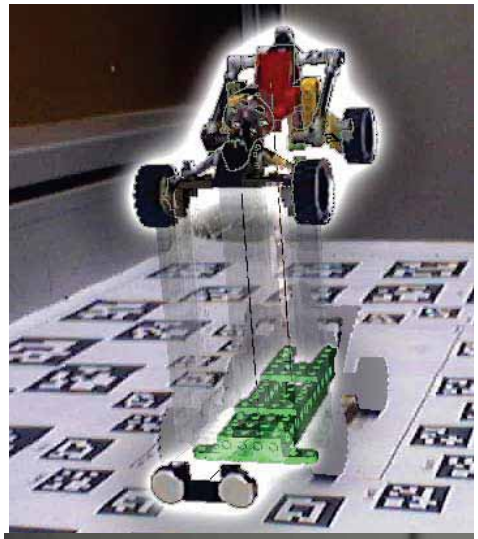
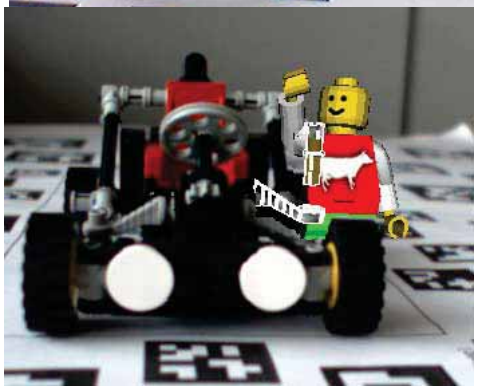
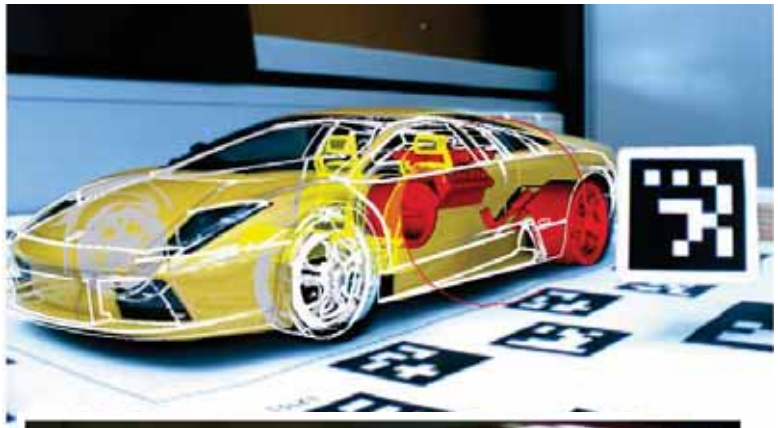
Graz University of Technology
Institute for Computer Graphics and Vision

X-Ray Visualization in Augmented Reality Environments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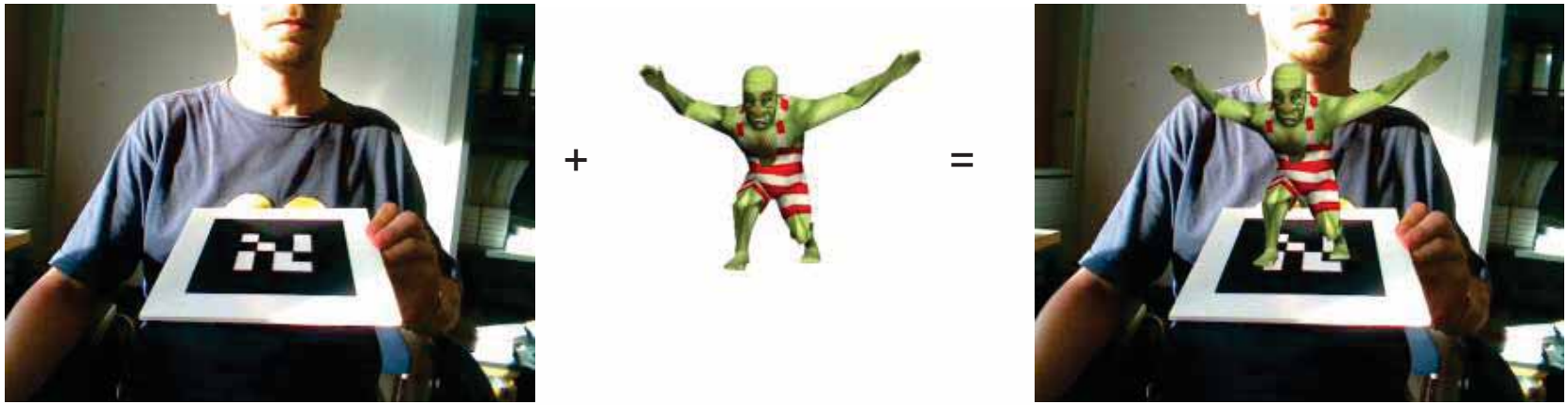
Visual Augmented Reality

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

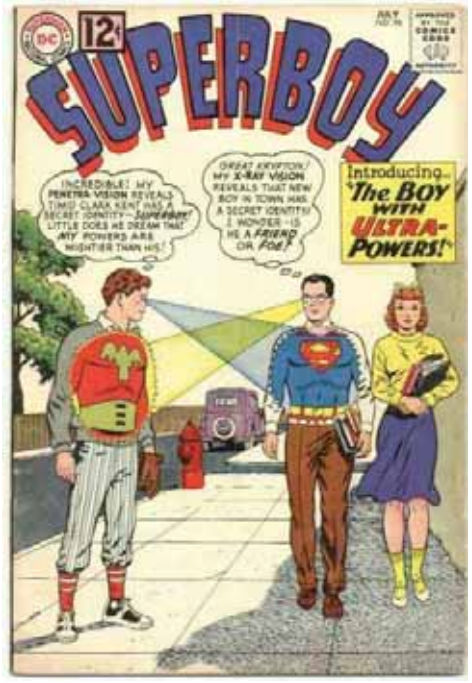


Visual Augmented Reality

Video

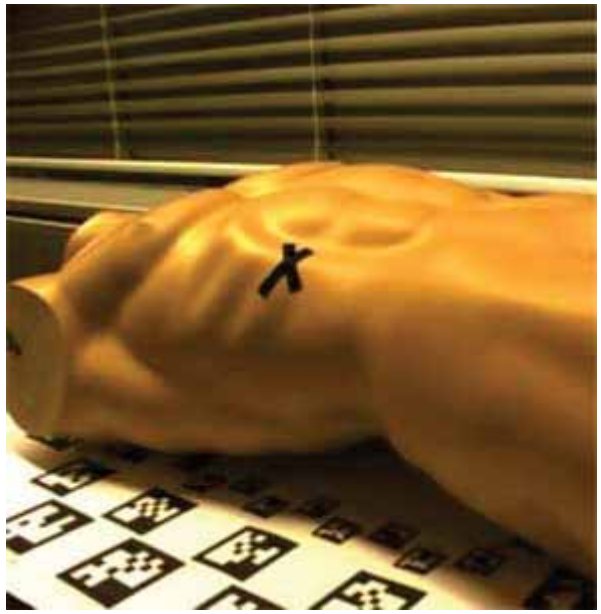
X-Ray Visualization

- Augmentation of hidden objects



Careless Visual Augmentation

- Overrides important landmarks

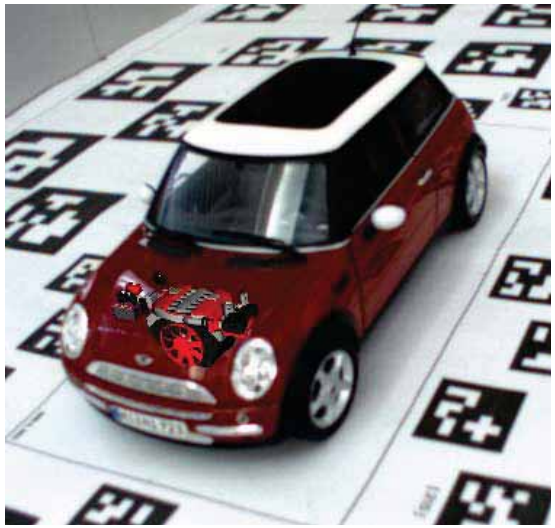


- Override important depth cues

Video

Careless Visual Augmentation

- Override important depth cues (occlusions)



Perception of Spatial Arrangements
- Depth Cues -

- Occlusion
- Relative size
- Perspective
- Texture Details
- Motion Parallax
  - Far distant objects appear to move slower than near objects
- ...

Video

Perception of Spatial Arrangements
- Depth Cues -

- Occlusion
- Relative size
- Perspective
- Texture Details
- Motion Parallax
  - Far distant objects appear to move slower than near objects
- ...

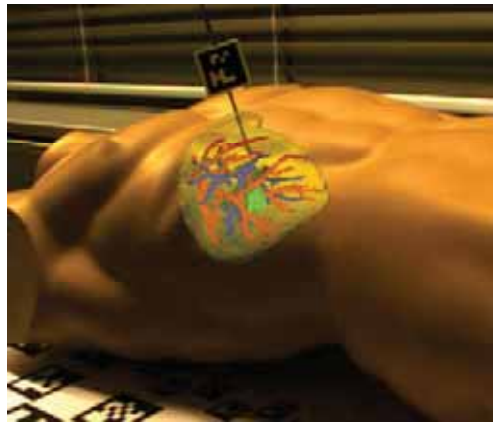
Video

Occlusion Handling
- Phantom Rendering -

- Init depth buffer by rendering the virtual counterpart of a real object, registered in 3D

Video

Correct Occlusion Rendering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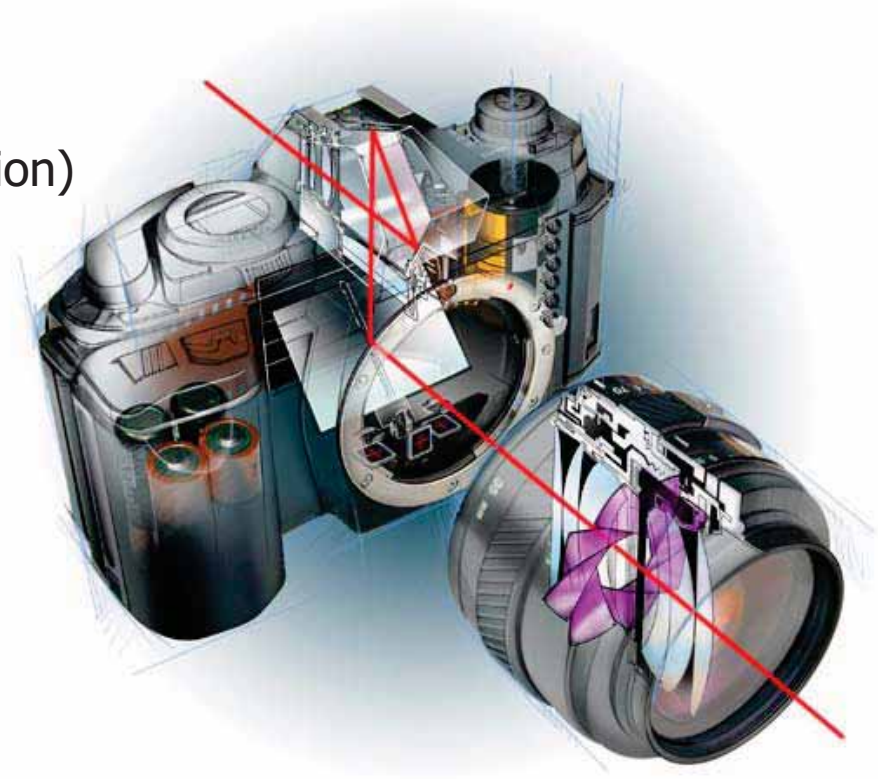
Uniform Transparency Modulation

- Blend foreground pixel where object is hidden (via stencil masking & pixel blending)

Video

Illustrative X-Ray Visualization

- Preserve occlusion cues
- Perception of spatial relationships
  - Ghosting (non-linear transparency modulation => sparse representation)
  - Cutaway
  - Explosion



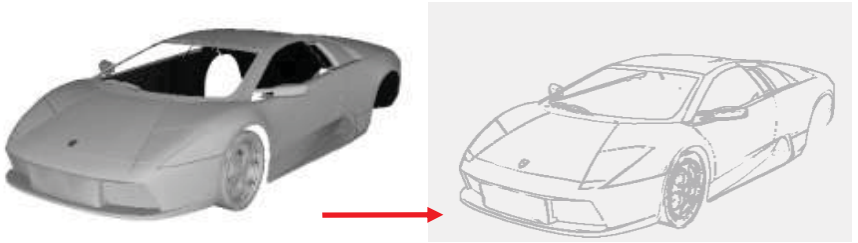
http://www.cutaway-illustration.com

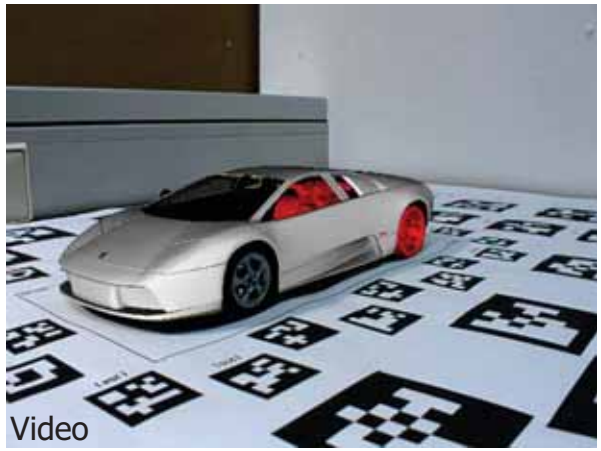
Illustrative X-Ray Visualization in AR

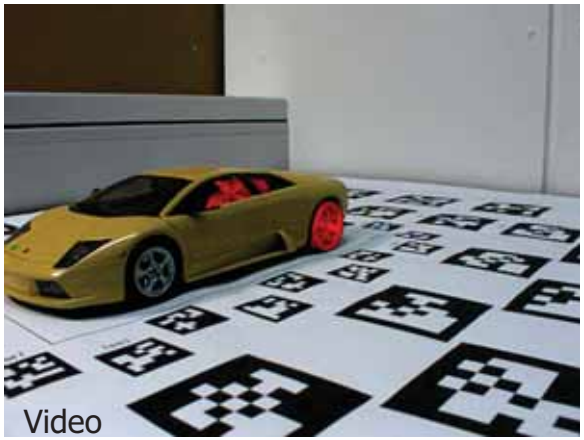
- Ghosting, Cut-away & Explosion Views -

