

AUGMENTED REALITY KITCHEN DESIGN

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Abstract Kitchen represents a space with great importance for one family. That's why the goal is to have a kitchen with the best possible design. This implies the creation of a kitchen with the best possible organization, maximal space usage and aesthetic appearance in accordance with the owner's taste. The traditional kitchen design process assumes the use of professional services, such as an interior designer or architect. The kitchen design process consists of several steps:

- Space measurement and initial design discussion;
- 2D / 3D design;
- Design evaluation;
- Technical drawing creation.

Professionals in the design phase use different manual and digital tools and software. Precise kitchen space measurement is done in a family home using measurement tools. Design discussion has a goal of understanding the homeowner's taste and desire for the kitchen appearance and functionality. Based on discussion and measurements, the designer creates first kitchen visualizations in the form of sketches, 2D images, or 3D models. This design is then discussed with the homeowner and readjusted several times until the final version. This final version is then used for the creation of technical drawings that are used for kitchen assembly.

The evolution of contemporary devices and computer graphics lead to the development and adaptation of Augmented Reality in design. Augmented reality (AR) is an emerging computer technology where the perception of the user is enhanced by the seamless blending between a realistic environment and computer-generated virtual objects coexisting in the same space. The resulting mixture supplements reality, rather than replacing it.

In this paper possibilities for Augmented Reality use in the kitchen design process are investigated. Analysis and comparison of currently available, state of the art solutions for Augmented Reality kitchen design are performed. State of the art in the field of AR space measurement, AR 3D model presentation, and AR kitchen design are investigated. Analysis of currently available solutions for Augmented Reality kitchen design is performed and compared.

Keywords: Kitchen design; augmented reality; computer graphics; visualisation.

1. INTRODUCTION

Kitchen represents a space with great importance for one family. That's why the goal is to have a kitchen with the best possible organization, maximal space use, and aesthetic appearance in accordance with the owner's taste. In order to meet these criteria, homeowners in most cases decide to create a fully custom-made kitchen [18]. This requires many elements disposition rules to be respected in order to get a functional kitchen [18].

The traditional kitchen design process assumes the use of professional services, such as an interior designer or architect. The kitchen design process consists of several steps:

- Space measurement and initial design discussion;
- 2D / 3D design;
- Design evaluation;
- Technical drawing creation.

Use of interior designer services for 360cm length, I-shape kitchen can be 30 days long process (Figure 1). The process starts with the first meeting between the homeowner and interior designer, space measurement, and design discussion. Based on homeowner preferences and dimensions, designer creates 2D drawings and 3D visualizations using architectural software's such as AutoCAD, SketchUp or 3D max. Created kitchen design is then evaluated by homeowners and usually redone a couple of times until final approval. The final design is then transformed into the kitchen project, which includes detailed technical drawings with a list and quantity of all parts and equipment needed for kitchen assembly.

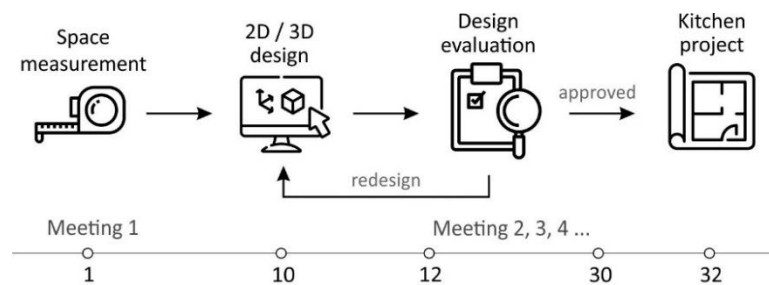


Figure 1. Process of custom made kitchen creation.

The current process of custom-made kitchen design is time-consuming, project completion timing is usually extended and budget surpassed because of two main challenges:

- Miscommunication between homeowner and designer results in multiple redesigns and a high level of stress;
- Need for prior knowledge for the use of complex 2D drawing, 3D modeling, and visualization software.

Solution for miscommunication can potentially be found in the application of Augmented Reality for kitchen design. Augmented Reality (AR) is an emerging computer technology where the perception of the user is enhanced by the seamless blending between a realistic environment and computer-generated virtual objects coexisting in the same space [14]. The resulting mixture supplements reality, rather than replacing it [1], making it possible to supplement real space with a digitally created 3D model of kitchen. Augmented Reality enhances a user's perception of and interaction with the real world [17].

