
Learnability	4.45

Figure 4: SmartReality APP Usability Score (Waraporn Viyanon, 2017)

Referencing the chart you can see that the app is super easy to learn and retain the information. This is a huge asset to any client using this app, as they can learn how to design and utilize the augmented reality software to their advantage. In addition, error being the lowest bar that resulted for this sample helps to highlight the huge advantage of this program. While satisfaction and efficiency are second highest showing us that this application is vastly beneficial. This proving that in order to combat the learning curve these applications have made modeling and designing easy and user friendly for all users in order to optimize the service of the system.

Moreover, another challenge that may come out of this is the power this gives to everyone on the project team. This product allows all members of the team to essentially be able to give their opinions and edit or make changes virtually they see fit. This can increase the project duration and prolong any systems that may need longer procurement times. However, to combat this the management team can create more goal oriented meetings to focus only bigger aspects and details of the project. This will decrease time spent on small designs and systems and therefore fast track the progress to only review bigger key factors of the project.

Conclusion and Future Research

In conclusion, this case study brought insight as to why Augmented Reality is the perfect tool for managing any construction site efficiently and effectively. Given these facts, we can see how Augmented Reality can help maintain a budget and save costs, help detect more clashes, and lastly enhance the design and layout of the project. RCI Builders implementing this system help to shed light and show us that Augmented Reality can help in this detailed oriented and complicated tenant improvement project. Even Though the technology still has so much room for improvement, this system still proves itself to be easy to use and effective in the workplace. Augmented Reality has the power to become the next dimension of construction management and be utilized by all members of the team. Foremans can use this to ensure that all moving parts being built are to plan and save money and time.Foreman's can also use this for managing and logging material, helping with purchasing and ensuring no material is wasted. In addition, owners can use it as well to help them visualize what their final product will look like. This system is so versatile and innovative that is can be used in all aspects of the project, thus creating a more diligent management team, helping everyone save money and time.

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