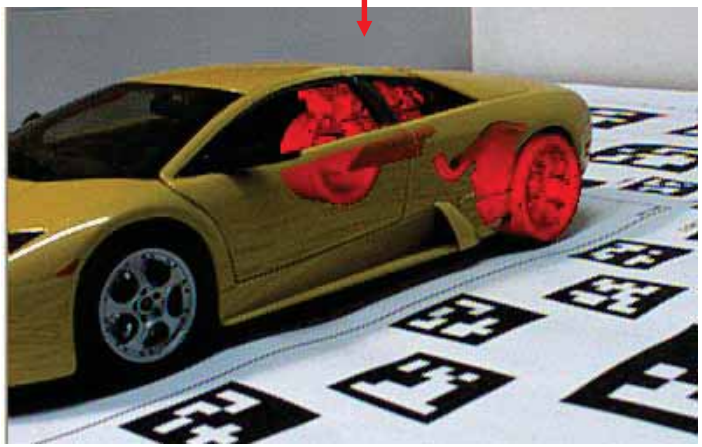
Ghosted Reality

Stylized phantom controls opacity of video pixel





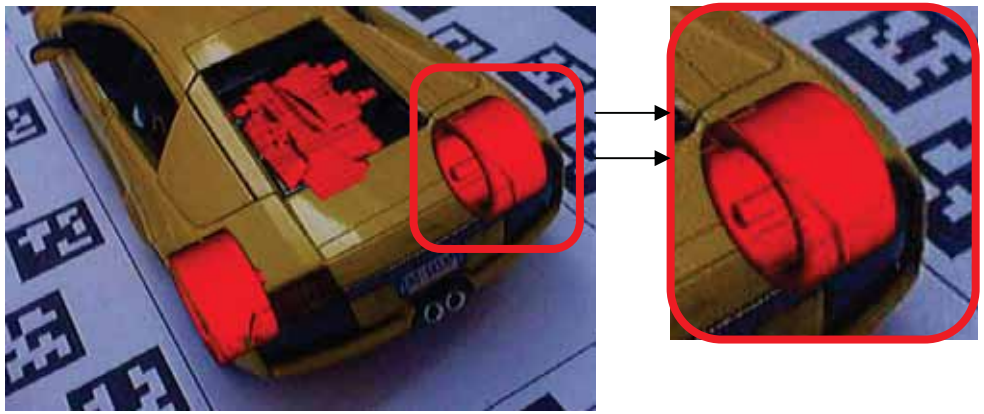




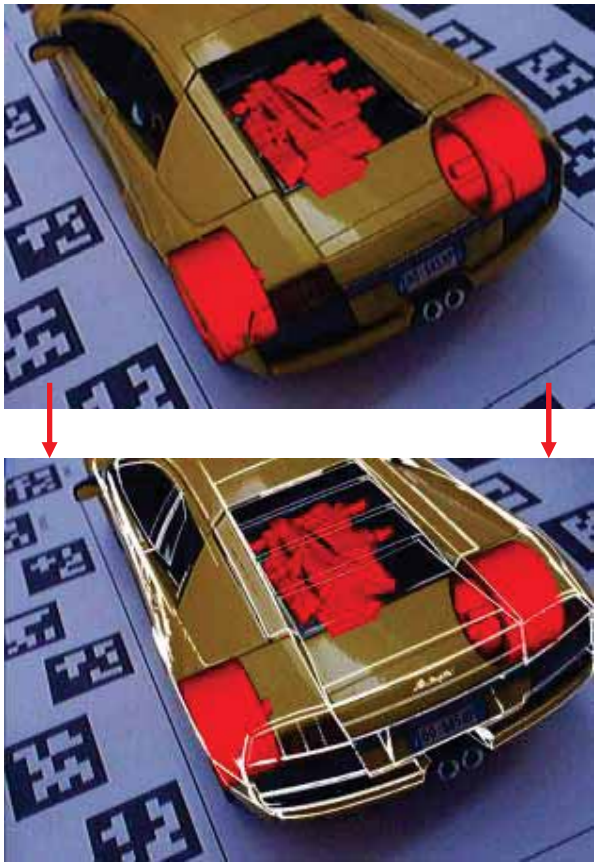
Shading occluding structures in AR - Video vs. Virtual Preservation -

- To 'understand' the occluder, we need to perceive its ghosting as one object
- Very sparse video preservings are difficult to identify

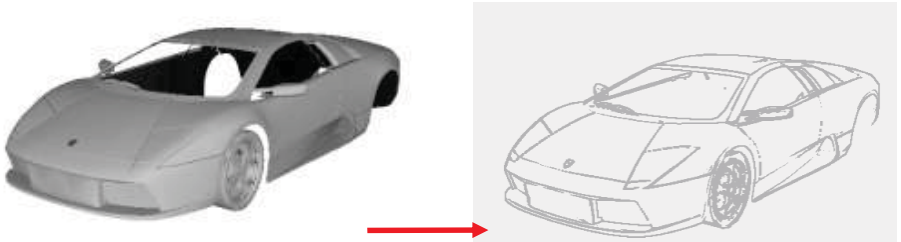
=> Enhance preserving to perceive ghosting <=

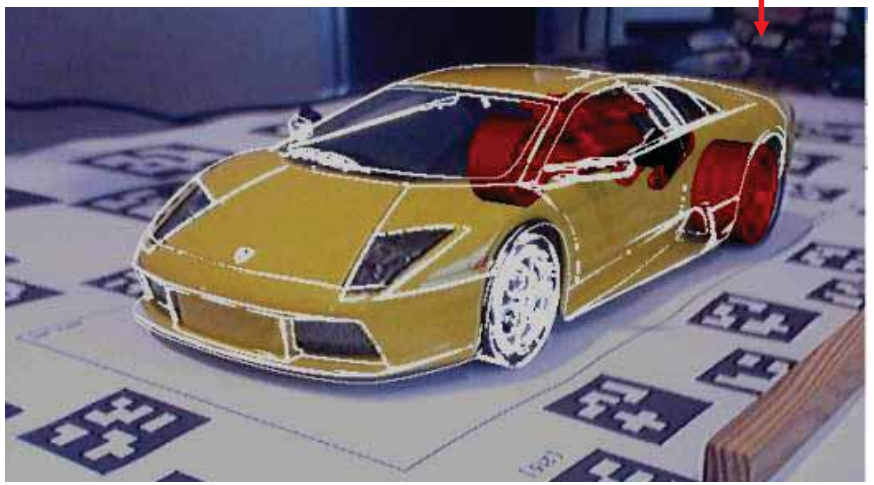


Ghosting in AR



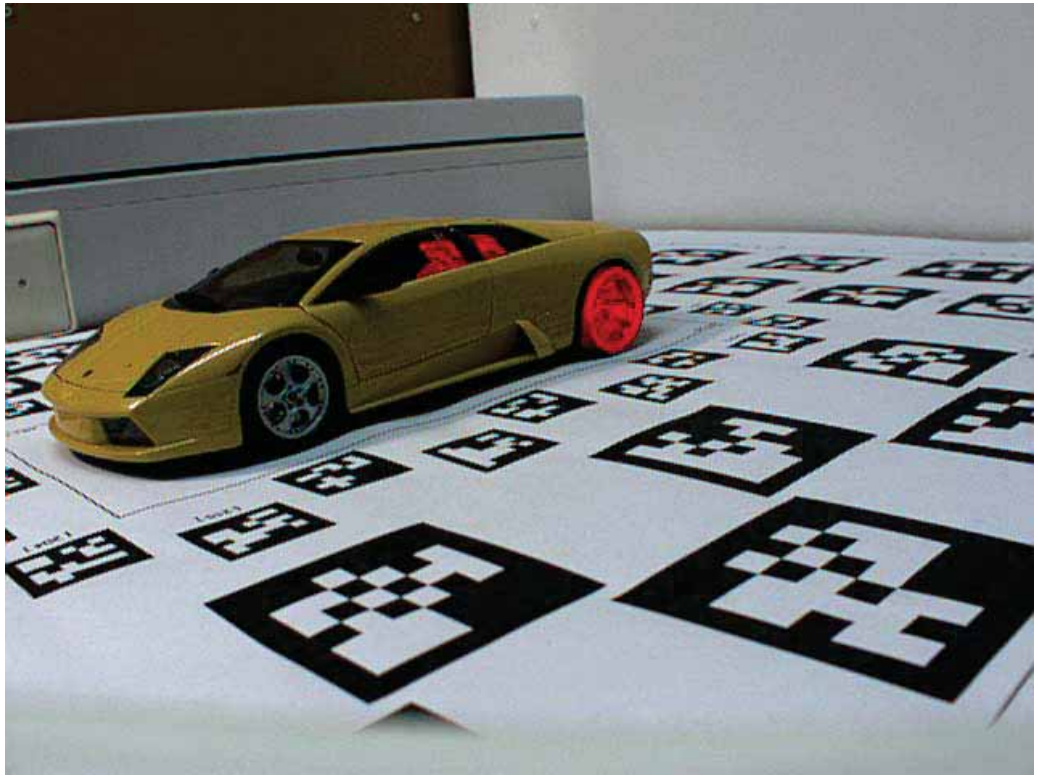
Augment stylized phantom





Virtualized Ghosting

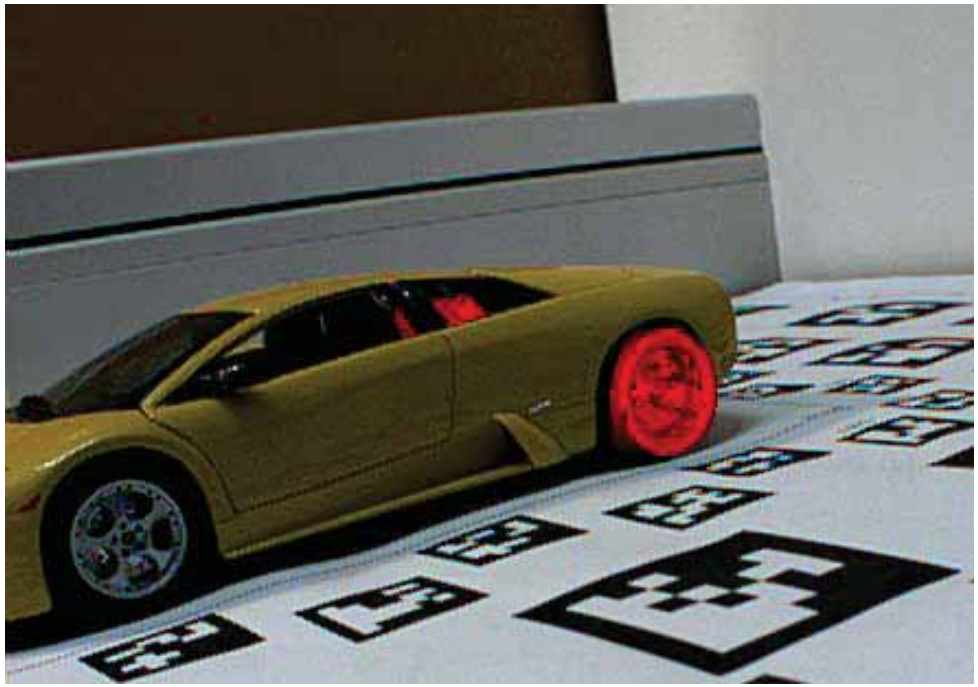
Where to use virtual and where to preserve real information?



Video

Mixed Ghosting

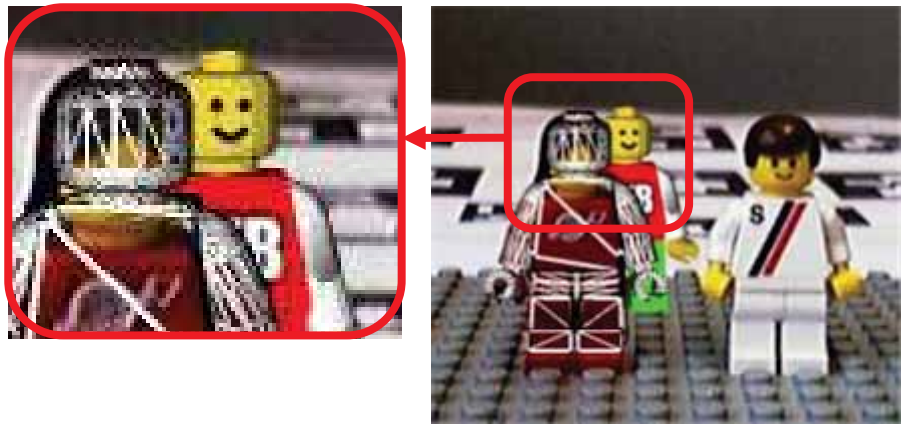
- Mix virtual and real information based on weighted opacity of stylized phantom



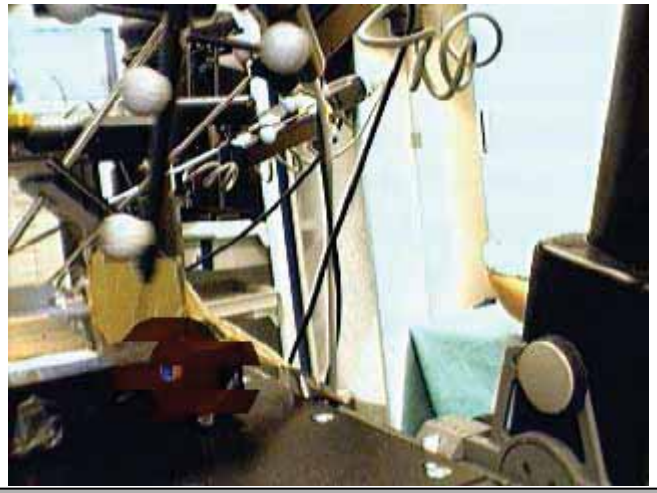
Video

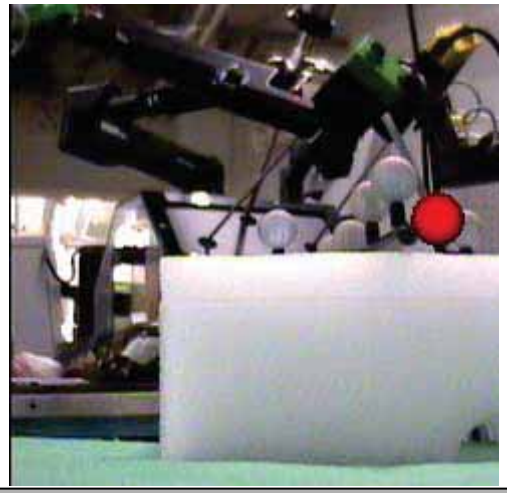
Registration Error

- Phantom does not perfectly fit to real object!
  - Modeling error
  - Tracking error
  - Offset data synchronization
  - ...

