# Digital Content Creation for Seamless Augmented Reality

Marc Fischer, 14.04.2015

Image Source: [A]

# What is augmented reality?

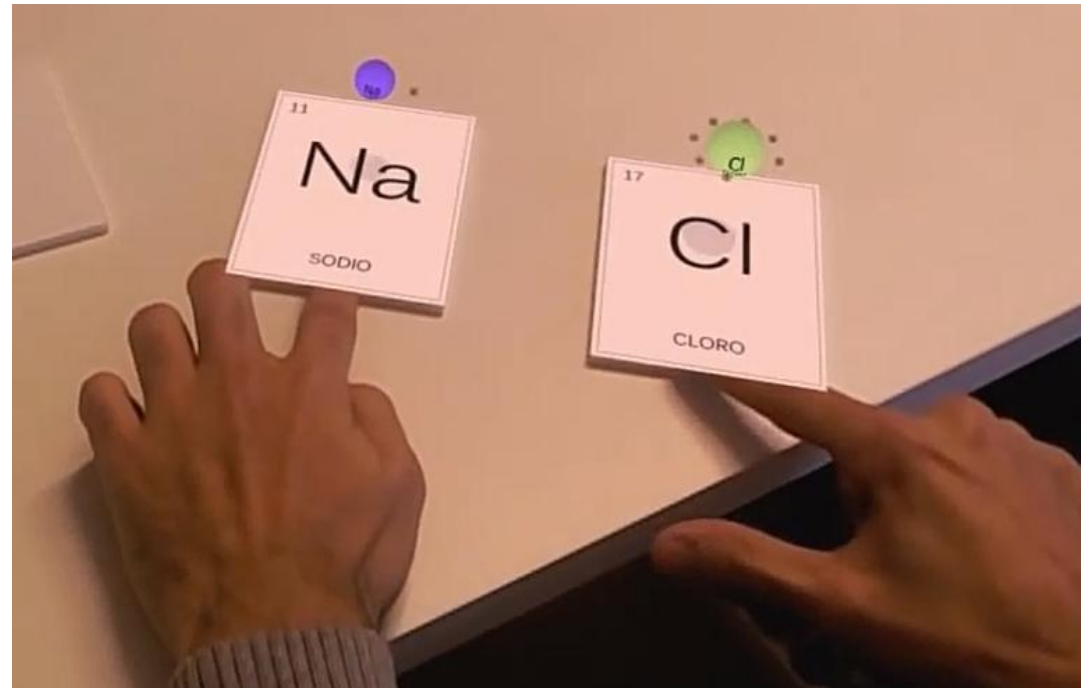„AR as any system that has the following three characteristics:

1. Combines real and virtual
2. Is interactive in real time
3. Is registered in three dimensions"

- Enrich the environment
- Support user

[Azuma, 1997, Image: A]

# Where is augmented reality?

- **Education**
- Advertising and Marketing
- Architecture and Construction
- Entertainment
- Medical
- Military
- Travel

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# Where is augmented reality?

- Education
- Advertising and Marketing
- **Architecture and Construction**
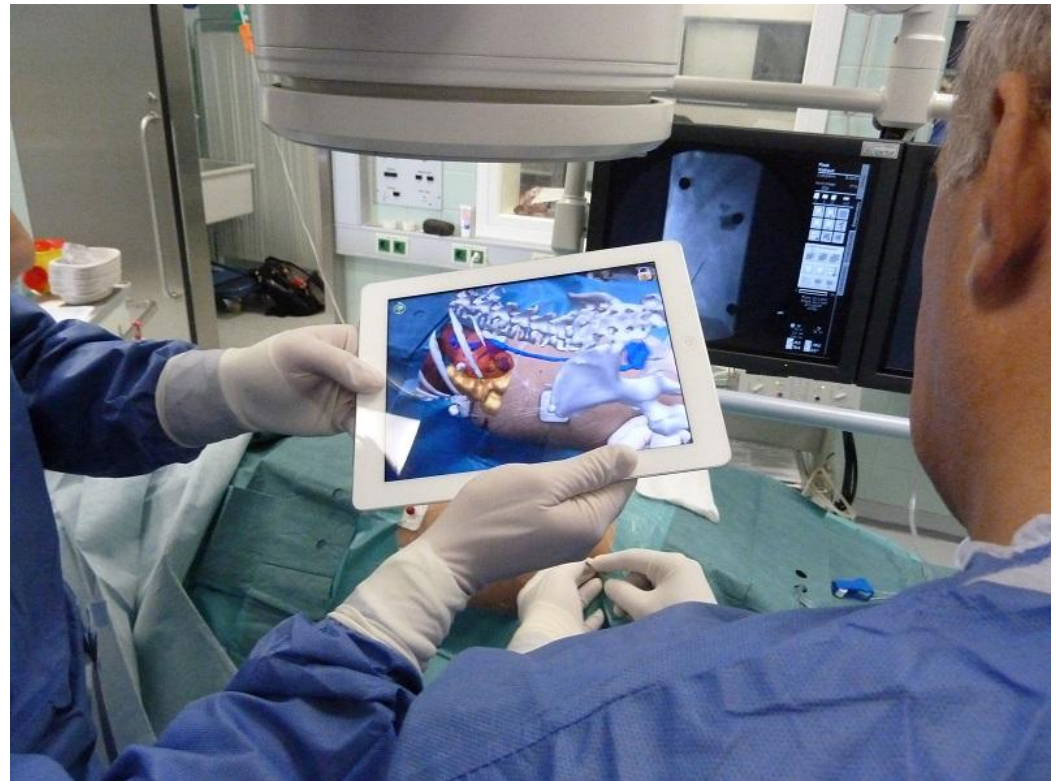- Entertainment
- Medical
- Military
- Travel

# Where is augmented reality?

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- Education
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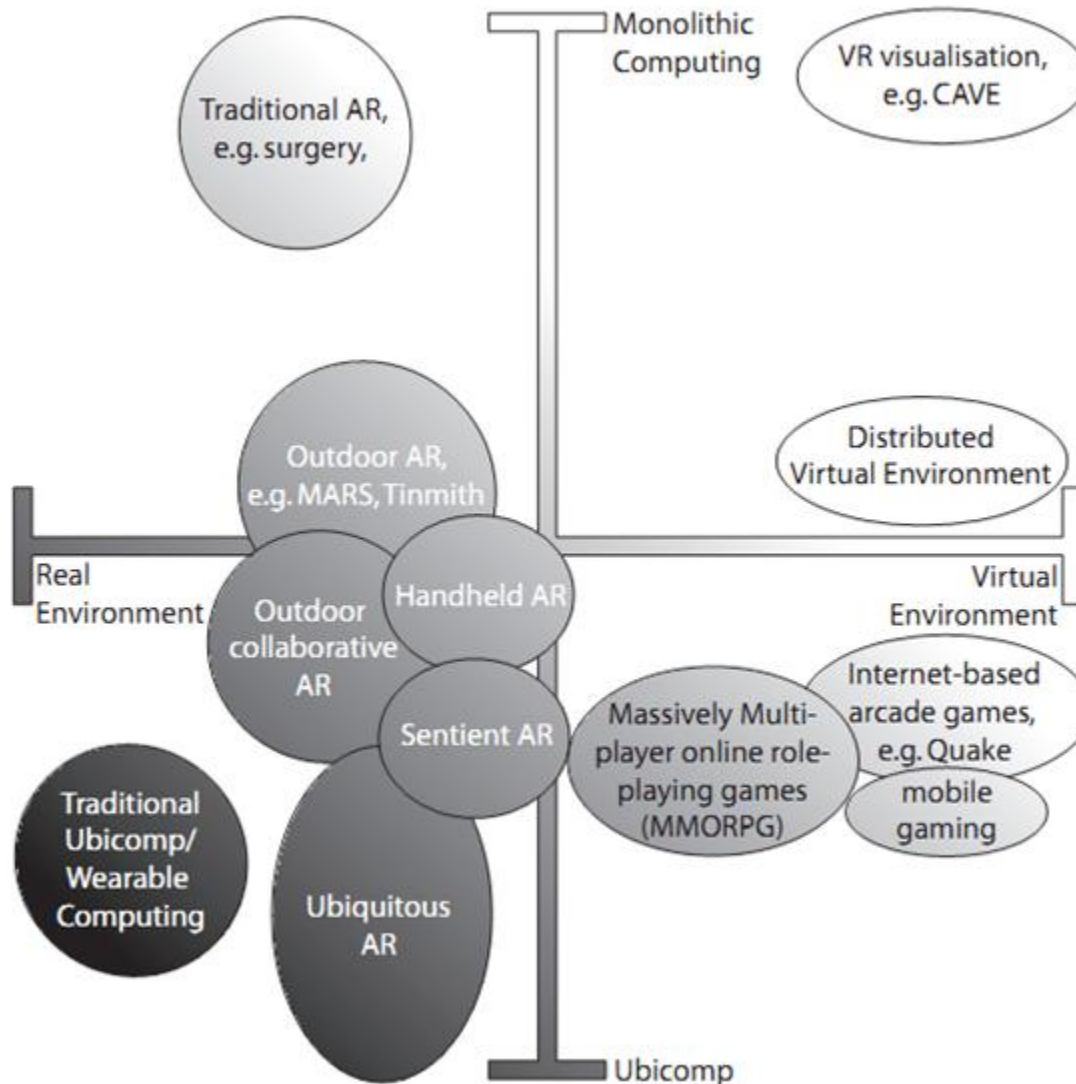- Medical
- **Military**
- Travel

