An Augmented Reality Design Tool to Guide Furniture Arrangements at Home

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Home is a place to live and an environment to support and enhance our psychological well-being. Factors such as furniture selection and arrangements can contribute to more harmonized and balanced home environments. Augmented reality (AR) tools have recently gained attention in home interior design due to their competencies and potential in improving and envisioning the experience of living at home. Following Feng Shui principles and iterative prototyping processes, we designed a high-fidelity AR prototype to guide users in making informed decisions about furniture arrangements at home. We then recruited nine participants to evaluate the tool's usability and usefulness. We discuss our preliminary findings on the benefit of the Feng Shui-supported AR design tool for users. We hope this research inspires future development of AR tools with embedded design recommendations for guiding users in advancing their home environments.

CCS CONCEPTS • Human-centered computing → Human computer interaction (HCI) → Interaction paradigms → Mixed / augmented reality • Human-centered computing → Interaction design → Interaction design process and methods → Interface design prototyping

Additional Keywords and Phrases: Augmented Reality, Home Interior Design, Furniture Arrangement, Feng Shui Theory.

1 INTRODUCTION

Home environments are the sources of "comfort, belonging and other psychological richness" [19]. We spend almost one-third of our lives in our homes, so these environments should support our optimal health and experience [19]. Designing home environments requires taking into consideration factors beyond pure function and aesthetics to support our comfort and emotional wellbeing [30]. In the absence of professional designers, people face challenges to make informed decisions about their living space, such as the size, fit, and arrangement of objects and furniture [23]. So, it is essential for home habitants to use/follow guidelines to make informed decisions about choosing, planning, and arranging items at home.

Studies in interior design have shown that furniture choice and arrangement can somewhat affect comfort living and improves the emotional well-being of their habitants [24]. Furniture can take up about 40-50 % of the floor space so should be well-positioned in a room layout [28]. The right combination of pieces of furniture provides a balanced look and feel to an environment [12]. One of the guiding principles with reference to historical building and environmental science is known as Feng Shui. The term Feng Shui began to appear frequently in popular interior design periodicals in the early 1990s [13]. The literal translation of Feng Shui literally is 'wind and water' which is defined as "the art and science of designing harmonious environments based on the profound Chinese understanding of how people are connected to and affected by their close surroundings" [1]. Though Feng Shui philosophy originated in East Asia, it also has remarkable

influence in the West; many Feng Shui theories aligned with western beliefs which also provide design guidelines to modern designers [17]. Despite the use of modern interior design principles, the Feng Shui principles are still commonly used in architectural studies to guide designers in making better use of their living spaces [13]. While many well-known design principles for architecture and interior design are mostly focused on principles of functionalism, Feng Shui adds feeling as an additional dimension, inviting users to reflect on their emotional connection with a place [1]. The philosophy behind Feng Shui encourages design conditions that favor a living design tenet, implying room for growth, change, and flexibility within an environment [16]. Also, Feng Shui can provide suggestions on addressing cluttered homes to bring a good mood and optimize habitants' wellbeing [13].

Augmented reality has the potential to support envisioning the most appropriate home arrangement scenarios by visualizing objects' relations in the space. AR can enhance users' perception and boosts the sense of reality by superimposing virtual items over the real-world environment in real-time. Previous research into the use of AR in domestic environments demonstrated high potential for deploying AR systems in homes [10], [14], and several applications have already been explored or developed for improving the experience of living at home. For example, a recent study illustrated the benefit of AR visualizations in enhancing people's knowledge and awareness about domestic technology in their homes by offering intuitive interaction mechanisms with items [4], [5]. An augmented kitchen with overlaid projections on objects can facilitate an interesting, safe, and accessible cooking experience, or an augmented home window can display information or facilitate personal and family communication [7], [29]. Other studies on AR for homes have examined the customization of interior design, allowing users to model their homes by manipulating (e.g., inserting, moving, and/or removing) 3D virtual furniture through an augmented image of the domestic environment [21], [22] or enabling a couple to explore the furniture design of their living rooms collaboratively [25]. In the 'IKEA Place,' the AR application supports customers' decision-making by allowing them to explore virtual furniture items fit and look in a physical environment [26]. Other styling apps allow object resizing and displaying in real-time to support customization [23]. Despite the novelty of the above-mentioned tools, none of them provide a concrete guideline to users on how to arrange objects and furniture pieces around their home to enhance harmony and balance according to design principles.

