

Using Virtual Tours as a University Campus Guide: Al-Zaytoonah University Case Study

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Abstract: Most university campuses, such as the campus of Al-Zaytoonah University of Jordan (ZUJ), are usually large and comprise many buildings. Finding the location of an office, a lecture hall, a service center, etc. is not an easy task for most visitors and even for many students and employees. Therefore, a virtual tour of the campus and its buildings will provide a valuable tool that eases this task, especially when it is available on a public website and accessible without the need for special virtual reality devices. Previous studies on virtual tours focused on their important marketing aspect. On the other hand, this study is focused on using virtual tours as a guide for finding the specific locations that different users seek to visit. Consequently, a virtual tour of ZUJ has been designed and provided via the university website. The building names and numbers are provided on the website in Arabic and English with links to their tours. The tours that lead to the important locations include many significant details inside the buildings such as room numbers, bathroom signs, and door signs. The study showed user satisfaction with the tours and the efficacy of using the website without special virtual reality devices.

Keywords: Virtual Reality, Virtual Tour, 3D Model, Matterport.

1 Introduction

Recently, especially after the COVID-19 pandemic, many venues, universities, and tourist locations have developed three-dimensional (3D) virtual tours to guide people who are hesitant or unable to visit them in person. Overall, virtual tours were used as a successful marketing tool that can boost revenues [1,2]. Furthermore, virtual reality therapy has been found to reduce stress and anxiety among university students in Jordan where computer usage is ubiquitous [3,4].

A virtual tour can be built from one or more sources including video, image stitching, and a 3D-modeled interactive walkthrough [5]. The user of a virtual environment can move around this environment to explore it and to become familiarized with it using specialized devices such as headsets, multi-projected settings, or other specialized devices [6]. Nonetheless, less extravagant virtual tours can be provided via common screens or smartphones. Currently, students are more used to mobile applications in the university environment [7].

Virtual tours have been designed for many universities even before the COVID-19 pandemic because campus tours, whether in-person or virtual, were found to increase the enrolment of potential students [8-14]. Furthermore, when touring the campus becomes difficult due to inclement weather conditions or lack of time or financial means, virtual tours provide the most feasible solution.

A virtual tour of the Al-Zaytoonah University of Jordan (ZUJ) campus and inside its buildings can encourage prospective students to learn more about ZUJ and be more likely to choose it for their higher education studies. Furthermore, a virtual tour can guide visitors of all kinds through the campus and help them find the locations they need to visit in person and make their physical trips easier and faster. Consequently, this paper uses ZUJ as a case study for designing a web-based virtual tour and analyzing its effects on different users who need to find specific locations. The virtual tour will be available on a public website and accessible via common devices including computers and smartphones and will allow the utilization of virtual reality (VR) equipment. Then, user opinions will be analyzed to assess their satisfaction with this service and determine the need for VR goggles to enhance its efficacy.

The rest of this paper is organized as follows. A brief discussion of the works related to this study is presented in Section

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2. The virtual tour environment is described in Section 3. The tour design methodology and the challenges it encounters are discussed in Section 4. The evaluation of the system is presented in Section 5. Finally, the conclusion and suggested future work are presented in Section 6.

2 Related Work

Previous works in general did not focus on using virtual tours as a guidance system. Furthermore, no prior studies have been done on virtual tours utilizing a web-based system at any Jordanian university, including ZUJ, up until the date of this study. Nonetheless, several institutions in Jordan and abroad have conducted studies on the design and implementation of virtual tours in the educational environment and examined their effects on the exposure of campuses and the highlighting of their features and activities.

Some universities utilized 3D modeling in the development of campus tours such as the 3D modeling prototype developed at the University of Cantabria [15]. Rahmat et al. [16] used VR to convey information about buildings at Universitas Sumatera Utara (USU), where USU has more than 100 buildings and a total area of more than 133 square meters. They employed 3D modeling and VR technology to show the locations of USU institutional buildings engagingly and creatively. Perdana et al. [17] introduced a web-based campus virtual tour for Telkom University. They captured a series of videos and images for selected places to construct a 3D panoramic view of the campus using a 3D Vista tool, and they published it on a public website. Moloo et al. [18] created a web-accessible 3D virtual tour of the University of Mauritius using WebGL technology to give viewers a more realistic 3D depiction of their campus. The 3D object creation, loading, and manipulation were all done using the SketchUp program.

