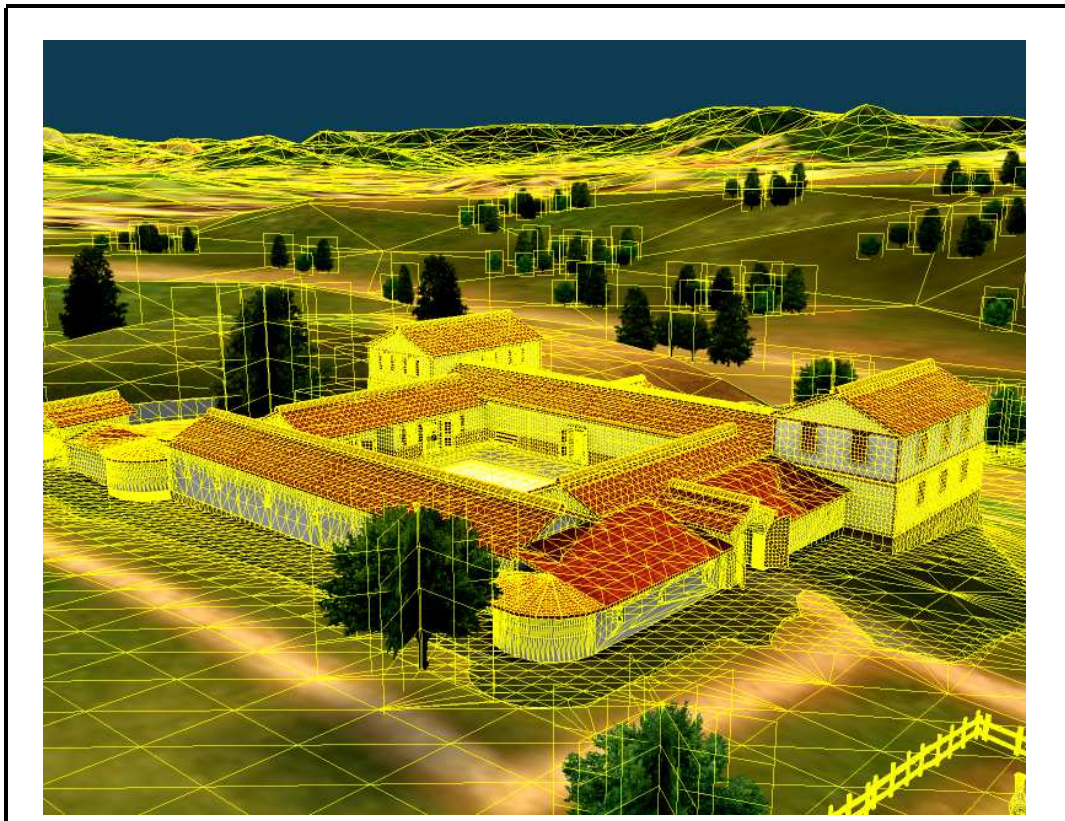




# NORSIGD INFO

Nummer 1 2004



NORSK SAMARBEID INNEN GRAFISK DATABEHANDLING

ISSN 0803-8317

## Aktivitetsskalender

### *Hva skjer når og hvor?*

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#### April 2004

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19–21 **CESCG 2004**: 8th Central European Seminar on Computer Graphics, Budmerice, Slovakia. <http://www.cg.tuwien.ac.at/studentwork/CESCG/CESCG-2004/>.

#### Mai 2004

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19–21 **VisSym04**: Joint Eurographics–IEEE TCVG Symposium on Visualization, Konstanz, Tyskland. <http://www.inf.uni-konstanz.de/cgip/VisSym04/>.

27–28 **NOBIM 2004**: Norwegian Conference on Image Processing and Pattern Recognition, Stavanger, Norge. <http://www.nobim.no>.

#### Juni 2004

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16–19 **CGI 2004**: Computer Graphics International 2004, Hersonissos, Hellas. <http://www.ics.forth.gr/cgi2004/>.

7–9 **NPAR 2004**: 3rd Int'l Symp. on Non Photorealistic Animation and Rendering, Annecy, Frankrike. <http://www.npar.org/2004/>.

#### Juli 2004

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7–9 **CASA 2004**: 17th International Conference on Computer Animation and Social Agents, Genève, Sveits. <http://casa2004.miralab.unige.ch>.

#### August 2004

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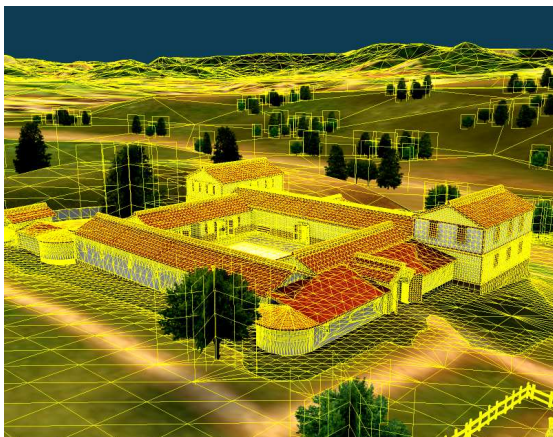
8–12 **SIGGRAPH 2004**: 31st Int'l Conf. on Computer Graphics and Interactive Techniques, Los Angeles, CA, USA. <http://www.siggraph.org/s2004/>.

30–(3) **EG 2004**: 26th annual conf. of the European Association for Computer Graphics (EUROGRAPHICS), Grenoble, France. <http://eg04.inrialpes.fr/>.

