Applet Competition as an Educational Tool in Creating Novel e-Textbook

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Abstract

We introduce a long-term competition-oriented project, using learning by doing (applets). The output of this project is updated every year at http://www.netgraphics.sk/. Many undergraduate students at the University of Warwick and the Comenius University compete in developing the e-Textbook, called Computer Graphics Virtual Textbook. The current version offers supplementary material for particular CG courses but it is also an independent source of information for all people interested in CG. There is currently 126 students enrolled for this competition. Every year, the number of valuable applets or applet innovations is lower than the total number of students. The three winners of 2008 round of applet competition will be announced before Christmas (and their creations will be presented at the SCCG09 conference). The best units of this project will be submitted to CGEMS.

Categories and Subject Descriptors (according to ACM CCS): K.3.2 [Computer Graphics]: Computer and Information Science Education—

1. Introduction

In total, our initiative is involving hundreds of undergraduate students (UK, SK) in developing a locally and globally valuable Computer Graphics Virtual Textbook. Computer graphicists are the speakers of the world and because of growing popularity of visual information processing, there is probably the biggest group of computer graphics students at Comenius University. We offer here six BSc. level courses, three graphics-oriented MSc. study programs and tens of mandatory or optional courses in geometric modeling, computer vision, and computer graphics. Therefore we plan to improve the e-learning of graphics as well as possible, in a long-term perspective. To achieve this, we have to discuss the relevant issues from scratch. This is the goal of the paper itself. A global trend in Technology-Enhanced Learning (e-learning, course-management systems, etc.) can be understood as a never ending process of balance/searching between two content development streams - 1. **standardization** and 2. **innovation**. While standardization (vocabularies, curricula, study programs, knowledge bases, textbooks, and international standards) conserves or tries to preserve and/or structure the valuable part of knowledge, innovation relativizes everything to bring new values and to deconstruct the older ones. Innovation varying priorities can be easily documented with sets of open problems in Computer Graphics from Ivan Sutherland [SUT66] through [NB77], [HEC87], [CF91], [Bli98], [Fei00], to [GO97]. As it can be risky to follow the innovation stream in educating fundamentals, the very first short conclusion can prioritize the most respected conservative sources like [FOL90] and [HB94] in multiple editions. But having the content for learning, which way of technologic enhancement is the right one? In our paper we discuss our project decisions, which we consider aware enough of global menu of alternatives. The ultimate goal should be a contribution to Semantic Web [BL01], future web of knowledge, supporting human creativity as the top value. Pat Manson, EC Head of Unit Cultural Heritage and Technology Enhanced Learning, observes even three prospective directions/elements [ERC07]: "Technology-enhanced learning may not flow readily off the tongue or be easily translated as a brand name, but it very consciously reflects what it is: using ICT (Information and Communication Technology) to secure advancements in learning. By taking advancements as the objective, we go beyond the attempt to reproduce classical ways of teach-

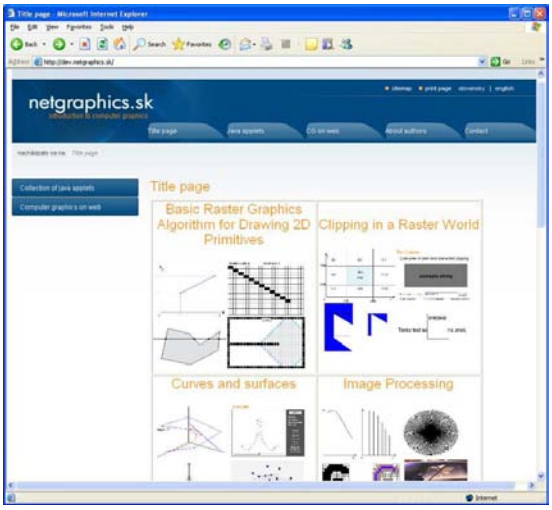

Title page - Microsoft Internet Explorer
http://dev.netgraphics.sk/
netgraphics.sk
introduction to computer graphics
Title page
Java applets
CG on web
About authors
Contact
Collection of java applets
Computer graphics on web
Title page
Basic Raster Graphics Algorithm for Drawing 2D Primitives
Clipping in a Raster World
Curves and surfaces
Image Processing
Internet

