Trends and Challenges of Augmented Reality

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Let's Start With A Quiz

- Who knows the name of this device?

Microsoft Hololens,
a head-worn device for Augmented Reality

How Does Augmented Reality Work?

Overlay the real world with computer graphics

Virtual content

SPATIAL MODEL

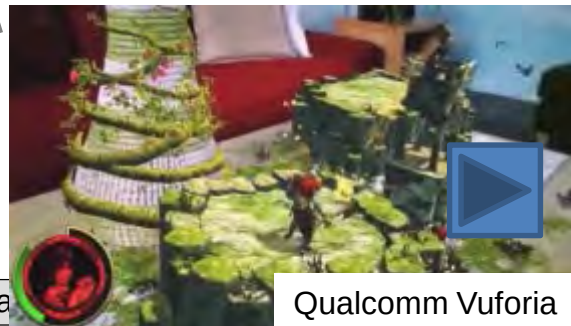
Real world model

Registration of virtual content

Situated visualization

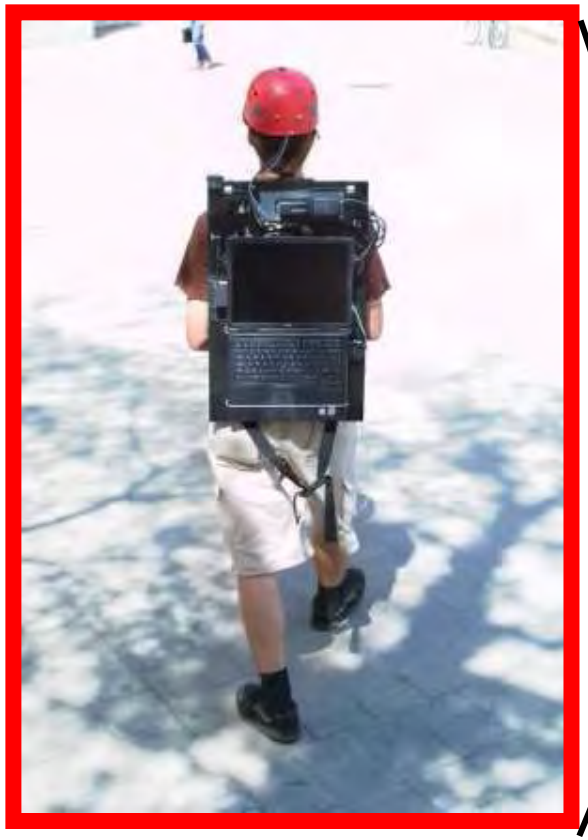
Pose tracking

User input



Qualcomm Vuforia

We Have Come A Long Way

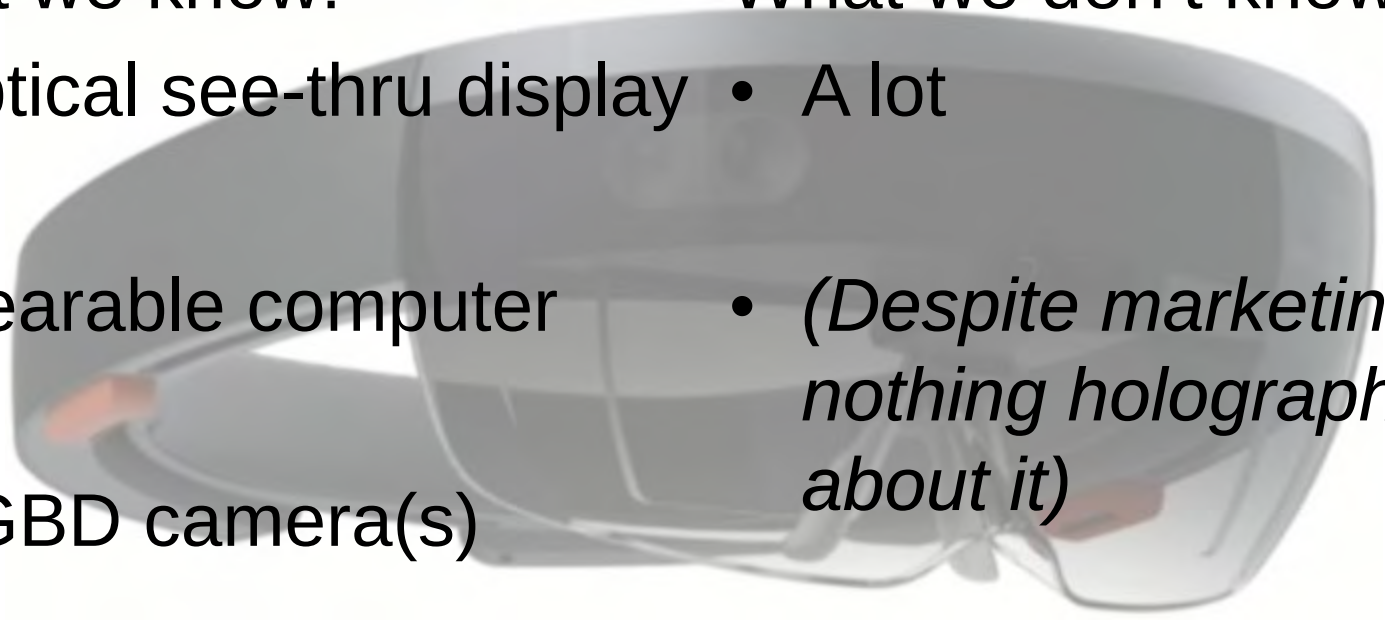


2000
6-8kg
€12,000

2006
1.5kg
€5,000

2008
0.1kg
€500

2016: Microsoft HoloLens



What we know:

- Optical see-thru display
- Wearable computer
- RGBD camera(s)
- Hardware-accelerated tracking and mapping

What we don't know:

- A lot
- *(Despite marketing, nothing holographic about it)*

A Strong Disturbance in the Force

- 1990s: 1st wave of excitement about Virtual and Augmented Reality
  - But remains a niche market
- 2010s: Massive investments by industrial players
  - Microsoft releases HoloLens
  - Facebook acquires Oculus Rift
  - Apple acquires PrimeSense, Metaio etc.
  - Valve, Sony, Samsung launch VR gaming platforms

- What is the goal this time?

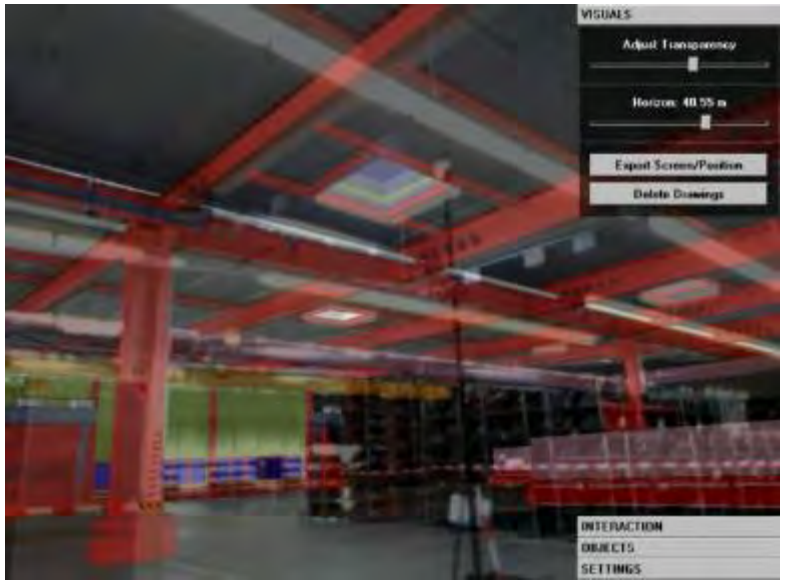
AR Business Models

- Business models not yet clear
  - Increase **consumer** adoption, games, advertising
  - Consumer (currently) drives hardware development
  - Increase **industrial** use
  - Industrial may allow higher cost, more learning?
- Example
  - Vuforia, a leading AR SDK
  - Marketed by Qualcomm for consumer
  - Sold to PTC (industrial solution provider) in 2015
- *My speculation: Industrial use will be big first*

What are Industrial Use Cases?

