

# The Present Position of VRML in Web3D Educational Projects

Tomaz Amon

*Center for scientific visualization ([www.bioanim.com](http://www.bioanim.com)) Ljubljana, Slovenia*

*tomaz.amon@bioanim.com*

2010

## Abstract

*Web3D or virtual reality on the web used interactive, immersive three-dimensional worlds, not to be mistaken with video clips. We write here about our experiences and suggestions on this attractive technique, which we use and develop for more than ten years. Our field of work is natural science e.g. biology.*

## 1. Introduction

The young generation is faced today with many sources of information, sometimes too rich to be digested “in time”. In addition young people are not keen to accept any more the traditional ways of teaching that emerged before the age of computers, internet and mobile phones. Many studies show that in young generation the interest for experimental sciences is much lower as it was some decades ago. So we need new educational tools that provide modern means of teaching and understanding the science. Cleverly used computer – aided education with the help of educational games and virtual reality worlds provides here a significant step forward.

In addition the world is becoming more and more globally connected. Europe and Asia (especially China) experience today a much more intensive exchange of knowledge and information as it was the case some years ago. Since the cultural history of these countries is very different, it is necessary to devise tools that make the cooperation easier and lead to less “culture shocks” that often appear when people that have grown up in different cultures meet and need to work together on the same project. New software tools that combine art, education and science and are tightly connected with “the real world” can be of great help here.

## 2. Towards A Tool for Exploring Modern Education, Art and Science

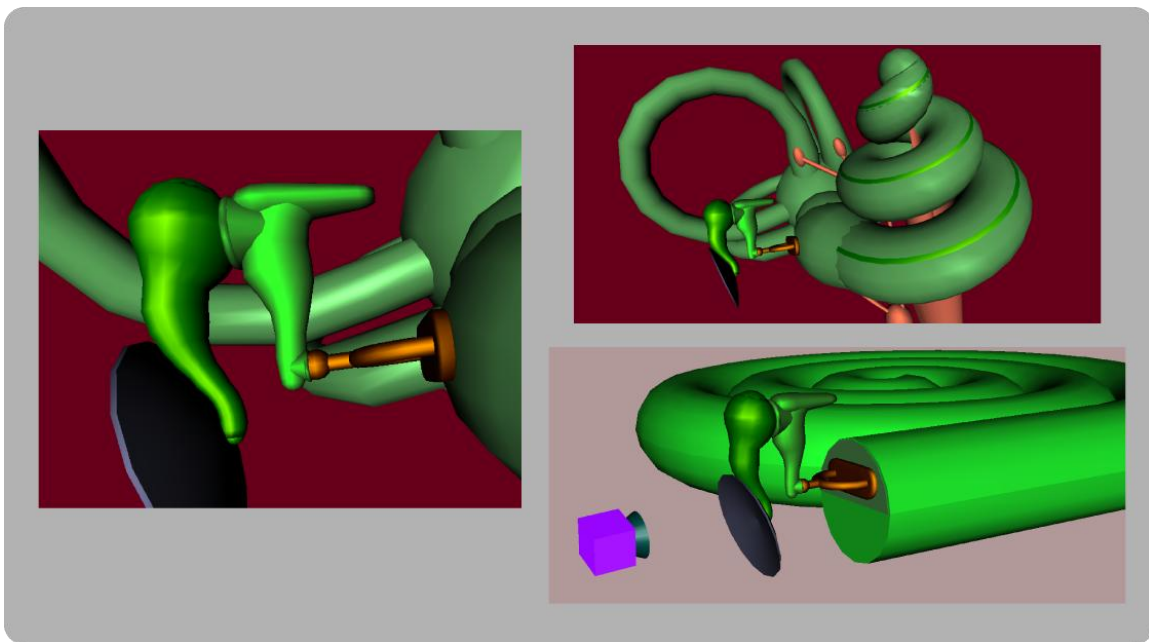
### 2.1. Background

Present biology education sources are mainly textbooks and the study of living material like observing and dissecting animals or plants. Books are very practical if you have them and they are not too many. On the other hand, if a student doesn't have the appropriate textbook he typically visits internet to learn about the topics he is interested in. In contrast to books, which are practical because they do not need any special rendering equipment, one needs a computer to visit internet and authoring of rich and attractive high quality internet content might be technically more difficult than writing a book. Today we are confronted with enormous inflow of information we have to digest daily. The classical style of a textbook becomes obsolete when simply uploaded as a website on the web server – because it requires too much time to read. A good web page should explain in minutes something what would require hours of study from a classical book. However, when we find the relevant information, we often turn back to the classical book style to read the details slowly and clearly. The key to such an enhancement of the speed of learning are the interactive illustrations, animations and web3D worlds with relative little text, but a lot of expression. For example, biological structures and processes are especially suited for such a representation because they all occur in

space. Technology now enables us to use a rich variety of web3D tools. The first to appear was VRML (Virtual Reality Modelling Language) .