Augmented Reality allows intuitive presentation and manipulation of 3D models in a real environment. The use of Augmented Reality for kitchen design has the potential to bring new tools

and possibilities for professionals. Intuitive use of Augmented Reality applications also allows everyday customers with average knowledge of smart device used to design a kitchen on their own.

There is plenty of research addressing the topic of interior design using Augmented Reality [8, 12, 13, 19, 22, 25, 26, 30]. There are different approaches to the topic, one group of authors investigates the application of AR in renovation planning [23, 24]. Another group use AR to visualize building and construction projects [4, 30]. Some authors investigating the specifics of mobile Augmented Reality for interior design [10] or application in education [6].

Recently AR furniture arrangement systems help users overlay virtual furniture onto the real world. Such systems allow people to see how the room will look with new furniture without actually buying or moving real furniture [28]. The majority of existing Augmented Reality applications are providing placement and preview of 3D furniture models in the interior. These applications are limited to provide furniture (e.g. table, chair, etc.) without the possibility to present custom made furniture (e.g. closet, kitchen, etc.).

In this paper possibilities for Augmented Reality use in the kitchen, the design process is investigated. State of the art in the field of AR space measurement, AR 3D model presentation, and AR kitchen design are investigated. Analysis of currently available, solutions for Augmented Reality kitchen design is performed and compared.

2. AUGMENTED REALITY SPACE MEASUREMENT

The process of custom-made kitchen design as one of the first steps requires precise space measurement. In order to measure existing space using Augmented Reality different approaches can be implied [7].

The simplest approach assumes the use of AR tape measure (Figure 2) which uses Augmented Reality technology and a smartphone camera to visually detect space and tape measure the real world. This approach allows users to replicate the same procedure as in the case of manual space measurement using tape, just in this case on a smartphone. The advantage comparing to the traditional approach is faster and easier measurement, especially in the case of hardly reachable parts of the space. The disadvantage is the precision of AR scene tracking, which can result in incorrect real space dimensions. This approach required the same steps and measurement one length at the time and manual sketching of geometry. Comparing to traditional, this AR approach can be a little bit faster, but less precise.



Figure 2. AR tape measure [2].

More advanced approaches to the space measurement assume use Augmented Reality technology and smartphone camera to visually detect space and create a simple 3D model of the space (Figure 3). In this approach, user draw lines on the floor to mark the edges of the room and then extrude created shape to the height of ceiling inside AR. The next steps allow marking of additional details of the space such as doors and windows. The end result of this process is a 3D model of the space with all measurements which further can be exported and used in software for 2D drawing and 3D modeling. This approach is faster than traditional and AR tape measurement and requires less time for complete space measurement. It has some technical limitations as AR tape measurement regarding precession due to visual AR space tracking.

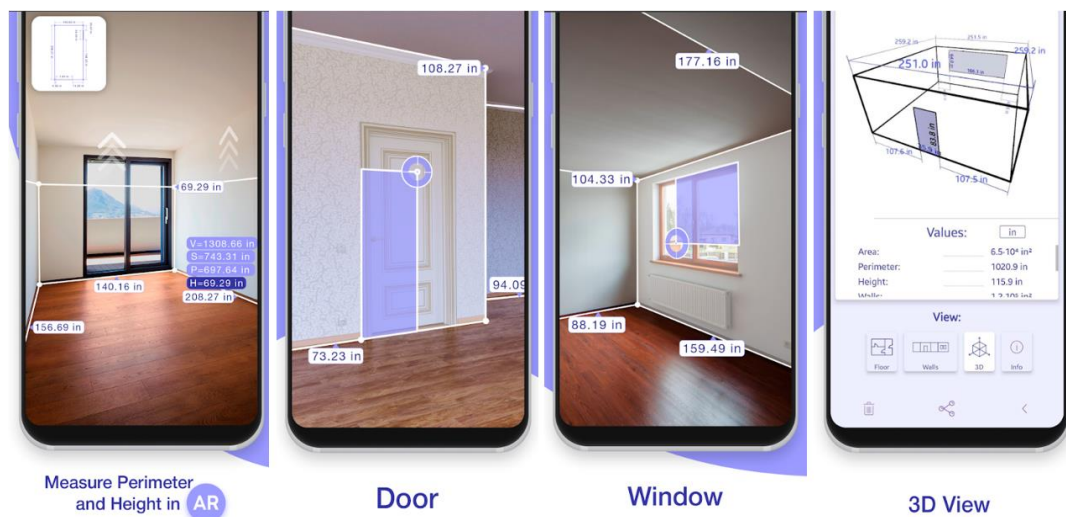


Figure 3. AR 3D space modelling [5].