# Where is augmented reality?

- Education
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- Architecture and Construction
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- Military
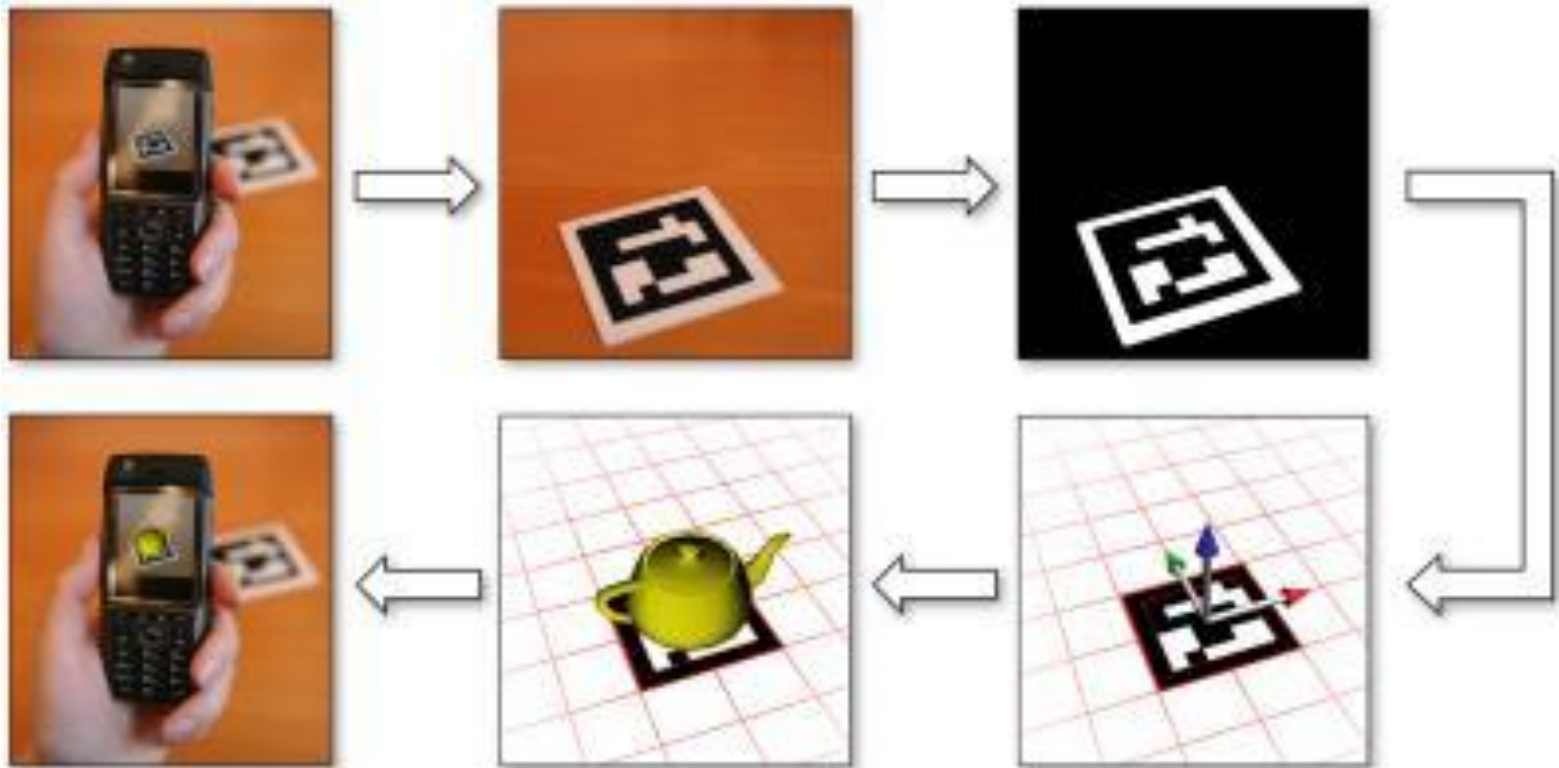- **Travel**

# Milgram-Weiser continuum

# Devices

[I, J, K, L]

# What does AR need?

- Content
- Registration

- Tracking
- Display techniques



[Wagner Daniel, PhD Thesis
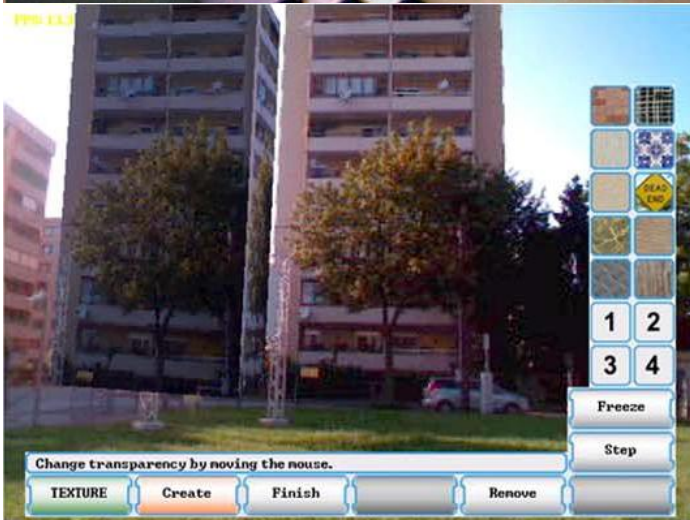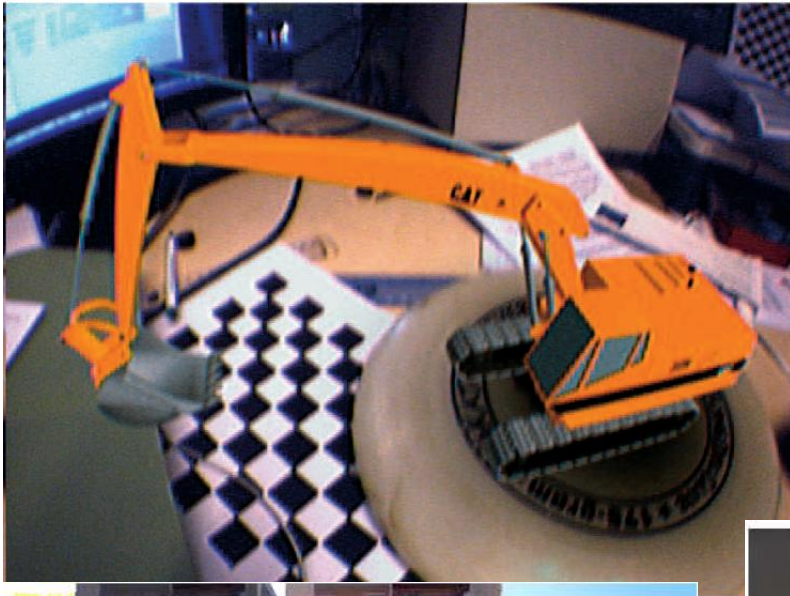„Handheld Augmented Reality", M]

# What does AR need?

- Content

- Registration

- Tracking

- Display techniques

# What does seamless AR need?

# Roadmap

*Next-Generation Augmented Reality Browser: Rich, Seamless, and Adaptive*



*Handling Motion-Blur in 3D Tracking and Rendering for Augmented Reality*



*Simulating Low-Cost Cameras for Augmented Reality Composing*

# AR Browser: Introduction

- Langlotz and Schmalstieg, Next-Generation Augmented Reality Browser: Rich, Seamless, and Adaptive (2014)
- AR anywhere
- Information from social media, crowd, database
- Smartphone or head mounted displays

[3]

# AR Browser: Challenges

- Content density
- Mostly static content, bad content integration
- Accurate and global, seamless registration
- Precise tracking
- Adaptivity (context awareness)
- View management techniques

# AR Browser: Registration

- Localization and tracking step
- Without prior knowledge
  - Tracking on the mobile phone
  - Create panoramic image in the background
  - The panoramic image is uploaded to a server
  - Server searches in Database for localization
  - Returns localization of features
- Limitations
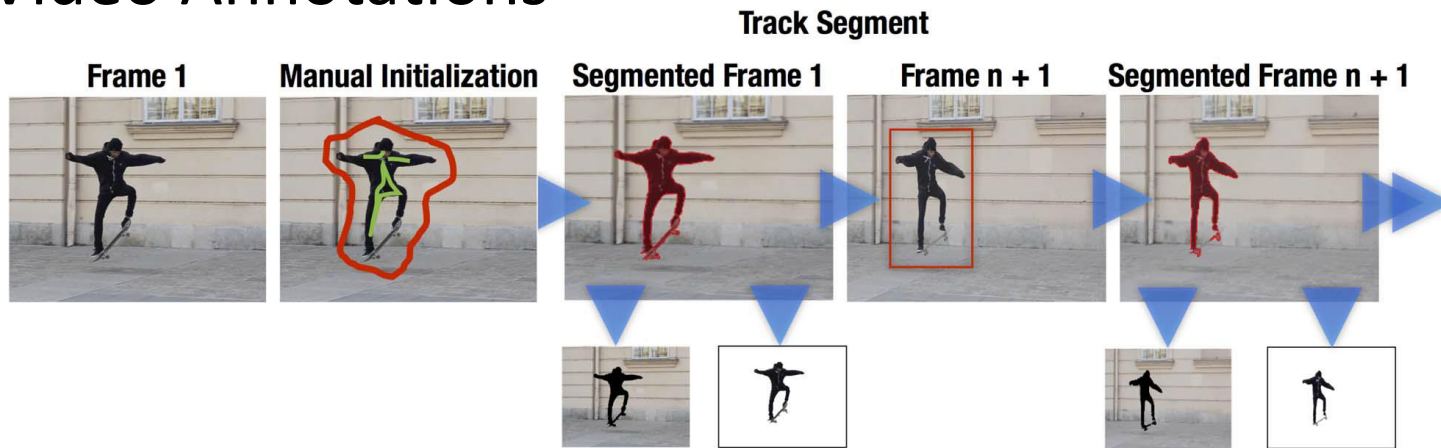  - Manual effort, crowdsourced map labeling

