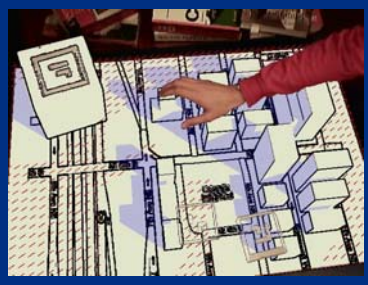
Selective Stylization for Visually Uniform Tangible AR



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Eurographics Virtual Environments

Tangible User Interfaces

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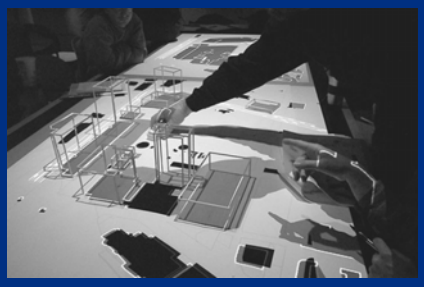
- **Physical objects** (*props*) used for user input
- **Immediate relationship** between props and virtual representation



Ishii et al. 2002

Haller et al. 2006

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Mixed Reality

- Tangible interaction often requires a **graphical overlay**
- **Mixed Reality**: Combination of real world, computer graphics
- Possibilities
  - Head-mounted display
  - Mobile devices
  - Projectors

Digital video overlay, Fischer et al. 2004

Projected augmentation, Raskar et al. 2001

Mixed Reality Rendering

Which one is real?

- Standard **real-time** rendering (e.g., OpenGL)
- Rendering **artifacts** like aliasing
- Inconsistent **illumination**

⇒ Virtual objects **stand out** from the real world

Stylization in Mixed Reality

Slide 4

- Idea: Apply **artistic / illustrative stylization** in mixed reality
- Real world and virtual objects look **very similar**

Stylized Augmented Reality, Fischer et al. 2005

Pointillism style

Technical illustration style

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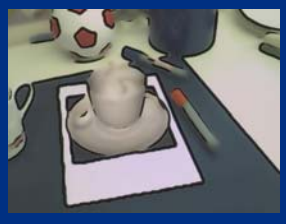
Stylization in Mixed Reality (2)

Slide 5

- Challenges:
  - **Real-time** performance
  - Process **2D** video and **3D** models
- Psychophysical study [Fischer et al. 2006]
  - Virtual objects **less discernable**



GPU-based cartoon-like style

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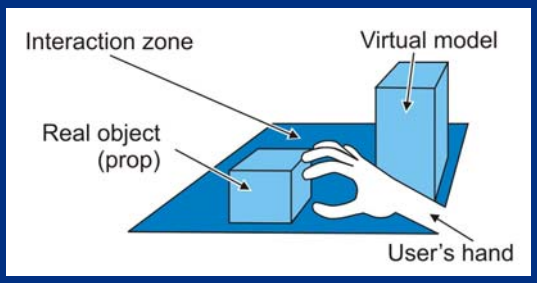
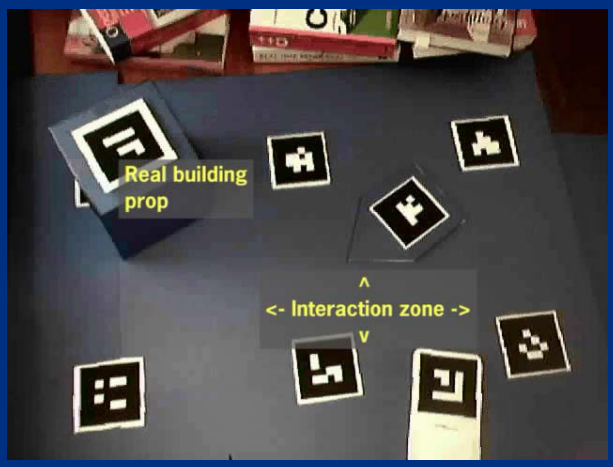
Selective Stylization

