

Augmented + Mixed Reality



Extending X3D for AR/MR apps!

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BOF on AR & MR at Siggraph 2011
Vancouver, August 2011

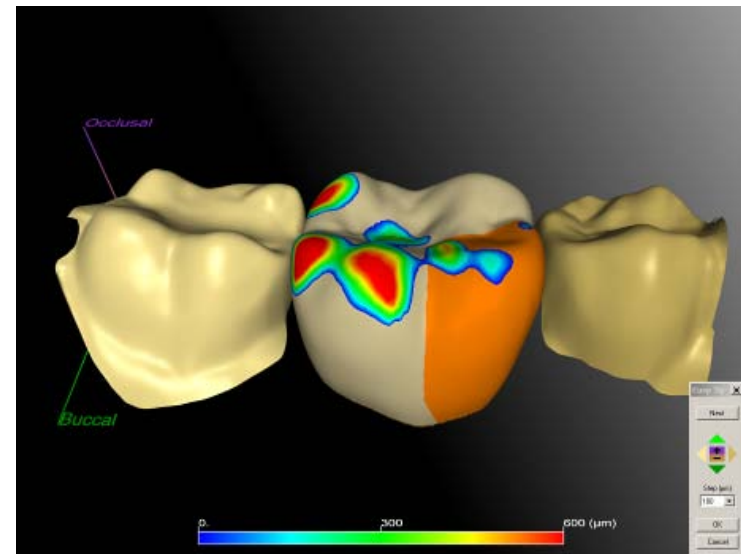
Fraunhofer IGD

Applied Science and Technology Transfer



- World leading network for applied research and development in the field of Visual Computing
- Director: Prof. Dieter Fellner
- 160 Scientists
- 15,8 Mio € Budget
- 4 locations
 - Darmstadt, Rostock, Singapore, Graz
- 12 R&D Departments

- VR/AR department
 - Exists since 1992, ~ 20 Scientists





Computer Vision



Computer Graphics



Interaction Technologies

Competence Center Virtual & Augmented Reality




- **High Quality Rendering**
 - High Quality Realtime Rendering
 - Scalability from Smartphone to PC-Cluster
- **Multimodal Interaction**
 - Immersive Interaction
 - Multi-Touch-Systems, Haptic Interaction
- **Development of VR-Systems**
 - Tiled Display HEyeWall 2.0 & Cave
 - Movable Screen
- **Computer Vision Based Tracking**
 - Markerless Tracking
 - Combination of CV & Inertial Sensors
 - Augmented Reality on Smartphones