# AR Browser: Content

- Most content stored in proprietary formats
- Hard to create content on mobile device
- Textual Annotations: point and click
- Audio Annotations

# AR Browser: Content

- Video Annotations



**Track Segment**

Frame 1 | Manual Initialization | Segmented Frame 1 | Frame n + 1 | Segmented Frame n + 1
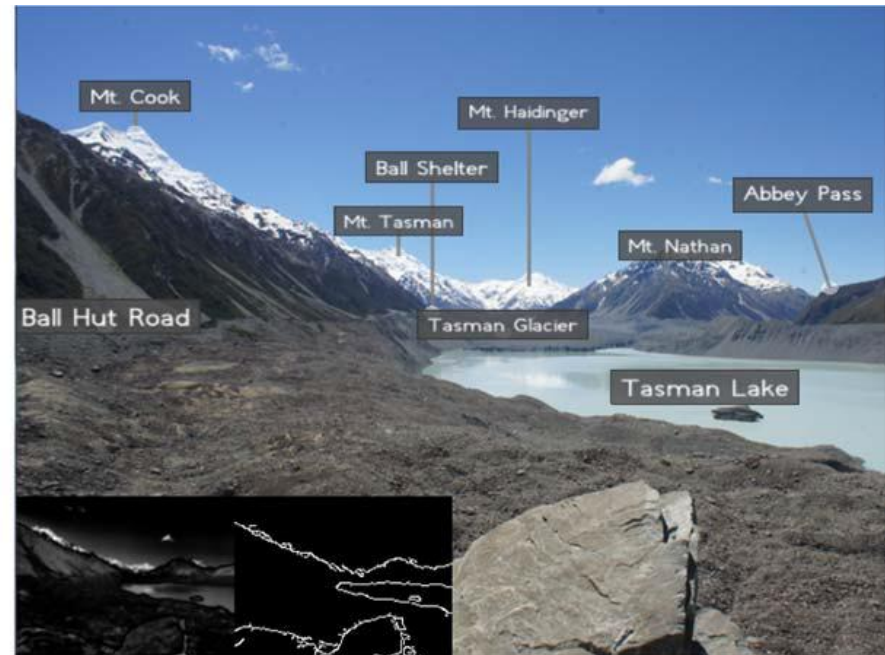
- Three dimensional media

# AR Browser: User Interface – View Management: Placing labels

- Image importance: do not cover important content
- Generation of an edge map, passed then to a layout solver to rearrange the labels

# AR Browser: User Interface – View Management: Image Geometric Structure

- Get a better placement and orientation
- Compute the vanishing plane to align the label
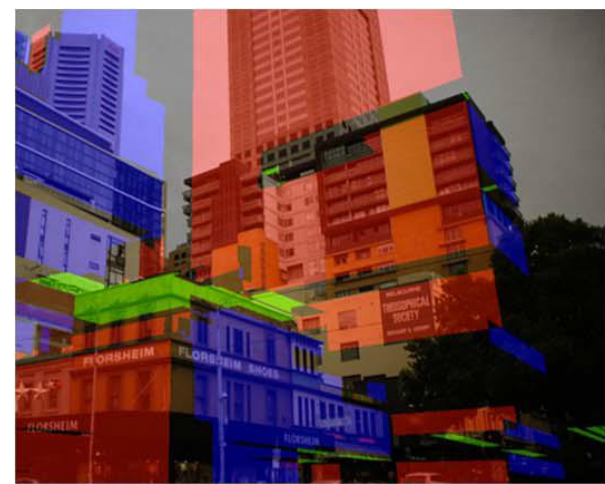
# Roadmap



**Next-Generation Augmented Reality Browser: Rich, Seamless, and Adaptive**



**Handling Motion-Blur in 3D Tracking and Rendering for Augmented Reality**



**Simulating Low-Cost Cameras for Augmented Reality Composing**

# Handling Motion-Blur: Introduction

- Park et al., Handling Motion-Blur in 3D Tracking and Rendering for Augmented Reality (2012)

- Motion blur makes tracking hard

- Motion blur introduced in rendering

- Cheap motion blur

# Handling Motion-Blur: Image Model

- Image model with blur

- Minimization problem

- Iterative solution

- ESM-Blur
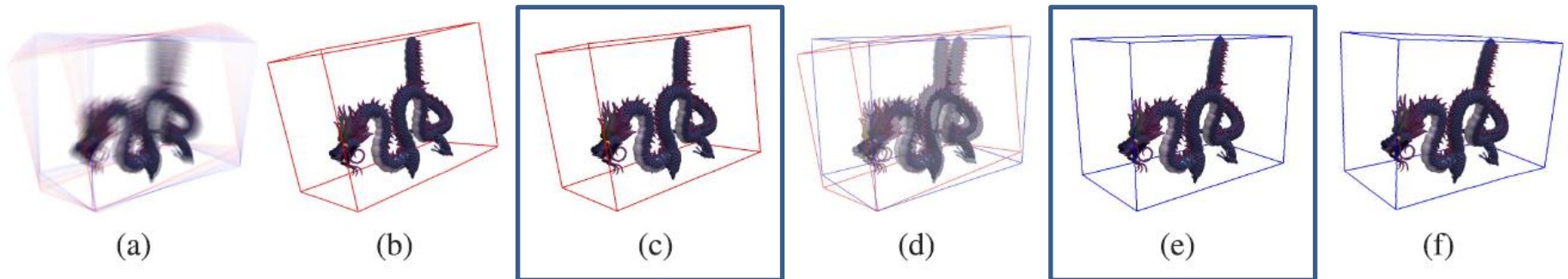
- Depending on shutter time

- ESM-Blur-SE
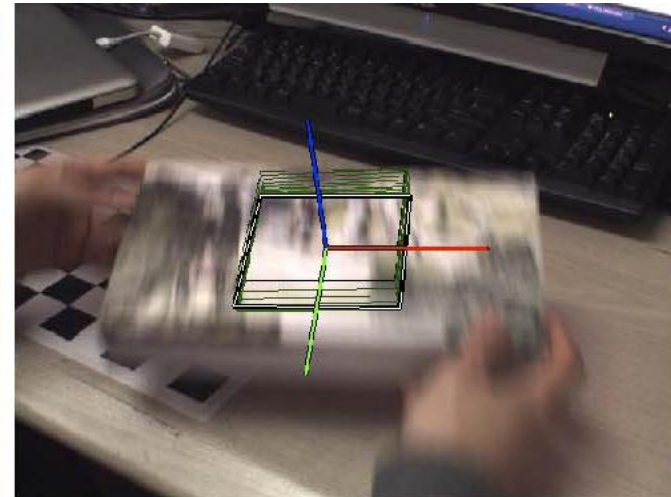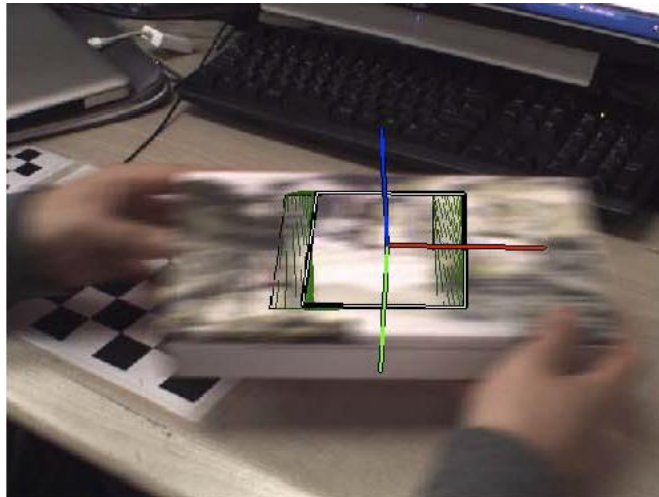
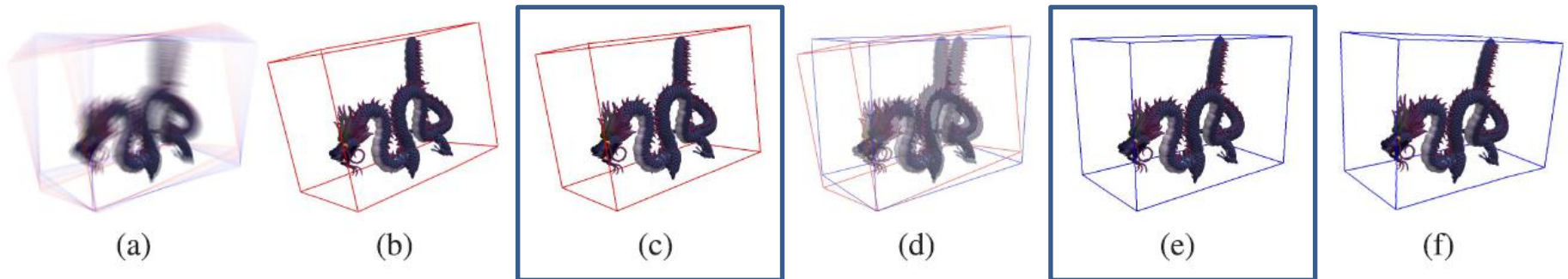# Handling Motion-Blur: 3D Motion Blur Generation

# Handling Motion-Blur: 3D Motion Blur Generation

- Goal: Blur the rendered image
- Old: Blend many images – expensive
- New:
  - Render virtual object in 3D twice (intraframes: c, e)
  - Generate more images by 2D warping (intermediate frames: b, d, f)
  - Result: a
  - Much faster



(a)   (b)   (c)   (d)   (e)   (f)