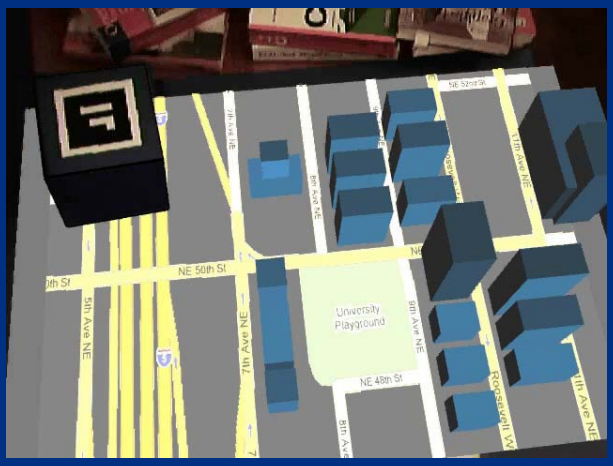
- Problem: **Entire image** is stylized
  - **Dissociation** of user from observed scene?
- Idea: **Select** regions where stylization is **useful**
  - Depends on **application** case



Tangible Interaction Setup



Graphical Augmentations



- Hand is **occluded** by augmentations

Image Processing for Stylization

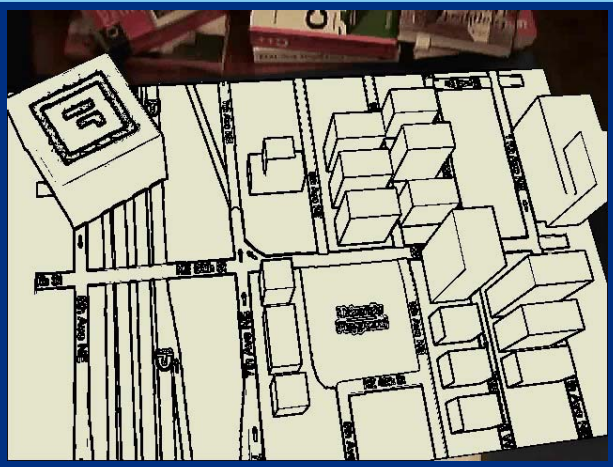
- Stylization filter executed as **image processing** step
- Gradient-based **edge detection**

$$edge_{Comp} = (1-\alpha)\cdot|\nabla Y_{Comp}| + \alpha\cdot\frac{|\nabla U_{Comp}| + |\nabla V_{Comp}|}{2}$$

- α determines influence of **color / intensity** gradient
- (∇Y, ∇U, ∇V): gradients in **YUV components**

- Execution as postprocessing filter **on the GPU**

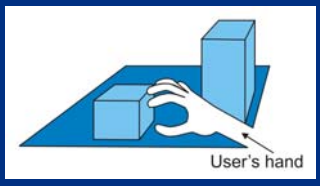
Stylized View



- **GPU-based** image stylization filter, resembles **technical illustration**

Stylization Domain

- **Selective** Stylization: only where it is **useful**
- Useful regions defined by ***stylization domain***
  - Exclude background (based on z-buffer values)
  - Exclude user's hand and arm



- Hand detection using a **color-based image segmentation** step

Stylization Domain – Rules for Tangible Interfaces

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(S1) Stylize the base plate of the interaction zone.

(S2) Stylize virtual objects, e.g., graphical building models.

(S3) Stylize physical props, which represent relevant elements in the tangible application.

(U1) The background, i.e., areas outside of the interaction zone, should not be stylized.

(U2) The user's hands and arms, which are not an immediate part of the tangible application, should not be stylized.

Hand Segmentation

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- Assumption: User's hand and arm (or sleeve) approximately **skin-colored**
- Define **reference color** values for skin

$$Bin_{Hand}(x,y) = \begin{cases} 0, & Y_{min} < Y_{Cam}(x,y) < Y_{max} \wedge \\ & U_{min} < U_{Cam}(x,y) < U_{max} \wedge \\ & V_{min} < V_{Cam}(x,y) < V_{max} \\ 1, & otherwise \end{cases}$$

- (Y_{min}, U_{min}, V_{min}) and (Y_{max}, U_{max}, V_{max}) determined **empirically**

Stylization Domain - Video

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- White regions will be stylized

