

Body-Mounted Cameras

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Outline

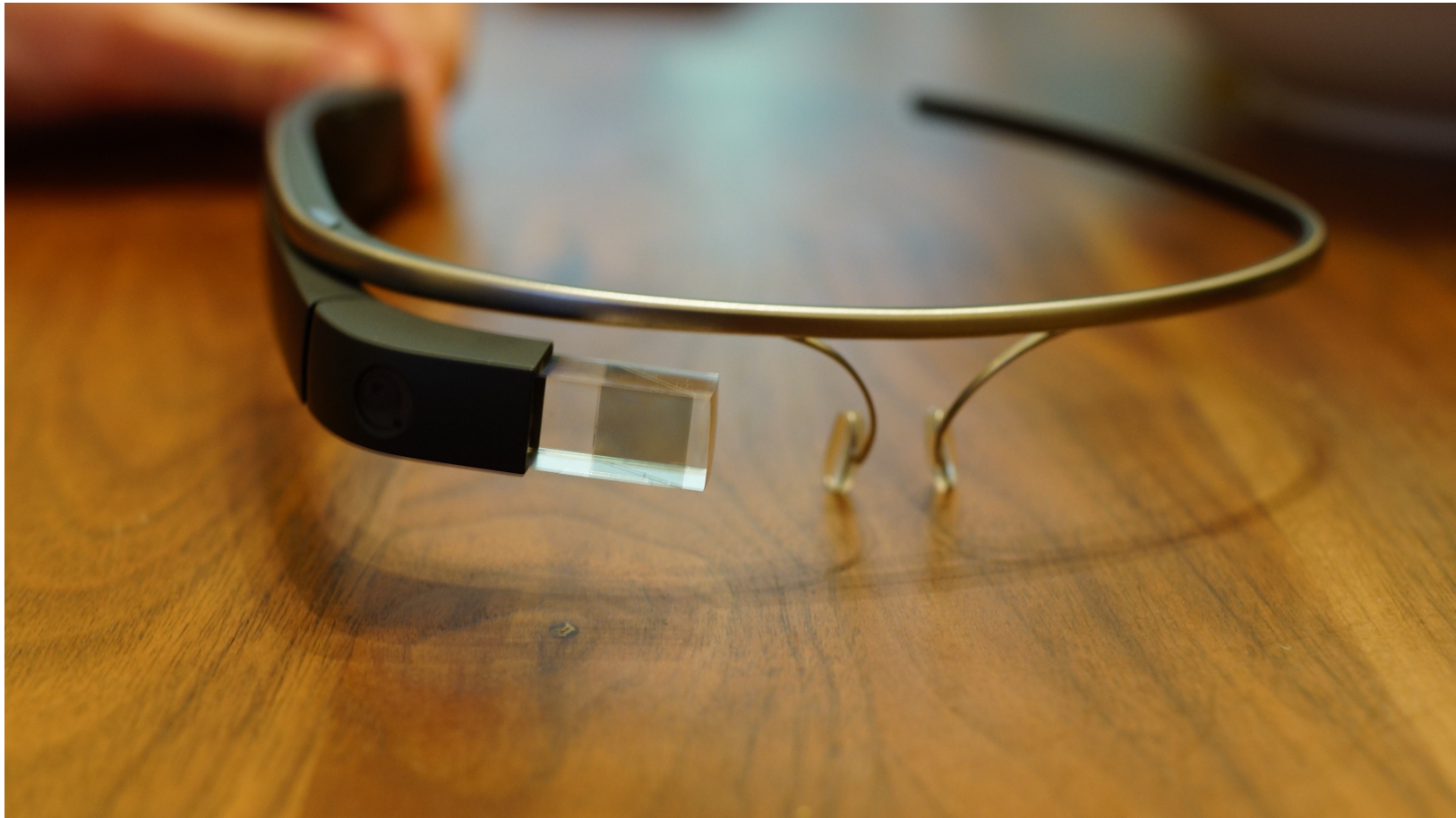
- Google Glass
- EyeTap
- Motion capture
- SenseCam

Introduction

- Cameras have become small, light and cheap
- We can now wear them constantly
- So what new things can we do with them?