# Handling Motion-Blur: Generating the Intermediate Images

- How many intermediate images?
  - Adapt to the motion amplitude
  - Distance in pixels
- How do we generate the intermediate images?
  - Rely on intraframe closest
  - Blend at the gap
- Where do we get the affine transformation from?
  - Use of bounding boxes



(a)    (b)    (c)    (d)    (e)    (f)

Video:

[http://ieeexplore.ieee.org/xpl/abstractMultimedia.jsp?arnumber=6025351&tag=1](http://ieeexplore.ieee.org/xpl/abstractMultimedia.jsp?arnumber=6025351&tag=1)

# Roadmap



**Next-Generation Augmented Reality Browser: Rich, Seamless, and Adaptive**
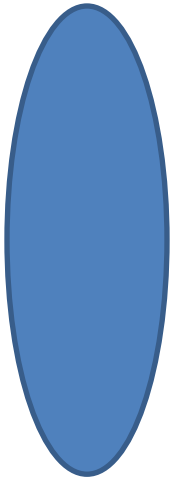


**Handling Motion-Blur in 3D Tracking and Rendering for Augmented Reality**


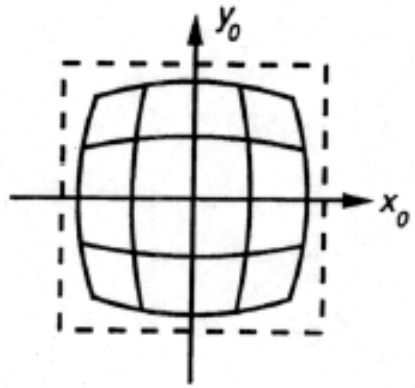
**Simulating Low-Cost Cameras for Augmented Reality Composing**

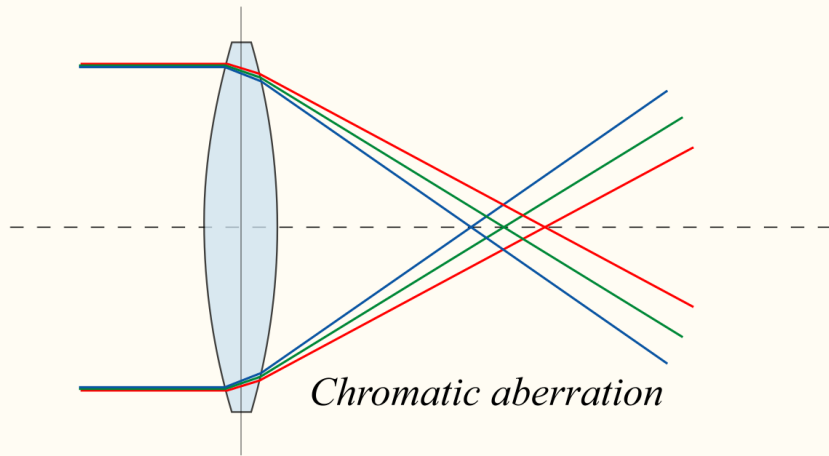# Simulating Camera: The imaging pipeline

Lens

# Simulating Camera: The imaging pipeline



**Barrel Distortion**

Lens

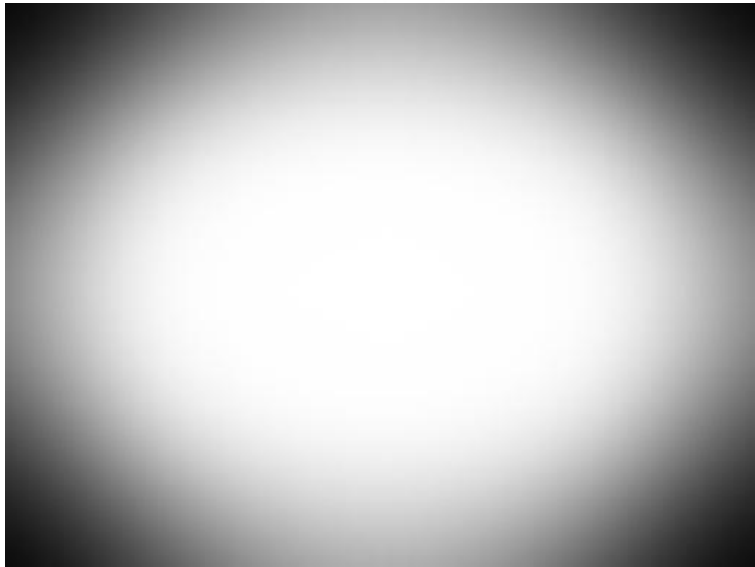# Simulating Camera: The imaging pipeline