#### Helwig's Conference Calender

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Flere aktiviteter finner du på <http://www.vrvis.at/ConfCal/>.



### Om forsiden

Bildet viser Figur 4 fra artikkelen om fotorealistisk presentasjon av arkeologiske rekonstruksjoner som gjengis fra side 4. Underskriften på bildet er “Wire-frame rendering of the virtual model”.

## Hilsen fra styret

Kjære medlemmer,

I denne utgaven starter vi en serie på tre deler om en medisinsk anvendelse: virtuell endoskopi. Dirk Bartz fra Universitetet i Tübingen gir oss en introduksjon og litteraturoversikt over denne nye grenen innen medisin.

Også fra Universitetet i Tübingen presenteres det en metode for å visualisere arkeologiske rekonstruksjoner på en fotorealistisk måte.

Ved Høgskolen i Bergen er det et aktivt datagrafikkmiljø. Vi presenterer en semesteroppgave innen datagrafikk-faget som omhandler å visualisere et skihopp. Studentene har vært meget kreative, og vi viser noen prestasjoner.

Hilsen,

Wolfgang Leister



## NORSIGD Info

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Ettertrykk tillatt med kildeangivelse

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## Interactive photorealistic presentation of archeological reconstructions

*Robert Kuchar and Timo Schairer, WSI/GRIS, University of Tübingen<sup>1</sup>*

This paper is case-study in the field of cultural heritage. Firstly we will describe the reconstruction of the archaeological model and extensions made to the radiosity-software RadioLab in order to generate real-time photorealistic indoor and outdoor scenes. The next part will be about the requirements posed onto a museum-installation. Lastly we will give an overview of the implemented controller-interface Commander used to navigate within the reconstructed scene.



**Figure 1:** Excavation-site(left) blended with reconstructed virtual model(right)

The main intention of the presented work is to give interactive access on archaeological information to scientists and the public. In order to create a virtual supplement for a museum, the most important aspect is to display a highly realistic real-time presentation of a 3D-model. The museum installation should offer an easy-to-use intuitive interface for people who are not familiar with virtual environments while providing additional information of the scene. Using our navigation-interface and a reconstructed virtual model of the archaeological facility, it is a fairly easy task for the archaeologist to create a model for presentation which is based on his discoveries and which can be used in museums, exhibitions and for educational purposes. The archaeologist is capable of presenting his work not only to a small group of scientists who have special interest in the topic, but to a much broader audience using a highly precise and scientifically serious virtual reality-model and vr-installation. This paper is based upon a presentation at AVIR 2003 [1].

Firstly, we extended the existing walk-through-environment RadioLab to work hand in hand with the controller-interface Commander. Secondly, in order to simplify the creation of realistic outdoor-scenes, we developed an automated realistic daylight-simulation based on correct physical data and used it for radiosity-lighting and displaying the sky dome. We added realistic visual effects

and a 3D-sound-system using environmental audio effects to provide better immersion in the scene.



**Figure 2:** Excavation site with museum

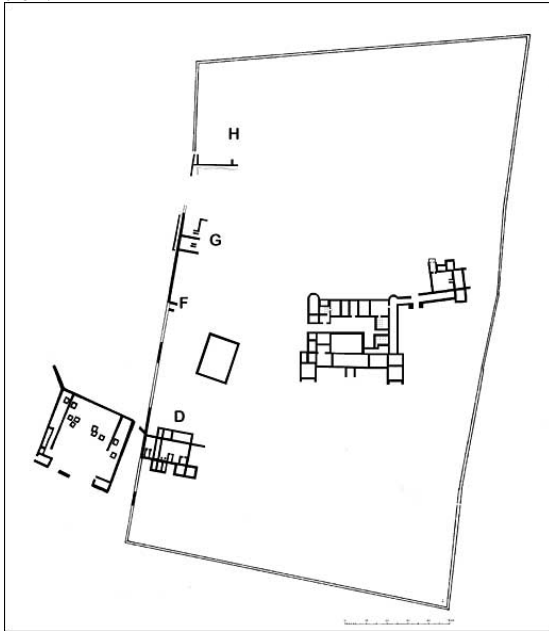
### Excavation site

The reconstructed object is an ancient Roman villa called “Villa Rustica”, situated in Southern Germany right next to the city of Hechingen near an important Roman street.

It was built around 100 AC and had been inhabited for about 200 years. The villa was discovered in 1973 by Gerd Schollian, the mayor of the nearby village “Stein”. The cultivated size is approximately 40.000  $m^2$ . Since 1991, a partial in-situ-reconstruction of some of the buildings is ac-

<sup>1</sup>{kuchar, schairer}@gris.uni-tuebingen.de

cessible for the public. See [2] for further information.



**Figure 3:** Base plane of the excavation site

### Virtual reconstruction

There are already some excavation-sites that have been virtually reconstructed, but almost all of those lack one or more of the following:

- Most models are not very detailed and exact, thus they are good in giving an overview of the scenery, but are not very useful for archaeologists.
- The virtual model is lit using only phong- or gouraud-shading, yielding in unrealistic lighting situations. Furthermore, no conclusions can be drawn about how dark or bright the interior of the original building was.
- The model is not embedded in the environment, rather it is placed on a leveled ground plate, creating the odd sensation of living on a small plate. This not only creates an unrealistic look, but also makes it impossible to get the idea why the buildings were originally placed there.