Figure 1: *Screenshot from the newest version of Computer Graphics Virtual Textbook showing the title page. The WEB address is as follows: http://www.netgraphics.sk/*

ing via technologies. Technology-enhanced learning combines but places equal emphasis on all three elements - on 1. technologies, on 2. learning and on enhancements or 3. improvements in learning (numbering and boldface added by authors). This will help us in devising ICT-based solutions which motivate and inspire learners and teachers, engaging them in meaningful learning and teaching experiences." In computer graphics, measurements of learning improvements lacks of having no didactics (theory of education), which is available e. g. in computer science, math education, and other more established areas. In graphics education, one can opt for graphics-specialized CGEMS approach [CGE07], or adopt more general Moodle "de facto" standard. Moodle is a course management system (CMS) - a free, Open Source software package designed using sound pedagogical principles, to help educators create effective online learning communities [Moo07]. There are even more e-learning standards and standardization bodies - among others - with CEN/ISSS [ISS07], IEEE [LTS07], [ADL07], ISO, and IMS. They focus on interoperability, innovation, adoption, learning etc. The latest says explicitly: "In service to the community of organizations and individuals enhancing learning worldwide through the use of technology, IMS GLC is a global, nonprofit, member association that provides leadership in shaping and growing the learning and educational technology industries through collaborative support of standards, innovation, best practice and recognition of superior learning impact." Computer graphics community can learn from this global competition good practices, guidelines, standards, and methodology.

The rest of the paper is structured as follows. Section 2 discusses relevant aspects and content. Section 3 is dedicated to methodology. Section 4 surveys the collaboration and types of e-learning we experimented with. The project outcomes are summarized in Section 5. Section 6 refers on class assignments and competitions at Comenius University. Finally, Section 7 draws conclusions.

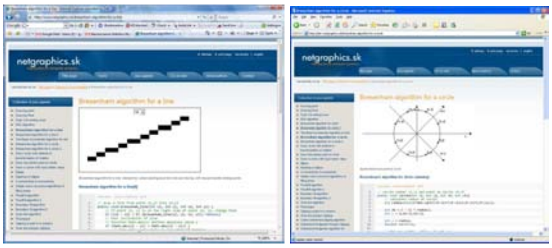


Figure 2: *Screenshots from the newest version of Computer Graphics Virtual Textbook. An example of Java applet integration showing Bresenham's algorithm for a line (left) and circle (right)*

2. Teaching and Learning Aspects

We all consider teaching as an integral part of learning and we have always given as much effort to teaching as to our own research. Our vision is to use this interactive web page, nicknamed CG Virtual Textbook, as a main or as a supplementary material for the undergraduate Computer Graphics course. This web page is going to be a part of e-learning system in which students are going to have an opportunity to test themselves by using didactic tests. They will be also able to find here more theory about CG and many Java applets. It will also be used as a source of the important information for scientific community. All applets can be easily migrated to another spoken language context.

Most of the CG web posted algorithms are programmed as java applets and offered in an interactive form to users. Whole web page will be published as an open source in a way that the user can add to the existing material his/her own applications. Mathematics in CG algorithms/methods is described using MathML code, which is a standard for visualization of a mathematical text on the web.

