

## Effective Visualization Communication in Augmented Reality

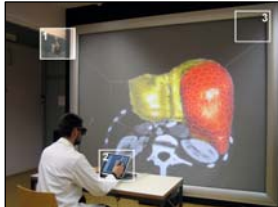


Dieter Schmalstieg

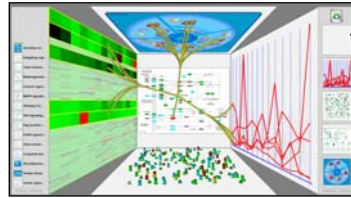
## ICG Graz - Key Data

- Founded in 1992
- Headed by Prof. Franz Leberl
- Professors: Horst Bischof, Franz Leberl, Dieter Schmalstieg
- Members: total 58, CG group: 25
- Publications 2007: 88
- Soft money 2007 (research and industry projects): € 1.802.910,-
- Collaboration with 5 K+ centers
  
- Diploma theses 2008: 19 (164)
- PhD theses 2008: 9 (55)
- PhDs in progress: 47

## Research Areas



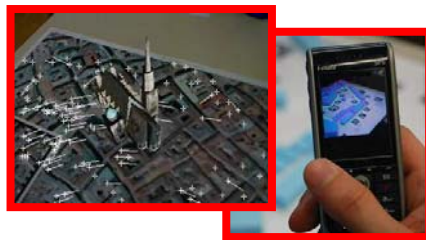
Virtual Reality - Medical Vis



InfoVis - Biomed



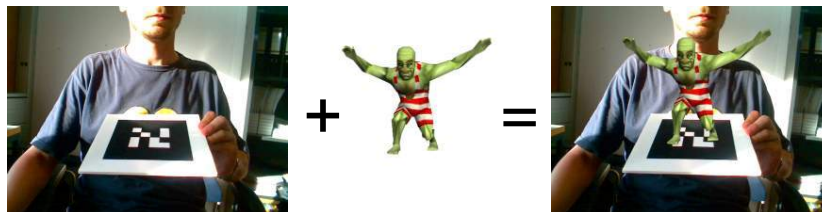
Multi-Display Environments  
Projector-Camera Systems



Augmented Reality - PC and Mobile Phones

## Visual Augmented Reality

- Combine real and virtual imagery
- Tracking & Registration data is used to align virtual objects within real imagery



# Example 1: Underground Visualization

Geospatial Data + AR = 3D real time visualization of underground



# Example 2: Liver Ablation

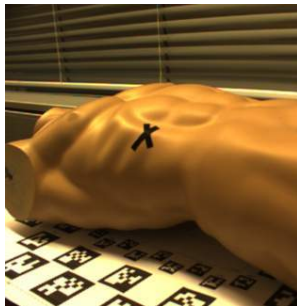
Intra-Operative

-Navigation Aid-

Color Coded Rubber Band

## Careless Visual Augmentation

- Overrides important landmarks



## Careless Visual Augmentation

- Override important depth cues (occlusions)



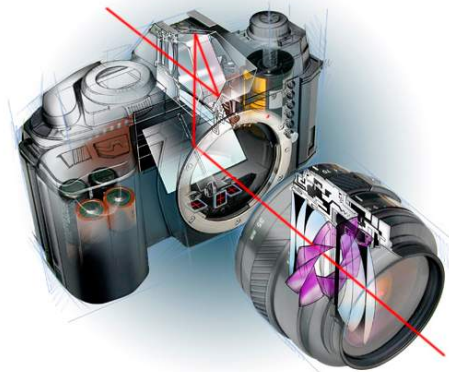
## Correct Occlusions



## Illustrative Rendering

Objective:  
preserve context

- Ghosting
- Explosion

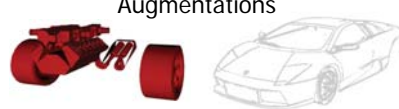


<http://www.cutaway-illustration.com>

## Ghosting in AR

Preserve depth cue (occlusion)

