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Developing 360° Virtual Tours for Promoting Tourism in Natural Parks in Chile

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Abstract: In recent years, the tourism industry has undergone substantial transformations, integrating new technology to lead to a new era termed Tourism 4.0. These innovations enhance the customer's travel experience. An emerging trend in travel technology is the application of virtual and augmented reality, facilitating virtual tours that allow tourists to explore destinations without physically being there. We present the experience of developing 360° virtual tours for reserves and natural parks across the four provinces of the Maule Region in Chile including information, 360° images and videos, as well as several other interactions. A descriptive and correlational analysis was carried out with a total of 147 participants that evaluated the virtual tour, showing a positive correlation between the perceived attractiveness of the 360° experience and behavioral intention. Participants had an overall positive perception of the virtual experience; they found it involving and attractive, felt immersed in the environment, and were able to make decisions and interact with static and dynamic objects. The contributions of the present work are as follows: the process and what has been learned and can be recommended based on the experience for developing 360° virtual tours, combining dynamic and stationary elements in 360° in a virtual experience, and the results of an exploratory study that present the interaction with and user perceptions of the virtual environment.

Keywords: human–computer interaction (HCI); natural heritage; Tourism 4.0; 360° video and photography; virtual reality; virtual experience; interaction technique

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1. Introduction

Tourism has changed as an industry and as a social phenomenon in recent years. The industry has made significant efforts to improve the customer experience by integrating different technologies as well as process automation, saving time, and creating personalized and smooth trips for tourists. This is the so-called Tourism 4.0. Implementing these technologies may improve customer experience before, during, and after the trip [1].

In Chile, different programs aim to bring small and medium-sized enterprises (SMEs) in national tourism closer to new technological solutions, to improve their processes and productivity. The National Tourism Service (SERNATUR) (https://www.sernatur.cl/ accessed on 14 November 2023), for example, has Technological Extension Centers (CETs) financed by the Corporation for Promoting Chilean Production (CORFO) (https://www.corfo.cl/ accessed on 14 November 2023) to promote tourism companies adopting technology from the public sphere, providing technical assistance services, technological surveillance, and activities to disseminate new technologies.

Reserves and natural parks in Chile, however, also benefit from the use of technology for tourism. In this context, we present the experience of developing 360° virtual tours

for reserves and natural parks across the four provinces of the Maule Region in Chile, considering the technology to be implemented and an exploratory analysis in a user study (possible or future customers).

Several factors are responsible for changes in consumer behavior and driving many travel technology trends that are currently highly relevant [2]. One of them is the use of virtual and augmented reality, which is driving the adoption of virtual reality tours in travel companies and resorts to promote available offers, allowing tourists to see faraway places from the comfort of their homes and encouraging them to make a reservation [3,4].

With the implementation of virtual reality, tourists can experience virtual tours of trails, hotels, museums, restaurants, and even additional activities specific to each tour [5,6]. Interactivity and immersion provide a competitive advantage over those products that do not take full advantage of these technological trends. However, adopting and integrating these technologies must be linked to both the tourist and the tourism providers, who must also keep up with the trends to find the best solutions for each business and thus obtain a competitive advantage [7].

Especially for SMEs and public programs, it is essential to estimate the effort of the technological solutions developed and the experience and perception of the users, making it possible to obtain metrics associated with the implementation, risk management, and benefits that its use entails.

As we present the experience of developing the virtual tours in Maule, Chile, this paper is structured as follows: first, we describe the background of this work; second, we present the methodology of the development process and evaluation; third, we present the results; and finally, we describe our discussion and future work.

2. Background

2.1. Tourism 4.0

The term Tourism 4.0 is a recent one and first appeared in documents from governmental institutions and policymakers in Europe around 2016 [8]. It rapidly spread to some Southeast Asian countries. It describes the application of Industry 4.0-enabling technologies—like the Internet of Things, Big Data, or Augmented Reality—to the tourism sector. The concept of Tourism 4.0 is closely related to another one, Smart Tourism. The former is usually used to refer to the technology (software and hardware), while the latter includes social aspects and sustainability [9].

As tourists use the Internet to search for travel information, companies and organizations establish themselves online and offer their services through this type of media [10]. These new tourists are called Tourists 4.0, born under the influence of digitization and new consumption habits. These new tourists have different travel concepts than previous generations. Their mentality is focused on always enjoying quality time, a fundamental factor in acquiring a satisfactory travel experience. This radical evolution in the tourism sector requires a continuous reorientation, firmly linking the needs of tourists, marketing, and experience management.

Marketing Tourism 4.0 is a risky endeavor. A gradual process of building trust, uncertainty reduction, and closing the skills and process gaps in the target groups is needed [11]. A human-centered design can have goal-surpassing effects, enhancing tourist experiences by requiring engagement and active participation in co-creating the experience [1].

2.2. Virtual Tourism

The transformation of the value chain in tourism is accompanied using new technologies. These technologies are being developed at an accelerated rate, especially with the health crisis experienced in recent years, anticipating the projections of digitization and the use of technological tools in 5 years [12]. Organizations increasingly use digitization to create and offer value to consumers, involving creating products or services and the respective new value proposition. Technology has offered a new opportunity to be more attractive to the tourism and hotel sector [12]. This is how virtual tourism has emerged as

an alternative to physical tourism, to provide a digital preview of real destinations and attractions [13].

Virtual tourism emerged as a new mechanism to transform the tourism value offer, where virtual reality allows for an interactive and credible navigation of a place. These technologies change how tourists experience destinations due to the degree of immersion and presence they achieve.

In this context, virtual and augmented reality create attraction to shape future trends [14]: (1) Augmented Reality (AR) uses synthetic images over real images to project virtual objects as part of the real world [15]; and (2) Virtual Reality (VR) involves multiple senses such as vision, sound, and touch for an immersive 3DOF or 6DOF experience in virtual tourism [16]. Therefore, AR technology is spatial; meanwhile, VR technology is three-dimensional. Virtual reality discerns the real illusion in the virtual world, while augmented reality displays the virtual image in the real world [17].