Discrepancy checking→

[Schönfelder, Schmalstieg, ISMAR2008]



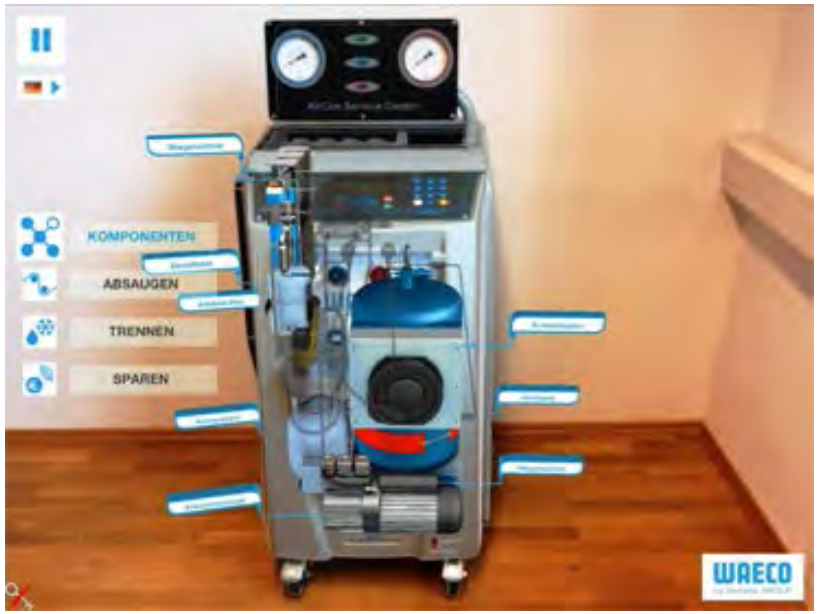
←Construction progress monitoring

Hidden infrastructure visualization→

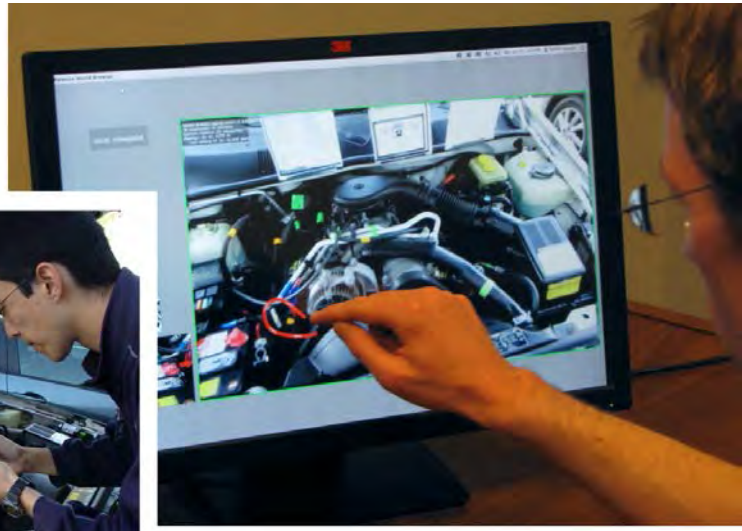
[Schall. Mendez, Schmalstieg, ISMAR2008]