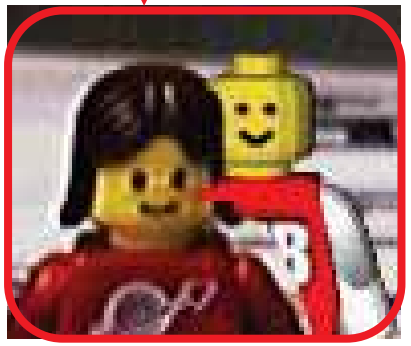


Video



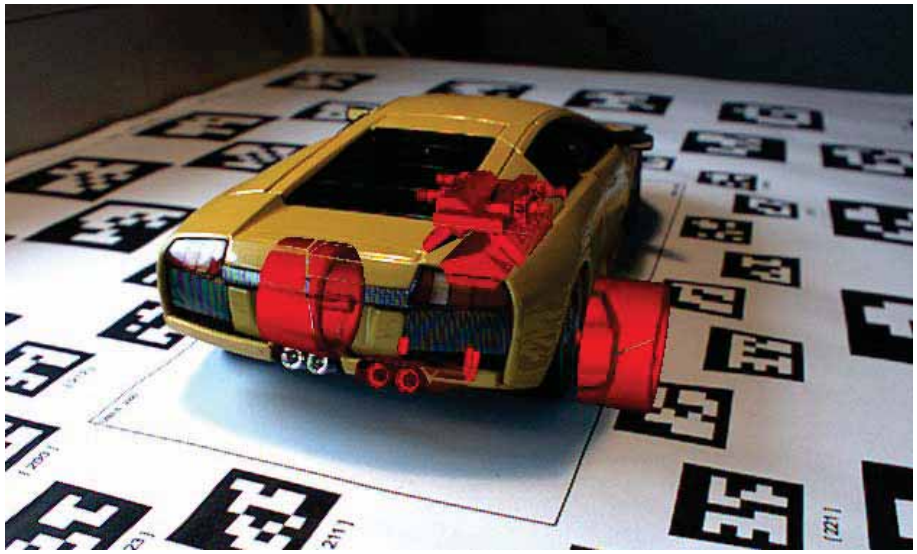


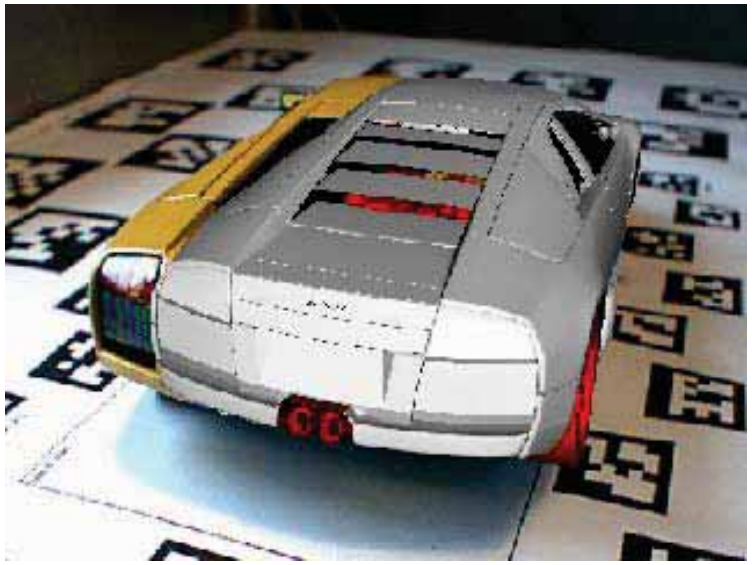
Video



Ghosting Erroneous Phantoms

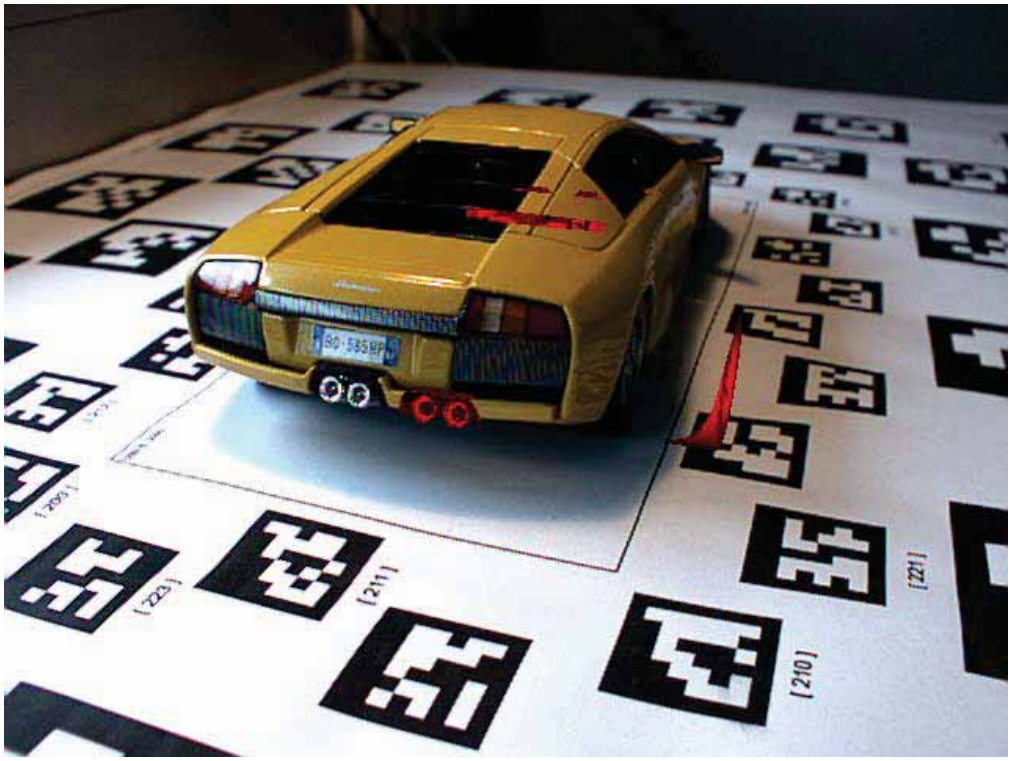
- ”Regular” ghosting is difficult to understand





Error Compensation

- Virtualized ghostings are able to communicate the error

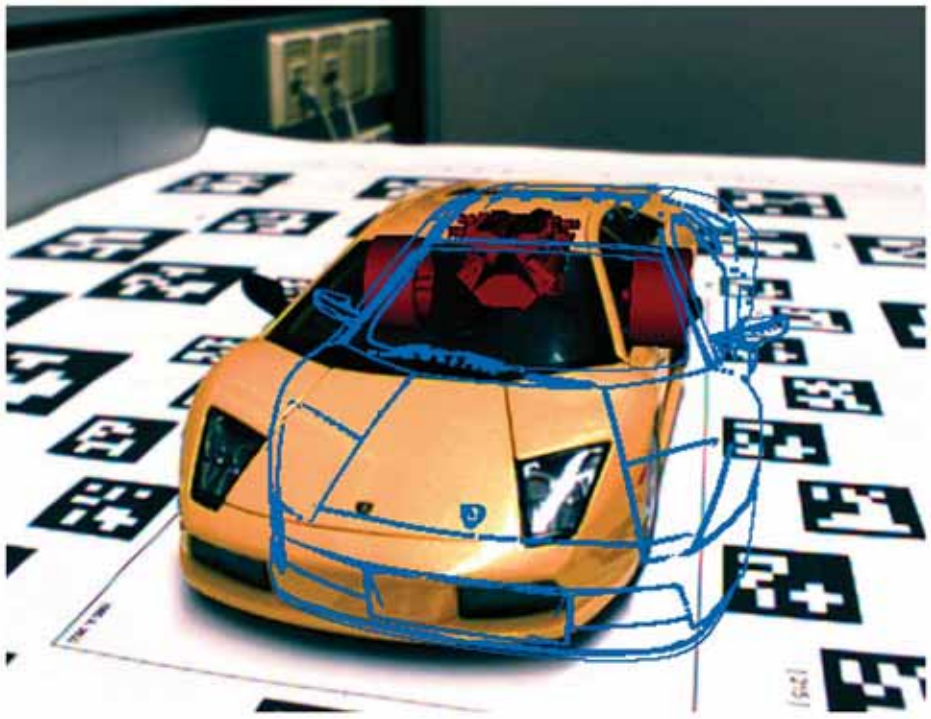


Video

Video

Error Compensation

- Phantom and hidden object should use the same registration data!
  - Tracking
  - Modeling
  - …



Missing Phantom

- Stylize video directly
- Object order has to be known !

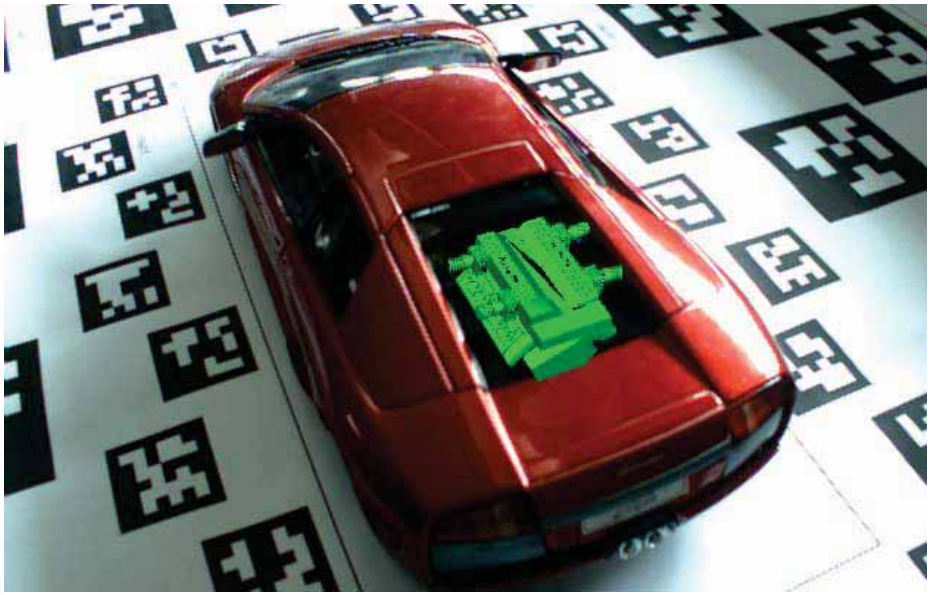


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Image Space Ghosting

- Feature Distribution!

Video feed →

Feature detection →

Feature distribution →

Derived transparency →

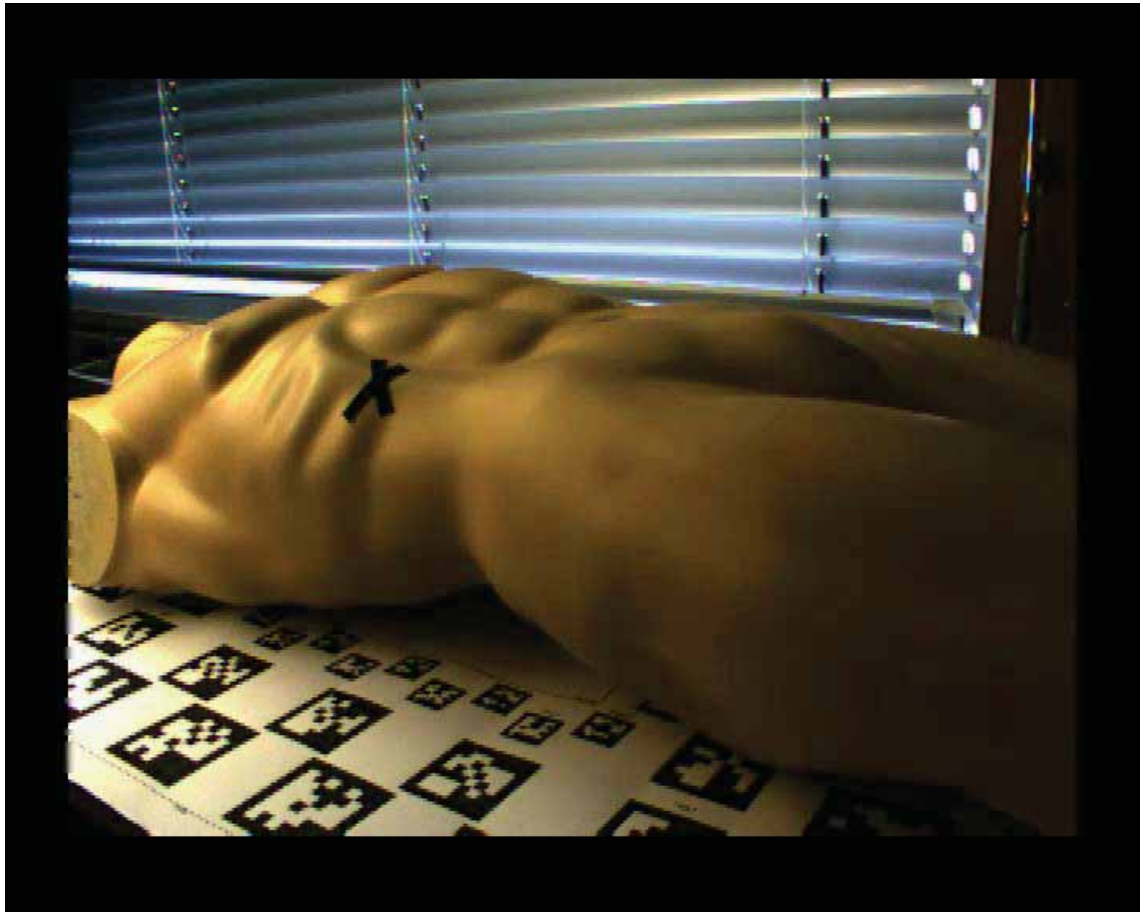
Blend VR →

Blend video →

Ghosting from Video

- Indendent from tracking error => NO error communication!
- Virtualized ghostings may produce clutter (need information filter: mask)
- Depth order must be known

Hybrid Ghosting from Video

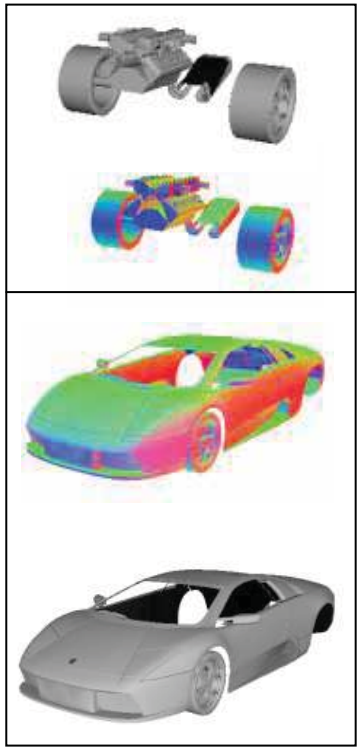


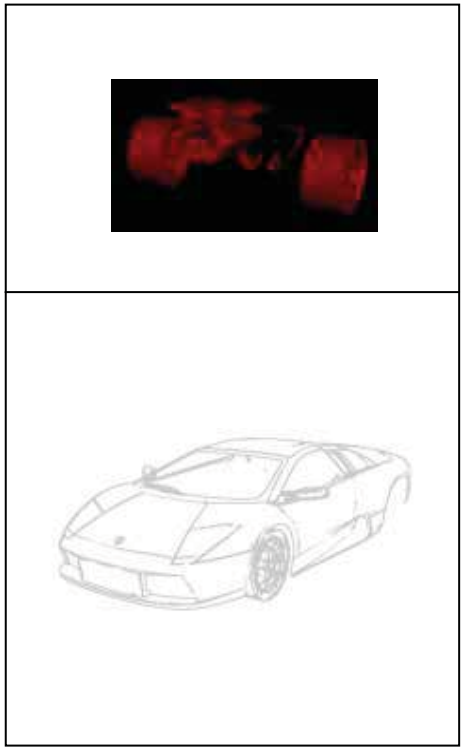
Video

Video

Rendering Ghostings

G-Buffer Extraction → G-Buffer Processing → Scene Compositing



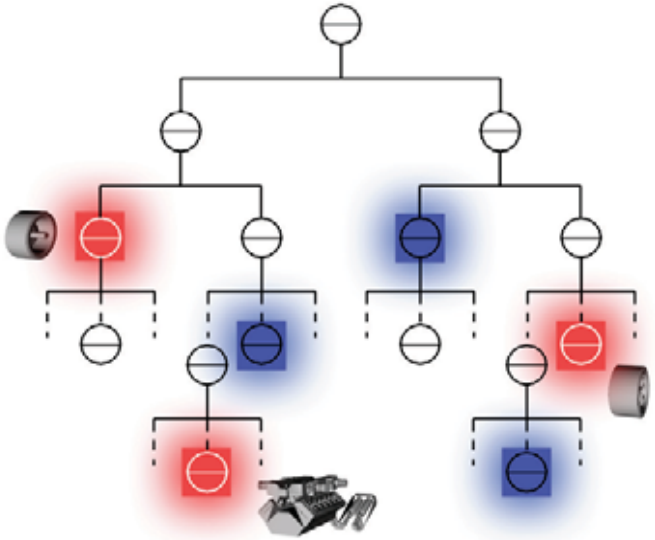


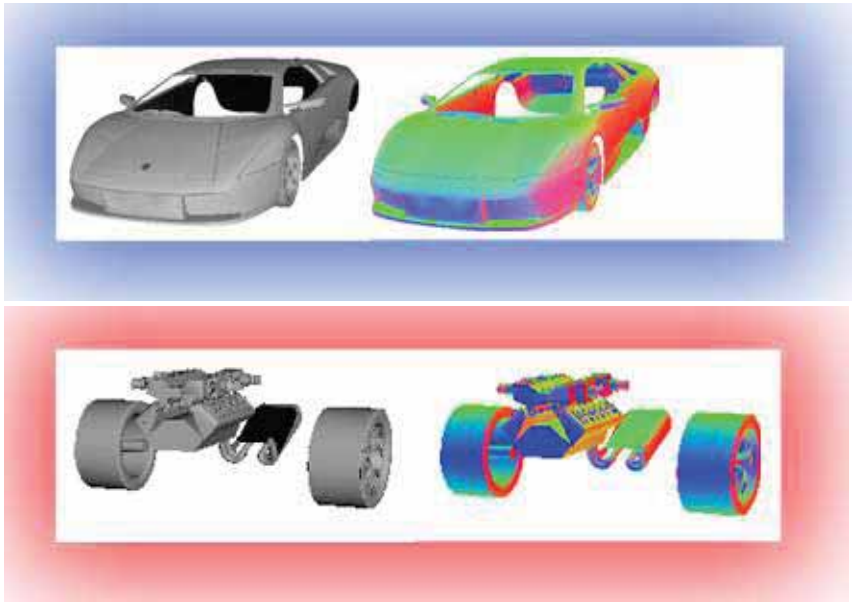
Apply Object based feature extractor

Apply Image based feature extractor

GBuffer Rendering: Object Grouping

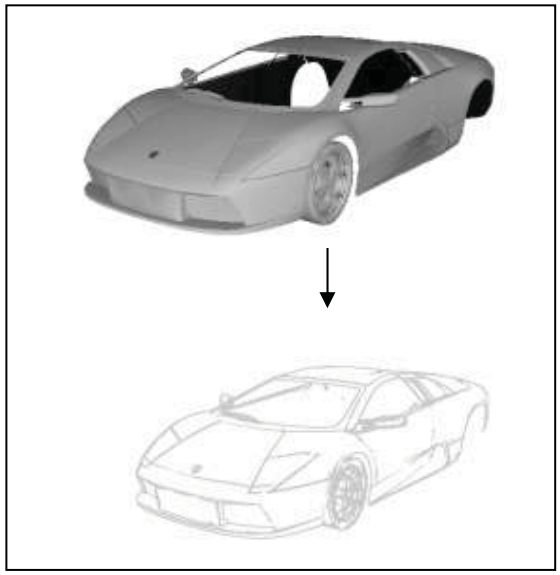
- G-Buffer's content spread over scene graph
- Context sensitive scene graph traversal
  [Reitmayr05]