Tussyadiah and colleagues [18] concluded that spatial presence contributes to a positive attitude change toward tourist destinations. In addition, based on this, it was presumed that the perception of presence perceived by the user when using this type of tool would be related to a change in attitudes; that is, the level of perceived presence would enhance positive attitudes. In a second work [19], two studies were conducted to evaluate how the use of virtual reality affected an interest in going to certain tourist places. The obtained results show that presence has a direct effect on the change in attitudes; in this way, the level at which the participant processed information in the virtual environment influenced the preference or interest in the real environment. Thus, the fact of being in a park or city in the virtual environment, and being able to carry out tourism as such, results in a more favorable attitude toward these places. Therefore, participants whose interest in the city or park increased after the virtual reality experience have a greater intention to visit. It is evident in this way that the sense of presence efficiently incites an intention to visit for the first time, or revisit, different destinations.

The interactivity of these technologies involves the tourist's attention for an unparalleled tourist experience [20]. Likewise, accessibility to smartphones has been key since it allows for a direct and immediate immersive experience for the tourist, and its functionalities facilitate tourism through behavioral and emotional influences [21], where trust in smartphones and their daily usage patterns enrich the tourist experience by providing instant personalized information using past data. The tourist experience supports tourists' perspectives, ideas, and fantasies, and technology enhances the overall experience [22].

2.3. National Parks

Nature tourism, particularly in national parks, has acquired significant importance in contemporary societies [23]. Nature reserves or protected areas are fundamental to global biological conservation strategies [24]. Within this type of reserves are national parks, whose objective is "the preservation of environments not significantly altered by human action, capable of self-perpetuating over time, ensuring the continuity of evolutionary processes, in which ecosystems and their species, as well as cultural features, geological formations, and scenic attractions, are of special educational, scientific or recreational interest" [25]. An economic and social impact accompanies this objective on the surrounding communities, who see this tourist attraction as an opportunity for economic development. The magnitude of the economic impacts of tourism depends on the number of visitors and their expenditure on local and regional services and products [26], so encouraging visits to these parks becomes fundamental for the functioning of the economic and social ecosystem of the associated community.

Since parks with better qualities attract visitors from a wider area [26], it is beneficial to highlight the national parks´ characteristics through an easily accessible medium, so that users can learn about their potential attractiveness and be encouraged to visit these places.

3. Methodology

In this research, the methodology follows the Design and Creation approach [27] to develop and evaluate virtual tours. First, the development and process of creating a 360° virtual tour is presented. Second, a user evaluation of the virtual tour is addressed.

3.1. Developing a Virtual Tour

The development of the 360° virtual tours in this project, known as Maule360 (https://maule360.cl accessed on 14 November 2023), aims to contribute to the visibility and promotion of the natural and tourist heritage of the region. For this, 360° tours were generated with extensive interactive features, highlighting the geographical, tourist, and biodiversity qualities that the locations provide. The places chosen to generate these virtual tours were four reserves and natural parks in the Maule region:

- Reserva Nacional Altos de Lircay;
- Reserva Nacional Los Ruiles;
- Parque Nacional Radal Siete Tazas;
- Reserva Nacional Laguna Torca.

These reserves are some of the main natural tourist attractions in the region, as seen in Figure 1A. They have a wide variety of native biodiversity and are visited by national and international tourists. In order to design each virtual tour for the reserves and natural parks, the activities mentioned below were developed:

- Identification of places;
- Coordination of visits to CONAF (National Forestry Corporation);
- Visits and registration of images of tourist places;
- Product development;
- Product release;
- Tracing.

For each visit, an image registration map was initially prepared based on the recognition of each place, considering a minimum of six 360° photographs, according to the characteristics of each location. The aim was to capture images that account for the real state of the tourist offer, focused on emphasizing the place's qualities. Then, the registration of the images was carried out, which later went to the post-production stage in the laboratory. The capture of photographs and recordings was made during the months from July to November 2020. The team moved to the four planned locations to inspect the area and then to make the final captures of the established nodes.

As previously described, the capture technique was carried out with a DSLR camera and subsequent alignment was performed by "Stitching" processing. Additionally, 360° videos of the complete route of each tour were included.

One of the significant benefits of the Maule360 tours is the amount of contextualized multimedia content within the experience. Each virtual tour presents information sheets on flora and fauna, geography, data related to visits, informative videos, 360° videos, an image album with reserve details, a georeferenced map, a location scheme, and developer information, which are elements that enrich the user experience and that entail a greater development requirement, as seen in Figure 1B.

The 360° photographs became the central axis of virtual tours, thanks to the immersion that allows users to see every detail of a specific environment. Virtual tours are a useful tool for simulating a real space and have the potential to add interactive elements such as informative content, movable markers, images, maps, and videos, among many other resources that make this a contextualized interactive experience. These elements complement the 360° image and add value to the user experience.

