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Exploring museum visitors' virtual reality experiences: An online user-generated content approach.

Introduction

Virtual reality (VR) is becoming an attractive technology in the cultural tourism industry as the effective association of VR tourism with cultural heritage destinations offers meaningful value to tourist during their pre, onsite, and post experiences (Jung & tom Dieck, 2017). Museum is one of the important tourist destinations by offering edutainment opportunities to tourists, which in turn increase the chances of diverse tourist experiences within a destination. In particular, the application of VR technology in a museum setting showed that users on the site not only perceived usefulness and learning opportunities from VR experiences, but also attained more accessible information regarding the history and cultural site (Errichiello, Micera, Atzeni, & Del Chiappa, 2019). As a result, a few studies have attempted to expand our knowledge of VR in the museum context by examining museum visitors' VR experience (Errichiello et al., 2019; Jung, Dieck, Lee, & Chung, 2016).

However, our knowledge about VR in the museum setting is still at the beginning stage. Although existing studies (Errichiello et al., 2019; Jung et al., 2016) meaningfully provided museum visitors' VR experience, it is still possible to further expand our knowledge about market circumstances, diverse evaluations, and perceptions. In addition, the studies have attempted survey method to understand museum visitors' VR experience; however, the survey approach tends to be limited to data collection periods and sample sizes. Online user-generated content, on the other hand, may overcome the limitations by accessing data more conveniently and comprehensively. Indeed, online user-generated content has been regarded as a significant source of product information (Karimi & Wang, 2017) and a trustworthy data source (O'Connor, 2008) in accordance with reviewer experiences and ratings (Xiang, Schwartz, Gerdes, & Uysal, 2015). TripAdvisor is one of the principal online travel review websites with 878 million reviews (see https://tripadvisor.mediaroom.com/US-about-us) as of December 2020.

Accordingly, this research empirically explored museum visitors' VR experiences by analyzing online user-generated content. To fill the existing gap, temporal, spatial distribution, satisfaction, bigram co-occurrence network graph, and sentimental (Russel's Circumplex Model of Affect) analyses were employed. One of the expected contributions of this study was to offer various online reviewers' evaluation views. As a consequence, these findings can help museum managers understand how visitors perceive, feel, and evaluate VR in the museum context, which is crucial for effective marketing strategies. In turn, the results will offer practical insights on how to increase the levels of positive satisfaction, emotion, and perception of potential VR customers in the museum setting. Moreover, it is expected that this research outcomes may reflect potentials of online user-generated content through various analytical approaches.

Literature Review

- Virtual reality experience in museum and tourism

Hobson and Williams (1995, p.2) described that "VR is an interactive computer-generated medium that allows participants to create simulated experiences of both real and unreal simulation"

VR is somewhat different from AR and MR. VR was suggested to be a closer concept to the virtual environment while AR is more relevant to a real environment (Milgram, Takemura, Utsumi, & Kishino, 1995). Integrating both, Milgram et al. (1995) suggested that the MR concept encompasses both VR and AR together.

In more detail, VR experience can be divided into two areas: VR tourism and VR as a function of tourism attraction on-site. VR tourism is about experiencing VR before making a decision to travel, as explored by a few studies (Bogicevic, Seo, Kandampully, Liu, & Rudd, 2019; Kim et al., 2020; Tussyadiah et al., 2018). The VR as a function of the attractions involves VR experience on-site. To enhance visitor experiences on-site, attempts have been made in various fields such as art gallery (tom Dieck, Jung, & tom Dieck, 2018), museums (Errichiello et al., 2019), national park (Jung, tom Dieck, Moorhouse, & tom Dieck, 2017), and theme park (Wei et al., 2019). Among them, cultural heritage organizations have also actively adopted new technologies for better visitor experiences (Jung et al., 2015).

