AR Interior: Guidance Tool for Interior Designing

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***Abstract*—The ability to think in three dimensions and to visualize is of greater significance in the field of Interior Designing. It is well examined, that the most prevalent concern about interior designing is the interpretation gap between the client and the designer. The clients' imagination to visualize the final arrangement of the interior is more dominant than metaphysical concepts in the conceptual Interior design stage. The purpose of the study is to analyze Human-Computer Interactions (HCI) utilizing the widely researched Augmented Reality (AR) technologies, to decrease the gap of the design interpretation in the process of traditional Interior Designing. Specifically, it evaluates the best way to communicate the concept of Interior Designing to the client in an immersive virtual blueprint and to analyze the process. To examine the requirement of a virtual interior design that leads to attaining client affection, an interview was conducted with interior designers and people who recently got houses built or re-furnished. The results revealed the difficulties in understanding the client's personality and preferences in the designing process. Moreover, clients are more likely to encounter a high cost for designing before the dissatisfaction of the physical application of the interior. This paper presents four enhanced methodologies to make an impact on the visualization and analysis of the design process, to produce a room with a new look cost-effectively, create a virtual measuring tool by utilizing the AR and computer vision algorithms such as Canny edge detection, dilation, and erosion, to sort out the best wall paint and to estimate the number of coats by applying Machine Learning (ML) algorithms, to sort out the best-matched furniture by utilizing decision tree algorithm and to distinguish the best furniture to position according to Interior design principles by using marker less Simultaneous Localization and Mapping (SLAM) mobile technologies.**

Keywords – Augmented Reality (AR), Interior Design, Android platform, Concurrent Odometer and Mapping (COM), Simultaneous Localization mapping (SLAM), Virtual Reality (VR)

I. Introduction

It is stated that "Less than 5% of all interior designers allow customers to purchase products directly through them if they see something they like [1]. The basic principles of the Interior Designing: color, scale, and proportion within a predetermined space [2] which in turn, are noticeably assumed by the work of presentation in the conceptual design of the project, where scaled furniture floor plans for furniture placement, mood boards for color, paint and other theoretical design plans and statements may require to finalize the design by the interior designer to their clients.

Enabling interior projects to shift from conceptual designing to the outcome by simulating the process that visualizes and helps to analyze the interpretation gap between the client and the interior designer, using augmented and other computer vision technologies reduce omissions and help to gain many advantages. Less effort may be required if a virtual mobile measuring tape is created, user can save cost by realistically visualizing and estimating the color of the wall paint, more reliability in furniture suggestions can be obtained by studying the user personalities. Furthermore, well accurate, less time consuming, cost-effective furnishing can be designed by placing three-dimensional (3D) furniture following the principles of Interior Designing.

In spite of overlaying virtual objects in real world for visualizing furniture or paint for interior designing, smart and convenient system is not available so far to direct designers in making decisions to manage the distress situations, cost effectively, over the limitations of traditional interior designing and guide them to improve accuracy of designing throughout the designing stages from the sketch to the end to propose a successful interior design according to the standards of interior design principles.

Considering the least number of functions accessible in already available Augmented Reality (AR)-based applications for Interior Designing; AR Interior apply Image Processing, Machine Learning (ML) algorithms along with Augmented Reality (AR) technologies despite designers effective experiences or clients own expectations, to implement a virtual conceptual design tool focusing on the three basic principles of interior designing by creating different arrangements in a real-world environment on a mobile platform which in turn ease the mental exhaustion of the design professionals.

II. Literature Review

Even though AR has only been studied for a decade many types of researches are conducted using AR technologies even in the industry of Interior design. Santosh Sharma, Yash Kaikini, Parth Bhodia, Sonali Vaidya have been researched [3] about marker-less Augmented Reality based Interior Designing System. In the research, they mentioned a new method for applying AR technology to interior design work, where a user can view virtual furniture and communicate with 3D virtual furniture data using a dynamic and flexible user interface. Another research was done by Jiang Hui [4] about the approach to

interior design using this technology. The research's target is to analyze and evaluate the impact of AR Technology in interior design. The research context is associated with the consumers' perception of the project in the management and execution of the interior design. Finally, it provides a design framework which shows that the augmented reality technology is the way of future of interior designing so that the cooperation of designers and consumer would be convenient and efficient.