Some previous studies employed special tools to improve the virtual tour experience. Mobile Robots were used by Kusu et al. [19] to improve virtual tours and give spectators a real-time environment. Espinueva [20] implemented a virtual tour system using an information kiosk with a touch screen at Laguna State Polytechnic University. The virtual campus tour by Maines and Tang [21] was presented through an application game while Pick et al. [22] developed a collaborative 2D and 3D virtual tour using a digital camera. Giraldo et al. [23] built a virtual tour of the University of Quindo campus using augmented reality. Additionally, they employed usability and user-centered design assessment techniques for enhancing user experience and tool usage consistency.

Szeliski [24,25] used photo stitching with high-resolution images, as photo-stitching techniques require less storage and execution power than VR. Photo stitching was also used at Tsinghua University to create virtual environments that were made from static images using inverse projection [26].

A VR system was developed by Knabb [27] to allow users to make multiple virtual visits to the desired archeological sites in Jordan and some other countries using a personal computer. Immersive virtual tours were also provided using large screens and VR goggles. This system provided means for education and entertainment for virtual visitors whether or not they plan to make in-person visits.

Overall, the previous research studies did not focus on virtual campus tours that allow visitors to enter the main buildings and see the inside details. This study will provide such tours and analyze their effects on different users seeking guidance at various indoor and outdoor on-campus locations.

3 The Virtual Tour Environment

A virtual tour of the ZUJ campus has been constructed for this study to include walkthroughs inside all academic and main services buildings. A series of 360 panoramic photos were merged to create each building's virtual tour to be accessible online by anyone who desires to explore the ZUJ campus or find a location to visit. These photos were created by a Matterport camera and then built and developed through the services provided on the Matterport website [28]. In addition, a written and visual manual has been written to explain how to use the system from various locations.

This study involves building a web-enabled user-friendly system that allows users to take virtual tours of the ZUJ campus and virtually enter its buildings. The campus of ZUJ, shown in Figure 1, comprises one of the largest private universities in Jordan. ZUJ was established in 1993 and now has approximately 12000 students from more than 30 different countries. ZUJ has more than 18 buildings located on a land of 296000 m² with different elevations where the various areas are connected by streets, walkways, and stairs. Buildings have different designs, and each building has up to four floors. Table 1 specifies the main details involved in creating the virtual tour, which is now available via the ZUJ website [29].



Fig. 1: A partial aerial view of the ZUJ campus

The detailed images used in creating the virtual tour were captured on the ground by a 3D camera, described in Table 2, to be used in creating the virtual tours inside and outside the campus buildings. In addition, a drone, described in Table 3, was used to take aerial photographs of the campus to be used in creating the outside virtual tour. Video capturing was not provided by the available 3D camera, but an available alternative was capturing panoramic images to be assembled into a full tour. In addition to the public website, the virtual tour has been made available using the VR goggles described in Table 4.

Table 1: The details used in creating the virtual tour

Number of Building Covered Externally	23
Number of Buildings Covered Internally	18
Building Areas Covered (All Floors)	73000 m ²
Percentage of Campus Area Covered	100%
Number of Picture Captures Taken	360
Number of Ground-View Videos Recorded	18
Number of Aerial-View Videos Recorded	5

Table 2: The ground-view camera specifications

Make	Matterport
Type	Pro2
Image Dimensions	3D
Accessories	Tripod with Wheels
Subscription	Pro & Business

Table 3: The drone camera specifications

Make	DJI
Type	Mavic 3
Image Dimensions	2D and 3D
Specifications	4/3 CMOS Hasselblad
Resolution	5.1K

Table 4: The VR goggles specifications

Make	Oculus Quest 2
Type	Virtual Reality Headset
Memory	6 GB LPDDR4X
Storage	64 GB, 128 GB, 256 GB
Display	RGB LCD 1832 x 1920 per Eye @ 72 - 120 Hz
Graphics	Adreno 650 , 1.1 TFLOPS
Sound	Integrated, In-Strap, 2 Built-In Speakers
Camera	4 Infrared Cameras

4 Tour Design Methodology and Challenges

After capturing the 3D panoramic photos of the ZUJ campus with the 3D camera, the camera manufacturer's online service was used for processing the images and creating the virtual tour. The tour has been made available online with a webpage

served by the ZUJ domain and accessible worldwide [29]. The main webpage of the application, as shown in Figure 2, displays the names and pictures of the campus buildings and gives an option for traveling through the campus. Selecting an image starts a tour of the selected building where the user can start from the default location or choose a different starting location. The user can click on any visible location on the floor or the wall to move closer to it but the locations with the best view are shown with circles augmented on the floor.