Fraunhofer IGD

Application Areas



Industrial

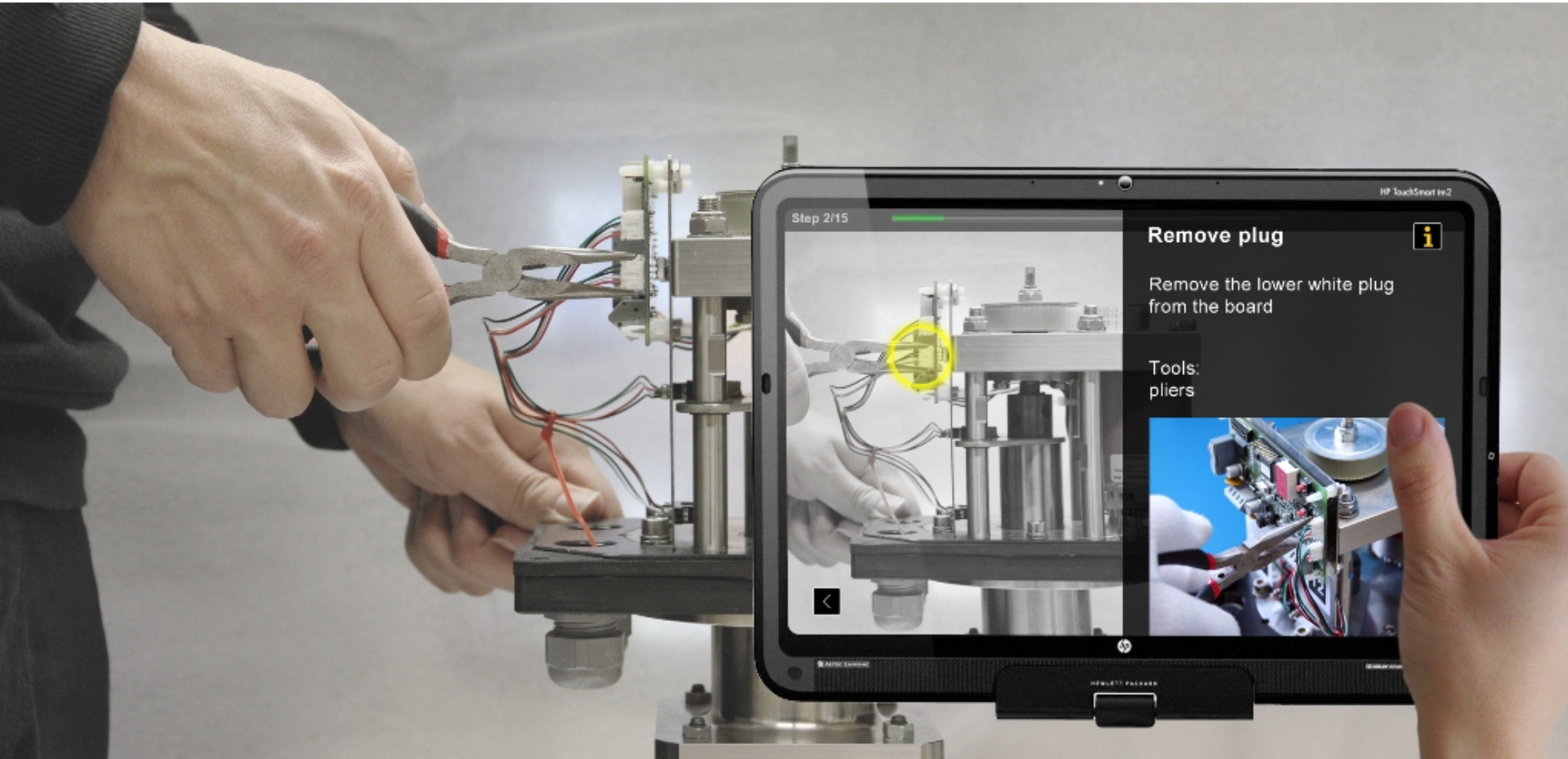


Cultural Heritage / Tourism



Fairs / Museums

Augmented & Mixed Reality

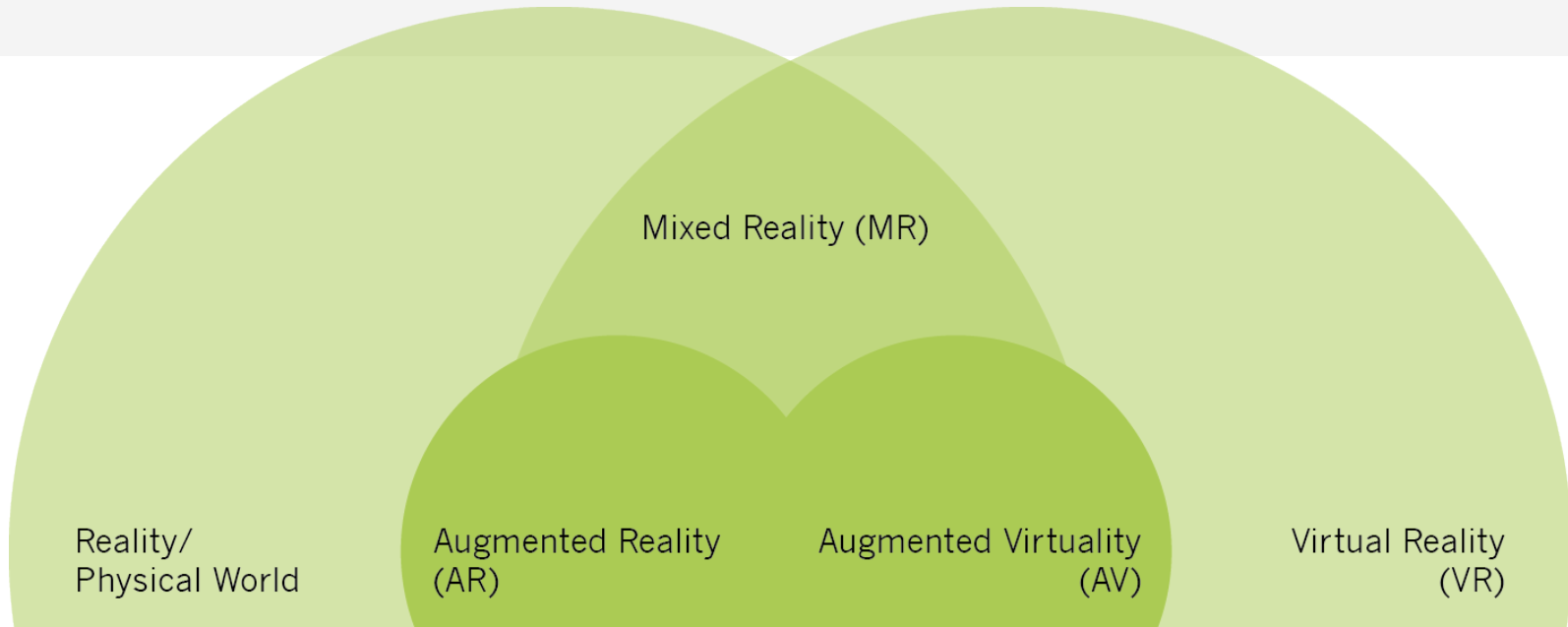


Augmented & Mixed Reality



Presenting information in the user's view
superimposed on & aligned with reality

Augmented & Mixed Reality



Based on Milgram, 1994

Virtual Reality (VR) – Only virtual objects/ data

X3D as standardized model & application description language

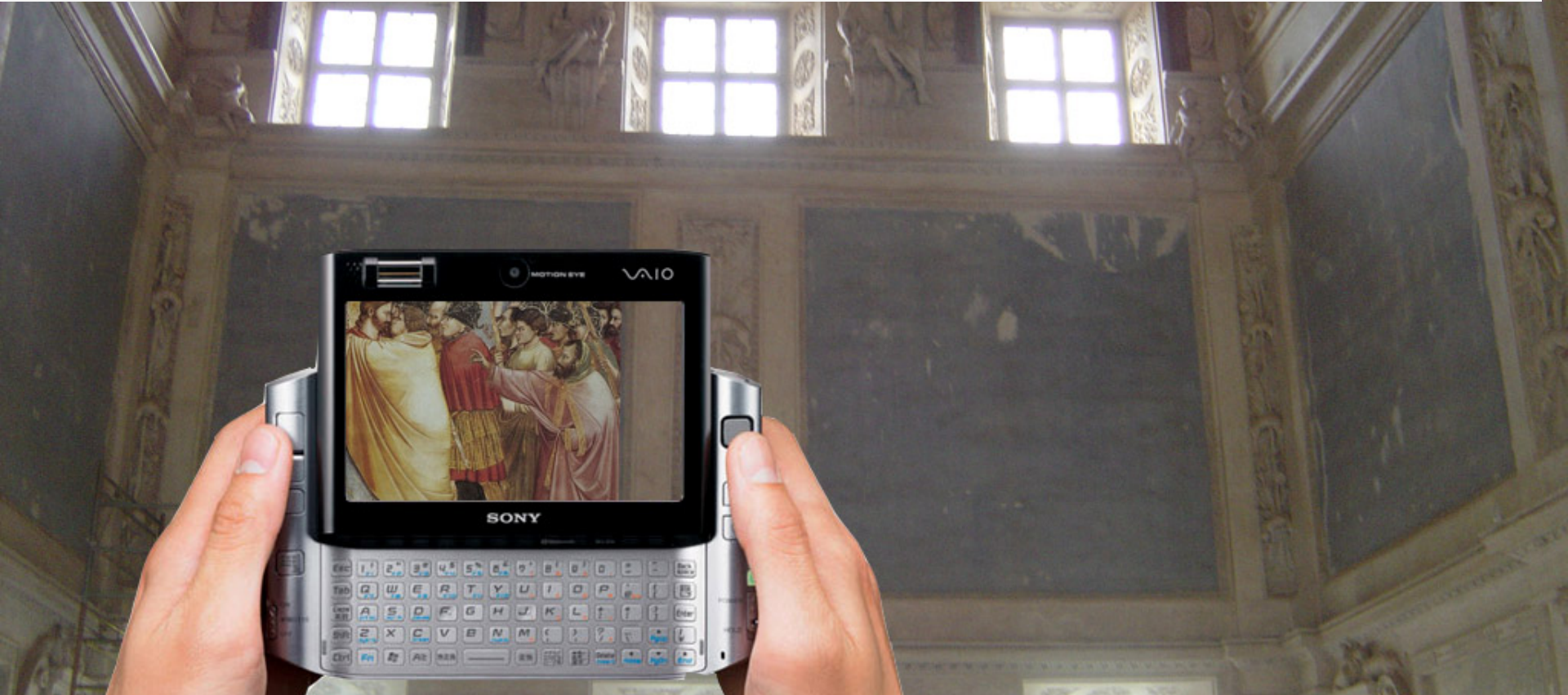
Augmented Reality (AR) – Virtual and real objects

X3D as platform (loader) for geometric models

Mixed Reality (MR) – Continuum between VR and AR

X3D still misses some features (sensor data stream integration + rendering extensions)

Augmented Reality

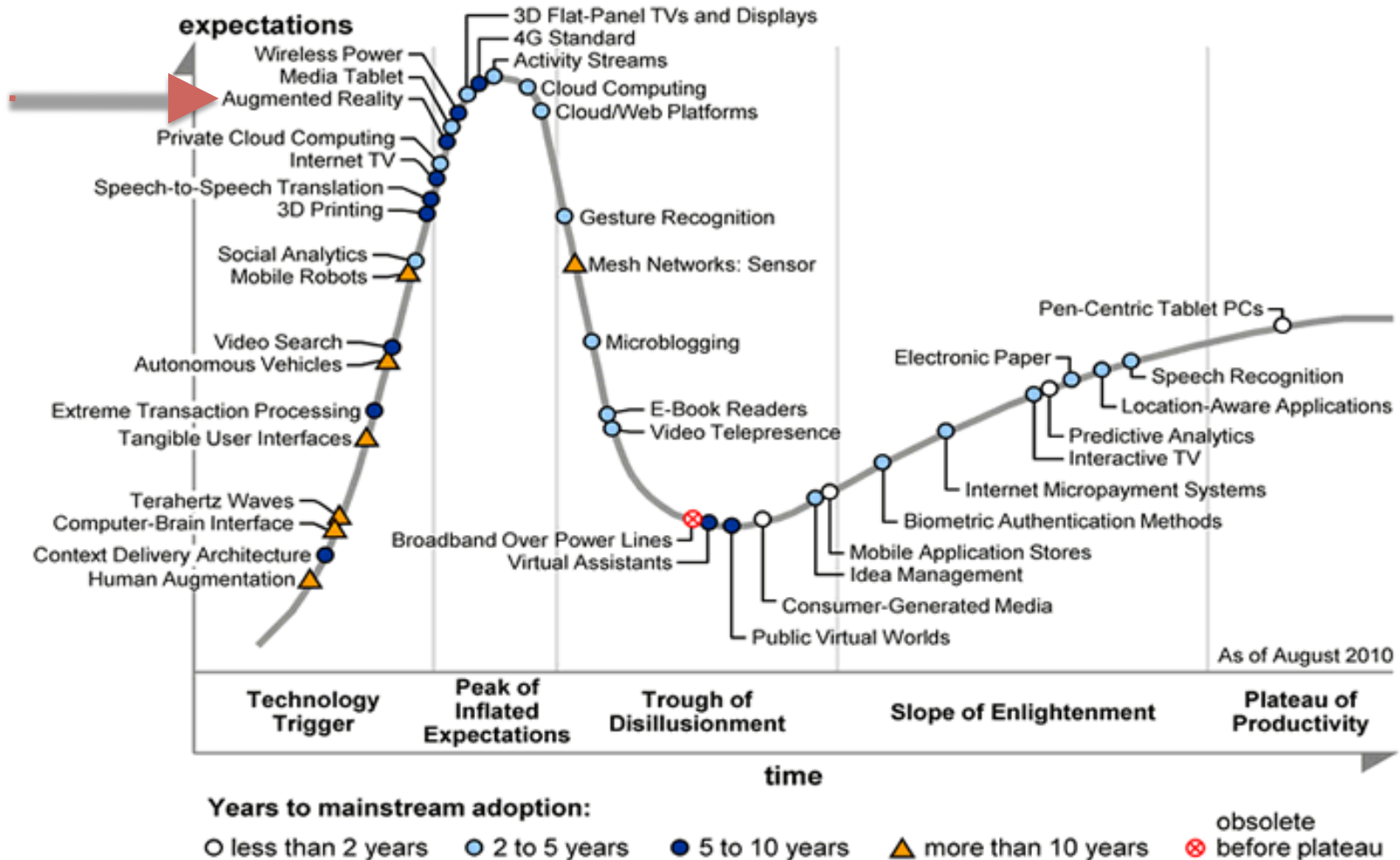


Fusing real and virtual objects with the camera of mobile devices.
video-see-through: the real world is viewed and perceived through a camera with superimposed information

AR: Still an emerging technology ?



Source: Gartner, Technology Hype Cycle 2010



Hardware Solutions for AR

yesterday, today, tomorrow



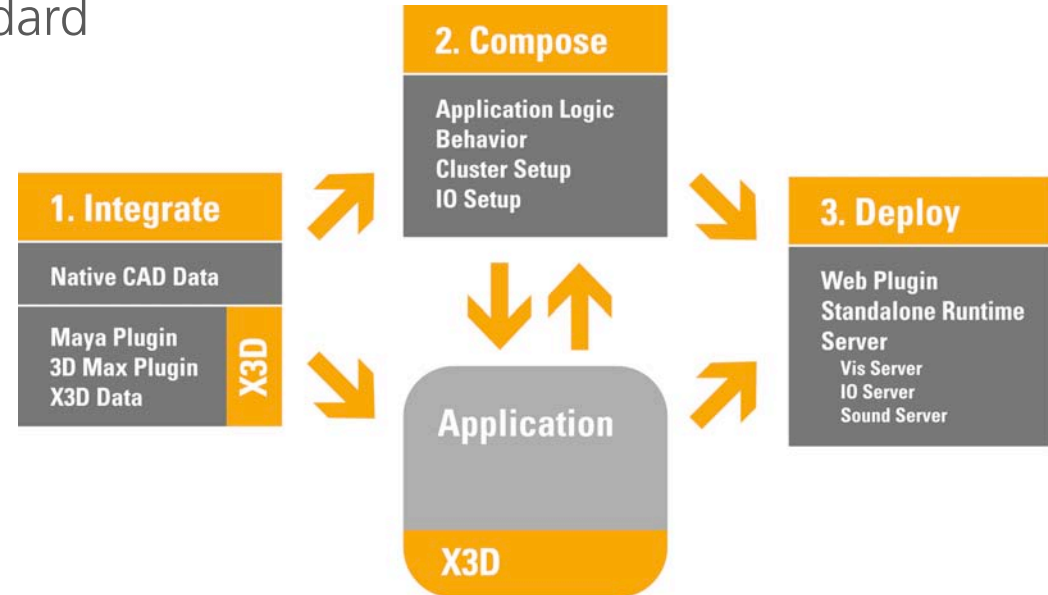
- Head Mounted Display
 - Video See-Through
 - Optical See-Through
 - Immersive but tunnel vision
- Installations
 - Augmented Reality Telescope
 - MovableScreen
- UMPC / Tablet PC
 - Digital Magnifying Glass
 - Poster Tracking
 - Not immersive but flexible
- Smartphones
 - Platform of today & the future



Standardisation !?