## 2.2. Photography, video, HDV and Web3D

Computer virtual reality, filming and photography – three different technologies, but now more and more connected. I was lucky to photograph for 30 years, shoot video for 20 years and do computer virtual reality for 10 years. I mention this because I always wanted to join the photography and video with “modern” technologies of the time. So my way of creation has been influenced by the technology that was available to me. For example, with virtual reality worlds on the web ten years ago one had to take care that objects with not too many polygons were published on the server and the file sizes of the textures (images on the models’ surfaces) was small enough. The idea of broadcasting the video on the web was more or less unrealistic. So at that time modern (and still alive!) VRML – Virtual Reality Modeling Language was very practical because e.g. to produce a sphere one only needs to write the name “Sphere”, add its location in space, the radius and optionally the texture description and so with less than 50 bytes you publish on the web a nice sphere with many polygons that are not downloaded through the internet, but created on the fly at the user’s platform. The more advanced VRML node is called the “Extrusion” which is defined by its “spine” and “cross sections”. We modeled this way for example the human middle ear, which is less than 100KB large (Fig.1). The VRML worlds of that time as you can see e.g. on Bioanim (2006) are instructive, but they lack the richness of good graphics which we experience in professional films and computer games. So the next step (fortunately connected with the increased internet speed nowadays) is to make the web3D look more professional. We decided to do this in the Macromedia (now Adobe) Director (Macromedia 2006)[3] with the virtual reality capabilities which include not only nice graphics but also Havok physics simulation engine. Because VRML plugin has not become popular and there are rumors that also Java is not used on all computers, we chose to publish on the web mainly HTML and Flash content as well as video and allow the users then to download the Director virtual reality worlds to use them later on offline or online.



**Figure.1.** VRML model of the human middle and inner ear. The models are the extrusions what makes them very small in the file size.

There is a significant difference between video and internet: Video is typically just to watch and internet is interactive. We expect to go to cinema or to watch TV and not to do anything else except getting the

information and eating popcorn during the show. On the other hand internet is an interactive experience, like going to a library and searching for books there. So according to this definition, internet is more a tool to work while TV and film is more for relaxing or “relaxed learning”. Of course also the opposite can happen, but most of us expect to relax when watching video. The authors need to know this habit of their audience well; otherwise they might disseminate their products to the wrong target audience.

A combination of entertainment and education is called edutainment. Basically any modern education needs to be interesting; too, otherwise it is only a data bank or just an obsolete way of education. We today expect to become motivated for some topics by our teacher and the teachers who do not succeed here, lose much of the impact of their lesson. Edutainment can be very variable in the regard of the percentage education: entertainment. So one would immediately think that edutainment with a high percentage of entertainment and just a bit of education is naturally more attractive as if composed the opposite way. But it is in fact the expectance of the user which is crucial here. So a software tool that makes easier the study of the living cell structure and function is quite different from a computer game one uses to play and then learn at the same time a bit of the cytology.

The advantage of the virtual reality (VR) is that it appears in space where we can walk or fly and is completely interactive. So a lot of textual or spoken explanations regarding the cell structure and function become unnecessary since the user already sees it and interacts with it. VR worlds can also have very nice and detailed pictures on the surface of their models. These pictures are called textures (fig.2). Imagine a plane in the VR space bearing the texture which is the picture of the living cell structure. As you travel in the space above this picture, it helps you to learn this way: The cell nucleus pops up like a volcano when you are above it, the same happens with mitochondrion etc. So it is much easier to remember the names of the cell organelles if they “emerge out of the picture” when you study them. However, good pictures are also very large (10MB or more per picture) because they need to retain high definition also when the user is inspecting the picture from a very close distance. So the virtual reality worlds with many pictures (textures) become huge in file size and therefore more appropriate for local use. Their web variants have smaller textures, stimulating us to download the detailed version to our computer.