2 METHDOLOGY

2.1 Survey

We created and distributed a survey to gain insights into how people view the interior design of their current home environment and if they were familiar with existing AR tools. There was a total of 19 questions in the survey of which 16 of them were multiple choices with three open-ended questions. Participants were above 18 years old and living in the US. The survey question included multiple choice, ranking, and open-ended questions. We initiated the survey by collecting demographic information followed by asking about their satisfaction with current living spaces and their opinion on factors contributing to elevating interior design. We collected a total of 107 responses, of which 82 were valid. 38% of participants were homeowners and 62% were renting. Participants shared furniture arrangement (15.95%), choice of color (15.70%), and lighting (15.19%) as three primary factors in the interior design of their home. Most participants stated (85.36%) that they would prefer to design their home interiors themselves or with the help of family/friends. Only 10.98% of participants stated they would recruit professional interior designers. Participants shared their insights on the importance of furniture placement and associated strategies: "*furniture choice and placement play a major role in my home, but I don't know how to do it*" and "*without good functionality and arrangement, the space doesn't feel calming*." Only 20.73% of participants were familiar with AR technology for interior design and tried them before.

2.2 Augmented Reality Prototyping

2.2.1 Design specifications for AR tool

The primary purpose of the tool is to guide people's strategies for placement and arrangement of furniture at home based on the Feng Shui method. We developed and considered a set of design requirements, to enable and support users: 1) choosing/viewing different types of 3D models of furniture pieces from the menu; 2) superimposing the desired furniture onto a physical environment; 3) adjusting the model's scale and direction in the environment, and 4) learning how a specific Feng Shui principle can be applied in placing or arranging the selected piece of furniture.

2.2.2 Furniture pieces and guideline included in the AR tool

We identified several furniture models to be included in the AR application based on Feng Shui definition and guidelines. We included six different types of furniture in the prototype as described below:

Sofas. are furniture pieces usually placed in the living room for family gatherings. Feng Shui guideline suggests placing sofas with a wall behind them as a means to convey the feeling of protection [20]. When seated, people should be able to see the entrance to the room, which is called the "command position" [8]. We provided this guideline as applied to straight, L-shape, and high-back sofas in the application.

Coffee tables. are centerpieces in living rooms, which can be placed together with sofas and side chairs. Feng Shui guideline suggests arranging seats and the coffee table facing the entryway of the room [18]. We included two different types of coffee tables (rectangular & oval) and provided associated placement guidelines in the application.

Wall arts. Wall decoration, including artworks, photos, or sculptural pieces, are the most common ways to decorate environments. They bring inspiration and creative energy to shift and enhance the home environments [9]. Feng Shui suggests careful considerations in choosing and placing wall arts.

Dining tables. as the focal point of dining rooms, they support family gatherings and sharing food. Feng Shui suggests using round tables to create a smooth and gentle flow of 'chi' around the room and provide equality in the placements of seats around the table [27]. To lessen the disturbance of energy flow by sharp edges of rectangular tables, Feng Shuis suggests using rounded shapes and objects in the rest of the room [15]. We considered both types of tables in the application.

Beds. bed placement is critical in supporting peoples' comfort and privacy in bedrooms [20]. Feng Shui theory suggests a concrete guideline for proper placement of bed pieces, such as "bed should not be placed in line with the door, which can make people restless and vulnerable to the surprise of unexpected visitors" [30].

Green plants. Plants are essential items to create a positive flow of energy in the home environment. They act as natural air filters, provide good 'chi' and increase the life energy at home. The appropriate placement of plants in corresponds to a specific space is critical [11]. Feng Shui suggests a few places to put indoor plants including the entry hall and living room to support creating a lively and welcoming space for living.

2.2.3 Processes

We created the AR prototype using Apple's ARKit 5, Reality Composer. This software allows developers to create interactive augmented reality experiences with 3D models. Users could view and place objects directly in the environment, moving or scaling the virtual object on their device. We implemented and ran the AR prototype on iPad and iPhone, which was also used later for usability tests.