More Industrial Use Cases

Maintenance instructions→



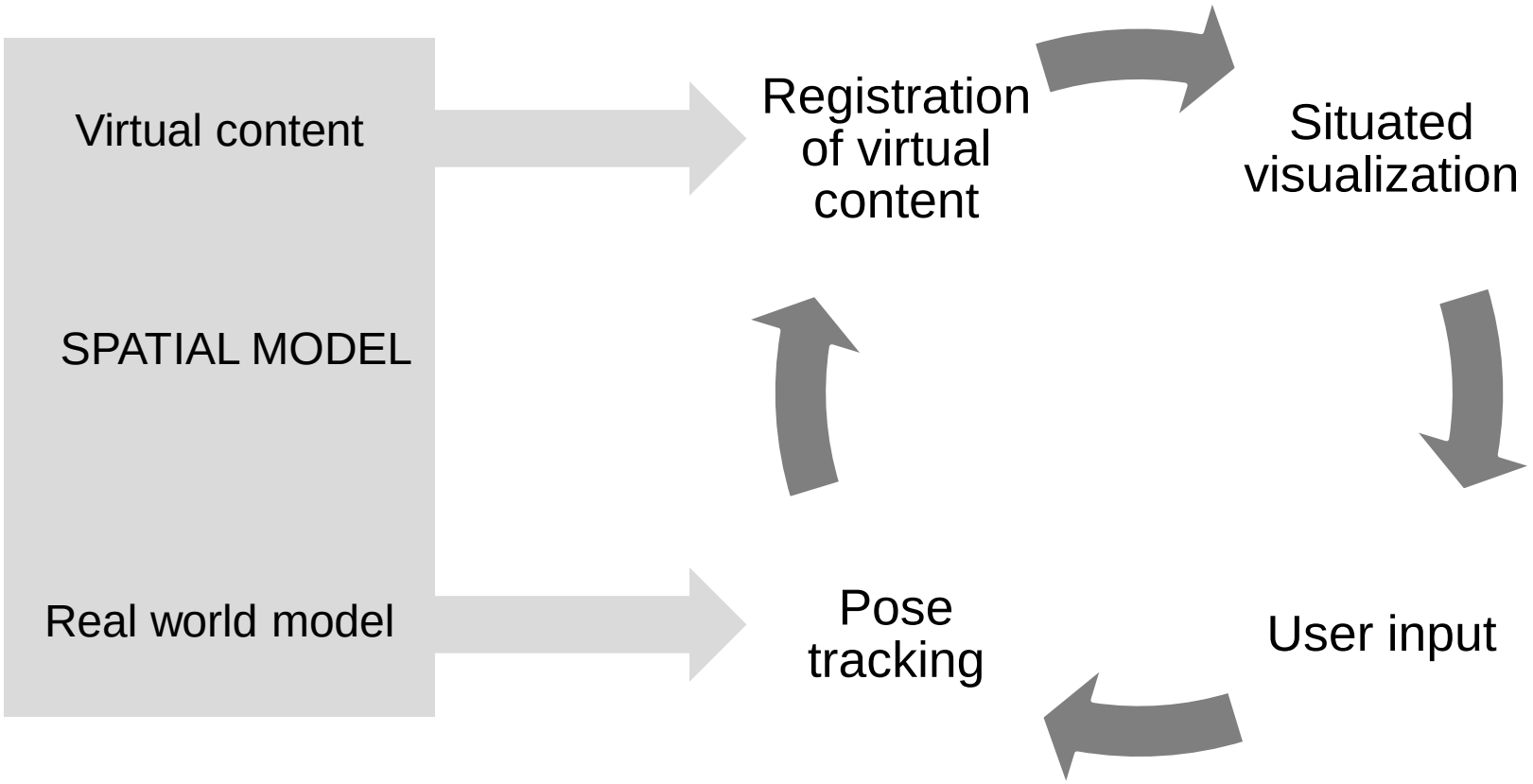
Process data visualization and control



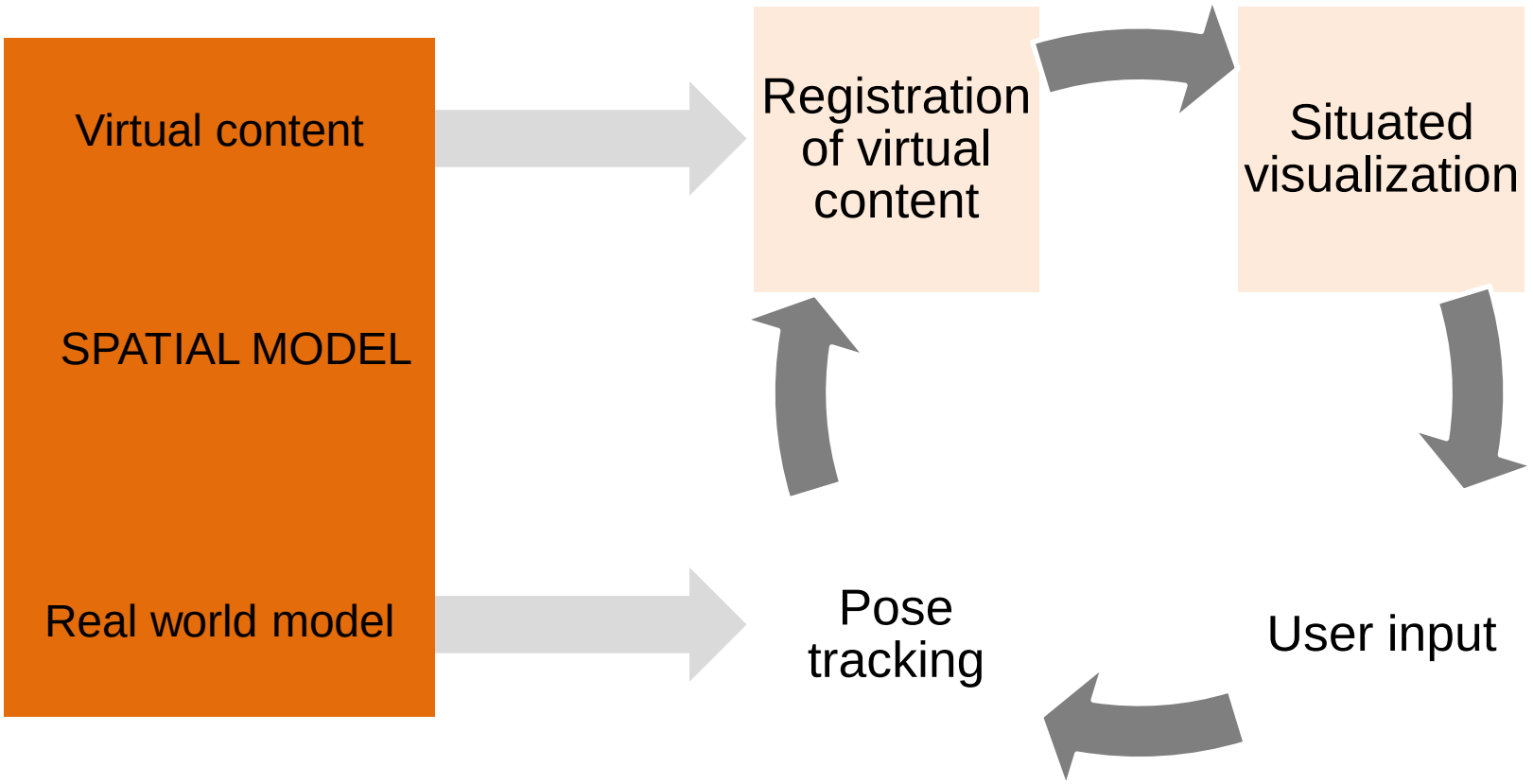
Tele-assistance→

Image courtesy of Steffen Gaugglitz

Recap: Augmented Reality Systems



Topic Today: Authoring of Instructions



What is Required for AR Instructions?

- *(A Kinect for tracking; won't talk about it)*
- 3D model of the real object
  - Scanned with Kinect or existing CAD model
- Decomposition of model into parts
- Sequence of parts
  - Disassembling: remove parts
  - Assembling: add parts
  - Maintenance: remove, manipulate, add
- Representation of the necessary motions
- Visualizations that convey the actions well

How Can We Generate AR Instructions?

- Manually
  - Use 3D modeling tools + (maybe) scripting
  - Tedious, requires expert modeling knowledge
- From existing printed instruction manuals
- From existing videos

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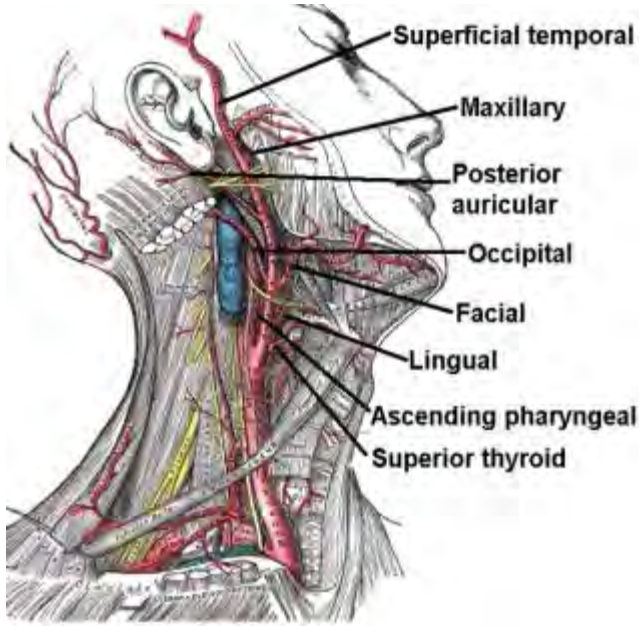
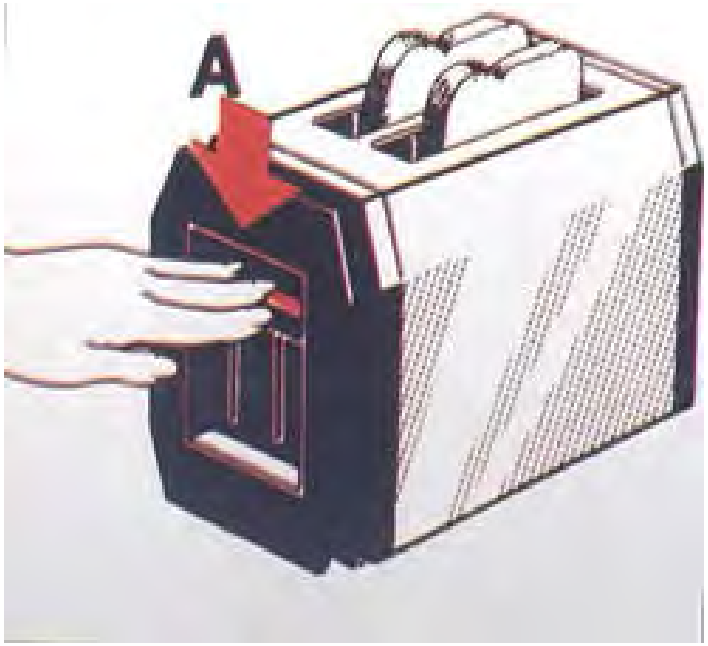
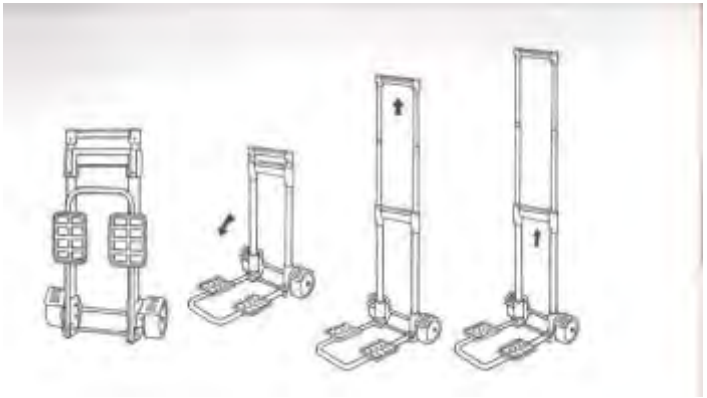
What are the Elements of a Manual?

- Labels
- Directional arrows
- Before-after sequences
- Explosion diagrams







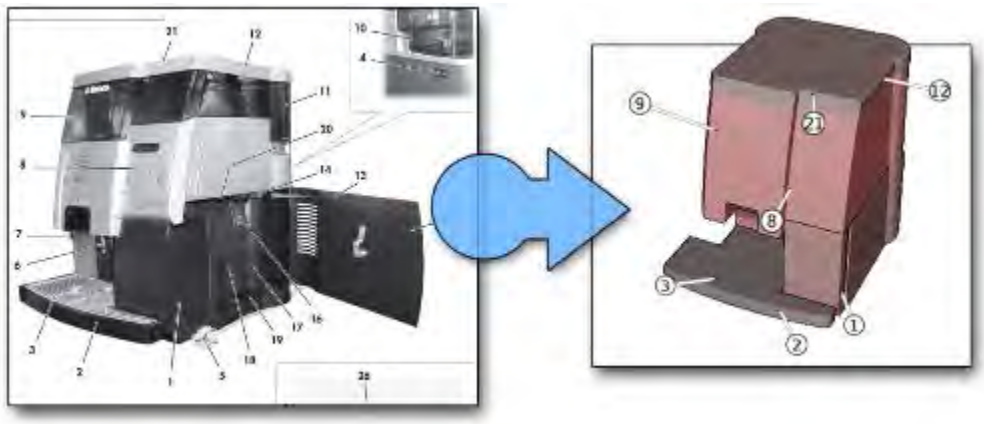
Retargeting from 2D to 3D

- Problem 1
  - Where is every part located in real world?
- Approach
  - Must be able to find parts (semi-)automatically

