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Research Paper

A multisensory virtual experience model for thematic tourism: A Port wine tourism application proposal

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ABSTRACT

Technological evolution has led to a significant transformation in tourism organizations, particularly in those who focus their activities on particular themes or segments, such as wine tourism. This can be transposed to Portuguese wine tourism organizations because the majority lack the necessary information and communication technologies (and inherent technologies) to become globally competitive. As highlighted in the literature, for a tourism experience to become memorable it must be emotional and immersive in such a way that the tourist becomes fully involved with the existing surroundings. This leads to the notion of using virtual reality experiences as triggers for the development of wine tourism. Considering the relevance of Portugal's Douro Valley to the country's wine tourism segment, a theoretical model that supports the implementation of multisensory (hence more immersive) virtual wine tourism experiences is developed. While considering the international success of Port wine tourism, this paper also presents a conceptualization of a multisensory virtual Port wine experience that includes a conceptual perspective and a technological solution proposal.

1. Introduction

In line with international comparators, Portugal has in recent years begun to view wine tourism as an interesting activity that can foster the country's economy and, simultaneously, trigger economic and social progress in regions with underdeveloped economic and social situations. Despite the existing knowledge on Portuguese high-quality gastronomy, it was not until a few years ago that other wine-related products began to be produced, despite consistent concerns being expressed regarding whether high quality levels can be maintained, the aim being to emulate the successes of Port wine (Correia, Ascenção, & Charters, 2004).

According to Gonçalves and Maduro (2016), some of the most interesting features of the northern area of Portugal are its vineyards, which are typically spread across a steep and rugged landscape that triggers tourists' enthusiasm for both its beauty and its natural resources. In this respect, the Douro Valley (DV) is the most relevant region. Initially demarcated as a wine region in 1756, it currently has a total area of over 250,000 ha, of which almost 15% is occupied by vineyards that are owned and exploited by almost 40,000 wine producers (Brito & Correia, 2006; Sousa, 2013). For tourism experiences to be memorable in these regions, they must generate an emotional connection with the tourist. A good example of such experiences is the one provided by wine tourism, mainly due to the authenticity that is recognized in all things related to wine making, from the harvest to the degustation (Slåtten, Mehmetoglu, Svensson, & Sværi, 2009).

In their research, Fernandes and Cruz (2016) claim that despite the broad scope of elements associated with wine tourism, tourists are most enchanted by wineries due to their physical features and attractive atmospheres. In the majority of cases, this multiplicity of interests is caused by interactions between winery collaborators, tourists and the ambient and physical elements of the wineries themselves, thus creating a holistic tourism experience that expands beyond merely wine tasting.

As argued by Pérez-Calderón, Ortega-Rossell, and Milanés-Montero (2016), Schlüter and Norrild (2015), the process associated with producing wine blends extremely well with touristic activities. However, despite the magnetism that tends to entice tourists to visit the DV region and enjoy the wine-related experiences available, much is yet to be done to provide them a unique and immersive sense of what really exists throughout the region and to align their expectations with what wine tourism has to offer (Quadri-Felitti & Fiore, 2016).

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In order to address the new challenges that exist in all thematic tourism and, in particular, wine tourism, virtual experiences are being created that mimic the reality of tourism destinations and attractions, without requiring the tourists to leave their present location. This paper proposes a theoretical model that supports multisensory virtual tourism experiences and applies it to Port wine tourism. This proposal, while still in the conceptual stage, aims to make a valid contribution towards future developments in this area.

2. ICT applied as tourism experience enhancers

The dynamics of the digital-age society have led many organizatons to embrace information and communication technologies (ICT) as critical tools, not only to support but also to develop their business activities and to reach new customers that would otherwise be very difficult to reach (Gonçalves, Martins, Pereira, Cota, Branco & Gonçalves, 2016). By applying ICT to tourism business activities, these technologies have not only helped organizations to develop, manage and publish their tourism-related products but have also helped customers to search and purchase tourism products and services with a high degree of personalization (Bethapudi, 2013).