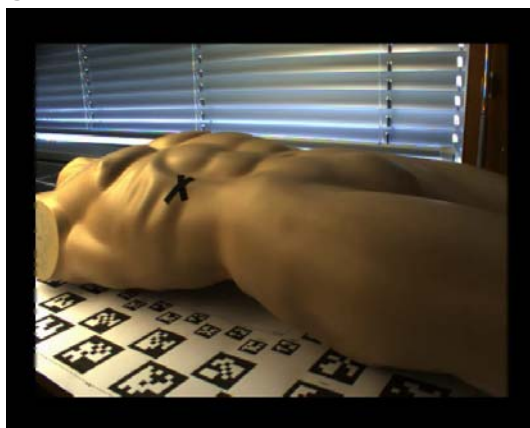
Augmentations



- A) Identify Focus + Context
- B) Keep context information visible

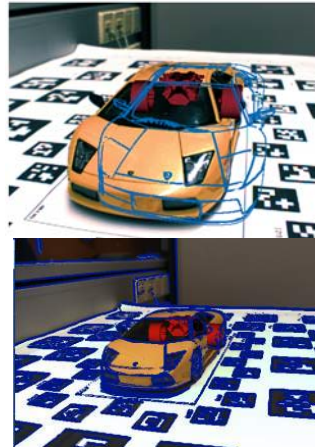
## Ghosting from Video

- No model needed
- Feature detection influenced by scene conditions (e.g. lighting)
- Depth order must be known
- Independent of tracking error



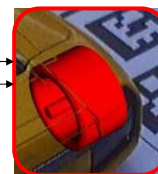
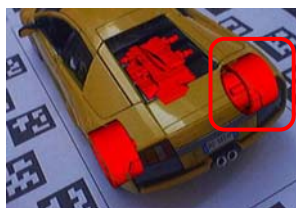
## Model vs. Image based Ghosting

- Object space
  - Need good/stable registration
- Image space
  - Detection of comprehensible features difficult
- Hybrid
  - Use model to define area of image detection



## Video Preserving

- Sparse preservings difficult to identify in AR
- Need to perceive ghosting as one object to understand occluder shape
- Enhance preserving to perceive ghosting or use continuous preserving



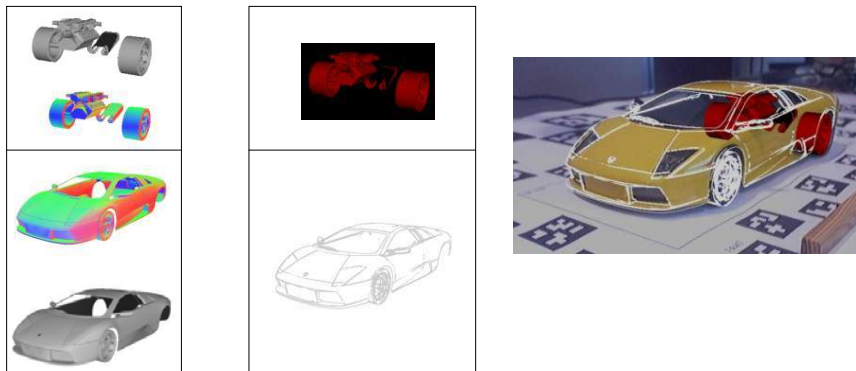
## Image Space Feature Distribution

- Video feed →
- Feature detection →
- Feature distribution →
- Derived transparency →
- Blend VR →
- Blend video →



## Algorithm for Rendering of Ghostings

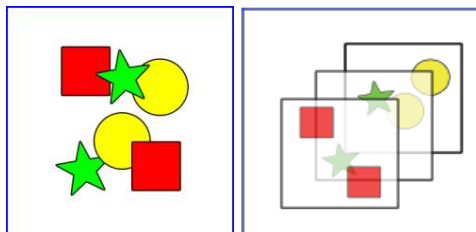
(A) G-Buffer Extraction → (B) G-Buffer Processing → (C) Scene Compositing



[Saito90]