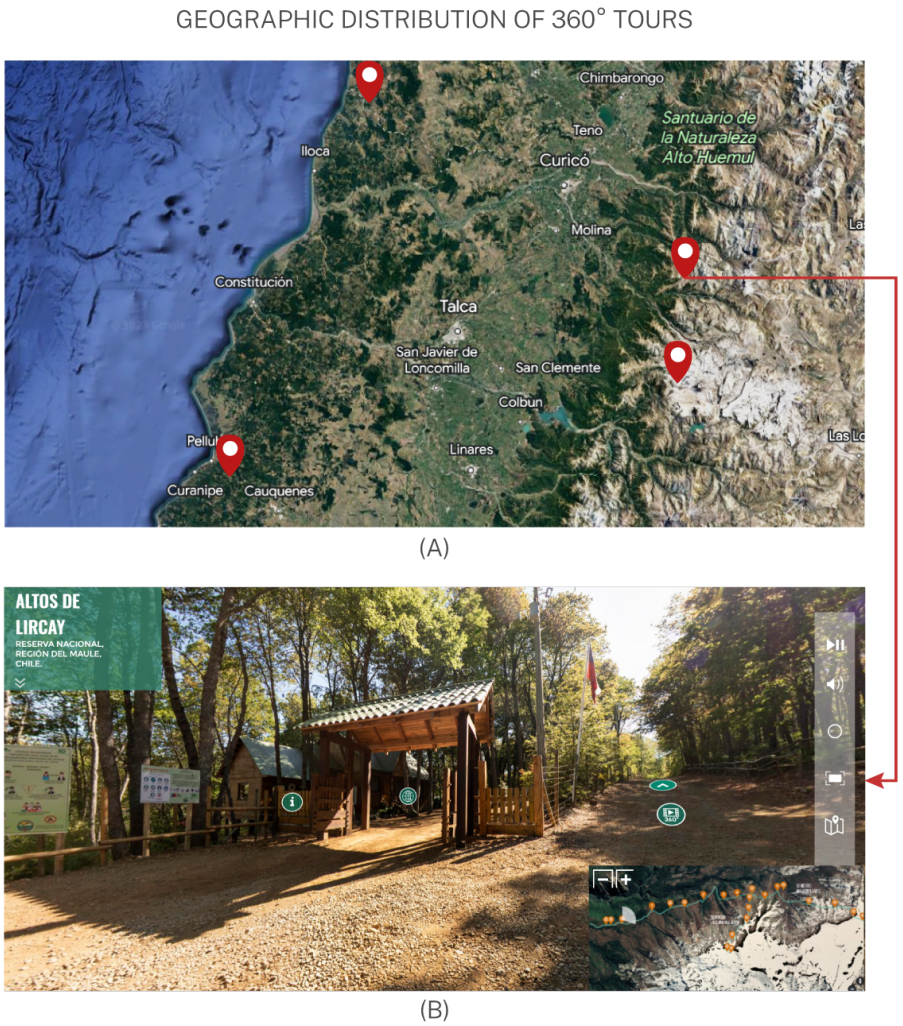

Figure 1. (**A**) Distribution of the four 360° virtual tours and (**B**) HUD (Heads-Up Display) of presentation of the Altos de Lircay tour, where information related to location and 360° videos can be seen.

The Development Procedure

In order to develop a 360° virtual tour that highlights the place's main qualities, the following must be taken into account: the type of construction, location, light, and attributes of the space. Figure 2 presents the pipeline of development of the virtual tours.

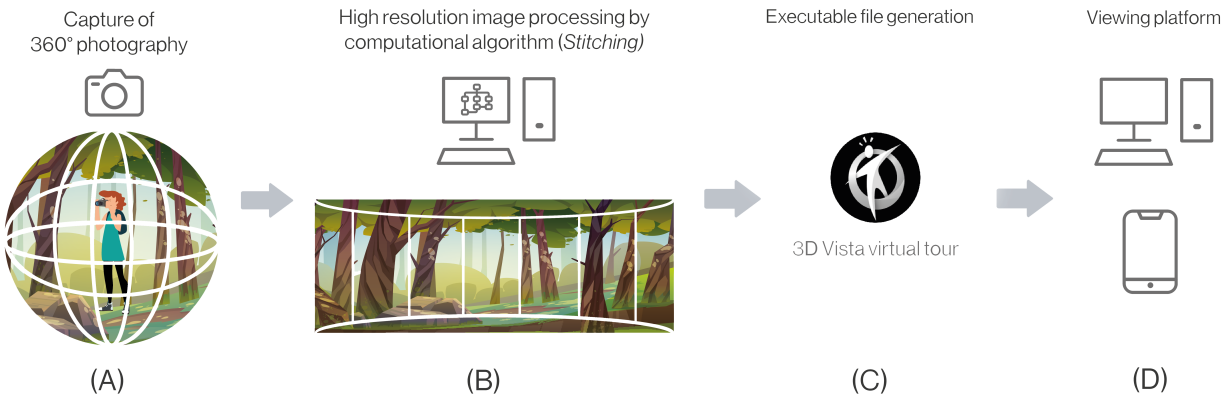

Figure 2. Pipeline of development of the virtual tour: (**A**) Capture of the 360° photography; (**B**) High-resolution image processing by computational algorithm; (**C**) Integration and generation of executable file; (**D**) Export for multiple platforms.

(a) Capture of the 360° photography: To capture the 360° photographs (static element), a high-resolution image capture methodology was used that allows for the generated images to be adapted to different viewing platforms without losing their quality. This process is carried out by capturing photographs with a DSLR camera (Digital-SLR, Single-Lens Reflex). The used accessories were a tripod, a panoramic ball head to capture images from the nodal point of the camera (or non-parallax), and a wide-angle lens, whose focal length is less than that of the normal lens, which results in a viewing angle greater than human vision. The use of this type of lens makes it possible to take as few shots as possible so that alignment errors in the image are minimized, as seen in Figure 2A. Another of the interactive elements to be generated is the 360° videos (dynamic element). The technique of this type of video brings new variables to consider. The purpose of the 360° video must be taken into consideration when choosing the type of camera; in fact, it is the main requirement when choosing. This objective defines the characteristics to be prioritized.
Among the variables are the following:

- Resolution: a resolution of the best possible quality must be achieved. The more frame size available, the better it will look in 360° mode.
- Ease of movement, transfer, and stabilization: to define which camera to use, the movement level that will exist at capture time must be considered. The types of videos necessary for use in the virtual tours developed for Maule360 require that the camera be easily transportable and with good image stabilization since all the capture will be performed while moving on uneven terrain.
- Resistance: the camera will be exposed to different climatic and terrain conditions, so it must have a minimum resistance to dust and blows as well as lens protection.
- Stitching process: it is convenient for the camera to have its own automatic stitching process in order to speed up post-production processes.
- Final display mode: it is necessary to consider how the 360° video will be displayed. This means that, to choose which camera to use, it is advisable to consider which device the video will be displayed on. The larger the screen, the better the resolution that will be needed; if it will only be viewed on mobile devices, a lower-resolution camera can be used.