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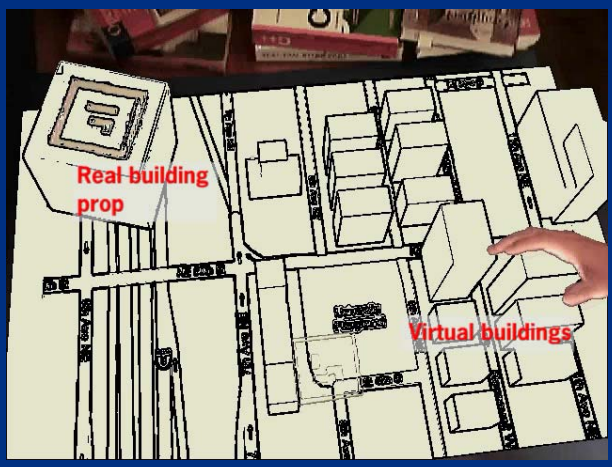
Selective Stylization - Video

Slide 15



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Example Application

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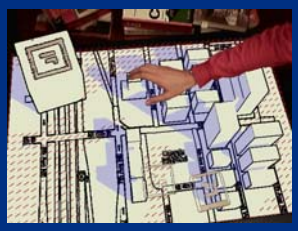
- **Demonstration application** for Selective Stylization
- Tangible **urban planning** system
- Movable **cardboard building** prop



- Visualization of basic **simulations**
  - Shadows cast by buildings
  - Flow of wind between buildings
- **Tangible input** for simulation parameters

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Example Application - Video

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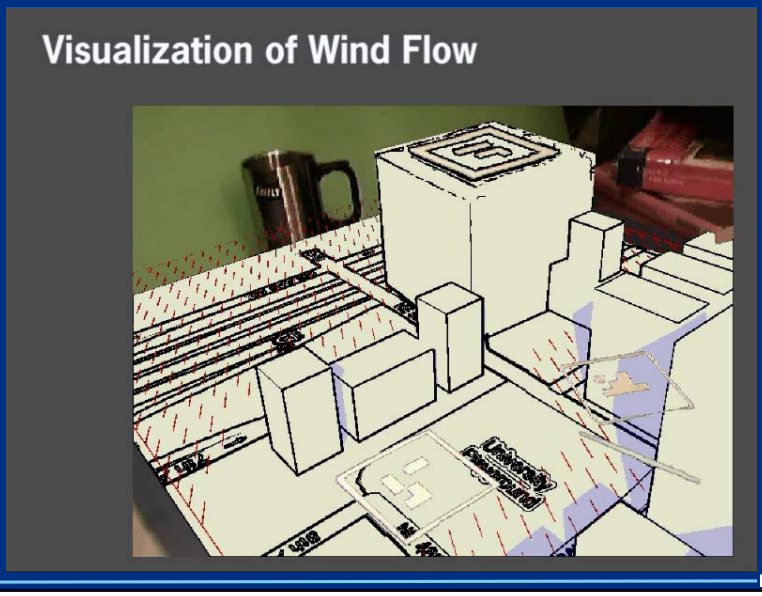

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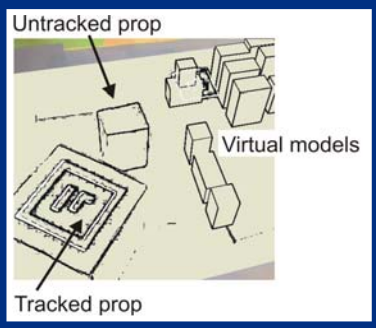
Summary

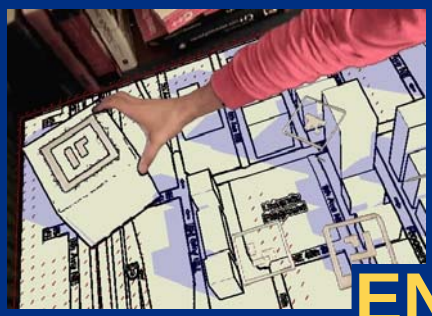
- **Selective Stylization** for tangible user interfaces
- **Equalized level of realism** for
  - Physical objects
  - Virtual models
- Outside regions are **not stylized**
- **Real-time** image generation pipeline

Future Work

- Explore additional **stylization types**
- Improve **hand segmentation**
- Handle physical **props without** artificial **fiducials**



The End



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