*Chromatic aberration*
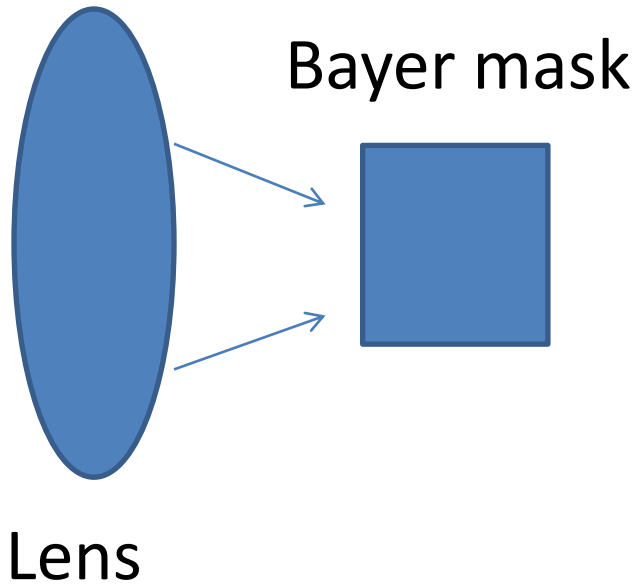
Lens

# Simulating Camera: The imaging pipeline



Lens

# Simulating Camera: The imaging pipeline

Bayer mask

Lens

# Simulating Camera: The imaging pipeline

Image
Sensor

Bayer mask

Lens

RAW data

Full R,G,B color file

# Simulating Camera: The imaging pipeline

Image
Sensor

Bayer mask

Lens

# Simulating Camera: The imaging pipeline

Image
Sensor

Bayer mask

Lens

# Simulating Camera: The imaging pipeline



Image Sensor

Bayer mask

Lens

In camera processing

# Simulating Camera: The imaging pipeline

Image
Sensor

Bayer mask

YUV to RGB

Lens

In camera
processing

The quick brown fox jumped over the lazy dog.
The quick brown fox jumped over the lazy dog.
The quick brown fox jumped over the lazy dog.
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The quick brown fox jumped over the lazy dog.
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[5]
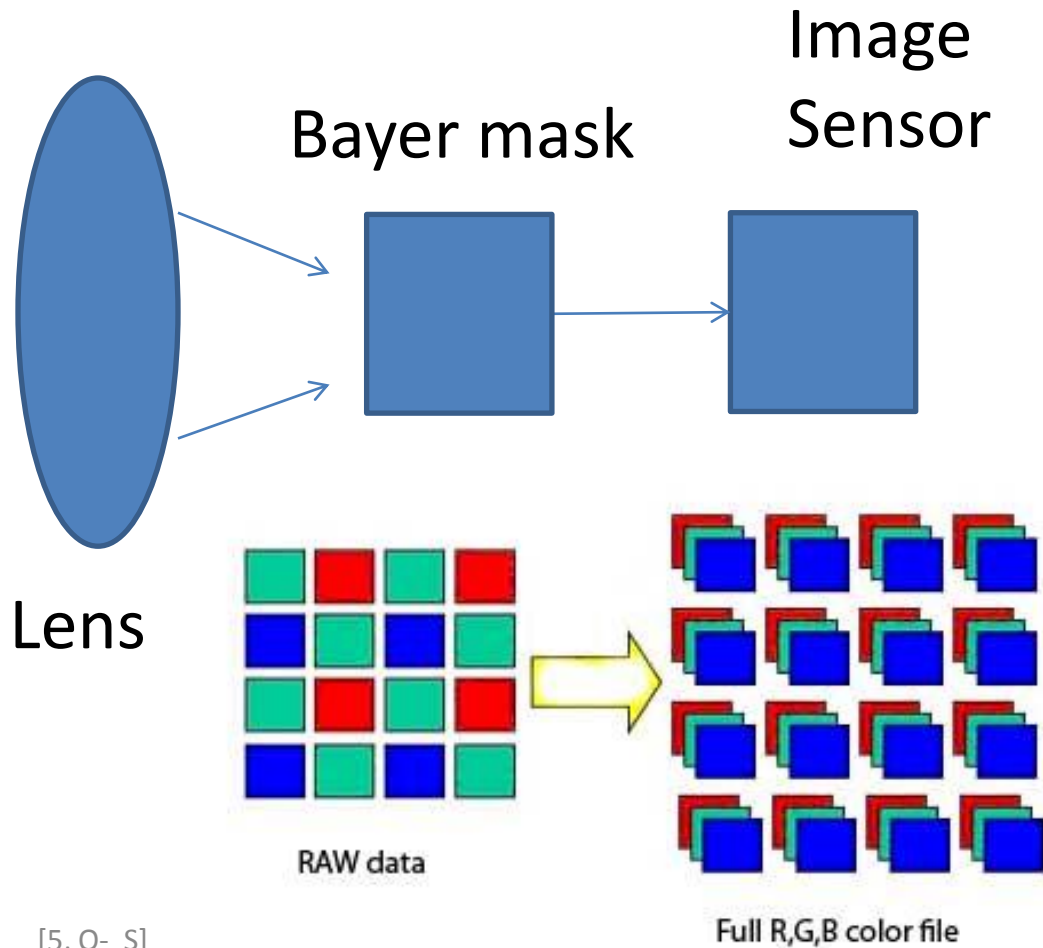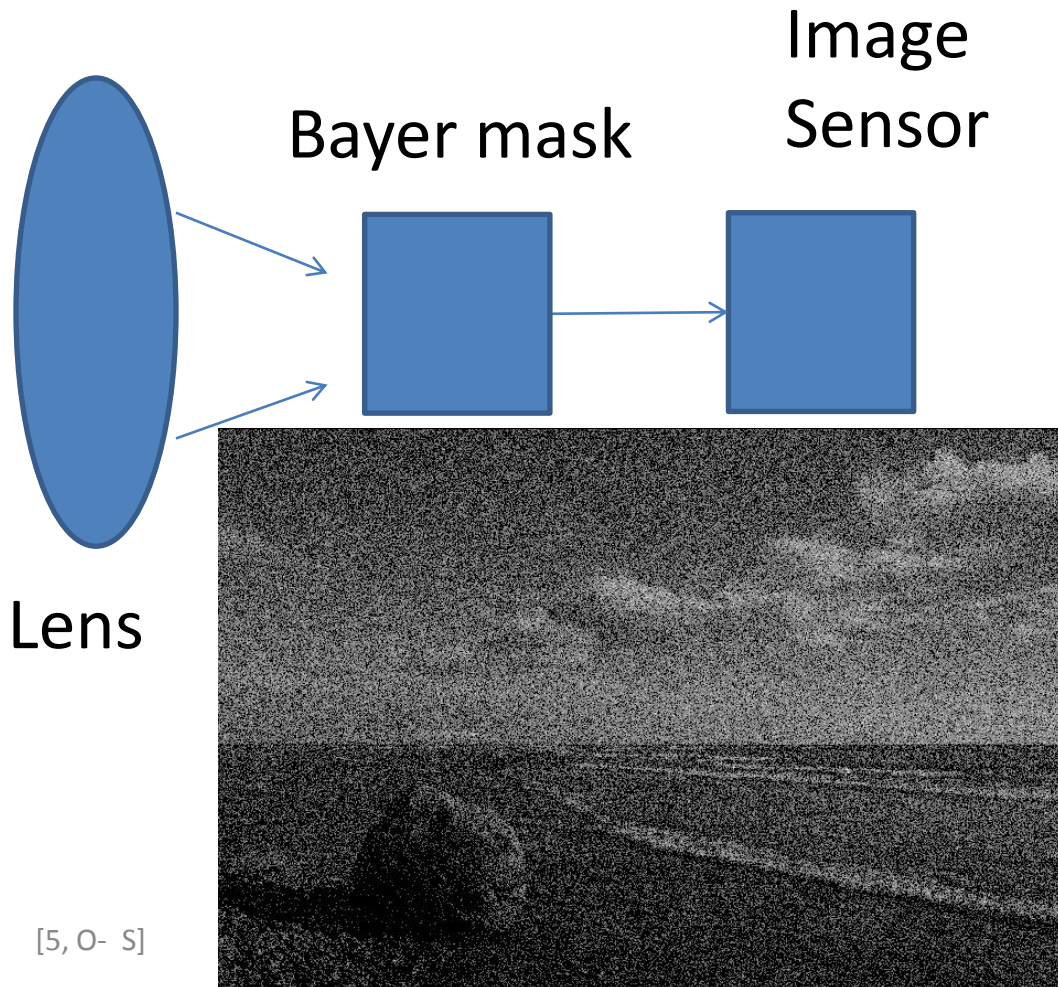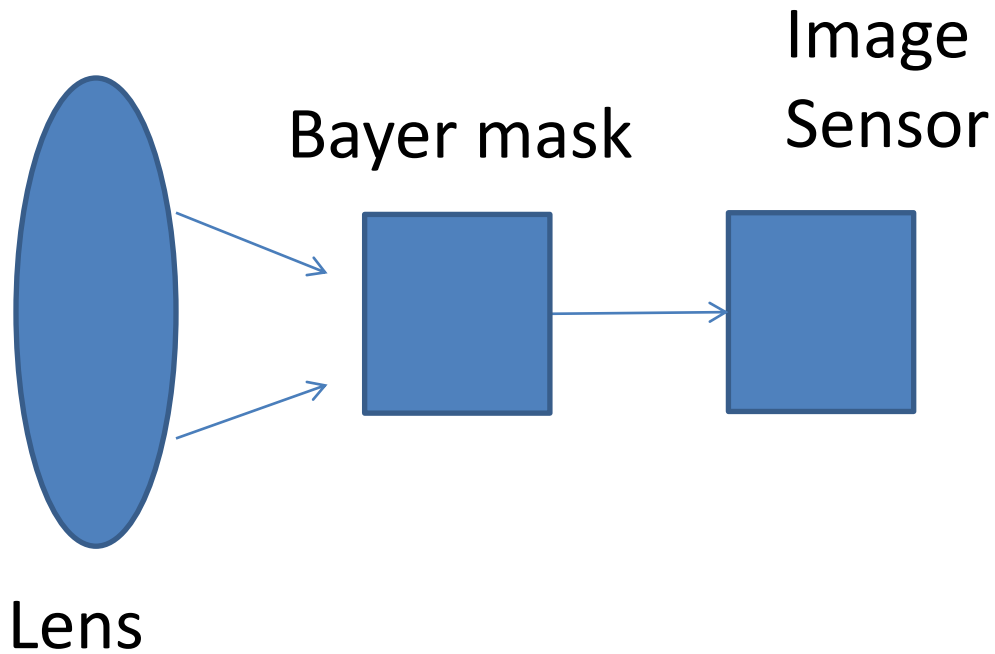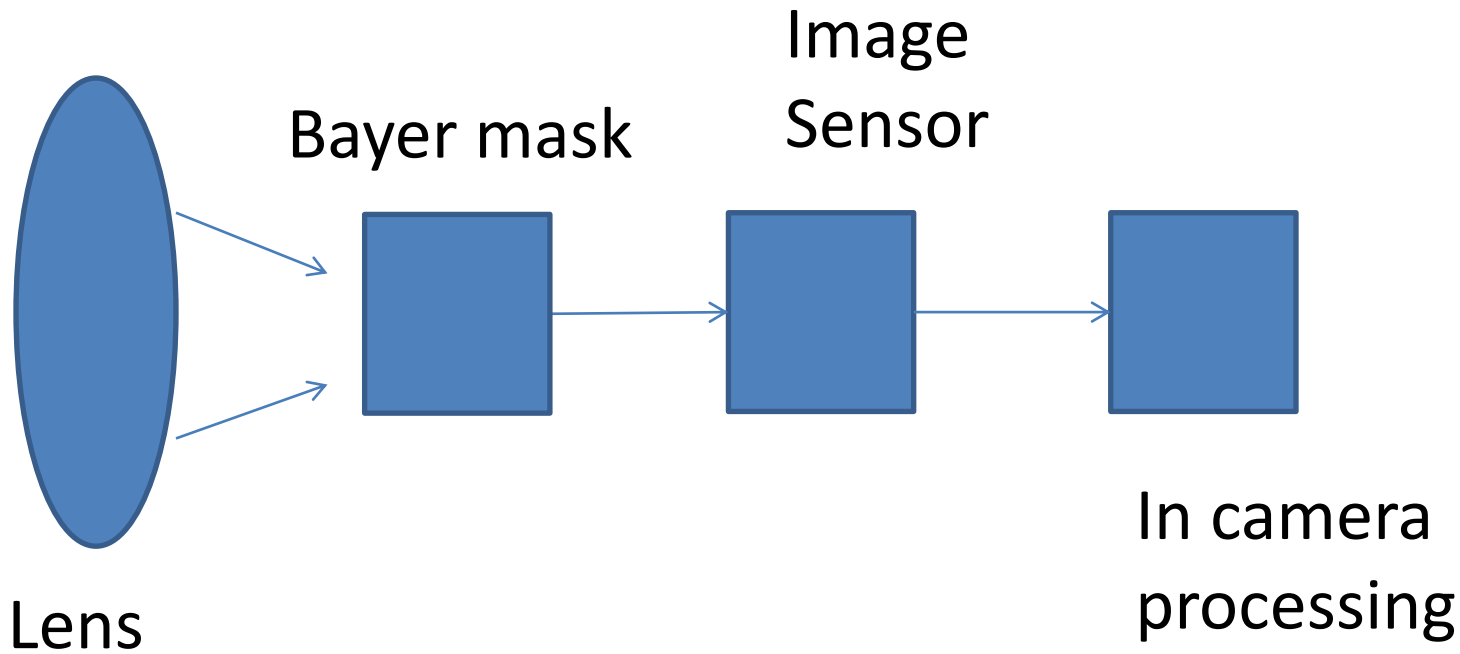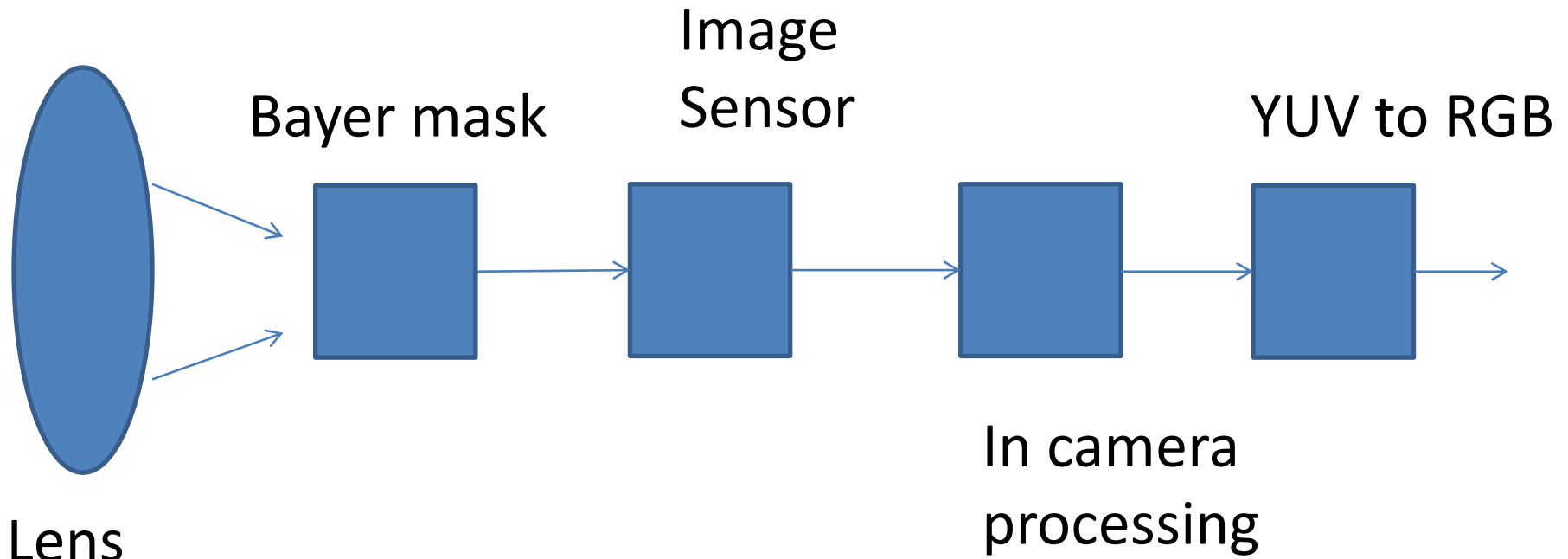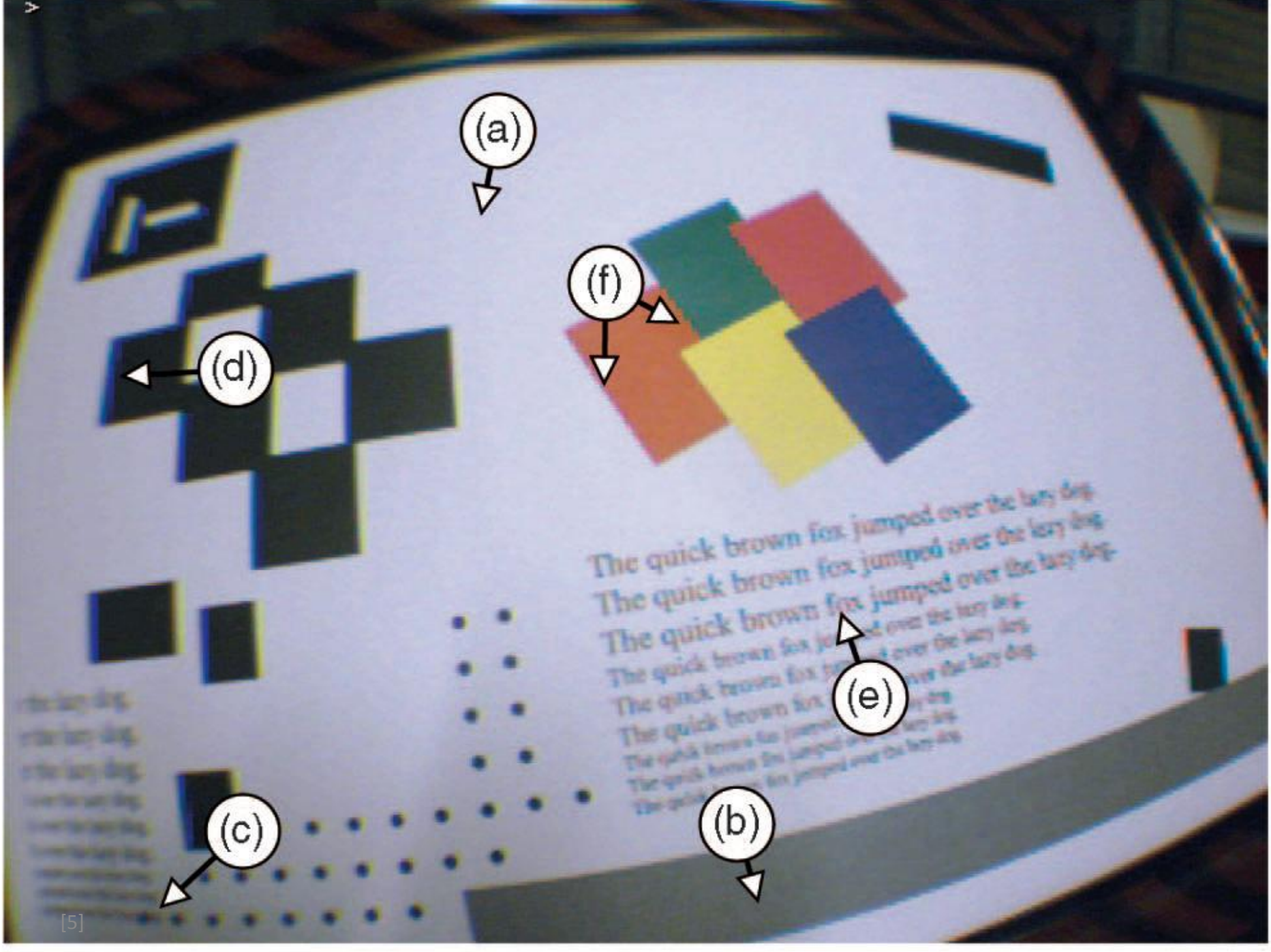
# Simulating Camera: Implementation