**Figure.2.** Maybe the most rudimentary of influencing the picture in the 3D world. The picture above (the photography of a stone relief in grass) is the texture put on a polygonal mesh in Macromedia Director. The mesh is created “on the fly” what means that it is not imported into the world as a model, but instead the coordinates of the vertices are given and the model is built and refreshed while we are moving with our

avatar around in the virtual world. The avatar here is the blue shark, just the same as shown in fig.2 and the deformation shown here is a “growing volcano”. So it is possible to make any desired deformation on the model that is covered by the picture - e.g. pointing out some interesting details on the image as we approach their locations. Such a tool can have both educational and artistic values.

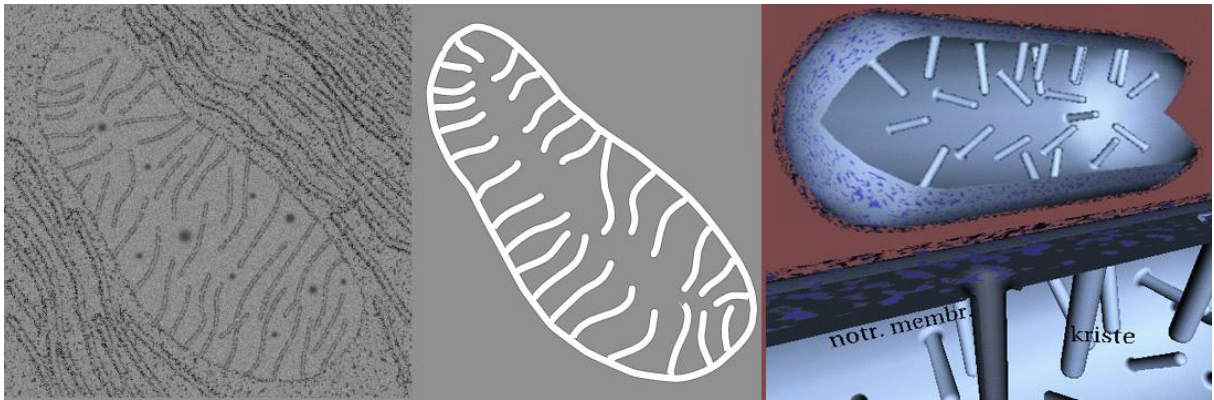
As I bought my first HDV (high definition video) camera a year ago, it was a real discovery to me! High definition video is a kind of marriage of the video with photography. Before it appeared, we had used to say: “Video is nicer because it effortlessly captures the action and sound, but photography has a much better resolution and so it is better for recording details and expressing moments frozen in time”. With HDV suddenly both issues become technically possible during the same act of shooting. An image captured during playback of a HDV is good enough to be used also as a good web photograph. Officially it has the same resolution as had my first digital photo camera, but when I compare the photos, it is clear that the ones captured from the HDV are far better. So it is not just the formally declared resolution that is important, but also the way the picture is internally processed in the camera. There is also another interesting phenomenon that I noticed during the summer holidays. A big ship was passing quite far away from the coast. I filmed it with HDV and then also made some photos with the same video camera, but in the photo modus. After I inspected the photographs and video I tried to read out the name of the ship. Although the resolution of the still image was twice the HDV video camera resolution, I could read the name of the ship on the video, but not on the still photos! The continuously changing picture of the video gives our brain more information as the fixed image, in spite of the fact that the fixed photograph has a better resolution! Especially for documentaries HDV is of great value. We just primarily shoot the video. If we have opportunity, we use also the still digital camera to make good photos. But in case the target is gone, we have already captured useful photos in the previously recorded HDV.