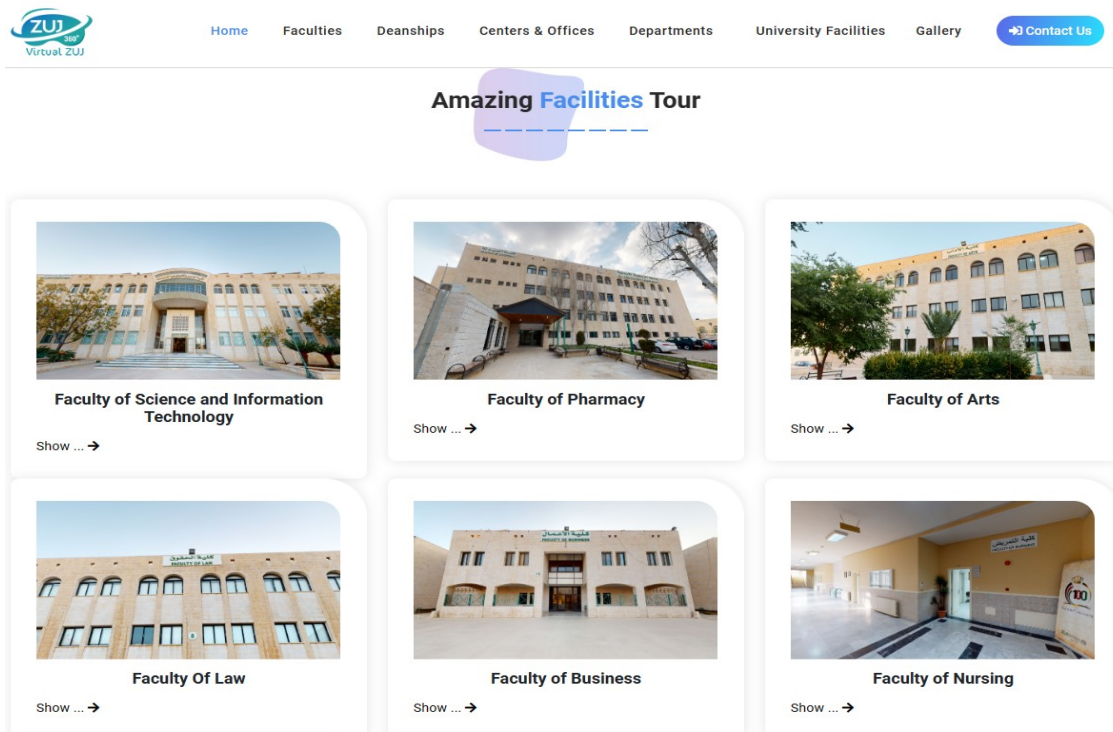


Fig. 2: A part of the main webpage of the virtual tour system

The main features of the virtual tour system are as follows:

- The tour can be made via the website either using a screen, such as that of a laptop or a phone or using VR goggles.
- The general tour option allows the user to virtually travel on the campus with an aerial view and see the buildings from outside. When the user selects a building, a virtual tour of that building starts.
- A dollhouse 3D model is available for each building, such as the example in Figure 3. It allows viewing the building from different angles and viewing a 3D model of each floor, as in the example shown in Figure 4. The user can transfer directly to any selected location in this model.
- When touring the inside of a building, the user can select any floor from the floor menu and transfer to it directly. The location of the user will be directly above or below the previous location.
- The user can view the floor plan of any floor, such as the one shown in Figure 5. Then, the user can select a desired location and transfer directly to it such as the locations shown in Figure 6 and Figure 7.
- The graphics are in high resolution that allows the user to zoom in and see fine details including the room numbers and locker numbers, as seen in Figure 6.
- A measurement tool is available in all locations to allow the user to determine the actual distances.
- A hyperlink can be produced for any selected location to allow users to save and share it.
- The types of users who can benefit from the tours vary widely to include all of the following:
 - Students (Prospective, New, Current, and Alumni).
 - Mail Carriers and Delivery Services.
 - Employees (Prospective, New, and Current).
 - Event Participants (Graduation Ceremonies, Conferences, Workshops, Seminars, Arts and Entertainment, etc.)

- Other users are trying to meet with a person or need to use a service.
- The website is bilingual (Arabic and English) to serve local and international users.

The tour design must deal with a variety of challenges. First, the cost of capturing equipment and working hours are significant, especially for a university with a moderate or low budget. However, the benefits of the tour may justify this cost. Then, the image-capturing process needs to overcome some obstacles. The 3D camera requires manual control and a good connection to a computer (possibly a tablet) during the capturing process. People and cars may pass within the viewing area of the camera. Poor weather may affect the capturing process outside, and inadequate lighting may affect it inside the buildings or in shaded areas. Furthermore, the privacy of people, personal offices, and confidential documents must be protected. Once the virtual tour is ready to use, more factors that affect synthetic videos may enhance or diminish the user experience. These factors include transmission bit rate, availability of videos, and the quality of these videos [30-32]. Extra challenges to consider when designing a virtual tour at a Jordanian university include a relatively low internet speed and limited data caps [33,34].



