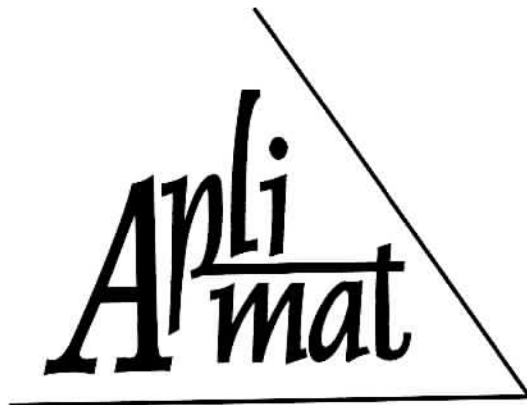


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**GRAZIA: THE GRAZ ACM COMPUTING CURRICULUM  
INTERACTIVE & ANIMATED COURSEWARE  
ON GRAPHICS & VISUAL COMPUTING**

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**Abstract:** We combine previously unrelated requirements and approaches for the support of classes for graphics and vision. ACM Computing Curriculum provides the contents guidelines, TU Graz fundamental lecture on Graphics and Visual Computing implements the lecture notes, with frequent hyperlinks into the slides. Applets at [pg.netgraphics.sk](http://pg.netgraphics.sk) offer the interactive experience. Algorithm animation, open problems and knowledge tests enhance the topics understanding and feedback. All the above mentioned main components represent the layers of the open source international educational student project. All the features will be presented to the conference audience either online or using videos.

## **1 Introduction and Motivation**

We are distant of distant learning. Our intention is not the distant learning, e-teaching or so. It is our strong belief that the essence of the university is the authentic human communication among students and teachers. We would like to support the true classes by advanced additional courseware: interactive applets and animated algorithms and asking more inspiring questions. This is why we can directly adopt the arising contents standard, body of knowledge: the vividly discussed **ACM Computing Curriculum**. The document known as the Strawman report [Stra00] that time, appeared about eleven months before WSCG 2001 conference. The later Ironman Report [Iron01a], appeared in February 1, 2001. The detailed description of the courses is at [Iron01b]. Probably the first European discussion on the curriculum was held at the WSCG 2001 in the same February 2001. The disputes, obviously, discussed the previous (Strawman) version. The updated version and the appendix on **CS Body of Knowledge** are in the Steelman Report [Stee01]. The discussions continue at the ACM Computing Curricula website, as well. Let us quote from the discussion the – evidently, although partially, accepted – opinion of Vaclav Skala [Skal01]: „*Geometric Modeling GV4 and Computer Vision GV11 should be in the CORE, while GV3 Graphic Communication I would see as an elective... Reason: Geometric Modeling GV4 - gives methods, algorithms and data structures, which can be, used also in others fields. Computer Vision GV11 - gives*

*long term knowledge based on math.*” Indeed, graphics, visualization and multimedia were originally not included into the core CS body of knowledge in [Stra00].

On the other hand, ACM Computing Curriculum can be discussed, but up to now this is the leading global current CS education standard, maybe under the further development, converging or ongoing, eventually, to the future „formal“ standard. It seems evident that the recommended courseware based on the requirements of the Curriculum can start to be built. For the education of computer graphics there are two most relevant units **CS250 Human-Computer Interaction**, and **CS255 Computer Graphics** (CS stands for Computer Science). Up to now, there are the “official” SIGGRAPH course notes, slides, and other educational tools in the Education part of the web-page, including the computer graphics taxonomy and the slide sets. No respect to Curriculum up to now. Probably the most popular (more than 34 000 visitors) web page on image processing is the Hypermedia Image Processing Reference (HIPR) [Fish00].

The paper is organized as follows. We discuss the courseware contents (Section 2) and form (Section 3). We review the methodology of the used presentation technologies, giving by the way the incomplete selection of prospective recent projects (Sections 4, 5, 6). Many other educational URLs are provided at [Stug01], evaluated by the speed of downloading, extent of the material presented and other criteria. Section 7 is Conclusion.

The motivation for teaching the graphics and visual computing is obvious.

## 2 Graphics and Visual Computing

The courseware content is given by the contents of classes. Note that there is the usual and frequent practice to teach certain parts of methodology and technology separately, although they may have many common points, like computer graphics and vision [Sche01]. The first Visual Computing book has been written by Markus Gross [Gros94]. At the Institut fuer Maschinelles Sehen und Darstellen (the original German name) there is taught by Franz Leberl the rare combination of computer graphics and vision for many years. This has been influenced by many practical TU Graz projects, mainly creating virtual cities in former years, including the record speed modeling French village in the Alps within two days [Lebe96] for the simulation of a rescue action in one of the wars in Yugoslavia. The web presentation of the lecture is available at [Lebe01], webmaster is Markus Grabner. The efficiency of the fruitful combining Graphics and Vision is obvious when teaching fill area procedures along with the border and skeleton algorithms or explaining geometric transformations applied in graphics and vision, as well.