- Start with high-resolution image
- Blur, downsample
- Simulate Bayer-pattern
- In-Camera processing
- Three inputs per frame
  - Virtual graphic
  - Image of the camera
  - Camera's rotation

RAW data

Full R,G,B color file

# Simulating Camera: Processing – Radial distortion & Half sampling and color mixing

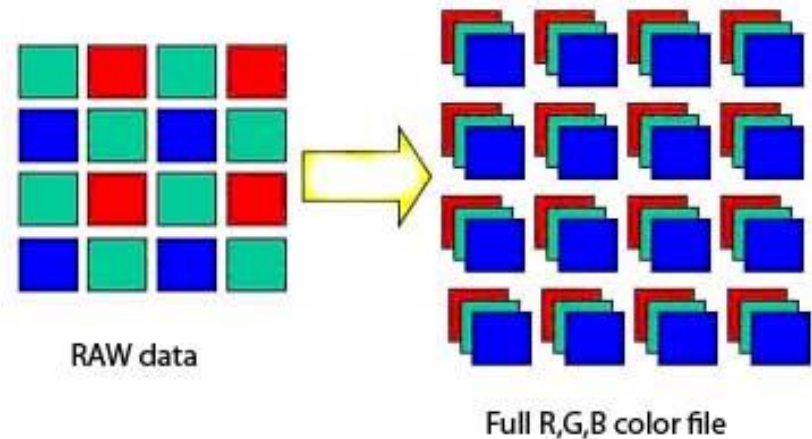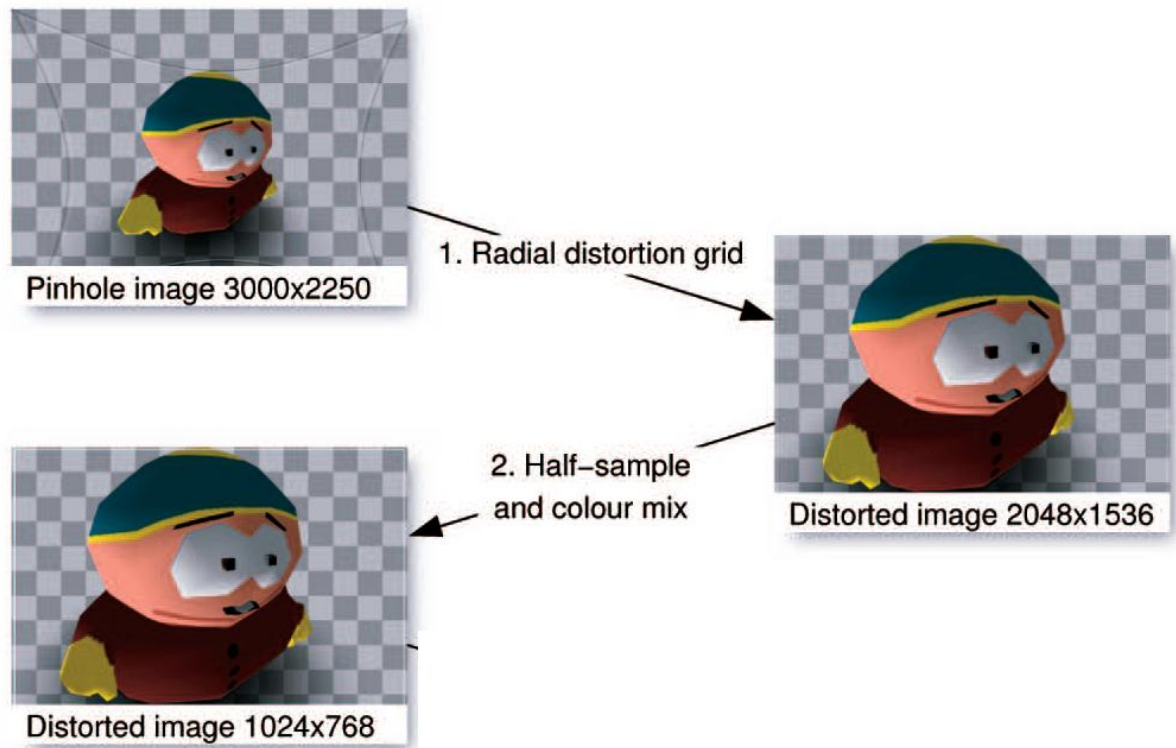1. Radial distortion: Barrel distortion
2. Color mix
   i. Subsampling of the image
   ii. Filter to avoid artifacts
   iii. Desaturation of the image