More than hundreds of undergraduate students participate in creating the Virtual Computer Graphics Textbook. This promotes their learning of CG in several ways:

- It helps them better understand the new learned ideas in the Computer Graphics course, to apply them and to bring their new ideas.
- This project gives students big opportunity to further discuss the applications of CG with experts.
- It gives the undergraduate students opportunity to learn about and to participate in a project that is more extensive than the projects done as homework. It shows them how to do their own research of the newest trends in Computer Graphics

Students and scientific community are the final users of the proposed Virtual Computer Graphics Textbook. We believe that it is very important to know how the algorithms are used in real life. Here the Virtual Computer Graphics Textbook holds great potential as it will help undergraduate students and the scientific community:

- to understand mathematics (geometry, linear algebra) employed in CG algorithms and methods.
- to understand techniques of the image generation, image processing, modeling and visualization.
- to understand and to be able to implement basic CG algorithms using graphical programming standards(e.g. OpenGL, Java applets).

2.1. Content Issues

However, for **content guidelines** we have to take into account general recommendations ACM Computing Curriculum, part Graphics and Vision, related and specialized fields [BAN01] [BRO87], [CHA96], [RF00], [GW93], [LEB01], and last but not least the recent SIGGRAPH Knowledge Base Report [ALL06]. We took into account nearly all these materials when innovating the courses at Comenius University. In particular, the ***Computer Graphics Introduction*** course for mathematicians (Bs study program) covers: Computer graphics definition and reference model. History, fundamental problems and their solutions. Transformations in the plane. Basics of functional specification of graphic systems and standards. Graphical objects creation, modification, and coding. Rasterisation. Clipping and intersections. Image processing algorithms. The same course for computer science students covers not algorithms but focuses on tools. Then, an optional course named ***Web Graphics*** offers know-how and hands-on experience in a dynamic area of internet communication using multimedia objects. The rules and methods of the efficient authoring work using recent technologies according to the ACM Computing Curriculum recommendations are taken into account in 15 units.

1. Basic definitions. Historic survey, state-of-the art and the future of WWW. Semantic Web a Digital Libraries.Mobile communication. Security, legal and social aspects. Webby awards.
2. Client-server architecture. Dominant web services and technologies. SGML, HTML, VRML, UML. Java, php, ASP.NET and others. Examples of proper use. MIME formats and RFC standards. WWW Consortium.
3. Text creation, digital typography and DTP. On-line publishing authoring legal aspects.
4. Creation and use of pictorial data for WWW.
5. WWW sound processing and applications.
6. Internet animations and video.
7. WWW virtual interaction. Face demo by Ken Perlin. WWW as a procedural sketch book.
8. Web design styles and rules after classical Siggraph course notes by B. Mitchell and A. Glassner.
9. 3D web graphics, VRML a X3D.
10. Virtual galleries, gardens, thematic parks and chat rooms.
11. Social and philosophic aspects of virtual environments. Netiquette. Third wave by A. Toffler. History of virtual reality (Gibson, Krueger, Lanier, CAVEĚ). Cult movie Matrix and implications of its message.
12. Interaction, navigation, and cooperation in virtual environments. Distributed VR. Games and simulators.
13. Combining text and graphics. Visually critiquing of web pages.
14. Cyber cities. Acquisition, construction, presentation, and applications.
15. Groupware. Group communication. Avatars and on-line communities. MPEG-7 and MPEG-21

Within this context students create their individual contributions: an applet, web page, and a 3d model online. Typically, they opt for a cultural memorial, e.g. a church.

3. Methodology

We have used following methodology for our project:
Goals: The main challenge of the project how to make the learning more interesting for the students and at the same time prepare them for real life situations in programming.
Type: We decided that the type of approach will be the Guided discovery what means the project. And we connect it with a competition, what helps to get high-quality results.
Analyze:

1. What is the previous knowledge of the students? We have undergraduates in computer graphics so their knowledge in this area is sufficient. They have also experience in the area of programming in different computer languages.
2. What we want to teach the students? We want the students to use java applets to create learning tools for them and for the next students. They are supposed to create java applets of geometry of curves, visualization between two objects and many other themes.
3. How we want to teach the students? We prepare the problems for them. Every student must choose one problem. Then they get a template that they must use in solving. There will be 4 levels of difficulty: easy, medium, hard and very hard. According to the chosen difficulty level they have the possibility to work in pairs and it will figure also in the evaluation part.

