The 3D Digital Guiding of the BNCT Therapeutic Room Based on Gaussian Splatting

Jui-Ching Kuo*, Yu-Chun Hsiao*, Shang-Hong Lai†,and Shun-Chi Wu‡
*Interdisciplinary Program of Nuclear Science, National Tsing Hua University, Hsinchu, Taiwan
†Department of Computer Science, National Tsing Hua University, Hsinchu, Taiwan
‡Department of Engineering and System Science, National Tsing Hua University, Hsinchu, Taiwan
*Contact: rosieeee321@gmail.com or yuchunhsiao123456789@gmail.com

Abstract—**The THOR is the only site in Taiwan where Boron Neutron Capture Therapy is conducted. Despite this critical medical role, it has been misunderstood due to its nuclear-related background. To give a better introduction to the patients, public, and researchers, we utilized Gaussian Splatting to reconstruct part of the indoor environment and designed a game to teach users with an expert virtual guide, which demonstrates the potential to reduce communication barriers for nuclear-related facilities like the THOR.**

I. Introduction

The THOR(Tsing Hua Open Pool Reactor) on the National Tsing Hua University campus has served as the key facility for nuclear science research for several years. Recently, it has transitioned to the only site in Taiwan where Boron Neutron Capture Therapy (BNCT) [1] is conducted.

Even though it stood in such a critical position in both academic research and medical treatment, the association with radiation and numerous restrictions brought a magical veil and the related problems. Not only the individuals in Taiwan had a negative misunderstanding about it [4], but patients who needed to use BNCT also felt more anxiety [1]. Additionally, the visiting researchers must overcome the regular barriers to design their experimental procedure. These three issues raised us to ask:

RQ1: How can we utilize kind of introduction about THOR to enhance public understanding and alleviate negative misconceptions?

RQ2: What strategies can be employed to inform patients about the treatment as detailed as possible to reduce their psychological burden?

RQ3: How to minimize the geographical and procedural obstacles to promote academic accessibility

II. Related Work

In response to the three issues, we decided to use 3D digital guiding to solve the problems.

Nowadays, the integration of 3D construction into digital guiding had become significantly prevalent. The success of Google Earth and Google Culture also proved the feasibility of introducing a site through internet.

In most of these systems, there is a virtual guide with human figure served as the digital agent to provide designed information. Research showed that the number of digital guides could be distinguished by the purpose. Single one gave the best performance to create an immersive environment, while multiple avatars were preferred to exploring larger spaces. [2], [5]

On the other hand, the personalized chat interactions and guiding topics could also improve user engagement to enhance user experience, learning, and satisfaction. [3], [8]

[1]Boron Neutron Capture Therapy (BNCT) is a radiation science that selectively aims to treat tumor cells sparring the normal cells using Boron compound [7]

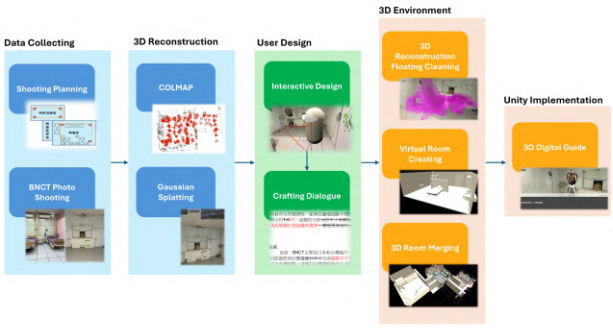


Fig. 1: The flow chart of our project processing.

III. Methods and Designs

We designed and made a project focused on the therapeutic room of BNCT in the THOR reactor, by developing a 3D reconstructed internal space tour. The flowchart in Figure 1 illustrates the project's design and development process.

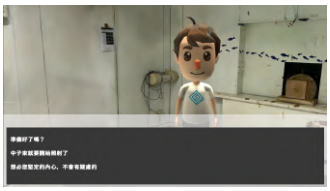
A. Data Collection and 3D Reconstruction

To reconstruct the whole space, the images were collected from four non-contiguous rooms separately. In each room, we capture the photographs along the edges. At each fixed position, the upper, middle and lower sections of the BNCT directly in front were captured. Additionally, taken at the corners of each room to include both adjacent walls in a single photograph, ensuring comprehensive coverage of the structure. After collecting images from each rooms, we used

(a) Free movement mode

(b) Irritation mode

(c) Educational guiding



(d) Recovery guiding

Fig. 2: User perspectives from our interactive tour.

COLMAP to obtain the camera positions and generate discrete point clouds. Finally, Gaussian Splatting [6] was applied to reconstruct each room based on its COLMAP results respectively.