- 2011: Still no deployment-standard for AR/VR Application
- IGD adopts and extends related standards
- X3D/Web3D ISO Standard
- Describes abstract functional behavior time-based interactive 3D environment
- W3C POI Group, AR Working group



Easing Creation & Deployment with Standards



- X3D, JavaScript, HTML
- instantReality, x3dom, mobileAR (instantMini)
- X3D App-layer
- > 40 Device Handler
- > 15 CV Tracker
- Distributed Rendering
- IO-Handler-SDK
- Windows/Mac/Linux, iOS, Android coming
- Free for non-commercial use
- HTML compatible (X3Dom)
- Running on Mobiles (instantMobile)



Scenarios & requirements for industrial AR applications

AR as Mixed Reality Technology

AR 2010 and 1995



Since 2008

- Mobile/Smartphone technology
- POI is geo-position
- Layar, Wikitude, Google Goggles
- Vision-based-tracking is optional



Since 1995

- Stationary, based on VR technology
- POI was marker (CyberCode, 1996)
- Part of MR-continuum (Milgram, 1994)
- Vision-based-tracking is mandatory





AR-Service Application

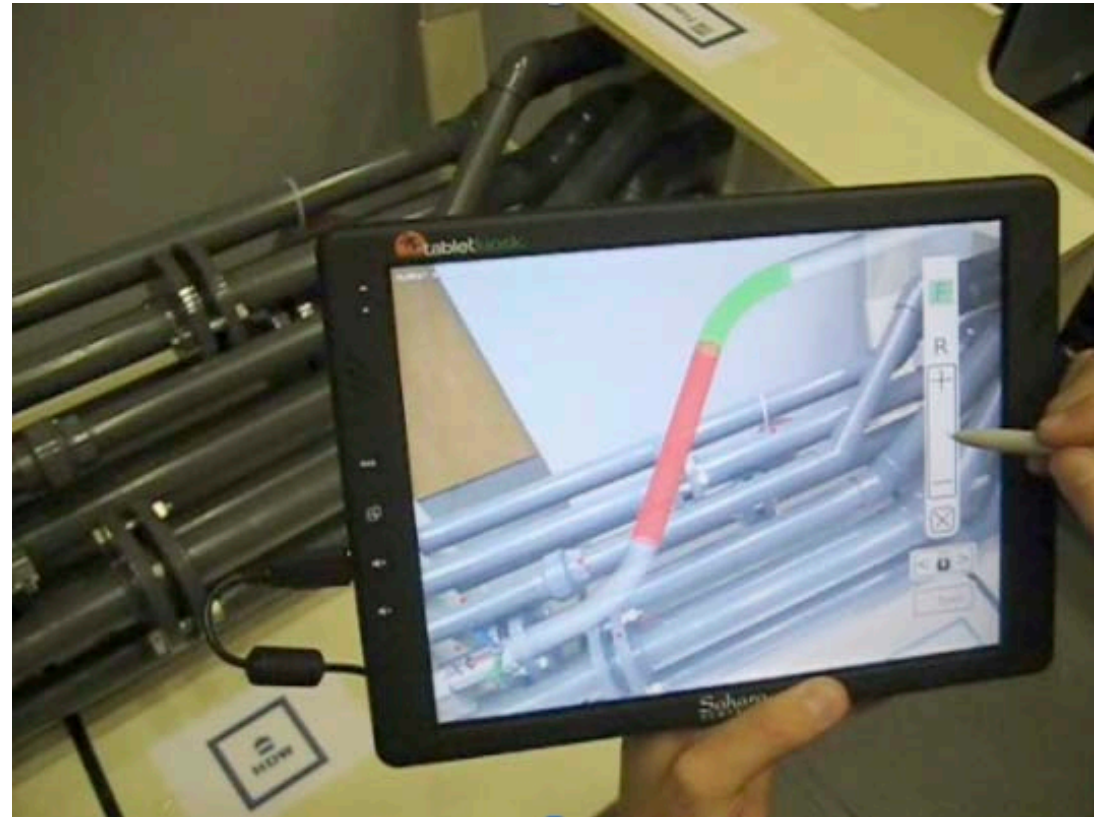
- First industrial AR scenario
- Marker based tracking
- Modified VR-HMD
- SGI for rendering





Comparison of Planning and Reality

- Visualization of Geometry Differences
- Inclusion of Simulation Data into real Environments
- Verification of virtual/ CAD Models
- Planning of Pipes



Service application scenarios

Industrial Applications developed at Fraunhofer IGD

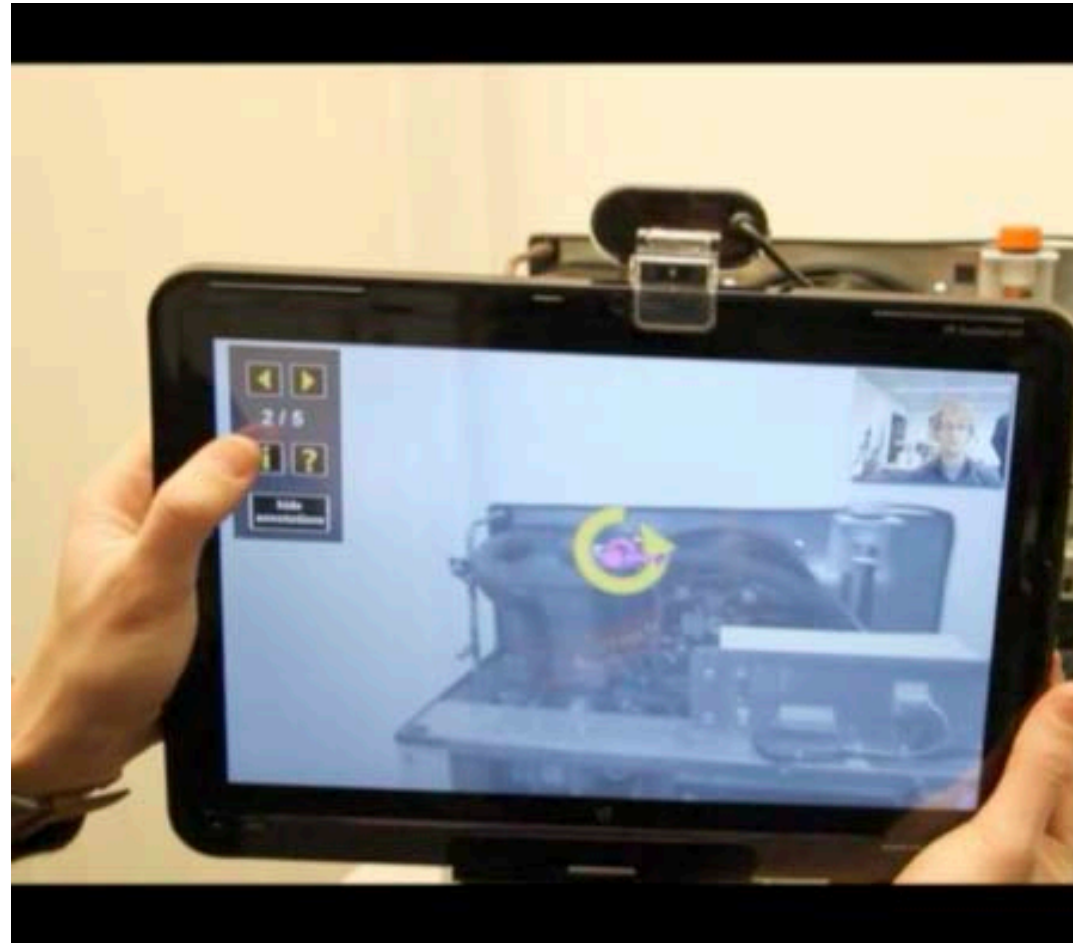


Remote Expert Scenario

- Distributed Mixed Reality
- Video Streaming
- Annotation/Scribbling Tools

AR Maintenance

- Rittal as a main partner
- Support Service Technician
- Visual Guidance
- 3D-Animations
- Authoring Tool



In Practice: X3D Integration CV Component Extension



- CV-backend:
IO-Node type 'VisionLib'
- VisionLib pipe configurations
are in external file (*.pm)
- Maps VisionLib DataSet
elements to X3D fields
(e.g. camera)
- instantVision to
author action pipe (*.pm)