In order to create a scientifically serious and photorealistic-looking virtual model, we worked very closely with the chief of the excavation project Dr. Schmidt-Lawrenz, who supervised the work guaranteeing historical correctness. We were given very exact plans of the excavation site along with illustrations of this villa and similar Roman villas. Since the excavation site is near Tübingen, we often went there to take pictures of certain details and discuss architectural problems with Dr. Schmidt-

Lawrenz. The Roman architects kept close to Roman building standards (e.g., the slope of the roofs) enabling us to make realistic guesses about the probable appearance of the model. We modeled the scene using the Pytha CAD-system developed by Pytha Lab. Now the model consists of 1.730 Objects represented by 275.000 points.

The scene was embedded in the environment using high-resolution hand-measured height-data for the nearer surroundings. The more distant environment was created using 50 m DEM (Digital Elevation Model) data and satellite imagery.

The scene was lit using the radiosity technique working hand-in-hand with our daylight simulation described below.



**Figure 5:** Overview of the reconstruction

### Photorealistic Environment System

A lot of computer-generated imagery has a synthetic look although the 3D-models are very detailed. The main reason for this is an unrealistic illumination of the scene.

The radiosity-software used to generate highly realistic lighting scenarios is RadioLab, developed at the WSI/GRIS by Ralf Sonntag in the early 90's, distributed by Pytha Lab since 1997 and improved ever since. We extended the radiosity-simulation to correctly calculate the light-distribution in outdoor scenes using a realistic daylight-model. Lighting a scene with parts of it being in- and outdoors can be far more difficult than modeling it. The brightness outside often gets exaggerated while rooms tend to be very dark. As a result, the scene has got unrealistically low contrast. Our daylight-simulation is very easy to use and provides intuitive parameters while creating physically based indoor/outdoor lighting. Our environment system generates the sun, the sky dome, realistically lit volumetric clouds and lens-/glare-effects automatically, using the same daylight parameters. To be able to display the high dynamic range scene on current graphics hardware, a tone mapping algorithm must be applied to the radiosity values and all environment objects.

It is also possible to automatically adjust the daylighting-solution matching the actual time.



**Figure 6a:** Phong-shading of the patio



**Figure 6b:** Patio lit with our daylight simulation combined with the environment system

### Interactive Navigation

The virtual reality-installation consists of two programs capable of running on one or two computers, connected via TCP/IP, wireless LAN, Bluetooth, etc. using various different communication-APIs. The reason for using two separate programs – one to control the movement and display information such as a map and particularly highlighted points of interest, and one to display the 3D-scene – is increased flexibility and a maximized spectrum of usage. When visualizing smaller scenes, both programs can be run on one computer using a graphics-card with multi-monitor-support; very detailed 3D-scenes with a high polygon count imply the use of two computers, one of those with a very powerful 3D-graphics-card to display the 3D-view.



**Figure 7a:** Scene at 10:00am on the 14th of March



**Figure 7b:** Scene at 05:30pm on the 14th of March

The vr-installation uses a touchscreen as the input-device. It is not only robust and almost wear-free, but it also directly connects the input- and display-device to the user, making it a good choice for unattended use in a museum or an exhibition. Last but not least, the system is easily adaptable and extensible for many different applications and is informative and interesting not only for the active user but also for other visitors.

In order to get the user quickly accommodated to the user-interface, the primary navigation context has to be very intuitive. We chose a very straightforward controlling metaphor (visitor walking through the scene), that not only matched the input device but also met the requirements of the navigation. This metaphor implies several restrictions to the movement of the virtual camera, mainly that the movement is normally restricted to a horizontal plane. The 2D-navigation corresponds to the 2D-input-device, making it very easy for people with no or very little experience in navigating 3D-space to understand the internal model of the interface, which, on the other hand, will help the user in understanding the system's behavior from the very beginning.

Using 2D-navigation and input device, it was self-evident to display a map as a navigational aid,

implying position, size and reference of excavated objects.



**Figure 8a:** Setup of the installation



**Figure 8b:** Installation in use

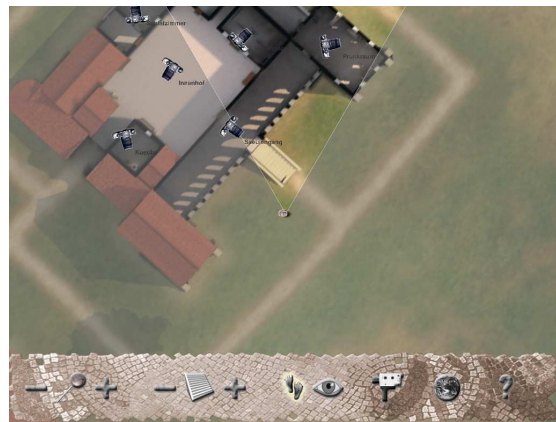
### Results and Future Work

The museum-installation is in use since April 2003 at the ancient Roman “Villa Rustica” in Hechingen-Stein. We modeled all of the buildings, did the texturing and performed the lighting simulation using our daylight-model. The chief of the excavation project Dr. Schmidt-Lawrenz supervised the work guaranteeing historical correctness. Additional pictures and movies can be found at [3].

The RadioLab system is capable of displaying real-time interactive animations which can be seamlessly integrated into the vr-installation. In this way the scene can be enriched with animations ranging from illustrating simple mechanics to the blending of different building phases. The program *Comman-*

*der* will be enhanced to display interactive multimedia content in form of text, audio-files and 3D-animation presenting the user even more information of certain points of interest.