"AR Interior" is the proposed system that combines interior designing with AR. Detecting dimensions, wall paint visualization, furniture selection, and position recommendation for furniture are a combination of components. "Magic Plan" [5], "Berger Color app" [6], "Houze" [7] and "Planar" [8] are popular applications that are similar to "AR Interior". "Magic Plan" get the measurement of the wall, "Berger Color" app select the wall color for the wall, "Houze" only selects furniture for room and position for furniture, and "Planar" get the measurement for the wall. Proposed AR Interior get measurement by vertical and horizontal space distance, select the wall color for the walls, suggest how many paint coats needed, select furniture for the room, filter out the best furniture matching using smart technology and select the furniture position into a location properly according to rules and practices of interior designing.

A research report by Juniper (2011) highlights that Mobile applications incorporating AR elements will lead to nearly 1.4 billion annual downloads worldwide by 2015.up from just over 11 million in 2010 [9]. Researchers have pursued AR because it allows the enhancement of users' perceptions, knowledge, and interaction with the real-world environment and improves productivity. Most of the AR-based Interior Designing applications available appear to be visualizing, designing, transforming, and sharing digital information for clients' needs, however, no facility visualizes the measurements of room space to make the client even more reliable and confident in making design decisions for designing a perfect new home.

We can conclude that visualization is a mandatory feature in wall painting before purchasing the paint. Many applications have been implemented to visualize colors on the wall. Many authors said that visualizing is an important factor in designing. According to the post in www.import.io [10] (what-is-data-visualization/), it is important because it allows trends and patterns to be more easily seen. They have used various techniques to visualize color on the wall. According to P. Duth and M. Deepa [11], the color preferred by the user in the picture beside, the shade of the picture element is identified by examining the RGB value of every picture element present in the picture. The color detection algorithm is executed utilizing the MATLAB Picture handling Toolkit. Detect colors from a picture. Color picker from the system is absent in this research. P. Duth and M. Deepa listed the limitations in their research published on research gate. Former wall paint applications allow user to pick a color and replace on the wall but absent to perform a suggestion to have the number of paint coats needed.

In 2011, Elizabeth Simão Carvalho, Isabel Varajão, Gustavo Mações, Paulo Brito, and Nuno Sousa conducted research [12] about the use of AR in the furniture industry. However, using AR, it was able to offer a preview of furniture as a 3D model. Therefore, for the client, it will be easy to understand what it will look like and even better to incorporate some changes before purchasing it. They get the 35 participant's responses using a questionnaire. There have been three types of users. They were Vendors and influencers. After collecting data, they found out 19 user requirements. They analyze all this and then came up with a solution called VRINMOTION. The prototype of the VRINMOTION platform was implemented and tested for PCs. The present version of the platform provides the facility to select, insert, delete, and change the color of the furniture. The main purpose of that research is solving the gap between interior designer and client.

One of the studies, Ananda Poudel and Omar Al-Azzam from the Department of Computer Science and Information Technology Saint Cloud State University have focused their study towards [13]; the paper presents an application with AR for interior design. The attempt was to use various AR technologies such as Marker-less AR, Superimposition based AR to assist in interior designing. The application can select a piece of furniture from a menu, place, change material, or remove it by tapping on the screen.

And another research done by Lap-Fai and Yu Sai-Kit Yeung [14], have focused on automatic optimization of furniture arrangement, a system that automatically synthesizes indoor scenes realistically populated by a variety of furniture objects. Their research is about a method to arrange furniture pieces realistically. They achieved this task by giving examples of sensibly arranged furniture sets and generating new furniture arrangements for new scenes by learning from given examples. These furniture sets are deployed in a 3D model of the actual room. This method was ideal for generating random interiors for games like "sims" or "second life".

Instead of automatically generating realistic furniture arrangements based on provided examples, Paul Merrel, Eric Schkufza, Zeyang Li and Vladlen Koltun has focused their attention on generating furniture arrangements according to simple interior design rules and practices. Their attention was given to basic principles such as clearance, circulation, conversation, and pairwise relationships. Clearance is the space that must be between furniture pieces. Circulation is the fluid flow of space that does not interrupt a person's paths or views [15].