As argued by Buhalis and O'Connor (2005), Ye, Li, Wang, and Law (2014), the constant evolution associated with ICT and its growing application to tourism activities (*e*-tourism) have led tourism organizations to change their mindsets and assume that 21st century tourism must be focused on consumer preferences and, at the same time, be supported by consumer-centric technologies, hence ensuring sophisticated and memorable experiences. In parallel, as a result of consumers' desire to collectively and cooperatively describe and rate existing tourism products through the use of online tourism-directed platforms, only those companies that are focused on taking advantage of ICT and all emergent technologies to provide their customers with more dynamic, interesting and immersive experiences are going to be competitive in the existing global tourism market (Ku & Chen, 2015; Pantano & Di Pietro, 2013).

According to Szopiński, Staniewski, and Jansen (2016), the existing internet-based platforms directed at tourism have greatly impacted the majority of tourism organizations, mainly through the possibility of analysing, in a simple and quick manner, customer feedback and other customer preferences and requests. This has led organizations to make considerable changes to their products and services, thus adjusting their offerings according to the customers' desires (Lucchetti & Arcese, 2014).

2.1. Multisensory virtual systems

A common goal of virtual reality (VR) applications is to transport users to a virtual environment (virtual environment, VE) and have them experience that environment as though it were real. The feeling of 'being there' increases significantly the effectiveness of VR applications and enables their use in many applications, such as training and certification. Among the scientific community, the 'transportation' of users to the VE is widely measured through the level of presence felt by the users (Schubert, Friedmann, & Regenbrecht, 2001; Slater, Usoh, & Steed, 1994; Witmer & Singer, 1998). Due to the nature of VR applications, they can be valuable for promoting tourism because tourism is based on discovering new places and having new experiences. Indeed previous work has already addressed the topic of virtual tourism for marketing/promotional purposes and showed that it is effective (Cho, Wang, & Fesenmaier, 2002; Hyun, Lee, & Hu, 2009).

Several studies have confirmed this, as they revealed that the more human senses that are engaged in a VE, the more immersive is the experience and the better is the performance of the subjects (as in real environments) (Dinh, Walker, Hodges, Song, & Kobayashi, 1999; Feng, Dey, & Lindeman, 2016; Slater & Wilbur, 1997). Therefore, the closer to reality the VR system is, the greater will be its effectiveness as a marketing tool for tourism. As humans sense the surrounding environment through the five senses, multisensory cues are important to achieve a high level of presence in VEs. Multisensory integration seems to be based on the principles of Bayesian decision theory, incorporating maximum-likelihood estimation (MLE) (Deneve & Pouget, 2004; Ernst & Banks, 2002; Ernst & Bülthoff, 2004; Knill & Richards, 1996). There is also evidence showing that adding a supplementary sensory modality to a display may affect the way participants respond to a given stimulus but not their actual experience (Gallace, Ngo, Sulaitis, & Spence, 2012).

Since an early stage of VR technology there has been work that has addressed multisensory stimulation, such as Sensorama (Heilig, 1961, 1998). Sensorama was, to the best of the authors' knowledge, the first multisensory VR system to be proposed. It consisted of a set of equipment arranged in a structure with a seat that allowed viewers to sit and enjoy a multisensory experience. This system was capable of displaying 3D stereoscopic images, reproducing stereo sound, simulating wind, and delivering aromas. The results have had an impact on society but the system was not widely adopted because it consisted of a large apparatus and the technology did not satisfy the standards for creating a credible experience. The VR systems that have been developed since then have therefore been simpler, and the majority of the available VR applications still rely only on visual expression and presentation, occasionally complemented with sound as an additional sensory input (Agapito, Mendes, & Valle, 2013).