A PDA-version of the Software Commander communicating via wireless LAN, Bluetooth, etc. would be a handy tool for presentation, for example in a meeting. Lastly, one could think of a communication interface for a multi-user environment making it possible to have many avatars walking around in the virtual scene, the computers connected via a local area network or the Internet.



**Figure 9a:** Screenshot of the Commander-software



**Figure 9b:** Screenshot of corresponding 3D-image

### References

- [1] Robert Kuchar and Timo Schairer, Interactive multimedia walkthrough for museum installations, in: Proc. AVIR 2003, 2003
- [2] <http://www.villa-rustica.de/>
- [3] <http://www.gris.uni-tuebingen.de/projects/villarustica/index.html>

## Visualisering av et skihopp

Harald Soleim, Høgskolen i Bergen

Studentene i kurset SOD165 Grafiske metoder ved dataingeniørutdanningen, Høgskolen i Bergen, må gjennomføre en rekke obligatoriske øvinger. I den siste øvingen blir studentene invitert til selv å foreslå en oppgave. I år kom det forslag om å visualisere et skihopp. I denne utgaven av NORSIGD Info presenterer vi denne oppgaven, skisserer løsningsforslag og viser noen resultater som studentene fikk til.

Vi har nå kommet i mål med oppgaven vår. Det var mange kreative løsninger, men alle fulgte de fysiske lovene som ble gitt i oppgaveteksten.

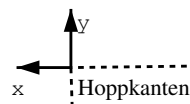
Vi brukte OpenGL. Noen grupper brukte Bezier for å lage hoppbakken. Problemet med Bezier i OpenGL er at funksjonene ikke gir oss kurvepunktene som var nødvendig i forbindelse med nedslaget. Derfor programmerte de Bezier ut fra kjente formler.

I noen løsninger kunne vi velge å følge hopperen fra hoppkanten, bakken eller at kamera fulgte hopperen. Ulike effekter som lys, tekstur, skygge og "fog" ble benyttet. Studentene likte tydeligvis denne oppgaven.



### Problembeskrivelse

I denne oppgaven skal vi visualisere et skihopp. Det som skal tegnes er: Person som hopper på ski, overrenn og underrenn. Det som er viktig er å få til selve hoppkurven. Det er også ønskelig å få til en riktig skiføring og bevegelse av skihopperen. Skiene og hopperen skal rotere underveis om hopperen sitt fotpunkt. Det som gjør at hoppet blir langt er at hopperen har god utgangshastighet, sats og minsker luftmotstanden i svevet. Samlet masse (ski og hopperen) vil også ha betydning. Bevegelsene kan beskrives vha Newtons 2. lov.



$$m\dot{\vec{v}} = m\vec{g} - k \frac{|\vec{v}|^2}{|\vec{v}|} \vec{v} = m\vec{g} - k|\vec{v}|\vec{v} \quad (1)$$

$\vec{g}$  betegner tyngdens akselerasjon,  $k$  koeffisient for luftmotstanden. Prikken over  $\vec{v}$ -vektor symboliserer tidsderivert.  $\vec{g}$  går nedover, langs negative  $y$ -aksen, med  $\vec{g} = -g\vec{j}$ .

Vi setter  $\vec{v} = (v_x, v_y)$ , har da  $|\vec{v}| = \sqrt{v_x^2 + v_y^2}$ .

Multipliserer vi vektorligningen (1) først med  $\vec{i}$  og deretter med  $\vec{j}$  får vi  $m\dot{v}_x = -k\sqrt{v_x^2 + v_y^2} \cdot v_x$  og  $m\dot{v}_y = -mg - k\sqrt{v_x^2 + v_y^2} \cdot v_y$ .

I stedet for å løse disse differensialligningene eksakt som kan være vanskelig, bruker vi ligningene over til å regne tilnærmet ved å la akselerasjonen være konstant innenfor små tidsintervaller.

Tidsintervallet fra hoppersatsen til nedslaget deles inn i små tidsluker av samme lengde og vi regner akselerasjon som konstant i hver tidsluke.  $\vec{a}_0$  betegner den konstante akselerasjonen i tidsluken og  $\vec{v}_0$  betegner starthastigheten i tidsluken.

Vi setter opp:

$$ma_{0x} = -k\sqrt{v_{0x}^2 + v_{0y}^2} \cdot v_{0x} \quad (2)$$

$$ma_{0y} = -mg - k\sqrt{v_{0x}^2 + v_{0y}^2} \cdot v_{0y} \quad (3)$$

som gjelder i første tidsluke.

Vi kaller koordinatene til et punkt i banen (banen for skihoppet) for  $x(t)$  og  $y(t)$  og tilsvarende hastighetskomponenter for  $v_x(t)$  og  $v_y(t)$ . Da får vi siden vi har bevegelse med konstant akselerasjon:

$$v_x(t) = a_{0x}t + v_{0x} \quad (4)$$

$$v_y(t) = a_{0y}t + v_{0y} \quad (5)$$

$$x(t) = \frac{1}{2}a_{0x}t^2 + v_{0x}t + x_0 \quad (6)$$

$$y(t) = \frac{1}{2}a_{0y}t^2 + v_{0y} + y_0 \quad (7)$$

Vi kan sette  $z(t) = 0$  dvs. at hoppet utføres i  $xy$ -planet.

