TECHNICAL ASPECTS OF THE URBAN SIMULATOR IN TAMPERE UNIVERSITY OF TECHNOLOGY

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The colour video recording Urban Simulator in TUT was built very early compared with the development of video systems.

A contract for planning the simulator electronics, mechanics and camera systems was made in january 1978 with two TUT students: Jani Granholm (computer science and engineering) and Ilkka Alavalkama (machine design and automation).

Ease of control and maintenance were asked by side of ”human movement inside coloured small-scale architectural models”. From the beginning, all components of the system were carefully tested and chosen from various alternatives. Financial resources were quite limited, which lead to a long building process and to self-planned and produced mechanical and electronical elements. Some optical systems were contructed by using elements from various manufacturers.

DESIGN OF THE SIMULATOR SYSTEM

Following components were considered to be main targets of research and planning when a mechanically moving periscopic video recording system is constructed:

- Endoscope
- Cameras
- Relay optics
- Picture recording methods
- Lights
- Camera movements
- Camera rig

— Motion control
— Model support
— Background
— Presentation equipment
— Supporting electric and mechanical systems
— Technical assistance

All of these main themes were carefully checked and all information necessary for system design was written down to ”demand-lists”. The start of design work was a long period of collecting information, testing possible solutions and technical devices and cross-checking components, combinations and still growing and varying demand-lists.

Following chapters demonstrate main themes from some of these lists. Final solutions on ”choosing-lists” are *italicized.*

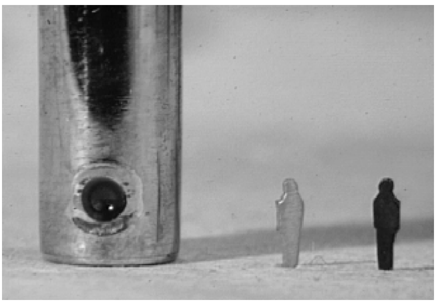
ENDOSCOPE

— Diameter
— Length
— Minimum eye level
— Picture angle (diagonal = circle)
— Direction of view
— Focus
— Sharpness, depth of field
— Conrast, reflections in optical elements
— Quality, optical problems

Small endoscope diameter and very short lens-to-endoscope-end distance were wanted for photography of small-scale models (1:200 - 1:1000). A french Fort MA-

Figure 1
Endoscope head with 1/200 scale models.

Figure 2
Endoscope head with 1/500 scale models.



1 Maquettoscope was found to be suitable for the job. Storz and Olympus modelscopes are used today for bigger scale models.

CAMERA

Photography
- Picture size
- Viewfinder brightness
- Light metering, automation
- Data back

Video
- Target size
- Sensitivity
- Picture quality
- Output format

Miniature camera systems

For endoscopical photography, a Nikon F3 SLR camera body with motor drive and data back was chosen to be the best recording system for 35 mm film(Nikon system was a standard at the Department of Architecture, TUT). 100mm telephoto lens was a suitable adapter optic, giving a picture diameter of 22 mm.

The first endoscopic camera was a Hitachi VK-C500 (target size 1", serial n:o 81200003), which was the first one-unit compact PAL-system colour video camera available in Europe.

The video camera has been changed four times, always to a smaller target size (1" - 2/3" -1/2"), better sensitivity and higher resolution. Today we are using a Panasonic WV-CL700 (1/2”-target) which is already far behind the best possible equipment. New camera models with Hyper-HAD-targets, digital picture processing and higher number of picture elements are offering picture quality equal to the possibilities of modern professional S-VHS recorders and Y/C- or component picture processing.

RELAY OPTICS

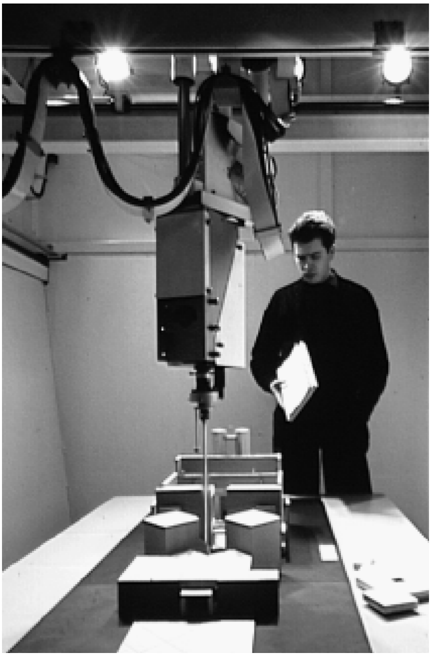
- Focal length / picture size, zooming?
- Focus
- Aperture control?
- Remote controls
- Mechanical couplings
- Optical quality
- Safety mechanisms

For safe remote control of camera movement and optimum endoscope-to-camera fitting a new flexible relay optic adapter for 1"-target was developed for TUT simulator.