The most advanced approach to the space measurement use Augmented Reality technology and smartphone TOF camera for space detection and virtual reconstruction (Figure 4). In this approach smartphones or tablet with TOF camera is used to scan and create a precise virtual 3D model of existing space (Nguyen, et al., 2018). This 3D model is then used for measurement of needed distances or export to the 3D modeling software. This approach is more precise and faster than AR tape measurement and AR 3D space modeling. The downside of this process is a need for a special device equipped with a TOF sensor, which is not widely present in smart devices.



Figure 4. AR space capturing using TOF camera [16].

3. AUGMENTED REALITY INTERIOR DESIGN

Every interior space has a certain design, some simple and some complex. The design is created for the purpose of coordinating with the rules and technical regulations on construction and aesthetic appearances. The interior design is a trade dealing with creative and technical aspects of the creation of arranging interior space (Kymalainen, et al., 2012). The generally accepted method of presentation of the architectonic design of interior comprises the production of a design, which contains the 3D presentation of space. As architecture is dealing with the modeling of the actual world, the Augmented Reality is becoming an increasingly used method of design presentation (Pejic, et al., 2014). The application of augmented reality in the interior design can be with the goal of:

- Finished design presentation (Figure 5). This is applicable in the case that design and 3D models are done in some of the software such as SketchUp or 3D Max and then imported into the software for Augmented Reality presentation.



Figure 5. AR finished design presentation [9].

- Creation of design in real-time (Figure 6). This assumes the use of specially developed Augmented Reality based applications that allows interior design in real-time inside real space.



Figure. 6. AR real time interior design [29].

4. AUGMENTED DESIGN EVALUATION

Design evaluation represents an important step in the process of interior or kitchen design. In kitchen design, evaluation assumes presentation of kitchen 3D model to the owner in order to approve or request an additional correction in order to fit his requests. Presentation of final 3D models in Augmented Reality can be performed in two ways dependently of scale:

- In a small scale (Figure 7-a).
- In a 1:1 scale (Figure 7-b).

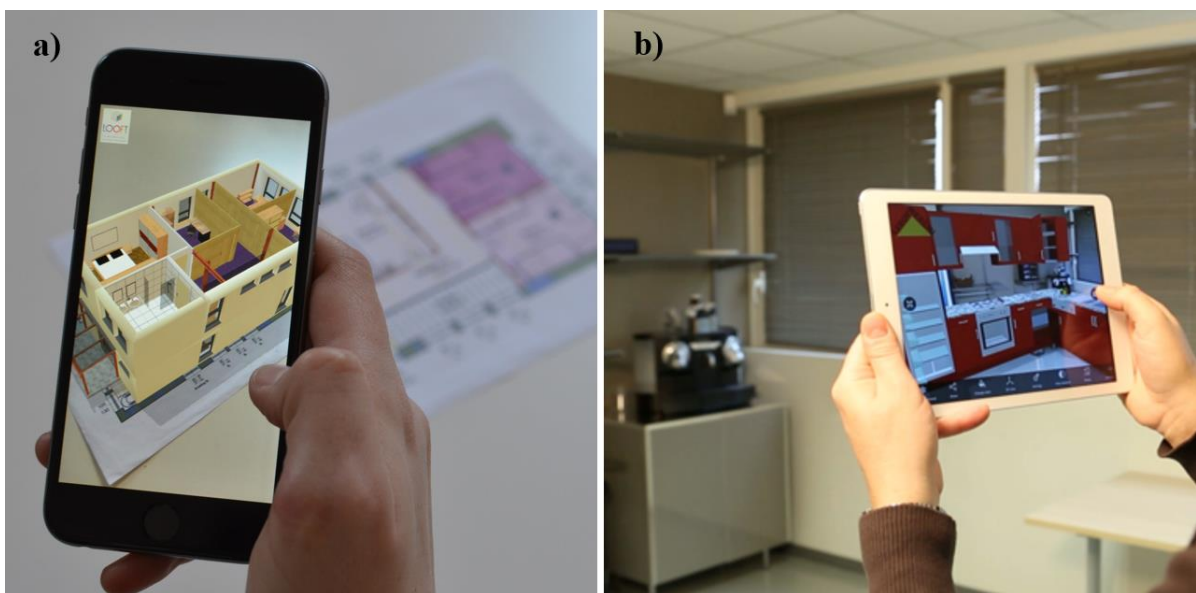


Figure. 7. 3D model evaluation in: a) small scale [3] and b) 1:1 scale [11]

5. RESULTS AND DISCUSSION

Traditional custom-made design requires a lot of time, previous knowledge, and experience in order to finalize the process. It requires a lot of digital 2D drawing and 3D modeling skills in order to transform kitchen design discussion and measurement of space into kitchen visualization. To reach a final design couple of meetings between homeowners and designers are needed because of common misunderstandings resulted from miscommunication.