Methodology

- Data preparation

Data preparation consists of four steps. First, target museums were chosen. Specifically, museums that have more than 30 reviews containing the keyword "virtual" in TripAdvisor were selected for the next data collection. The 30 reviews criterion is based on central limit theorem that sample size equal or greater than 30 can achieve the normal distribution (Plane & Gordon, 1982). Second, data collection was conducted. In detail, reviews of visitors' VR experience and attributes (i.e., reviewer ID, reviewer's registered location, experience date, and bubble score) were collected during 24th of November and 12th of December, resulting in data range from 2010 to 2020 after all. Third process is data cleaning. Through this process, unrelated data sets were removed (duplicate data sets and data sets of a museum that contains less than 30 reviews). In the meantime, distant blank gaps between some sentences of reviews were also eliminated. After cleaning the data, a total of 1,891 data sets (reviews and attributes) remained in 22 museums.

Fourth, an attempt was made to improve the validation of review content in relation to VR. In detail, this process includes inspecting 10 random reviews that contain "virtual tour" to ensure that the reviews were relevant to on-site VR experience. Then, further investigations were conducted on whether selected museums offer services for VR. Regarding a museum that provided a virtual tour service with a mobile phone or audio guide, a whole review from the museum was removed. Among the 1,891 reviews, 1,379 (about 73%) contained 'virtual reality'; 81 cases had 'virtual tour' in reviews. Additionally, extractions of core sentences were followed. Reviews deal with not only VR but also with impressions or evaluations of other characteristics about museums. In such a case, the results are more likely to reflect general evaluations. Specifically, this process extracted a key sentence containing 'virtual' along with surrounding four sentences together. In a case that some reviews contained 'virtual' more than two cases, the first-mentioned keyword became the target of the extraction.

- Data pre-processing and analysis

A total of five analytical approaches were conducted in association with spatial, temporal, satisfaction, perceptional, and sentimental considerations. Initially, the spatial analysis was mainly considered to have geographical distribution patterns of museums and reviewers. Through this analysis, we can explore museums that provide VR services from a geographical viewpoint. For the analysis, particular data pre-processing of the reviewers' address data was carried out. That is, reviewers' addresses were divided by state (only for the United States), national, and continent levels. As a result, geographical patterns of the museum and reviewers was presented.

Second, temporal analysis was implemented to comprehend the flow of the VR market size in a museum setting. Indeed, as shown in some study (Kim, Thapa, & Jang, 2019), temporal patterns can show valuable insights of visitation patterns, which are practically applicable. In other words, the results may reveal predominant visitation patters at certain periods. Since the TripAdvisor offers temporal data in year and month base, this study attempted to analyze the temporal patterns by year and month. Third, satisfaction analysis was employed to find patterns of museums with high rating score. In this study, the rating (i.g., bubble score) was regarded as satisfaction as used in Xiang et al.'s study (2015). Satisfaction is one of the widely used factors, contributing loyalty and behavior intentions (Oliver, 1996). To do the analysis, the collected satisfaction scores were first transformed into quantitative outcomes to analyze the score (i.g,. from text to number). Fourth, Bigram co-occurrence network analysis was performed. This approach has been attempted to understand perception of service or product in consumer research (Deneulin & Bavaud, 2016; Yano, Blandford, Maruyama, & Nakamura, 2018). This method can offer word co-occurrence in a graphical visualisation based on graph theory (Yano et el., 2018). To have the graph, particular functions were used (i.g., tokenize, transform data to lower case, stopword) as data pre-processing. As a conditional input, only more than 30 cases of bigram pairs of words were displayed. This 30-cases criterion is also based on central limit theorem of the normal distribution as mentioned earlier (Plane & Gordon, 1982). Finally, sentiment analysis was carried out in accordance with Russel's Circumplex Model of Affect (Russell, 1980, p.1168). This analysis process was particularly adapted from Park, Kim, Lee, and Ok (2020). To be specific, endeavors have been made to match the extracted words from the reviews with sentiment words suggested in the Russel model. During this process, some of the words were treated to be equal (bore with boring and sad with sadly). As a result, word frequency was identified by each stage of High arousal x Pleasure, High arousal x Displeasure, Low arousal x Displeasure, and Low arousal x Pleasure. Next, we sorted reviews that contain the aforementioned stages. After this work, a text-mining was performed for reviews stage by stage.