In Practice: X3D Integration

CV Component in X3D



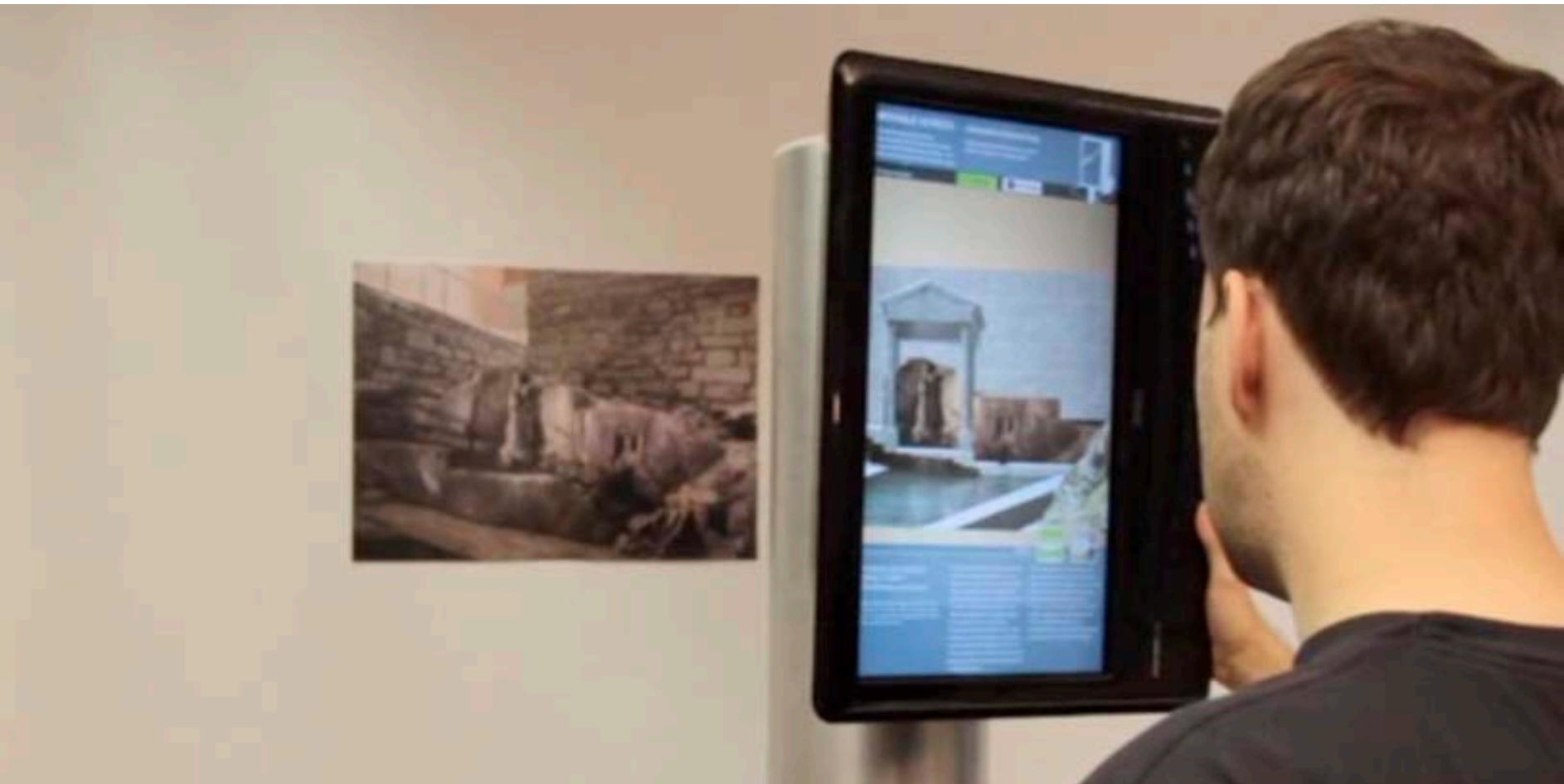
```
<IOSensor DEF='vl' type='VisionLib' configFile='visionlib.pm'>
  <field name='VideoImage' type='SFImage' />
  <field name='ModelView' type='SFMatrix4f' />
  <field name='Projection' type='SFMatrix4f' />
</IOSensor>
<Viewfrustum DEF='vf' />
<PolygonBackground>
  <PixelTexture2D DEF='tex' />
</PolygonBackground>
```

```
<Group DEF='sceneObject'>
  ...
</Group>
```



```
<ROUTE fromNode='vl' fromField='VideoImage' toNode='tex' toField='image' />
<ROUTE fromNode='vl' fromField='ModelView' toNode='vf' toField='modelview' />
<ROUTE fromNode='vl' fromField='Projection' toNode='vf' toField='projection' />
```

In Practice: X3D Integration MR Installation



In Practice: X3D Integration

Organizing the AR-App in X3D



```
<Scene DEF='scene'>
  <!-- Protos -->
    <ExternProtoDeclare name='ModelOverlay' url="PROTO_ModelOverlay.x3d#ModelOverlay" />
    <ExternProtoDeclare name='TextOverlay' url="PROTO_TextOverlay.x3d#TextOverlay" />
    <ExternProtoDeclare name='ImageButton' url="PROTO_Interface.x3d#ImageButton" />

  <!-- Overlay: Text/Video -->
  <Viewspace DEF='GUI' translation='0 0 -0.9' >
    <ScreenGroup>
      <Transform translation="0 -535 0" containerField="children">
        <TextOverlay DEF="textOverlay" image_url="carvalh_text.png" size="768 300"/>
      </Transform>
      <Transform translation="310 -360 0" containerField="children">
        <ImageButton DEF="bt_video" image_url="vid-thumb0.png"
          imageOver_url="vid-thumb1.png" size="96 96" toggle_onTouch="TRUE" />
      </Transform>
    </ScreenGroup>
  </Viewspace> ...
</Scene>
```



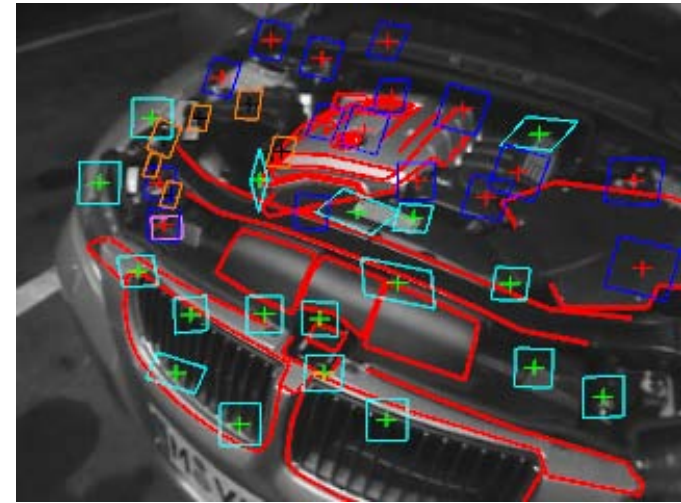
Robust and Markerless Tracking

Robust and Markerless Tracking

Industrial Applications at IGD



- Initialisation
 - Edge Model
 - Poster Tracking
 - 3D-Reconstruction
- Frame-to-Frame Tracking
 - KLT
 - Edge Model
 - Poster Tracking
- Hybrid sensory
 - Inertial Sensor & CV based Tracking
 - TOF & CV based Tracking



Robust and Markerless Tracking

Initialisation of the Tracking with line model



- Line model is brought near to the real object
- Automatic and precise registration
- No key frames
- No learning phase



Robust and Markerless Tracking

Point Tracking & 3D Reconstruction



- Point tracking
 - Extraction of new points
 - Pose computation with known 2D/3D correspondences
 - Estimation or refinement of the 3D coordinates
- 3D-Reconstruction
 - Iterative refinement
 - Computation of the uncertainty (covariance)
 - Refinement with each new frame



Robust and Markerless Tracking

Hybrid Tracking Technology

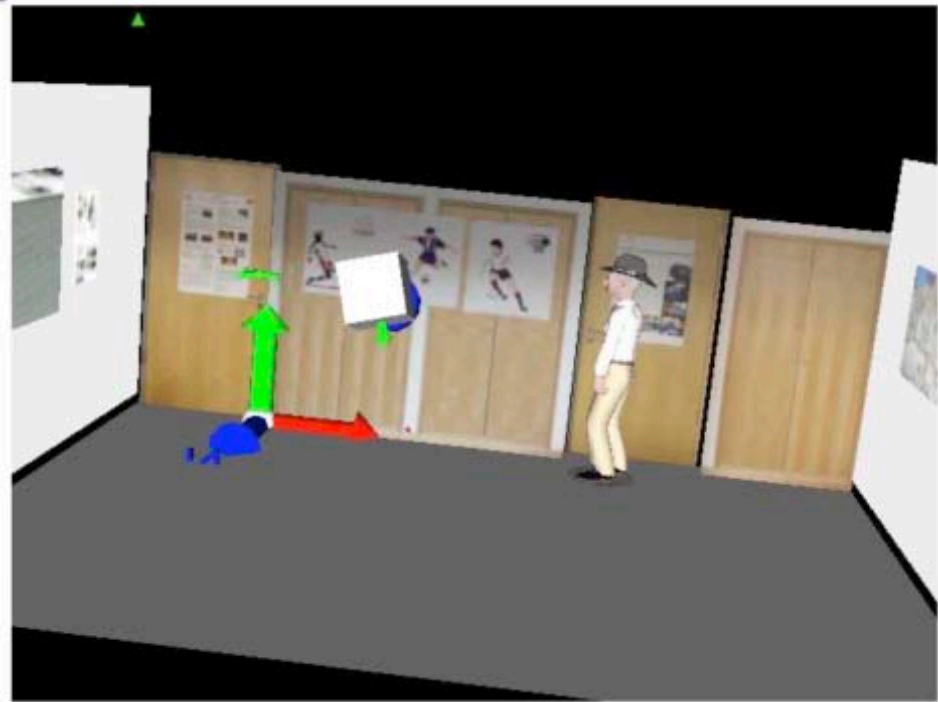
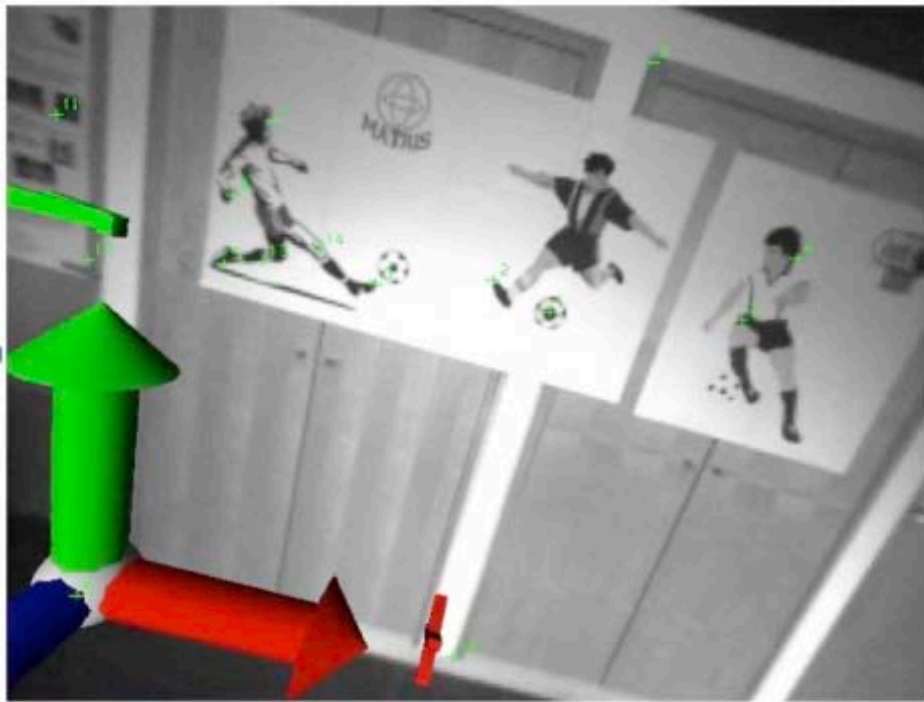


