Using Versatile Cartographic Means in a Virtual Field Trip to Cologne

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This contribution was double-blind reviewed as full paper.

Abstract

New web technologies allow conveying spatial information to the public using versatile means. In a new project developing a virtual field trip for young students various degrees of interaction in different kinds of spatial representations are established to fully exploit the advantages of virtual field trips in education.

1 Introduction

Virtual field trips offer a new way to give students access via a computer to remote places they would otherwise be unable to reach, be it for monetary or organizational reasons. To meet these ends, virtual field trips must be easy to distribute and accessible from many places and devices. The internet is thus the ideal means for both distribution and display. It is widely available with a growing number of broadband connections worldwide. A virtual field trip retains the explorative character of a real field trip while providing information on a specific topic, which leads the user through the application. This is realized using a wide variety of media like video, graphics, animations, and even 3D models. JACOBSON et al. (2009) stress the students' appreciation of the use of multimedia in virtual field trips. In a learning environment not only the exploration of data but also building up of knowledge is a prerequisite goal. A virtual field trip using different kinds of media can help students to imagine what it would be like to actually be in the field. It can even give illustrative information a real field trip would not be able to provide, e.g. developments over time (JACOBSON et al. 2009). At least as important as the different media for the useful deployment of a virtual field trip is the aspect of interactivity. Only if the users are able to interact with the virtual environment they will be able to explore the information by themselves turning them into active learners or real participants. To make this information intuitively accessible to any user, be it amateur or expert, a good navigation scheme through the scene of the virtual field trip is essential. The information must be organized in a logical hierarchy so not all the data is displayed at the same time meaning there must be a way to choose topics and reach higher degrees of detail. But naturally a virtual field trip cannot provide the abundance of information the real world has to offer. One central topic has to be identified and the virtual field trip designed in a way that it throws light on all its facets and covering all viewpoints. An application mirroring a complex system will inevitably be complex in itself.

Jekel, T., Car, A., Strobl, J. & Griesebner, G. (Eds.) (2013): GI_Forum 2013. Creating the GISociety.

The virtual field trip discussed in this paper aims at students of (German) 8th to 9th grades. They are typically between the ages of 13 and 15 years. The target group includes students from all German speaking communities and is not limited to a confined space. In fact, the developers aim at translations into other languages especially English and Spanish to include students from around the world exploiting the advantages of internet applications. Communication between the spatially separated participants is enabled through integrated forums and chat functionality. The learning goals are thus manifold. They include the acquisition of factual knowledge concerning water management in a big city. The example of Cologne paradigmatically shows one possible way of how a city and its stakeholders deal with the challenges and opportunities a river bears. By offering different viewpoints through the eyes of different interest groups, the students are confronted with diverting and sometimes contradicting or conflicting opinions. The basic ideas and interests of the stakeholders can be compared to the participants' own contexts. They have to decide by themselves which of the arguments they find most convincing. In this way they are empowered to form their own opinion transcending the exemplary nature of this field trip. The debate portrayed in the virtual field trip offers an insight into grass root democratic processes in which different parties compete for their interests and exchange arguments and viewpoints. The virtual field trip transfers this argumentation to the students themselves giving them the opportunity to exchange their own viewpoints and compare them among their own peer group and also among other groups from many different countries in the world. Thus, learning goals include the transfer of geographic knowledge, the strengthening of argumentation skills in a geographic and societal context, and ideally an intercultural exchange. To achieve these goals maps are used extensively, since they are a major means of communicating geographic knowledge. They are used to form and support hypotheses in geography and furnish evidence. The use of many different kinds of spatial representations helps to discuss the role of maps in public debate. Complementary teaching material is provided in the form of exercise sheets available for download.