Fig. 3: The dollhouse 3D model of the Faculty of Pharmacy building

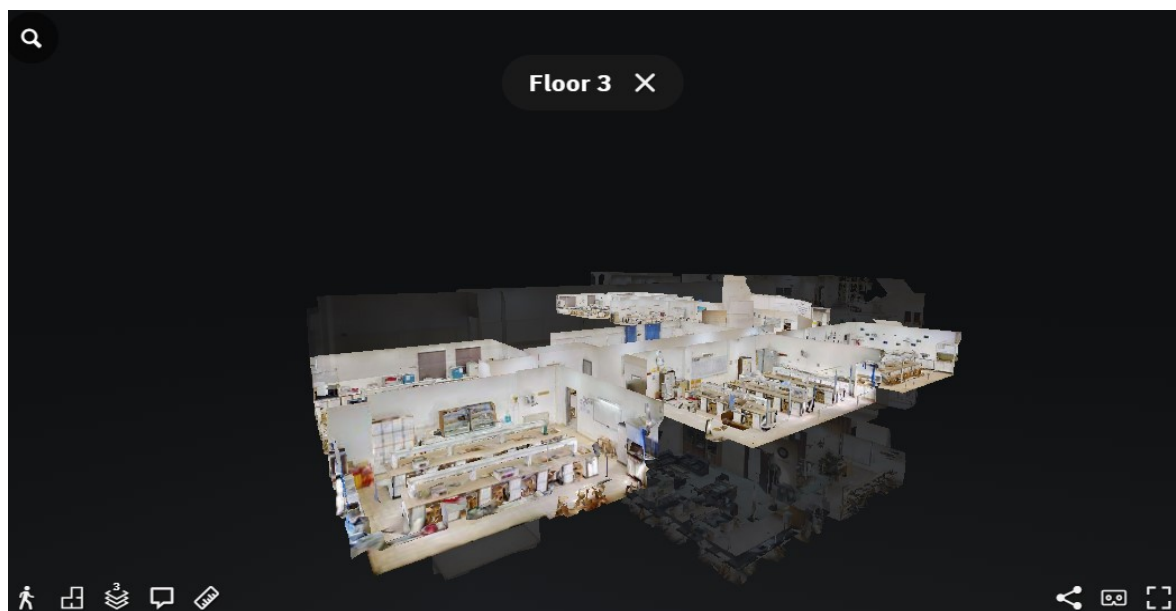


Fig. 4: The 3rd floor in the dollhouse of the Faculty of Pharmacy building



Fig. 5: The floor plan of the 3rd floor of the Faculty of Pharmacy building

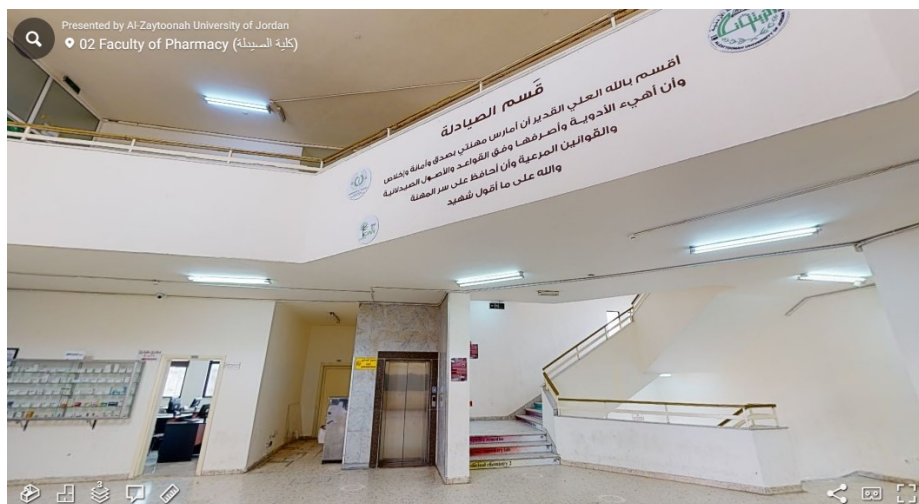


Fig. 6: A hallway on the 3rd floor of the Faculty of Pharmacy building



Fig. 7: A room on the 3rd floor of the Faculty of Pharmacy building

5 System Evaluation

The virtual tour system was tested extensively. First, functional testing was performed on the general campus tour and all building tours to verify that they work as desired. Then, 2240 users were asked to make tours at the same time to verify that the system can perform well with many simultaneous users.