With the evolution of VR-related technologies, there has been a push forward in the current state of the art for multisensory systems where several senses are stimulated at the same time, and users are presented with 'real experiences' designed in virtual worlds. Some good examples of such systems are the Multimodal Floor (Law et al., 2009), the multisensory management and visualization system for multisensory content (Freitas, Meira, Melo, Barbosa, & Bessa, 2015), the 7D interactive cinema system (Shuqee, 2016), and the LaparoscopyVR system (Healthcare, 2016). The Multimodal Floor consists of a multimodal interface that simulates a given floor and offers users immersion in virtual-reality and augmented-reality environments. The platform is able to simulate natural floors such as snow or ice and consists of 36 panels with a set of sensors that stimulate the users' vision, audition and haptics as though they were in the real-world scenario. The multisensory system proposed by Freitas et al. (2015) allows for the management and delivery of visual, auditory haptic and olfactory feedback. The management of the stimuli is conducted through an interface that allows the producer of the experiment to define the moment of the virtual experience at which each sense should be stimulated and the intensity of the stimulation. The visual stimulus consists of 360-degree videos delivered via a head-mounted display; the auditory stimulus is stereo and is delivered with a pair of headphones; the haptic feedback is achieved through simulation of wind, which is produced using a fan; and the olfactory feedback is delivered using a smell dispenser. The interactive 7D Cinema consists of an interactive stereo attraction, set in a cinema room, that makes use of 3D film technology and simulates the surrounding environment by stimulating the visual, auditory, haptic and olfactory senses. To achieve this, the setup includes a projection system, a 3D sound system, a motion chair, a set of air-related equipment (compressor, dryer, etc.), water sprays, a strobe lamp, a bubble machine and a snow machine. The interaction is achieved using multiplayer interaction technology that is prepared to receive input from a series of differently themed amusement equipment that is associated with the 3D simulation to be depicted. The LaparascopyVR system consists of a laparoscopic surgical simulator designed for teaching and training surgical students to perform minimally invasive laparoscopic procedures. It has proven to be a valuable tool, as it facilitates medical training and allows for risk-free training in a realistic environment through force feedback, which provides accurate tactile, visual and auditory responses to mimic the feel of real procedures.

3. A model proposal for multisensory virtual tourism

The advances associated with VR technologies have enabled their use in several business sectors, including tourism-related activities. By focusing on this particular sector of activity, there are many possible applications for VR with significant potential impact for both organizations and tourists (Guttentag, 2010; Huang, Backman, Backman, & Moore, 2013).

The most evident applications for VR associated with tourism are marketing, entertainment, education and cultural preservation. This paper presents a completely new model that is capable of delivering multisensory virtual experiences that can serve tourism by promoting touristic activities. This proposal will support the design and delivery of multisensory virtual tourism experiences that will allow for tourist organizations to virtually replicate tourism destinations and products and easily present them to new customers in their own environment, without them having to travel. To further prove the applicability of the platform, a case study is presented that allows the above-identified applications of VR associated with tourism to be explored, specifically for enotourism in the Douro Region.

3.1. Proposed model - global characterization

Achieving an optimal experience requires a realistic multisensory experience that allows for the recreation of the given environment with such fidelity that the user feels transported to the simulated scene. This requires the delivered stimuli to be credible and the environment to respond to the user's interaction in the same way as would occur in the real scenario so that the user can construct a mental image (Slater & Usoh, 1993). For this, a natural option is to use virtual environments, as their original concept was to transport the users to an environment and make them feel as if they are physically present in that same virtual environment through interaction with the system's human interface and subsequent perceptual feedback provided by the system.

The majority of VEs stimulate only the visual and auditory senses, but it is known that human beings perceive the physical environment through five senses. Therefore, if one wants to create a highly immersive experience, it is pertinent to include the other three senses in the VE and create a complete multisensory environment that has a high level of perceptual equivalence when compared to the real scenario (Gallace et al., 2012).

Although some multisensory systems have already been proposed, there is no distinct methodology behind their creation: they are based on complex setups with multiple devices attached that work independently. For instance, the Sensorama is a structure with attached stimulation equipment that has to be tuned to a video. The Multimodal Floor and the Laparoscopy VR are sets of instruments that work as buttons that give a certain feedback when pushed. Cinema 7D and the multisensory system developed by Freitas et al. (2015) are somewhat more complex. They share the same underlying principle, however: a set of equipment is assembled together and programmed to perform actions/stimulations at certain points. This approach seems to be common practice and has already proven to be efficient, but there are some limitations associated with it, such as difficulties in experience customization, stimulus synchronicity and scalability. Therefore, it can be said that there is a need for establishing virtual reality models that take full advantage of multisensory virtual reality.