III. Methodology

After interviewing interior designers and people who recently got houses built or re-furnished. The interior designers and customers were asked if they had any difficulties or problems when executing the interior design process. The interview revealed that one of the major problem interior designers' faces is the difficulties to understand the thought process, the personality of customers and hence it is difficult to select the designs furniture and color schemes that match to the

customer's preferences. Furthermore, most of the customers claim that result they received was not up to their expectations and it was not the result imagined. The research studied that the cause for the problems above is the lack of visualization and lack of understanding between the customer and interior designer. To address this problem, it was decided to develop a system with the use of image processing and machine learning techniques along with augmented reality. The system development consists of four main components as illustrated in the Fig.1.

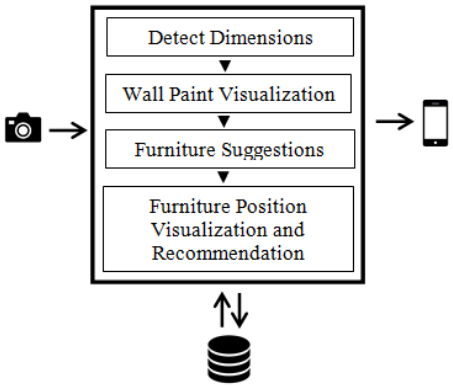

Fig. 1. Overview of System Architecture

A. Detecting Dimensions

In the process of designing an interior, one of the major tasks is getting the dimensions of the space, since the measurements obtained are used when planning the design, estimating the materials needed. The process of dimension detection consists of several steps. In the first part, the user launches the smartphone camera and randomly select any two points of the surface and find the distance between the two said points. To begin with, the application, launch the camera to scan the surrounding area enabling the sense of the environment. Then with the motion tracking, the phone camera identifies feature points and tracks the movements of that overtime to compute location changes. Using Concurrent Odometry and Mapping (COM) to see whether the phone is related to the world around it. And the anchor points ensure to maintain the exact position over time. Marker less Simultaneous Localization mapping (SLAM) technology allows us to view and interact in real-time with the AR content.

In the second part, the application can identify and measure the length and height of the detected objects within a room space. Firstly, the camera is pointed at the given object, then read the distance from a selected corner to the other using canny edge detection. For this process, the system functions to identify the gap between the detected edges using dilation and erosion algorithms, then discover and sort contours to measure the dimensions of the objects. With the help of the edge detector, the system will display a bounding box around the object with the relevant lengths detected. Finally, the system visualizes and measures the area of a wall by omitting the Windows, Doors that are available in the room in real-time as illustrated in the Fig. 2.

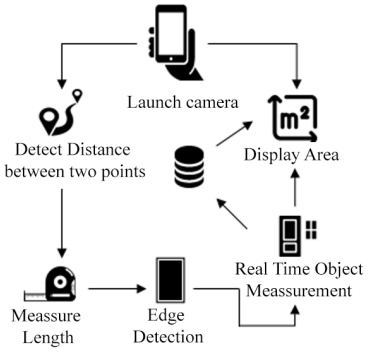

Fig. 2. System Diagram of Detect Dimensions

B. Wall paint visualization

Execution of wall paint visualization process consists of several steps. Firstly, the target wall should be captured by the mobile phone to visualize the paint color on the required wall. After the image is processed using a computer vision algorithm and system to identify the wall area where colors are needed to replace. As the next step using a color picker, or the color palette provided by the system able to select the color. The color picker feature can change the RGB value and select a color as user need. Afterward, the user can visualize the selected color applied on the wall in the taken image.

Wall paint visualizer components also provide the facility to recommend the quantity of the paint coats required. This was achieved by using an algorithm in machine learning which is called K-Nearest Neighbor (KNN) algorithm. KNN algorithm is mostly used for classification problems. Here, the color which is already on the wall is identified from a picture captured by launching the mobile camera. Afterward, the color is picked using the KNN algorithm to identify the specific color. The color where the user wishes to apply on the wall is picked by a color picker. Then the identified two colors are processed to give the result of the number of paint coats needed to apply on the wall as illustrated in the Fig. 3.