For each furniture piece, we included a general introduction on the top of each model and a simple interface on the right side to choose among different types of furniture. Using 'sofa', for example, users can tap the button to switch between each type of sofa in augmented mode (Figure 1). Additionally, we included an interface to introduce and guide users on the placement of each specific piece of furniture according to Feng Shui principles. Users can click on the description button to collect more information on recommended Feng Shui principles. We also included a 'hide all' button. This function allows hiding descriptions for those users who would prefer to further explore/view a furniture model in a physical environment. In addition to providing suggestions on furniture placements, we provided information on choosing furniture material and hanging wall arts according to the Feng Shui theory

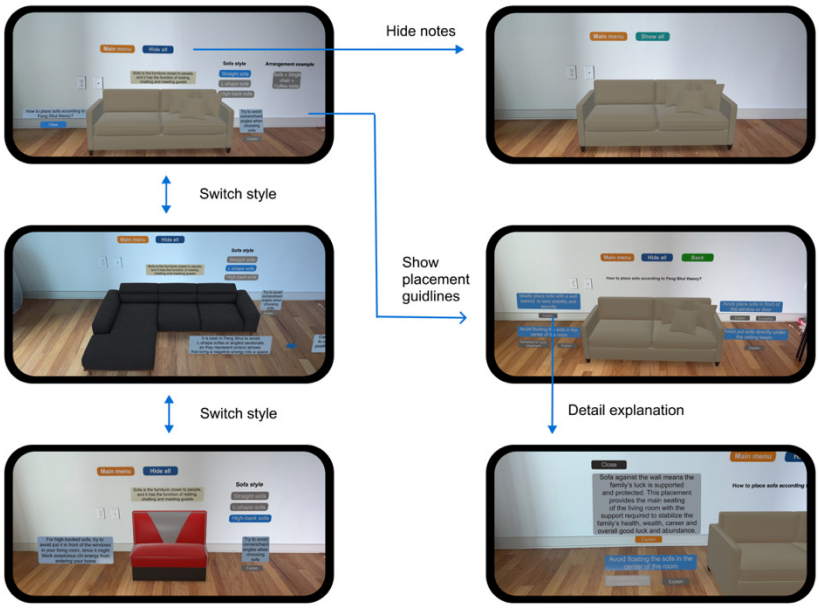

Figure 1. Interface design example of different types of sofas in augmented mode.

The tool allows users to freely scale or rotate a furniture piece model in the AR environment to enhance the AR experience. After we defined and integrated all primary features into the tool, we iterated on the current prototype by adding recommended 'furniture combination' to provide a guideline on ideal arrangements of furniture pieces according to Feng Shui theory. Users can choose furniture pieces and view the combination in the AR tool to better understand the Feng Shui theory application in a combined furniture setting (Figure 2).

Figure 2. Interface design example of combined furniture settings.

2.3 User studies

2.3.1 Participants

We recruited a total of nine younger adults (F=6, M=3) to evaluate the usability and usefulness of the proof-of-concept AR prototype. Five participants were graduate students, two studied at the undergraduate level, and two were full-time employees. Participants had no prior knowledge or experience with home interior design and associated AR tools (except one who used an AR application). Two out of nine participants had limited knowledge and the rest had no prior knowledge about the Feng Shui theory. Participants were recruited via an e-mail list, and they were invited to a design lab at Georgia Tech's School of Industrial Design to test the AR prototype. The Institutional Review Board (IRB) at the Georgia Institute of Technology oversaw and approved the study. Each participant received a $25 honorarium to compensate for their time and appreciation for their participation.

2.3.2 Procedure

We conducted in-person user study sessions with nine participants. The data collection methods included 1) think alouds; 2) interview sessions, and 3) SUS surveys to collect data on the usability and usefulness of the tool. There was also an optional take-home assignment for those who were interested in exploring the tool further in their home environment.

We initiated the session by introducing the purpose of the AR tool followed by providing an opportunity for participants to explore the prototype features. Participants were given enough time to learn about the prototype. Participants were allowed to walk around the testing area to explore the prototype and were asked to arrange and superimpose the 3D furniture models in a real environment. We encouraged participants to think out loud while using the prototype and share their thoughts or concerns. We also asked participants to read the associated quotes with each piece of furniture to get familiar with the Feng Shui guideline while they were exploring each furniture piece in the real environment. This step enabled us to observe users' challenges and learn about their mental models while they were interacting with the AR tool.

