

# Skybox as Info Billboard

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## Abstract

In this paper we propose a new way of information mapping to the upper part of the virtual skybox. This mapping brings improvement to the existing virtual world's projects with providing relevant information instead of a static or animated skybox. Information that is used in our approach is visualized in a chronological correspondence. We explain basic terms as well as previous similar projects. Application of the Ajax3D technology is described as a powerful method to provide the connection between database and X3D scene. Moreover, except the visible order also solution for the user interaction is provided. Implementation is shown in the SkyBoard application, that can be found in the page <http://www.dzana.sk/projects/bakalarka/index.html>. It is possible to use this method for educational or informative purposes.

**Keywords:** AJAX3D, Virtual World, Skybox, Education

## 1 Introduction

Information is everywhere nowadays. On the billboards, advertisements, TV's, walls, etc. On the other hand, virtual worlds either as social networks like Second Life [Lin 2003], or historical reconstructions like Virtual Heart of Central Europe project [VHC 2000] become more famous every day. Nevertheless, these worlds still have free space that can be filled with the information. In the real world everything tends to be effectively used. Why not combining all these ideas together? We propose an effective integration of these methods. Our approach fills relevant information in the sky-part of the skybox in a virtual world. Skybox is a box with, or without a bottom defined the infinity and whole world is bounded by this box. Properly textured, it creates an environment completion. Example of relevant information is when was particular building reconstructed, when there lived famous people, etc. These data are visualized in a way that the chronological order is visible, because the data we use are temporal.

There are approaches that deal with the information visualization in the virtual world projects, or scenes. In this paper only those that process Virtual Reality Modeling Language (VRML) or X3D formats are interesting. Reason for this assumption is that there have been already created many worlds in VRML format. Some of already existing approached use Java programming language that allows use the cooperation with database, but they are complex and hardly reusable. Therefore Ajax3D solution is more proper for our approach.

Moreover, also some problems arise. Either the problem with the interaction between the X3D scene, database of entities and user or with the visualization of the entities in the desired way. All of these problems are solved successfully, but there is still left part that could be better investigated.

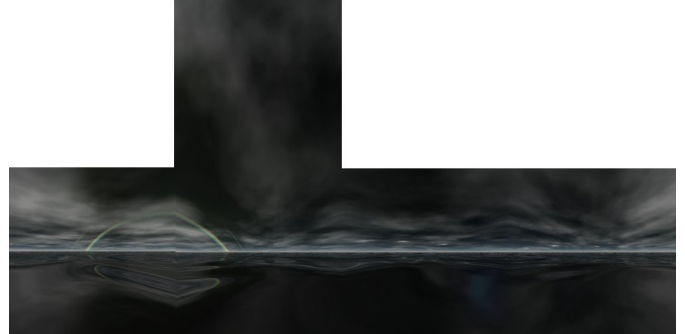


Figure 1: Texture for skybox used in Alpha World

This paper is structured as follows. At first, previous work and related projects are discussed. Afterwards SkyBoard application with technical background and implementation is described. Finally contributions, results and the future work possibilities are proposed.

## 2 Related Virtual Reality Projects

In the last years the expansion in the area of virtual worlds has increased. These improvements attract more a wide public.

### 2.1 Active Worlds

Active Worlds is one of the first projects in the field of virtual worlds. Interaction is made by sensitive objects that react on the avatar's hand. Moreover transportation here is also possible, through these sensitive objects. After clicking on the object, user is transported to the designed place. This is applicable when whole scene needs to be changed. On the contrary in our world, only view is rotated, because there is no necessity to change whole environment. Therefore user could be confused when moving somewhere else.

Basically, this world consists of many, that are created by users. Users could contribute in the building creation and the whole visual representation. This is first attempt of virtual world, therefore also skybox is conventional. It is usually static image that depends on the light change (Fig. 1) [Qvortrup et al. 2002]. From education point of view there exists also Active Worlds Educational Universe.

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It is possible to develop new way of distant education with cooperation of teachers and students [Act 2008]. The educational process is created in virtual buildings, but the way is similar to one in the real world. Therefore our method differs in this way, as it can not be used by placing similar approach back in a real world. There is imposed potential given by virtual world only.