Google Glass



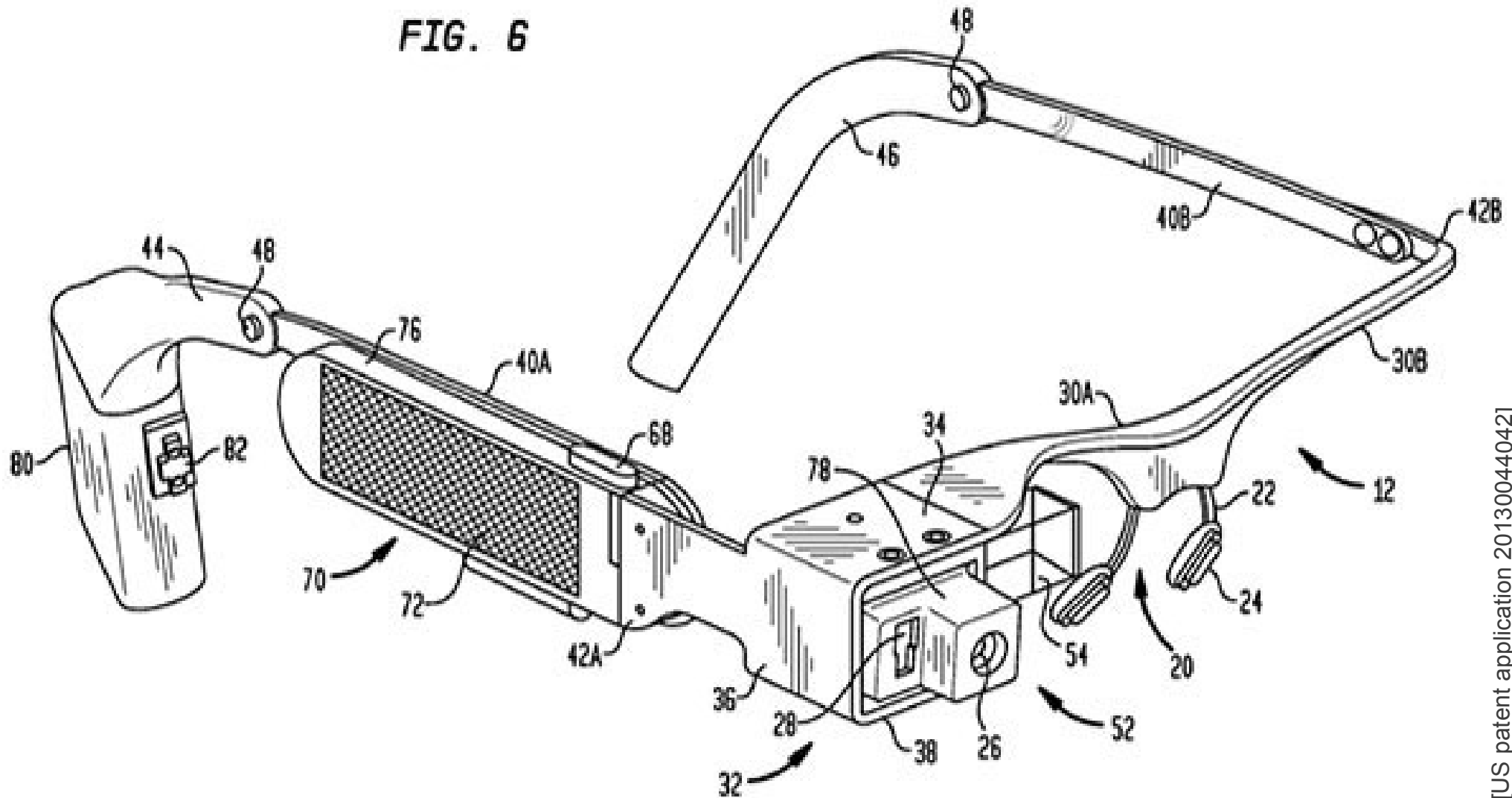
[http://commons.wikimedia.org/wiki/File:Google_Glass_Explorer_Edition.jpeg]

Google Glass

- Like a head-worn smartphone
 - Sensors, wi-fi, bluetooth, camera
- Input over voice commands, touchpad or phone app
- Runs Android
 - App support

Schematic

FIG. 6



Applications

- Lifelogging
- Looking up information on the internet
- Remote-controlling smartphone
- Getting notifications from smartphone

Too futuristic?