Second version of adapter mechanics was designed for 2/3" target size. Optical system for this new system was taken from Sony C-mount endoscope adapter . Simple perspective-control/picture centering-system was added later to this adapter.

Figure 3
Diploma work, Mikko Jaatinen, small church (scale 1/50).

Figure 4
Camera head and highway model scale.



PICTURE RECORDING METHODS

Drawing from screen
Photography
- Slides
- Negative
- *Polaroid*
- Photography from screen

Video recording
- Home quality
- *Hi- and Super- versions*
- Industrial quality
- Broadcast quality

Video printers, b&w/ color
Frame grabbing

The first recording unit was a 1:st-generation U-Matic, which was luckily chosen instead of a Philips VCR. Editing was started with second-generation U-Matic recorders (assemble/insert). VHS camcorders and an editing player for VHS-cassettes were added later to the system for student projects and excursions.

The video recording format has been changed to S-VHS three years ago. TBC:s and digital signal processing are keeping picture quality good enough for educational use. TBC video outputs are: composite, Y/C and component. The editing player operates with variable-speed tracking system and gives possibilities to slow-motion or varying ”drive-speed” with earlier recorded material.

A black & white video printer is used for quick access to picture material. This is very important for our student projects, and always, when simulator users don’t have possibility to use video player all the time. Color printers are too slow for this purpose and the price for a single copy too high for students or normal lecture use. A thermal printer gives out one low-cost print in 10 seconds. Roll of these prints is used as work-copy material during model-based design exercises.

PICTURE PROCESSING METHODS

Frame grabbing / digital image processing

- low quality
- *Broadcast video quality*
- Hi-resolution methods

386DX- and 486DX-computers are used for frame grabbing and image processing. Picture files are collected to SyQuest 88 Mb disks.

The video boards used are Truevision Targa+ and AT-Vista. The programs for picture processing are TIPS, RIO, PhotoStyler and PhotoShop. Word processing is done with WordPerfect (or MacWrite II, when pictures are used in Mac-system). WordPerfect Windows gives some possibilities to add pictures to documents. Desktop publishing systems are PageMaker or QuarkExpress.

Photo-CD and magneto-optical drives are going to be logical add-ons to this system.

LIGHTS

- Ambient
- *Spotlights, "Sun"*
- Background lights
- *Halogen*
- HMI
- Fluorescent tubes

Figure 5
Diploma work, Jouko Berg, highway / townplanning project

Because of technical and financial reasons, halogen lights were the only possible solution in 1978. Total light system was 24 pcs of 800 W spot units, which were all switched on for video recordings. This lead to a huge amount of heat, which had to be ventilated out out from the simulator room (Ø 400 mm ventilation channels in and out).

With modern video cameras this massive system is not needed anymore. Today, only 10 units are used for different light effects together with a 2000 W spotlight for ”sun”-effects.

CAMERA MOVEMENTS

- *Free, handheld endoscope*
- Moving table
- Moving camera with jib control
- *Moving camera with track control* (1 - *4* - 6 degrees of freedom)

A bridge system was constructed for smooth camera movements. Area covered by camera movement is 1800mm x 2400mm and maximun model size is 2000mm x 2800mm. Camera lift track (eye level) is 350mm long.

Instead of the heavy camera track control equipment, a light hand-held endoscopic video system is used for teaching and student projects. This system was designed when the first miniature-size Panasonic CCD-camera system (WV-CD1, camera head Ø 17mm x 48mm) was released. The coupling system betveen camera and

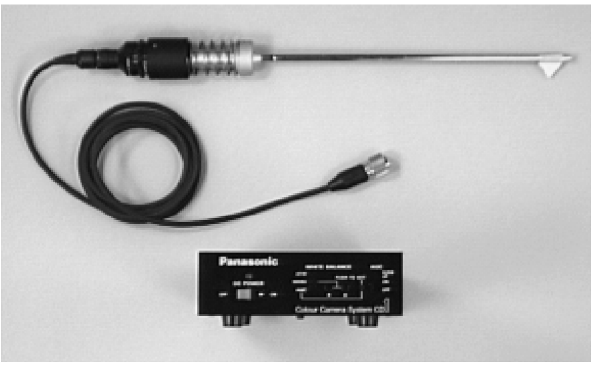


Figure 6
Hand-held endoscopic video-system with flexible camera adapter.

Figure 7
TUT, Institute of Urban Planning, professor Jere Maula: Lesson and workshop using simple cardboard models and endoscopy as a teaching method.

endoscope is made of a Fuji microscope adapter lens and a Canon Tele-Converter (1.5X). Only one 800 W light unit is needed for ”sunlight” with some extra light for softening the shadows. A direct video connection to monitors is normally used with this system.