Results

- Spatial distribution of museum and reviewer

Table 1 indicates the outcomes of the museum profile. Amongst the total 21 museums selected, 11 museums were located in USA; eights museums in Europe; and two museums in Oceania. And 721 (37.6%) of the reviews are from USA museums, followed by 712 (37.1%) of Europe and 458 (23.9%) of Oceania (i.g., Australia). In addition, 55.7 % of the reviewers' registered addresses

turned out to be from outside of the countries and the states (in the case of the USA) where the museums are located. This result implies that 55.4 % of the reviewers could be tourists.

Table 1 Museum profile by continent and country (n=1891).

	Museum location	**Number of museums**	**Percent (museum)**	**Review number**	**Percent (review number)**
Continent	North America	11	52.4%	721	38.1%
	Europe	8	38.1%	712	37.7%
	Oceania	2	9.5%	458	24.2%
	Total	**21**	**100%**	**1891**	**100%**
Country	USA	11	52.4%	721	38.1%
	Australia	2	9.5%	458	24.2%
	England	2	9.5%	71	15.7%
	Austria	1	4.8%	44	5.9%
	Belgium	1	4.8%	297	4.2%
	Holland	1	4.8%	76	4.0%
	Iceland	1	4.8%	112	3.8%
	Ireland	1	4.8%	79	2.3%
	Spain	1	4.8%	33	1.7%
	Total	**21**	**100%**	**1891**	**100%**

- Temporal analysis

As shown in Figure 1, VR experience cases dramatically increased since 2015. Whereas 2015 indicated 48 cases, 2016, 2017, and 2018 showed 228, 524, and 546 cases respectively. However, the experience cases in 2020 started to decrease. This result could be due to COVID-19. Figure 2 presents VR experience by month. In particular, July and August showed the highest frequency of the VR experience as 211 and 196 cases respectively. On the other hand, March (129) and October (129) indicated the lowest frequency of the VR experience.