2 Virtual Field Trips in Education

In recent developments, virtual field trips have become more and more popular as classroom aids. There is a wide range of concepts from using geobrowsers such as Google Earth (e.g. LANG et al. 2012) all the way to stand alone solutions similar to simulation games distributed as CD-ROM. This entails significant differences in user guidance. Standalone applications tend to be closed systems only offering information specific to the concerning field trip's topics. More open systems like geobrowsers are used as a platform to integrate one's data in a general framework. It is essential then to provide a focus on the topic, because all the other information offered by the provider like Google is also still available to the participants of the field trip. Virtual field trips are discussed controversially in the literature. But there are some distinctive advantages to them over traditional field trips. HURST (1998) states lack of finances and time that make it difficult to take students on a real field trip. This is confirmed by CALISKAN (2011) more than a decade later. Many researchers see virtual field trips in this context as a cheap and quick alternative to provide some of the information provided by a real field trip (e.g. HURST 1997; CHANG et al. 2009). CHANG et al. (2009) also emphasize as advantages of virtual field trips the first person perspective that can be provided by self-guided virtual field trips as well as the possibility to view an object in 3D and freely rotate it, which might not be true for all objects in the real world. But several conditions have to be met in the design of virtual field trips to fully exploit their potential. HURST (1998) criticizes the simplified nature of computerized objects but sees a great opportunity to train 3D spatial perception with the help of virtual reality, which allows applying different perspectives to one object. KORAKAKIS et al. (2012) believe that 3D virtual environments can improve learning processes in the sciences. However, the designers must be careful to provide enough guidance to the participants, since orientation might not be easy. Students can get lost (CALISKAN 2011), not only in the virtual environments but also in the abundance of different web sites holding the information of the field trip. PROCTER (2012) points out that 3D virtual environments enhance the feeling of the field trip's participants of actually being at the place they are looking at which can maximize the learning potential of a virtual field trip. Virtual environments in education should become virtual geographic places and capture the 'manifold qualities' of the real world, but they can never be authentic, because they do not have physical realness. So they must be convincing in their own terms (RELPH 2007). RELPH (2007) sees a challenge in building virtual worlds with a 'strong visual identity' making them popular with the dweller of this world. The building of a virtual world involves selection by the designer what will be reproduced and will be left out. So it also involves imagination by the viewer to fill the gaps (RELPH 2017). The author of a virtual world has to try to foresee how this world will be used by the participants and accordingly provide possibilities for its intuitive use (RELPH 2007). Virtual field trips that are well conceived have another benefit to the user, which is not very often discussed. When using maps as a central means of navigating the given information, they train the participants in using modern representations of space such as 3D maps. This is important, because today maps are used in a wide spectrum of media to convey key information concerning any topic. The authors of content in various media rely heavily on maps and that people understand them. Cartographic literacy in the average person is assumed as a given. Rapid evolution in the visualisation of spatial data must not surpass the capabilities of the public. A lot of spatial data is used in decision making. In order for the citizens to retrace those decisions they have to understand the data, which is visualized in ever more sophisticated maps. Although not the rule, maps can also be used to manipulatively twist data to persuade the observer to take on a specific view (MONMONIER 1996; BUDKE 2012). Citizens must be prepared for that and enabled to critically assess any map. For that, the use of maps has to be trained in education, revealing the flaws and benefits of different display methods. A virtual field trip which makes substantive use of maps is an ideal environment for young students to get accustomed to the use of many different kinds of maps and other visualisations of space.

3 The Virtual Field Trip to Cologne

The department for Geography and its Didactics of the University of Cologne is currently partnering in a project developing a virtual field trip with the Cologne University of Applied Science's department for informatics and multimedia systems. In a second phase the field trip will be methodically evaluated and the feedback incorporated into the application. The field trip itself will be an application running in any modern internet browser ensuring wide availability and compliance with different computer platforms. Part of the project is to show that such a complex and highly interactive application can be brought about using only freely available technology such as open source software and open standards. The content is managed using the Joomla![1] content management system. Media is provided using the HTML5[2] web standard which is also used to display the 3D content generated by the open source JavaScript framework x3dom[3]. Data was provided by the OpenStreetMap[4] project.