The combining of graphics and vision appears surprisingly compatible with the currently proposed curriculum substructure:

**Graphics and Visual Computing (GV):** GV1. Fundamental techniques in graphics [core], GV2. Graphic systems [core], GV3. Graphic communication [core], GV4. Geometric modeling [elective], GV5. Basic rendering [elective], GV6. Advanced rendering [elective], GV7. Advanced techniques [elective], GV8. Computer animation [elective], GV9. Visualization [elective], GV10. Virtual reality [elective], GV11. Computer vision [elective]. We took this from the Ironman Report because the link with the Strawman Report does not work... The „core“ and „elective“ markers identify the mandatory and optional parts of educational contents. Two examples follow. Part GV1. **Fundamental techniques in graphics** includes *Halftoning, Font generation, Representation of polyhedral objects, Scan conversion of 2D primitive, forward differencing, Tessellation of curved surfaces, Homogenous coordinates, Affine transformations, Viewing transformation, Clipping, Hidden surface removal methods, Z-buffer and frame buffer, color channels*. Part GV5. **Basic rendering** includes *Color models, Light source properties, Phong reflection model,*

*Rendering and shading of a polygonal surface, Texture mapping, Ray tracing, Image synthesis, sampling techniques, and anti-aliasing.* It can be easily seen that there is a significant overlap with the fundamental educational material in [Fole00] and [Gonz93], the key references for the TU Graz Graphics and Vision approach. Note that the content can be seen as stabilized in many other books: [Szir01], [Watt92], [Watt95], [Hill90]...

### 3 The GRAZIA Courseware Form

Evidently, the crystallization of fundamental graphics and vision educational material is completed, at the curriculum level, at least. Right time to prepare the appropriate courseware for computer science students. There arises the question of the form of the book. There are at least two very successful approaches, which we can characterize as **interactive webtextbooks**. (We measure the success by the response of our students.) One of them is the slideshow [Lebe01] containing more than 1000 slides, connected directly via hypertext with the English text. Another approach shows the Slovak text illustrated by interactive applets [Štug01]. The project originated as the diploma work by Juraj Štugel at the Comenius University, supervised by Andrej Ferko. The teacher or the student can change the input or display, e. g. Bézier knots positions or the size of pixels.

We try to combine both efficient approaches within the ACM Computing Curricula contents recommendation framework and extend them by the knowledge tests and the algorithm animations. We cannot accept two very different approaches. There is a very interesting solution using Virtual Reality by Wen-Tsai Sung at National Central University, Taiwan. At the site [Sung00] there is the project WebDeGrator, a constructivism based educational VR tool. In general, the VR hardware is not frequently available; therefore we opt for the standard PC platform. The constructivistic educational paradigm is both very suitable for VR and interesting educational approach, too. The second approach we do not adopt is simply to tape the lecture of the professor and put it on the web.

The detailed specifications for each subtopic (e.g. GV2. Graphic systems) will follow the identical scheme: each subtopic is rigorously defined, the method is explained by text and image, the static or dynamic example is provided, the tests of the knowledge are done and evaluated (in Slovak, German, or English), the links to other web sources are given. If possible, the algorithm animation will be available.

*The growing international team will consist of students and advisors. The work is very paralelizable. The bazaar approach and the open source license policy will be applied [Raym01]. All the slide shows, applets, animations and other courseware materials will be available in the languages provided by the authors. The implication of the bazaar development is that there is no rigorous scheduling of the project. In the following we will focus to particular parts of the courseware.*

### 4 Computer Graphics Applets

The top prominent web page on graphics education should be the SIGGRAPH page, including the HyperGraph educational project and a selection of SIGGRAPH course notes. Patrick Min at Princeton University has developed two groups of applets - JAR versions (for Netscape 4 and up: *Bézier applet, 2D Transforms applet, 3D Viewing applet, Cohen-Sutherland clipping applet, and Lighting applet*) and in separate class files (for Netscape 3: *Bézier applet, 2D Transforms applet, 3D Viewing applet, Cohen-Sutherland clipping applet, and Lighting applet*). Last modified on Feb 9, 2001. The ten applets are at the ACM education web page [Min99]. They illustrate five parts of the graphics computing.

