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Poster

A Rapid VR House Interior Generator with Eye-tracking Feedback for Home Staging

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Abstract

The employment of virtual reality (VR) technology in home staging (i.e., showcasing layout and interior design to influence potential homebuyers' purchases) has noticeable limitations. First, developing VR models by game engines may bring unaffordable workloads for real estate agencies. Second, pen-and-paper feedback on a VR model of the staged home is sometimes ambiguous and misleading. We developed an application that combines a virtual tour platform and a VR-based eye-tracker to address the two issues. The current work investigated the relationship between subjects' preferences and eye movements in a staged home. Our results support that subjects' eye-tracking data on layout and interior design differs following their preference change, reflecting the potential of eye-tracking in evaluating staged home models. In the future, we will examine the workload reduction in creating a VR model via the virtual tour platform.

CCS Concepts

*• **Human-centered computing** → Interface design prototyping; Activity centered design; User interface toolkits;*

1. Introduction

Layout and interior design of show houses are critical in influencing potential homebuyers' purchases. Relevant works regard the demonstration of visual attractiveness as a step in real estate marketing, namely *home staging* [LSS15]. The real estate agent may provide related materials in photographs or videos. Both buyers and sellers believe that appropriate home staging could positively impact buyers' intention to pay for real estate property [LSS15].

In recent years, *virtual reality* (VR) technology has been employed as a primary approach for home staging. As a 3-dimensional digital environment with a first-person point of view, VR shows game-changing strengths in conveying visual information and bringing presence and immersion to experience the staged home's layout and interior design. Additionally, creating the staged home in a VR model enables the seller to show the property still under development beforehand [FLL17] [JCC18].

However, the limitations of employing VR for home staging are also noticeable. First, developing VR models with game engines (e.g., Unity 3D) could be a massive workload for real estate agencies since most of those models are for temporary use; the cost-benefit trade-off must be considered. Second, obtaining effective feedback (mainly via pen-and-paper) on the VR model of a staged home is challenging and ambiguous, resulting in the sellers misallocating their efforts toward future steps because buyers' purchase intention could influence their final purchase decision.

We developed an application that combines a virtual tour platform and a VR-based eye-tracker to address the abovementioned issues. As a case study using this technology, we aimed to understand the relationship between subjects' preferences for specific rooms (favourite or not) and their eye-tracking data on the staged home's layout and interior design.

2. Methods

Generally, our application involves six steps to investigate potential buyers' inclinations towards particular parts of a staged home: 1. Taking panoramas for the target home, 2. Turning panoramas into a VR model, 3. Uploading the VR model to the host computer of a VR-based eye tracker, 4. Running the VR model with the VR-based eye tracker, 5. Outputting reports regarding raw data and eye-movement events (e.g., Areas of Interest), and 6. Further processing for an in-depth analysis of the staging case. Details are introduced in the following subsections (some steps are simplified in this project).

2.1. Subjects, Hardware, Software, and Materials

We hired 14 subjects (8 males), aged 21 to 63, with $M = 35.29$ and $SD = 13.18$.

We employed a VR-based eye-tracking HMD (FOVE0, display

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frame rate: 70fps, eye-tracking frame rate: 120fps) and a host PC (Alienware x14) as the hardware system.

We created the staged home via a virtual tour platform (Metareal Stage) with its provided sample house (Le Vertendre, a Canadian-style house).

We employed the Virtual Reality Sickness Questionnaire to measure the extent of motion sickness [KPCC18]. This questionnaire employs a scoring system ranging from 0 to 100, where higher scores correspond to a greater degree of severity. We also solicited their first-favourited room of the staged home.

2.2. Procedure

As preparation, we introduced the whole process to subjects, obtained their consent, and prepared a practice session to familiarise them with the VR environment and operations. Then, we calibrated the subjects' eye-tracking and instructed them to start. Subjects freely viewed the sample house in the VR HMD and got their eye-tracking data recorded. The free view was without time limitation; they informed us to terminate the program after they were satisfied with the participation. Finally, subjects submitted the questionnaires. The devices and environment see Figure 1.

Figure 1: *A subject is wearing the HMD in a room. The host PC records his eye-tracking data during the data collection process. He holds a controller with a press-to-teleport button to move in the VR environment.*

2.3. Analysis

We asked the subjects to rank their favourite rooms in the staged home. Then, we compared the duration percentage (proportion of time spent gazing at a specific room concerning the total time spent observing the entire staged home) difference between the top 3 popular rooms.

3. Results

3.1. Descriptive Statistics

On average, the gazing duration for the entire participation is 356.62 sec (SD = 157.08). The motion sickness scores are M = 9.76, SD = 6.41. As for the popularity of rooms, the living room

received 7 votes (No. 1), the kitchen received 3 votes (No. 2), and the dining room received 2 votes (No. 3).

3.2. ANOVA for Eye-tracking Duration Percentage

Levene's Test to confirm the equality of variances for duration percentage (F (2, 39) = 0.48, p = 0.62). Then, the ANOVA results revealed a significant difference in duration percentage between the three rooms (F (2, 39) = 17.05, p < 0.001). Finally, the Post Hoc Test by Tukey indicates the difference across three rooms for each event. The duration percentage for the living room (M = 29.55, SD = 8.30) is significantly higher than the kitchen (M = 22.38, SD = 7.72), with a mean difference of 7.16 (p = 0.03), and higher than the dining room (M = 13.80, SD = 4.99), with a mean difference of 15.75 (p < 0.001); the kitchen is also significantly higher than the dining room, with a mean difference of 8.59 (p = 0.008). Those results suggest that the duration percentage reduces over the decreasing room popularity.

4. Discussions

This work discovered a significant relationship between the duration of the subjects' gaze distribution by room and the rooms' popularity among subjects within the staged home, suggesting that eye-tracking data could determine room preferences. Our technology enables quantitative analysis based on eye movements regarding the evaluation of staged homes, which could reduce the workloads for both subjects and investigators, thereby being more effective than traditional approaches in accuracy and efficiency.

On the other hand, our technology is expected to provide a rapid way to generate the staged home model in two steps, namely taking panoramas and turning them into VR models. In this work, we employed the provided panoramic materials (the Canadian-style house), starting directly at the second step without taking panoramas. In a future project, we intend to test the workload of the entire model-creating process.

Also, this work analysed the gazing duration percentage based on raw eye-tracking data. In the future, we will define high-level events (e.g., eye movements, head movements, and walking trajectory) and develop in-depth analyses based on Areas or Periods of Interest. A scoring system powered by well-trained machine learning algorithms could also be provided to predict buyers' purchase intentions in various practical scenarios.

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