Design: First we had to think about concrete problems. We provide more than 70+ problems for the students to solve.
Development + Implementation: Dr. Stugel prepares the java template and also the lesson for the students to explain them way they should proceed. They also have great example in the web page pg.netgraphics.sk desing also by Dr. Stugel.
Evaluation: Evaluation of the competition: here we get

some results and we have to decide if the problem was solved correctly and also the quality of the applet. Consequently we have to make a final list of successful solvers who will get the awards.

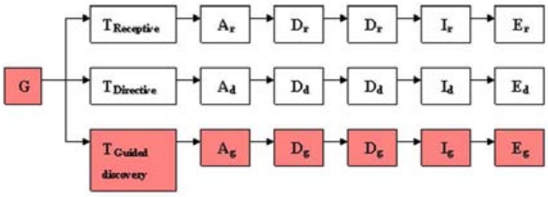


Figure 3: *A visual description of methodology used in this project.*

4. Research Question

The main part of the student research is presented in the development and the implementation of the CG algorithms in the form of Java applets. An applet is a program written in the Java programming language that can be included in an HTML page, much in the same way as an image is included in a HTML page [Jav07]. That allow users to see how the described algorithm/theory is working in real time. There already exist several approaches how to make algorithms more understandable. Most of them include following steps:

1. algorithm/theory description
2. static image or an animation and listing of an appropriate source code written in C/C++

To compare our approach with already existing we using the first step as well, but during the second step we implement the algorithms in a form of interactive Java applet, which allows the user to see the algorithm working in a real time and also to control setup of several variables and parameters.

4.1. Why Java?

Java is very similar to C++ so it can be easy to teach. It is completely object oriented language, with no direct access into memory, no preprocessor or macro. It supports unicode for ease of internationalization, multithreading, security. Java is platform independent (write once, run anywhere, any platform). Java's interpreter exist for all current operating systems.

4.2. Starting with Java

To translate java source code into binary format, we will need a Java compiler. You need to download Java Software Development Kit (JDK) and NetBeans IDE from http://java.sun.com/javase/index.jsp. NetBeans is an ideal programming development environment for developing Java applications or java applets. JDK version 6 NetBeans IDE contains very suitable visual editor for Swing. Swing toolkit is a set of GUI (graphical user interface) components. One can easy create dialogs or visualizations data. To start with Java we can use following URL link http://java.sun.com/docs/books/tutorial/index.html. To learn more about developing Java applets see following URL link http://java.sun.com/docs/books/tutorial/deployment/applet/.

4.2.1. Java classes

Classes are the fundamental building blocks of a Java program. Here is an example of few basic Java classes:

```
public class 2DPoint {
x, y;
2DPoint() {
}
//class constructor
2DPoint( int inputx, int inputy) {
x = inputX; y = inputY;
}
}

public class Main() {
public static void main(String[] arg){
2Dpoint point = new Point(10,10); // using class
point.showPoint();
}
}
```

Each class has a superclass (the class above it in the hierarchy), and each class can have one or more subclasses (classes below that class in the hierarchy). A big advantage for Java compared to C/C++ is, that Java is using memory manager - garbage collection. The name "garbage collection" implies that objects that are no longer needed by the program are "garbage" and can be thrown away. Programmers does not need manually freeing memory, garbage collection automatically scans unused objects and will free the memory space. The basic packages for creating applets are:

java.lang - basic language functionality and fundamental types
java.util - collection data structure classes
java.io - file operations
java.math - multiprecision arithmetics
java.awt - basic hierarchy of packages for native GUI components
javax.swing - hierarchy of packages for platform-independent rich GUI components

4.2.2. Java Applets

There are significant differences between Java applets and Java applications (http://www.javafaq.com/cjapaaa.html) Java applets can't read or write to the reader's file system, except in specific directories. They usually can't communicate with a server other than the one that had originally stored the applet. Applets can't run any programs on the reader's system. They can't load programs native to the local platform, including shared libraries such as DLLs. From the time, that java was introduced, applets were linked with web browsers. With the interactive Java applets one can make static web pages "live" and create the educational applications. Java applets are of a very small size, which is a major advantage concerning the downloading time for the slower networks. Application on the other hand must be installed on local machine , need main() method and has no inherent security restrictions.