## 2.2 Second Life

One of the most popular approaches seems to be Second Life (SL) project created by the Linden Lab [Lin 2003]. It is also user-created and they apply the idea of distant education [Ritzema and Harris 2008].

As most of the similar projects, also SL tries to be as realistic as possible. Unlike our application, where we try to extend virtual reality with additional information provided. Basically, in the conventional approach of virtual world whole skybox stands as a static image or animation. On the other hand, in our application, enhancement is provided by filling the sky space with relevant information.

## 2.3 Twinity

Twinity world is the youngest one from the mentioned. The main goal of this world is to bring models of famous building from real world [Met 2008]. Abstract and real mesh up here in virtual space. Moreover our approach is adapted exactly for purposes of this world, where visualized information adds interest to the real buildings.

## 3 Related Information Visualization Approaches

The base of visualization is in the timeline, because entities should be visualized in the recognizable and simple correlation. Therefore timeline is the core and has to be well chosen. Chronological information is an information that is relevant to the specific time, or time period, where begin and end dates are usually provided. However, our approach contributes not in the way how information is visualized, but where it is displayed. Similar projects, focused differently, represent [Andrews 2003] and [Blaise 2008]. They deal with displaying history or documents, but they are not explicitly focused on chronology. Following we present the main approaches in a temporal data visualization relevant for our research.

### 3.1 Calendars

Calendars are a way of visualization of events, where only one event is possible in a specific period of time. The events are defined for a period of time, or for specific time. Therefore the dimension of the displayed space is only 1 and only timelines define differences. Less space consuming is SpiraClock [Dragicevic and Huot 2002] and [Hicks 2001] than approach visualizing timeline as straight line. Second one exploits whole potential of 3D space by displaying in all three dimensions. This idea could be applied also in the sky space of virtual world.

### 3.2 Order over a time

Differently from previous section, another type of information exists. These events have dedicated specific date, when they happened, or are going to happen. Therefore in visualization no time period need to be considered. The problem here occurs with parallel events that need to be visible and more than one dimension space need to be used. Because of overlap currently interesting data are colored for better orientation, as in [Hsu 2004]. Different colors could be used for better categorisation of visualized data.

### 3.3 Historical diagrams

On the other hand, our visualization is more similar to the traditional approach, that was firstly introduced by Joseph Priestley in his Chart of Biography in 1765 [Dursteler 2006] and in 2006 [Gombrich 2006]. Information is combination of the previous two where both parallel and period of time are considered. The entities are arranged in order of time related to the straight scale. Instead of fact, that this visualization is 2-dimensional, mapping into three dimensions is possible. Moreover the third dimension allows for movements and wide view.

## 4 Related implementation approaches

Firstly, there are limitations because of given requirements:

- available access through web browser window
- use of existing VRML models
- interaction
- database of entities
- visible chronological order

Therefore, our solution has to satisfy all of them and that leads to problems. Similar approach is discussed in [Vataha 2008]. The main problems from the view of implementation are the connection to database and the display of entities, the scene representation and the database of entities. Following paragraphs discuss this issue.

### 4.1 Virtual Reality Searching Machine

Virtual Reality Searching Machine is name of the application that was introduced in 1999. The main goal is to combine data stored in the database and 3D model stored in VRML file. This approach is interesting in a way of combining technologies for database and VRML manipulation [Hanuska 1999]. Implementation is realized in a Java programming language and the digital content is displayed in the web browser window through Java Applet. The disadvantage of this method is dependence on the implementation. Java Applets are usually used for the specific purpose.

### 4.2 Embodying and Extracting Data in Web3D Models of Proposed Building Developments

There are many ways of providing extra information in the X3D scenes [Hetherington 2007]. This approach is one of them. Ajax3D model is used here for adding extra information to the existing models of buildings. Data are stored in the database. This approach is