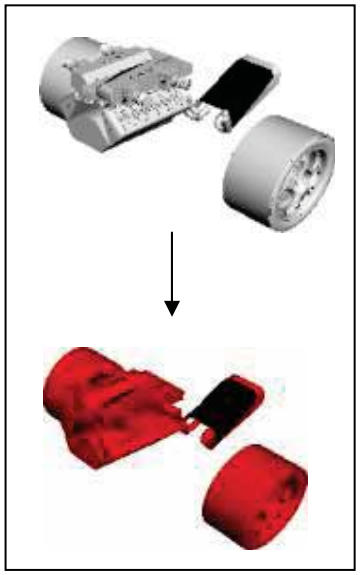




Rendering Algorithm II/III
- GBuffer Processing -

- 2D image operators on different 2-1/2d layer

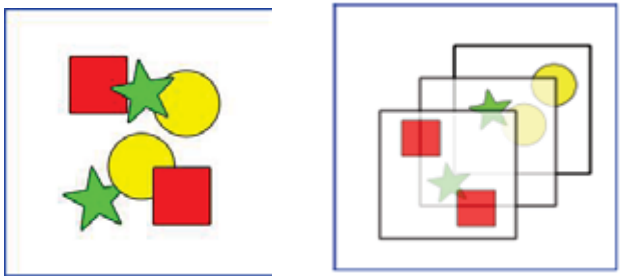


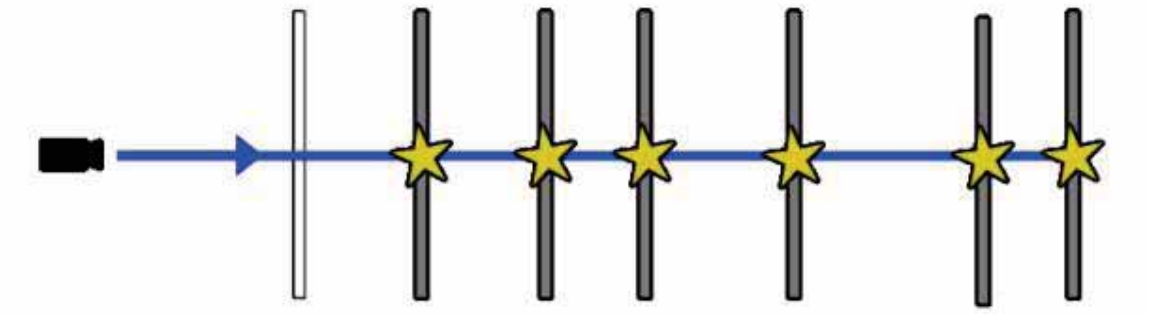


Rendering Algorithm III/III
- Scene Compositing -

- Can't simply blend !
- 'Raycast' into G-Buffer volume

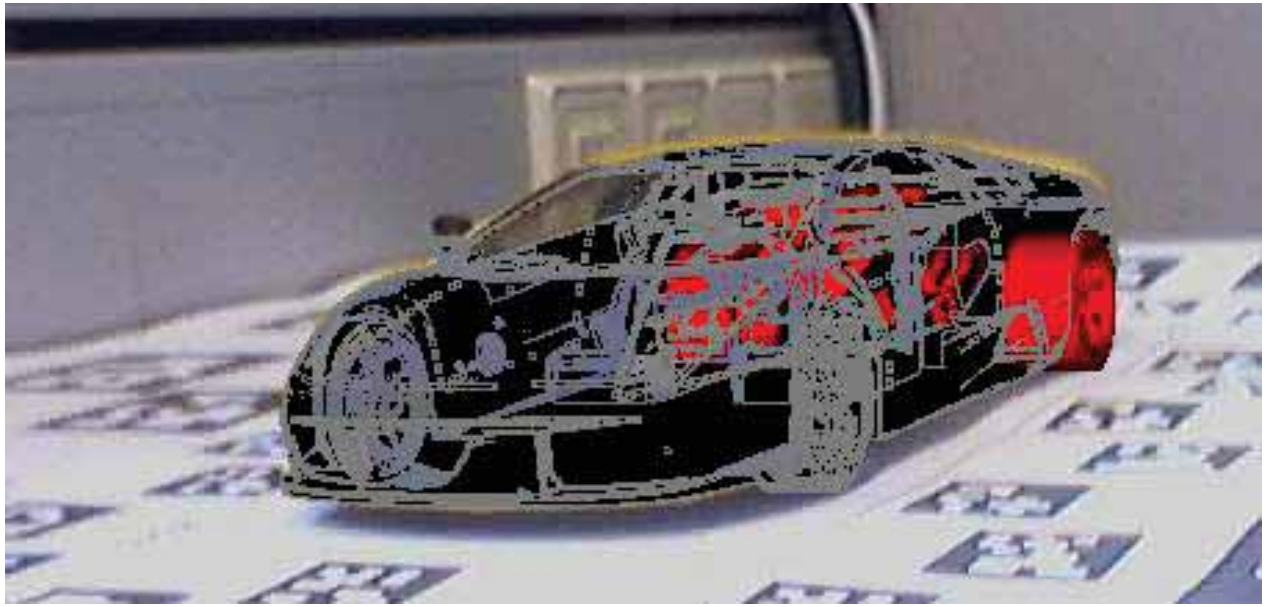
1) Sort G-Buffer per pixel
2) Blend fragments per pixel





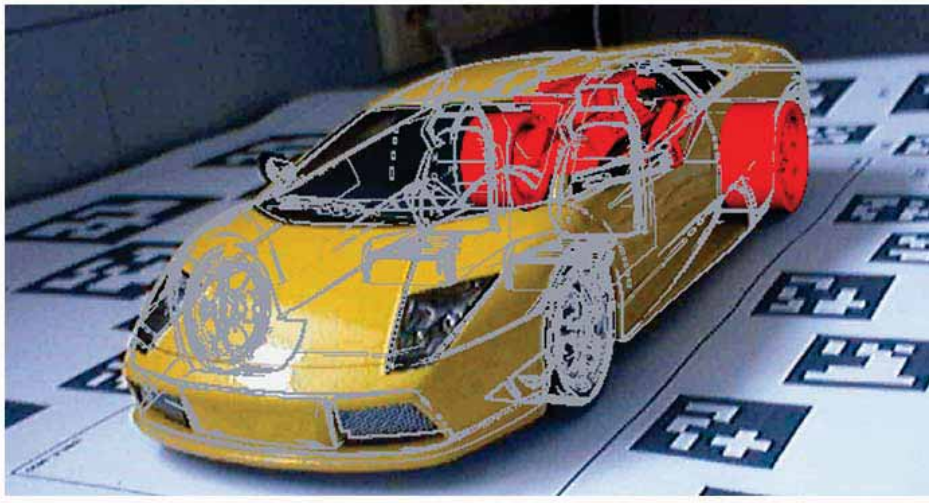
Multiple Object Occlusion

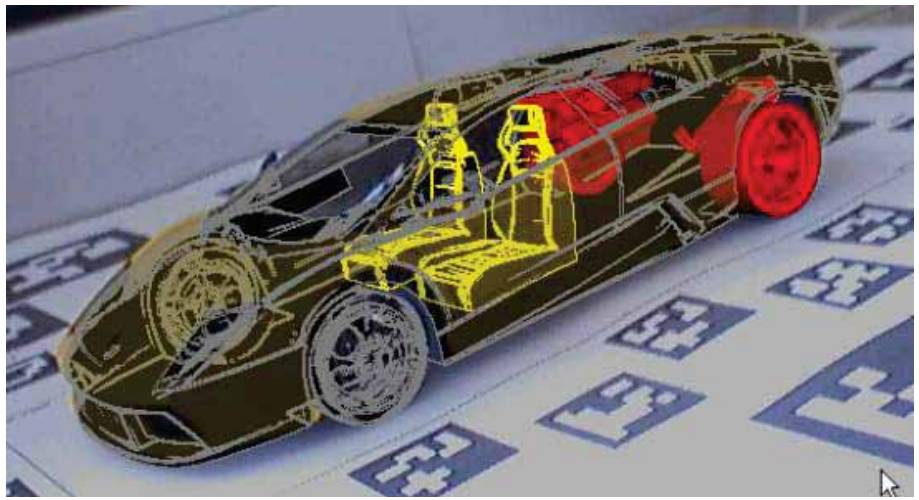
- Which object to preserve?
- Amount of preserving?
- Need information filter



Filtering by Object Discrimination
- during gbuffer processing -

- Limited to a few objects





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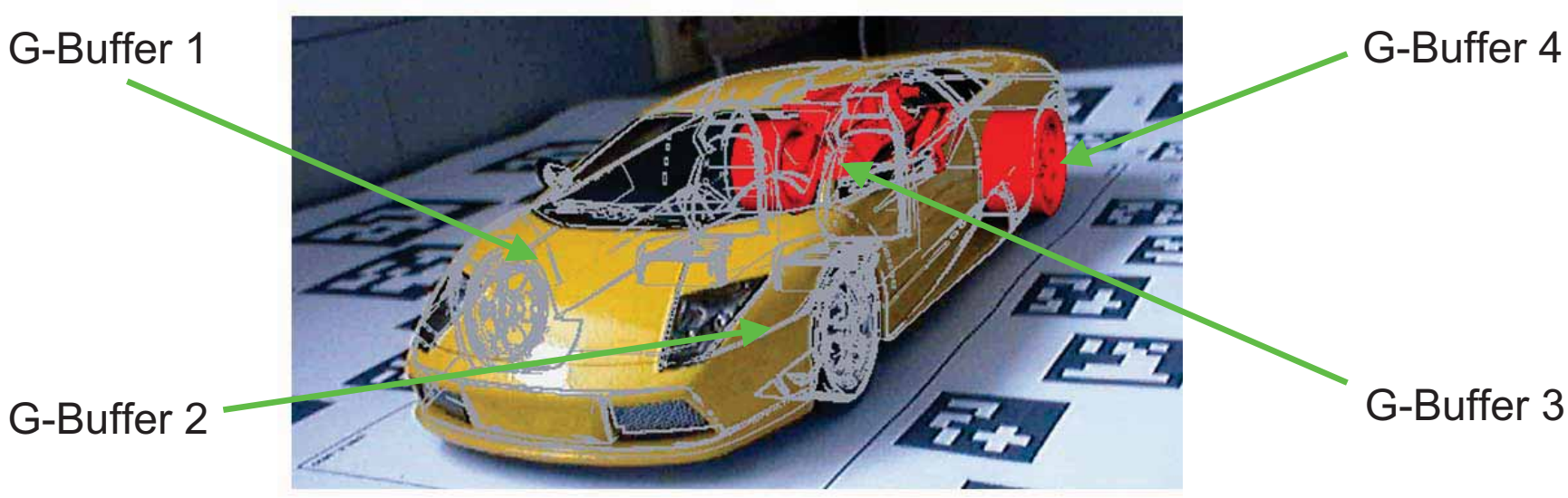
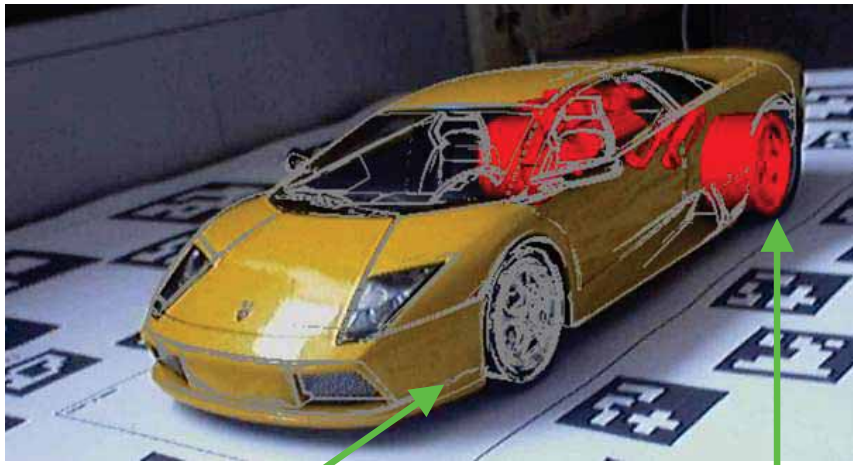
Fragment Reduction
- during gbuffer extraction -

- Use only visible fragments
- ... by regrouping G-Buffer



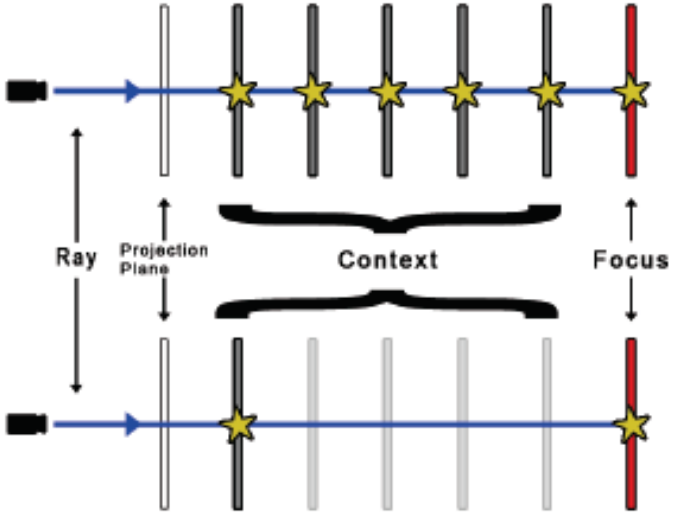
Fragment Reduction
- during gbuffer extraction -