4.3. Java and Computer Graphics

New extensions of Java: Java 2D, Java 3D and Java OpenGL support better usage of Java programming language for teaching of computers graphics. Java 2D API enhanced AWT (basic java package) for new 2D graphics object (rectangles, ovals, polygons any other geometric shapes). Graphics2D enhances graphics rendering for basic objects, text and images to support more graphics attributes (ex. stroke attributes, transparency, fill attributes, antialiasing, interpolation, rendering quality, color rendering, dithering, etc.). Java 3D API enables development of three-dimensional graphics applications and Internet-based 3D applets. (http://www.java3d.org/). Java 3D is using DirectX and OpenGL which is enhancing the graphics performance. Java 3D also supports reading of 3D objects.

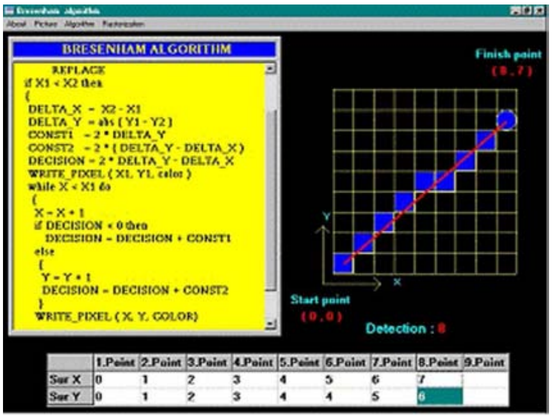
5. Nature of Collaboration

Part of the collaboration in this project is based on the interaction with undergraduate students. More then half of the Java applets are developed as small student projects under the course leader supervision during the course. Each student or group of students developed a single Java applet and its description for end user. Students are involved in the whole developing process starting with the study of the method, structure planning and design, project management, programming and final release. There were consultations, discussions and partial evaluations of the work progress on regular basis (one time in two weeks). Each applet has been accompanied with copyright due to students who developed it. Student's names with their affiliation at Comenius University and at University of Warwick are written on the web page under the appropriate Java applet.
Other important source of collaboration are based on a communication with other CG experts and colleagues from the University of Warwick and other European Universities.

Members of the Digital Laboratory at the Warwick University have a very successful and positive collaborating experience with people (Doc. Valent Zatko, Doc. Milos Bozek, Professor Jan Cizmar) from the Department of Algebra, Geometry and Didactics of Mathematics and from the Department of Applied Informatics at Comenius University, Bratislava, Slovakia. We collaborated on their various activities such as their yearly conference (Spring Computer Graphics Conference) or student seminar (Central European Seminar on Computer Graphics). We based on this experience and we will setup the possible collaboration with the experts from their department since we believe that it is very useful to start the discussion and exchange opinions with these very experienced people from the CG area.

5.1. Related Work

Work on similar projects started at Comenius University in 1999. One of the very earliest projects is *Animation of Computer Graphics Algorithms* done by V. Dudikova, Z. Cernekova, M. Prochaczka and S. Czanner [DCPC99]. The aim of this project was to create video and shipping documents. Material on the videotape illustrated some graphics algorithms "in action". The tape with animated algorithms has been used very successfully in education process.



