

Advantages of 360° Virtual Forest Tours to Supplement Academic Forestry Education

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Abstract

360° virtual forest tours (VFTs), created by state-of-the-art virtual reality technology, contribute to the progression of academic e-learning and forest management. The article proposes a conceptual framework for 360° VFT production and use to supplement field courses. Reflective insights into the authors' own learning process in the production of 360° VFTs, and a consideration of the general challenges of the medium are also presented. To conclude, the article summarizes the advantages of 360° VFTs for forestry education in an academic context.

Keywords:

virtual forest tours, forestry education, virtual reality, e-learning

1 Introduction

Excursions, field exercises and real-world laboratories are core elements of practice-oriented university didactics in education for sustainable development (ESD). The context-sensitive learning objectives of ESD cover knowledge transfer and cognitive experience, especially in the areas of nature conservation, ecology and forestry. Immersive and interactive learning is a modern didactic method in which 3D animation technology can be used to immerse learners in virtual realities (VR) and enable them to interact with so-called digital twins. This method is already widely used in technical sciences. It has been proven to promote learning efficiency by allowing learners to revisit the VR experience multiple times, in combination with more traditional forms of learning – or to use Pantelidis's terminology, through the combination of symbolic and experiential information (Pantelidis, 2009). The technological advancements in augmented, mixed and virtual reality (AR/MR/VR) applications support learning in cases of the physical or ethical inaccessibility of the object of study. Interactive 3D 'immersive learning spaces' bridge barriers of space and time, and enable focusing via AR/MR/VR on parameters or ratios in ecosystems that are invisible or not immediately comparable (e.g. size of tree stems compared to crown height; or crown size in relation to leaf cover, which can only be determined in different seasons). In the light of ongoing developments by the GIS Laboratory of the University for Sustainable Development Eberswalde, this article describes the creation

of a practical 360° virtual forest tour (360° VFT), which can be used as a tool for teaching and project coordination in forestry education. With suitable AR solutions already available (Mund & Müller, 2019), the development of VR teaching methods is the next logical step. The scope of the article includes the practical integration of the technology for individuals and institutions interested in the possibilities that 360° VFTs have to offer. An analysis of the didactical methods and advantages of the medium is not part of this article, as this would considerably extend the cover of the research. For an examination of immersive VR technology and learning theories for implementation in higher education contexts, see e.g. Radianti et al. (2020).

360° VFTs have become popular in environmental education as a way of informing people about how forestry benefits humans and wildlife (Kershaw, 2020). Transferring the didactic tool into an academic context serves as a supplement for field trips and partially solves limitations on financial and logistical resources (Reque Kilchenmann, García Ochoa, & Spathelf, 2017). To identify the contributions of 360° VFTs to higher education in forestry, the authors examined their personal experiences of 360° VFT production and the technical long-term implementation of the tours. A basic framework for the creation and comparison of 360° VFTs is presented, and the advantages of the medium are critically assessed in relation to the efforts required for successfully producing VFTs.

2 Materials and methods

Investigation into 360° VFTs as a possible tool for academic research and teaching was carried out using a basic technical setup. The equipment consisted of various digital single-lens reflex (DSLR) cameras, positioned in a panoramic head (Manfrotto, Cassola, Italy), mounted on a standard tripod in the field, and operated manually. Execution was constantly refined to evaluate the quickest and most reliable routine for photographing spots of interest for later digitalization. The image data acquired were then processed in PTGui (a software package that is currently available) and Panotour Pro (which is no longer released). This allowed the two-dimensional pictures to be re-arranged in a virtual simulation of the precise locations photographed.

Using PTGui, the photographs taken in the field were merged to create a spherical simulation of the site (see Figure 1). The software includes an additional masking tool for favouring or excluding areas in individual source images, as is found in most types of image-editing software. Basic functions such as the manual adjustment of anchor points shared by images and their placement within the virtual sphere, as well as simple graphic-adjustment tools, are also part of PTGui. The files produced allow a 360° experience of the virtual replica of a real-world location. To connect these files to an interactive tour, implement additional digital content, and generate a publishable HTML file, the Panotour Pro software by Kolor (Figure 2) proved sufficient, but distribution of the product was suspended and technical support discontinued during the period when this study was being carried out.