For the capture of 360° videos, the GoPro MAX camera was used, which has a high-definition image capture, surpassing the current portable cameras on the market during 2020. This increased frame size helped make the image look better in 360° format. In addition, it has hyper smooth technology, which means that, when used while moving, it preserves the horizon line, making its display more convenient for the user. Its attributes concerning frame rate, resistance, stabilization technology, and its conception as an action camera allowed this choice to provide the necessary features for recording on the move.

(b) Stitching: Image stitching is a process that combines images with overlapping areas to form one image with a wide view and high resolution [28]. Stitching is used to produce a panoramic or high-resolution image, usually through a computer program that, through algorithms, identifies the common points of the photographs to create a large image based on smaller ones, as seen in Figure 2B. PTgui Pro Software, version 11.20 was used to control HDR (High Dynamic Range) parameters, tone mapping and exposure blending, image correction, export options, and support of equipment types.

(c) Executable file generation: One of the most important requirements is to develop a virtual tour that can be used in a VR Head-Mounted Display (HMD); at the same time, HMD devices are under development and not yet fully present in people's lives. Therefore, the virtual tours should be fully accessible through the Internet on PC and mobile devices. In this sense, the software product that is developed should be able to be exported to any PC, tablet, or mobile device (Android and iOS) online and offline without prior installation or use of plugins (see Figures 2C,D and 3).

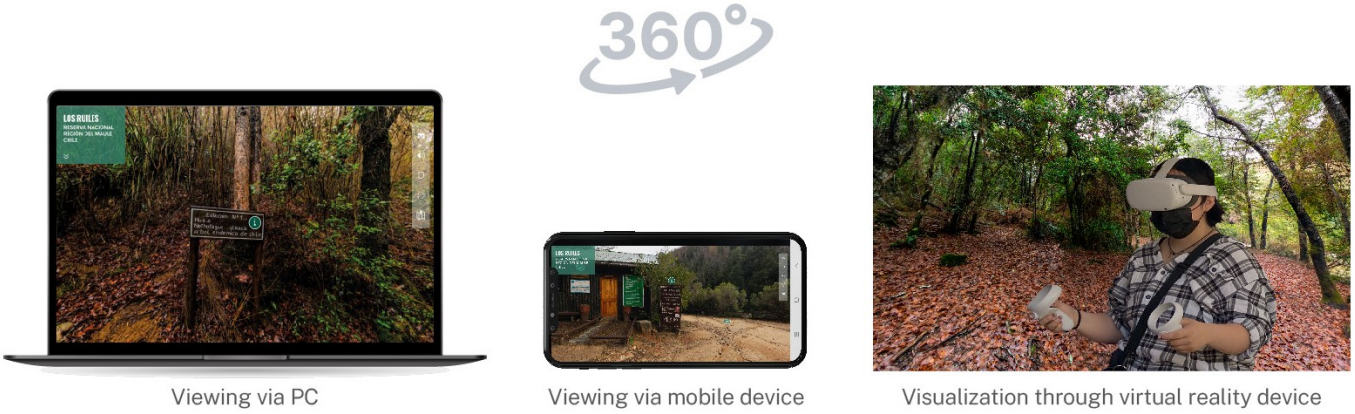

Figure 3. Ways of displaying the 360° tour on different types of devices (PC, mobile devices, and Oculus Go and Quest). A strength of the virtual tours in this project is that the software is exportable to multiple platforms, without needing to rewrite code to adapt it.

3.2. Experience Design

For the experience design of the tours, the steps to be followed and the moments to be recorded for the 360° video sequence were planned exactly, as the video needed to have a logical connection with the 360° images that were associated with the virtual tour. For this, a schematic map was drawn up with the capture points and the sequences to be recorded, which allowed for the planning of the use of inputs such as batteries and cards, as seen in Figure 4.

Figure 4. Planning outline for a 360° virtual tour of the Altos de Lircay reserve.

The 360° format is designed to put the audience at the center, so it is essential to consider how to guide each scene and what can be seen around it. Due to the fact that the viewer is at the center of the action and not behind the camera, shots need to be framed differently than with a flat capture. One way of capturing is to place the camera at the height of a person. To make the shot feel natural and achieve a first-person feeling, the camera is mounted just above the head of the person filming in a helmet, which ensures that the video is at an average height above the ground and the movement can be perceived as the user's own.

Considering these characteristics, the virtual tours were developed with 3DVista Pro, a 360° interactive virtual tour creation software. This software can be used to facilitate the visualization of diverse types of environments through elements such as 360° images and videos, embedded sounds, videos, photos, floor plans, clickable hotspots, various customizable hotspots, quiz cards, scores, and reporting systems, among other functionalities. The multiple customization features and the possibility of adding interactive elements make this software a powerful tool for developing immersive virtual experiences.

This makes the virtual tour a more dynamic and a fully interactive experience. The number of different elements means that the tour presents information on different levels, which makes the experience much more similar to the reality of going through a physical space. As mentioned above, the center of a 360° tour is the images and multimedia resources, and the software supports high-quality images and optimizes their display depending on the platform wherein the tour is run.

3.3. Device Access

To analyze the device's access to the virtual tours, the Google Analytics package was used in the four virtual tours. As mentioned previously, these virtual tours have been optimized for viewing on different types of devices, online and offline.

Currently, 3679 users have accessed the 360° virtual tours. The obtained data show that access has been mainly through mobile devices (see Table 1), corresponding to (82.4%) of the total visits, followed by desktop access with (16.7%) and tablet access with (0.7%).

It is important to note that HMD devices, such as Oculus Go and Quest, are considered part of the category of mobile devices. Furthermore, offline statistics such as uses of the 360° virtual tour in massive tourism fairs and business events are not considered in this table. Nevertheless, as can be seen, mobile devices are the major access point for the virtual tours, which confirms the relevance of producing multi-platform products to reach more people.