Pinhole image 3000x2250

1. Radial distortion grid

Distorted image 2048x1536

2. Half–sample and colour mix

Distorted image 1024x768

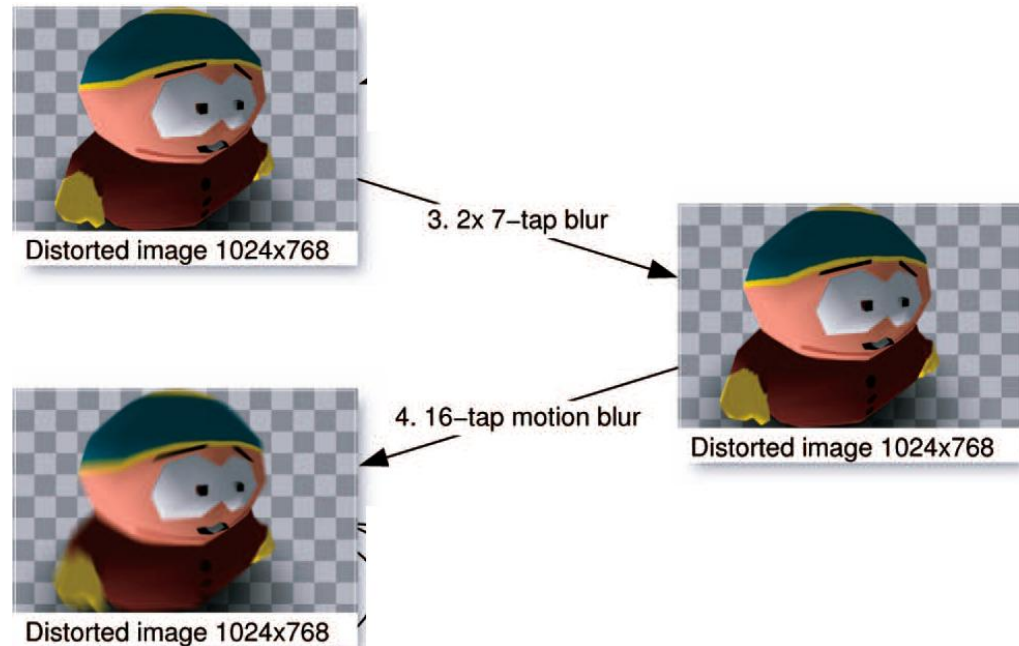# Simulating Camera: Processing – Gaussian Blur & Motion Blur

3. Gaussian blur filter

    i. Space variant blur (corners and edges)

4. Motion Blur

    i. Estimation of direction and magnitude

    ii. Gaussian blur in the direction of motion



Distorted image 1024x768

3. 2x 7–tap blur

Distorted image 1024x768

4. 16–tap motion blur

Distorted image 1024x768

# Simulating Camera: Processing – Bayer Sampling & Blur & Quantization
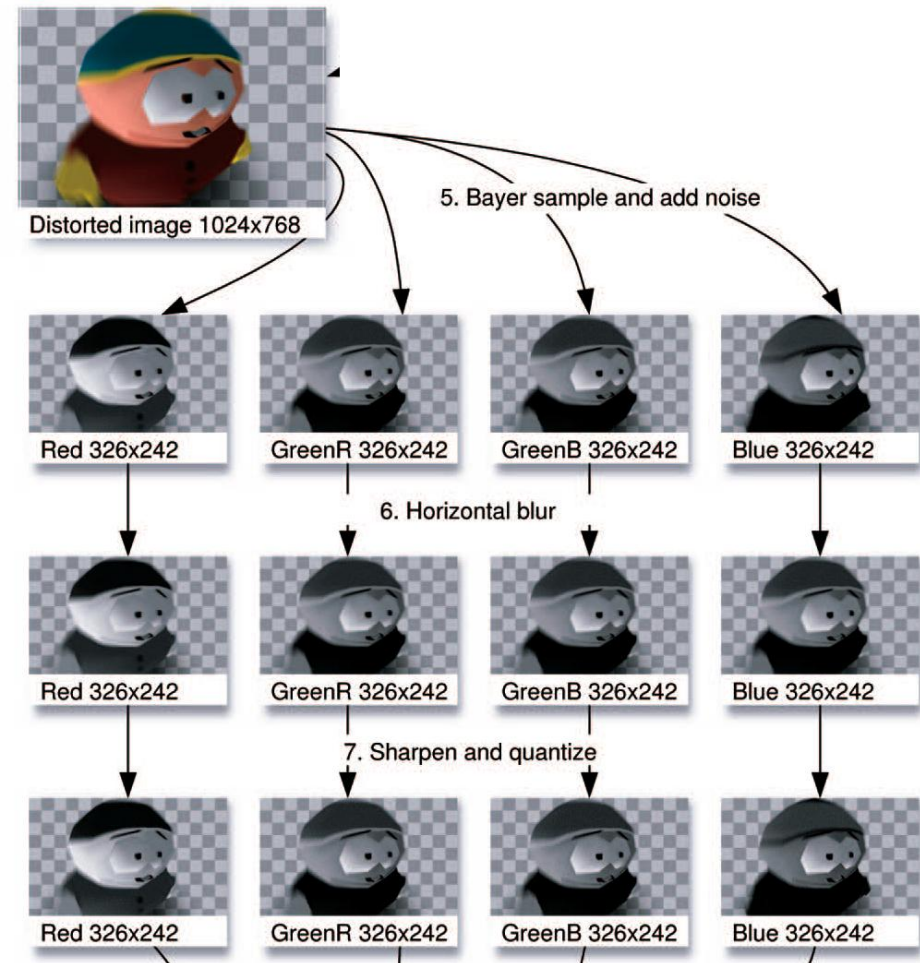
5. Bayer Sampling
   i. Subsample of the image with a Bayer mask
   ii. Noise is added
6. Horizontal blur
7. Quantize to 6bit
   i. Sharpening



Distorted image 1024x768

5. Bayer sample and add noise

Red 326x242    GreenR 326x242    GreenB 326x242    Blue 326x242

6. Horizontal blur

Red 326x242    GreenR 326x242    GreenB 326x242    Blue 326x242

7. Sharpen and quantize

Red 326x242    GreenR 326x242    GreenB 326x242    Blue 326x242

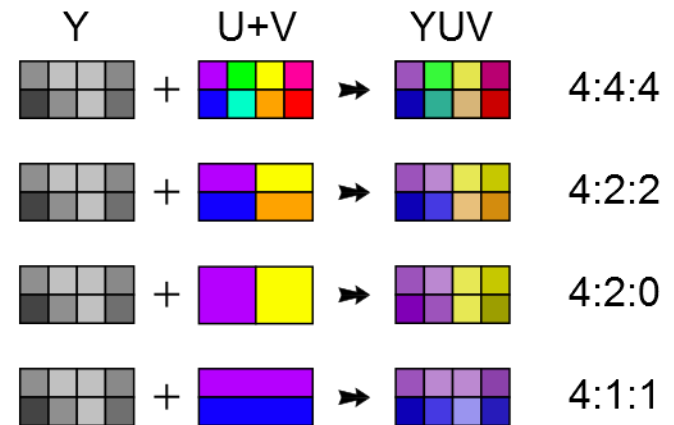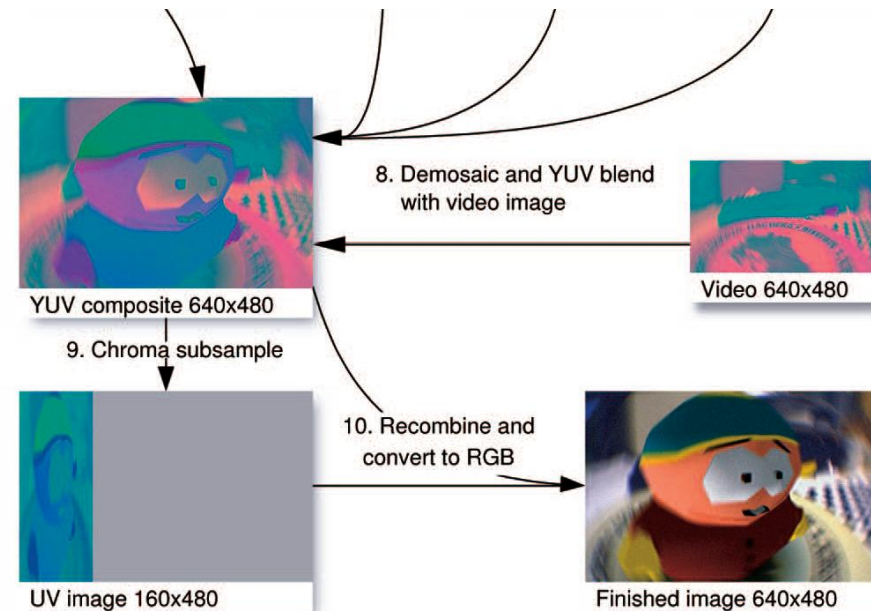# Simulating Camera: Processing – YUV blending & Split & Combine