As a result of this argument, the following multisensory virtual-reality tourism model was developed (Fig. 1).

The proposed model is composed of five stimulus-related blocks (visual, audition, olfactory, tactile and gustatory), directly associated with a 'thematic tourism' block that represents the specific features and characteristics of the tourism experience (e.g. Port wine tourism). The advantage of having a block for each of the senses is that it allows the fine customization of how each sense is stimulated at both the hardware and software levels. Please note that the 'thematic tourism' block is illustrative and can be replaced by any other field of application, depending on the goals of the system administrator. This allows for a consistent setup across different fields of application, minimizing the possible limitations associated with experience customization.

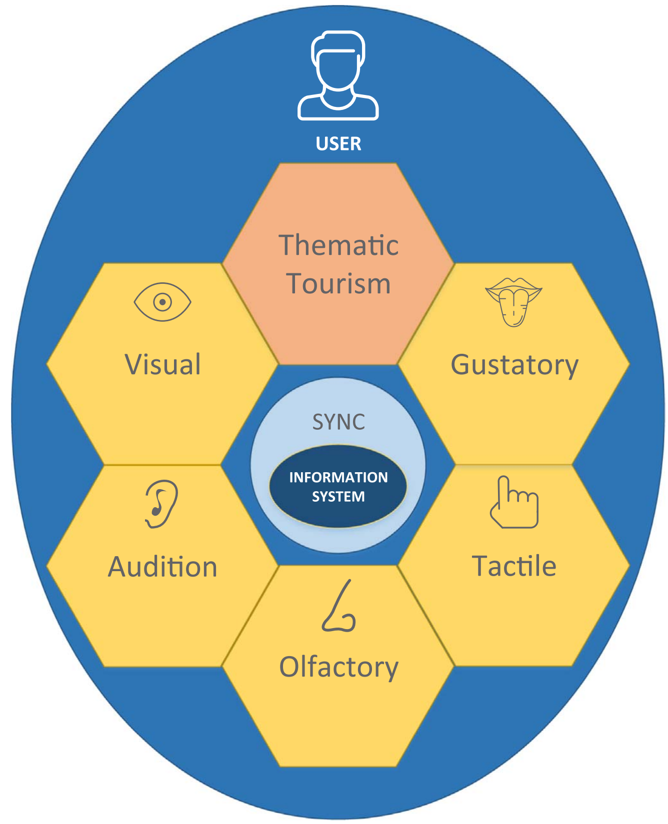

Fig. 1. Proposed multisensory virtual-reality tourism model.

All the blocks are controlled by an information system (IS) through a synchronization layer, which is responsible for transmitting the IS instructions to the technological components of each stimulus block and for passing the indicators related to the virtual world (that is being delivered) to the IS.

3.2. Proposed model – stimulus blocks

The stimulation of the five senses in a way that enables the users to create mental images of a given scene, thereby maximizing their immersion, is a challenge. This is because human perception is a complex system and there are important technical/technological aspects to take into account when providing such stimulation. On top of the integration of all the equipment required to provide a multisensory experience that stimulates the five senses, it is important to ensure that the stimuli are properly delivered in terms of content, timing, and intensity. To address this, this paper proposes an architecture that has a core block that is responsible for managing the delivery of stimuli to all five senses. This core block allows a more refined control over all the stimuli that need to be delivered by quantifying, prioritizing and synchronizing the delivery. Due to the different particularities of each sense, the senses are divided into single blocks that are connected to the core block, as this allows for greater control over all the variables associated with each sense.