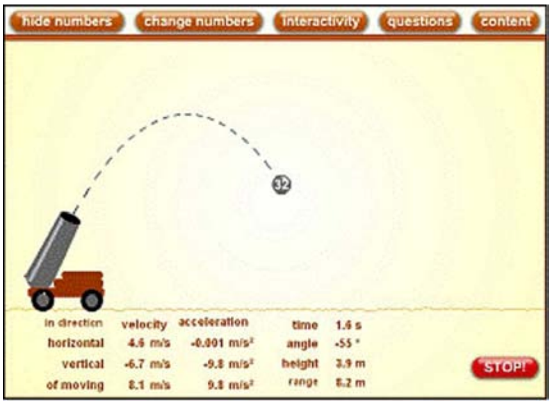
```
    REPLACE
if X1 < X2 then
(
 DELTA_X = X2 - X1
 DELTA_Y = abs ( Y1 - Y2 )
 CONST1  = 2 * DELTA_Y
 CONST2  = 2 * ( DELTA_Y - DELTA_X )
 DECISION = 2 * DELTA_Y - DELTA_X
 WRITE_PIXEL ( X1, Y1, color )
 while X < X1 do
  (
  X = X + 1
  if DECISION < 0 then
    DECISION = DECISION + CONST1
  else
   (
   Y = Y + 1
   DECISION = DECISION + CONST2
   )
  WRITE_PIXEL ( X, Y, COLOR)
```

	1.Point	2.Point	3.Point	4.Point	5.Point	6.Point	7.Point	8.Point	9.Point
Sur X	0	1	2	3	4	5	6	7	
Sur Y	0	1	2	3	4	4	5	6	

Figure 4: *A TV screenshot from education video titled Animation of the Bresenham Algorithm developed by Vladimira Dudikova.*

The goal of another very successful project named *Interactive Simulations of Elementary Physical Experiments* developed by Alena Kovarova was created as an interactive CD ROM, which will provide simulations of several elementary experiments in physics [KC04]. The CD ROM has been used as a learning tool in the educational process. Before entering this virtual laboratory, students are offered a brief introduction to the simulated problems. The software has been developed using Macromedia Flash MX, which offers the opportunity to control the running application by changing several parameters. After setting the parameters a physical experiment is simulated and shown to the student via animation. This TTA Awarded work was motivated by the book

Physics as an Adventure of Cognition written by Einstein & Infeld in 1971.



in direction	velocity	acceleration	time	1.6 s
horizontal	4.6 m/s	-0.001 m/s²	angle	-55 °
vertical	-6.7 m/s	-9.8 m/s²	height	3.9 m
of moving	8.1 m/s	9.8 m/s²	range	8.2 m

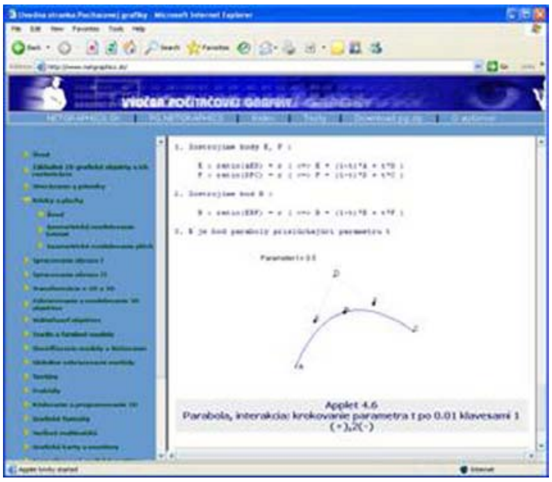
Figure 5: *A screenshot from interactive program called Shooting Cannon developed by Alena Kovarova.*

Also other very similar projects already exist, but most of them are either not available for the public use or they are written in other language than English. For example, four projects developed at Comenius University in Bratislava, Slovakia, written in Slovak language focus on geometric modeling [PZ05], image processing [GF04], graphics terminology [VF05], and algorithms [SF01]. Recent contribution at Comenius University represent step-by-step tutorials for urban reconstruction tools for creating panoramas and approximate models in Blender and TrueSpace tools [ONA07]. Lately some work has been done in the area of Geometry education. There is a system called Cabri geometry, which can be used to teach 3D graphics with the version Cabri 3D [NUN07].