8. Blending
   i. Bayer demosaic
   ii. Output: mixed YUV image

9. Split YUV image (640x480)
   i. 640x480 Y image
   ii. 160x480 UV image

10. Recombine & convert to RGB



8. Demosaic and YUV blend with video image

YUV composite 640x480

Video 640x480

9. Chroma subsample

10. Recombine and convert to RGB

UV image 160x480

Finished image 640x480

Y   U+V   YUV

4:4:4

4:2:2

4:2:0

4:1:1

# Simulating Camera: Processing – Result I
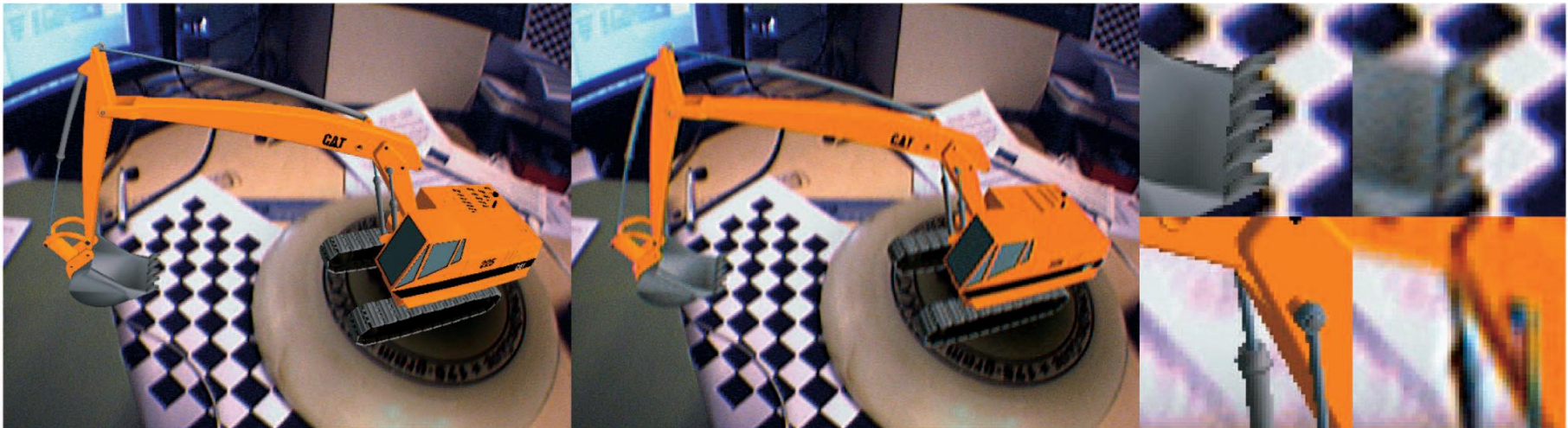
# Simulating Camera: Processing – Result II
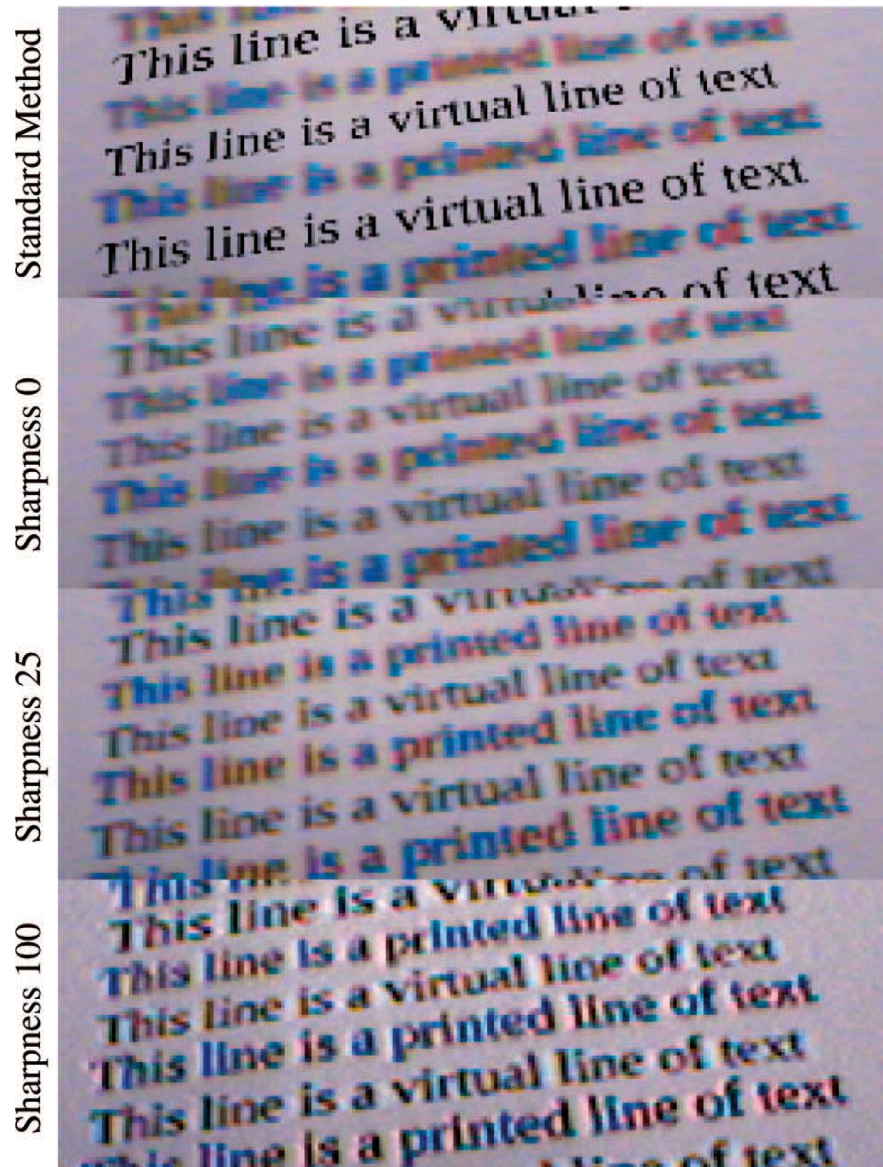
# Summary

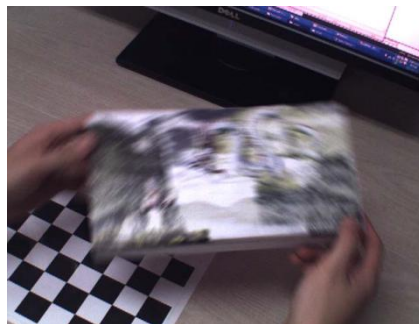| **AR Browser** | **Handling Motion-Blur** | **Simulating Low-Cost Camera** |
|---|---|---|
| - Seamless registration<br>- Rich content: text, video, audio, 3D<br>- Adaptive User Interface<br>- Scene analysis to improve the layout and representation | - Blur in the image model<br>- Iterative solution Shutter speed<br>- Intraframes and Intermediate frames | - Lense<br>- Noise<br>- Blur<br>- Calibration steps |
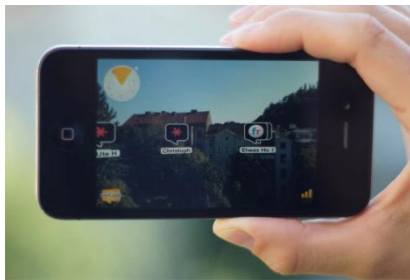
# Thank you

# References

[1]: A Survey of Augmented Reality, Ronald T. Azuma, 1997

[2]: Augmented Reality: An Overview and Five Directions for AR in Education, Yuen et al., 2011

[3]: Next-Generation Augmented Reality Browser: Rich, Seamless, and Adaptive, Langlotz and Schmalstieg, 2014

[4]: Handling Motion-Blur in 3D Tracking and Rendering for Augmented Reality, Park et al., 2011

[5]: Simulating Low-Cost Cameras for Augmented Reality Compositing, Klein and Murray, 2009

[6]: 3D High Dynamic Range Dense Visual SLAM and Its Application to Real-time Object Re-lighting, Meilland et al, 2013

# Image Sources

[A] : Screenshot, https://www.youtube.com/watch?v=m648ji7Ro8Y
[B]: Screenshot, https://www.youtube.com/watch?v=IpNrWKQFq6Q
[C]: Screenshot, https://www.youtube.com/watch?v=YAPmC6priqY
[D]: http://designbuildsource.com.au/wp-content/uploads/2013/03/Augmented-Reality-Architecture.jpg
[E]: http://7langit.com/wp-content/uploads/2013/03/AR-Sports.jpg
[F]: http://medicalaugmentedreality.com/wp-content/uploads/2012/03/P1000349.jpg
[G]: http://www.americansentinel.edu/blog/wp-content/uploads/2012/08/Military-GIS-augmented-reality1.jpg
[H]: Screenshot, https://www.youtube.com/watch?v=mVqSUtzCrl0
[I]: http://www.bosch.it/stampa/comunicato.asp?idCom=2196
[J]: Screenshot, https://www.youtube.com/watch?v=UOfN1plW_Hw
[K]: http://www.hiperfree.com/wp-content/uploads/2014/05/Oculus_Rift_-_Developer_Version_-_Front.jpg
[L]: https://montessoried.files.wordpress.com/2014/07/wpid-google_glass_with_frame.jpg
[M]: Screenshot, https://www.youtube.com/watch?v=vDNzTasuYEw
[N]: http://robagainsttheworld.altervista.org/wp-content/uploads/2013/07/zaza13.jpg
[O]: http://upload.wikimedia.org/wikipedia/en/a/aa/Chromatic_aberration_lens_diagram.svg
[P]: http://media.sparvagsmuseet.se/krpano/examples/xml-usage/compass/vignetting.jpg
[Q]: Cut, from http://www.uni-koeln.de/~al001/radcor_files/rad027.png
[R]: Cut, from http://upload.wikimedia.org/wikipedia/commons/4/42/Photon-noise.jpg
[S]: https://phaseoneimageprofessor.wordpress.com/tag/white-balance/
[T]: http://upload.wikimedia.org/wikipedia/commons/thumb/f/f2/Common_chroma_subsampling_ratios.svg/1024px-Common_chroma_subsampling_ratios.svg.png