### Løsningsforslag

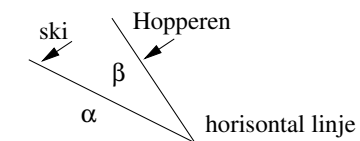
Av ligningene (2) og (3) beregner vi akselerasjonene i  $x$  og  $y$  retning,  $a_{0x}$  og  $a_{0y}$  gitt  $v_{0x}$  og  $v_{0y}$ . Første gangen kan vi gi verdier til  $v_{0x}$  og  $v_{0y}$  ved utgangshastigheten ved hoppkanten. De beregnede akselerasjonene bruker vi i ligningene (4) og (5) til å beregne sluthastighetene i  $x$  og  $y$  retning i den første tidsluken. Vi beregner så et punkt i banen vha ligningene (6) og (7) ved slutten av første tidsluke.

Sluthastighetene for første tidsluke er starthastighetene ved neste tidsluke. Vi bruker da på nytt ligningene (2) og (3) til å beregne akselerasjonene i neste tidsluke. Videre bruker vi ligningene (4) og (5) til å beregne slutt-hastighetene for denne tidsluken. Til slutt beregner vi neste punktet ved å bruke ligningene (6) og (7) på nytt.

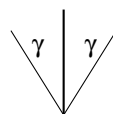
Slik fortsetter det til slutten på tidsintervallet som er tiden ved nedslaget. Vi simulerer tiden vha gjennomgang i en programløkke, dvs. det vi trenger er å simulere tidslukene. Vi må kalibrere slik at hopperen ikke hopper lenger enn underrennet.

En utviding av oppgaven blir å justere luftmotstanden ved å endre  $k$  underveis.

Vi ser på en forenklet figur.  $\alpha$  er vinkelen mellom horisontal linjen og skiene.  $\beta$  er vinkelen mellom hopperen og skiene. Luftmotstanden er mindre når vinklene gjøres mindre.



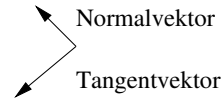
Luftmotstanden reduseres også ved å ha en viss vinkel  $2\gamma$  mellom skiene. Skihoppet sett oven i fra:



En annen utviding er å ta hensyn til  $z$ -komponenten.

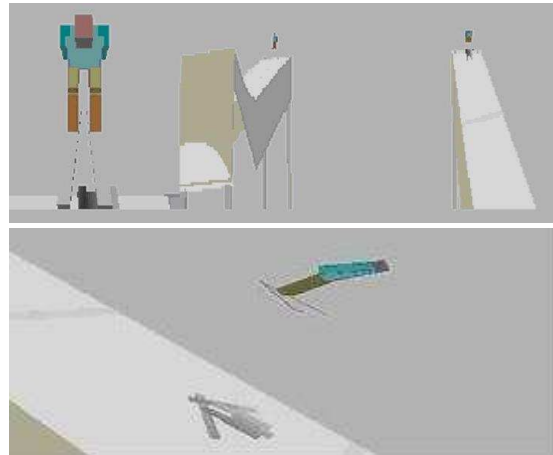
Hoppbakken kan ha lyskastere og det kan brukes "fog" for å øke realismen. Overrennet og underrennet kan for eksempel formes ved hjelp av grafene til funksjoner, for eksempel:  $f(x) = -a|x|^p$  for  $x < 0$  og  $f(x) = -b|x|^q$  for  $x > 0$ . Her kan koeffisientene  $a$ ,  $b$  og eksponentene  $p$ ,  $q$  endres for å få en form man er fornøyd med.

**Beskrivelse av bevegelsen fra nedslaget til hopperen stanser:** Vi legger tangenten nedover langs kurven.

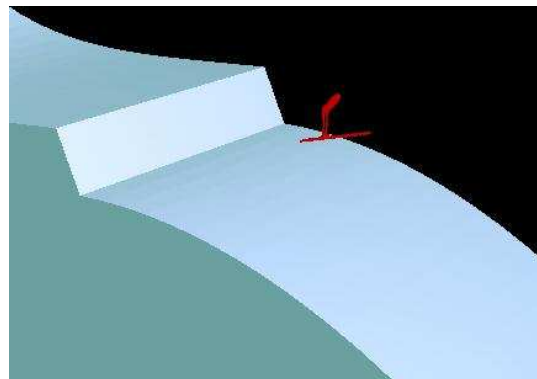


Vi kan da sette opp følgende **skalarligning**:  $ma_t = mg_t - \mu mg_N - k|v_t|v_t$ , der  $\mu$  er friksjonskoeffisienten og den vil kanskje ha mye mer å si enn luftmotstanden etter at hopperen har landet. Friksjonskraften virker langs tangenten, men størrelsen av denne er gitt ved størrelsen til normalkomponenten til tyngden.

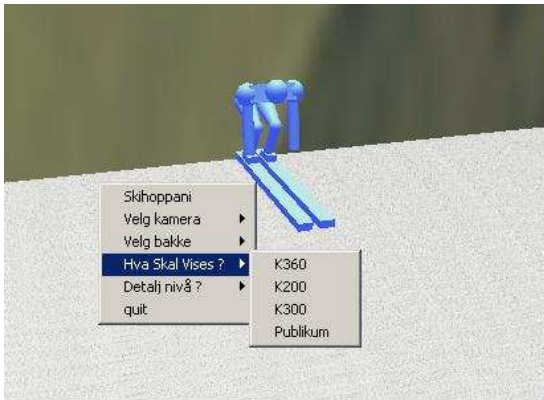
En spesiell takk til førsteamanuensis Hans Birger Drange som har bidratt med idéer, og til studentene som har gjort en god jobb. Her er noen av løsningsforslagene som studentene kom med:



Figur 1: Hoppet fra ulike kameraposisjoner. Løsningsforslag laget av John Erik Sloper.