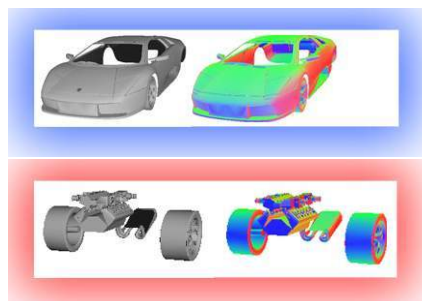
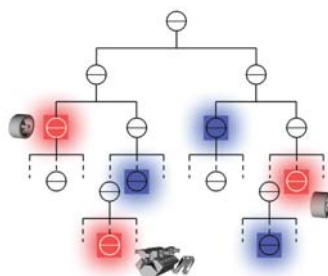
## (A) G-Buffer Extraction

- Notice: G-Buffer  $\neq$  Depth Layer
- Arbitrary object combinations possible

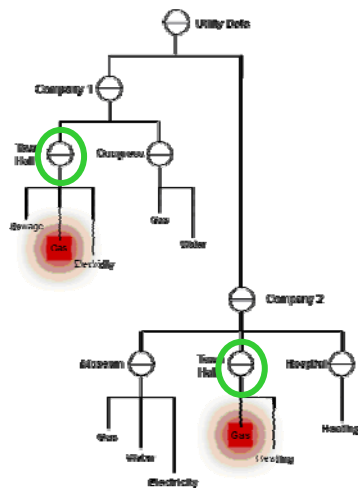


## Grouping Objects into G-Buffers

- G-Buffer's content spread over scene graph
- Organize information with "style sheets"



## Scene Graphs with Style Sheets

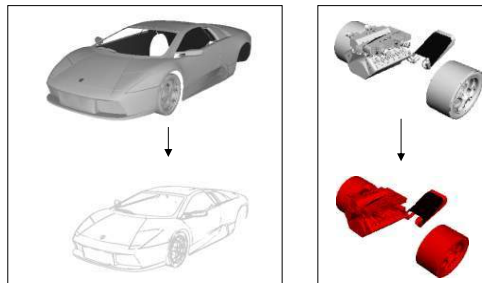


- Idea: not just filtering, but styling!
- Defer searching to traversal stage
- Solution known from XHTML:
  - Data belong to „classes“ (=metadata)
  - Visualization defined in „style sheets“
- Markup scene graph with metadata
- Example: Welding in the town hall must not happen near gas!

[Reitmayr VR05] [Mendez 08]

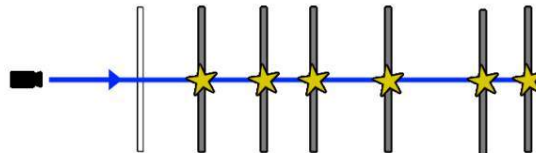
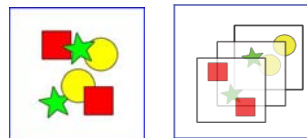
## (B) G-Buffer Processing

- Apply Filtering and Shading
- Full-Screen Fragment Shader



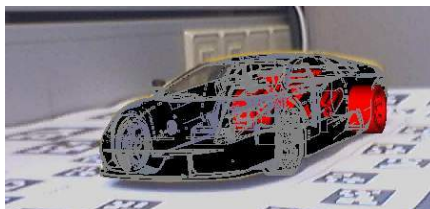
## (C) Scene Compositing

- Cannot simply blend !
- "Raycasting" into G-Buffer volume
  - 1) Sort G-Buffer per pixel
  - 2) Blend fragments



## Problems with Context Preserving

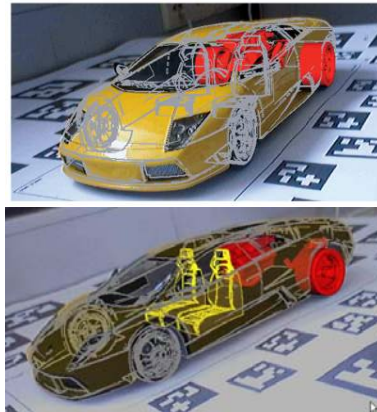
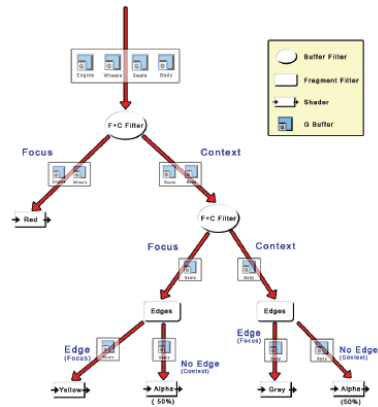
- Multiple object occlusions
  - which object to preserve?
- Amount of preserving
  - Under preserved
  - Over preserved