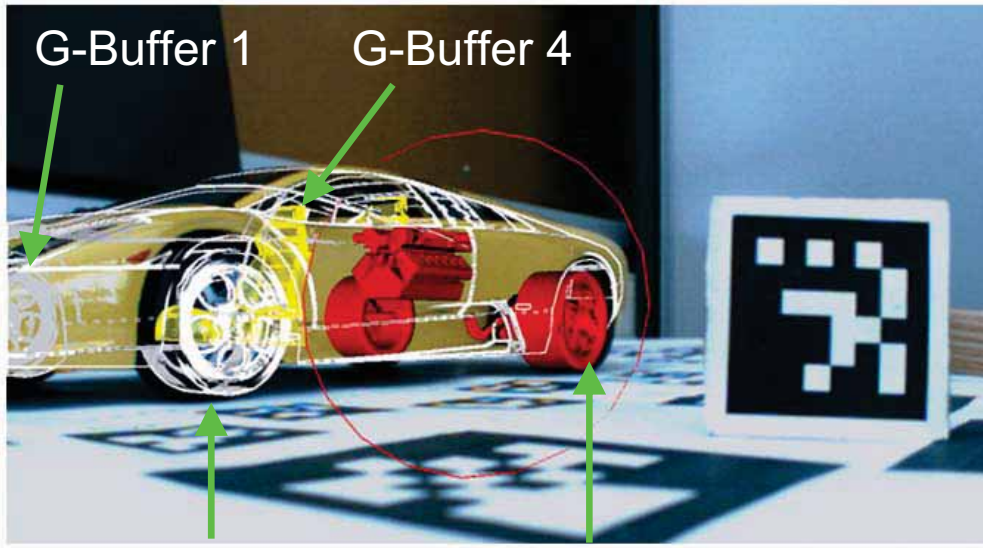
- Pros:
  - Fast (in hardware)
  - First step of the algorithm
- Cons:
  - Expensive to apply different object groupings in different areas of Framebuffer = different filter strategies



Fragment Reduction
- during scene compositing -

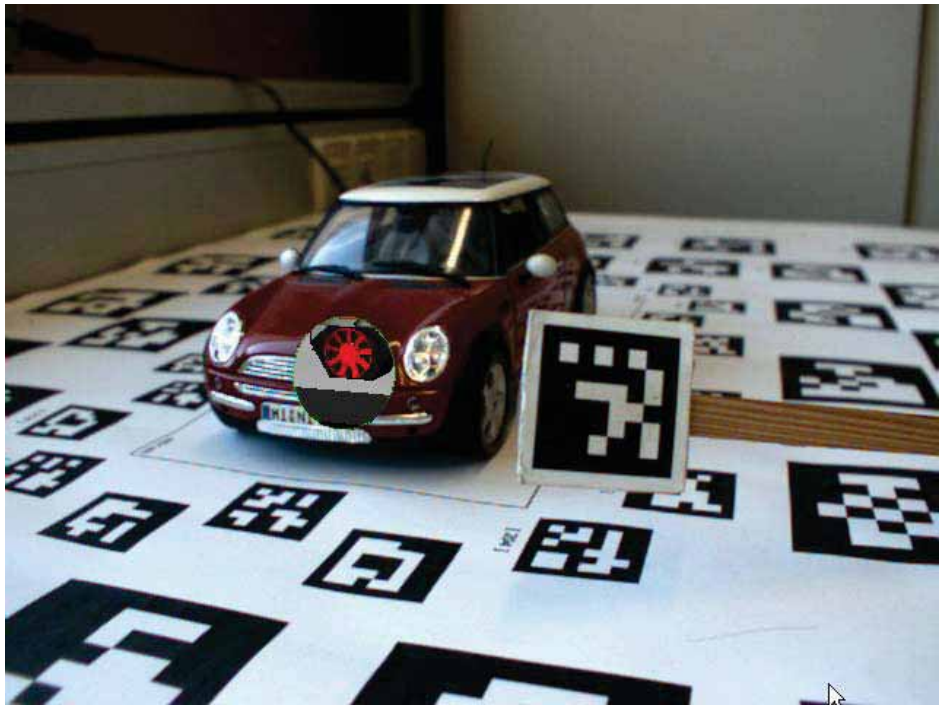
- Pro:
  - Compositing strategy changable at runtime (easily applicable per region)
- Con:
  - Last step of rendering





Cutaway

- Mentally interpolate occlusions
- Loose information!!
- Cut-out might become as big as occluder
  - No occluder = mental occlusion cue will remain
  - Mentally 'uncutting' becomes difficult for big cuts

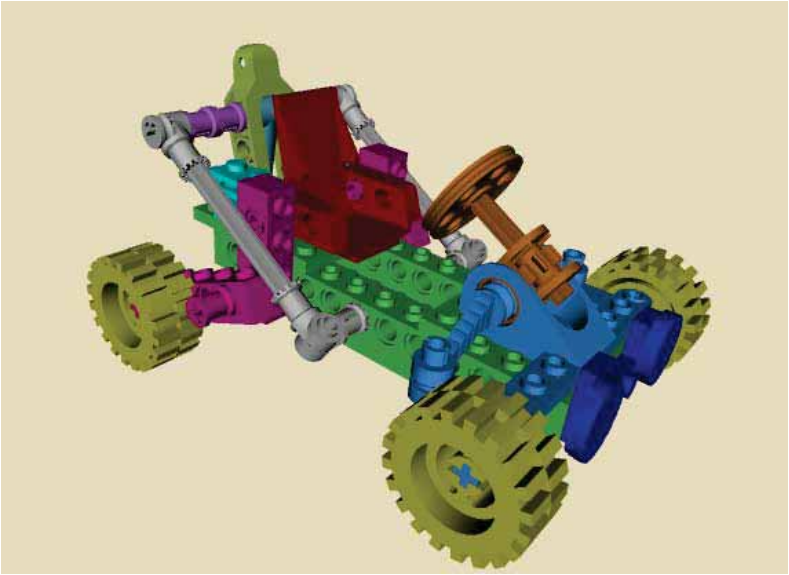


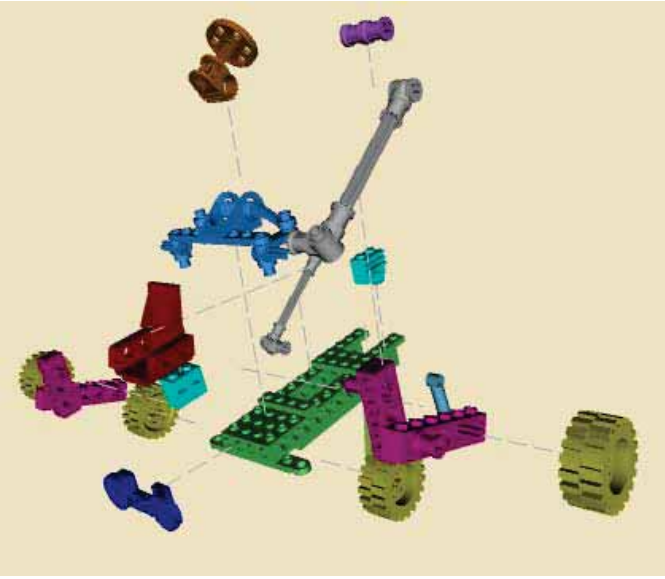
Explosion Diagrams in AR

- Keeps hidden AND occluding structure visible
- Also works for multi-layered occlusions

Explosion of Multi-Layer X-Ray

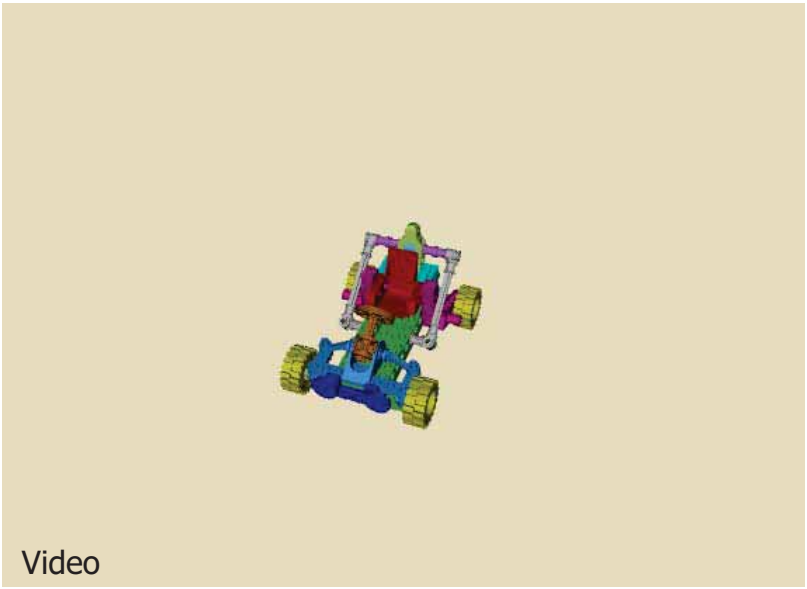
- Multi-layer explosions
- Bad layouts are not able to communicate the assembly => mental occlusion interpolation is impossible
- NEED to present a clear explosion sequence

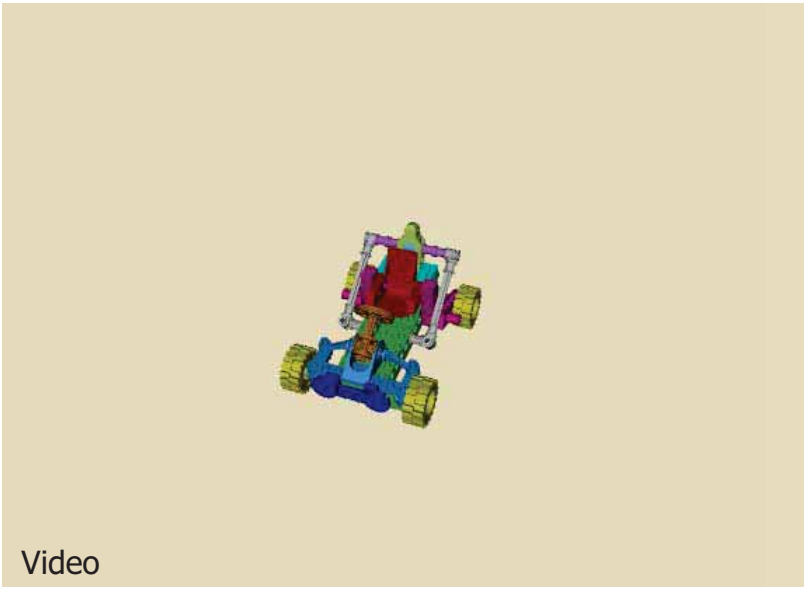




Explosion Layout

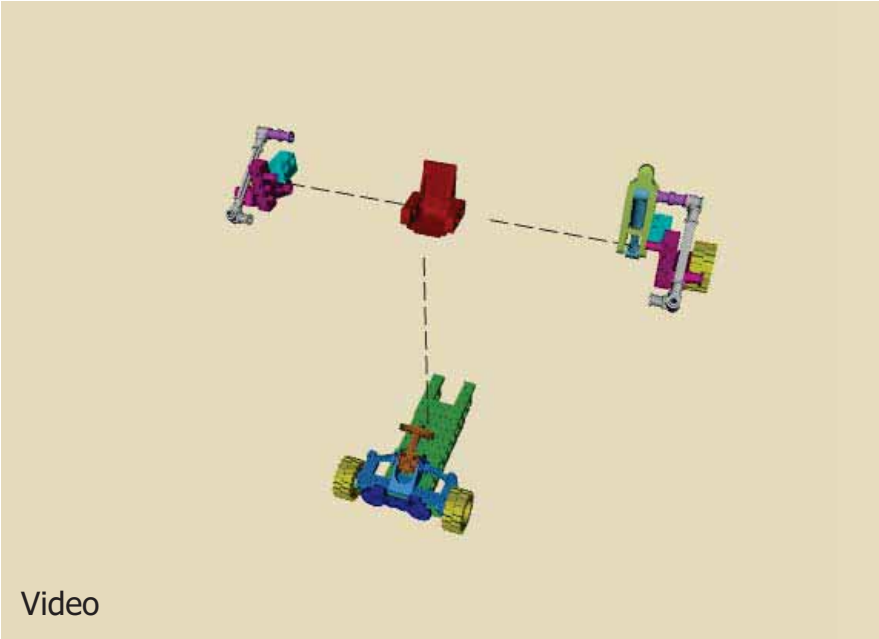
- Symmetry
  - Similar parts explode similar
- Limited number of explosion directions

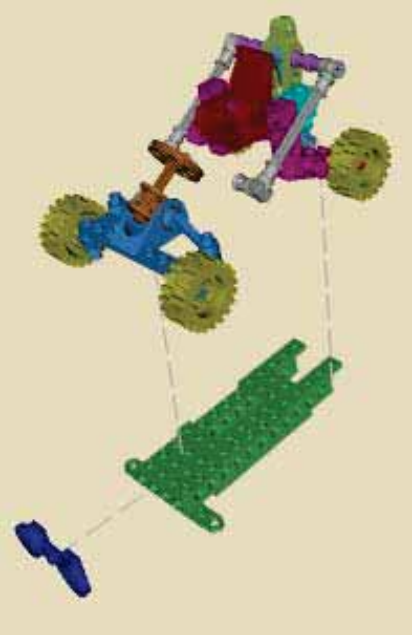




Grouped Layouts
- Focus & Context Layout -

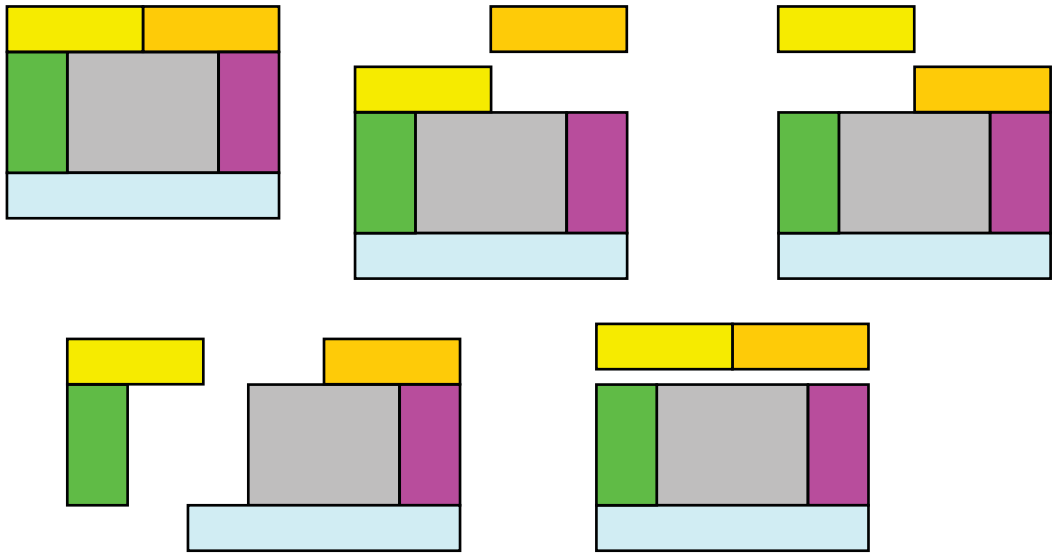
- Groups reduce complexity
- X-Ray visualization => Focus and Context visualization => Focus and Context explosions = minimal number of groups related to focus