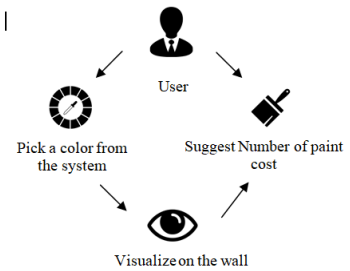

Fig. 3. System Diagram of Wall Paint Visualization

C. Furniture recommendation

The procedure for recommending furniture consists of several significant steps. First, when the client opens the application, he needs to answer a specially designed smart questionnaire with ten questions. The questionnaire is designed in such a way to understand the aesthetic sense or personality of the user. In general, each person has a unique personality. Everyone is different from everyone else. Therefore, understanding the personality of the user is not only essential in the design industry. It is significant in every field. It motivates us to realize how we should always communicate with others. So, personality is a significant factor. All answers of the user will be saved to the database as it supports to generate more combinations in the database. Afterward, the data gathered from the questionnaire is analyzed and processed through a trained machine learning model to recommend the most suitable matching furniture set out of a vast catalog of Furniture's' referenced of selected furniture is saved in the Database as illustrated in the Fig. 4.

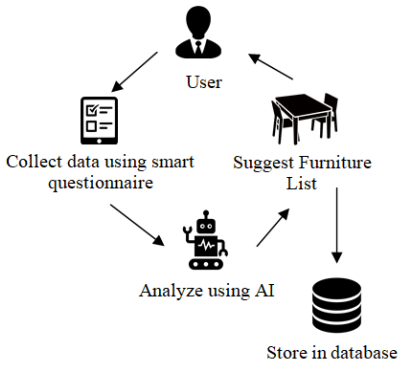

Fig. 4. System Diagram of Furniture Recommendation

D. Furniture position visualization and recommendation

As the first step to executing furniture positioning visualization, the system downloads the 3D models of the furniture recommended in the furniture recommendation component using the Reference IDs. Afterward, the system activates the device camera and instructs the user to point at the space where furniture is needed to visualize. Using the SLAM technology, the system identifies feature points of the flat surfaces. Next, the user can place furniture in augmented reality and visualize it. When positioning 3D models of furniture, the system recommends the user which furniture to place first. Furthermore, the system indicates relationships between furniture pieces and recommends distances between each furniture according to interior design rules and practices. This is accomplished by following a rule-based algorithm which describes relationships between furniture pieces. The furniture position visualization and recommendation process are illustrated in the Fig.5.

The system decides the order of the furniture by categorizing the furniture into three main types.

- Primary furniture: These are the main furniture in a room. Another piece of furniture is placed around it. Primary furniture is always placed first (e.g. Main sofa in a living room, Main bed in a bedroom, Dining table in a dining room).
- Secondary furniture: The furniture that placed with the Primary furniture
- Standalone furniture: The furniture that does not have any relationship with either primary or secondary furniture

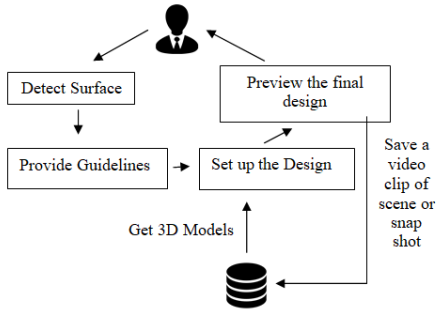

Fig. 5. System Diagram of Furniture position Visualization and Recommendation

The Furniture placement is executed considering the following rules.

a) Clearance: is the minimum space that should be kept around the furniture. Furniture should never be touching each other or walls. This gap between each furniture must be at least 3.5 inches. This prevents the furniture from damaging from the collision

b) Circulation: is arranging the furniture in a manner that people can move freely. Interior Design experts claim 1.5ft as the minimum space for effective circulation.

c) Conversation : is the guideline that must follow to preserve the connection between furniture. This defines the maximum space that furniture is allowed to place without losing the connection between the furniture pieces. For example, this preserves the ability of two people who sit in chairs having a conversation without feeling too distance

d) Space distribution ratio: is the percentage of the total room area against the area covered by the furniture. According to the Interior designer practices this value cannot exceed 80% as it would cause the normal person a small discomfort while curtail people can get claustrophobia. Claustrophobia is the fear of confined spaces.

IV. Results

The result of the implementation facilitates measuring the distance between two points within a room-scale after allowing the user to add virtual points as markers to measure a certain distance. Study of the result present that the best possible outcome can be produced when the detected surface is with diverse textures and with a bright light intensity level to produce feature points over the detected surface. Fig. 6. Illustrate the detected distance measurement between the selected two

points on the floor within a room-scale using the implemented virtual mobile measuring tape.