Need:

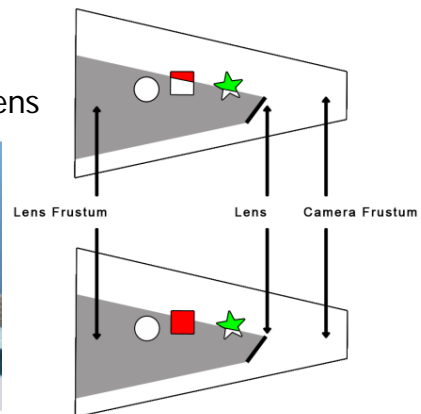
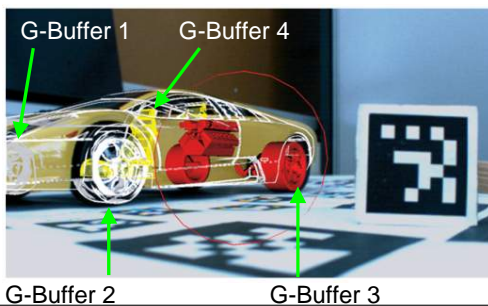
- Better feature detectors
- **Information Filter**

# Filtering by Object Discrimination - during G-Buffer processing -

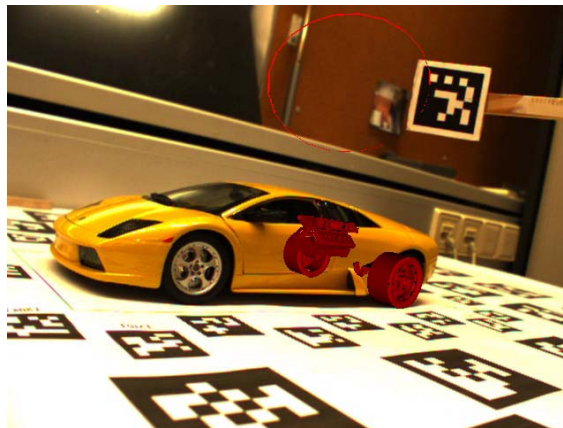


# Interactive Context Filtering

- Simultaneous filter strategies
- Compositing strategy per lens
- G-Buffer sensitive Flat Magic Lens

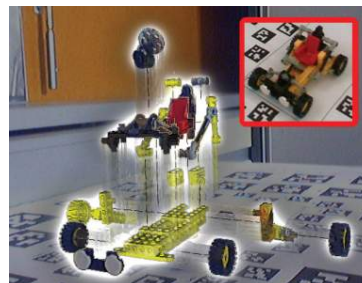
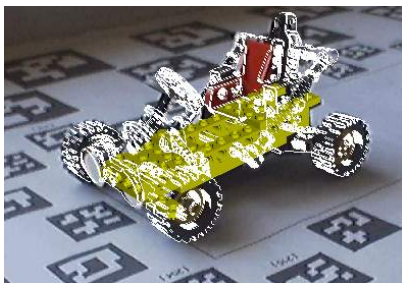


## Interactive Context Filtering



## Ghostings vs Explosions

- Ghostings depend on quality of feature detection
- Ghostings still override parts of the object of interest
- Multi-layered ghostings may be hard to understand
- Use explosion diagrams as alternative presentation