- Combination of CV & Inertial Sensors
 - Alignment with full textured 3D-modell
 - Rendering of hypothesis based on camera pose extrapolation
 - Registration of captured camera frame and rendered hypothesis
- Combination of CV & ToF camera
 - Measurement of depths information
 - Iterative Closest Point Matching



Robust and Markerless Tracking

Hybrid Sensor Technology



MATRIS: Hybrid Sensor Technology

- Combination of CV & Inertial Sensors
- Overcome struggling situations, where CV-only may fail (motion blur, fast cam movement)



Scenarios for industrial & heritage AR applications

Augmented Reality on Mobile Systems Industrial Applications



Downscaled Systems for mobile AR

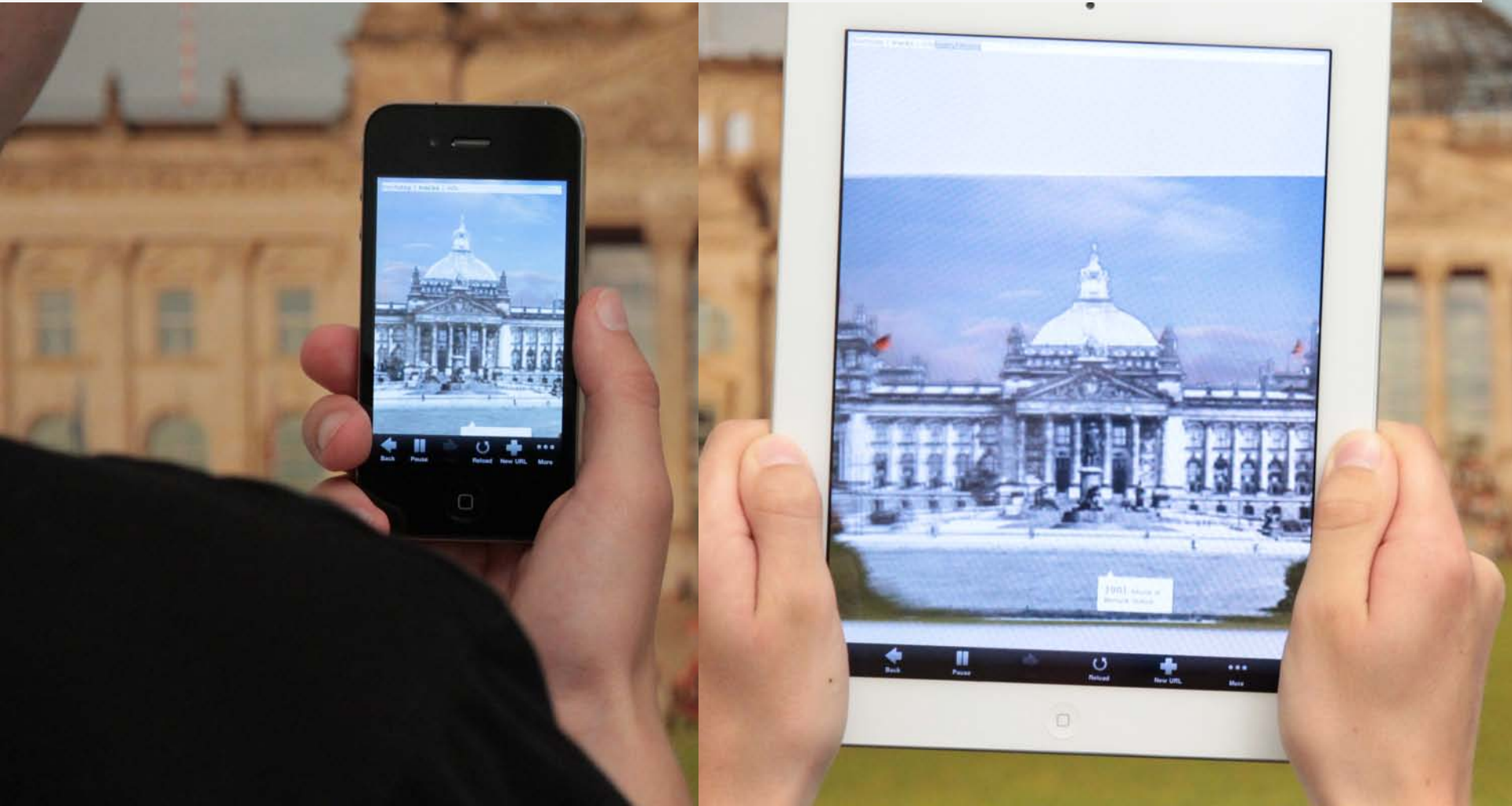
- Custom Hardware
- UMPCs
- Smartphones & Tablets
- Markerless Tracking
 - Distributed Mixed Reality
 - Video Streaming
 - Complete AR/CV Systems

Augmented Reality on Mobile Systems CV Tracking



Augmented Reality on Mobile Systems

CV Tracking



Smartphone Augmented Reality

Platform capabilities: Ready for AR



- Camera background
 - Video See Through
 - Image processing (Android)
- Compass, Gyro, Accelerometer (Viewing direction)
- GPS (outdoor position)
- 3G Network
- Computer Vision - capable

- No prototype platform anymore!
- Eased deployment: AR for mass markets
- Still custom solutions



Smartphone AR

Platform capabilities



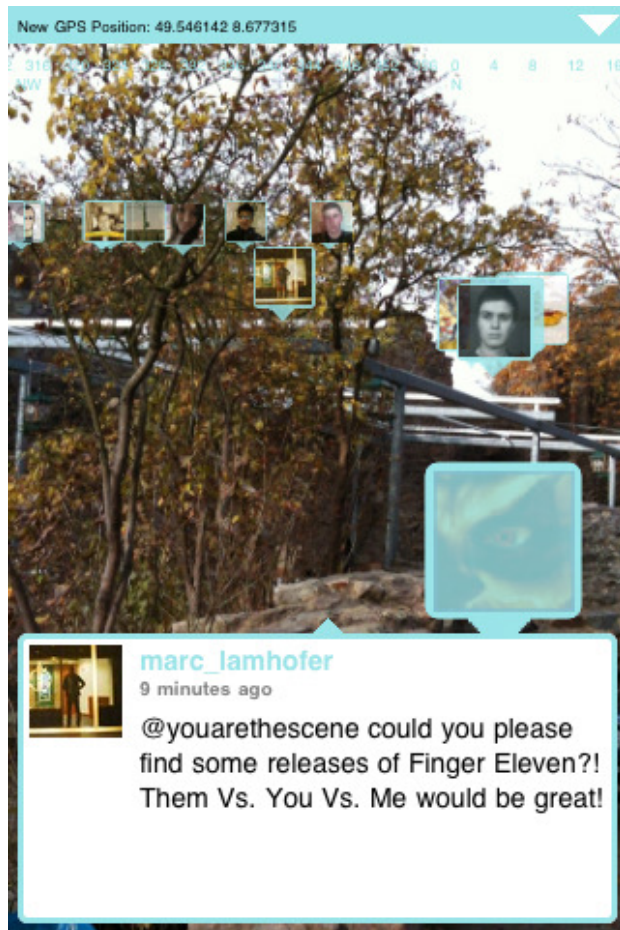
1. Generation: Sensor Tracking only

- Inaccurate sensor tracking
 - > floating/drifted overlays
- due to limited on-device CV Tracking
- Limited battery power
 - > draining very fast
- Lightweight AR Apps:
Annotated landscapes
(Wikitude, Layar, others ...)



Sensor-only „Bubble AR“

POI & Geo-referenced AR on Mobiles

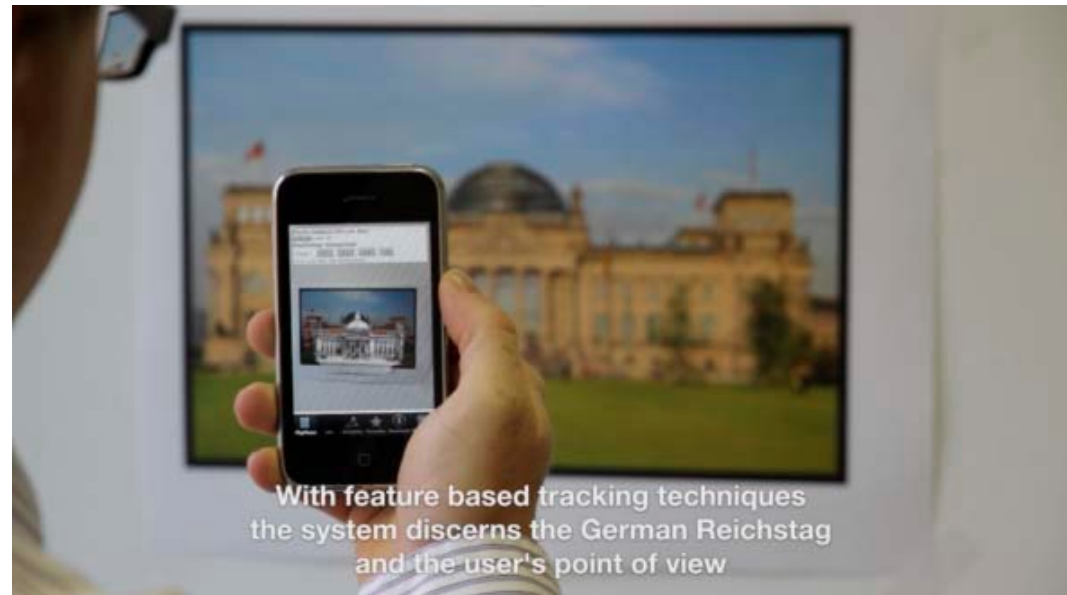


Smartphone AR

IGD: ComputerVision on Smartphones



- MobileAR: Markerless Tracking on smartphones
- CV enables more complex overlays
- But: Harder to obtain
- “X3D” on Smartphones
 - Webapp approach
 - HTML / X3Dom / JS / CSS
 - Include X3DOM approach
 - WebGL/native Wrapper