After the think-aloud session, we conducted an interview session to collect more data on the AR tool's usability and usefulness. We initiated the interview by asking participants about their overall experience with the AR tool and encouraged them to express their opinion about the tool's features that they liked/disliked most. Participants also commented on the tool's usefulness in furniture selection and arrangement and if the tool enhanced their knowledge of Feng Shui theory. The second part of the interview focused on the participants understanding of the Feng Shui theory. We provided participants with a case study of two-room layouts with inappropriate furniture arrangements and asked them to identify any improper placements and describe their design decisions to improve the environment based on the Feng Shui principles. In the end, participants were asked to fill out s SUS survey to evaluate the usability of the tool.

The optional follow-up take-home task aimed to explore the tool's usefulness further outside the lab and in participants' homes. We installed the prototype on three participants' devices who were willing to explore the application to explore/adjust their current furniture selections and arrangements. We used open coding and affinity clustering to analyze the qualitative data and identify recurring patterns in participants' responses to emerging themes/categories.

2.3.3 Findings

We calculated the average mean of answers provided to each question in the SUS survey result. The overall SUS score is 83.61 which falls above the standard satisfaction SUS grade. As shown in Figure 3, P2 and P5 rated the highest score, as they reflected in their experience in the think-aloud session. P2 who had prior familiarity with the Feng Shui theory shared positive feedback on his experience of using the prototype and stated, "*After learning from this tool, I felt like I need to*

take more considerations about my own home arrangement, I would also recommend it to my friends and family." On the other hand, P6 rated a slightly lower score and said, "*This tool provided a good example of what's the proper way to achieve a balance living environment, however, Feng Shui is new to me, I need to take longer time to learn the reason behind each arrangement*."

Survey Questions	P1	P2	P3	P4	P5	P6	P7	P8	P9	Avarage
I think I would use this tool	4	5	4	5	5	5	5	5	4	4.78
I thought the system is not complex to use	4	4	4	5	5	4	5	5	5	4.67
I found this tool is easy to use	4	4	4	4	4	4	4	5	4	4.33
I was able to learn quickly from this tool	4	5	4	4	5	4	4	4	4	4.33
I thought functions in this tool is well integrated	3	5	5	5	5	4	4	4	4	4.33
I thought the design of the tool is consistent	4	5	4	5	4	5	5	4	4	4.67
I would imagine most people learn to use this tool quickly	4	5	4	4	5	3	5	4	4	4.33
I'm satisfied with the function of this tool	4	5	4	5	5	4	4	5	5	4.44
I felt confident using this tool	5	5	5	5	5	4	4	5	5	4.78
I do not need to learn a lot of things before I could going with this tool	5	5	5	5	5	3	5	5	5	4.78

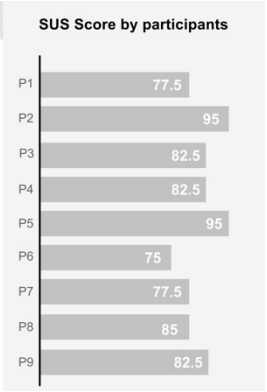

Figure 3. SUS survey questions and results.

Most participants were satisfied with the AR tool's experience and shared the value of the tool in providing a guideline and visualizing furniture arrangement possibilities in their living environment. P6 mentioned, "*What I learned helped me to find a balance in trying to achieve a better environment in my apartment*." P5 also shared his thoughts: "*I never knew and thought how to place furniture, since I usually buy first and then place it, but this helps me think more about the placement*." Most participants also mentioned that the tool enhanced their knowledge of Feng Shui theory and their awareness of the importance of furniture selection/placement at home. Interestingly, P2 who had prior knowledge about Feng Shui, stated that the integration of the theory into the AR technology further advanced his knowledge: "*the way Feng Shui integrated into the prototype enhances my understanding about the way of using Feng Shui in real design cases which is helpful."* Several participants expressed their insights about the advantage of observing Feng Shui theory along with furniture models, which enabled them to explore the tool and familiarize themselves with the potential furniture arrangements in an environment. They also appreciated the option of viewing different styles of the same furniture. Moreover, most participants shared positive responses on providing options to freely move, scale, and position furniture models in the AR environment; P9 stated that "*the way in which I can freely move, and scale furniture model is beneficial in terms of how easily I can view the placement*." Several participants mentioned that they favored the 'furniture combination' mode to get a better understanding of the arrangement. As P6 stated, "*the sofa, chair, coffee table combination was a good example of showing the proper way to arrange my living room*." Participants found the AR tool helpful in detecting improper furniture arrangements in their current room as they shared through the drawing exercise. As P1 described: "*My bed was placed at the corner of my bedroom, but from what I learned, I think I would move the bed to the right a bit and allow space for the nightstand. I would move the tall plants to the living room as well*." Likewise, P8 stated: *"Most of the tables in my home have sharp edges and now I know those are bad in Feng Shui. I would like to consider using more rounded tables in my living room and dining room."* P7 stated that theories about 'plants' and 'wall