3.2.1. Core block

The core block is responsible for delivering a credible multisensory virtual-reality experience to users. To ensure its performance, the block is designed to include the proper mechanisms that allow for the management and synchronization of the system blocks. It is at this level that the IS controls all of the information related to the virtual experience and the necessary stimuli. This core block is modular and ensures the flexibility of the system, as it is possible to configure or even deactivate a given module if required.

3.2.2. Visual

The human eye can distinguish between 8 and 12 million colours and can see detail in regions that vary in a range of four orders of magnitude at any particular eye adaptation level (Chalmers, Howard, & Moir, 2009). Currently, through the use of HDR technology, a large portion of the dynamic luminance range available in the real world can be represented and displayed. Furthermore, the visual sense is the most studied sense in VE and thus a high level of realism can be achieved. Technologically, stimulation of this sense can be delivered in a number of ways, such as using the Cave Automatic Virtual Environment (C AVE), head-mounted displays (HMDs) or panoramic displays. In terms of the stimulus itself, this block is responsible for handling the settings regarding the resolution, rendering quality and number of frames per second of the visual content.

3.2.3. Audition

Sound is widely used in 3D virtual environments, but not all systems use the spatial properties of this stimulus to increase its fidelity. Therefore, this block is responsible for handling spatial sound rendering in 3D environments. It takes into account the users' head movement; thus, the sound is an object that undergoes similar changes. The delivery can be made using headphones or properly calibrated sound setups that ensure a 360-degree 3D sound experience. Regarding the stimulus properties, this block is responsible for its quality level, intensity and spatial position.

3.2.4. Olfactory

Smell is not widely used in VEs; some studies have, however, used this stimulus for training (Washburn, Jones, Satya, Bowers, & Cortes, 2003) and therapy purposes (Barfield & Danas, 1996; Chen, 2006). Preliminary results have shown that introducing this sense in the VE can increase the user´s sense of presence (Dinh et al., 1999; Zybura & Eskeland, 1999). The inclusion of realistic smells, including the smells of burnt rubber and flesh, has been used effectively to treat soldiers with post-traumatic stress disorder after the Iraq war experience (Pair et al., 2006) and is currently being considered by the Ministry of Defence for interactive games for training British soldiers. This block manages the information regarding the stimulus intensity, duration and the smell-source position.

3.2.5. Tactile

Although haptic feedback in virtual environments is a large, active, multidisciplinary field, current haptic devices face several constraints, such as their limited feedback capabilities when compared to the human tactile sensory system. While the human hand has multiple tactile sensors working simultaneously, current haptic interfaces have fewer than 10 tactile feedback motors. Furthermore, current haptic devices face other limitations, such as high price, high weight and size, bandwidth limitations, latency between the human operator and the force feedback, and instability in cases when the update rate is much less than 1 kHz (Robles-De-La-Torre, 2006; Saddik, 2007). For this stimulus, the block determines the temperature of the VE (maximum, minimum and average), the air humidity, the air pressure, the spatial temperature ranges within the VE and the wind (direction and intensity).

3.2.6. Gustatory

Regarding taste, there are only a few prototypes that explore this sense, of which the 'food simulator' is one of the most recognized (Iwata, Yano, Uemura, & Moriya, 2004). It consists of a haptic interface that mimics the taste, sound and feeling of chewing real food. More recently, Hashimoto et al. (2006), Hashimoto, Inami, and Kajimoto (2008) were able to simulate a number of food items by using a virtual straw, which allows users to suck the virtual food and from which they therefore get the corresponding sound and vibrations. This sense is the most complex to simulate due to technology constraints, but one option is to use samples of the real stimulus and provide them to the participants directly. This action can be mediated by an assistant who is monitoring the experience.

3.3. Multisensory virtual experiences – Port wine enotourism applicability

Enotourism refers to a touristic activity that is motivated by the desire to taste new wines and to learn more about the traditions and culture of the places where the wine is produced (Serra, Serra, Choupinha, Henriques, & Pinho, 2014). In a Port wine multisensory virtual experience, tourists should expect to learn more about Port Wine history, the place where it is produced, the manufacturing process, and where it is stored.