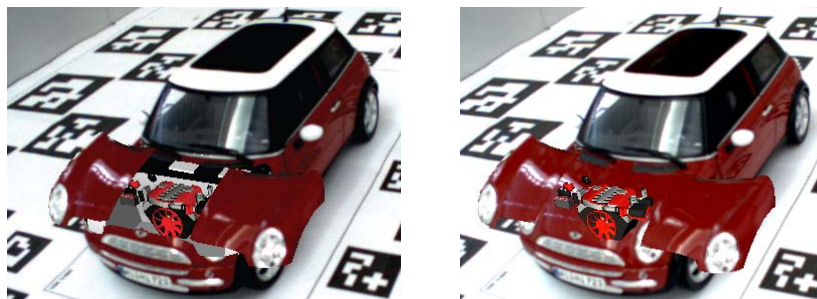
## Rendering Explosions in AR

- Transfer of real world information
- Video textured phantom objects
  - Explode (transform) phantom objects
  - Use original (untransformed) model-view-matrix to compute texture coordinates of transformed parts



## Video Textured Phantoms

- Problem 1: video textured phantoms need a complete virtual representation of hidden structure



Complete virtual representation  
of hidden structure

Incomplete virtual representation  
of hidden structure

## Dual Phantom Rendering

- Use a second phantom (next to the exploded one) to declare video information void

1) Render textured phantoms



2) Void video

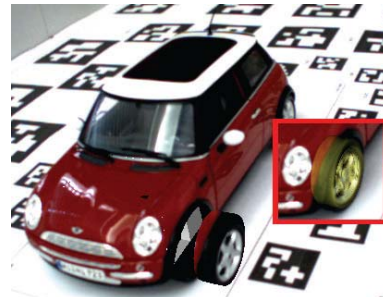


3) Combine masked video, textured phantoms and hidden VR



## Video Textured Phantoms

- Problem 2: occluded phantoms will transfer visible real world information



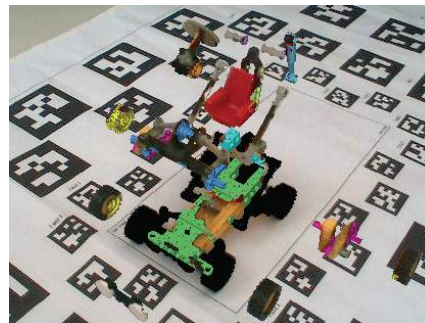
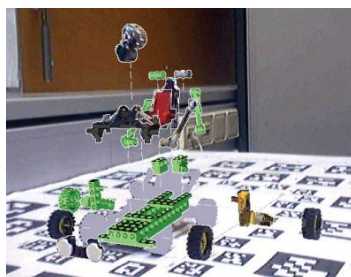
## Synchronized Dual Phantom Rendering

- Instead of simply declaring the video void, we write the object's id and let OpenGL's depth resolve the problem
- During texture transfer, we check the phantom's id with the value in the id-buffer (which represents the visible phantom)



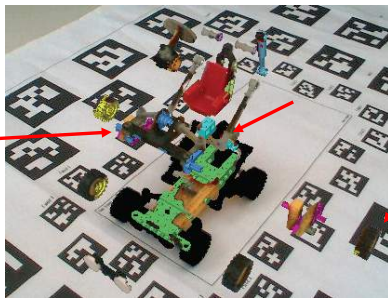
## Visualize Explosions in AR

- Simple transfer of video easily results in a visual mess consisting of virtual and real information
- Restore parts and background  
If (#vrInfo > 50%) shade all vr  
else in-painting from video



## Visualize Explosions in AR

- News contextual information around relocated objects may confuse the impression
- Visually discriminate exploded parts