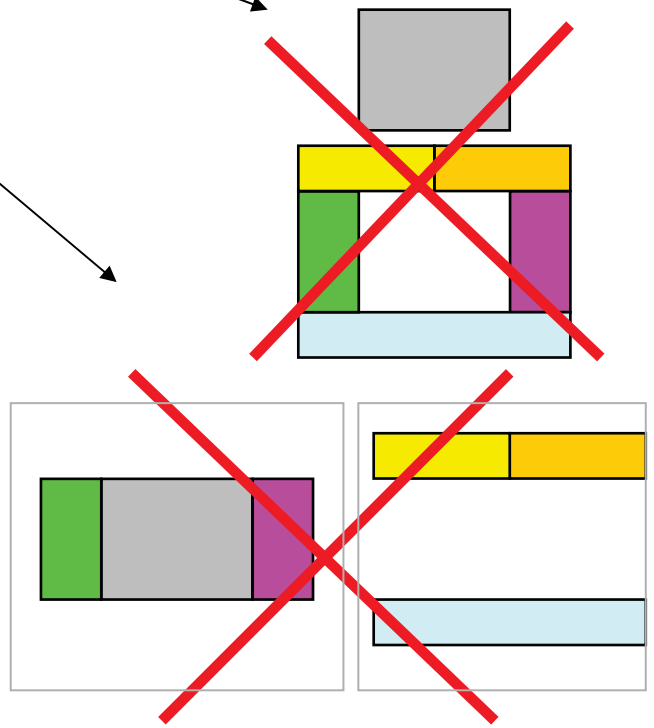




Partitioning

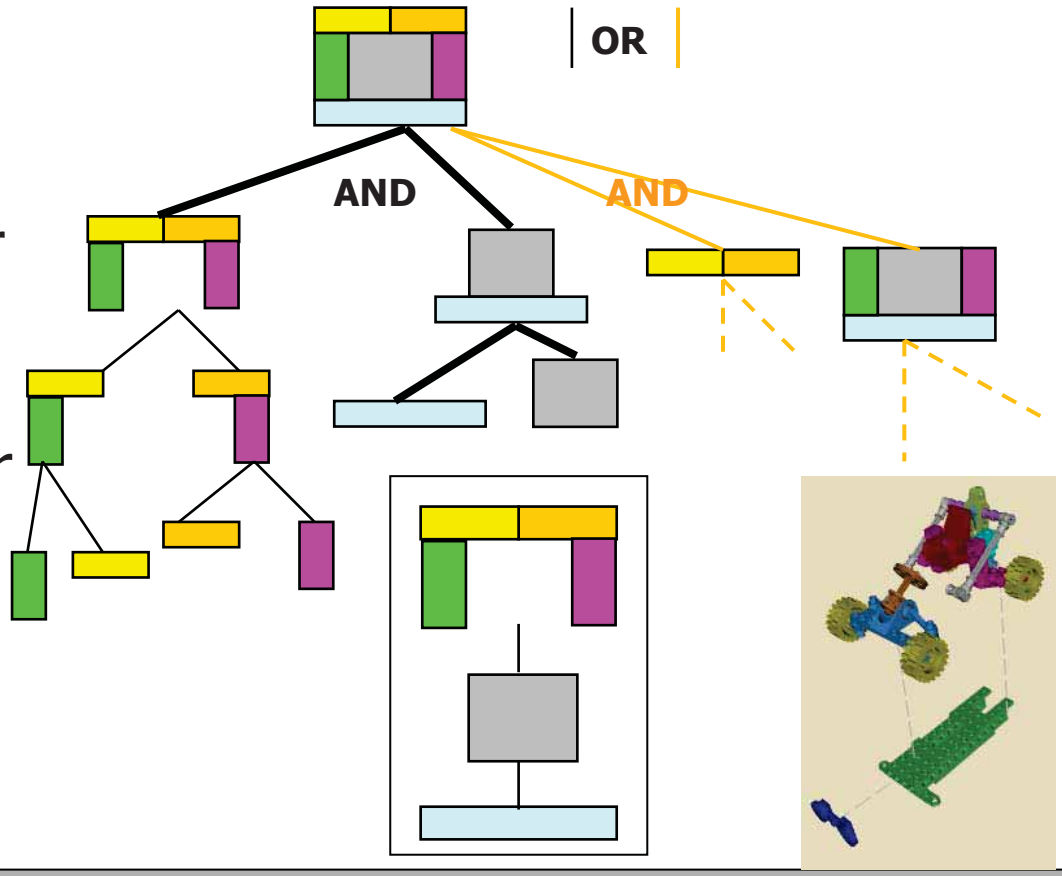
- Recursively find **ALL** valid partitions
  - Partitions do not collide on their path
  - To be able to further explode a partition: All parts have to be connected
  - Test only directions of main axis





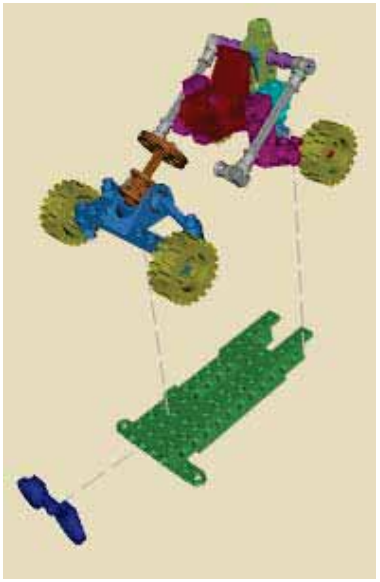
Grouping
- Focus and Context -

- AND/OR Graph=Sequences of ALL valid Partitions
- Layout => Search for a single sequence
- F+C Group => Recursively search for the biggest partition not containing the focus
- Biggest=number of parts



Rendering Explosions in AR

- Transfer of real world information


+

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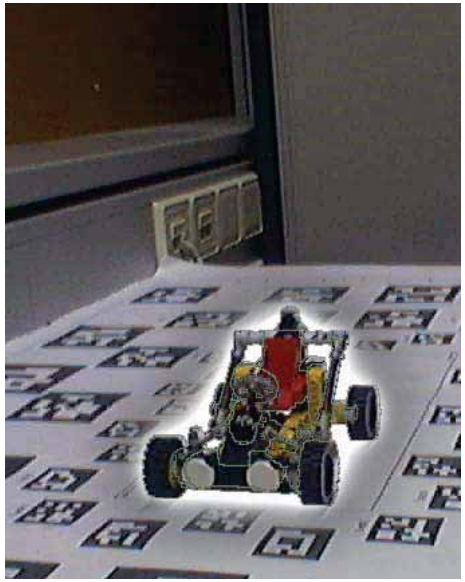


Video

Video Textured Phantoms

1) Texture virtual model with real world information
2) Explode video textured model

Problem1 of Video Textured Phantoms

- Problem 1/2: video textured phantoms need a complete virtual representation of hidden structure

Complete virtual representation of hidden structure

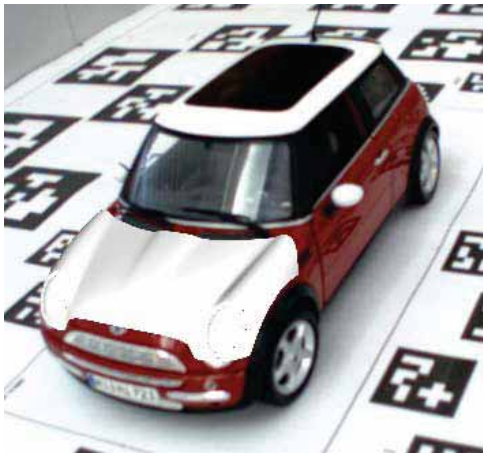
Incomplete virtual representation of hidden structure

Dual Phantom Rendering

- Use a 2. phantom (next to the exploded one) to declare video information void

1) Render textured phantoms

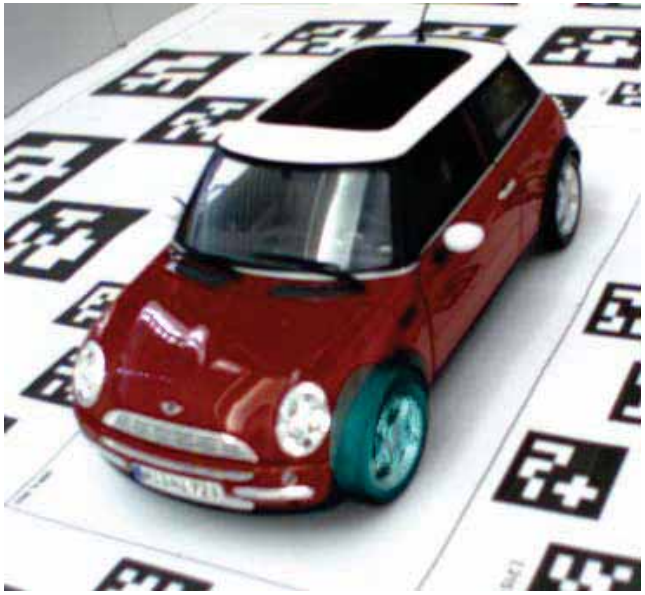
2) Void video



3) Combine masked video, textured phantoms and hidden VR

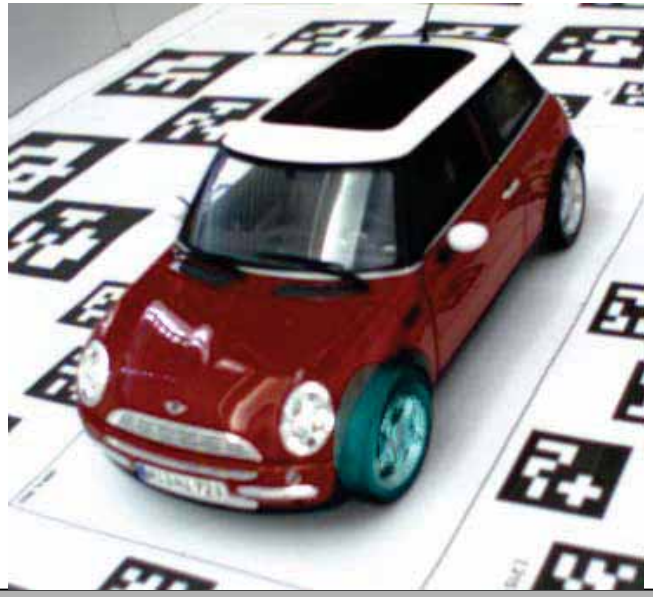
Problem2 of Video Textured Phantoms

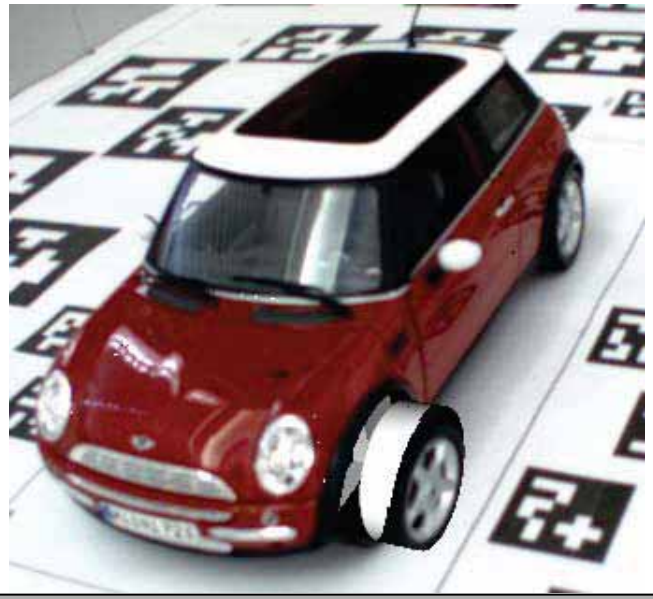
- Problem 2/2: occluded phantoms will transfer visible real world information



Synchronized Dual Phantom Rendering

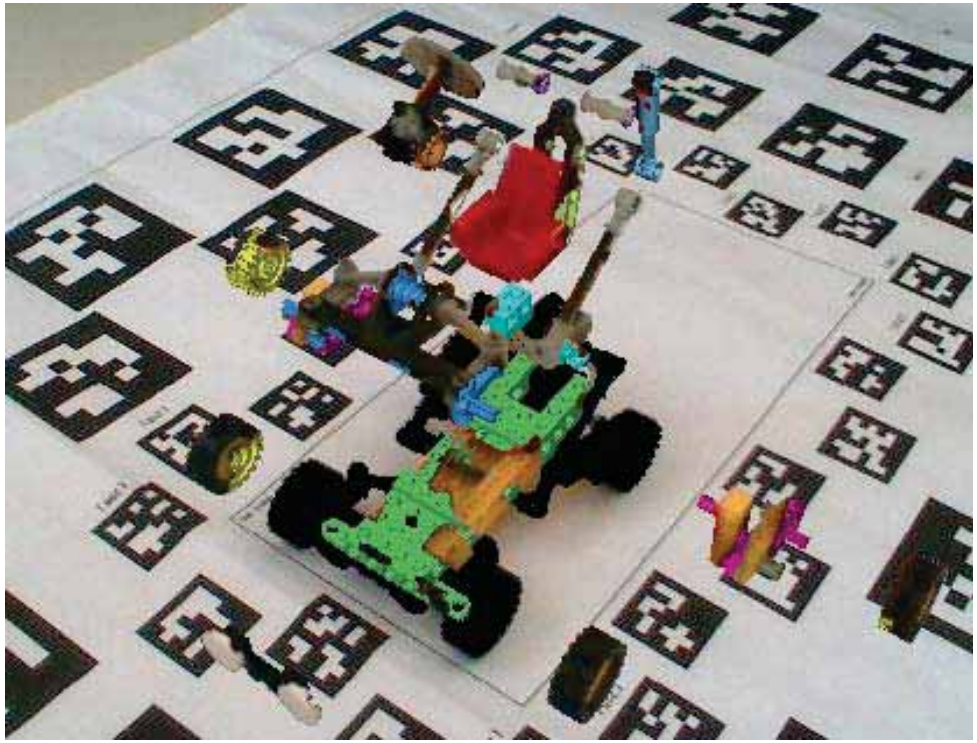
- Instead of simply declaring the video void, we write the object's id and let OpenGL's depth resolve the problem
- During texture transfer, we check the phantom's id with the value in the id-buffer (which represents the visible phantom)





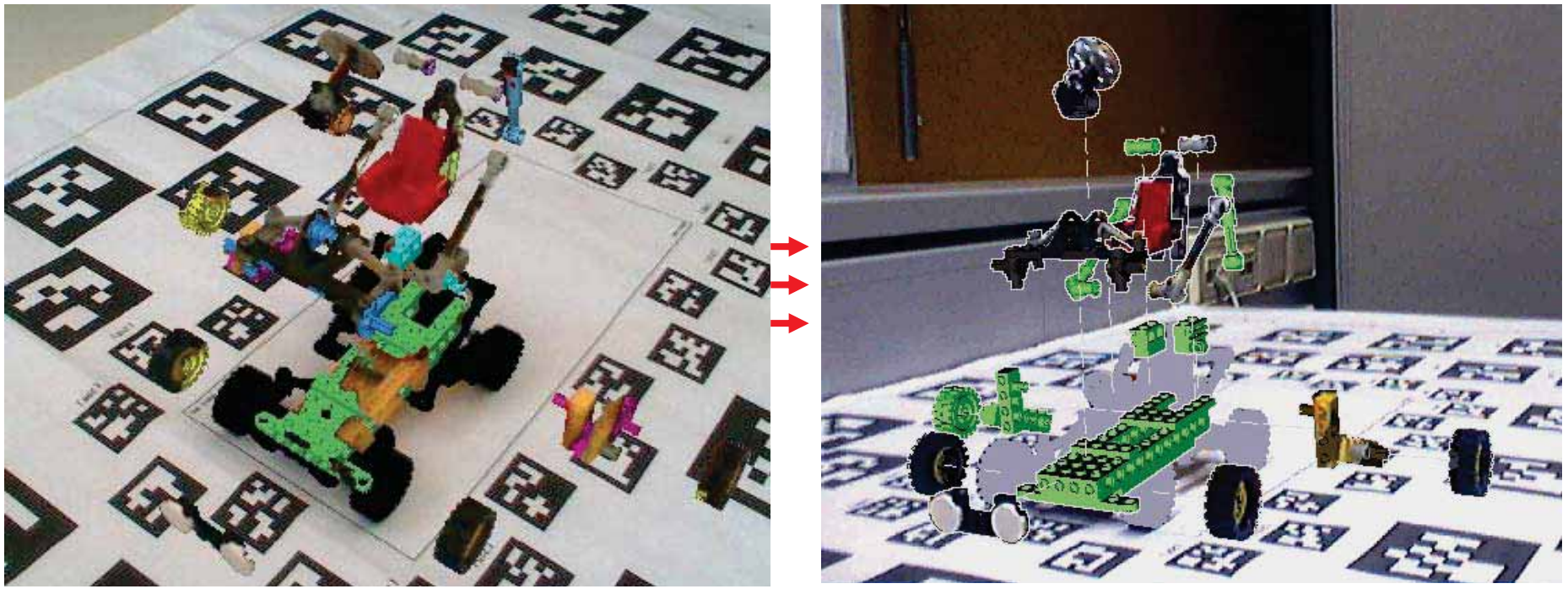
Visualization

- Simple transfer of video easily results in a visual mess of mixed information
- Identify a part as one object