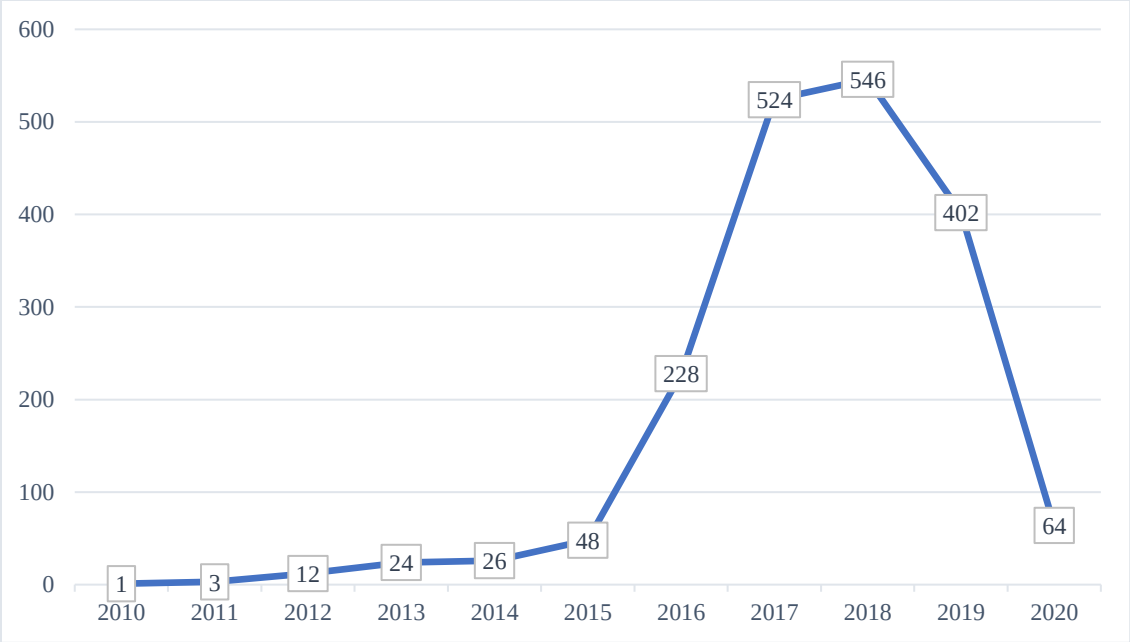


Fig. 1. VR experience by year

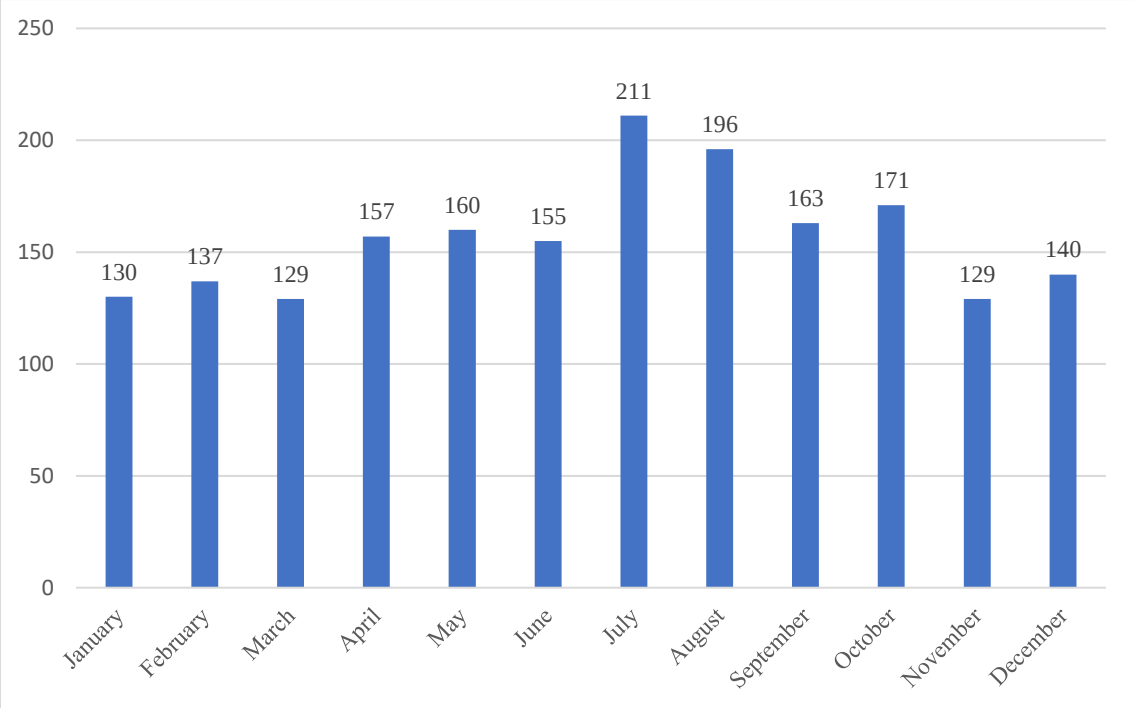


Fig. 2. VR experience by month

- Satisfaction analysis

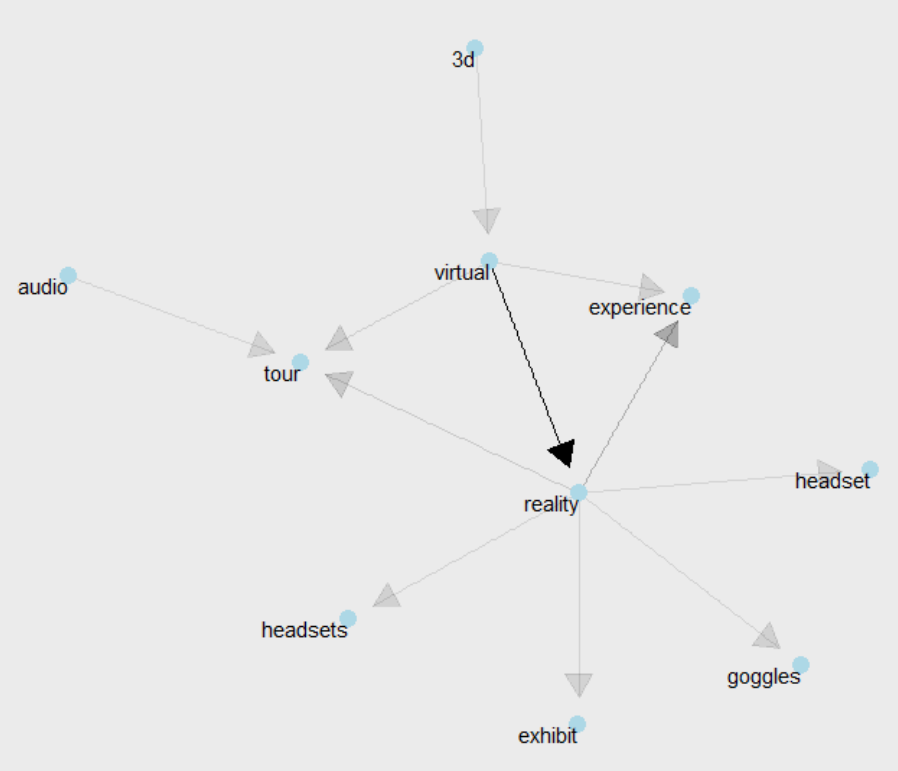
Table 2 represents the top five museums of the highest average satisfaction score. Among them, three of the museums were found to be related to historical war and military (USS Midway Museum, RFDS Darwin Tourist Facility, and The National WWII Museum). In addition, Evel Knievel Museum had the highest mean rating (4.95 out of 5.0). This museum provides motorcycle VR service, which could be somewhat dangerous in a normal life attempt. Such vivid experiences may have led reviewers to places high rating scores.

Table 2. Top five museums of the highest average rating scores

Museums	Average rating score	Documents
Evel Knievel Museum	4.97	86
USS Midway Museum	4.88	48
King of the Vikings	4.86	79
RFDS Darwin Tourist Facility	4.81	402
The National WWII Museum	4.73	45

- Bigram co-occurrence network graph analysis

Figure 3 indicates the Bigram co-occurrence network graph, presenting only “virtual” and “reality” related words from the original completed result. As indicated in Figure 3, directly relevant words with the keywords (“virtual” and “reality”) contain exhibit, googles, headset, experience, 3d, and tour whereas indirect words include audio in conjunction with tour. This results indicates that the afore-mentioned words were frequently associated in a pair of “virtual” or “reality”. That is, reviewers tend to comments functional elements of VR for their reviews as the four (i.e., 3d, audio, headset, and googles) out of eights words were relevant to the functional features.



Note: Extracted only a pair of words more than 30 cases

Fig. 3. Bigram co-occurrence network graph

- Sentiment analysis: Russel's Complex Model of Affect

The results are presented in Table 3 and Table 4. In particular, four different stages are shown in high arousal and pleasure, high arousal and displeasure, low arousal and displeasure, and low arousal and pleasure. In Table 3, the emotional stage of high arousal and pleasure showed the most frequent occurrence (155), followed by low arousal and displeasure (31), low arousal and pleasure (28), and high arousal and displeasure (6). In the Table 4, the emotional stage of high arousal and pleasure indicated the most frequent occurrence (207), followed by low arousal and pleasure (72), low arousal and displeasure (69), and high arousal and displeasure (19). As a result, the stage of the high arousal and pleasure tends to consist of positive expressions (i.g., 26 occurrence for great, 23 for interest, and 17 for amaz) and keywords (31 occurrence for tour, 21 for histori, and 18 for staff), implying the underlying findings' roles in this stage. Also, low arousal and displeasure may associate with kid and time (i.g., minut) since kid showed the seven occurrence and minut for six occurrences at the stage. And the components of VR (i.g., seven occurrence for glass, seven for headset, and seven for video) may bolster the sense of low arousal and pleasure.