To provide such information, this paper proposes different content for different parts of the virtual experience, which can be described as follows:

1. Provide information about Port wine history, where it is produced, and the manufacturing process. Immersive video enables the user to be transported to different locations where he can gain knowledge about these topics.
2. For tasting the wine, mixed realities should be used. The wine should be real wine, and the environments should be prepared to simulate the wine cellars and the activity being carried out, enabling the wine to be appreciated without the use of intrusive technologies, such as HMD and headphones.

For a better exposition on the content of each virtual experience, Table 1 shows the virtual experience, the type of content, the key points addressed and the stimuli used for each of the scenarios.

Contrary to the regular VR experience (where only visual and

Table 1
Multisensory virtual experiences specification.

Virtual Experience	Type of content	Key Points to be focused	Stimuli
Port wine history	Immersive documentary – virtual reality	• Definition of the Douro Valley region • Port Wine export	Visual, auditory
Manufacturing process	Immersive content with multiple viewpoints. The user can switch the location of the view point. - virtual reality	• cutting the grapes • crushing the grapes with their feet • treading grapes	Visual, auditory, olfactory
Douro Valley Region	Immersive content – virtual reality	• Douro river trip in traditional 'Rebelo' boats used to carry the wine to Porto wine cellars. • Douro Valley • Vineyards	Visual, auditory, haptics
Wine tasting	Immersive content – mixed realities	• Real port wine tasting • Port cellars	Visual, auditory, taste, olfactory.

auditory stimuli are provided), the multisensory virtual experience allows users to experience the following set of stimuli that are identified by tourists as being of paramount importance to this particular experience: the typical smell of the wine cellars; the smell of the wine grapes being crushed; the smell and taste of the wines; and the magnificence of the region (Joy & Sherry, 2003; Phillips-Silver & Trainor, 2005).

To achieve such scenarios, one must capture and deliver the content using robust and adequate methods. The next sections present our proposal for capturing and delivering the multisensory virtual experience based on the proposed model.

3.3.1. Virtual-environment content capture

In this section, we intend to show that it is already possible to capture all of the content needed to create the virtual multisensory experience described above. The following describes how each stimulus can be captured and what hardware can be used:

- Visual: Panoramic HDR video can be captured with a modified DSLR camera using dynamic multiple exposure capture and a fish-eye lens. On top of adopting the HDR technology that allows for the capture of real-world lighting levels, we plan to use a 360° video-capture system (360Heros, 2016) that will enable a first-person point of view that offers a full perspective of the surrounding environment of the given scene.
- Sound: By making use of a TetraMic (CORE, 2016) we can capture the 3D sound from the environment. This microphone is based on the principles of Ambisonic. Using this device, we will be able to record the sound in 'B' format (W, X, Y and Z) and then reproduce the captured data in any single-point configuration of microphones.
- Smell: A spectrum of characteristic smells associated with the tasks being considered will be captured and collected using an electronic nose. These will include wine, grapes, and earth. The collected data will be analysed in the laboratory to identify the key odorant markers that will allow a chemical re-synthesis from pure chemicals.
- Tactile: To allow physical feedback, we intend to capture environmental data such as temperature, humidity, wind and motion, in case the user is standing in an environment with associated motion (e.g. a boat in the river). These data can be collected using a meteorological station and accelerometers.
- Gustatory: For this sense, real stimuli such as actual wine samples can be used.

3.3.2. Virtual-environment delivery

According to the proposed model, the delivered experience will be the result of combining various stimuli and inherent techniques and technologies for the user to become fully immersed in the designed virtual world and enjoy the virtual tourism experience.