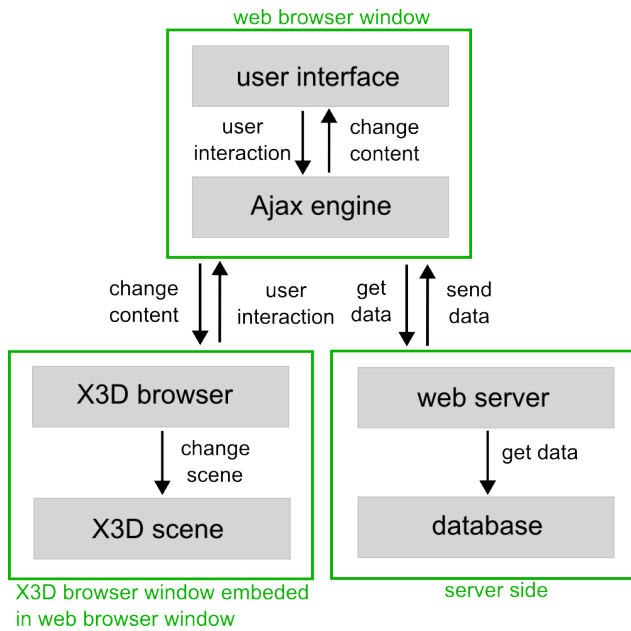


Figure 2: Communication between web browser, X3D browser and the server using AJAX3D

similar to ours in a way of connecting between database and X3D scene, not in a way of displaying the entities.

### 4.3 Ajax3D

Ajax3D is an approach that was presented on the SIGGRAPH 2006 as a White Paper [Parisi 2006]. It introduces a way of building interactive and dynamic virtual worlds and combines strength of AJAX and X3D (explained below). Basically, X3D scene is embedded in a web browser creating a Document Object Model (DOM) that allows interaction of model with a web document. Therefore scene is controlled by Scene Access Interface (SAI). This communication is shown in the (Fig. 2). Both these models are independent of the programming language, but in the Ajax3D approach Javascript is used for the control. In the paper mentioned above there is not described any particular way of cooperation with database. However, data retrieval used by Ajax affords way of cooperating with server-based programming language, for instance PHP.

## 5 Technology

Several terms need to be explained before further method description. First of these terms is Ajax as a method for creating dynamic web pages and another is X3D that is related to the scene description.

### 5.1 Requirements

As every web-based application, our project also has some client and server requirements. Nevertheless almost every requirement is common in the standard web applications.

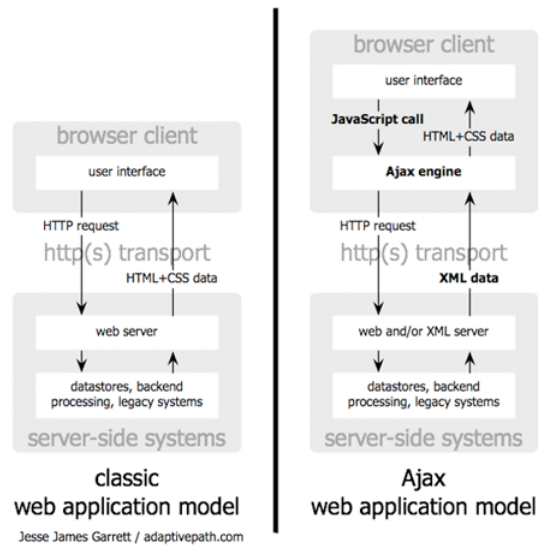


Figure 3: The traditional model for web applications (left) compared to the Ajax model (right)

#### 5.1.1 Client

Firstly our application is displayed in the window of the web browser, therefore user requirements start with the web browser. Firefox 2.0 is preferred, because the application was tested in this environment. Ajax engine as well as HTML page are another client-oriented parts, but these are provided by the browser and user does not care about it.

On the contrary the X3D browser is more interesting part to be obtained by the user. This browser has to be downloaded and installed as the plugin to the browser. Theoretically our application should be runnable with any X3D browser, but is recommended Vivaty player, because the application was tested with it. Vivaty player is free and easy to use with intuitive navigation in the scene [Viv 2008].

#### 5.1.2 Server

At first, server requires common web-based client-server communication. This includes database, in our case we tested the application with MySQL database. To run server based script, in our case PHP, the PHP server is needed. Recommended is the Apache server. Also the world that is initialized when the page is uploaded has to be stored on the server side.