Figure 1: Transformation and distortion of single photographs taken by DSLR cameras in the creation of a spherical virtual replica using PTGui. From top left to bottom right: generation of photographic source files; merged images in spherical simulation; mosaic display of source files; distortion of source files within the panorama

The combined efforts of several projects allowed the production of various 360° VFTs for the purposes of academic knowledge transfer and project transparency. In this way, methods of large-scale forestry management could be visualized and compared. The aspects looked at included areas for practical fieldwork in forestry (martelosopes), international ecosystem comparison, reforestation areas, and areas of storm damage and their structural development over time. Various ways of making the tours available for user interaction were compared and tested for accessibility, ease of application and sustainable data management.

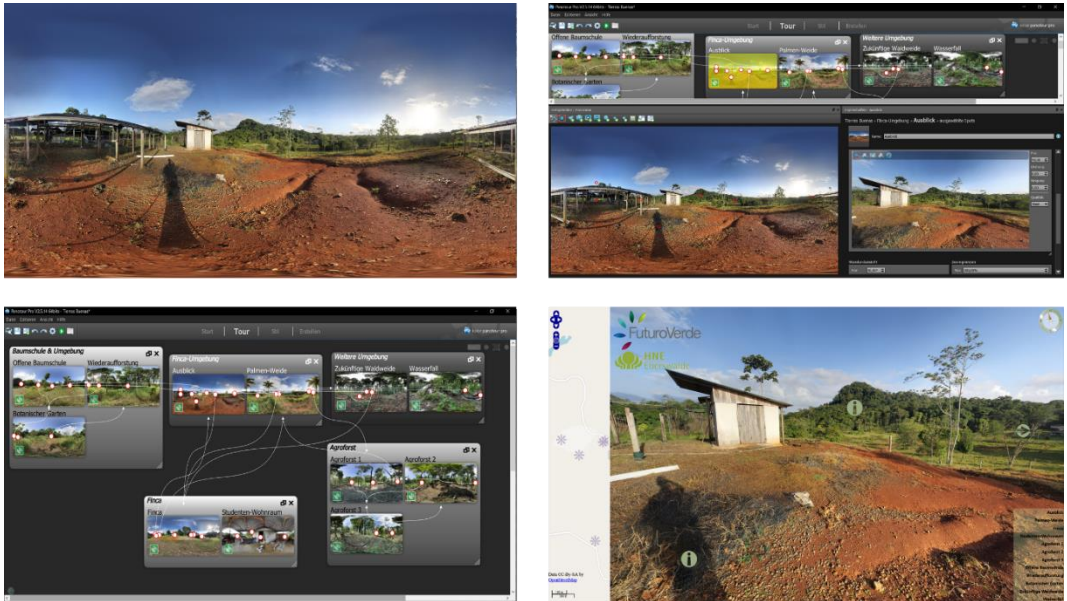


Figure 2: Implementation of the previously generated panoramic image into a virtual tour, including interactive and connective elements, using Panotour Pro. From top left to bottom right: panoramic image generated; implementation of spatial references and information; combining scenes into a tour; final tour as viewed in a web browser.

2.1 Subsequent reflexion

Based on their experiences in the projects undertaken, the authors refined the conceptual framework for the content-related production of a 360° VFT. After understanding the technological conditions needed to produce photographic material which meets the requirements for digital progression, the authors next examined the viewer's experience of the tour. For academic e-learning concepts in relation to forestry, tours that are publicly available were compared to the project results in order to extract preferred features. Additionally, a review of scientific and popular literature connected to forest-related VR research was carried out with a view to identifying possible implementations of 360° VFTs and their academic value.