To deliver the referred experience to the user, a set of technological equipment will be used, each specific to a single stimulus. Hence, the following stimulus-technology pairs are proposed:

- Concerning the visual stimulus, depending on the scenario, the user can use HMD (i.e. Oculus Rift; Oculus, 2016) or stand in a CAVE. The first option will be used to provide a fully immersive visual experience in which the user only visualizes the virtual world as an abstract of the real environment. The CAVE solution consists of a dedicated room where the virtual environment is projected on the walls, contributing to the creation of a mixed-reality scenario where multiple persons can share the same space and enjoy the virtual experience together;
- For the sound stimulus, the proposed model makes use of high-quality surround headphones that block out the sounds of the user's environment and, at the same time, deliver the designed virtual world sounds. If the experience is delivered in a CAVE scenario, the sound is delivered by a robustly configured and calibrated 360-degree 3D sound system.
- For the smell stimulus, smell machines (i.e. SmX-4DS; sensoryco4d, 2016) that can deliver different aromas and smells in real-time to provide the user with a truly immersive experience;
- The environmental conditions are a complex set of stimuli, combining temperature, humidity and wind features. Bearing this in mind, high-end air conditioning systems can be used to recreate environmental temperatures, the use of fans to recreate the wind and the use of humidifiers to deliver the environmental humidity;
- Motion feedback can be delivered using a 6-DOF motion platform that is synchronized with the motion of the virtual environment (i.e., (ckas, 2016)).

4. Implications for wine tourism

As technology advances, organizations and business sectors tend to adapt to it and try to take advantage of its newest features. This is even truer for ICT, considering the numbers of features and possibilities that the evolution of these technologies has brought to the hands of users during the last 5–10 years. The tourism sector is currently adopting ICT, and all inherent technologies, at a pace that will surely produce important results in the near future. However, as noted by Fernandes and Cruz (2016), this technological evolution has also transformed tourists, who are now more sophisticated and demand more dynamic, interactive and emotional tourism experiences. Hence there is a need for tourism organizations to adapt their businesses and thus remain competitive (Slåtten et al., 2009).

Incorporating VR experiences into the tourism sector has been considered very promising and capable of generating emotional connections between tourism destinations and (future) tourists (Huang et al., 2013). An analysis to existing literature evidences several examples of published research highlighting the advantages and possibilities of incorporating VR as a tool to help organizations to improve their planning and management activities (Guttentag, 2010), for producing more effective and attractive marketing campaigns (Huang, Backman, Backman, & Chang, 2016), for creating touristic experiences that allow tourists to experience cultural and social experiences such as viewing historical and cultural relics or events (Jung, Dieck, Lee, & Chung, 2016; Zhang, 2016) and for delivering information and education on the various features of tourism destinations (Potter, Carter, & Coghlan, 2016).

By merging this assumption with the growing market associated with wine tourism, one can easily perceive the possibilities associated with virtualizing certain wine tourism experiences, such as the grape harvest or even visits to wine cellars. Portuguese wine tourism is currently one of the most dynamic tourism segments, and the Douro Valley region is one of the highlights of this new trend. Initially known only for Port wine, currently the region produces a wide variety of wines, several of which are considered to be of excellent quality by international wine committees (CITMAD, 2016).

The proposed multisensory virtual-tourism model combines the above-mentioned reasoning with Dinh et al. (1999), Feng et al. (2016) and Slater and Wilbur's (1997) arguments on the relation between the number of human senses engaged in a VE experience and the degree of immersiveness: hence the existence of multiple 'stimuli'-related modules that are to be synchronized according to the commands of an IS. The high-level conceptualization of the presented model is, from this perspective, one of the aspects that increases its value because this will allow for a simple transposition from wine tourism to other thematic tourism areas, and with this, increase tourists' intentions to visit the regions and 're-live' the tourism experiences in the real environment. This assumption is in line with the existing literature (Grappi & Montanari, 2011; Kim, Park, & Morrison, 2008).

Port-wine related tourism has its own characteristics that separate it from other wine tourism activities. This becomes even clearer when recognizing the high levels of Port wine exports, which are responsible for the existence of this wine almost everywhere in the world. However, currently it is not possible to taste some Port wines outside the Port wineries. Hence there is a need for a multisensory virtual-reality system that allows (future) Douro Valley tourists to experience all the wine harvesting, treading, transportation and storage, while they are in their hometown pub or winehouse. This assumption goes alongside the argument presented by Benyon, Quigley, O'Keefe, and Riva (2014), according to whom, after a positive tourism experience, tourists are some of the most promising salespeople for the venue, influencing others to visit and delivering good publicity to their social networks.