Table 1. Number of users who have viewed each virtual tour and accessed devices throughout August 2023.

		Platform		
	Users	**Desktop**	**Mobile**	**Tablet**
Laguna Torca	465	78	384	3
Radal Siete Tazas	1004	150	846	8
Altos de Lircay	1540	217	1314	9
Los Ruiles	690	176	507	7
Total	3699	621	3051	27
Average	924.75	155.25	762.75	6.75

3.4. User Evaluation of the Virtual Tour

3.4.1. Participants

A total of 147 participants, of which 86 women (59%), 57 men (39 %), and 4 without reference (2%), with an average of age M = 35 years and SD = 9.7, participated in the study through social networks.

3.4.2. Procedure and Design

We invited people to participate through different social networks for research about the use and evaluation of a virtual tour with new technologies in tourism.

Participants were asked to visit a link describing the study. They received a link to access the virtual tour of the Radal Siete Tazas park. Then, they were asked to navigate through the virtual experience freely (without time limits or a defined path). Once finished, all participants had to respond to a questionnaire about their experience, future intention of visit, and a open question. The questionnaire was anonymous.

3.5. Measures

The questionnaire was formulated to assess two dimensions for an exploratory analysis: (1) Characterization with open and dichotomous questions, and (2) a correlational study.

3.5.1. Characterization

Several questions were assessed to characterize the participants with respect to two dimensions: (1) About the 360° experience and (2) About the place they visited through the 360° experience. An open question was also included: What did you find most attractive about this experience?

3.5.2. Correlational

For the correlational analysis, two variables were measured: (1) the attractiveness of the experience (software), and (2) the users' behavioral intention.

- Attractiveness: Participants were asked to rate their agreement with the statement "I found the 360° experience attractive". Responses were measured on a 5-point Likert scale, with 1 indicating "strongly disagree" and 5 representing "strongly agree". Higher values indicate that users perceived attractiveness.
- Behavioral Intention: Participants were asked three questions to assess their behavioral intention toward visiting the national park (that is, each question targeted one of three different aspects of their intention to visit: willingness, likelihood, and time spent considering a visit):
  - I am willing to visit the national park.
  - I am very likely to visit the national park.
  - I would consider visiting the national park.

  Responses were measured on a 5-point Likert scale, where 1 represents "strongly disagree" and 5 indicates "strongly agree". Finally, given their high internal correlation (α = 0.909 (Cronbach's alpha)), we averaged them to create a single-index behavioral intention. Higher values indicate more favorable intentions.

3.5.3. Data Analysis

Two sets of analysis were carried out: (1) descriptive and correlational, carried out with SPSS V29 software; and (2) content analysis of the qualitative data collected for the open question, carried out using Atlas.ti software.

4. Results

4.1. Characterization

The grand majority of participants had access to technology, and generally to smartphones and computers. While 96.6% (n = 142) declared to have a smartphone, 97.3% (n = 143) indicated that they had access to a computer. A smaller percentage, 48.3% (n = 71), had access to tablets. Therefore, the majority of the participants were technology users and had access to a smartphone or a computer. This is important because it shows that there is an ease of access to these technological devices, which support the hardware requirements necessary to visualize the virtual tours.

Table 2 presents a summary of the evaluation of the 360° experience, in which 53.7% of the participants declared to know the place (7 Tazas):

- About the 360° experience: Participants had an overall positive perception about the virtual experience. For example, 84.4% of users felt that they had been on the site for a moment, promoting a sense of presence in the place. Also, 78.9% and 95.2%, respectively, found the experience to be involving and attractive. This indicates that the design of the virtual experience has a positive impact on the participants' feelings. Furthermore, 76.9% felt immersed in the environment. This accomplishes the main purpose of the virtual experience: to let users make decisions in the experience, allowing them to interact with objects, as 75.5% of participants indicated. These

aspects are positive, with 91.8% of participants reporting that they would like to visit this place. This means that, after the virtual experience, users found the place attractive, and the virtual experience promotes visits to this place. Finally, 60.5% and 61.9% of the users changed their perception of the place, and would like to contact a tour operator from the sector, respectively.

- About the place they visited through the 360° experience: Most of the participants perceived the place visited through the 360° experience as attractive (94.6%) and special (93.2%). This figure, considering that only 53.7% of the participants knew the place previously, shows that the 360° experience manages to deliver part of the sensations produced by a visit to the real place, generating an emotional impact with the users. Furthermore, the participants considered the related services to be interesting (94.6%) and of high quality (87.8%), making the perception of the site as a tourist attraction highly positive and encouraging users to visit the sites in person.

Table 2. The table shows a summary of the questions asked to the users of the 360 experiences, accounting for the percentages of positive and negative responses received.

		Yes	No
About the 360° experience	Did you know this place?	53.7%	46.3%
	Did you have the feeling of being on site for a moment?	84.4%	15.6%
	Did you feel you could interact with the place?	75.5%	24.5%
	Was the service experience involving?	78.9%	21.1%
	Was the service experience attractive?	95.2%	4.8%
	Did you feel inmersed in the environment of the experience?	76.9%	23.1%
	After this experience, would you like to visit this place?	91.8%	8.2%
	After this experience, did your perception of the place change?	60.5%	39.5%
	Would you like to contact tour operators in this sector?	61.9%	38.1%
About the place visited through the 360° experience	I think it is a special place	93.2%	6.8%
	I consider the place very attractive	94.6%	5.4%
	I find the service interesting	94.6%	5.4%
	High quality of service is reflected	87.8%	12.2%

4.2. Correlation between Attractiveness of the 360° Experience and Behavioral Intention

Descriptive statistics were calculated for the two variables: attractiveness of the 360° experience and behavioral intention (previously defined in Section 3.5.2).