- Problem 2
  - What intent does the illustration have?
- Approach
  - Synthesize animation of the parts to communicate the intent

Preparations

- Scan 2D manual (or download PDF)
- Obtain 3D model of the machine
  - Get CAD data from vendor
  - Alternatively, use 3D scanner (Kinect again)
- Register 3D model with illustration
  - Same problems as 3D tracking-by-detection
  - For just a few camera poses, this is an easy task

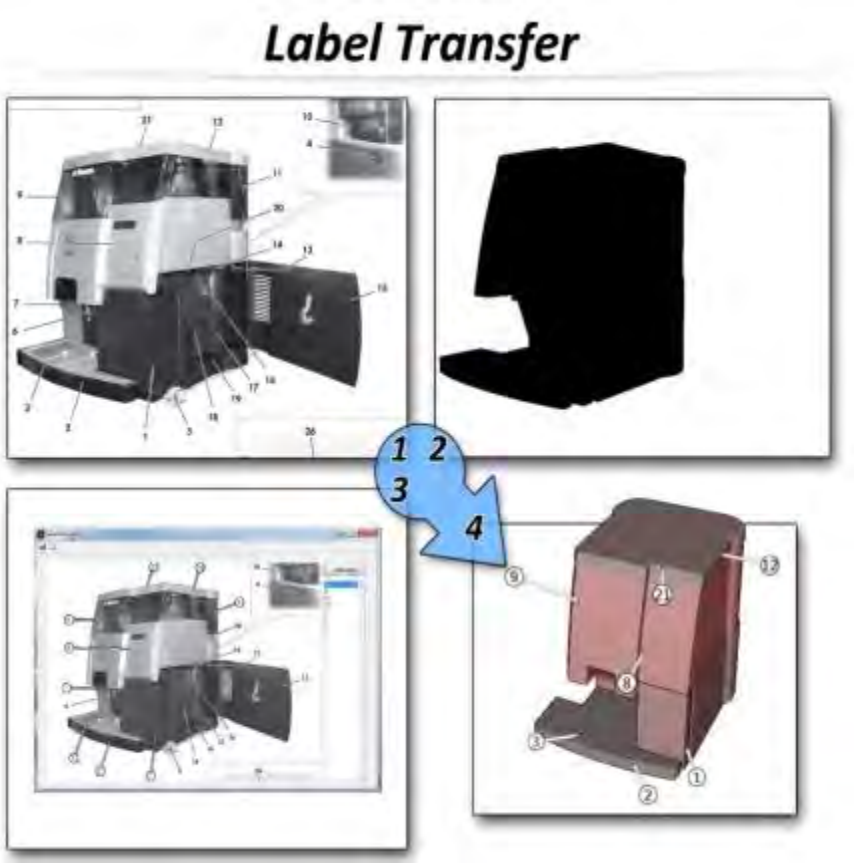


Labels

- Read labels with optical character recognition

- Generate ID buffer
  - Every pixel refers to the part underneath

- Search line
  - Look up endpoint of line in ID buffer
  - Points to the part

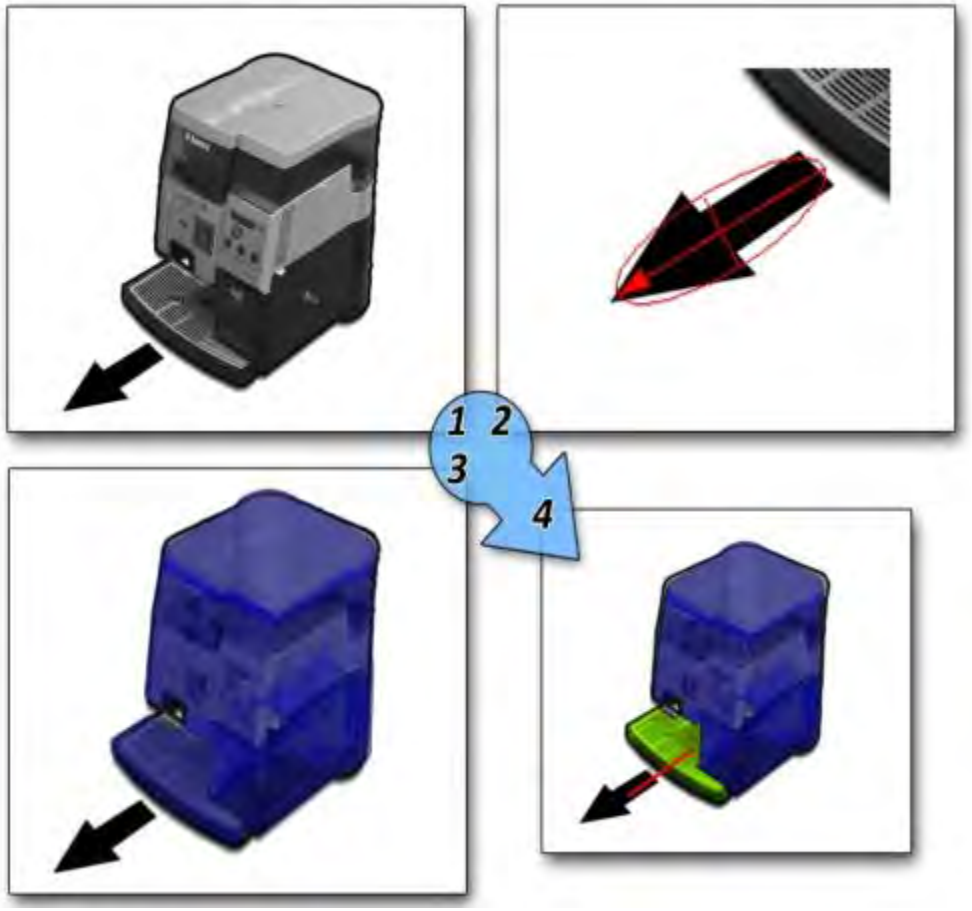


Motion Arrows

- Detect arrow shapes (they are *pointy*! ☺)
- Interpret direction of 2D arrow in 3D

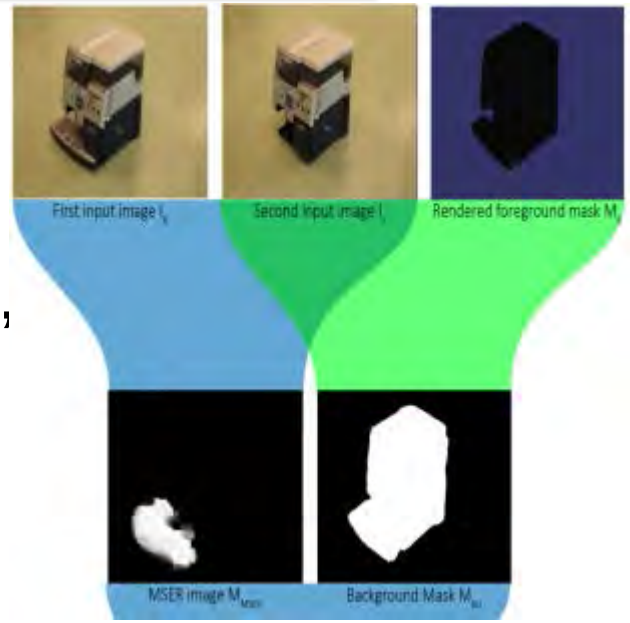
- Search referred part
  - Near arrow shaft
  - Must be removeable in direction of the arrow
  - Uses automatic CAD dissassembly planer

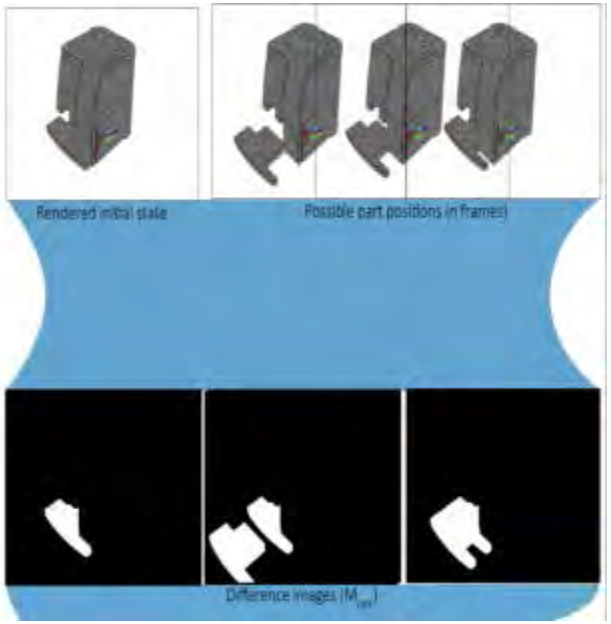
[Kerbl, Kalkofen, Schmalstieg, CGF2015]



