SECTION C: DOCUMENTATION PER PROGRAMME

1a Full title : Computer Graphics

1b Position within the Faculty, Research Institute, Research School, etc

Programme is part of the Department of Computing Science.
Research is incorporated in research school STEVIN, with commisioner TUE.

2 Subprogrammes
None

3 Programme members per 1 January 1996

WP1 dr. ir. C.W.A.M. van Overveld  08.11.57 UHD
    dr. C. Huizing           (from 1-9-94)  12.08.61 UD
    drs. W.A.A. Nuij        (from 1-9-94)  20.04.40 UD
    dr.ir. H.M.M. van de Wetering  11.08.61 UD

4 Key words : computer graphics, computer animation, graphical simulation, geometric modelling, dynamics simulation, animation language, geometric constraints, implicit surfaces
5 Research input of academic staff (wp)

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Main sources for contract research:
Stork Screens BV, Boxmeer;
Philips Research Laboratory, Eindhoven;

6 Research output

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7 Composition of research input academic staff 1995

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8 Programme design in brief (including a mission statement)

The research in the field of computer graphics in the Faculty of Mathematics and Computer Science of TUE is aimed at the development of tools, algorithms and paradigms for interactive real-time animation and real-time graphical simulation. An important aid in this research is the Generalized Display Processor, or GDP. The GDP is a universal and interactive animation system that is being developed in the group. The GDP is controlled by means of the object-oriented language LOOKS, which was especially developed for this purpose. LOOKS is tailored towards the description, viewing and manipulation of 3-D geometric objects with autonomous motion behaviour. A balance is maintained between relatively fundamental research (e.g. the algorithms and data structures for efficient collision detection; methods for real-time interactive dynamic simulation, the relation between object-orientedness and geometric constraints) and the application of the results of this research in the GDP. Moreover, in order to demonstrate the concepts of interactive animation, the research is characterised by an increasing emphasis on developing practical applications for the GDP that can be used in the contexts of education, virtual reality, games, and simulation.

When doing research on 3-D computer animation, geometric modelling is an indispensable sub-discipline. Hence, a secondary research goal (mostly carried out in the form of graduate projects) comprises methods for intuitive modelling of complex 3-D scenes, and almost half of the publications of the group is devoted to this theme. The interest in geometric modelling in the graphics group ranges from polyhedral modelling and variational surfaces to implicit surfaces.

Although the development of new graphics algorithms and their underlying principles and the dissemination of these results in the form of education, publications, conference contributions and PhD-theses comprises the primary responsibility of the graphics group, a major effort is also devoted to the actual implementation of these algorithms and to building a coherent software environment for computer graphics and computer animation experiments (algorithm prototyping, feasibility and performance testing, application development,...), of which the GDP is one of the most prominent components. Therefore a third goal of the graphics group is to maintain and extend this software environment, to make it available for a possibly wide community of users and to promote its usage for a variety of purposes. This means that effort is put into portability, maintainability and documentation.

To summarise:

- **Major research question**: what techniques should be used to develop software applications where 3-D interactive animation plays a central role?

- **Major goals**:
  1. develop algorithms and motion modelling paradigms that are central in the context of 3-D interactive animation;
  2. develop algorithms and geometric modelling paradigms that are central in the context 3-D geometric modelling;
  3. develop software both to demonstrate and to test the results of (1) and (2).

- **Product**: the GDP and related software components.

- **Methodology**: the concept of object-orientedness.
Overview of scientific results

Practically all research results that have been obtained in the graphics group thus far are more or less closely related to software systems that have been developed. Therefore we group our results in relation to these software systems, and we will elaborate on their innovative research aspects.

Computer animation:

Two systems have been realised: the GDP and its predecessor, WALT. The most important innovative ingredients are:

- a unified approach for rigid body dynamics and geometric constraint handling;
- a script-based animation specification style. In WALT, the script language is still quite rudimentary, but for the GDP a full-fledged object-oriented language has been developed which supports, among other things: genericity, multiple repeated inheritance, pseudo-concurrency integrated with event handling and a complete MOTIF-based user interface management system, runtime linkable class-libraries, direct modification (i.e. script fragments may be communicated to a running GDP), networking primitives, system classes that support kinematics, inverse kinematics and dynamics simulation, 3-D viewing and 3-D direct manipulation.