Figur 2: Løsningsforslag fra arbeidsgruppen rundt Trond Håkon Kiledal. Her kan en bl.a velge kameraposisjon og bakkestørelse.



Figur 3: Løsningsforslag fra arbeidsgruppen rundt Trond Håkon Kiledal.



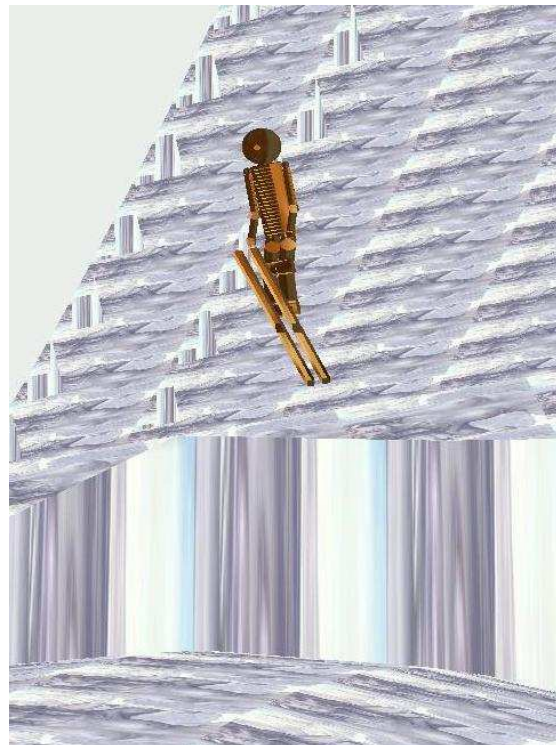
Figur 6: Løsningsforslag fra Kjartan Dencker.



Figur 4: Løsningsforslag fra Kjartan Dencker som bl.a. brukte lys, fog og tekstur.



Figur 5: Løsningsforslag fra Kjartan Dencker.



Figur 7: Løsningsforslag fra Kjartan Dencker.

## Applications of Virtual Endoscopy

*Dirk Bartz, WSI/GRIS - VCM, University of Tübingen*

**Minimally invasive procedures are of increasing importance in medicine because they have less deleterious effects on the patient. In particular, these procedures are used in gastroenterology, surgery, neurosurgery, (interventional) radiology, and many other fields.**

Usually, these procedures are performed using an endoscope, which is a fiber optic that is moved to the target area. The fiber optic itself can be flexible or stiff, depending on the size and other requirements of the endoscope. For instance, a typical endoscope for neurosurgery has a quite small diameter in order to minimize the impacted brain tissue. The small diameter reduces the possibilities to transport sufficient light through the fiber to the endoscope head. Building a stiff fiber to allow a maximum of light [1] compensates this effect. Beside the light source, an endoscope consists of the optic for a camera to transport the acquired image to a monitor, and has one or more “working tube” that are used to move tools such as pliers, to the target area. Cameras in the tip of the endoscopes have usually a large opening angle in order to provide a sufficient overview. Unfortunately, this also aggravates optical effects such as the fish eye view [2].

Other tools for minimally invasive interventions include catheters, which are moved to the target area using a guidance wire - which gives the very flexible catheter stiffness - and fluoroscopy/ x-ray control that provides an overview of the current localization of it. A specific application area of catheter are (usually arterial) blood vessels. Note, that usual endoscopes cannot be used inside the examined blood vessels, since they are usually too large. Therefore, imaging is limited to the fluoroscopy images, or provided by virtual endoscope, since a virtual camera cannot be too large.

Several drawbacks are associated with minimally invasive procedures. They are usually very unpleasant for patients, they are expensive (although they are still cheaper than “traditional” open surgery), and some areas of interest cannot be reached by the endoscope or catheter (due to folds and plaits). Especially in (neuro-) surgery, these procedures lack the fast access for open surgery in case of serious complications, such as strong bleeding. Therefore, careful planning and realization of these procedures is essential, in order to avoid such complications. This problem aggravates, because handling and control of many of these endoscopes is very difficult, mainly due to limited flexibility of and limited field of view through the endoscope, a very limited depth perception, and the sensitive na-

ture of the brain tissue.

In contrast, virtual endoscopy is a convenient alternative. It is based on a 3D scan of the respective body region. Examples for these scans are CT (Computed Tomography) scans, MRI (Magnet Resonance Imaging) scans of the abdominal area, the heart, the head, the lungs, or rotational angiography of blood vessels in various body parts. Based on the resulting volumetric data, the organs of interest are visualized and inspected from interior (“endo”) viewpoints. Depending on the original endoscopic procedure, which is mimicked by virtual endoscopy, different goals can be achieved. These goals range from intervention planning, intra-operative navigation, and teaching. In the following sections, I will present a variety of applications of virtual endoscopy.

### Virtual Colonoscopy

Cancer of the colon and rectum is the second leading cause of cancer deaths in the USA. Approximately 150,000 new cases of colorectal cancer are diagnosed every year [3]. Consequently, it is imperative that an effective diagnostic procedure is found to detect colonic polyps or tumors at an early stage. Currently, optical colonoscopy and barium enema are the major procedures available for examining the entire colon to detect polyps larger than 5mm in diameter, which are clinically considered to have a high probability of being malignant. In optical colonoscopy, a fiber optical probe is introduced into the colon through the rectum. By manipulating the tiny camera attached to the tip of the probe, the physician examines the inner surface of the colon to identify abnormalities. This invasive procedure takes about one hour and requires intravenous sedation, resulting in high costs. Barium enema in contrast requires a great deal of physical cooperation from the patient when the X-ray radiographs of the colon are taken at different views. Additionally, its sensitivity can be as low as 78% in detecting polyps in the range of 5mm to 20mm [4].