3 360° VFT production

The production of a 360° VFT requires the same conceptual framework as that found in most projects focusing on public interaction and media presentation. Informational content, contextual storyboard, publishing environment and technological capacities are defining factors for the composition of the tour. The extent of the information and additional data to include can then be determined. Interested parties may consider outsourcing the creation of a 360° VFT as a way of reducing time, effort and costs while still achieving satisfactory results; indeed, there are more and more professional service providers creating virtual tours. The

most prominent companies in this domain are Google Tour Creator, RICOH360 and 3DVista. To create or modify a 360° VFT, using a third party or in-house resources, a sound understanding of the basic procedures may shorten the development process and aid in the design of a working concept.

For the creation of a 360° VFT, interested parties first need to generate suitable visual content for the spherical replication – i.e. panoramic photographic images. This is followed by the implementation of additional information, choosing a didactic connection between scenes, and embedding the tour in its publishing environment. The continuous development of equipment and software makes the technical procedures in 360° VFT production increasingly easy, but creative decisions for the integration of content require a further skill set in addition to subject-knowledge of forestry. Depending on the target group and the purpose of a 360° VFT, creators may consider deepening their understanding of digital and visual media, immersive didactics and interdisciplinary knowledge transfer.

3.1 Preparatory framework

Most important during the outlining phase of a 360° VFT is determining how much time will have to be invested for individual stages of the project. Furthermore, it must be kept in mind that acquiring appropriate image data requires favourable weather conditions. To avoid accumulating unnecessary data, the number and location of scenes to be shot should be established before starting the fieldwork. The choice of equipment and software (see Section 3.2) determines how the tour will be published and what modifications will be possible, and should therefore be addressed as early as possible.

3.2 Technical requirements

Integrated functions for the generation of panoramic image files can be found in conventional hand-held photographic devices (mobile phones, compact cameras, or point-and-shoot devices like GoPro models). Unmanned aerial vehicles (UAVs) are the most convenient way to inspect hard-to-reach locations while assuring exact geographical references. Higher-priced models commonly include settings for panorama shots (Muliawan, 2017). For high-resolution image data and the option to adjust settings according to the circumstances in the field, manually operated DSLR cameras are sufficient. However, full-panoramic (360°) footage can only be produced by specific state-of-the-art cameras. These are not currently available commercially as integrated components of UAVs (Feist, 2020).

Digital processing of the photographs to create spherical virtual environments requires less computing capacity than, for example, editing movie clips, but extracting clipped scenes from high-resolution image data is still very time-consuming. To guarantee fluid progress on the technical work involved and editing procedures, devices rely mainly on graphic components, such as high GPU capacities, and adequate virtual working storage. The accumulation of data can cause files for a single VFT to quickly exceed 10GB. Adequate hard-drive space therefore needs to be ensured.

3.3 Project stages of VFT production

These basic guidelines offer the essential procedures for producing a 360° VFT. The concept can be applied to any location and desired subject.

Draft of the project's scope

A preliminary definition of the 360° VFT subject is reached by consolidating the knowledge that is to be transferred and identifying the geographical references to be included. Also during the planning phase, the means of transport to the locations for photographic fieldwork, the creative partners in the project and their intentions for specific content, and the choice of equipment and publication platform need to be decided. The conceptual framework determining how many scenes to create and their sequence also need to be decided in relation to the target viewers of the 360° VFT.

Fieldwork and post-processing

A basic understanding of photography is necessary to achieve suitable photographic image data at the geographic location of interest. Differing weather and light conditions require constant adaptation for optimal source material. The effort invested may vary widely based on the equipment used and the desired level of detail.

The individual photographic image files are merged into a single larger image file, which can be displayed using specific software as a virtual 360° spatial experience of the scene. Given appropriate source material and software, creating a spherical combination of the individual files requires minimal manual graphical corrections or selection/omission of individual source files in the mosaic display (Figure 1).