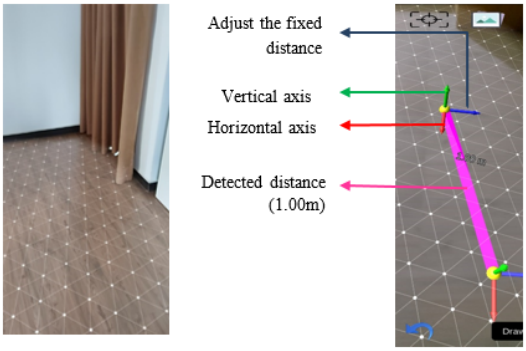

Fig. 6. Test Result of the detected measurement between two points

A. *Testing Real-Time Object Measuring for smaller objects*

The system is tested to measure objects on real-time pictures. After executing minor experimental setups with the help of OpenCV libraries, the tested system was able to nearly achieve 98% accuracy in detecting and measuring a certain object in real-time. Fig.7; presents the detected and visualized dimensions after applying the computer via algorithms on the captured frames.

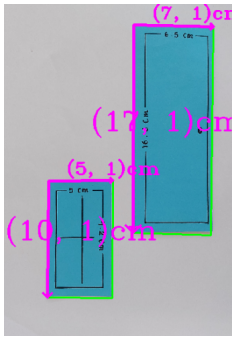

Fig. 7. Test Result of the detected measurement between two points

The system for the furniture suggestion is tested to identify the most suitable furniture according to users' aesthetic perspective and their personality. The furniture suggestion model was processed using the Decision Tree Classifier algorithm. According to Table I, 95% of accuracy was achieved from the resulting categorical data combined to match with the user personality.

TABLE I
TEST RESULT OF THE FURNITURE SUGGESTION MODEL

Function	Algorithm	Accuracy
Furniture Suggestion	Decision Tree Classifier Algorithm	95 %

Wall paint visualizer - The result of the system implemented to provide the number of paint coats needed to paint a wall is identified using a decision tree algorithm in machine learning. Wall paint visualization model were processed using the K-Neighbors Classifier and decision tree algorithm. Results of each algorithm are shown in Table II. According to the results KNN algorithm gives more accuracy than decision tree algorithm which gives 84% accuracy for prediction with the available dataset.

TABLE II
TEST RESULT OF THE ACCURACY CALCULATED FOR THE NUMBER OF COATS NEEDED

Function	Algorithm	Accuracy
Wall Paint visualization	Decision Tree Classifier Algorithm	79 %
Wall Paint visualization	KNN Algorithm	84 %

Furniture placement on an augmented platform is tested to identify the horizontal planes over the detected floor surface. Suggested furniture was positioned and visualized using the identified feature points of the flat surface as shown in fig. 8 and 9.

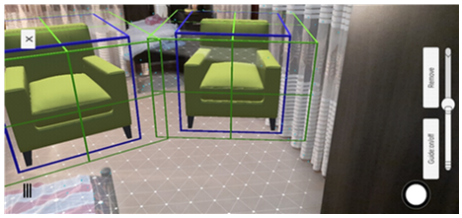

Fig. 8. Furniture that does not violate interior design rules

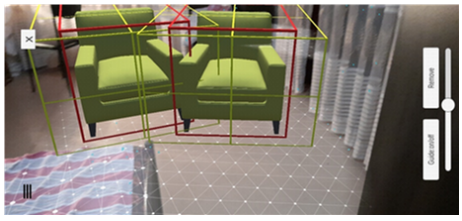

Fig. 9. Furniture that violate interior design rules

Upon all these predictions, combinations, and visualizations, it is also distinguished that this valuable result should have the same and proper idea without any gap between Interior designers and clients to create the best interior design of the house. It is also important to remember that all areas give a safe output. These results can be optimized with better effectiveness and better efficiency by having a realistic organizational data-set.

V. Conclusion And Future Dimensions

AR Interior provides interior designers to plan all designs within a single application. We hope to expand our application to build a system that assists the user to sell furniture, paint, and floor tiles and to partner up with multiple vendors.Future enhancement of this application may include the Virtual Reality(VR) technology. Users can get a comprehensive experience

of a virtually designed and decorated house. Therefore, the outer world can be replaced with a virtual environment with just a tap of a mobile phone and a VR headset to undergo the experience of a well-designed interior.

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