The core geographical problem underlying the field trip is the human-nature interaction between the River Rhine and the residents living along its banks. To get a grip on that content rich topic the application will focus on the City of Cologne giving information on five possible use cases representing five different interest groups: economy, ecology, residency, tourism/leisure time, and flood protection. These topics were identified in accordance to their controversial nature, bearing potential for conflict which has in the past resulted in many controversies. The groups' views and issues are captured by interviews, expert interviews, information material provided by the municipality and citizens' groups, news articles, and scientific research papers. Each interest group is symbolized by a single character making claims of how the river should be put to use benefitting the respective interest group. The architecture of the core application spreads over three levels. The heart of the application is a map (Fig. 1) giving an overview of the area to be explored by the participants of the field trip. The map is at the top level of the application. This is the interface for access to one of the five stations scattered around the map. By clicking one of the stations on the map the participant will reach the second level of the application providing a close up view on this particular station. There the participant will receive general information on the station's area and on the other hand specific information on places in this area where the interests of each group crystalize. From here the participants can proceed into the third level of the application where they will find games, texts, videos, animations, photos, and audio files etc. with further in-depth information. The top two levels are highly map related providing overview and close-up views of the area allowing free exploration of the territory. The third level does not necessarily consist of maps, but maps or map-like representations such as animated 3D models are deployed as means of illustration where it makes sense. We use four types of maps or map-like representations: interactive 2D maps, interactive 3D maps, interactive movies/animations, and non-interactive movies/animations.

3.1 Interactive 2D Maps

The main purpose of the first map the participant of the virtual field trip encounters is to give an overview of the terrain where the field trip will take place. On the other hand it shows all the topics that can be discovered during the field trip as icons on the map (Fig. 1). The informational content of the map must be reduced to the essentials so that it allows the users to orient themselves and recognize the City of Cologne and the position and course of the River Rhine. Emphasizing the relevant facts avoids confusion in the map users, e.g. while important streets can be used to reveal the city's structure dividing it into its distinct

1 http://www.joomla.org/
2 http://www.w3.org/html/wg/drafts/html/master/
3 www.x3dom.org
4 http://www.openstreetmap.org/

districts, highways (Autobahn) should not be emphasized, because it is doubtful whether children of the 9th grade have a close tie to this kind of feature, since they are not allowed to drive. Also, highways are not important to the main topic. Furthermore, the map does not offer a high degree of interactivity, because its function is to guide the participating viewer and not vice versa. It is even stripped from scrolling and zooming. At this stage of the virtual field trip, the participants are meant to find a quick entry into the application equipped with a general idea of what to expect. They should have just enough knowledge to decide which one of the stations they are most interested in.

The map was designed to make an appealing entry into the application and give an overview of the complete territory of the field trip. Its colours stand out from the traditional colouring of city maps awakening interest and inducing curiosity. However, the colour shades are in close relation to well-known representations of topography, built up areas containing a strong portion of reds, forests being coloured in dark green shades, agricultural land in a brownish-beige tone, and water represented in blue. All colours are very low in saturation, except for the signature of the River Rhine. This stresses the importance of the river as the main topic by making it stand out and contrasting the backdrop. The eye is drawn to follow the course of the river. This impression is enhanced by the signature of the river protruding the map's boundaries. Another advantage of low saturation of the base map's colours is that they do not compete with the signatures of the stations. Those are kept in strong hues and establish the colour themes that guide through the field trip.

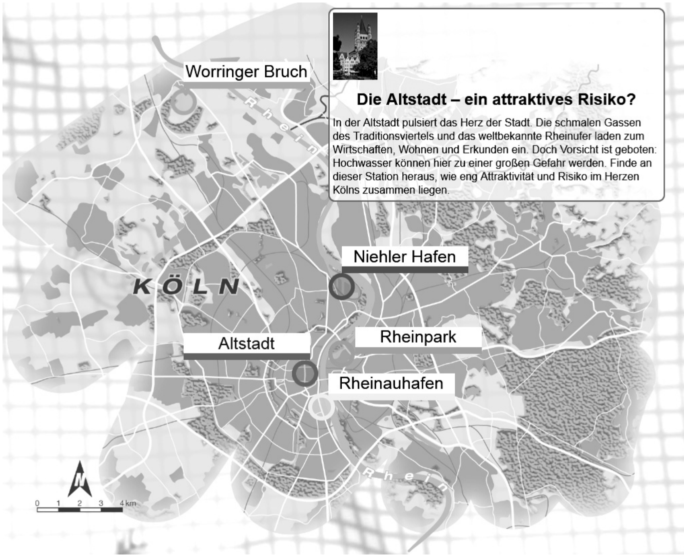

Fig. 1:
The central map of the virtual field trip on entry level showing the positions of the stations and an info window on one of the stations