Before-After Sequences

- CAD model registered to “Before”
- Difference to “After” applied to ID buffer generates candidates
- Disassembly planner determines possible motions of candidates
- Compare difference image of “After” to possible motions

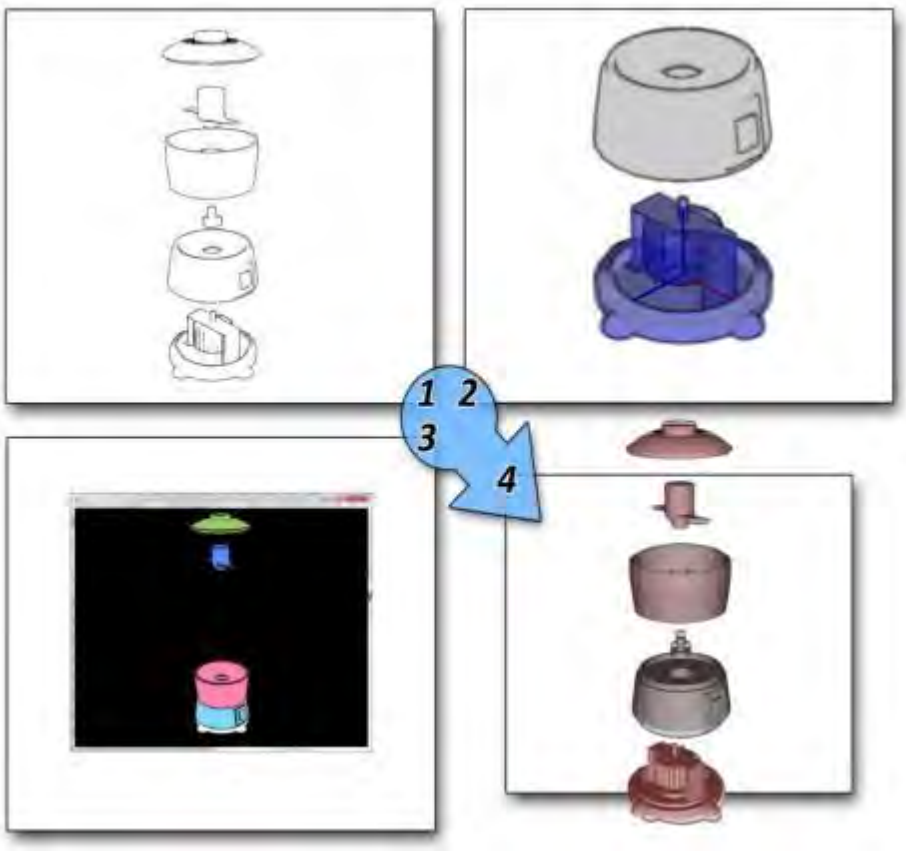




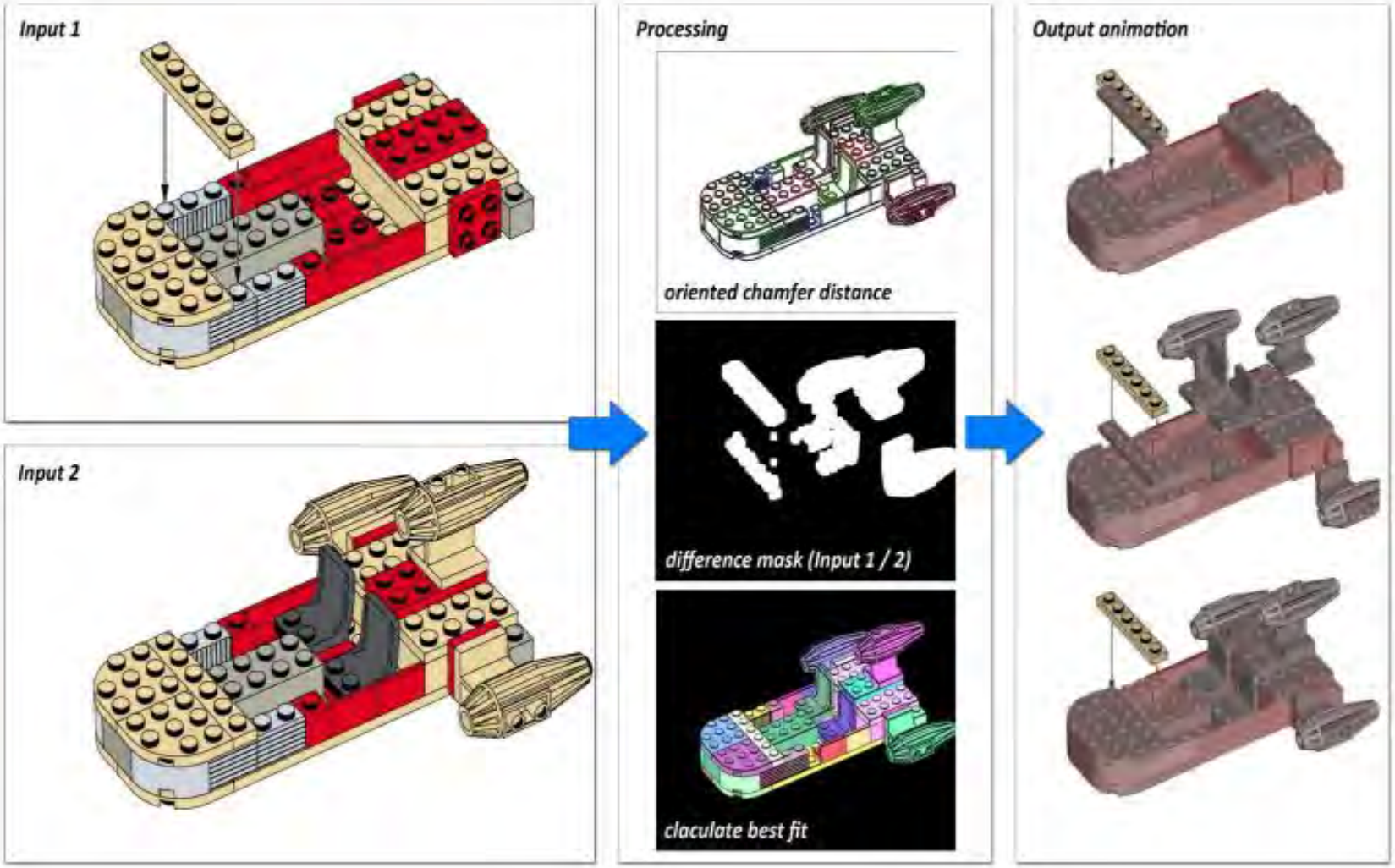
Explosions Diagrams

- Register CAD model to one part in the image
- Disassembly planner searches candidates for explosions