- For the attractiveness of the 360° experience, the observed values go from a minimum of 2 to a maximum of 5, with a mean of 4.66 and with an SD = 0.602.
- For the variable of behavioral intention, the observed values go from a minimum of 1.33 to a maximum of 5, with a mean of 4.297 and with an SD = 0.707.

For both indices, the SD suggest a relatively tight clustering of responses.

To assess the relationship between individuals' perception of the attractiveness of a 360° experience offered through the virtual tour and their behavioral intentions to visit the park, a correlation analysis was conducted indicating a statistically significant positive correlation between the perceived *attractiveness of the 360° experience* and *behavioral intention*, $r(145) = 0.303$, $p < 0.001$. Thus, there is evidence to suggest a relationship where increased attractiveness of the 360° experience is associated with a higher intention to visit.

4.3. Content Analysis

A content analysis was performed for the open question What did you find most attractive about this experience? The comparison of participants' written responses used

the qualitative method of grounded theory [29]. This analysis process is systematic and allows for data to be interpreted. Based on the participants' responses, a series of emerging categories were created through a cyclical and flexible process. The purpose was to identify patterns and their relationships using Atlas.ti Software. The analysis of the data and the identification of information relevant to the study were developed at an open coding level until data saturation was reached. To configure the most relevant categories, data were compared, contrasted, added, and sorted [30]. This procedure provided a list of codes (10) from which three categories were obtained: (1) Technology, (2) Emotional Response (participants' written responses were classified in this category if they made any reference to an emotion. No difference was made between positive, negative, or neutral emotions), and (3) Multimedia Experience. Three open code quotes were selected from each category to illustrate the variety of perceptions around the subject investigated.

1. Technology: In relation to this thematic axis, the participants expressed novelty and satisfaction when learning about a tool that allows for the promotion of the reservation through a 360° experience. For example, participant 26 states: "There is a technological tool that can virtually show you the destination you would like to visit"; participant 50 indicates: "New and innovative experience that brings closer the places that people would like to visit and decide their destination in a better way", and participant 121 comments that "The images are clear, and you can also see videos of the place, which makes the experience more realistic".
2. Emotional Response: Participants manifest different emotions related to the 360° experience, meaning that the interaction with the 360° experience evokes different emotions in them. For example, participant 19 notes that "It is interesting to visit a place without visiting it, it gives you the opportunity to learn about places without necessarily being there, and it brings you closer to a new stop or destination with greater motivation"; participant 72 indicates: "Feeling like I was there, even the weather was perceptible, memories came to me of the situations I experienced there. Nice experience"; participant 127 notes: "The fact that even the details of when you approached the information house were given to you as if you were really there, seemed like a curious detail to me".
3. Multimedia experience: The interaction of the users with the 360° experience involves all different senses and their interactions. Among several factors that influence computer interactions, sensation and usefulness are commonly studied in this field. Positive feedback was found in relation to this main axis, and participant 90 remarks that "The sensation of interaction with the site in a quality of resolution and images that gives the feeling of being in the place"; participant 103 states: "The Web itself is very intuitive, it greatly compensates those who are not related to technology. On the other hand, the experience was quite pleasant and nutritious in terms of additional information"; finally, participant 141 mentions that "Being able to access different points of view, one place takes you to another and you can watch informative videos".

5. Discussion

The objective of this work was the design and development of 360° virtual tours for four national parks across Maule, Chile. The principal contributions of this research include the following: (1) the process and knowledge gained, including recommendations drawn from this work for developing 360° tours or experiences, combining dynamic and stationary elements in 360° in a virtual experience; (2) the results of an exploratory study, which evaluate the 360° experience correlating the attractiveness of the experience with the intention of visiting the place, among other variables involved in characterizing the 360° experience.

The first contribution relates to the pipeline development process of the four tours (see Figure 2). This process allowed for the generation of a multi-platform software that runs not only on Oculus HMD, but also on mobile devices and PC computers. This is relevant because it is not necessary to develop a separate experience for each device (cell phone, tablet, PC computer, HMD). Therefore, the development process of the software is

sustainable and centralized. Although HMD devices may have become more accessible in recent years, due to advancements in technology and lower costs, they are still not as common as mobile devices or PC computers. Thus, 360° experiences that are available on mobile devices and computers are more relevant than experiences available exclusively for HMD; users have a similar type of experience (free range of motion without time limits, interacting with dynamic and stationary elements, etc.), where the only change is the medium. Interactions with these elements are slightly different on the different devices. For the 360° movement, for example, mobile device users move an accelerometer, on the computer they use a mouse, and with an HMD device they move their head. However, the objective and way of expressing the information is the same. The participants in the study declared to have a smartphone and a computer, at 96.6% and 97.3%, respectively, showing that access to these devices is straightforward. This is related with the empirical data collected from the tours where the major visits occurred on these devices (see Table 1).

The second contribution of this research is the exploratory study, including the characterization of the participants, the correlational study, and the content analysis. First, according to the characterization of participants, the 360° virtual experience was positively received by users. A total of 84.4% indicated that they felt psychologically present in the place, emphasizing the sense of presence that the experience can evoke. The metrics associated with feelings were also high: 78.9% found the experience involving, 95.2% considered it attractive, and 76.9% felt immersed in the environment of the experience. In accordance with the behavioral intention of the experience, 75.5 % of users felt they could interact with the place. In particular, after the virtual experience, 91.8% of the participants expressed interest in visiting the real place, which illustrates that a promotional effect exists with this type of virtual tools.