These animation systems have been used for a variety of demonstration applications, such as bipedal and quadrupedal walking, a roller coaster, interactive physics demonstrations, a railroad simulation, a set-up for discrete production including 4-link robot and conveyor belt, a container terminal transport system, etcetera.

Geometric modelling:

A variety of systems has been developed (some systems are still under development): GBOB/GBI, PER, WSOID, GRADED, POMO.

GBOB/GBI form a portable C++ class library to facilitate the rapid prototyping of 3-D geometric applications. They are particularly suited for manipulating boundary representations of polyhedral objects, but also object hierarchy maintenance, 3-D interaction, viewing and graphical user interface layout are supported.

PER is a 3-D geometric modelling system based on direct manipulation of vertices, edges, and faces in 3-D space.

WSOID is an environment for experimenting with implicit surface models. It supports (smooth) boolean operations on implicit primitives and it has been used while developing the shrink-wrap concept (the idea of gradually increasing the shape complexity of implicit surfaces in order to achieve adaptive tessellation). The research interest in implicit surfaces is a shared activity with the University of Calgary, Canada. The joint research focuses on visualisation of implicit surfaces, either via (preferably fast) ray-tracing or (preferably adaptive) polygonisation developing implicit primitives that allow a wide variety of composition operations (e.g. combining ‘soft’ operations and CSG-like operations, warping, etc.) applying implicit surfaces in the context of animation, e.g. for facilitating collision detection and deformation. See e.g. http://www.win.tue.nl/win/cs/tt/kees/MPEG/kws.mp.

GRADED is a system for free-form definition of double curved functional surfaces which operates by means of image processing operations (smoothing, warping, distorting,...) and by direct modification of a shaded
POMO is a suite of tools to experiment with variational modelling both for curves and curved surfaces. It operates by means of minimisation of the curvature energy of a curve or surface, where additional operators serve to influence the shape.

10 Programme development

The following trends characterise the research in the graphics group:

1. further development of algorithms for collision handling, geometric constraints and dynamic simulation of rigid bodies. The link between implicit surfaces and collision handling will receive closer attention.

2. a stronger emphasis on the development of practical (GDP-) applications. These applications can be distinguished in (a) demonstrators to illustrate motion modelling paradigms and other GDP functionality; (b) educational software to be used in teaching computer science, but also in collaboration with other faculties, as in virtual laboratories and interactive assignments; (c) industrial applications.

3. initiating a closer collaboration with the group Numerical Analysis to provide geometric modelling and computer animation as support tools for setting up the geometrical (boundary) conditions, both for continuum problems and discrete problems (such as rigid body simulations) and visually inspecting the numerical results of these computations.

11 Societal/technological relevance

Research has been done for trade and industry in several fields. Some examples are:

- a pilot study within NOB, the facilities division of the NOS, on the usability of free-form curves for computer animation with the style of cartoon movement;
- the development of algorithms for laser printers, to print curves (so-called Bezier curves) with high efficiency and high accuracy;
- the visualisation of the fairness (smoothness) of the surface of a boat. A special rendering technique was used, that adds extra emphasis on possible irregularities in the surface;
- a tool for post processing scanned images to obtain spline representations for boundaries.

More recently, contacts with industry have developed to a somewhat more structural form:

- Contract research for Stork Screens (Boxmeer) on the problem of colour separation for textile printing.
- A regular consultancy contract (0.2 fte/year) with Philips Research Laboratories.

12 Other indications for quality and reputation
13 Five key publications

1. Overveld, C.W.A.M. van:

2. Overveld, C.W.A.M. van:

3. Overveld, C.W.A.M. van; Ee, J. van:

4. Overveld, C.W.A.M. van; Barenbrug, B.:

5. Bergen, G.J.A. van den; Huizing, C.; Nuij, W.A.A.; Overveld, C.W.A.M. van; Veltkamp, R.C.; Wetering, H.M.M. van de:

14 Dissertations

category I:

1991

Wetering, H. van de:
Chain coding in Computer Graphics.