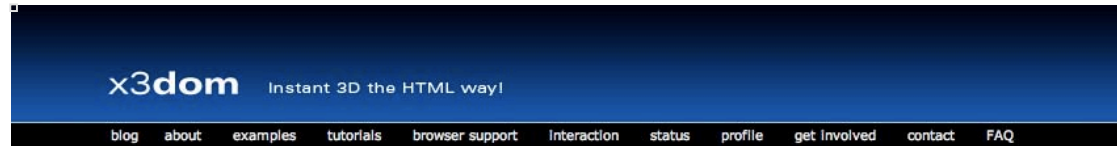


Excourse: instantReality & X3DOM

www.instantreality.org, www.x3dom.org



- HTML5/X3D App-Layer
- Integrates Supports Native, X3D-SAI-Plugin and WebGL for rendering
- Works without plugins
- Open-source / LGPL
- X3DOM: Web browser
- IR: Standalone-App
- both free for non-commercial use



Application specific navigation

November 12th, 2010

Another [interesting external show-case](#) which demonstrates how you can build any form of application-specific navigation. You, as application developer, can decide whether you allow no navigation at all, use some of the internal navigation modes or code your own way to map any user-input to any form of camera motion.



The shown auto-navigation scenario is also interesting for people which try to find the shortest way as quickly as possible in an unknown building. This is an important question for e.g. search and rescue teams.

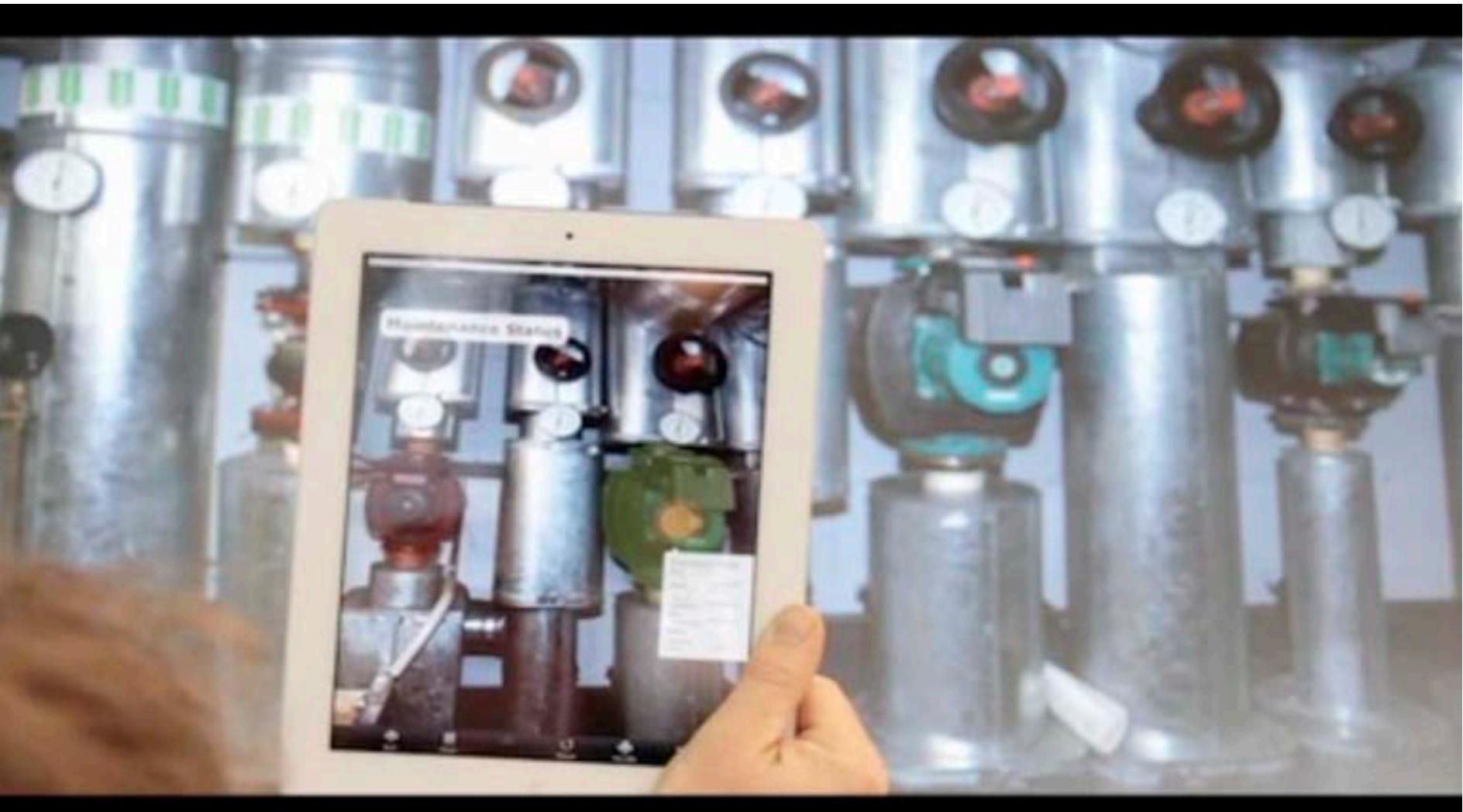
Posted in [Uncategorized](#) | [Edit](#) | [No Comments](#) »

Smooth camera animation added

November 5th, 2010

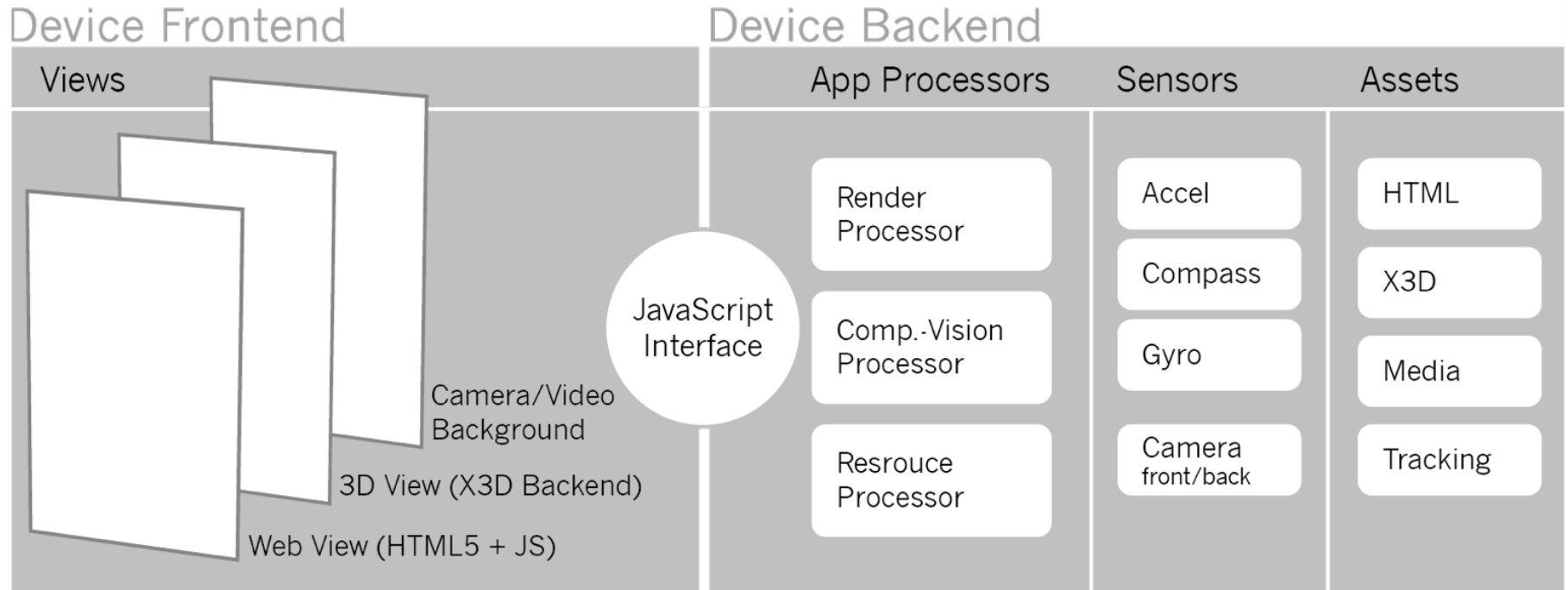
Thanks to Yvonne and [Marc](#) we have now the same smooth camera animations as in [instantReality](#). These animations are automatically generated if you bind the camera. This example allows you to switch between different viewpoints (cameras) which are part of the content.