Augmented Reality kitchen design has the potential to allow a much faster design process, due to intuitive use and a higher level of process automation. In theory, kitchen design can be performed on the first meeting between homeowner and designer, presenting and live designing a kitchen using 3D Augmented Reality. This can remove the possibility of misunderstanding because the homeowner takes part in the process of 3D modeling and can see the final kitchen design on the spot inside his home using AR.

Analysis of currently available android and iOS applications (Table 1) for smartphones and tablets does not show an existing solution that allows complete Augmented Reality kitchen design.

Table 1. Comparison of available smartphones and tablets applications for AR kitchen design.

Application name	Kitchen design	Space measurement	Space design	Design evaluation	Platform
<i>Kitchen planer 3D</i>	Yes	Manual	3D	3D	Android
<i>Kitchen design</i>	Yes	Manual	3D	3D	Android
<i>Kitchen design pro for Ikea</i>	Yes	Manual	3D	3D	Android/iOS
<i>Cambria AR</i>	Partly	AR Distance	AR	AR	iOS
<i>5D</i>	-	Manual	3D	3D / VR	Android/iOS
<i>Houzz</i>	-	-	AR	AR	Android/iOS
<i>Roomle 3D & AR Room planer</i>	-	-	AR	3D / AR	Android/iOS
<i>Augment</i>	-	-	-	AR	Android/iOS
<i>AR Ruler</i>	-	AR Distance	-	-	Android/iOS
<i>Measure (by Google)</i>	-	AR Distance	-	-	Android
<i>Measure (by Apple)</i>	-	AR Distance	-	-	iOS
<i>AR Plan 3D</i>	-	AR Space	-	-	Android/iOS
<i>Magic plan</i>	-	AR Space	-	-	Android/iOS
<i>AirMeasure - AR Tape & Ruler</i>	-	AR Space	-	AR	Android/iOS
<i>3D scanner for ARCore</i>	-	AR TOF	-	-	Android
<i>3D Scanner</i>	-	AR TOF	-	-	Android
<i>Structure Sensor</i>	-	AR TOF	-	-	iOS

There are available kitchen design applications for Android and iOS smart devices but none of them are AR-based. This application requires user manual space measurement and input using the application interface. Space design and evaluation are performed in 3D on the device screen and their use requires a certain level of experience and previous knowledge. Smartphone application “Cambria AR” allow AR design and evaluation, but it is used only for kitchen countertop design.

On the market, there are available AR solutions for general purpose interior design and 3D model presentation, such as “5D”, “Houzz”, etc. These solutions do not address custom made kitchen design and allow the presentation of previously constructed furniture only. The joint characteristic of this group of applications is that they do not provide any possibility for space measurement.

There are many solutions for space measurement, with different approaches. The first group of applications allows simple distance measurement between two points in space. The second group represents applications that allow all room measurements and require user interaction and manual point of interest marking. The third group allows precise space reconstruction using a device TOF camera. None of these applications provide a possibility for the kitchen or any other space design. Only the “AirMeasure - AR Tape & Ruler” application allows the presentation of 3D models in AR, but they have to be created using some other software.

6. CONCLUSION

This research analyses possibility for Augmented Reality use in the kitchen design process and compares currently available, state of the art solutions for Augmented Reality kitchen design. The augmented Reality kitchen design has great potential compared to the traditional approach, which is much slower, requires a lot of prior knowledge and in most cases results in a misunderstanding between homeowner and designer. As presented, the Augmented Reality applications for kitchen design have the potential to significantly improve speed, make the process more intuitive, and easier to use. Analysis of available smart device applications show solutions for AR measurement, AR design, and AR design evaluation, showing technology readiness for AR kitchen design application. Unfortunately, the ultimate application with all these features integrated does not exist. The reason for this can be a need for a high level of precision during space measurement or the complexity of custom-made kitchen 3D modeling. Future research should be focused on the creation of the demo application that will integrate all mentioned features for Augmented Reality kitchen design.

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