Both methods are either too expensive or to circumstantial for prophylactic screening examinations – resulting in a low patient acceptance –, hence virtual colonoscopy was proposed to limit optical

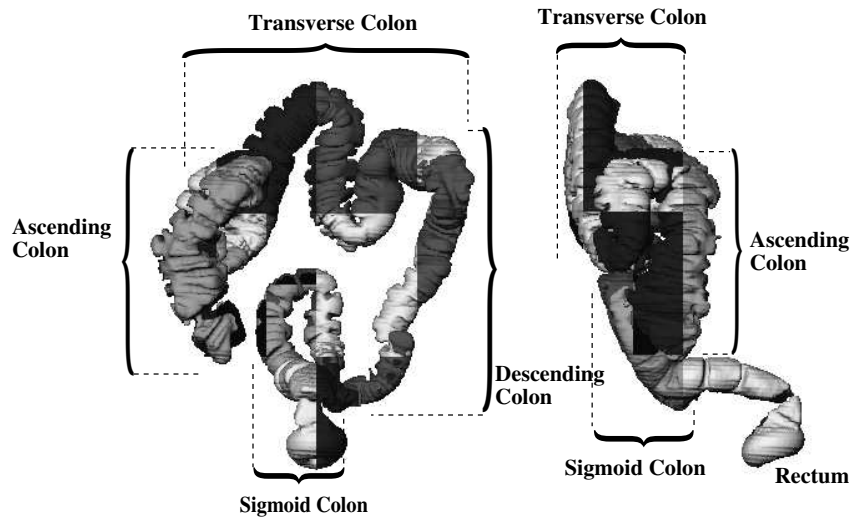


Figure 1: Octree-based decomposition of colon dataset; the octree leaf blocks of the isosurface are represented with different colors. The left image shows a coronal view, the right image shows a sagittal view.

colonoscopy to cases in which either a suspicious polyp was found – which induced a biopsy or removal of the polyp – or which were inconclusive in virtual colonoscopy [5]. The latter happens if (shape) defects of the graphical representation of the inner colon surface cannot be identified as polyps or residual stool. A study on the advantages of virtual colonoscopy compared to optical or conventional colonoscopy has been presented by Fenlon et al. [6]. The authors found that the performance of virtual colonoscopy is comparable to optical, as long as the data resolution is sufficient to detect polyps of the respective size. Problems arose from residual stool, which often was the cause of a false positive finding.

After cleansing and inflating of the colon (both actions are also required for optical colonoscopy), a CT scan (or alternatively an MRI scan) is performed. The resulting image stack is pre-processed and examined using the VIVENDI system.

### Optical and Virtual Endoscopy

We compare the results of optical and virtual endoscopy based on polyps found in both procedures. In particular we compare snapshots of two polyps (see Fig. 2). The first polyp (Fig. 2ab) is located in the descending colon, close to the sigmoid colon. It is of a size of 8mm and hence of high clinical relevance. Figure 2a and c show the information provided by optical colonoscopy, while b and d show the information provided by virtual colonoscopy. The shape information of the polyp is well represented by the virtual technique. However, textual information is not available, while it is very help-

ful in optical colonoscopy (although not obvious in Fig. 2ac).

The second polyp is of a size of 4mm and it is located in the transverse colon, not too far away from the hepatic (right) flexure. Similar to the previous polyp, the actual location is quite different from the rough estimation in the overview image of optical colonoscopy, which locates the polyp in the ascending colon.

To summarize, virtual colonoscopy is an alternative procedure for the diagnosis of polyps in the human colon. However, it does not replace optical colonoscopy, which is still required once a found polyp has to be removed or a suspicious structure needs to be identified with additional information, such as texture, color, and histological information through a biopsy, which is generally not available by means of volume scanning methods,

Other applications of virtual colonoscopy include teaching, planning of optical colonoscopy procedure, and of intra-operative navigation.

### Virtual Bronchoscopy

Among the most important organ systems of the human body are respiratory functions. They transport air into the body (inhaling) and removes exhausted air from the body during the exhale. The exchange of the air takes place in the lungs, which are a complementary system of airways and blood vessels. Both systems are supplied through large pipe-like structures which split successively into smaller ones, thus creating the tracheo-bronchial (airways) and blood vessel tree.

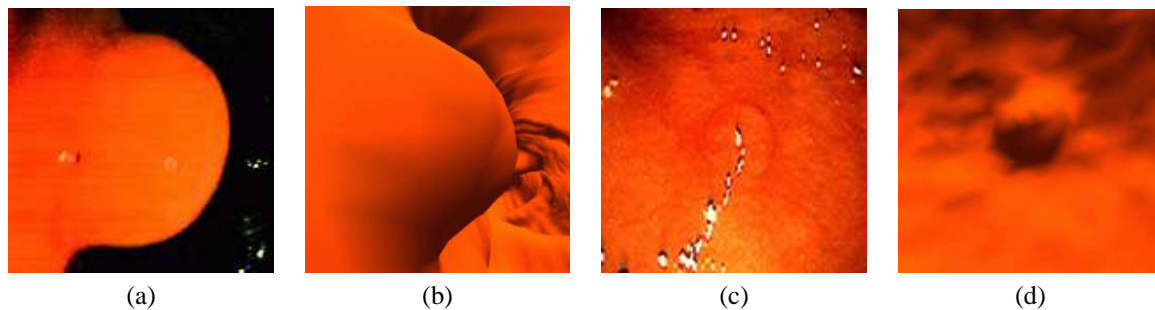


Figure 2: An 8mm and an 4mm polyp; left (a,c): Optical colonoscopy, right (b,d): virtual colonoscopy [7].