Table 3. Classification of sentiment words and occurrences

High arousal x Pleasure		High arousal x Displeasure		Low arousal x Displeasure		Low arousal x Pleasure	
Word	Occurrence	Word	Occurrence	Word	Occurrence	Word	Occurrence
aroused	0	alarmed	0	sleepy	0	content	8
astonished	2	afraid	3	droopy	0	satisfied	2
excited	31	angry	0	bored	21	at ease	0
delighted	9	tense	0	gloomy	0	serene	0
happy	17	frustrated	3	depressed	0	calm	1
glad	37	annoyed	0	sad	10	relaxed	17
pleased	19	distressed	0	miserable	0		
				tired	2		
Subtotal	115		6		33		28

Table 4. Text-mining result of reviews

	High arousal x Pleasure		High arousal x Displeasure		Low arousal x Displeasure		Low arousal x Pleasure	
Rank	Word	Occurrence	Word	Occurrence	Word	Occurrence	Word	Occurrence
1	tour	31	abl	3	exhibit	9	good	9
2	great	26	audio	3	tour	9	shop	8
3	interest	23	tour	3	great	8	exhibit	7
4	histori	21	exhibit	2	interact	8	fun	7
5	enjoi	19	found	2	kid	7	glass	7
6	inform	18	good	2	enjoi	6	great	7
7	staff	18	includ	2	look	6	headset	7
8	thing	18	interact	2	minut	6	light	7
9	amaz	17			headset	5	video	7
10	look	16			histori	5	set	6
Subtotal		207		19		69		72

Note: Occurrence is based on a count per document, not all frequency counts

Conclusion and Discussion

As the first endeavor with the approach of the online user-generated content in the museum and tourism contexts, the present study attempted to expand its existing views (Errichiello et al., 2019; Jung et al., 2016; Trunfio & Campana, 2020, Trunfio et al., 2020) by sharing varied angles of VR user experiences in consideration of spatial, temporal, satisfaction, perceptional, and sentimental analyses. As shown by this study, online user-generated content can be a useful study approach, understanding visitors' various evaluations. And the potential impacts of VR in the tourism field have been identified.

There are key implications and findings from the results. First, spatial and temporal patterns of VR reviews may provide current market situations of VR in a museum context. To the best of our knowledge, no studies have provided VR museum market circumstances in spatial and temporal view by using online reviews in the tourism field. The spatial pattern result implies the current museums which provide active VR service in Europe, North America, and Oceania. Possibly, the markets in these continents can expand in the future as the VR market in museums is still growing. Or it is also likely that active museum VR markets will construct in new continents (e.g., Asia) considering benefits and high evaluations found in this research. Since there is no research revealing such spatial and temporal perspectives, the results can be important resources, enabling practitioners to understand the market.

The result of bigram co-occurrence graph analysis implies visitor perceptions of VR (Deneulin & Bavaud, 2016; Yano et al., 2018). The outcome shows the underlying visitors' general perceptions of VR in functional elements (audio, 3d, google, headset(s)), which may distinguish from Trunfio et al.'s (2020) functional outcomes of immersive technology in image and video. Indeed, functional quality is of great importance in enhancing the user's virtual experience as presented in Wei et al. (2019). Thus, in line with this study's result, it would be necessary for museums in tourism destinations to improve the functional quality in an attempt to offer better visitor experiences.

In line with Park et al. (2020) based on Russel's Complex Model of Affect, this study also showed the museum visitors' VR experiences dominantly generated high arousal and pleasure emotions. In association with this result, practitioners may have to center on important keywords that can bolster the visitors' pleasurable and unpleasurable senses. That is, to improve the pleasurable environment with VR, the museum can consider history, staff, shop, and functional components of VR (i.e., video, glass, and headset). On the other hand, museums may concern about audio, interaction, kid, and time views to reduce the chance of displeasure. Functional elements were revealed as one of the dominant perceptions in addition to the importance of the quality highlighted by Wei et al. (2019). The result suggests that practitioners should have special attention to functional components.

To conclude, diverse analytical approaches conducted in this research provided useful insights in terms of pragmatic views and market circumstances. In particular, the outcomes reflect dominantly positive evaluation and emotions whereas the cases have been recently increasing. In this regard, VR in museums can be attractive tools for tourists.

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