### **2.3. Cell-Tissue-Body Project**

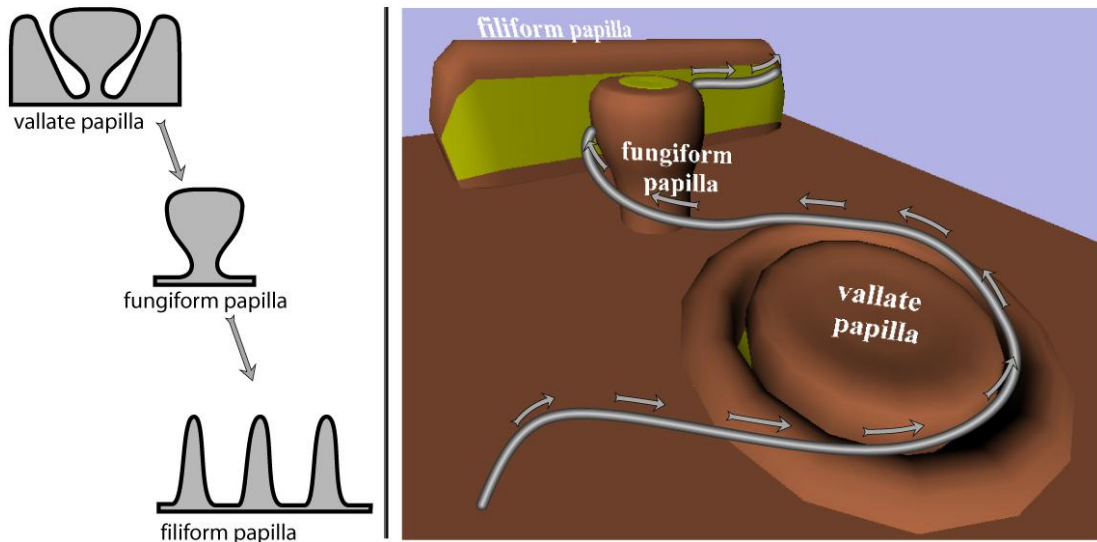
Our web3D project named “Cell-Tissue-Body” explains with VRML worlds some of the biological structures and functions that are difficult to understand from the textbooks only. The project was supported by the Ministry of Education in Slovenia (2000) and is now accepted as one of the official learning tools for biology in Slovene secondary and primary schools. The project is available for free in Slovene, English and Chinese language.

As we were producing the software package we were working together with teachers to obtain their feedback in order to make our product better. First of all they asked not only to produce web3D worlds. but to paint also the illustrations like the illustrations of classical textbooks. In other words, there appeared the need to enable a smooth transition from the classical textbook style to the web-textbook and finally web3D worlds. So we added also the illustrated atlas in Adobe PDF format which could be printed on paper and displayed also with traditional projectors. This resulted from the fact that in Slovene schools the computers and the projector are typically located together in a special room (“computer room”).

In one of the first phases of the project we were exploring the major requirements for a project bringing virtual reality worlds into the classroom. We asked the teachers and students about their needs. Teachers wanted that the project does not only contain the interactive computer software, but printable transparencies as well. Regarding the content it was decided to primarily explain topics that are difficult to understand from the textbooks only. For example, to investigate the structure and function of the living cell, one needs special equipment (microscope) and then the microscope images have to be further explained in order to understand them. There is a common practice in schools to use video equipment to record microscope images. This represents the starting point for spatial visualization (fig.3). The digitized (microscope) image is undergoes treatment with an image editing program so that the structural entities come to different images. Then the picture is reassembled into a dynamic HTML web page so that user that glides with the mouse over some structural detail instantly gets information about it: the detail becomes highlighted while other elements are shown in gray.



**Figure.3.** The picture of a mitochondrion on the left, its drawing (middle) and its virtual reality model (right). The noise on the left picture is eliminated on the drawing, while the 3D model tells us about the real form of the mitochondrion. It is modelled in VRML using the so called LOD (level of detail) function. This means that when our camera is far away the mitochondrion looks like a simple cylinder with the outer more permeable membrane (shown here as a patchwork) and the inner membrane. As we approach the mitochondrion, it “opens” (in fact being replaced by another model that is partly open) and we see the invaginations inside which bear the enzyme complexes for the respiratory cycle.