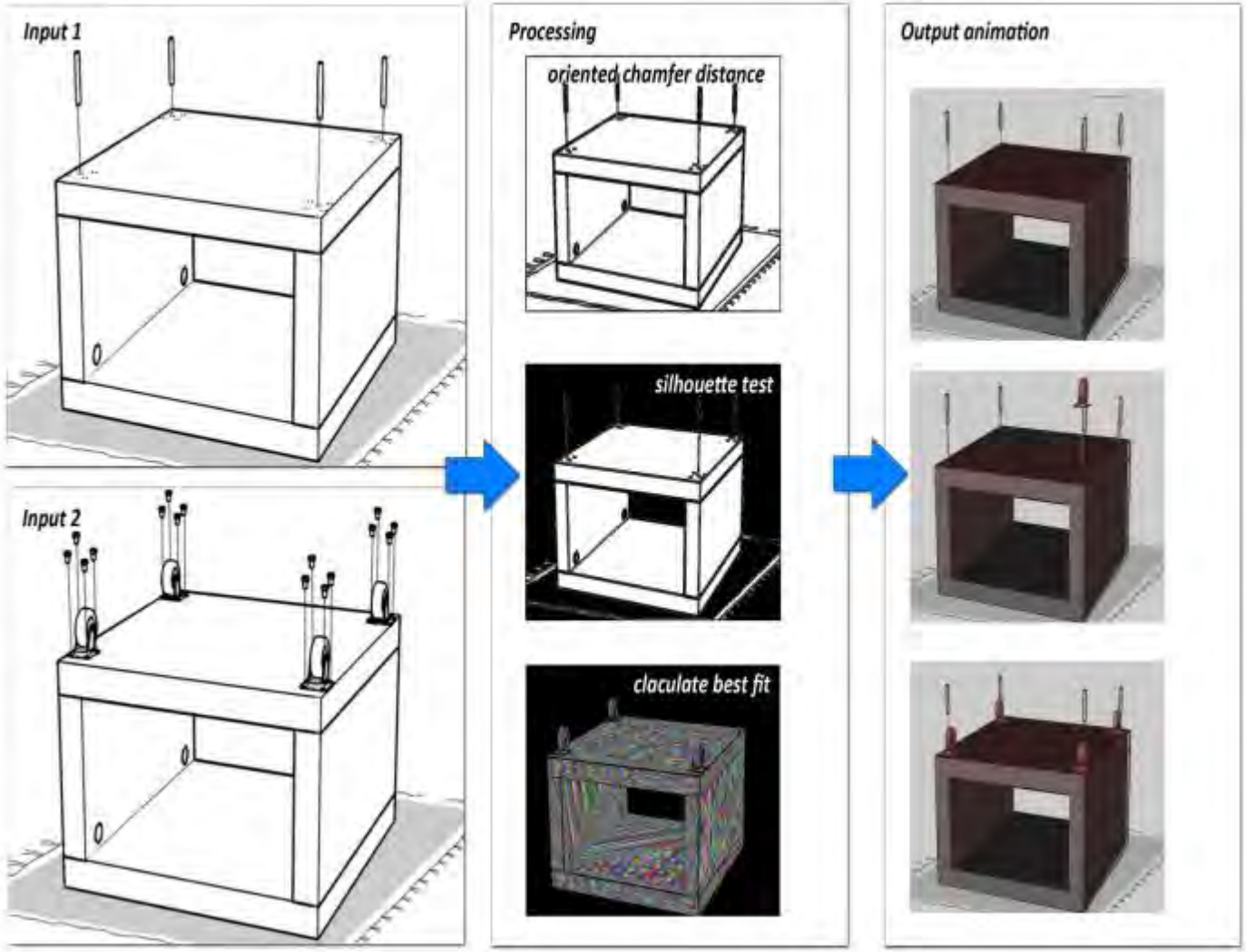
- Move candidate
- Compare to image
- Robust comparison with oriented chamfer distance



Multiple Moving Parts



Results


Input 1
Input 2
Processing
oriented chamfer distance
silhouette test
claculate best fit
Output animation

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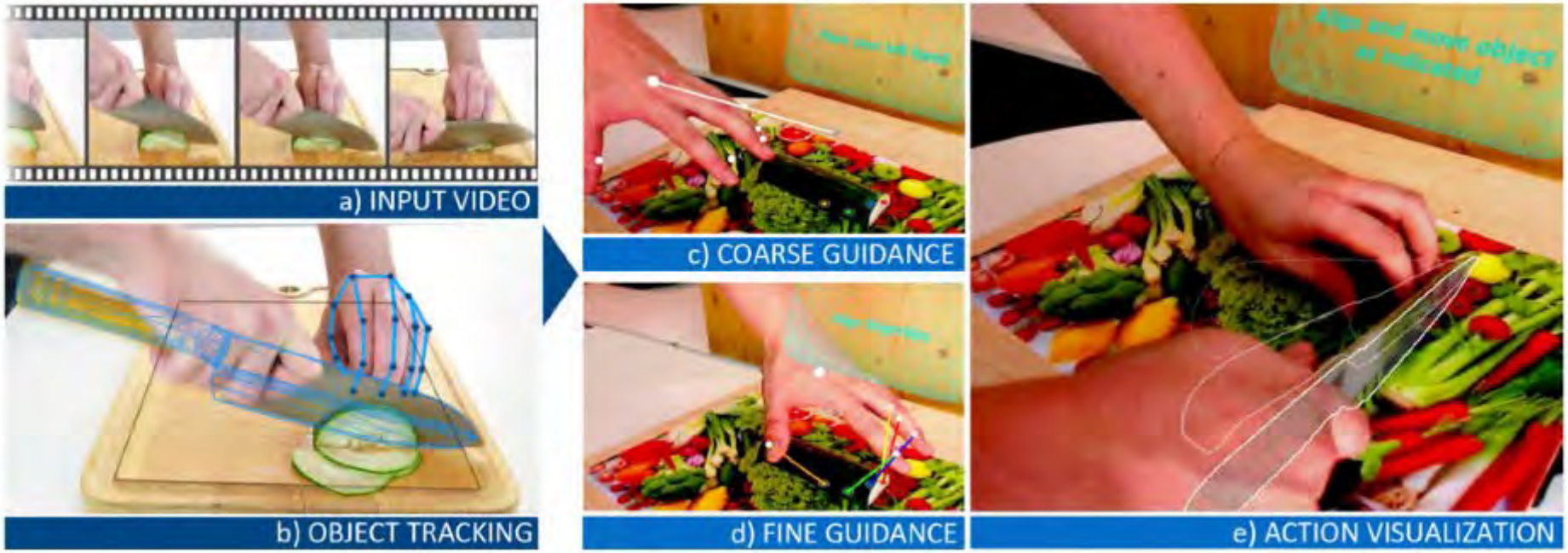
Cooking as a Video Game

“Sight” (short film by Eran May-raz and Daniel Lazo, Israel, 2012)

Note: These images are created offline by an animation artist!

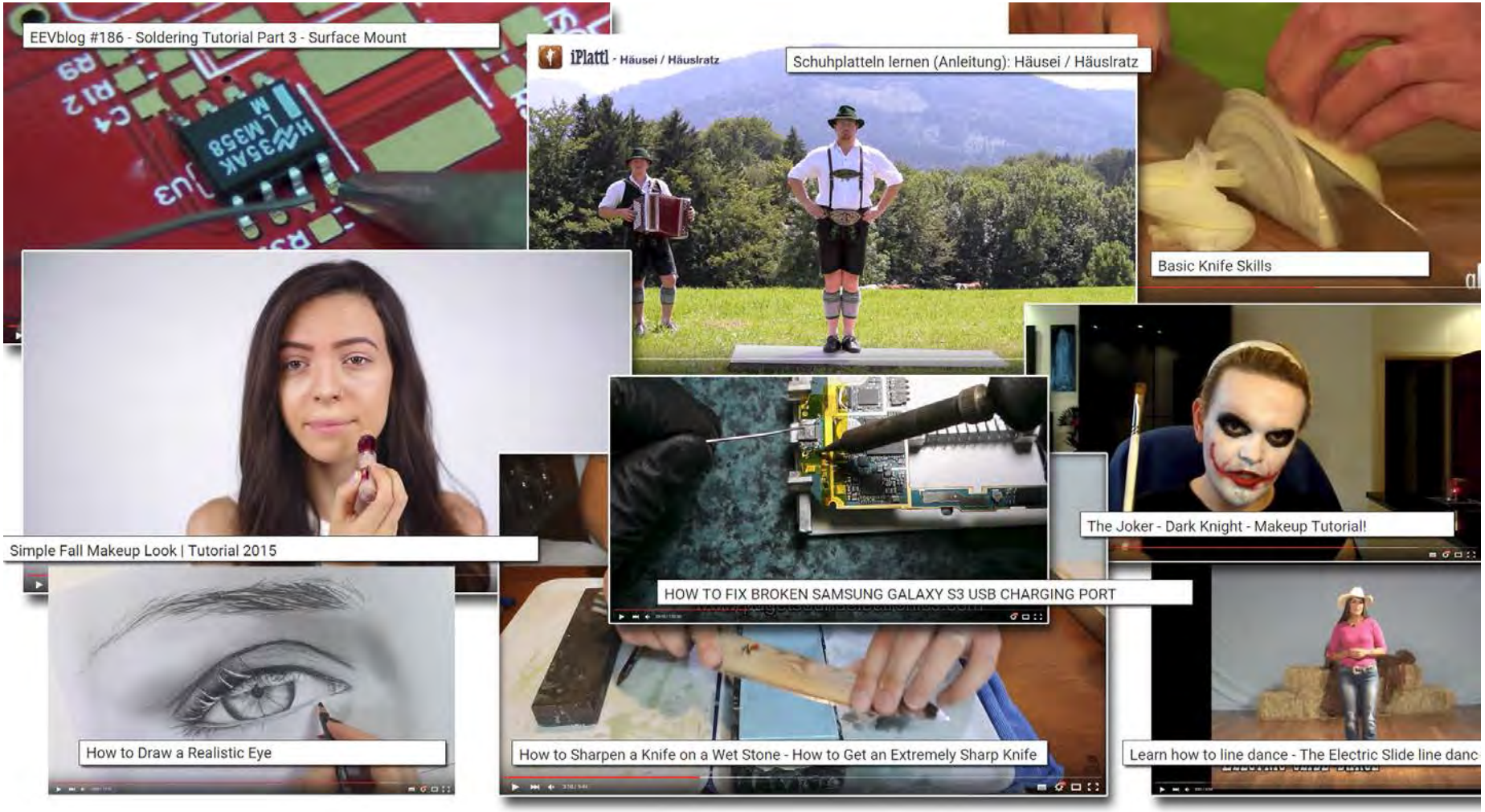
Here is our version ☺

Knife skills video



Knife skills AR tutorial

Your Whole Life Is Alreasy On Youtube



We can use these videos!