art' benefit him the most: "*I have over ten plants in my apartment. These are small pieces which I move often, so I consider more about their placement at home*."

Three out of nine participants (P2, P4, and P5) took the take-home assignment to explore the prototype on their own devices at home. All participants shared positive feedback about the experience of using the prototype in real home environments. As P5 said, "*using this tool in a real home is different from what I feel during the study session; I am able to check and see how the furniture looks at my home*." P4 also stated, "*I am now able to see how plants look in my living room and where I should place them.*" P2 also stated that "*One of the major differences from what I felt in the user testing session is that I pay more attention to the 'south/north' direction settings at my home. I consider my housing situation at the same time when I tried to learn from this tool.*" Obviously, using the tool in real home environments provided a more realistic and tangible experience for the participants compared to the lab settings. All in all, the AR application has empirically improved participants' knowledge of Feng Shui theory by enabling them to explore and apply the application's features and learning components in real environments.

While the proof-of-concept prototype was satisfactory, participants shared some feedback for further improvement of the tool. For example, P5 mentioned: "*this tool does not provide dimensions and measurement of the furniture model.*" While the option for scaling 3D models was useful in visualizing the overall arrangements, the lack of specific measurement was an issue as P1 stated: "*I like the way it can be scaled; however, when I consider the way of placement, I would like to see its actual size relative to other furniture in my home*." The second issue shared by several participants was the limited option for "*customization of the furniture placement*." A few participants hoped that the future iteration of the tool/guidelines should consider their specific home conditions such as lighting direction.

3 DISCUSSION AND LIMITATIONS

Previous studies have shown AR's potential in enhancing users' perception of ideal interior design by allowing them to explore, envision, and visualize the most appropriate home arrangement scenarios [10], [14], [23]. AR visualizations enhance people's knowledge and awareness about their homes by offering intuitive interaction mechanisms with items [4]. For example, an augmented kitchen with overlaid projections on objects can facilitate a safe and accessible cooking experience, or an augmented home window can display information or facilitate personal and family communication [7], [29]. Nevertheless, the lack of guiding principles in AR technologies can leave the users with no design knowledge and expertise clueless in deciding on how to use these technologies effectively. Despite the unquestionable affordances of AR technologies in envisioning potential design scenarios in the home environment, users may find these technologies less effective and eventually useless in the absence of guiding principles.

Our study contributes to the HCI community by integrating an interior design guideline and associated principles in AR technology and evaluating the benefit of the tool in enhancing users' design knowledge and perceptions. The proof-of-concept AR prototype enabled participants to not only explore the explicit affordances of the AR technology but also enabled them to visualize furniture arrangement scenarios by superimposing 3D furniture models onto their living environment in real time. The integration of Feng Shui theory along with furniture models enabled participants to simultaneously explore and brainstorm furniture arrangement options in real environments. The complementary application features (e.g., moving around, scaling up/down, and positioning furniture models in the actual environment) further enhanced and facilitated the envisioning of interior design possibilities for users.

According to the participants' reflection, the tool guided them in the decision-making of furniture arrangements at home. In real-world scenarios, providing a workable design guideline along with furniture options can support users in visualizing pieces of furniture fit, look, and arrangement in the home environment and envisioning the best design scenarios before

making any purchase. The tool supports users to make better decisions on their home interior arrangement, comfortable living, and aesthetically balanced compositions as essential components for human comfort and well-being [30]. The integration of Feng Shui theory with AR technology can also support designing harmonious living spaces and providing suggestions on addressing cluttered homes to bring a good mood and optimize well-being [13]. Other studies in interior design showed that furniture choice and arrangement can influence comfortable living and can improve the emotional well-being of individuals [24].