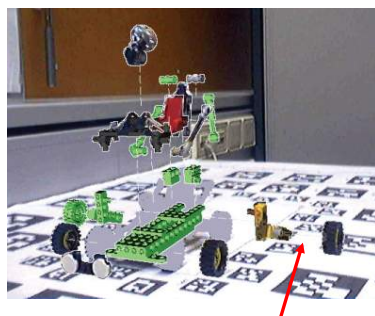


Effective Visual Communication in Augmented Reality

Dieter Schmalstieg

## Visualize Explosions in AR

- Embed connection lines in motion blur

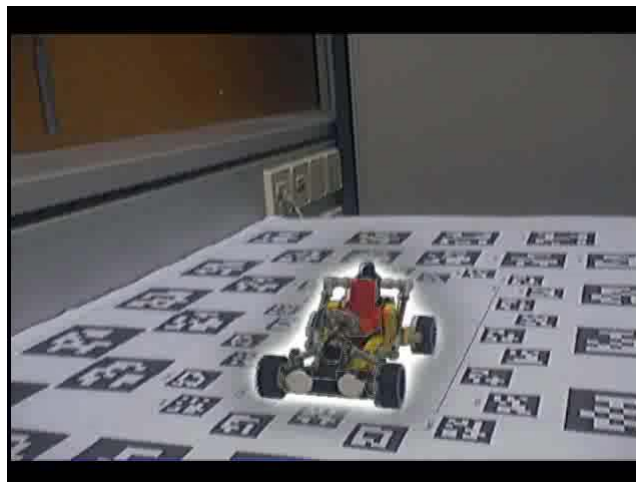
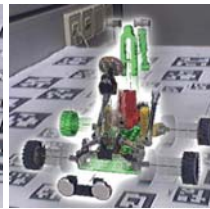
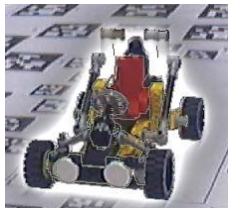


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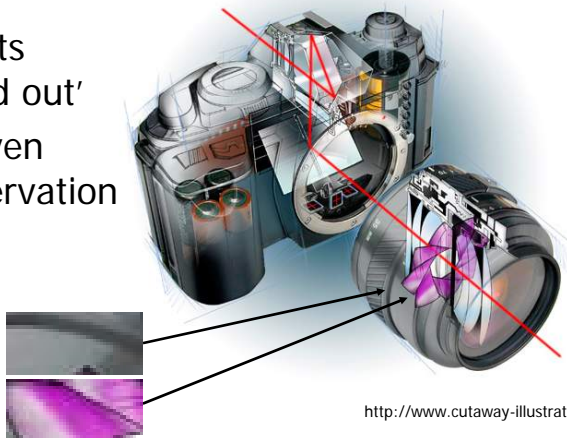
# Explosions in AR

- Different animations can be used to explore the object depending on the current task
  - Explode all but one
  - Explode one after the other
  - Explode groups of parts



## Shading for X-Ray Vision

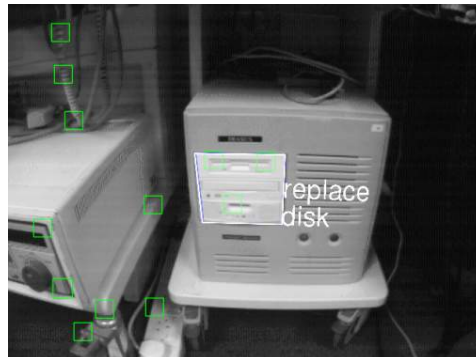
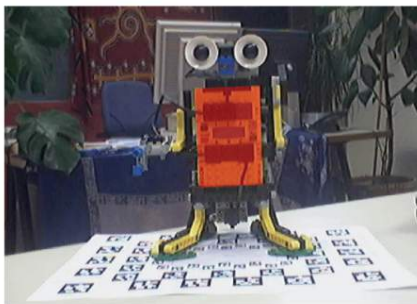
- Hidden objects visually 'stand out'
- Attention driven context preservation



<http://www.cutaway-illustration.com>

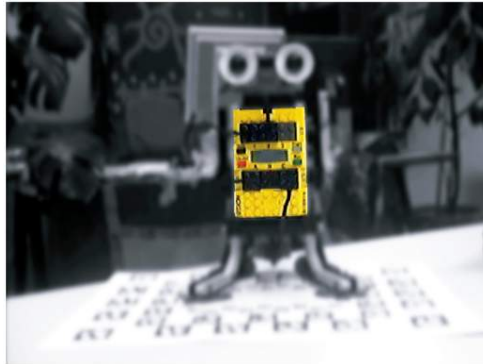
## Control of Attention

- General problem in AR



## Focus and Context

- Binary classification
  - Object relations are lost



## Multi-Level Focus and Context

- Cascaded classification
  - Apply filter operator on results of former operators
- Non-Uniform shading



Manually adjusted shading parameter

## Automatic Shading - saliency guided -

- Use saliency computation
- Saliency = combination of conspicuities from different parameters (e.g. brightness, saturation, blur, color,..)
- Use saliency to identify pixel of higher attention than the object of interest
- Reduce conspicuities for such pixels



## Augmenting the real world

- PC based not really practical
- What else?