Overview of the Approach

Edit motion

Temporal segmentation

3D registration

Extract from input video

Track objects

Reconstruct 3D motion

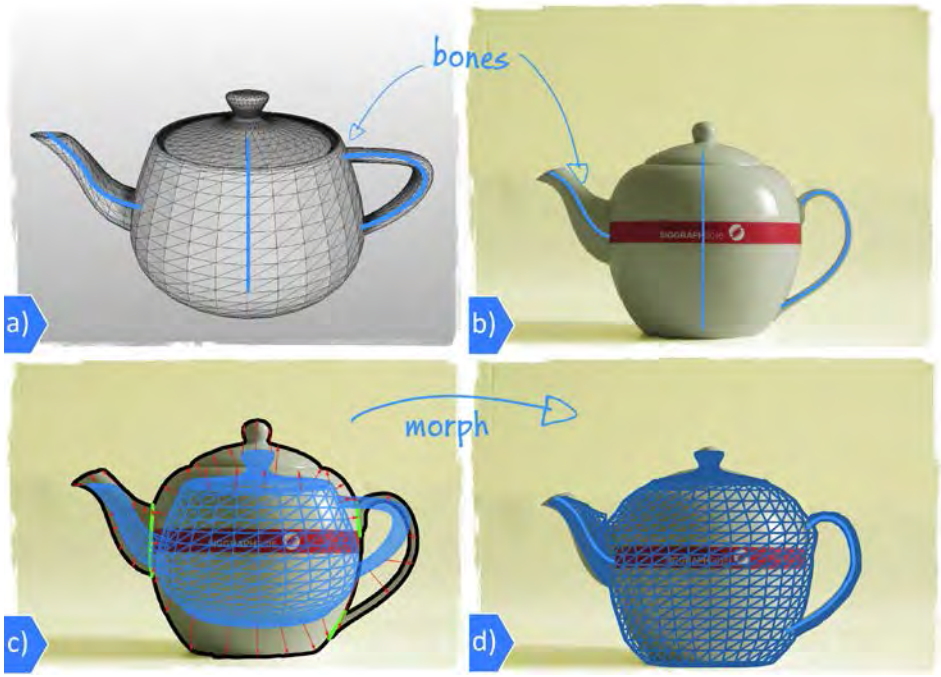
Visualize

3D glyph synthesis

Ghosted rendering

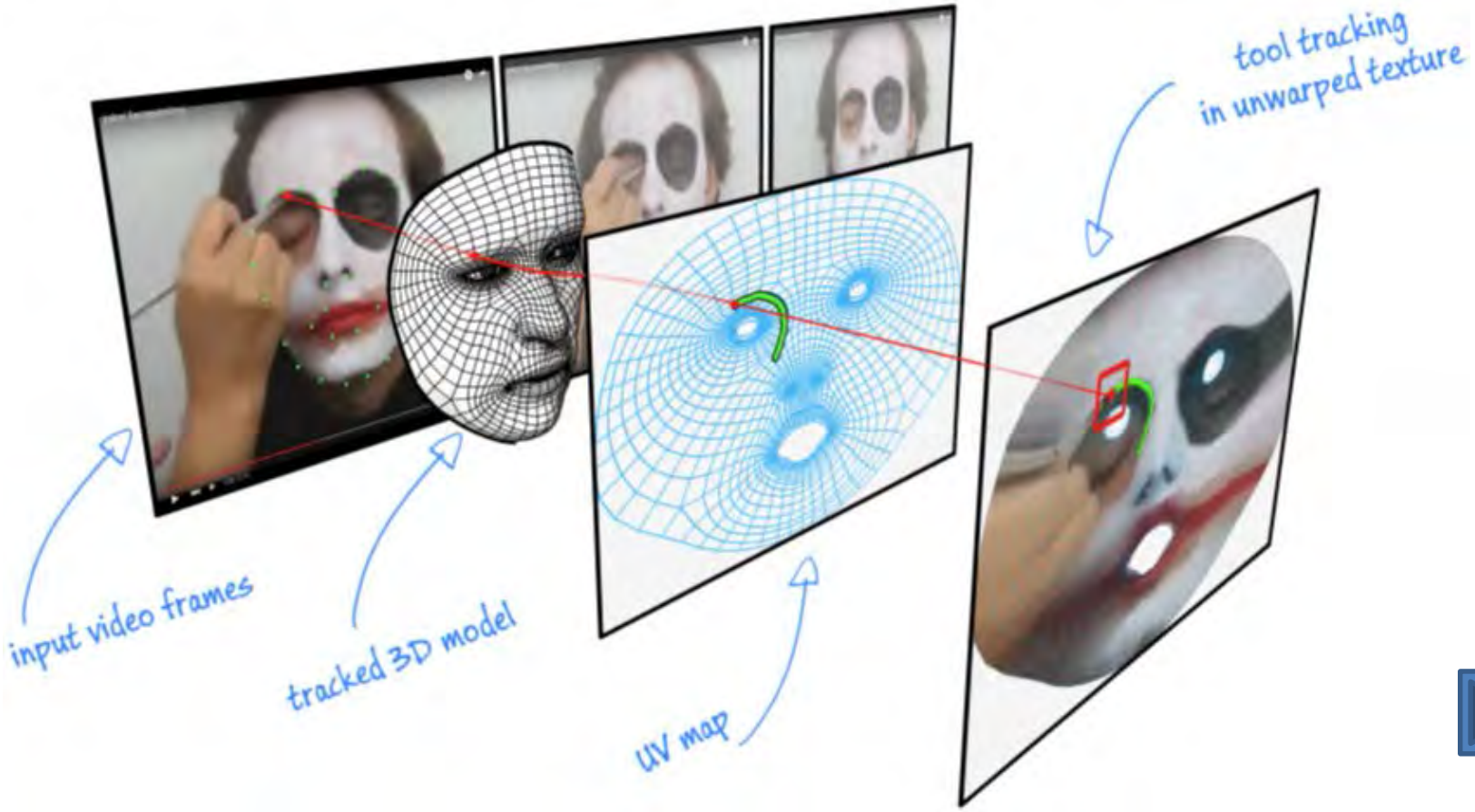
1 Motion Extraction of Unknown Rigid Objects

- Unknown object in video → no 3D model
- Input video material usually not good enough for structure from motion
- Scan a similar object with a Kinect
- Create a simple rigging
- Automatically deform by skinning
- Deformed object can be tracked