Tens of applets are at [Štug01], based on [Ruži95] the first Slovak book on computer graphics and image processing. These interactive applets were awarded in the international

SUN Company competition and in fact they recorded many visits after being published. Their interactivity is highly appreciated by frequent visitors. Juraj Štugel at Comenius University developed the interactive page, which currently became very probably the most popular page among Slovak and Czech students of graphics. This is the biggest group of computer graphics education applets, to our best knowledge: *point drawing, DDA algorithm slope value, DDA algorithm increments, DDA algorithm slopes, Bresenham algorithm with zoom, Bresenham algorithm for moving endpoint, circle drawing and rasterizations by four methods, ellipse drawing, pixel neighbourhoods, fill area, scan line demonstration, and scan line algorithm* are the 15 applets for raster conversions. There are 7 applets for clipping, 10 applets for various curves, 4 applets for surfaces, 10 applets for elementary image processing, 10 applets for transformations, 5 applets for projections, 3 applets for solid modeling, 5 visibility applets, 14 applets for color and illumination, 3 texturing applets and several fractal applets. This applet set rapidly grows. Tens of remarkable applets are at the courseware pages of Andy Van Dam, Brown University [VanD01] and Tomoyuki Nishita, Tokyo University [Nish01]. The GRAZIA will provide links to graphics and vision applets worldwide. Would you be so kind as to contribute by sending links to the applets and other valuable courseware?

## 5 Algorithm Animation

Marc Brown at Brown University wrote his classical book [Brow87] in 1987 and Alejo Hausner and David P. Dobkin give the recent informed representative survey [Haus99] - Making Geometry Visible: An Introduction to the Animation of Geometric Algorithms. Regardless, there are the well done and well working principles and some excellent projects, even there is a remarkably ambitious try to make algorithm animation automatically. However, the use of algorithm animations in education is rare up to now. Instead, the animations showing the algorithm results are widely used. The example for this approach is the HyperGraph, on-line educational project [Owen01], at ACM SIGGRAPH page. The essence of methodology introduced by Marc Brown is to show the algorithm in both static and dynamic forms, using multiple windows for simultaneously viewed algorithm work. The audience shares code or pseudocode, history of main data structures, input, processing, and output. The experience with animated algorithms shows the superiority of this way of teaching. By the way, the teacher in the class animates somehow the algorithm explained. Markus Grabner at TU Graz has created the scenario [Grab01] for animation of the Phong illumination model and Phong shading by visualizing all the input parameters using advanced visualization techniques. The key idea is to show the audience the difference between illumination model and shading. The explanation will be based on [Hear90] and other books. This algorithm animation will be presented at the APLIMAT 2002 conference. Note that the approach is not suitable for graphics only, [Cres98] reports on a „Multi-Platform Collaborative Tool for Teaching Graph Algorithms“, but graphics, unlike other disciplines, provides itself the appropriate tools for animation. The movie means usually fun. Our intent is not to make show but to teach ideas for image synthesis and analysis. This position holds for more than animations. The fundamental role of each form of courseware is to support the true classes.

## 6 Web Links, Open Problems and Tests

We adopt the strategy of [Štug01] to introduce the page content by providing as many as possible pointers to other similarly oriented or concurrent pages. In addition, we shall add the list of open problems. They inspire the best students, some of graphics ones can be found in [Chaz96], [Good97]. The GRAZIA courseware should contain the updated collection of open problems. Maybe, including the eight millennial open problems in mathematics donated



by the eight millions dollar rewards. At least one of them, the famous  $P=NP$  open problem could belong to the far horizon of challenges known to graphics and vision students and graduate students worldwide.

The knowledge tests are very suitable, even unavoidable, tools for providing the feedback by simple fill-ins or more intriguing questionnaires. The success-based learning [Eric98] requires the immediate feedback. While open problems stimulate the far future professional orientation and the touch with the emerging inherent problems of the field, the immediate knowledge tests support the short time progress self-evaluation of the webtextbook visitors. The testing part of the project will be omitted in the first version.

## 7 Conclusion

The unlimited creativity of students seems to be the most valuable advantage of academic institutions over the industrial ones. The GRAZIA project is targeted to feel students free to create for students, for themselves and for their younger colleagues. The up to now developed components of the interactive courseware inclining to the open source „bazaar“ international project could fit with the recent curriculum initiatives of ACM, the largest scientific society. The lovely woman *allegro grazioso* name of the project includes, in addition, the semantic layers of expressing gratitude, thanksgiving of students to teachers, and vice versa.

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