Despite the proven benefit of using the Feng Shui theory as a guideline in supporting users in making informed decisions about arranging their interior spaces [13], it should be noted that the theory has been critiqued as a pseudoscience. Nevertheless, the application of this theory in designing the proof-of-concept AR technology illustrated a practical example of how design guidelines can be embedded in AR design tools to lead users' decision-making. Future studies can be conducted to explore the integration and deployment of other more contemporary interior design principles in AR systems to provide effective solutions to users who are willing to improve their living space for better comfort in the absence of professionals [10], [14]. Integrating and providing comprehensive design guidelines in AR technologies can improve built environments beyond the interior design principles of functionalism, i.e., in assessing and designing more accessible environments to support the health and well-being of individuals living with health conditions and disabilities. For example, AR tools can support and advance real-time assessment of home environments to detect and prevent falls in the elderly [6] or to modify home environments for people with disability by occupational therapists [3], [2].

Our study has some limitations. For example, seven out of ten participants in the user study were college students and did not own their homes; therefore, they were less concerned, involved, and aware of interior design challenges. Additionally, our user study was conducted in a studio space to facilitate the study setup and provide a convenient location for participants. However, the studio space was less of an ideal environment for envisioning furniture placement due to the differences in the studio and home space configurations and layouts. In the future study, we plan to recruit design professionals and homeowners to further explore the AR design tool in professional design practices and in real home settings.

4 CONCLUSION AND FUTURE WORK

In this study, we developed and evaluated an AR design tool to envision furniture selections and arrangements for living spaces. The AR application provided Feng Shui guiding components and 3D visualizing models to enable users to simultaneously explore, envision, and apply design principles in organizing furniture items in living spaces to improve their livability. The findings from the user study revealed the AR tool's benefit for users by providing a practical guideline for enhancing their home interior design. More specifically, the proof-of-concept prototype revealed the need and potential application of AR technologies that embedded design guidelines to better support users with no/limited design background. The future iterations of the AR tool should include actual measurements and dimensions of the furniture model to allow for better design perceptions. We plan to provide more design principles such as color harmony and interior design styles on the menu page for better customization of furniture models. These iterations would make the AR tool more comprehensive and provide realistic visualizations of items in a physical environment.

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REFERENCES

[1] Ahmadnia, Hourakhsh, Majid Gholizadeh, Mahdi Bavafa, and Rokhsaneh Rahbarianyazd., "Art of Feng Shui and its Relationship With Modern Interior Design," 2017.

[2] Aoyama, Hiroo and Leila Aflatoony, "HomeModAR: A Home Intervention Augmented Reality Tool for Occupational Therapists.," *Ext. Abstr. 2020 CHI Conf. Hum. Factors Comput. Syst.*, pp. 1–7, 2020.

[3] Aoyama, Hiroo and Leila Aflatoony, "Occupational therapy meets design: An augmented reality tool for assistive home modifications.," *Int. ACM SIGACCESS Conf. Comput. Access.*, pp. 426–436, 2020.

[4] Bellucci, Andrea, Paloma Diaz, Alvaro Montero, Ignacio Aedo, and Pablo Lopez Coya., "'See with the app's eyes what your real eyes cannot see': design potentials for Mobile Augmented Reality at home," in *In Proceedings of the 2022 International Conference on Advanced Visual Interfaces*, 2022, p. 105.

[5] Bhatt, Tuhin, "How AR is revolutionizing the world of interior design," 2021. https://arpost.co/2021/11/13/augmented-reality-interior-design/

[6] Lo Bianco, Michael, Sonja Pedell, and Gianni Renda, "A Health indus¬try perspective on augmented reality as a communication tool in elderly fall prevention.," *ACM Int. Conf. Proceeding Ser.*, 2016, [Online]. Available: https: //doi.org/10.1145/2996267.2996268

[7] Bonanni, Leonardo, Chia-Hsun Jackie Lee, and Ted Selker, "CounterIntelligence: Augmented Reality Kitchen.," *Assoc. Comput. Mach. (ACM).*, 2004.

[8] Cheung, Victor, "27 Feng Shui Living Room Tips & Rules: Location, Design, Furniture, and Items," 2018. https://fengshuinexus.com/feng-shui-home/feng-shui-living-room-tips-rules/

[9] Cho, Anjie, "Feng Shui tips for selecting and placing art," 2021. https://www.thespruce.com/how-art-can-attract-good-energy-1275343.