CAMERA RIG

— Pedestal with arm (”jib”)
— Crane
— Portal
— *Bridge*

Star linear ball bearings with Ø 25mm and Ø 30mm hardened steel shafts are used for minimum friction and maximum rigidity. Machine frame elements are welded from square steel tube and bolted together.

Mechanics and electronic control systems were totally planned and built in TUT, including about 1000 kg:s of steel and aluminium parts and a microcomputer with stepping motor controls and power units. 150 companies were involved by delivering components to the project.

TUT simulator is still after 15 years using the same steel frame. The basic concept of simulator construction and drive method has been kept the same throughout the years. Some modifications have been made to the drive mechanics and camera cradle. Future developments of the mechanical concept are going to be visible in Otaniemi simulator later this year.

Figure 8
TUT, Laboratory for Visual Simulation, Urban Simulator.

MOTION CONTROL

— Manual control of camera
— Remote (electric) control of camera
— *Real-time computer control*
— Programmable computer conttrol

A simple computer controlled drive method was developed for first remote-controlled camera movements. This system is based to simple speed vector calculations. Parameters for calculations are: speed, moving direction, model scale, maximum scale speed and (later, after system modifications) view direction.

Drive speed is conrolled with a pedal. Acceleration and braking are smoothened with an electric filters, giving maximum speed 4 seconds after ”kick-down” and braking camera to full stop in 3 seconds after releasing the pedal. Speed is adjusted to model scale (1:100, 1:200, 1:500) and to the drive path (car, bike, walking) with selector knobs.

Camera direction is controlled with a steering wheel. Basically, the camera is allways moving to the direction of camera view. This makes the camera wery easy to control at the beginning, but limits a lot possibilities to smoothtrackcontrol.

Eye-level is controlled with a contact sensor, or (in smaller models, where sensor takes too much space) with variable-speed manual control.

For more complex camera movements, a new control method was added later. A selector swith is used to lock driving direction, leaving steering wheel free for camera direction control. An another switch position makes it possible to keep a constant angle between driving and camera directions. This makes it possible to drive around corners and look towards the centre of path circle. Third position of the same swith is used to reset drive direction to follow camera direction.

This drive method is very easy to learn. Usually students are ready to use simulator system alone after 15 - 30 minutes of training.

MODEL SUPPORT

- Table
- *Table with lockable wheels*
- Rotating support
- Ball-bearing support
- Cross-feed table
- Special table with height adjustment
- Model in vertical position

The basic design principles of TUT simulator lead to a simple table construction. High models and high-angle shots are a bit complicated to handle with this system. Plans for table-height adjustment are being prepared.

BACKGROUND

- Flat (or roll material)
- Round, *half* or full circle, or *rounded corners*
- Cyclorama

Background colouring:

- Grey
- *Constant colour* (skyblue)
- Chroma key blue
- Coloured
- Sky
- Landscape
- Cyclorama, white surface for light effects:
  Colour light sets for cyclorama

Balcar cyclorama lights (fluorescent)

Background and background colour/light systems are part of simulation methods needed for real-life-like model photography.

Chroma key makes it possible to cut backgrounds from real landscapes. An even background illumination and high-quality video material are the technical base for using this technique. The recent S-VHS system with Targa+ video board allows only low-quality use of this technique. Painted ”sky-backgrounds” are used for photography.

Round corners or a full circle background makes it possible to make free, non-planned camera movements without the danger of visible errors in background. Full circle of background and freedom of camera direction makes it a bit tricky to arrenge lights to best positions. Background is shading low-angle lights, reflects its own color to models and gets sometimes too much light from too close light unit setups. Backlight-situations, when camera is aimed against the ”sun”, are sometimes very close to full scale photography and its contrast- and lens reflection problems.

PRESENTATION EQUIPMENT

— Slide projectors
— *Preview room for small groups* , video monitor
— *Video projection system*
— Multi-projection systems (drive simulators)
— Headset (virtual reality)

From the beginning a 60"-projection-television was chosen to be the minimum-distortion presentation technique for wide-angle architectural photography.

Today we are using a 250 cm -diagonal (100") video projection system (Sony VPH-1270QM) with Dolby ProLogic Surround sound system. Room height is limiting the screen size, which could be optimized to 300 or 350 cm for our auditorium.

SUPPORTING ELECTRIC AND MECHANICAL SYSTEMS

— Air conditioning
— Video editing
— *Photolab*
— *Computers and picture processing*
— Printers
— *Model shop*
— Room and shelf system for models

TECHNICAL ASSISTANCE

— Training of new users
— Professional quality video recording, editing and photography
— System maintenance
— Design of new equipment