Augmented Reality on Mobile Systems



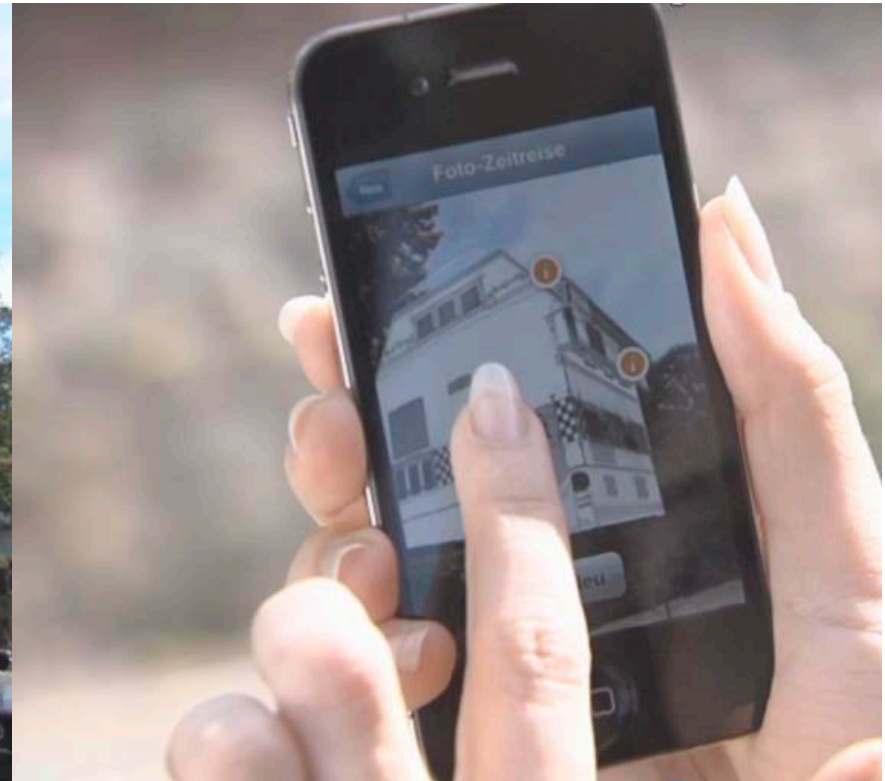
WrapperApp Concept on Mobiles

IGDs MobileAR Framework



Smartphone AR

AR-Browser: Apps in HTML





Fusion of CV & CG

Ongoing Development



- High Quality Rendering in AR
 - PRT Rendering
 - Capturing of Illumination Environment using a Fisheye Camera
 - Realtime Simulation of Illumination
- High Quality Rendering in AR
- Architecture, Interior Design



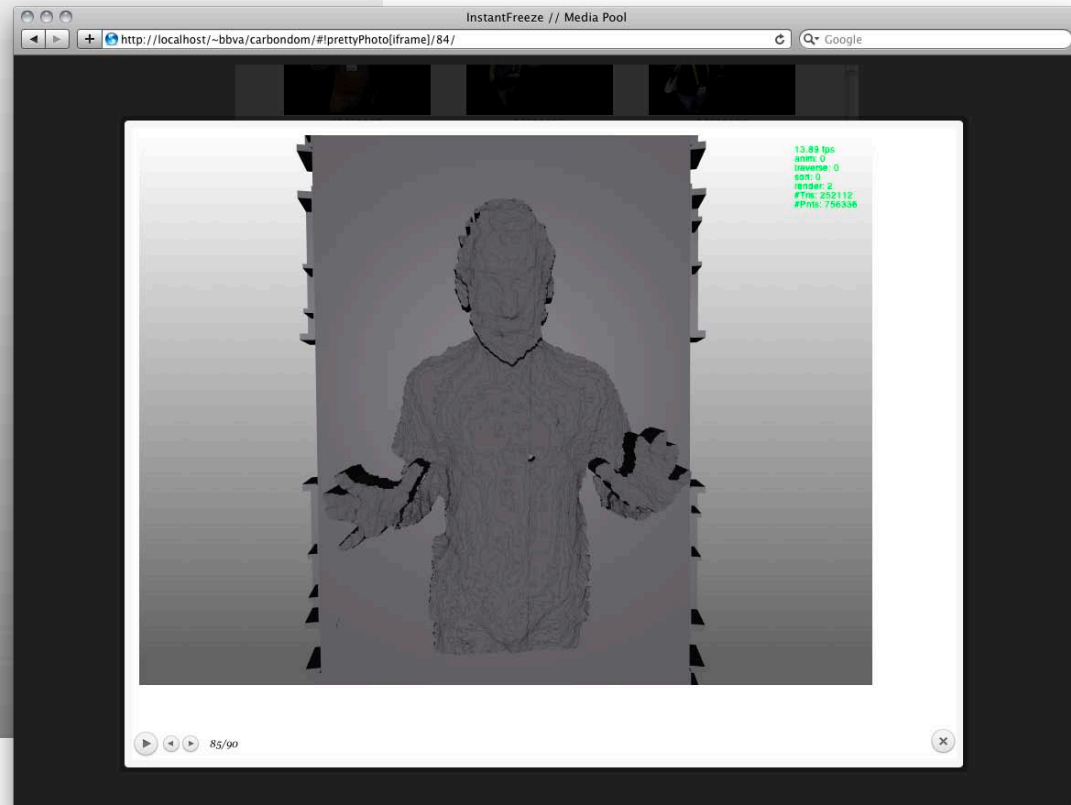
Fusion of CV & CG

Laboratory-solved issues: Lighting & Occlusion



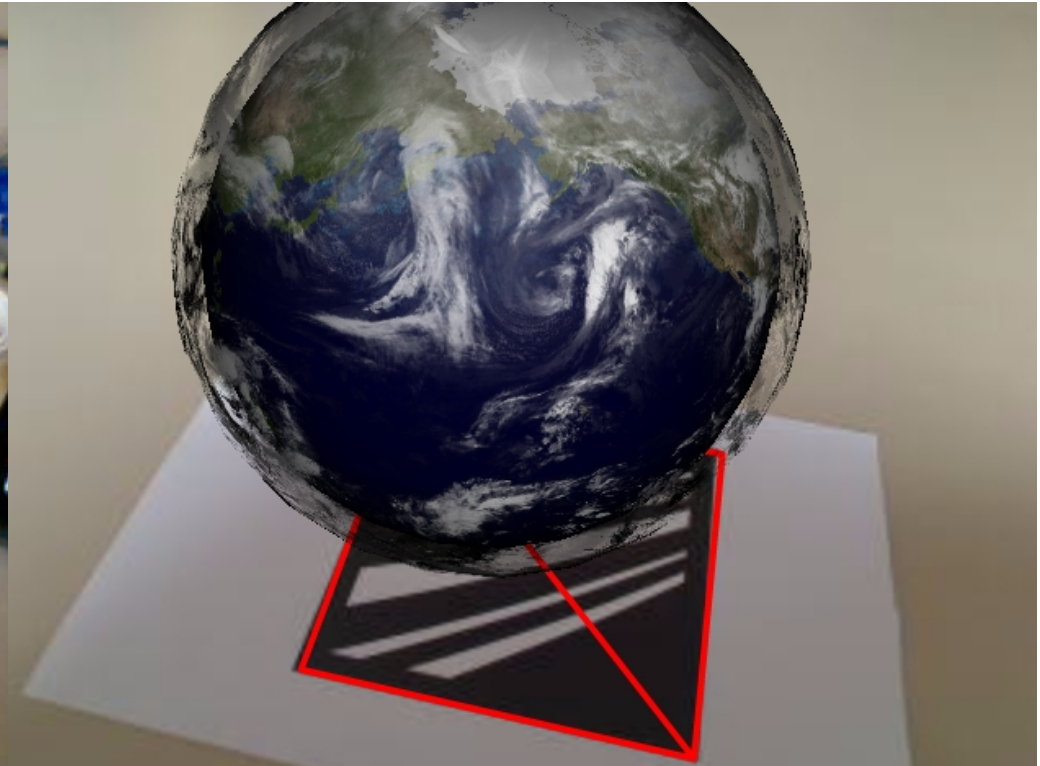
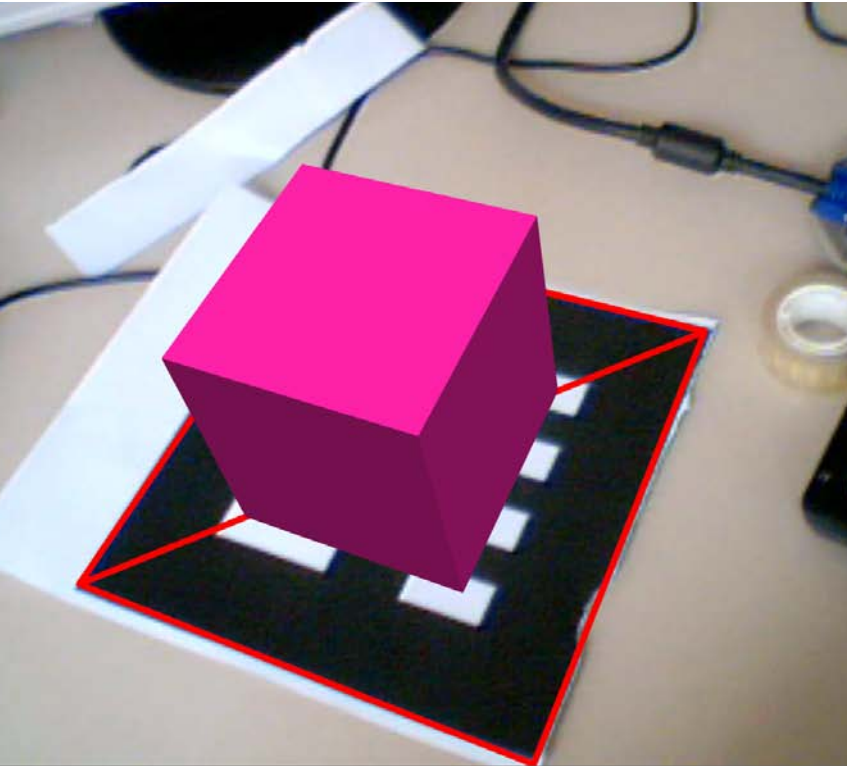
Fusion of CV & CG in X3D

Live-Demo at our booth #814:



Hands On!