The tracheo-bronchial tree is connected to the outside through the trachea which splits into the main bronchi (left and right lungs) at the main bifurcation. The inhaled air is distributed through the bronchial tree down to the alveoli where the oxygen/carbon-dioxide exchange between air and blood takes place. The exhausted air (enriched with carbon-dioxide) is then transported back up to the trachea during the exhale. The tracheo-bronchial tree is complemented by a system of pulmonary venous and arterial blood vessels which transports the blood to and from the heart into the lungs.

Several pathologies can jeopardize a sufficient lung function. Among them are tumors, pulmonary embolism, collapse of the lungs (atelectasis), pneumonia, emphysema, asthma, and many more. For a proper diagnosis and treatment, the respective pathologies need to be identified and in some cases quantified. In the case of lung-surgery, this information is necessary for the intervention planning where the anatomical relation of diseased bronchi to non-diseased areas is required pre-operatively, ie. to provide a safe distance to essential structures and to determine resectability. However, the usage of virtual bronchoscopy as a diagnostic tool is limited, since detailed information on the mucosa is not available, thus tumors limited to that areas cannot be detected easily [8].

The current gold-standard to identify the respective lung parenchyma and airways is computed tomography (CT) that is performed prior to a bronchoscopy, a tool for inspections of the trachea and central bronchi and deriving tissue samples. Due to the recent technical development improving resolution and scan velocity, multi-slice CT – in connection with virtual bronchoscopy – became a promising alternative to bronchoscopy, if tissue samples are not required. This is amplified by the fact that optical bronchoscopy is limited by smaller, lower airways (third generation and up) or by obstructions. Nevertheless, even smaller structures of the lower

airways are extremely difficult to segment from CT datasets, due to leakages, caused by the notorious partial volume effect and due to the lack of sufficient contrast to surrounding tissue or air. We presented a segmentation approach [9] that enables also the segmentation of small airways. Here, we concentrate on the virtual endoscopy of the airways, the virtual bronchoscopy to visualize airways, blood vessels, and tumors (Fig. 3).

### Next Issue ...

In the next issue, I will continue on the methods for virtual bronchoscopy and I will present applications of the cerebral ventricular system and of the vascular system.

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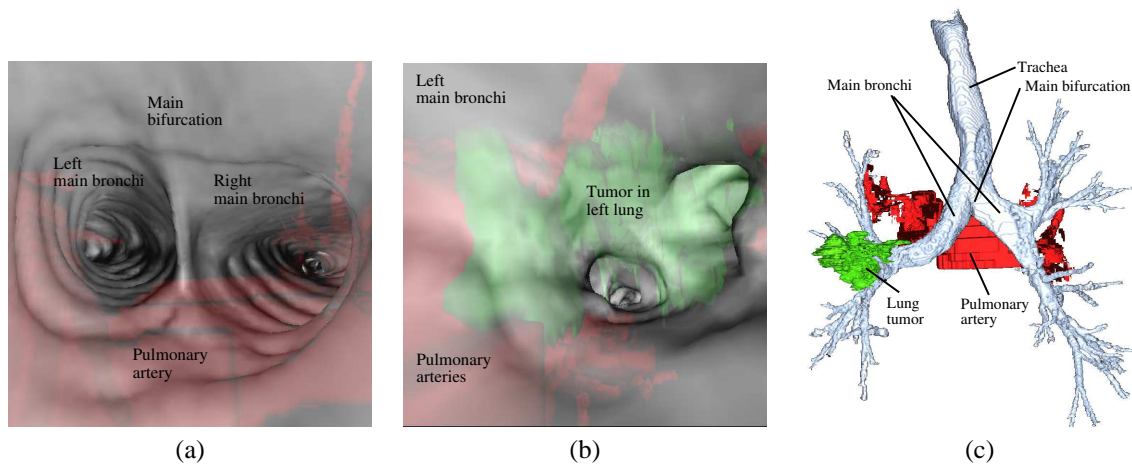


Figure 3: Virtual endoscopy: (a) Semi-transparent rendering of view in trachea at main bi-furcation. The pulmonary arteries (red) are visible through the inner surface of the tracheo-bronchial tree. (b) shows the a similar situation further down the left bronchi. Straight ahead is a large tumor (green) of the left lungs, which eventually will obstruct the left bronchi (same dataset as in Fig. 3c). (c) shows an annotated outside representation of another dataset with the tracheo-bronchial tree (grey), pulmonary arteries (red), and a tumor (green) in the left lung (view from behind the patient).

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Det finnes versjoner av GPGS for en rekke forskjellige maskinplattformer, fra stormaskiner til Unix arbeidsstasjoner og PC. GPGS har drivere for over femti forskjellige typer utsyr (plottere, skjermer o.l.). GPGS støtter mange grafikkstandarder slik som Postscript, HPGL/2 og CGM. GPGS er fortsatt under utvikling og støtter stadig nye standarder.

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