### 5.2 Ajax

Asynchronous Javascript and XML (AJAX) is a method for the creating of the dynamic web pages [Garret 2005]. The method is new in the philosophy, but the technologies used are well known for the web designers. This method allows to build interactive internet applications that are real-time (user do not need to wait for the response). Actually, the difference between traditional way is only in the one command:

```
XMLHttpRequest()
```

This command is used for the communication between Ajax engine and server script. As the Ajax engine is usually used JavaScript,

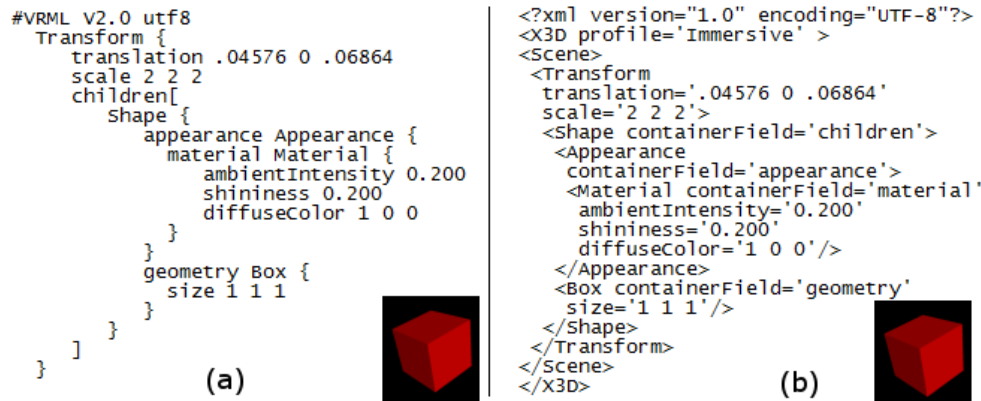


Figure 4: The difference between source codes for the simple 3D scene, where each rendered output could be seen in the right bottom corner. (a) VRML format (b) X3D format - XML syntax

and we also used this programming language, because of its simple cooperation with the X3D scene. However, it is not needed to download whole updated page and wait for the server response. In the older, or more traditional way the whole browser window is reuploaded and therefore also X3D browser with whole scene and current setting will be reseted. This reset will cause the values set to default values and moves avatar to the entrance.

Ajax Engine is responsible for handling events from user and JavaScript as well as for passing server script result to the X3D browser.

X3D scene is embedded to the web browser as Document Object Model (DOM). There are well known approaches of working with this model. The difference is shown in (Fig. 3). Following commands are used for the cooperation between X3D browser and the Ajax engine:

- `browser.createX3DFromString()` - creates scene from the input string
- `browser.loadUrlIS ()` - creates scene from the input urls, or file
- `context.getRootNodes()` - as a result gives an array of the rootnodes
- `context.removeRootNode()` - removes the node from the scene and the scene graph
- `context.addRootNode()` - adds new rootnode
- `addFieldEventListener()` - add listeners to the objects, so the browser observes attempt to interaction

These few commands are sufficient for the cooperation between JavaScript and X3D browser. This cooperation is essential, because this is the bottleneck of all other communications.

### 5.3 X3D

EXtensible 3D Graphics (X3D) is an ISO standard for 3D scene description, whose main purpose is to be displayed in the web browser. This allows to build robust, interactive virtual worlds applications. This standard originates in the VRML standard but brings XML syntax that is popular and widely used in the creation of the web pages. Fortunately X3D is also back compatible with older format. Therefore, instead of the fact, that the scenes used

in our final application are saved in the VRML format, also X3D format can be used. The difference between these two formats can be seen in (Fig. 4)

Moreover, to be able to display the X3D scene in web browser window, the plugin needs to be installed and the whole scene needs to be embedded in the web browser window with the following line:

```
<embed TYPE="model/x3d">
```

After successfully fulfilling these two conditions no other plugins are needed.

### 5.4 Server and Database

Finally, when AJAX method allows scene to be uploaded and provides interaction and X3D handles geometry of the scene the upload facts from the database has to be researched. The request is sent to the Ajax engine and followed to the server script as is described before (see Section 5.2). In our application the server side script is implemented in the PHP programming language that has intuitive cooperation with the database. Here we have used MySQL database for its robustness.

PHP script has as input the position of the actual viewpoint. Afterward with this position, the specific SkyPort can be identified from the table of SkyPorts. Moreover with this identification relevant facts are extracted from the table of facts. Entities are created as nodes of the X3D scene filled with these facts. This whole part of the world is then positioned above the avatar and centered. Processed output from the PHP file is sent back to the Ajax engine.