1995

Peeters, E.A.J.:
Design of an Object-Oriented, Interactive Animation-System.
University : TUE
Programme : Computer Graphics
Research director : dr.ir.C.W.A.M. van Overveld

15 Scientific publications

1991

International journals


1992

International journals


1993

International journals


Veltkamp, R.C.: 2D Computational Morphology.
CWI Quarterly 6 (2), 1993, pp. 121-138.

Veltkamp, R.C.:
3D Computational Morphology.

Refereed contributions to international conferences

Overveld, C.W.A.M. van:
The application of relaxation and optimisation methods in computer aided geometric design.

Overveld, C.W.A.M. van; Wyvill, B.:
Shrinkwrap: an adaptive algorithm for polygonizing an implicit surface.

Peeters, E.A.J.:
Design and Implementation of an Object-Oriented, Interactive Animation System.

Veltkamp, R.C.; Wesselink, W.; Wetering, H. van de:
Constrained Variational Triangular Surface Design.

1994

International journals

Overveld, C.W.A.M. van:
A simple approximation to Rigid Body Dynamics for Computer Animation.

Overveld, C.W.A.M. van; Ee, J. van:
Casting shadows with approximated object space accuracy by means of a modified Z-buffer.

Overveld, C.W.A.M. van; Ko, H. van:
Small steps for mankind: toward a kinematically driven dynamic simulation of curved path walking.

Refereed contributions to international conferences

Pelachau, C.; Overveld, C.W.A.M. van; Shea, C.;
Modeling and Animating the Human Tongue During Speech Production.  

Veltkamp, R.C.; Blake, E.H.:  
Event-based constraints: coordinate satisfaction \(\rightarrow\) object solution.  

Wesselink, W.; Veltkamp, R.C.:  
Interactive Variational Curve Design.  

Wetering, H.M.M. van de; Overveld, C.W.A.M. van:  
Chain codes and their application in curve design.  

(Contributions to) books

Veltkamp, R.C.:  
Closed Objects Boundaries from Scattered Points.  
Lecture Notes in Computer Science 885, Springer Verlag, 1994, pp. 144.

1995

International journals

Overveld, C.W.A.M. van:  
Pondering on discrete smooth interpolation.  

Veltkamp, R.C.,  
Boundaries through Scattered Points of Unknown Density,  

Wesselink, J.W.; Veltkamp, R.C.:  
Interactive design of constrained variational curves.  

Bergen, G.J.A. van den; Huizing, C.; Nuij, W.A.A.; Overveld, C.W.A.M. van; Veltkamp, R.C.; Wetering, H.M.M. van de:  
AD REM: Accessing Distributed Resources via Executable Media.  

Refereed contributions to international conferences


(Contributions to) books

16 Professional Publications and Reports

1994

Overveld, C.W.A.M. van:

A. Glim; J. Schoenmakers; E. Luit; H. van de Wetering:

1995

Overveld, C.W.A.M. van:
Review of 'Zhao, Jianmin; and Badler, Norman. I., Inverse Kinematics positioning using nonlinear programming for highly articulated figures in the September 1995 issue of Computing Reviews of ACM Transactions in Graphics

Overveld, C.W.A.M. van:

Veltkamp, R.C.,

17 Designs, software, etc.

Several major software systems have been produced in the graphics group over the last 5 years; the most important are the animation systems WALT and GDP; the geometric class libraries GBOB and GBI; the geometric modelling systems PER, WREL, WSOID, WNR, WATT, GRADED and several others; the rendering systems POLYGONS and RT; the image processing system IPROCPIC plus a host of support tools.

1995

Peeters, E.: Huizing, C.; Wetering, H.M.M. van de:
Extension of the GDP (Generized Display Processor) with networking capabilities.
Aim: extension with new classes for networking, kinematics, dynamics and in- and output.