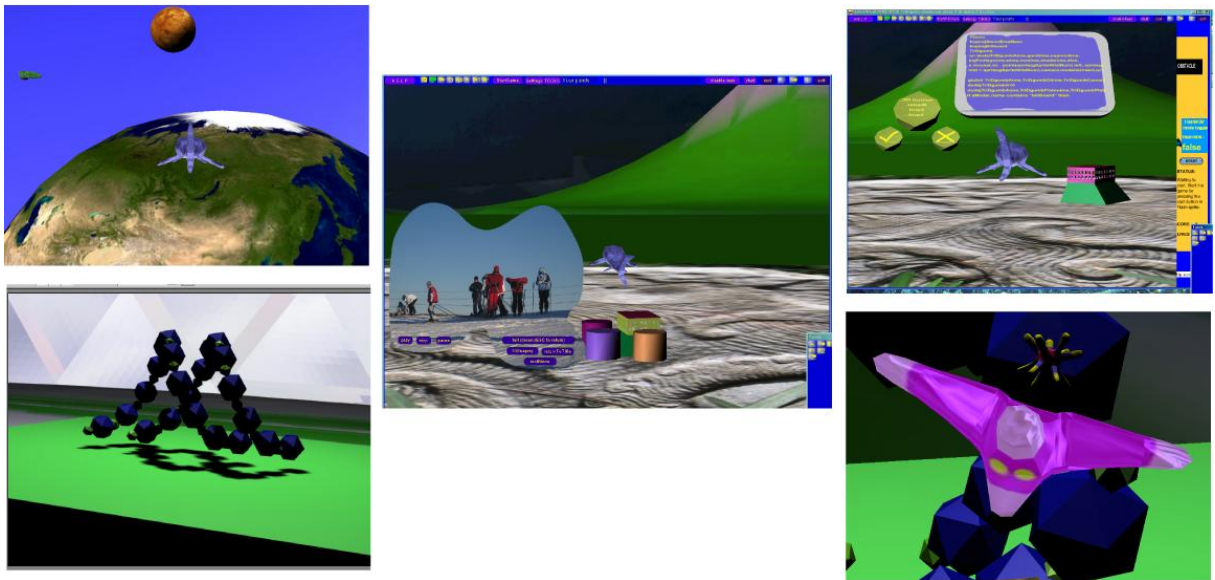
**Figure.4.** Comparison of a 2D drawing and its corresponding virtual reality world. The object are the different morphologies of the taste buds in our tongue. The drawing on the left is simple, expressive and immediately illustrates the difference between three kinds of taste buds. Excellent to retrieve just the fact – in this case the shape difference.

On the other hand, the virtual reality world on the right seems to be more complicated at the first glance. The “hose” with arrows denotes a typical itinerary through this world with our camera. Although the shapes are not so clear and straightforward as on the drawing left, they (because they are 3D models) give a richer impression. If you are diving “inside” you are likely to remember better the different taste bud morphologies.

Understanding the taste receptors (fig.4), bioelectricity and the potentials on the synaptic membrane is often difficult for students. We provide here some animations and simulations that help to understand at the first glance what happens on the excitable biological membrane. First we made a simulation where the student gets two compartments containing two kinds of ionic solutions. Initially the compartments are separated by a membrane not permeable to any ions. If this membrane is made a semi-permeable that lets through larger ions, but not the smaller ones, an equilibrium soon takes place where the diffusion forced get balanced with the electric forces – the smaller ions would diffuse through the semi-permeable membrane out of the compartment, but they are attracted back by the electrical forces of larger ions which cannot diffuse through the membrane. The bioelectrical potential builds across the membrane. In this phase the user can add channels to the membrane. Opening such a channel depolarizes the membrane, but after the channel gets closed again, the resting potential is re-established. So the student plays producing bioelectric spikes and learns about the postsynaptic and action potentials. He can place on the membrane also the ion pump which pumps the ions thorough the membrane against their concentration gradient thus increasing the resting membrane potential. After gaining the understanding of the processes on the molecular level we advance to the cellular level to study the mechanism of the synaptic connection between two cells. There is provided the “classical” illustrated material and animations describing the neuronal synapse with the presynaptic cell which contains synaptic vesicles that contain the synaptic transmitter molecules. The electrical depolarization is the trigger which makes the vesicle membrane to fuse with the outer cell membrane and the transmitter molecules enter the synaptic cleft. The transmitter diffuses rapidly and some of its molecules hit the receptor molecules of the membrane channels on the postsynaptic membrane. We provided a VRML world where the user can virtually travel with a transmitter molecule through the membrane channel. He triggers the process by clicking with the mouse on the pre-synaptic cell. The transmitter molecules are released and reach the membrane channel of the postsynaptic membrane. The activation gate opens, and sodium ions pass through the channel into the cell interior. We also follow their path, go through the channel and come out in the interior of the cell. We see how the channel “trembles” as it rapidly goes very fast from its open and closed states for several times and finally, as the transmitter molecules diffuse away, the gate. We modeled the channel, which is composed of several subunits, so that we first created one subunit from extrusions only and then copied the remaining units as instances of the first one. The functionality was achieved through VRML script. The whole VRML world is less than 80KB large. We produced two versions: one to be observed with VRML plugin and the other one to be observed without any plugin by the help of the Shout3D applets.

#### **2.4. RGAMES AND LAKE POLLUTION PROJECTS**

Rgames (fig.5) are educational games explaining the hazards that can be provoked by radiation, impairing the living cell and hence also our organisms. This is the entering point to teach about the function and structure of our genetic and cellular system and the possible dangers arising in this respect. We use the web technologies like web3D, Havok physical simulations and DHTML to produce spontaneously attractive teaching material and electronic interactive “textbooks” covering selected topics that are taught in the secondary and primary schools in Europe and are difficult to learn from only paper textbooks.