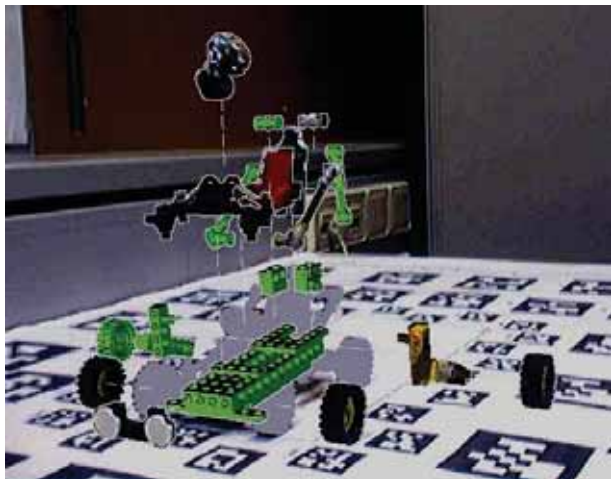
Restauration

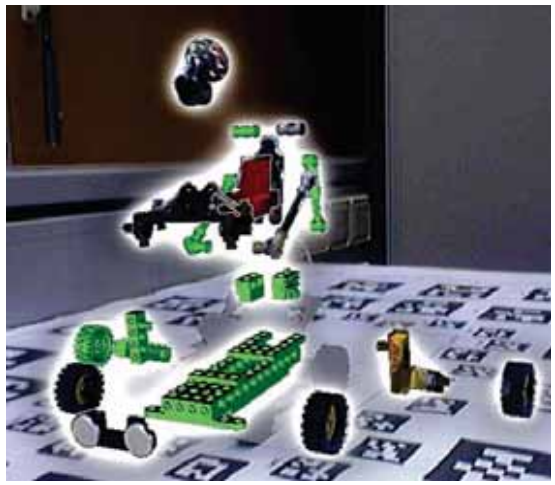
- Restorate **parts** and **background**
  If (#vrInfo > 50%) shade all VR
  Else ‘guess real world information’



Part Discrimination

- New contextual information around relocated objects may be confusing
- Visually discriminate exploded parts
- Background vs. part neighbors)





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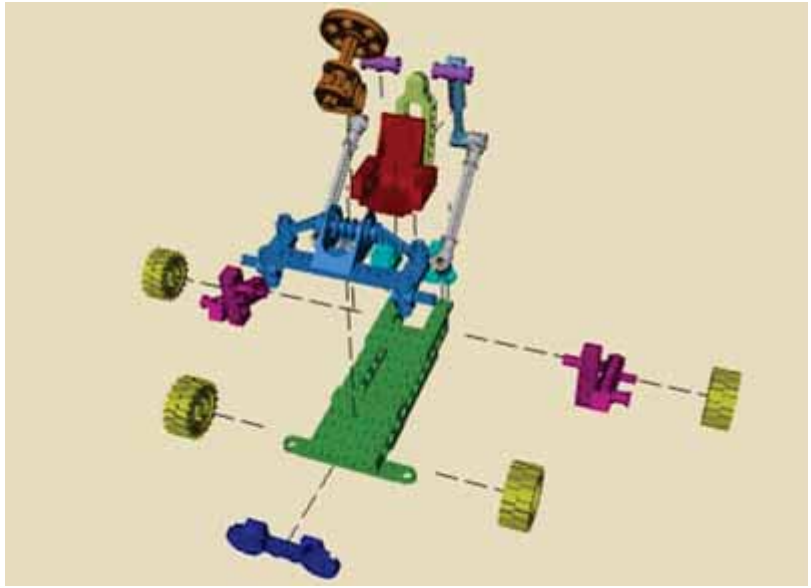
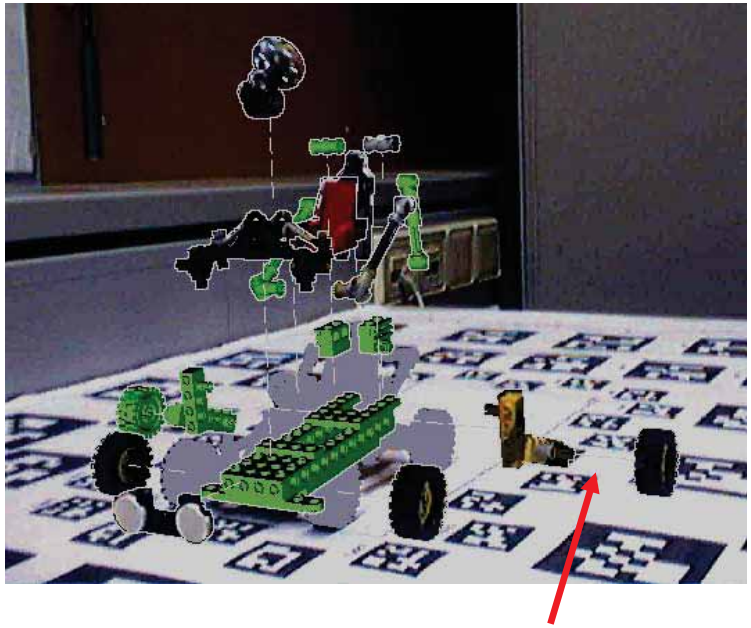
Connection Lines in AR

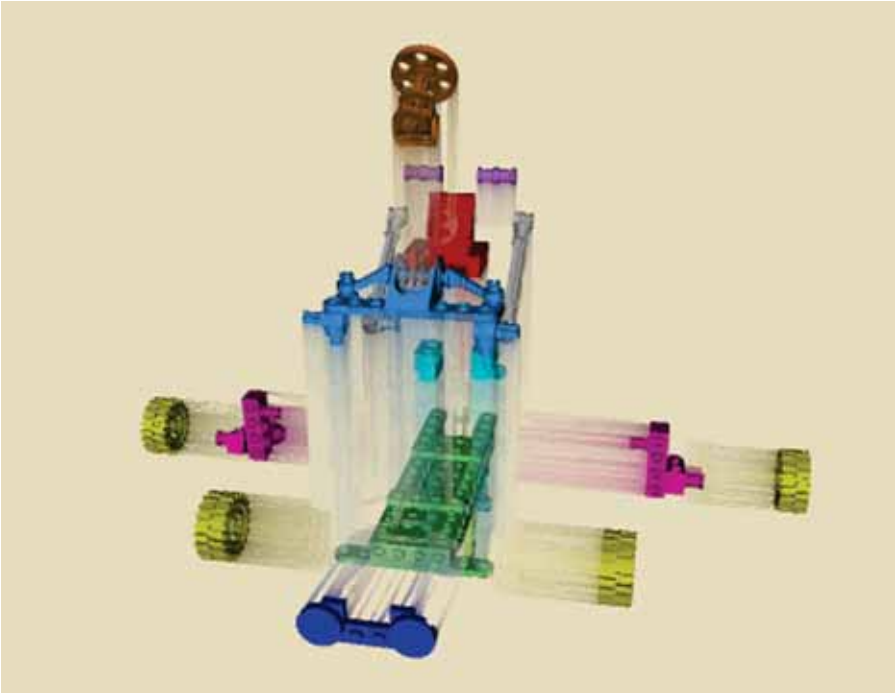
- Help communicate transformations
- Thin and unconnected information over real background
  - May result in clutter
  - May be visually lost

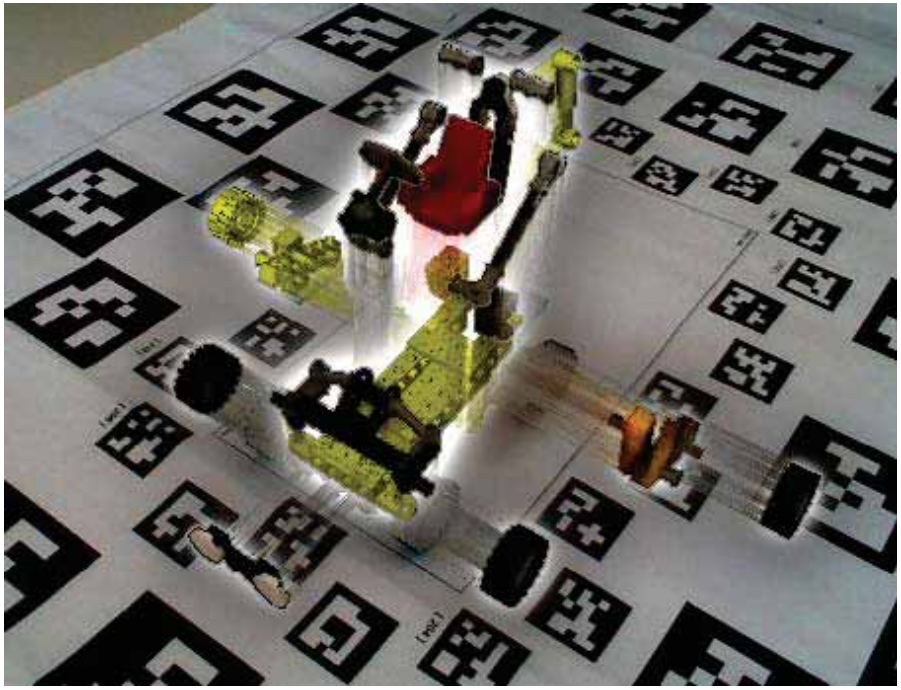




Connection Lines in AR

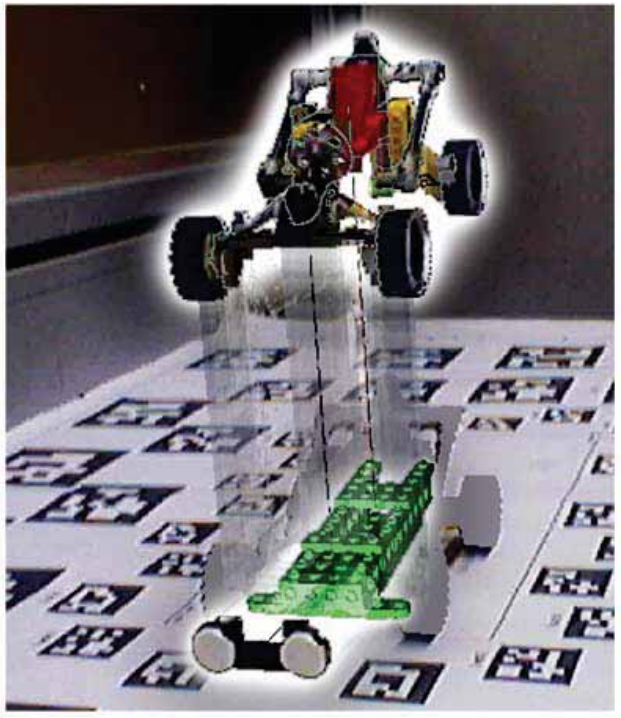
- Motion blur is a stronger visual communicator