6. Intended Outcomes of the Project

The first intended outcome of the described project was to enhance the undergraduate student research-based activity by involving several of them in creating the web page for Computer Graphics. It is helping them better understand the new learned ideas in the Computer Graphics course. It is showing them how to do their own research of the newest trends in computer graphics. Further, it gives students opportunity to further discuss the applications of computer graphics with experts.

Finally, students get opportunity to participate in a project that is more extensive than the projects done as homework as they are involved in all aspects: project management, development and programming techniques and releasing of an open source web material for public.



Applet 4.6
Parabola, interakcia: krokovanie parametra t po 0.01 klavesami 1 (+),2(-)

Figure 6: *A screenshot from an interactive web page titled: "Vyucba Pocitacovej Grafiky" (Computer Graphics Training) in Slovak language. An applet for changing parabola parameters developed by Dr. Juraj Stugel, who authored the complete page 2001 version, containing up to 300 pages of text in 18 chapters and about 50 applets.*

The second outcome of this described project is an interactive web page, which contains description of CG algorithms and methods. The mathematical/CG text is illustrated with interactive Java applets, which allows users to observe the algorithms/methods in progress.

7. Student Competitions and Work Organization

For class assignments, we experimented with practical tasks like creating MathML typesetting of formulas, but currently we moved to Java applets and the large cooperation team for online textbook. A partial motivation for this stems from the fact that many students at Comenius speak poor English. Therefore, the terminology and explanations from a local textbook [RF95] was adopted for [SF01]. We see the contribution of this project both in English and local language versions in enrichments of global graphics community with possibly world largest family of applets, which will grow and grow. The best parts or units of this textbook aim at being contributed to CGEMS finally [CGE07].

Students have to complete their own web page, one applet and a 3D object, e.g. a church VRML model from their village. The applets are evaluated in a contest. The best students can enter two more competitions to get themselves to SCCG and CESCG international events. In total, one student must enter one competition and two more competitions are available each year. Each student can modify an existing educational applet from [SF01] or develop an original design. Eventually, two students can cooperate, when the topic is too complex. The first three prizes are recent Computer Graphics books. The jury is composed from teachers and PhD students. It is possible to replace the educational applet by a more complex applet in other competitions, named Equilibrium & Solver IT 2008 and SOFTIP 2008, according to their sponsors. It is allowed to enter all competitions. The response from students is very challenging.

8. Conclusion

Evaluation of the project has been based on the evaluation of the progress of the project of each involved undergraduate student (i.e. on evaluation of the development of the individual interactive Java applets). Each project was done in several stages and each stage was evaluated separately. The stages are:

- Each student will have to become familiar with the chosen CG topic
- The students will need to write codes to implement the chosen CG topic and it will be tested
- Next the students will create interface and design suitable for the Internet

Finally the student's interactive Java applets were implemented for final release and tested. At the end of this phase of the project we got about 60 new or significantly improved Java applets from which 25 are very suitable to enter one of the competitions. The results of the class competition 2007 are as follows:

1. place: Raytracing Java applet developed by Peter Paulis, http://www.pixellove.eu/wega
2. place: Texture mapping Java applet developed by Martin Madaras, http://www.st.fmph.uniba.sk/ madaras2/Applet.html
3. place: RGB to HSV converter Java applet developed by Daniel Pohanka a Peter Pech, http://pesto.peterpech.com/wega

The first three prizes were awarded by the following recent book: Selling Graphic and Web Design by Donald Sparkman, February 2007.

The project will continue in future years with identifying relevant ideas from all references, which were not cited above (curricula, textbooks, etc.) and grow the coverage of graphics topics with applets. In the year 2008 the introductory graphics classes are attended by 385 students at Comenius University. Extrapolating from previous years, we can expect about 150 enrollments for WEGA class and creating applets in the year 2008.