## 6 SkyBoard Application

SkyBoard is a name for the application that we developed to show our approach in practice. Contribution of this method is in visualization of chronological information and mapping to the sky space in a virtual world and display all in the web browser window.

The largest difference between our proposed solution and the one used in all previously described virtual worlds (see Section 2) is in access. All three are accessible through internet, but downloading the special browser is needed. They are not displayed in the web

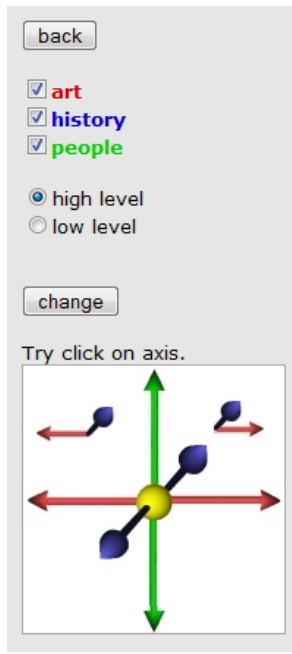


Figure 5: Navigation panel for the nodes that include visualized information on the virtual sky

browser window. Instead of own browser AJAX3D is more suitable. Moreover Ajax3D approach is applied for its flexibility and compatibility in re-using instead of Java.

Facts that are included in the entities are exported in a format from the book [Gombrich 2006] that provides various historical milestones. Therefore these entities in our example application are not really relevant for the place they are associate to. In the next section is detailed description of the implementation we have used specific for the target groups.

## 6.1 Target Groups

Different groups of people have different requirements. It is necessary to adapt our application for the special needs of each user. Difference is in the amount of entities displayed. Therefore each user can customize the environment depend on the needs. The groups mentioned above are these:

- **students** - want to easily learn relevant facts usually because of school purposes. *Option:* display all relevant entities.
- **historical enthusiasts** - want to have entities in a transparent order and want them as many as possible. *Option:* use high detail option and coloring of the categories.
- **sightseers** - are more interesting in visual part of the city and less about the fact. *Option:* choose option less detail.
- **others** - not interested in the facts. *Option:* for these is there an option of not clicking on the sensitive object and no entities will be displayed.

### 6.1.1 Web Page

Web browser window is the first part of the application seen by the user. The whole virtual world is embedded in the scene, but there

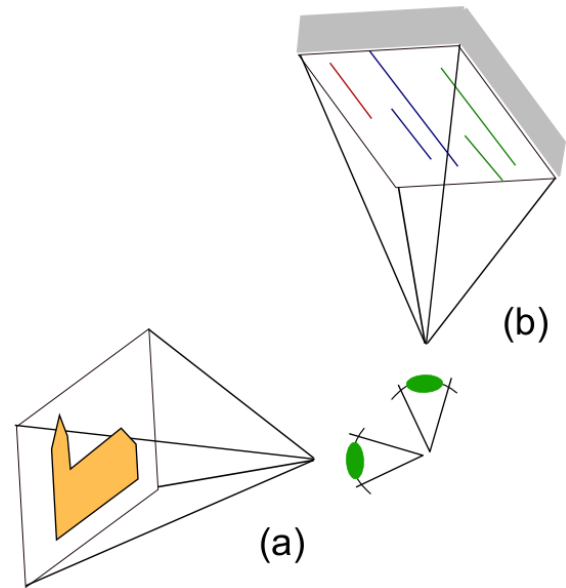


Figure 6: (a) standard view (b) rotated view to the sky

are still some controllers left out of the world. These is status bar for the better orientation of the user, navigation window (Fig. 5), and text window. In the navigation window user can navigate whole skybox with the entities and create events. On the other hand the text window is displayed only when specific entity is interacted and detailed information are displayed here.

## 6.2 Scene

Firstly the scene is initially uploaded from the VRML file to the X3D browser. VRML format is used only because of existing VRML worlds. X3D as a new format has better perspective use and in this upload the world can be easily changed to another X3D/VRML world.