Second, in the correlational study, the users' perception of the attractiveness of a 360° experience offered through the virtual tour, and their behavioral intentions to visit the park, suggest a relationship where increased attractiveness of the 360° experience is associated with a higher intention to visit. This can be related with other factors in which an attractive virtual experience has positive effects. For example, (1) Immersion: virtual experiences that are attractive and realistic increase the user's sense of immersion, which can awake the user's curiosity. Aspects within the virtual environments can include how extensively a display system is able to create for the user an all-encompassing, sizeable, and realistic virtual environment [31]; (2) Positive Experience: positive emotions and feelings generated during the virtual experience can influence people's future intentions. After all, emotions are an essential part of how people experience the world [32]; (3) Interaction: interactive experiences increase the participation and connection between the user and the content. In virtual environments, the computer simulates a natural interaction with the physical world. Intuitive movements and interactions become computer commands [33]. The interactions of the 360° virtual tours were designed to allow the user to act and move freely in the virtual environment, promoting a natural interaction with the system; (4) Promotional Tool: virtual experiences can act as persuasive marketing tools, increasing interest and an intention to buy. Several studies have shown the relationship between virtual reality satisfaction and behavioral involvement, as well as behavioral involvement and visit intention [5,34].

Finally, in the content analysis, the categories "Technology", "Emotional Response", and "Multimedia Experience" present positive characteristics in terms of technology, immersion, interaction, and promotion. The participants found the 360° experience very attractive (M = 4.66), and this content analysis allows us to identify several concepts associated with this dimension. These concepts are relevant for the process of developing software, which has a positive impact on the user.

In the case of tourists, not everyone is looking for the same experiences, but they do maintain common patterns, such as the use of technological tools to improve their travel experience. The results of this study show that this type of 360° virtual tours positively influences the user's behavioral intention, like others studies suggest [18,34].

It also considers, as an important added value, the idea of "try before you buy". The proper dissemination of this type of technology in marketing strategies is relevant, adding value to the tourism sector. Travelers increasingly use information technologies to choose their destinations and plan their trips, so the integration of new technological tools allows them to influence or present an alternative in the decision-making process for future customers.

Finally, tourism is a conservative sector in Chile, where the adoption of innovative technologies has not been developed with full intensity and dedication, both in terms of time and budget. This sector has had to adapt in a forced way in recent years, according to the new preferences and demands of 4.0 Tourists. However, the setback experienced in the last two years, due to the health crisis, generated a low demand for the services provided by the tourism sector, but it also promoted the application of technological solutions that would maintain the interest of future tourists or even include technologies such as Augmented Reality into their experiences to promote a memorable experience [35]. Increasingly, clients want to buy a complete experience in which they are able to learn, have a good time, and participate in various activities, resulting in worthwhile memories [36].

Limitations and Future Work

One limitation is the time that participants dedicated to the virtual experience: since the virtual tour was hosted on different server, we were not able to measure time of observation.

Another limitation is that we did not control which device was used to access the virtual experience (PC or mobile device), since it was not a main goal of the exploratory study. Instead, the study focused on obtaining information about the experience in global terms and the users' thoughts about it.

In the future, additional research should focus on different methods for improving interaction between the user and the software, making comparisons related to how the software, through different technologies, impacts the user's intention to visit a national park and the user's attitude. After all, the evolution of hardware is constantly growing with the availability of HMD devices, which will allow for a more immersive experience; therefore, this could have an impact on some effects of the 360° virtual tours.

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Abbreviations

The following abbreviations are used in this manuscript:

AR	Augmented Reality
CET	Technological Extension Center
CONAF	National Forestry Corporation, Chile
CORFO	Corporation for the Promotion of Production, Chile
HDR	High Dynamic Range
HMD	Head-Mounted Display
HUD	Heads-Up Display
DOF	Degrees of Freedom
DSLR	Digital Single-Lens Reflex
SERNATUR	National Tourism Service, Chile
SMEs	Small and Medium-sized Enterprises
UNWTO	United Nations World Tourism Organization
VR	Virtual Reality