B. User Design

Gaussian Splatting had already enhanced the user experience. It not only provided a high-quality visual without traditional heavy computation compared to NeRF, but also allowed free movement, and enabled direct import into Unity. These features foster greater immersion in digital environments.

To further increase user engagement, we created a character, DR. B, to guide the user by introducing detailed information tailored to their visiting purpose. Therefore, we designed three modes of introduction to satisfy different purposes: recovery journey, research visit, and educational tour.

To develop the introduction text, we designed the text advised by Dr. Huang working in THOR to ensure relevance, relation, and engagement. We enhanced the text by three key fields from the feedback: structuring the content, increasing the correctness and relevance, and adjusting the details to maximize our educational effectiveness.

C. 3D Environment and Unity Implementation

To develop an educational guiding game to help users learn more about BNCT, we integrated results from previous steps into Unity engine. First, we refined the 3D results by removing extraneous floating artifacts. Next, we merged the four individual room models to create a merged BNCT environment. Finally, we incorporated user-designed elements—including introductory dialogues, the guiding character, navigation paths, and the merged environment—into a fully interactive guiding game.

IV. Result and Discussion

A. Visit Mode

In order to let the user visit the BNCT in their prefer mode, two modes, free moving and guided tour, have been developed. The free moving mode (Figure 2-(b)) allows users to navigate freely inside the BNCT space by using a keyboard, it enables the user to explore the BNCT space not only more details but also in their preferred sequence. As for guided tour mode (Figure 2-(a)), it let the users be led by the virtual researcher, Dr. B, in the BNCT space. This guided experience includes detailed explanations and structured navigation, enhancing the overall comprehensiveness of the visit.

B. Purpose of visit

Since that users may visit the BNCT with varying objectives, we aim to provide tailored information to meet each user's needs. We have categorized these objectives into three main types: Recovery Journey, Research Visit, and Educational Tour. During the guided tour, Dr. B introduces content specific to each visiting purpose. For the recovery journey, the focus is on alleviating anxiety related to the treatment environment and process, with Dr. B providing psychological support and emphasizing key therapeutic aspects. In the research visit mode, Dr. B offers more academic and theoretical insights, conveyed in a formal and precise tone. For the educational tour (Figure 2-(c), Figure 2-(d)), rather than delving into complex academic details, Dr. B presents historical context and fundamental principles in a conversational and humorous style to general audiences.

V. Conclusion

Our product, the digital guiding of BNCT therapeutic room, demonstrated a unique application of 3D reconstruction. The current result provided new visual perspectives with commendable quality. This advantages include not only the alleviation of anxiety among patients and the general public but also the feasibility of reducing researchers' barriers. Looking ahead, we will focus on refining the interaction design to further improve its usability and maximize its effectiveness as a useful tool.

References

[1] Barbara L. Andersen and Hamed H. Tewfik. Psychological reactions to radiation therapy: reconsideration of the adaptive aspects of anxiety. *Journal of Personality and Social Psychology*, (4):1024–1032, 1985.

[2] B. Fanini and A. Pagano. Interface design for serious game visual strategies: The case study of "imago bononiae". In *Digital Heritage, 2015*, volume 2, pages 623–626. IEEE, 2015.

[3] Nadine Glas and Catherine Pelachaud. User engagement and preferences in information-giving chat with virtual agents. In *ESIVA*, pages 33–40, 2015.

[4] Martin J. Goodfellow, Hugo R. Williams, and Adisa Azapagic. Nuclear renaissance, public perception and design criteria: An exploratory review. *Energy Policy*, (10):6199–6210, 2011.

[5] S. Kennedy, R. Fawcett, A. Miller, L. Dow, R. Sweetman, A. Field, and C. Allison. Exploring canons & cathedrals with open virtual worlds: The recreation of st. andrews cathedral, st. andrews day, 1318. In *DigitalHeritage*, pages 273–280. IEEE, 2013.

[6] Bernhard Kerbl, Georgios Kopanas, Thomas Leimkühler, and George Drettakis. 3d gaussian splatting for real-time radiance field rendering. *ACM Transactions on Graphics*, 42(4), 2023.

[7] K Nedunchezhian, N Aswath, M Thiruppathy, and S Thirugnanamurthy. Boron neutron capture therapy - a literature review. *Journal of Clinical and Diagnostic Research*, 10(12):ZE01–ZE04, 2016.

[8] Georgios N. Yannakakis and Julian Togelius. Experience-driven procedural content generation. *IEEE Trans. Affective Comput.*, (3):147–161, 2011.