After initial upload of the scene, the user can move and navigate in the world by the controllers provided by each browser as in normal X3D scene. Unlike the common X3D scene in ours are yellow balls (SkyPorts) near interesting places. These SkyPorts start to pulse, when virtual hand is on them. This indicates response for user interaction. After clicking to the SkyPort, user is smoothly teleported to the new ViewPoint, that has the same coordinates but rotation directs to the sky. This teleportation is provided by the X3D browser. Therefore it looks like the user only rotates virtual head of avatar and this is not confusing. It is also possible to rotate back, but this option is not supported by the X3D browser (Fig. 6). The view point is changed with rotation back to the scene and again with the same x, y coordinates.

Moreover it is possible to interact also with the displayed entities by clicking on them and more detailed information are visualized. This visualization of additional information is not in the X3D scene browser, but in web browser window. Therefore layout looks like common website with special part, where is the virtual world displayed. User should have feeling also of being in the web page on the internet, not only in virtual world. The semantic connection is in visualizing additional information as a 2D paper from the book. In this case of requesting these entities semantic meaning of the web page is a newspaper or a book and the world is 3D image of the

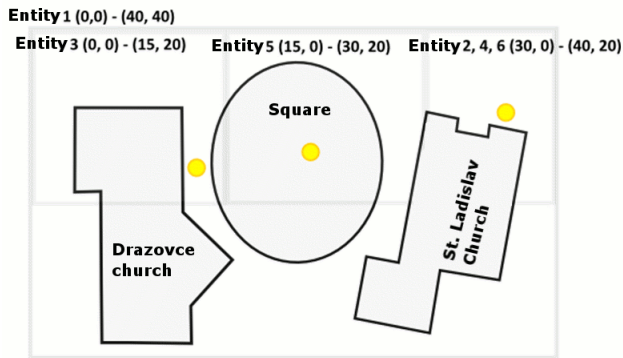


Figure 7: Ground-plan of the scene. Yellow balls - SkyPorts. Rectangles - relevancy of the entities. Only the first entity is defined for the whole scene, because all SkyPorts are inside the rectangle.

world with additional possible interaction.

### 6.3 Pre-processing

Pre-processing is necessary, because the whole scene and database has to be created. Assumption is that this application is only extension to the existing virtual world, therefore the scene is already created. Afterward SkyPort objects have to be added into the file. SkyPorts are defined as yellow balls, but for the customization is available any object with defined Sensors in a special form. These sensors are TouchSensor for interactivity with the user and TimeSensor to create pulsing effect. Defining is as follows:

```
<TouchSensor DEF='TouchSensor1' />
<TimeSensor cycleInterval='5.000' />
```

Where TouchSensor1 is the name of the sensor, therefore it can be easily identified. Exactly these names are stored in the database. The name of the TimeSensor is not important, because it is not dynamically manipulated. Better adding algorithm is left to the future work.

Afterward, when sensitive objects are added, they have to be processed and therefore SkyPort database need to be created. In the database are the unique names and position of the skyports stored to be easily identified after interaction.

Another database has to be created to store facts, dates and relevancy to the facts. Relevancy is stored as x, y coordinate of the rectangle's corners where the entity is displayed. Therefore after the interaction with the SkyPorts located inside this rectangle the specified entity is displayed (Fig. 7).

### 6.4 Display

As it was said before, the displaying of the entities in the skyspace is not a trivial problem. There is possibility to fill information with using the all dimensions offered in the 3D space. Our approach is inspired by the book [Gombrich 2006] (see Section 3.3). Comparison of these results can be seen in the (Fig. 8). In this approach, information is visualized only in two dimensions and are clear despite the projection distortion. Although we successfully improved this method by moving the box with the entities forward and backward to have better look at the display.

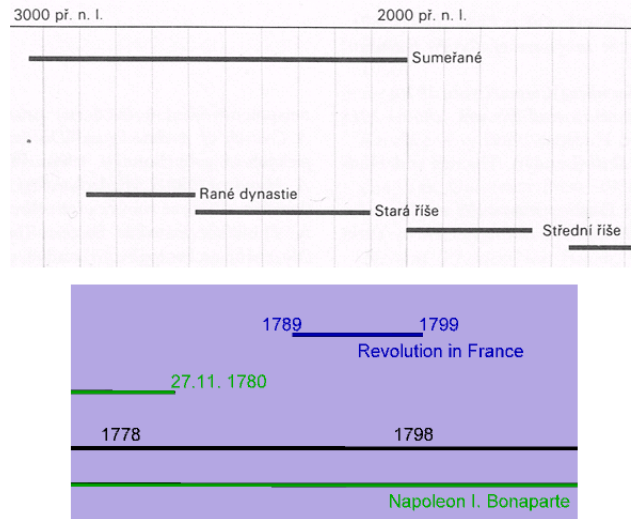


Figure 8: (top) Scan from [Gombrich 2006]. Visible chronology of facts. (bottom) Our method. Visible chronology and method similar to the [Gombrich 2006] with use of straight timeline.