The top level navigational interface map is a static representation of the City of Cologne. It is scaled so it fits most screen sizes of desktop or laptop computers to avoid scrolling. The map also does not allow zooming in or out. While hovering with the mouse cursor over the icon of one of the stations an info box appears in the map. The box contains a photo giving a general idea of the surroundings. This picture is accompanied by a short text describing the most important issues at that particular station. A mouse click on the respective icon will bring the user to level two of the application, the close-up view on this station.

The map was rendered using the OpenStreetMap, which was digitized by hand. This method allows integrating a highly defined concept of generalization by the map author in contrast to automated generalization. The advantage is that different degrees of generalization can be applied to features belonging to one class, e.g. different kinds of roads. High degrees of simplification were used for highways which are not significant to students in this context. Low degrees of simplification were used for important routes facilitating the orientation in the city. Another example is the emphasis of just the River Rhine and no other waterway. The icons were made interactive using cascading style sheets (CSS3) and JavaScript.

3.2 Interactive 3D Maps

On the second level of the virtual field trip, detailed cartographic or otherwise spatial representations will be made available to the participants of the field trip. After having chosen a station on the interactive map on level one, the participants are now empowered to freely roam the region of their choice. The characteristics of a real field trip should be simulated as closely to reality as possible. It is important for the participants to take on an active role and to enable them to explore the virtual environment in a self-guided manner. This leads to a sense of space, a feeling of immersion. The possibility to discover virtual objects, which react e.g. through mouse events, will foster curiosity and open mindedness. Here the participants encounter the characters representing the interest groups at a specific location. The participants can interact with them to retrieve more information and consecutively move on to the third level. So the 3D map also serves as a navigation interface. The 3D scene needs to load quickly and function fluidly in a browser not to disrupt the immersive feeling. So it must not exceed computing power of the client responsible for rendering the scene.

In the current version of the virtual field trip the Old Town of Cologne, a distinct part of the city, is designed as an interactive virtual 3D scene. The data for the buildings of this district are provided by the municipality of Cologne. They constitute a model with the Level of Detail 2 (according to the cityGML LOD hierarchy, Fig. 2), meaning they include the base area of each building, its height, and roof characteristics. Architectural details like window openings, overhangs and the likes are not part of the model. Textures were not provided. A large 3D scene can be a cognitive overload at first sight. So the design concept distinguishes between points of interest (POIs) and objects of secondary importance. The POIs are places of significance either for the topic of the field trip itself or for the orientation in the city, such as landmark buildings, in our case e.g. the Cologne Cathedral, which stands out in height compared to the other buildings giving a sense of direction from various vantage points. The POIs received remodelling incorporating detail of the facades, textures and materials, and where appropriate animated features. They resemble reality as closely as possible. The other buildings are kept in a uniform appearance not to distract the participants too much from the relevant content. A slight transparency lets them move even more to a semiotic background. The ground of the 3D model is a digital elevation model (DEM) – again provided by the municipality of the City of Cologne. A bitmap of the city map is attached to the DEM as a texture. The map uses the same colour scheme as the entry map, but uses a much lower scale according to the level of detail required for close-up views. It includes features like parks, ponds, and even street names.

The participants can freely navigate through the scene, meaning they can “fly” to any vantage point. This provides them with a high degree of freedom, but also makes it easy to get lost. This is why different viewpoints are predefined which can be reached through a side panel for easy access to an overview perspective and the five POIs representing the different perspectives on the main topic. At these locations they will encounter the five main characters. They are 2D objects textured with an image of the character. By hovering with the mouse over the characters an audio file is played telling the participants about a specific conflict of interests at the location. By clicking on the character, the participants will reach the next level.