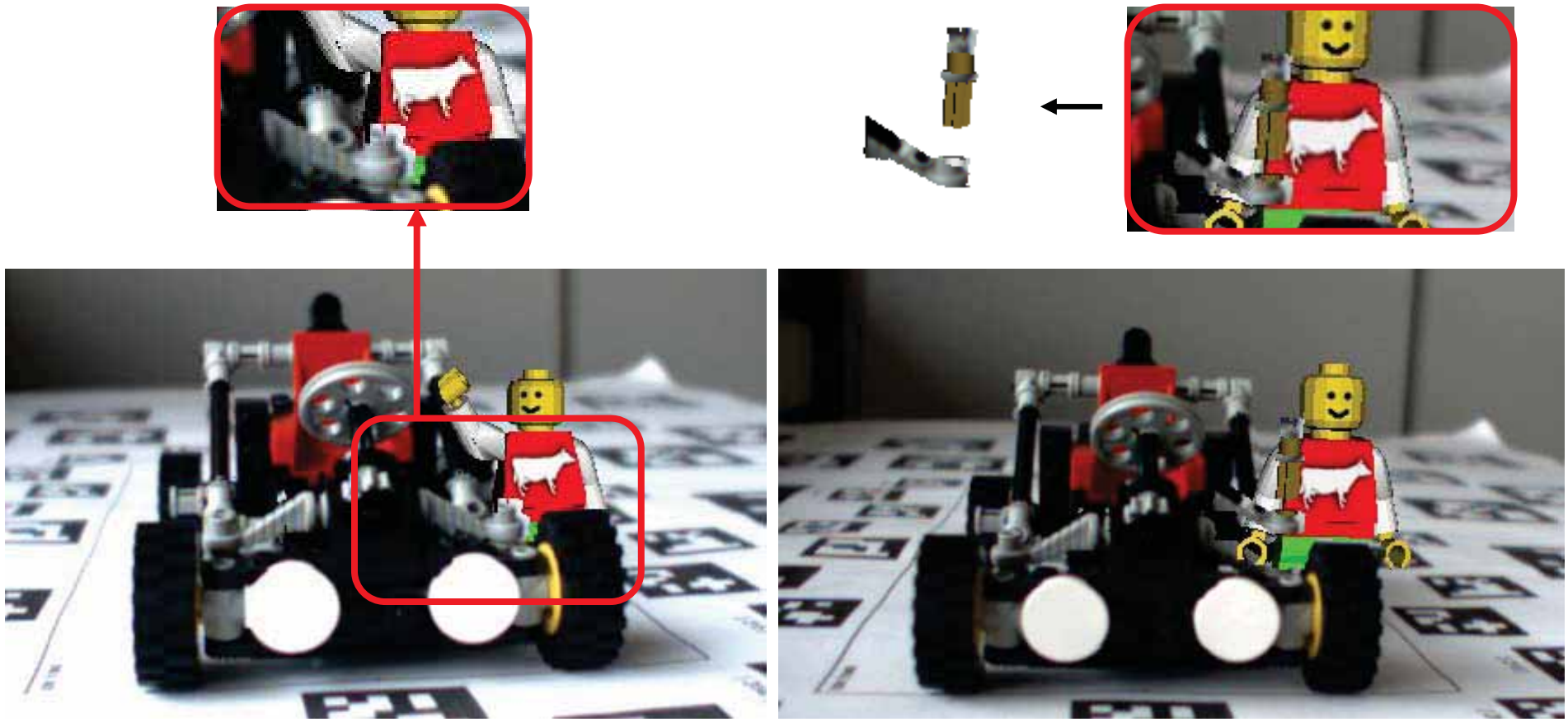


Embedded Connection Lines

- Motion blur is less cluttered
  - Embed connection lines in motion blur

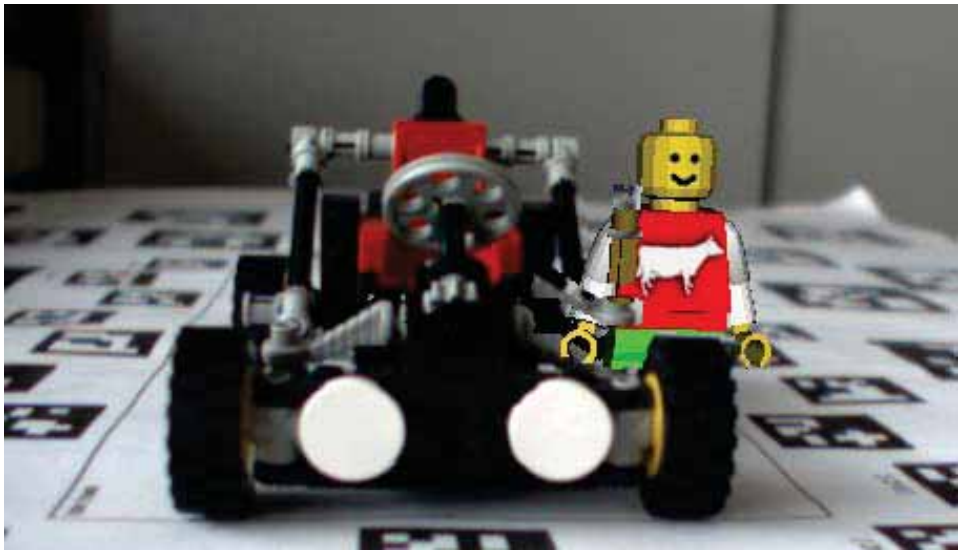


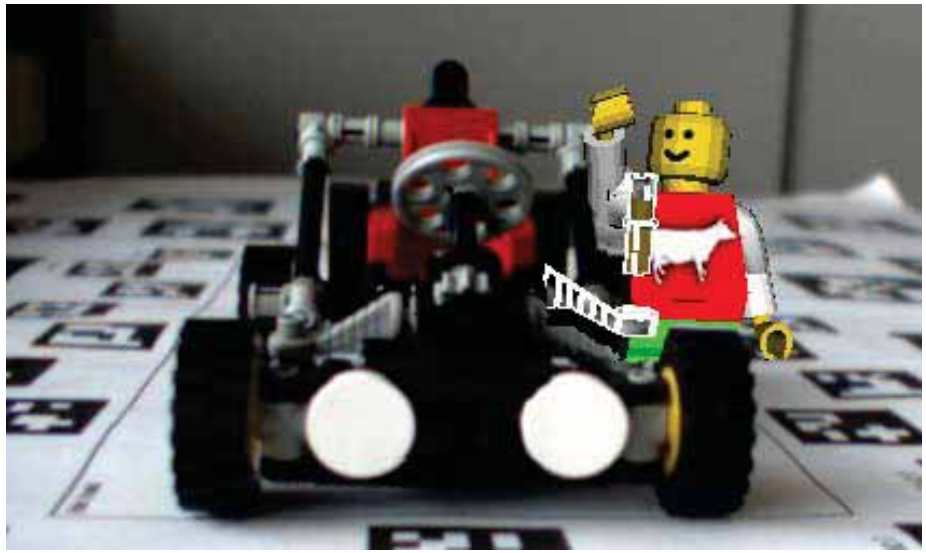
Error Compensation



Error Compensation

- … by virtualization (adding virtual context)



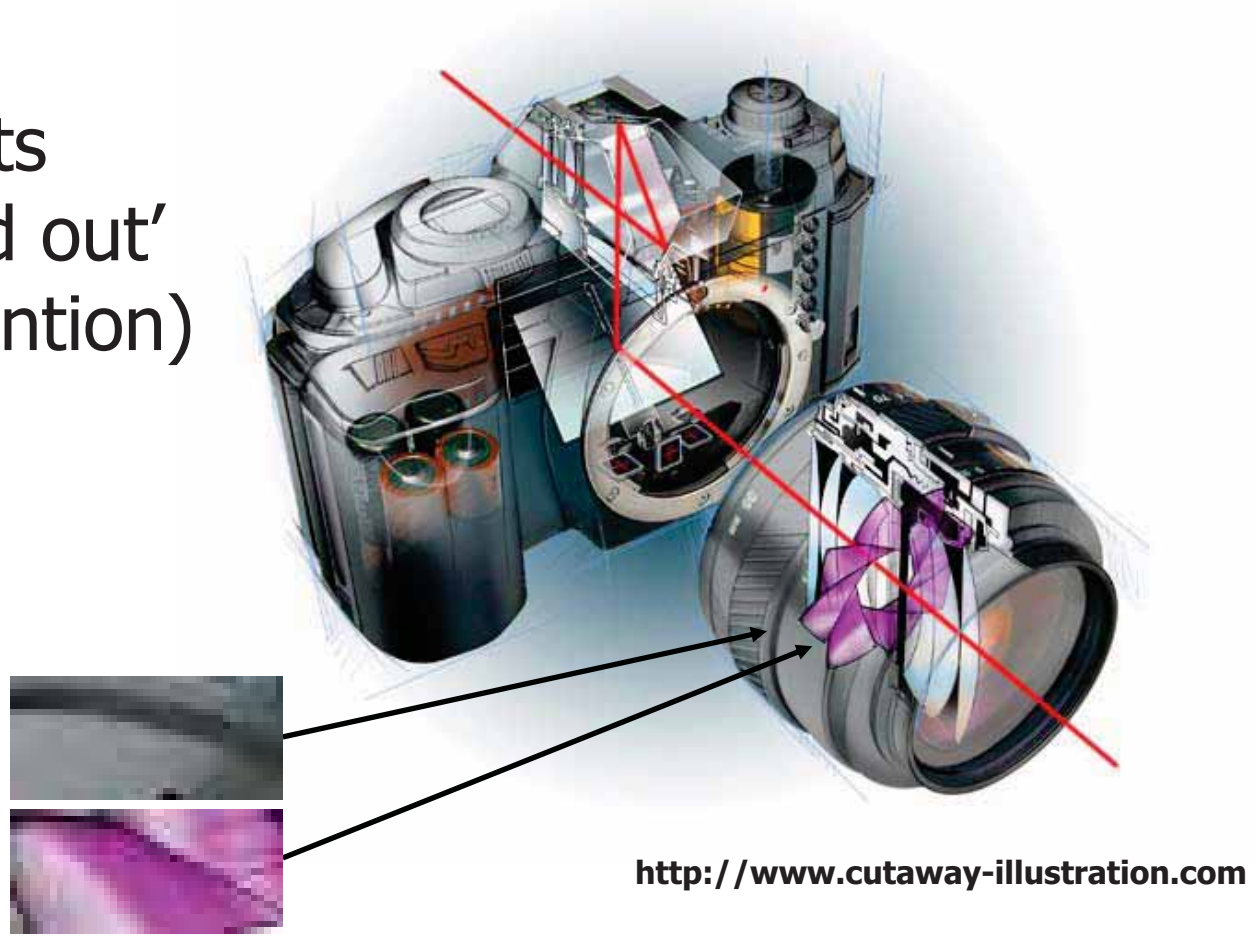


Illustrative X-Ray Visualization in AR

- Ghosting, Cut-away & Explosion Views -

Shading X-Ray Vision

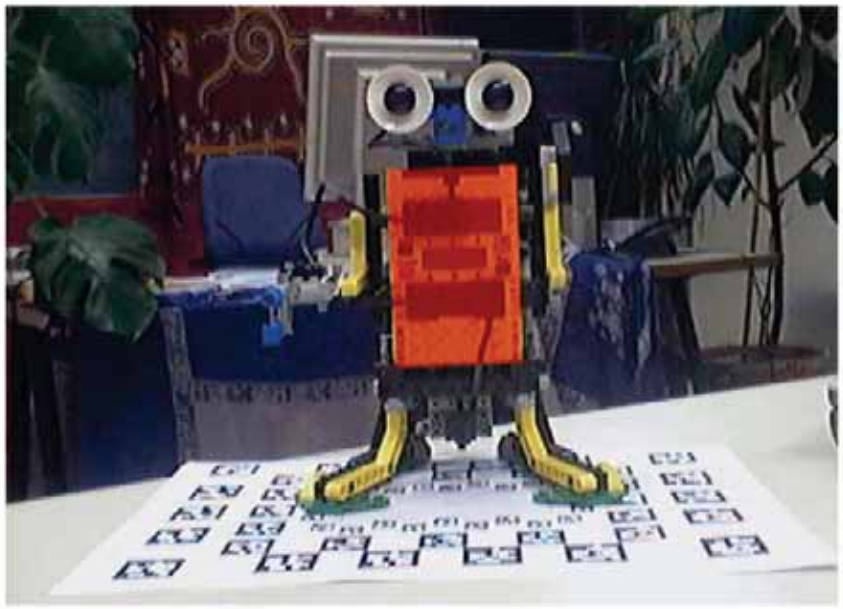
- Hidden objects visually 'stand out' (focus of attention)

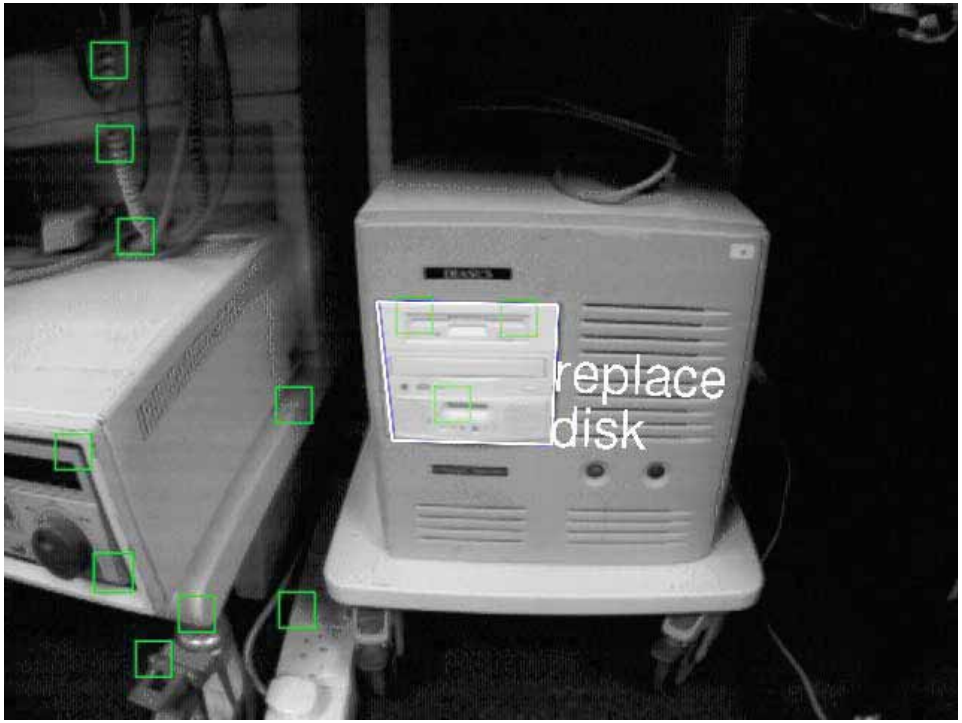


http://www.cutaway-illustration.com

Control of Attention

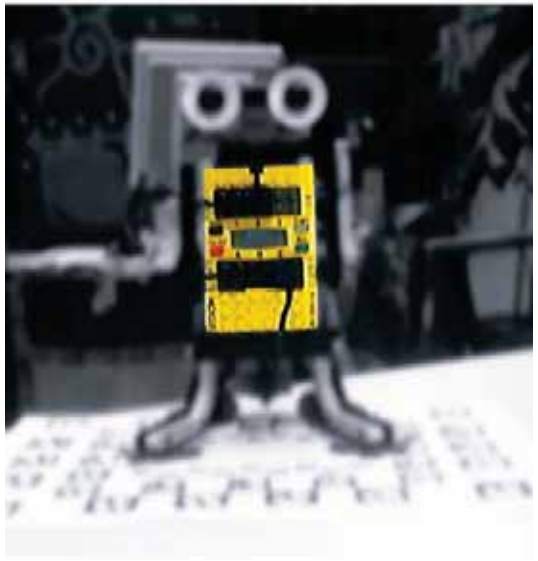
- General problem in AR
- Frames and arrows are impractical in x-ray visualization
- Need F+C shading/colorization





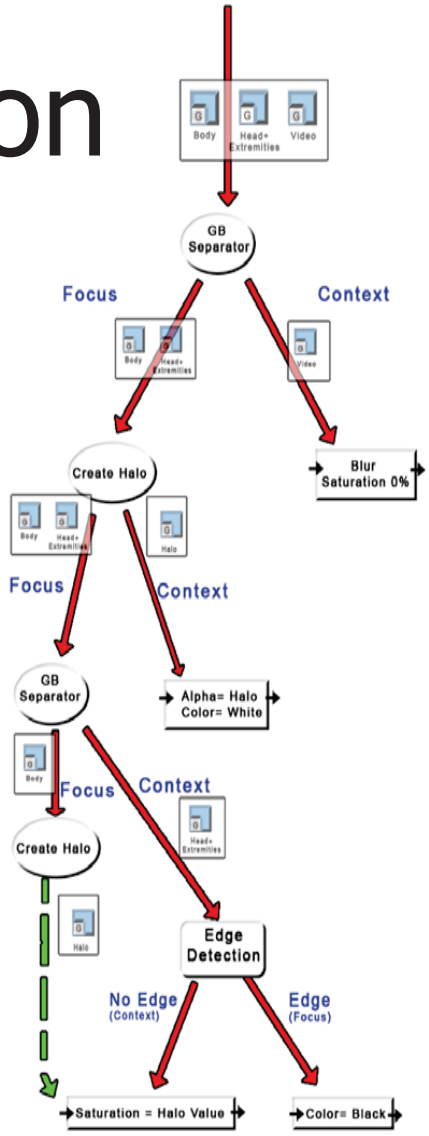
Focus and Context

- Binary F+C classification
  - Object relations are lost



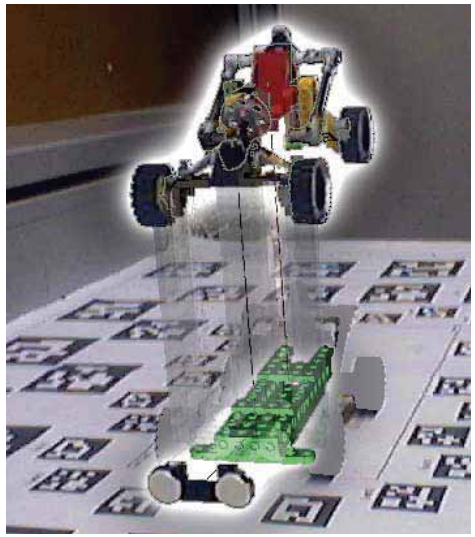
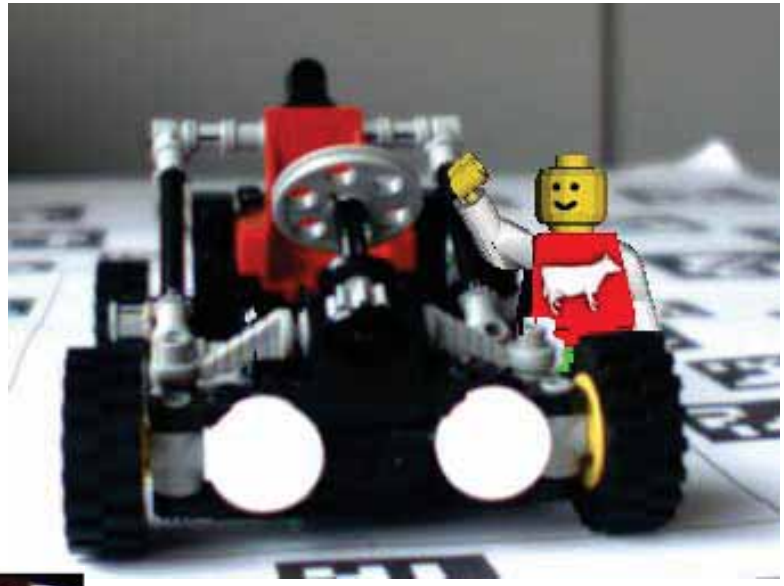
Context Preserved Attention

- Non-Binary, Non-Uniform F+C classification
  - … by cascading F+C classifications
- Emphasizing real focus:
  - Add virtual context (halo, de-emphasize mask)
  - Substitute with more salient VR
- Deemphasizing real context
  - Image operators (de-saturation, blur)



Visual Communication in AR

https://www.icg.tugraz.at/~denis/visualAR



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