Firstly the whole sky space is displayed as a group, with an unique name that includes all entities. This group is then the last added rootnode and can be therefore easily found in the scene graph. The entities are displayed as the thin cylinders, where each represents time distribution of the entity. The length of the cylinders we compute from the difference between begin and end time of the fact. If only year is provided, the distribution is the whole year. It means counting begin date as first of January and end time as end of December. Similarly with only year and month dates, without the day.

Entities are categorized so that the groups are displayed together. Therefore these groups are colored by a specific color, similarly to [Hsu 2004].

Moreover for the better orientation the scale is displayed in the middle of the skybox. Therefore, when moving whole skybox also the scale is moved and entities stay at their right places relative to the scale. To compare, in the Gombrich's approach scale is at the top (Fig. 8 (top)) and in our method scale is in the middle. This improvement allows scale to be seen also when whole box is moved in the top or bottom direction. Differently from the solution in Section 3.3 entities here carry exact information of beginning and end time. These timestamps are visualizes with every entity and there are no orthogonal lines corresponding to specified time on the scale. The scale is straight and each entity is parallel to this scale. Another improvement could be non-uniform scale, where length for each interval vary according to the actual entities. We left this idea for the future work.

Because the events are not distributed linearly in the scale, the problem in displaying of them arises. Therefore holes can be seen, when there are short entities far away. Holes problem could be resolved by filling more than one entity in a row, similarly to [Dursteler 2006]. Further investigation of this problem is left for the future work, as well.

## 7 Results

We have used two churches that have been artificially added to the scene, which means that are not in real world near each other. One

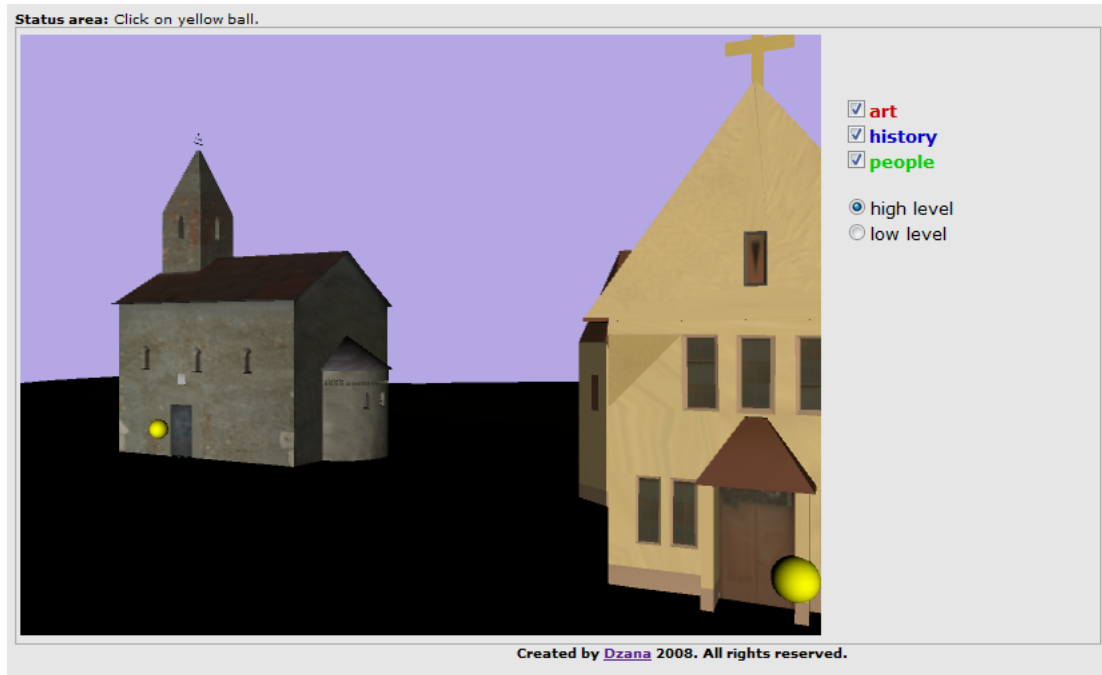


Figure 9: Avatar looking on the world in a common way.