Tour creation and publication

Subsequently, the individual scenes are connected to form a virtual tour. If augmented by geographical references, the sequence of the individual scenes can deliver an understanding of the environmental conditions at the geolocation, at a specific point in time (Figure 2). Metadata or the appropriate EXIF files should therefore always be accessible for auxiliary information – but via icons or other interactive functions, so as not to obstruct the viewer's undisturbed field of vision. Trade-offs between fostering the benefits of an intuitive understanding of the virtual replicated environment, ease of access to supplementary technological components, and software limitations are to be expected during this phase.

When a 360° VFT is created for public access, online lessons or as a stand-alone production, webhosting, remote access or a server structure is necessary to deliver the tour to interested viewers. Hosting services like WordPress or Wix have published technical expansions to integrate virtual 360° content. Software that can produce virtual tours generates usable data formats (HTML5 or JavaScript are common) and may include complementary software to present the created tour via an Intranet or a local host. If technical training and resources are available, the tours may also be made available through in-house webhosting.

4 Utilization of 360° VFT

Especially in the context of a worldwide pandemic, the advantages of remote-access study courses and virtual excursions have become ever more apparent. A virtual replication of real-world forest stands allows for repeatable experience in a specific area of interest, independently of the current weather conditions, season of the year or transport. The exchange of (detailed, computerized) academic knowledge in connection to forestry (e.g. types of vegetation and structural composition, growth over time, or effects of natural disasters) can be fostered by the opportunities offered by 360° VFT, and vice versa.

One example of 360° VFTs being used to supplement or complement traditional courses of study, classroom teaching methods and fieldwork are the teaching units designed by the Institute for Sustainable Forest Management Research, University of Valladolid, Spain (Figure 3), which are based on interactive online walks through real forest stands (Instituto Universitario de Investigación Gestión Forestal Sostenible (iuFOR), 2018). Documentation of experiments, of extraordinary events such wildfires or storms, of harvesting, planting or fencing allows for immediate visual comparison of plant growth, for example, and offers a holistic perspective on the ecosystem (Figure 4). The European-Vietnamese Higher Education Network for Sustainable Forest- and Bio-Economy, another instance of a 360° VFT used in education, aims to examine issues in a multidisciplinary fashion and to compare different forest ecosystems on a global scale.



Didactic materials

Virtual Visits

MARTELOSCOPE XAMK_South-Eastern Finland University of Applied Sciences (Mikkeli)

Marteloscope XAMK (Mikkeli, Finland)

Key words: Forestry, silviculture, harvesting, thinning, clear-cut, tending, regeneration, Hippala, Mikkeli, BIOECON.EU, ERASMUS MUNDUS

[HOME](#)

Fullscreen : http://sostenible.palencia.uva.es/rutas/Marteloscope_XAMK/index.html

[View Virtual Visit >>](#)

MARTELOSCOPE Thai Nguyen University of Forestry_Vietnam (Virtual Forest Tour)

MARTELOSCOPE TUAF Thai Nguyen University of Forestry, Vietnam

Figure 3: Screen shot of 360° VFT to supplement academic field courses sostenible.palencia.uva.es (Instituto Universitario de Investigación Gestión Forestal Sostenible (iuFOR), 2018)



Figure 4: Sample images showing different site conditions after storm damage (Mund, Beiler, & Manh, BioEcoN, 2019)

The development of a virtual teaching environment for owners of small-scale forests to ensure adaptation of their stands to future conditions caused by climate change is the subject of a recent project by the Department of Information Management and Information Systems at the University of Osnabrück (Thomas, 2021). This example of the use of 360° VFTs in higher education is aimed at young forest owners who have little forest management experience, for the identification of tree species, assessment of forest stands, identification of habitats, timber harvesting, and rejuvenation.

5 Discussion

Setting up a suitable collection of 360° VFTs for academic e-learning and knowledge transfer requires a considerable investment of time, suitable equipment, relevant media competence, photography and programming skills, and secure web hosting. Consequently, virtual tour production and webhosting are now carried out predominantly by businesses instead of individual creators. Cancellation of support for the Panotour Pro production software by developer Kolor was a further complexity encountered during the learning process.