5. Conclusions

This article presents a proposal for a model that supports multisensory tourism experiences. This model is intended to be a step forward in the delivery of multisensory experiences, as it allows for the fine customization of the experience by enabling one to define how each sense is stimulated at both the hardware and software levels. Additionally, the proposed method allows for a consistent setup across the different application fields, minimizing the possible limitations associated with experience customization and overcoming the limitations of previous works in the area.

Through the analysis of existing literature, it was possible to perceive that the tourism sector, particularly that which is related to the food and beverage industry, isinterested in multisensory experiences that allow tourists to experience both the products and the surrounding environment at the same time. By correlating this argument with the growing adoption and use of virtual reality, it becomes clear that there is a research and business opportunity to conceptualize virtual multisensory experiences and apply them to thematic tourism, and particularly to enotourism.

As several authors argue in the existing scientific literature, both VR and multisensory technologies have evolved to a point where they can be used to conceptualize solutions in which users can virtually experience a set of senses in a way that allows them to be totally immersed in a more interesting and realistic experience.

This research is primarily intended to present the initial argument that it is possible to conceive of multisensorial thematic tourism experiences that can be delivered to tourists in a virtual manner, without the need for the user to be in the exact location where the experience takes place in reality. An example of this situation is the ability to experience the sensations inherent to a Port wine cellar while being at a local tourist pub. From our perspective, the dice have been rolled, and an enormous set of opportunities and challenges lies ahead.

5.1. Limitations and Future Work

Despite the level of detail of the model and its components, there were still concerns and goals that were not achieved at this point. One of the initial concerns associated with this research project was the implementation of a prototype drawn from the proposed model that could deliver multisensory virtual tourism experiences to tourists while they were in a location closer to their homeland. This became even more relevant when the focus of the research project turned to wine tourism, particularly Port wine tourism. Efforts are being put into the development of the Port wine tourism application based on the proposed model for thematic tourism multisensory virtual experiences. However, considering the inability to present, at this time, a valid prototype that could accurately represent all of the ambitions of the proposed model, this must be considered to be a limitation of the project and a topic for future work. Nevertheless, exploratory work is being carried out to determine the multisensory stimulation thresholds that will allow to establish the specifications of the stimulus-related blocks of the proposed model. This specification will be important to ensure the proper development of a credible multisensory experience that will ensure the success of such proposal.

Even though no prototype has been built, the results from the exploratory work on the multisensory stimulation in virtual environments have returned encouraging results that confirm that the proposed model is feasible and has the potential to become a valuable marketing tool for thematic tourism. For instance, the research presented by Feng et al. (2016) indicates that the use of directional wind at the same time that a vibrating footstep is simulated, allows VE users to not only have an improved haptic experience but also to feel more immersed in the experience. Tachi (2016) work has also been an important footstep on opening very interesting perspectives on the possibilities of assembling VEs where several human senses are stimulated at the same time and on the importance of the haptic sense as a moderator of the entire virtual experience. Another very important set of research that influences our present and future work has been the one developed by Baus and Bouchard (2016) and by Delplanque et al. (2008), whose results allow to perceive that the development of multisensory experiences is very much possible with existing technology but is also crucial to give the user a more attractive and immersive experience, hence triggering user interest on the topics approached during his experience.

It is also important to report that after some rounds of discussion with tourism-related organizations and experts, it was possible to perceive their willingness to participate in a tourism experience supported by the model developed in this paper. For instance, according to Di Franco, Matthews, and Matlock (2016) VR experiences that incorporate a multisensory stimuli might be used to improve the perception on how ancient and historic artefacts existed and how they were used, hence providing an improved cultural (and touristic) experience to those who experience it. Additionally, some indicated their availability to perform case studies in their own organizations. Despite this positive acceptance, there is a concern related to the extent of the personalization of a virtual experience, which is particularly important to those who are virtually experiencing a tourism destination to which they have already been.

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