1 Motion Extraction of Tools on Surfaces

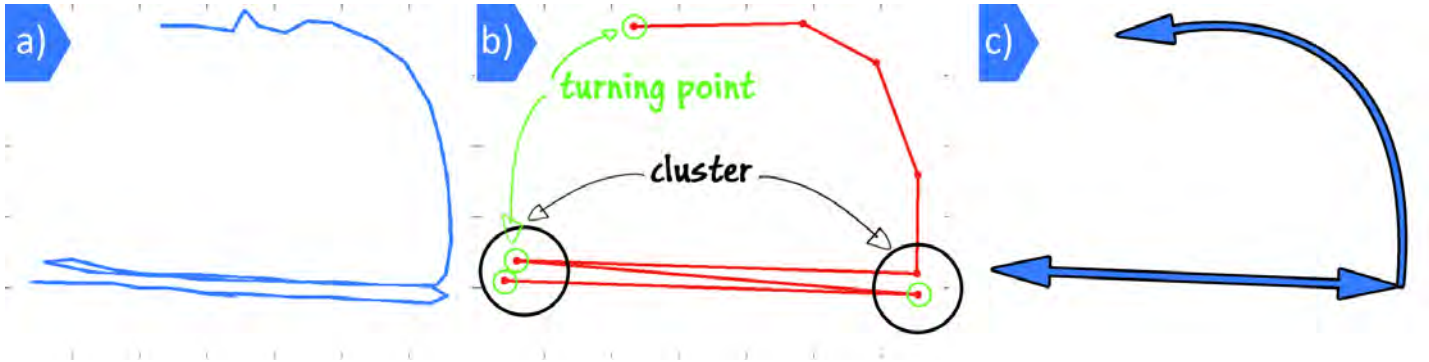
- Track the tooltip and map trajectory to atlas
- Can retarget motion to any surface with same atlas



2

Motion Segmentation

- Segment the motion by combining
  - Path: only unique motions
  - Curvature: separate orientation change from jitter
  - Velocity: cut, if no motion for a certain time

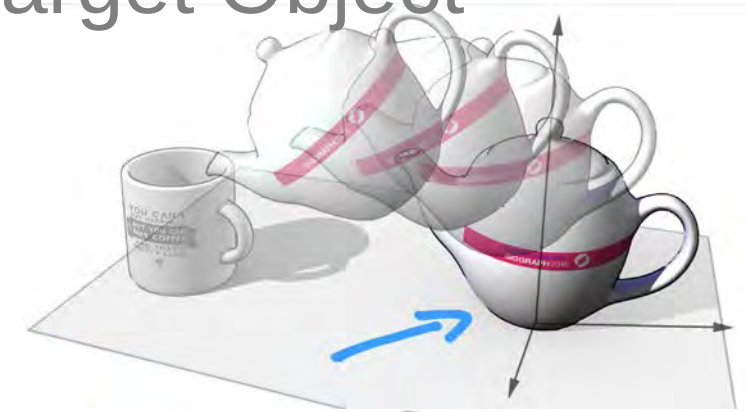


- Can be extended to skeleton tracking
  - Greedy segmentation based on all bones
- Can be used as input to synthesize arrow glyphs

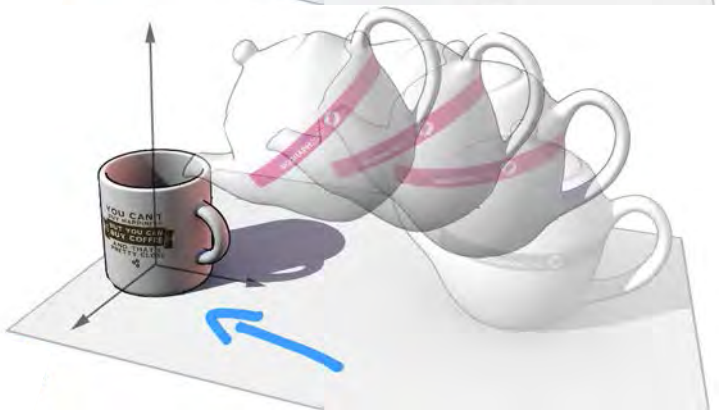
2

Motion Registration to Target Object

- Attach to source of motion
  - Guide user to source object



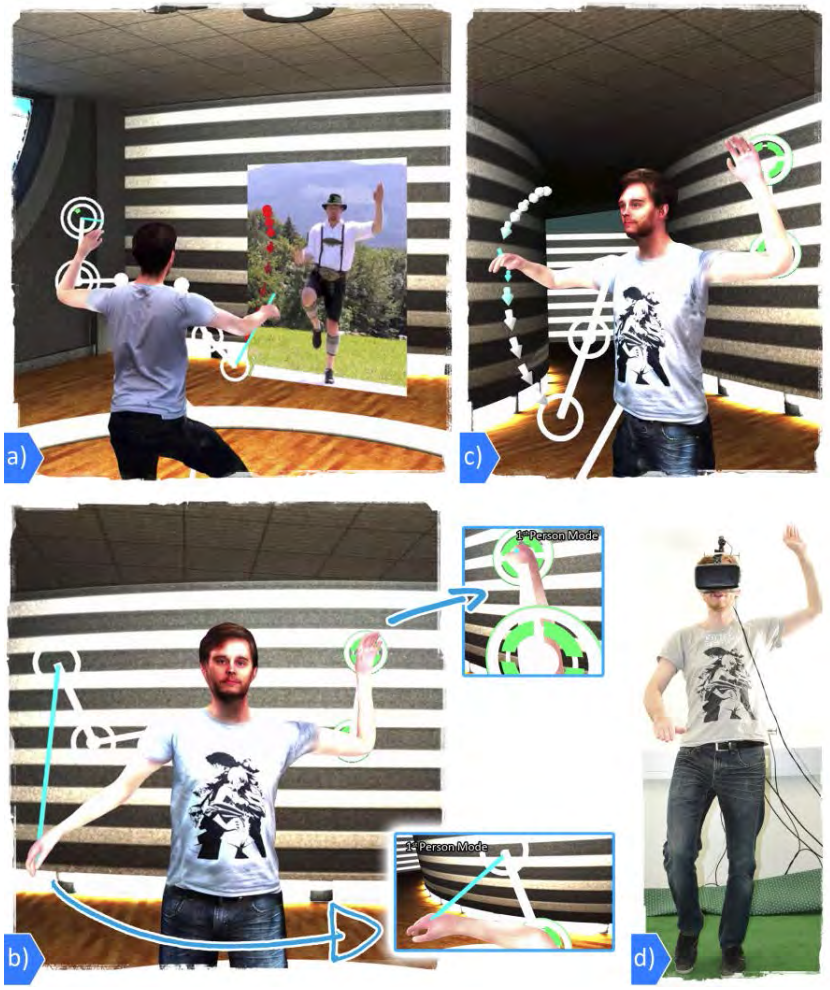
- Attach to target motion
  - Guide user to destination object



- Attach to both source and target
  - Rarely needed
  - Must scale the motion

3 Visualization

Ghosted objects



Arrow glyphs

Summary

- Authoring is overlooked as an important element of AR experiences
- Re-use of existing media sources
  - Printed manuals, video tutorials
- Future alternative: authoring by demonstration inside AR

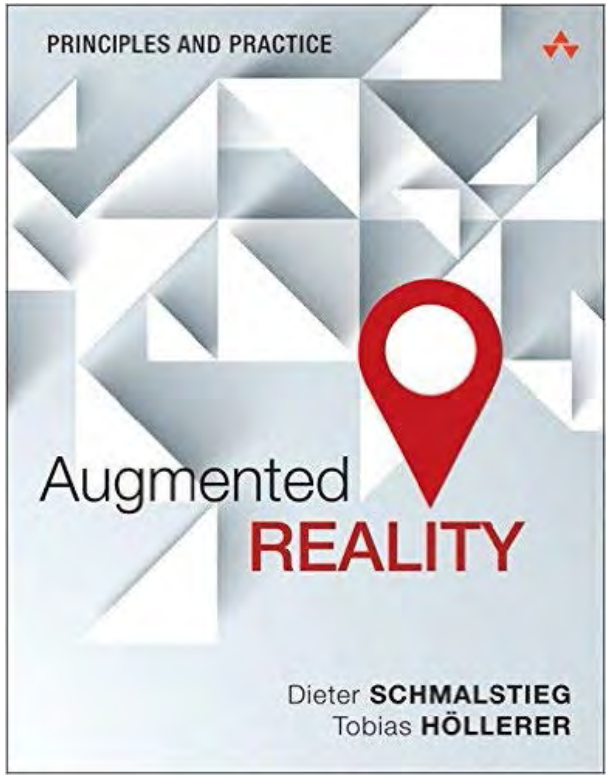
What Comes Next?

- Better Input
  - Programmable cameras, camera arrays, better optics
- Output
  - Wide FOV, lightfield displays, adjustable focus, eyetracker
- AR meets the Internet of Things
- Storytelling: AR as a dramatic medium
- Social Computing: Situated Facebook?
- *Industrial it great, but consumer success would be even better…*

Questions?

Ask Now!

Spring 2016



www.augmentedrealitybook.org