The importance of ethics and moral sensitivity to be integrated into new technologies reached new levels with the development of VR. Referred to as ‘anticipatory technology ethics’ by Philip A. E. Brey (Brey, 2012) and ‘responsible research and innovation’ by Hilary Sutcliffe (Sutcliffe, 2011), the responsibilities and moral obligations of technology designers to the public may include a wider long-term view, taking into account social involvement, environmental impacts and other repercussions. Predictions, forecasting impacts, and evaluating and elaborating on possible consequences need to be integrated into the development of VR applications to guarantee early identification of issues with openness and transparency. Additionally, profound acknowledgement of active, real, lived experience needs to be a fundamental psychological element in VR development for the provision of a ‘positive’

experience in a virtual environment, which is supposed to stay as close to reality as possible (Kenwright, 2019).

5.1 Advantages of 360° VFT in forestry education

The potential of 360° VFTs to offer visual impressions of environmental conditions at a particular geographical location that can be compared with each other makes this a holistic and comprehensive medium for understanding the complex interdependencies that exist within a forest ecosystem. The level of immersion provided by 360° VFTs cannot be accomplished by traditional textual or photographic learning materials. By connecting geographical references, extracted in semi-autonomous fashion from existing image metadata, and photo-optic panoramic portrayals of a location, remote users are able to immerse themselves in the scene and to experience its content in an interdisciplinary and unbiased way. Further implemented data, accessed via intuitive and meaningfully (spatially) oriented links/icons within the scenes, can supplement a tour. In this way, the visual concept of a 360° VFT supports memorizing, understanding, and the creation of links between different pieces of information (Kouyoumdjian, 2012). VR implementations, due to their intuitive, digital and transdisciplinary nature, facilitate increased learning engagement, higher accuracy in planning processes, decreased costs of prototype development, as well as the generation of new ways of communicating and interacting between collections of data, products, locations and stakeholders (Marr, 2017).

Regarding forestry education specifically, the digital recreation of real-world forest structures in a 360° VFT provides an objective picture to unify all available data, combined with analytical tools to support collaborative decision-making and stakeholder engagement. Cost reduction and increased productivity are possible by minimizing the reliance on field trips and using 360° VFT for forest management decisions (Roeser, 2020). Current 360° VFT applications include updating forest asset information, automatization of data integration via remote sensing, and improvement of forest machinery and management simulators for staff training (Fabrika, Valent, & Mokroš, 2016). Highly immersive VR simulations are of increasing value for school purposes due to their independence of time and location. They also provide a risk-free environment and room for mistake-driven experiences (Pappas, 2017). In the long term, ambitions are set to create digital replicas of forests, including the modelling of every tree in terms of its location, height, diameter and species. It will become possible to visit timber transactions virtually and compare management decisions. The simulation of stand conditions after the application of different management decisions will be another convenience of 360° VFTs (Hofmann & Jumppanen, 2017).

6 Prospects and developments

Digital replications of real-world forest stands are expected to become further enhanced. They will provide geospatial references for silvicultural objects improved by the integration of multi-sensory data, generated by autonomous and manually-operated vehicles in forest operations. Using photogrammetric or LiDAR technology in 360° VFT could allow the display of point cloud data in a graphically enhanced way within a tour. Viewers would be able to carry out

assessment tasks for which natural human perceptual skills are required, without the restrictions of a conventional display screen (Chinthammit, 2017). Calculations performed by integrated functions within the software could reduce manual documentation and automate basic assessments (Fabrika, Valent, & Mokroš, 2016). It may soon be possible to create autonomous inventories, as shown by developments discussed in (Mohan, et al., 2017). Given the increasing accuracy of sensor technologies, inventories will achieve greater levels of reliability through autonomous, technological means than human observation alone is able to accomplish.

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