Small X3DOM/AR Tutorial



Desktop-based AR

X3D: Browsers, Installations, Mobiles

« Write once, run anywhere »

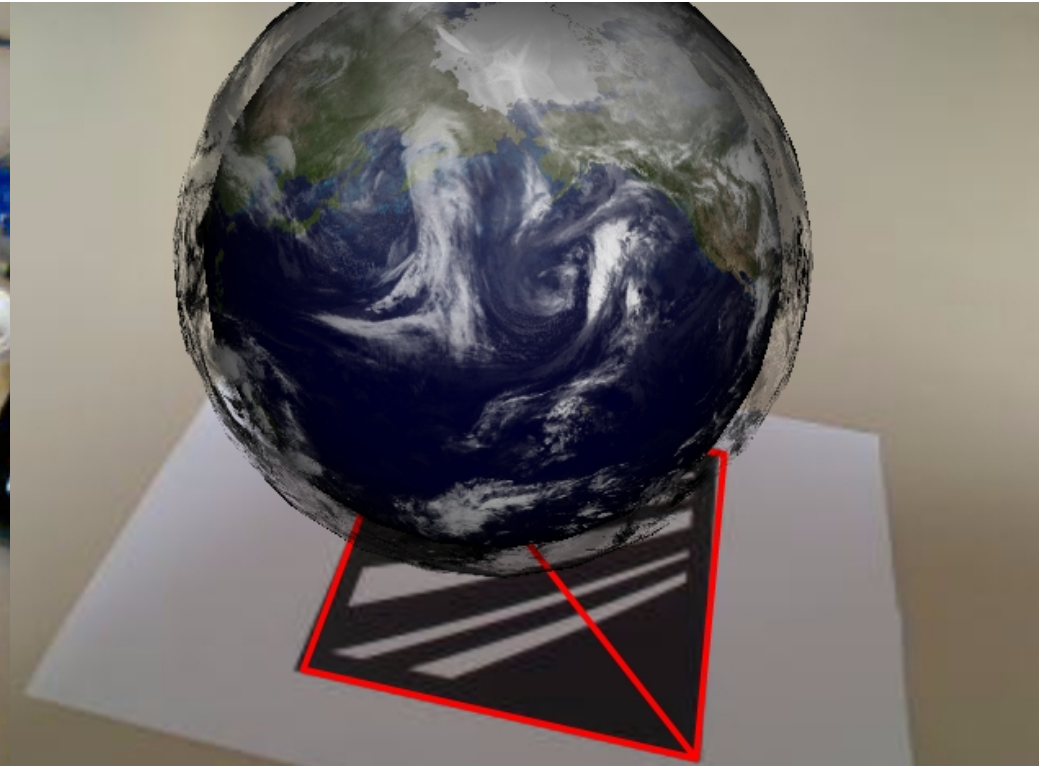
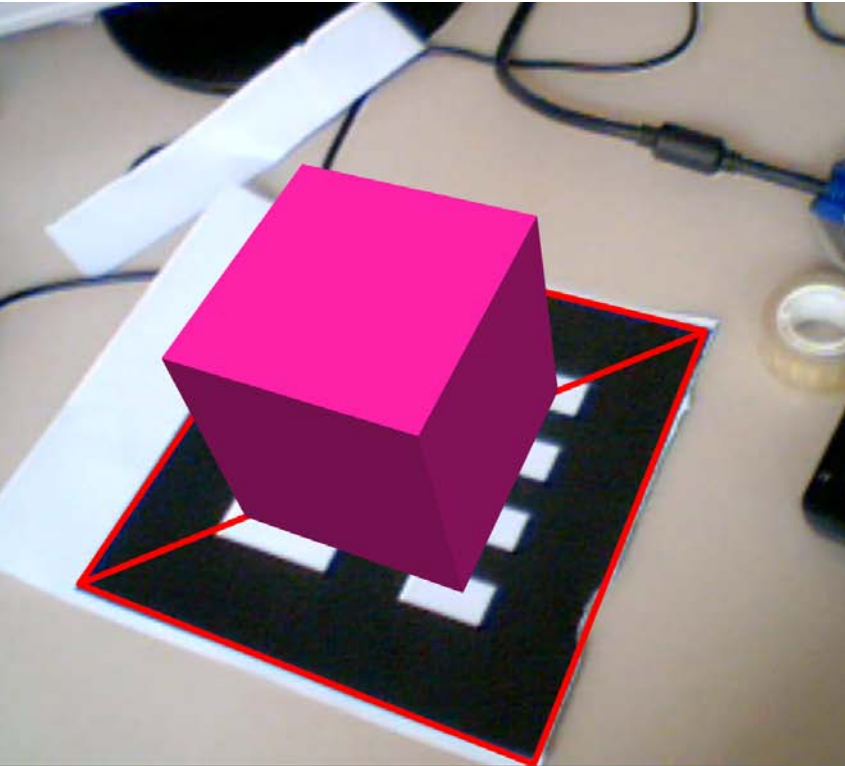


Flash-only solutions:

- working well, hardware access in browsers
- But: Data is boxed, process-pipeline missing, compilation needed
- No hardware acceleration until recently

X3D: Browsers, Installations, Mobiles

« Write once, run anywhere »



Best of both worlds:

- Flash-based tracking (hardware access)
- X3DOM rendering and DOM/HTML integration
- fast, anti-aliasing, diff. threads, hardware-acceleration

X3D: Browsers, Installations, Mobiles

« Write once, run anywhere »



```
<body>
  <h1>Augmented Reality with X3DOM and FLARToolkit</h1>
  <p>
    This Demo makes use of Adobe Flash based FLARToolkit for marker tracking and X3DOM for 3D rendering.
    <br />Please print out this marker: <a href='Data/x3dom-marker.pdf'>x3dom-marker.pdf</a> or
    <a href='Data/x3dom-marker.png'>x3dom-marker.png</a>
    <br /> and point it to the camera.
    <p> The files of the X3DOM/AR application are available here: <a href='demo-sources.zip'>demo-sources.zip</a>. <br />
    The sources of the FLARToolkit based tracking are available here: <a href='flash-sources.zip'>flash-sources.zip</a> <br />
    Note FLARToolkit is under <a href='http://www.libspark.org/wiki/saqoosha/FLARToolkit/en'>GPL license</a>.
  </p>
</div id="root_canvas">
  <div id="topLayer" >
    <div id="x3div" >
      <x3d id="x3d" showStat="false" showLog="false" x="0px" y="0px" width="640px" height="480px" altImg="helloX3D-alt.png">
        <scene>
          <viewpoint fieldOfView='0.60' position='0 0 0'></viewpoint>
          <background transparency='1' skyColor='0 0 0'></background>
          <matrixtransform id="root_transform">
            <transform def="universe" translation='0 0 20' scale='50 50 50' rotation='0 1 0 3.145">
              <transform def="earth" rotation='1 0 0 -1.57' >
                <shape>
                  <appearance>
                    <imageTexture url='footage/nasaworldp2.jpg'>
                      </imageTexture>
                  </appearance>
                  <sphere>
                    </sphere>
                </shape>
              </transform>
            <transform def="clouds" rotation='1 0 0 -1.57' scale='1.1 1.1 1.1'>
              <shape>
                <appearance>
                  <material diffuseColor="0 1 0" shininess="0.5"></material>
                  <imageTexture url='footage/cloudimage.png'>
                    </imageTexture>
                </appearance>
                <sphere solid='false'>
                  </sphere>
              </shape>
            </transform>
          </matrixtransform>
        </scene>
      </x3d>
    </div>
  </div>
  <div id="x3domflartoolkit" style="position:absolute; z-index:-10;"
  ridth="640" height="480" id="x3domflartoolkit" align="middle">
    <object classid="clsid:d27c6be-ae6d-11cf-96b8-444535400000" codebase="http://download.macromedia.com/pub/shockwave/cabs/flash/swflash.cab#version=9,0,0,0"
    <param name="allowScriptAccess" value="always" />
    <param name="allowFullScreen" value="false" />
    <param name="wmode" value="transparent" />
    <param name="movie" value="x3domflartoolkit.swf" />
    <param name="quality" value="high" /><param name="bgcolor" value="#808080" />
    <embed wmode="transparent" src="x3domflartoolkit.swf" quality="high" bgcolor="#808080" width="640" height="480" name="x3domflartoolkit"
    align="middle" allowScriptAccess="always" allowFullScreen="false" type="application/x-shockwave-flash" pluginspage="http://www.adobe.com/go/getflashplayer_de" />
  </div>
  <script type="text/javascript" src="http://www.x3dom.org/x3dom/example/x3dom.js"></script-->
  <script type="text/javascript" src="lib/x3dom.js"></script>
</body>
```



X3D: Browsers, Installations, Mobiles

« Write once, run anywhere »



```
<div id="topLayer" >
  <div id='x3div' >
    <x3d id='x3d' showStat="false" showLog="false" x="0px" y="0px" width="640px" height="480px" altImg="helloX3D-alt.png">
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                </appearance>
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                </sphere>
              </shape>
            </transform>
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                </imageTexture>
                </appearance>
                <sphere solid='false'>
                </sphere>
              </shape>
            </transform>
          </transform>
        </matrixtransform>
      </scene>
    </x3d>
  </div>
</div>
```

only few lines
of code

earth texture

clouds texture

x3dom is part of DOM/HTML

- valid X3D
- directly editable

X3D: Browsers, Installations, Mobiles

« Write once, run anywhere »



```
// Hide x3dom canvas on page load
$(document).ready(function() {
    $('#topLayer').hide();
    show_canvas = false;
});

// Show x3dom canvas again
// function is triggered inside set_marker_transform()
function show_x3dom_canvas(){
    $('#topLayer').show();
    show_canvas = true;
}

var root_transform = document.getElementById('root_transform');
root_transform.setAttribute('matrix', q.toString());
```

x3dom is part of DOM/HTML

- valid X3D
- directly editable
- fetch/manipulate nodes with JavaScript



Thanks! Questions?

Online resources:

www.igd.fraunhofer.de/igd-a4

www.instantreality.org

www.x3dom.org