**Figure.5.** Our “home made” software tool used to learn or play in virtual reality and/or multimedia. The picture on the upper left shows the space (learning about astronomy) while the picture on lower left shows the model of a short segment of DNA (desoxyribonucleid acid). Its bases are set on springs thanks to the Havok physics simulation. So when our avatar (the spaceship on the lower right image) fires a projectile – the photon modelled as a sphere with spines – it may hit the DNA base and make it vibrate. The vibration reflects the instability of the real DNA when hit by a photon of great energy like UV or gama waves. The middle picture shows the integration of video in the virtual reality world. It is possible to play video and one can clip it with a clipping mask like the butterfly shape here.

We created a web portal explaining some of the themes that are now much discussed by young people and difficult to teach only with written or spoken explanation. We concentrated on the themes connected with the living cell and its genetics like radiation – from natural (visible or invisible) sunlight to other radiation sources (radioactivity). The living organisms face radiation from the early times of the evolution of life on Earth. Radiation has harms as well as benefits for the living beings. It is also an excellent starting point to play, explore and learn in the virtual reality environment.

We made the experiments’ designs according to the suggestions of experts in physics and biology and we accepted the pedagogical theories of expansive learning and constructivism, where student learns as he constructs things.

First we made our models with Z-Brush modeler, then added animations in Discreet Plasma and finally ported the functional models into the Adobe Director, where the final product was assembled and further programmed. In Director we programmed the code related to the virtual reality world, while the educational game engine itself was done in Macromedia Flash and then ported to Director. So it was possible to produce in addition to the virtual reality Director world also a “planar” Flash version of our game that is running well also on older computers that children or some schools sometimes still have. This Flash – Director combination enhances also the collaboration between pupils. They can write their Flash code – a simple game for example. After playing it in Flash planar environment they can plug it into our Director code (with models and 3D world already available there) and instantly they get a real virtual reality game. So their motivation for learning natural sciences gets enhanced.

In the virtual simulation/play about the lake pollution the user can experiment how to manage and clean the polluted lake without previous knowledge of biology and ecology. However, if you want to be successful in playing the game, you need to gain knowledge about the biology and ecology of clean and polluted lakes.

The virtual environment is represented by the model of the lake which has inflow of fresh water, outflow of lake water and the lake depth is divided into three levels: shallow, medium and deep. Plants can only grow in the shallow part of the lake, deeper there is no light for them even in the unpolluted lake. The deep part of the lake contains cold water which almost never mixes and is vulnerable to accumulation of toxic agents of

pollution as well as potentially toxic sediments. The border around the lake contains a virtual farmland (the source of organic pollution), a factory (the source of chemical pollution) and a cleaning plant.

### **3. Acknowledgements**

Our projects were supported by the European Union and Ministry of Education in Slovenia (IST-2001-34204, Minerva 100152-CP-1-2002-1-EE-MINERVA-M, 116947-CP-1-2004-1-SI-MINERVA-M, FP6-511114).

### **4. References**

- [1] Bioanim 2006. From <http://www.bioanim.com> Retrieved on December 15th 2006.
- [2] Algorithmic Arts 2006. From <http://www.algoart.com/> Retrieved on December 15th 2006.
- [3] Macromedia 2006 From <http://www.macromedia.com> Retrieved on December 15th 2006.
- [4] Ministry of Education in Slovenia (2000) From <http://www.eduanim.com> Retrieved on December 15th 2006.
- [5] Pixologic 2006 From <http://www.pixologic.com> Retrieved on December 15th 2006.
- [6] Discreet 2006 From <http://www.discreet.com> Retrieved on December 15th 2006.
- [7] VRML 2006 From <http://www.web3d.org> Retrieved on December 15th 2006.
- [8] Alias 2006, Autocad 2006 From <http://www.autodesk.com> Retrieved on December 15th 2006.
- [9] NIH Image 2006 From <http://rsb.info.nih.gov/nih-image/> Retrieved on December 15th 2006.
- [10] PlantStudio 2006 From <http://www.kurtz-fernhout.com> Retrieved on December 15th 2006.
- [11] Terragen 2006 From <http://www.planetside.co.uk> Retrieved on December 15th 2006.
- [12] Brand Worlds Tools 2006 From <http://www.brandworlds.com/> Retrieved on December 15th 2006.
- [13] Poser 2006 From <http://www.curiouslabs.com/> Retrieved on December 15th 2006.