References

1. Stankov, U.; Gretzel, U. Tourism 4.0 technologies and tourist experiences: A human-centered design perspective. *Inf. Technol. Tour.* **2020**, *22*, 477–488. [CrossRef]
2. Bowen, J.; Whalen, E. Trends that are changing travel and tourism. *Worldw. Hosp. Tour. Themes* **2017**, *9*, 592–602. [CrossRef]
3. Kim, M.J.; Lee, C.K.; Jung, T. Exploring Consumer Behavior in Virtual Reality Tourism Using an Extended Stimulus-Organism-Response Model. *J. Travel Res.* **2020**, *59*, 69–89. [CrossRef]
4. Guttentag, D.A. Virtual reality: Applications and implications for tourism. *Tour. Manag.* **2010**, *31*, 637–651. [CrossRef]
5. Jego, L.; Gallardo, I.; Besoain, F. Developing a Virtual Reality Experience with Game Elements for Tourism: Kayak Simulator. In Proceedings of the 2019 IEEE CHILEAN Conference on Electrical, Electronics Engineering, Information and Communication Technologies (CHILECON), Valparaiso, Chile, 13–27 November 2019; pp. 1–6. [CrossRef]
6. Besoain, F.; González-Ortega, J.; Gallardo, I. An Evaluation of the Effects of a Virtual Museum on Users's Attitudes towards Cultural Heritage. *Appl. Sci.* **2022**, *12*, 1341. [CrossRef]
7. Stappung, Y.; Besoain, F. Strategy for evaluation, characterization and adoption of immersive technologies to the public of the tourism industry in Maule Region. In Proceedings of the 2021 IEEE CHILEAN Conference on Electrical, Electronics Engineering, Information and Communication Technologies (CHILECON), Valparaiso, Chile, 6–9 December 2021; pp. 1–6. [CrossRef]
8. Korže, S.Z. From Industry 4.0 to Tourism 4.0. *Innov. Issues Approaches Soc. Sci.* **2019**, *12*, 29–52.
9. Pencarelli, T. The digital revolution in the travel and tourism industry. *Inf. Technol. Tour.* **2020**, *22*, 455–476. [CrossRef]
10. Burdea, G.C.; Coiffet, P. *Virtual Reality Technology*; John Wiley & Sons: Hoboken, NJ, USA, 2003.
11. Starc Peceny, U.; Urbancic, J.; Mokorel, S.; Kuralt, V.; Ilijaš, T. Tourism 4.0: Challenges in Marketing a Paradigm Shift. In *Consumer Behavior and Marketing*; IntechOpen: Rijeka, Croatia, 2020.
12. Sharma, P.; Leung, T.Y.; Kingshott, R.P.; Davcik, N.S.; Cardinali, S. Managing uncertainty during a global pandemic: An international business perspective. *J. Bus. Res.* **2020**, *116*, 188–192. [CrossRef]
13. Pestek, A.; Sarvan, M. Virtual reality and modern tourism. *J. Tour. Futur.* **2020**, *7*, 245–250. [CrossRef]
14. Yung, R.; Khoo-Lattimore, C. New realities: A systematic literature review on virtual reality and augmented reality in tourism research. *Curr. Issues Tour.* **2019**, *22*, 2056–2081. [CrossRef]
15. Wedel, M.; Bigné, E.; Zhang, J. Virtual and augmented reality: Advancing research in consumer marketing. *Int. J. Res. Mark.* **2020**, *37*, 443–465. [CrossRef]
16. Kang, H.J.; Shin, J.h.; Ponto, K. How 3D virtual reality stores can shape consumer purchase decisions: The roles of informativeness and playfulness. *J. Interact. Mark.* **2020**, *49*, 70–85. [CrossRef]
17. Fan, X.; Jiang, X.; Deng, N. Immersive technology: A meta-analysis of augmented/virtual reality applications and their impact on tourism experience. *Tour. Manag.* **2022**, *91*, 104534. [CrossRef]
18. Tussyadiah, I.P.; Wang, D.; Jia, C. Virtual reality and attitudes toward tourism destinations. In Proceedings of the Information and Communication Technologies in Tourism 2017, Rome, Italy, 24–26 January 2017; Springer: Berlin/Heidelberg, Germany, 2017; pp. 229–239.
19. Tussyadiah, I.P.; Wang, D.; Jung, T.H.; Tom Dieck, M.C. Virtual reality, presence, and attitude change: Empirical evidence from tourism. *Tour. Manag.* **2018**, *66*, 140–154. [CrossRef]
20. Flavián, C.; Ibáñez-Sánchez, S.; Orús, C. Impacts of technological embodiment through virtual reality on potential guests' emotions and engagement. *J. Hosp. Mark. Manag.* **2021**, *30*, 1–20. [CrossRef]
21. Wang, D.; Park, S.; Fesenmaier, D.R. The role of smartphones in mediating the touristic experience. *J. Travel Res.* **2012**, *51*, 371–387. [CrossRef]

22. Iquira Becerra, D.A.; Sharhorodska, O.; Tacca Barrantes, C.A.; Monroy Vilcahuaman, J.L.; Sumire Coasaca, B.J.; Collazos Ordoñez, C.A. Proposal for a User-Centered Virtual Reality System for Promoting Tourism in Peru. In Proceedings of the International Conference on Human-Computer Interaction, Virtual Event, 26 June–1 July 2022; Springer: Berlin/Heidelberg, Germany, 2022; pp. 62–73.
23. López, I.; Pardo, M. Tourism versus nature conservation: Reconciliation of common interests and objectives—An analysis through Picos de Europa National Park. *J. Mt. Sci.* **2018**, *15*, 2505–2516. [CrossRef]
24. Pauchard, A.; Villarroel, P. Protected Areas in Chile: History, Current Status, and Challenges. *Nat. Areas J.* **2002**, *22*, 318–330.
25. Gaymer, M.; Guillermo Donoso, M.G. *Informe Final Programa: Sistema Nacional de Áreas Silvestres Protegidas por el Estado (SNASPE)*; Technical Report; Ministerio de Agricultura, Corporación Nacional Forestal CONAF: Santiago de Chile, Chile, 2005.
26. Neuvonen, M.; Pouta, E.; Puustinen, J.; Sievänen, T. Visits to national parks: Effects of park characteristics and spatial demand. *J. Nat. Conserv.* **2010**, *18*, 224–229. [CrossRef]
27. Oates, B.J.; Griffiths, M.; McLean, R. *Researching Information Systems and Computing*; Sage: Thousand Oaks, CA, USA, 2022.
28. Wang, Z.; Yang, Z. Review on image-stitching techniques. *Multimed. Syst.* **2020**, *26*, 413–430. [CrossRef]
29. Strauss, A.; Corbin, J. *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*, 2nd ed.; Sage Publications, Inc.: Thousand Oaks, CA, USA, 1998; p. xiii, 312.
30. Stake, R.E. *The Art of Case Study Research*; Sage: Thousand Oaks, CA, USA, 1995.
31. Slater, M.; Wilbur, S. A framework for immersive virtual environments (FIVE): Speculations on the role of presence in virtual environments. *Presence Teleoper. Virtual Environ.* **1997**, *6*, 603–616. [CrossRef]
32. Huang, M.P.; Alessi, N.E. Presence as an emotional experience. In *Medicine Meets Virtual Reality*; IOS Press: Amsterdam, The Netherlands, 1999; pp. 148–153.
33. Biocca, F.; Delaney, B. Immersive virtual reality technology. *Commun. Age Virtual Real.* **1995**, *15*, 10–5555.
34. Nguyen, T.B.T.; Le, T.B.N.; Chau, N.T. How VR Technological Features Prompt Tourists' Visiting Intention: An Integrated Approach. *Sustainability* **2023**, *15*, 4765. [CrossRef]
35. Li, S.; Jiang, S. The Technology Acceptance on AR Memorable Tourism Experience—The Empirical Evidence from China. *Sustainability* **2023**, *15*, 13349. [CrossRef]
36. Obradović, S.; Stojanović, V.; Tešin, A.; Šećerov, I.; Pantelić, M.; Dolinaj, D. Memorable tourist experiences in national parks: Impacts on future intentions and environmentally responsible behavior. *Sustainability* **2022**, *15*, 547. [CrossRef]