To evaluate the tour’s ease of use, the system was evaluated by 30 users consisting of 10 senior high school students, 15 ZUJ students, and five ZUJ employees. Each user was asked to visit one location using a personal computer, rest for 10 minutes, and then visit it using goggles. Then, at least one hour later, the user was asked to visit a different location with the goggles first and then with the personal computer. Finally, each user was asked to answer the following two questions for the personal computer tour and again for the VR goggle tour. Each answer is an integer ranging from 1 to 5 where 5 represents the best experience and 1 represents the worst.

Q1) How easy was it for you to find the exact location you are seeking?

Q2) How do you rate the comfort of using the tour system for finding the desired location?

The Mean Opinion Score (MOS) results obtained for these questions are summarized in Table 5. It can be observed from the table that, on average, the users favored using the personal computer over using the VR goggle. Additionally, the high averages of MOS indicate general user satisfaction overall. However, more analysis is required to determine the significance of the effect of changing the device (screen versus VR goggles) on the user experience.

Table 5: MOS for Q1 and Q2 for Personal Computer and VR Goggles Tours

Source	Q1	Q2	Average
Personal computer	4.533333	4.266667	4.433333
VR Goggles	4.333333	4.000000	4.133333
Average	4.400000	4.166667	4.283333

Consequently, an Analysis of Variance (ANOVA) was performed to provide a better comparison of the MOS results. If the three conditions for using ANOVA apply, using ANOVA will be beneficial for this comparison since it can help determine if the MOS differences are significant or not. In particular, the p-value in two-way ANOVA of these two questions’ MOS results needs to be below the threshold of 0.05 to indicate the significance of the difference between them [35].

It is assumed that the three conditions for using ANOVA apply as follows. First, the sample size (30) is sufficiently large for justifying its normality. Second, the trials were conducted with an intermission to ensure their independence. Third, Levene's Test of Equality of Variances was conducted and the results, as shown in Table 6, show that this condition is observed because the p-value of this test was larger than 0.05 as required.

Table 6: Test of Equality of Variances

F statistic	Degrees of Freedom 1	Degrees of Freedom 2	p-value
2.124173	1	118	0.147647

To test the effect of using the personal computer versus using VR goggles on MOS, 2-way ANOVA was adopted in this analysis and the results are shown in Table 7. As seen in the table, the p-value was larger than 0.05, which indicates that using the VR goggles and using the screen did not have a significantly different effect on the users’ opinions. This gives an advantage to using a personal computer via a screen as it achieved user satisfaction at a lower cost compared to using VR goggles.

Table 7: Two-Way ANOVA on MOS

Sum of Squares	Degrees of Freedom	Mean Square	F statistic	p-value
1.633333	1	1.633333	2.153030	0.144995

Later, a follow-up poll was conducted to determine the usefulness of the designed tour for prospective and new students. The research team contacted 10 high-school students who participated in the previous study and 20 fresh ZUJ students who did not participate in virtual tour experiment previously. The goal of the new poll was to get their opinions on the usefulness of the virtual tour using a scale from 1 (Not Useful) to 5 (Very Useful). The question directed at high-school students was “How useful was the virtual tour in helping you decide to choose a university for your enrolment?” and resulted in a MOS of 3.80. The question for fresh ZUJ students was “How useful was the virtual tour in helping you find your way around the ZUJ campus?” and resulted in a MOS of 4.15. Consequently, the virtual tour was somewhat helpful for student recruitment and more useful for fresh student navigation [36,37].

6 Conclusions

A virtual campus tour has been developed for the ZUJ campus and used for analyzing its effect on potential users. Furthermore, the tour was tested using a personal computer and VR reality goggles to determine the need for using specialized devices to provide the desired benefits of the tour. Analysis of the experiments showed that the users were generally satisfied and comfortable with using virtual tours for finding the locations they seek. Nonetheless, the VR goggles did not provide a significant improvement to the user experience, and using the tour's website using a personal computer was satisfactory for the users in general. This was inferred from the ANOVA analysis of the MOS comparing the use of VR goggles and computer screens. Additionally, a follow-up study found the virtual tour to be useful for prospective and new students. Experiments with mobile devices were not conducted and may be done in future works. Moreover, future works may consider using different equipment and additional features such as video and audio.

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Conflict of interest

The authors declare that there is no conflict regarding the publication of this paper.

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