# Augmented Reality on Handhelds



**Rucksack+HMD:**  
...5-8kg  
...€10-15.000



**Kleiner:**  
**Handheld PC:**  
... Sony UMPC 1.1GHz  
... 1,5kg  
... trotzdem >€5-10.000



**Am kleinsten:**  
**Smartphone...€500**  
...All-in-one  
...0.1kg  
...Milliarden Stück(!)

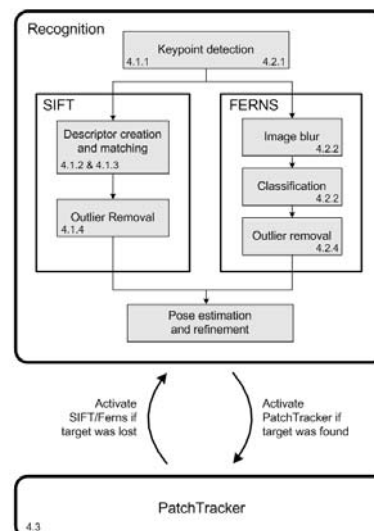
**ROBUST HIGH SPEED  
NATURAL FEATURE TRACKING**  
TRACKING OF MULTIPLE TARGETS  
MEMORY REQUIREMENTS:  
~300KB/TARGET  
  
DEVICE: ASUS P552W, 624MHz  
RENDERING: OpenGL ES 1.1  
CAMERA: 320x240, 20Hz

## Requirements

- Realtime at camera frame rate (>15Hz)
- 3D Registratuion: Overlay with 6DOF, not just 2D painting into video frame
- Scalability: No thin-client solution!
- No inappropriate simplifications (eg slow movements, memory >5mb...)
- Natural features: no unnatural scenes
- Evaluation with real end users

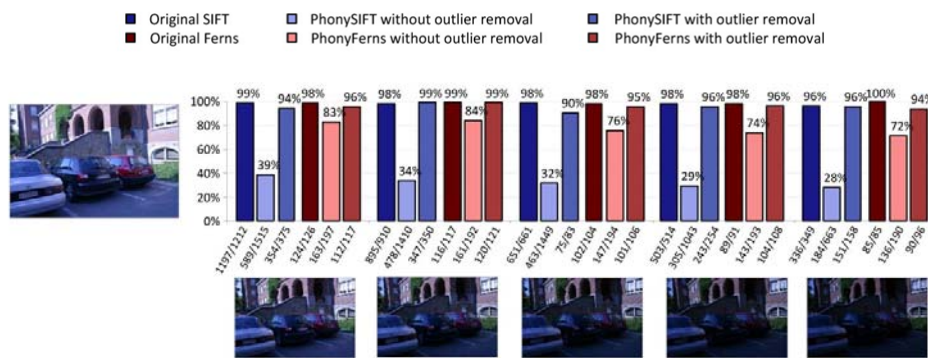
## Tracking

- (1) Modified SIFT/FERNS
  - FAST keypoints
  - No scale space
  - Explicit orientation
  - Search in spill-forrest
  - Elaborate outlier removal
- (2) Patch tracker
  - Affine patch warping



## Comparison to Standard Techniques

- Percentage of features with reprojection error < 5 pixels



## Graphics on Phones

- Phones have shaders now!
- Use the phone CPU for tracking
- Use the phone GPU for rendering
  - OpenGL ES 2.0 renderer
  - Prototype hardware – NVidia Tegra

## Augmented Reality on nvidia's Tegra

Lukas Gruber  
Erick Mendez  
Daniel Wagner  
Alesandro Mulloni



## Future work

- Visualization
  - Scene adaptive filtering
  - Multi-viewpoints
- Mobile Phones
  - Authoring as Social Networking
  - „Augmented Reality 2.0“

Thank you!