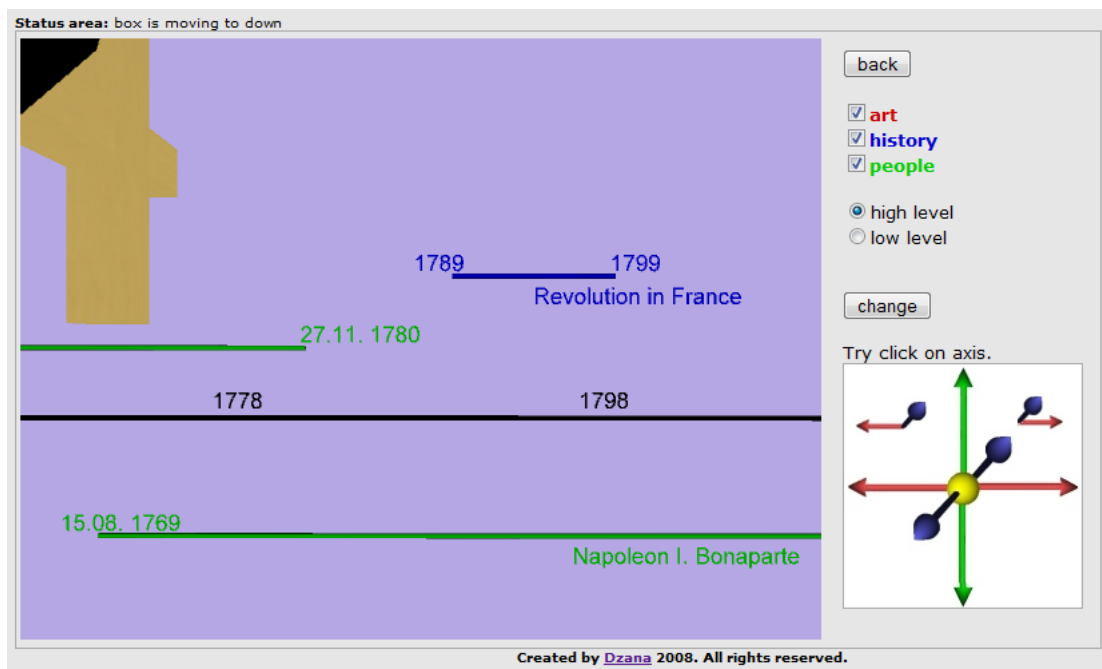


Figure 10: Avatar looking on the sky. Viewpoint is only rotated to the sky.

of this models was created by Peter Kan [Kan 2007]. For now, only sample information and scene are used.

Friendliness of our application and the whole new approach was validated by the questionnaire. It was included in the page with the whole world. The basic question was, if this new method is better than the traditional way of displaying of information in books. More users claim that like our display more however we do not have information about affiliation of these users.

Our results are shown in the (Fig. 9) where is the front look at the sample scene without any additional information. Second figure (Fig. 10) show view from another view port, which is rotated to the sky and entities are added.

## 8 Conclusion and Future Work

In conclusion, this approach is one of the first ones, which visualize chronological entities in the upper part of skybox in the virtual world. Advantages of our method are in flexibility of display and embedding of X3D browser. Instead of chronological information other kind of nodes can be similarly visualized. Opposite of existing virtual world projects, this is embeded in the web browser and can be used to extend the web browser functionality.

Nowadays visualization is very simple, but understandable to the wide public and this is main pupose of the web applications.

There are still parts of the algorithm that need to be further investigated. There is visualization of the entitled and user interaction provided, but the display still has holes and better solution could be find. In our method there are some pre-processing steps, that are time consuming therefore the more automated approaches has to be more investigated.

To sum it up, this approach could be used in the virtual worlds to provide more information in unsued space or in the virtual museums projects for educational and informational purposes.

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