9. Acknowledgement

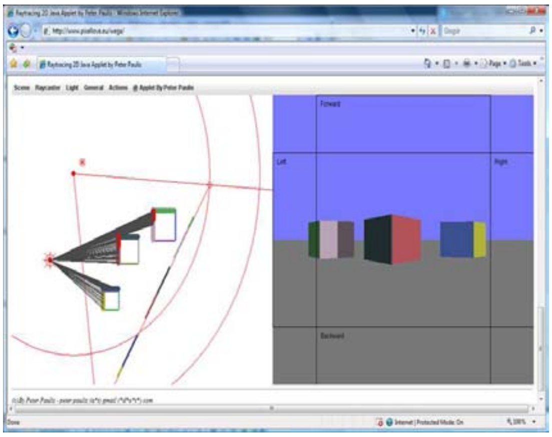


Figure 7: *A screenshot from the Raytracing Java applet developed by Peter Paulis.*

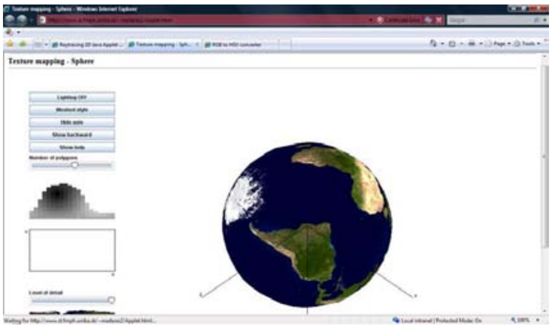


Figure 8: *A screenshot from the Texture mapping Java applet developed by Martin Madaras.*

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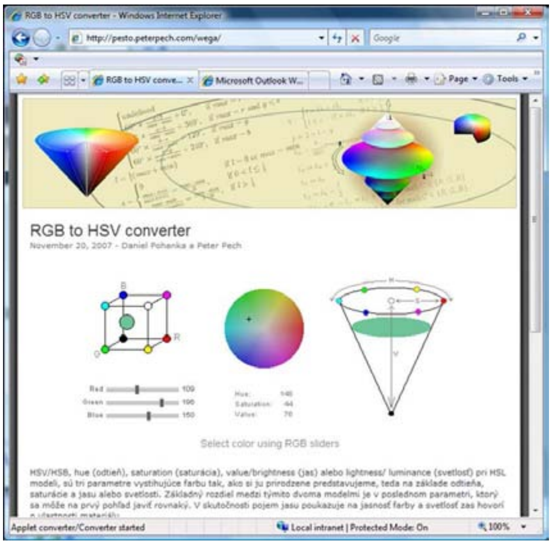
RGB to HSV converter - Windows Internet Explorer
http://pesto.peterpech.com/wega/
Google
RGB to HSV conve...
Microsoft Outlook W...
Page
Tools
B
R
G
H
S
V
Red 109
Green 190
Blue 150
Hue: 148
Saturation: 44
Value: 70
Applet converter/Converter started
Local intranet | Protected Mode: On
100%

RGB to HSV converter

November 20, 2007 - Daniel Pohanka a Peter Pech

Select color using RGB sliders

HSV/HSB, hue (odtieň), saturation (saturácia), value/brightness (jas) alebo lightness/ luminance (svetlosť) pri HSL modeli, sú tri parametre vystihujúce farbu tak, ako si ju prirodzene predstavujeme, teda na základe odtieňa, saturácie a jasu alebo svetlosti. Základný rozdiel medzi týmito dvoma modelmi je v poslednom parametri, ktorý sa môže na prvý pohľad javiť rovnaký. V skutočnosti pojem jasu poukazuje na jasnosť farby a svetlosť zas hovorí o vlastnosti materiálu

Figure 9: *A screenshot from the RGB to HSV converter Java applet developed by Daniel Pohanka a Peter Pech.*

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