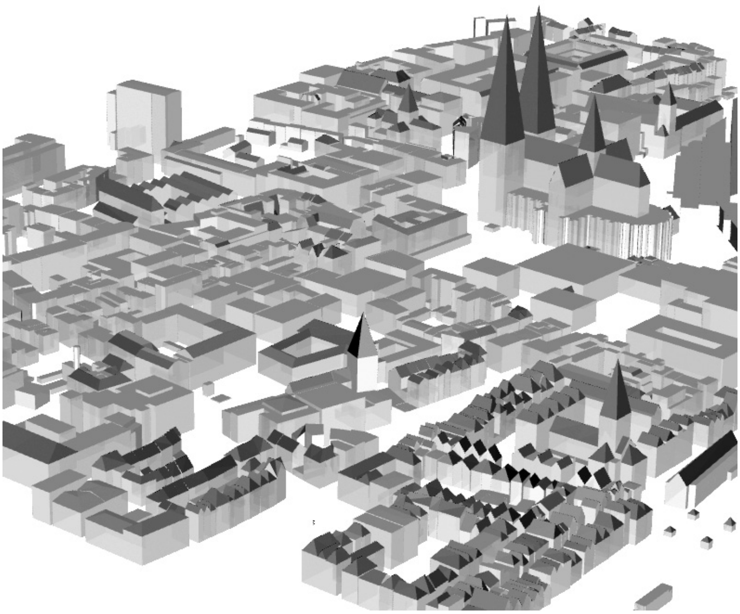

Fig. 2: The 3D model of the old part of town (Old Town of Cologne) showing the buildings in Level of Detail (LOD) 2

The city model and DEM were transferred into a common coordinate system with GIS software and exported to 3D formats. Using OpenStreetMap data an overlay for the DEM was created according to the design rules established for the 2D maps of this field trip (see chapter 3.1). With the help of a 3D modelling software the scene was equipped with textures, materials, fogs, and lights and subsequently exported to the X3D[5] file format. Using the JavaScript framework x3dom the X3D files can be integrated directly into an HTML document and interpreted by browsers without the need for a plug-in. The scene can then be manipulated dynamically using JavaScript. This allows for extensive interaction with the scene and its objects.

5 http://www.web3d.org/x3d/

3.3 Interactive Movies

Photos and videos convey an unmatched impression of realism and objectivism. The observers feel like they get a glimpse of what the depicted object really looks like. However, photos and video usually offer only a low degree of interactivity. But with modern web technologies like CSS3 and JavaScript libraries such as jQuery it is possible to add interactive features to videos in a seamless fashion turning them into an interesting solution for exploring an environment from the first person perspective.

The movies were shot following predefined routes through the area of Rheinauhafen, a station of the virtual field trip located at a former inner city river port. For our purposes the scene had to be filmed with linear camera movement capturing as much as possible of the locality of the station and containing at least the POIs (see chapter 3.2). The Rheinauhafen stretches along the river banks for more than 2km. However, the interactive movies have to be very short, no longer than 1 minute, due to possible computational restraints of the client. This means that in order to be able to present all the POIs we had to split the camera route into several legs. For better orientation a small inlet map shows the current location of the camera in the scene. When a movie frame is reached where more detailed information is supposed to be given to the participants of the field trip interactive icons are inserted into the movie. These icons react to mouse events such as clicking and hovering.

By scrolling, be it via mouse wheel, dragging the scroll bar or any other technique, the participants play the movie. Scrolling down results in playing the movie in forward motion, scrolling up has the effect of playing it backwards. This way, participants can determine themselves how fast they want to move through the scene or even whether they want to stop for a while to take a closer look at something. When coming across POI while moving through the scene, icons appear that give a short introduction to what is being seen. By clicking on them the participant receives a more detailed description of the object. At critical points the participants encounter one of the five characters. These are small animations overlying the video in combination with an audio file.