[10] Colley, Ashley, Juho Rantakari, and Onna Häkkilä., "Augmenting the home to remember - Initial user perceptions.," *UbiComp 2014 - Adjun. Proc. 2014 ACM Int. Jt. Conf. Pervasive Ubiquitous Comput.*, 2014, [Online]. Available: https://doi.org/10.1145/2638728.2641717

[11] Gaumond, Andrew, "How AR is revolutionizing the world of interior design," 2021, [Online]. Available: https://www.petalrepublic.com/best-feng-shui-plants-living-room/

[12] Habel, Katherine L., *Furniture arrangements*. 1980.

[13] Kiehl, Kathryn A., "FENG SHUI: THE USE AND VALUE OF FENG SHUI IN INTERIOR DESIGN IN NOTHERN OHIO," 2005.

[14] Knierim, Pascal, Paweł W. Woźniak, Yomna Abdelrahman, and Albrecht Schmidt, "Exploring the potential of augmented reality in domestic environments," 2019. [Online]. Available: doi:https://doi.org/10.1145/3174910.3174930

[15] Lagodinsky, Victoria, "8 FENG SHUI STEPS TO MAKE YOUR DINING ROOM A HAPPY SPACE," 2014, [Online]. Available: https://nourishbooks.com/8-feng-shui-tips-for-your-dining-room/

[16] Lynch, Erin S., "Feng shui as a site design tool: Assessing conditions of human comfort in urban places," *Univ. Arizona*, 2003.

[17] Mills, James E., "Western responses to feng shui," pp. 71–77, 1999.

[18] Nicholson, Alix., "10 feng shui tips for your living room," 2021. https://www.bhg.com.au/top-10-feng-shui-tips-for-your-living-room

[19] O'Rourke, Sheila M, "Designing Deeper: Creating Interior Spaces that Support Well-Being through Explorations in Process Driven Design," *ProQuest Diss. Theses*, p. 139, 2017, [Online]. Available: https://search.proquest.com/docview/1994187962?accountid=45153

[20] Painter, Sally, "Is Placing a Couch in Front of a Window Good for Feng Shui?," 2022. https://feng-shui.lovetoknow.com/feng-shui-home/is-placing-couch-front-window-good-feng-shui

[21] Perusquía-Hernández, Monica, Hella Kriening, Carina Palumbo, and Barbara Wajda, "User-centered design of a lamp customization tool," 2014. doi: 10.1145/2582051.2582087.

[22] Phan, Viet Toan and Seung Yeon Choo, "Interior Design in Augmented Reality Environment," *Int. J. Comput. Appl.*, vol. 5, no. 5, pp. 16–21, 2010, doi: 10.5120/912-1290.

[23] SANDU, Mihai and Ileana Simona SCARLAT, "Augmented Reality Uses in Interior Design," *Inform. Econ.*, vol. 22, no. 3/2018, pp. 5–13, 2018, doi: 10.12948/issn14531305/22.3.2018.01.

[24] Saruwono, Masran, Nur Farhana Zulkiflin, and Nik Mastura Nik Mohammad, "'Living in living rooms: furniture arrangement in apartment-type family housing.,'" pp. 909–919, 2012.

[25] Shin, Joon Gi, Gary Ng, and Daniel Saakes., "Couples Designing their Living Room Together.," 2018.

[26] Siltanen, Sanni, Virpi Oksman, and Mari Ainasoja, "User-Centered Design of Augmented Reality Interior Design Service," *Int. J. Arts Sci.*, vol. 6, no. 6, pp. 547–563, 2013.

[27] Smart, Brittney, "Feng Shui your dining table," 2017. https://www.homedit.com/feng-shui-dining-table/

[28] Thogersen, K., "Small Spaces Need Smart Solutions Designing Furniture for Small Spaces. Connection With Human Wellbeing," 2017.

[29] Ventä-Olkkonen, Leena, Jonna Häkkilä, and Kaisa Väänänen-Vainio-Mattila, "Exploring the augmented home window-user perceptions of the concept.," *ACM Int. Conf. Proceeding Ser.*, 2014, [Online]. Available: doi:https://doi.org/10.1145/2677972.2677994

[30] Wang, Chen, Wan Thing Hong, and Hamzah Abdul-Rahman., "Architectural examination on Feng Shui Bedroom.," *Open House Int.*, 2018.