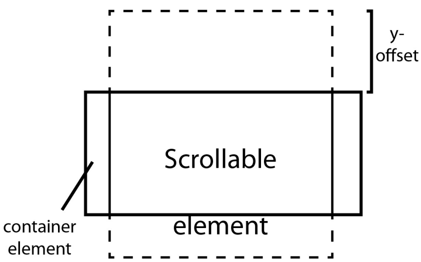

Fig. 3:
The functionality of the interactive movie depends on the y-offset representing the position on the timeline

A regular HTML page is used for displaying the interactive movies without the need for any plug-in technology. The movies are shot with a regular digital video camera. The single frames are then rendered to a batch of numbered stills in JPG format. The y-offset (cf. Fig. 3) of the scrollable element showing the movie is retrieved. Its value is linked to a position in the movie by loading the film still that equals the y-offset. The y-offset can be compared to an external clock determining the position on a timeline. So depending on its value other elements such as icons can be timed to show up and fade out as the appropriate movie frames appear.

3.4 Non-interactive Movies and Animations

A short film is used to introduce the topic of the virtual field trip as well as the location of the territory. The participants learn about the position of the River Rhine in Europe and consecutively the position of the City of Cologne on the River Rhine. An overview is then presented of the five stations and their respective locations in Cologne. Afterwards the characters are introduced commenting on the main topic of the field trip from their perspectives.

The 3D animation showing the River Rhine was constructed in 3D modelling software like 3DStudioMax or Blender. Digital elevation models (DEM) and texture maps were used in different scales, blending in to each other as the camera moves closer. The models display a slightly artificial finishing, corresponding to the real time 3D model of the Old Town described above, using the same colours as the base maps. This way, the participants will recognize the localities with greater ease and will not feel lost so easily.

The functionality of this feature in the virtual field trip is kept to a minimum. Almost no interaction is allowed except for skipping it altogether. This is important in the case of a recurring use of the virtual field trip where no further explanation is needed. However, all participants can go back to this short introduction at any time and watch it again if needed.

Several incoherent 3D scenes were constructed, one for each zoom level. The first one is an overview showing the River Rhine in Europe. Low resolution DEMs like GTOPO30 are deployed here. The next scene moving closer to the Cologne required SRTM data, and for the near zoom levels close to the City of Cologne high resolution DEMs were available with a resolution of 1 meter. The city's built up areas were modelled using the same data as for the Old Town (see chapter 3.2). Since the output of the process was a movie that had to be rendered just once the 3D models could be very rich in detail. Also the lighting in the scene could be designed in a much more sophisticated way and geometries could have a much higher number of polygons. Fog and clouds were used for the camera movement's transitions between the incoherent scenes. This allows a smooth movement between zoom levels.

4 Results

The resulting virtual field trip is a highly diverse multimedia application using many kinds of cartographical and map-like representations of space. This way not only the content is shown from different points of view but also the participants' concept of what is conceived as reality can be challenged. Exploring the different spatial representations young learners can playfully retrace the 'constructedness' of maps, realizing while solving geographical problems that there are different ways to portray reality resulting in quite different impressions. Along with the different viewpoints presented to the participants in terms of content the field trip is an excellent tool to show the various facets of one geographic topic. The prerequisite seems to be the equal representation of each stakeholder group. The field trip allows comparing directly the different ways of rendering 'reality' on the computer screen and at the same time in the participants' minds.

5 Conclusion and Outlook

This project has shown that it is possible with modern web technologies to offer a wide variety of spatial representations using freely available software and data, open standards and no proprietary plug-in technology. Various grades of interactivity have been implemented successfully. The next phase of the project is to evaluate its use and usability. How will students react to the multitude of spatial representations? Which one of them will they prefer, if any? We would like to find out what degree of freedom to explore a virtual world is best suited for this kind of application. Further research could be directed towards bringing the virtual field trip back into reality with the help of Augmented Reality. This new technique enriches the real environment in which a person moves with extra information or simulations.

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