[plus.google.com/105804767481830727070/photos]

Meet Thad Starner and Steve Mann



[<http://www.histancia.com/wearable-computing/>]

Steve Mann over the years



(a)
1980



(b)
Mid 1980s



(c)
Early 1990s



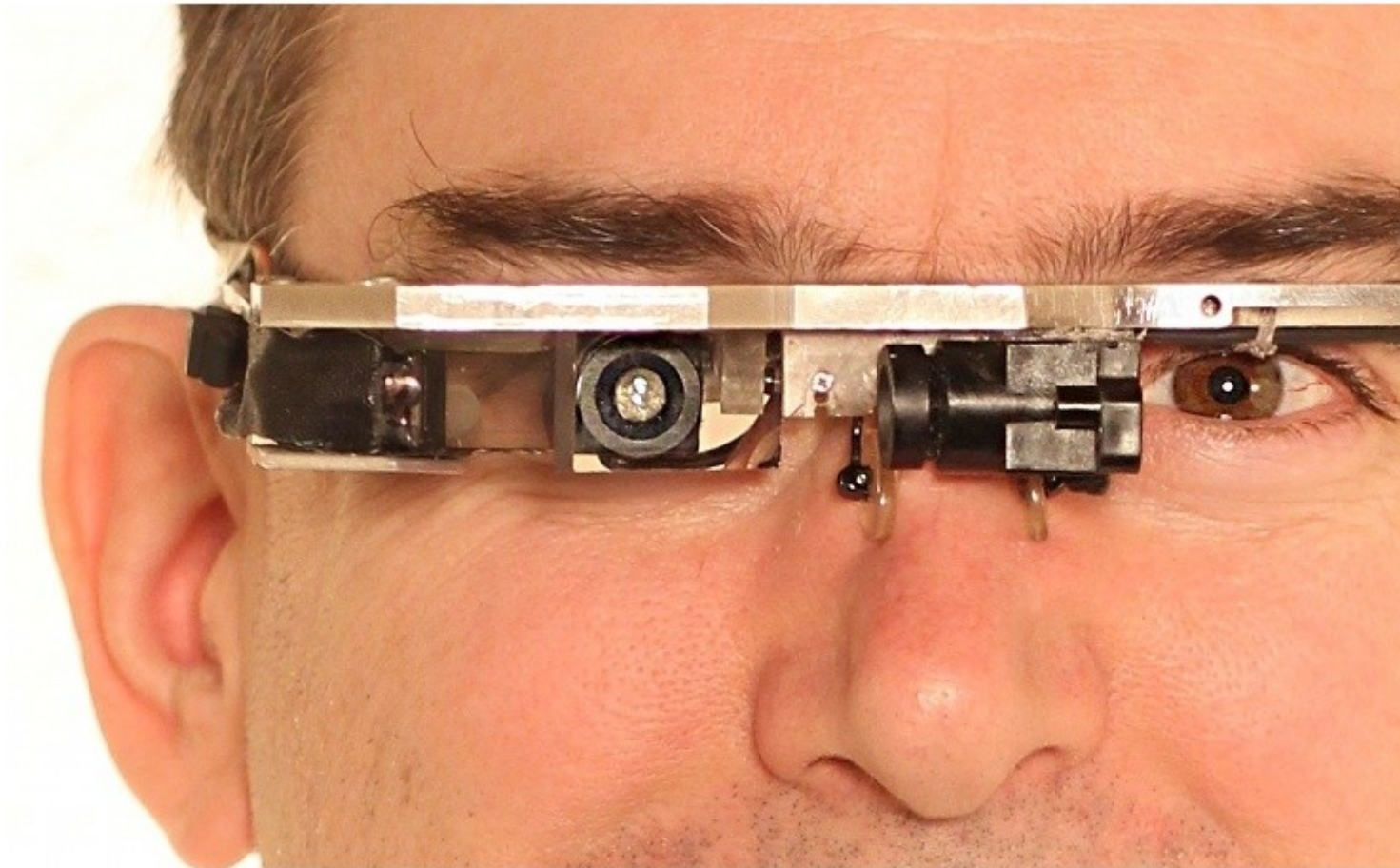
(d)
Mid 1990s



(e)
Late 1990s

[Mann 2004]

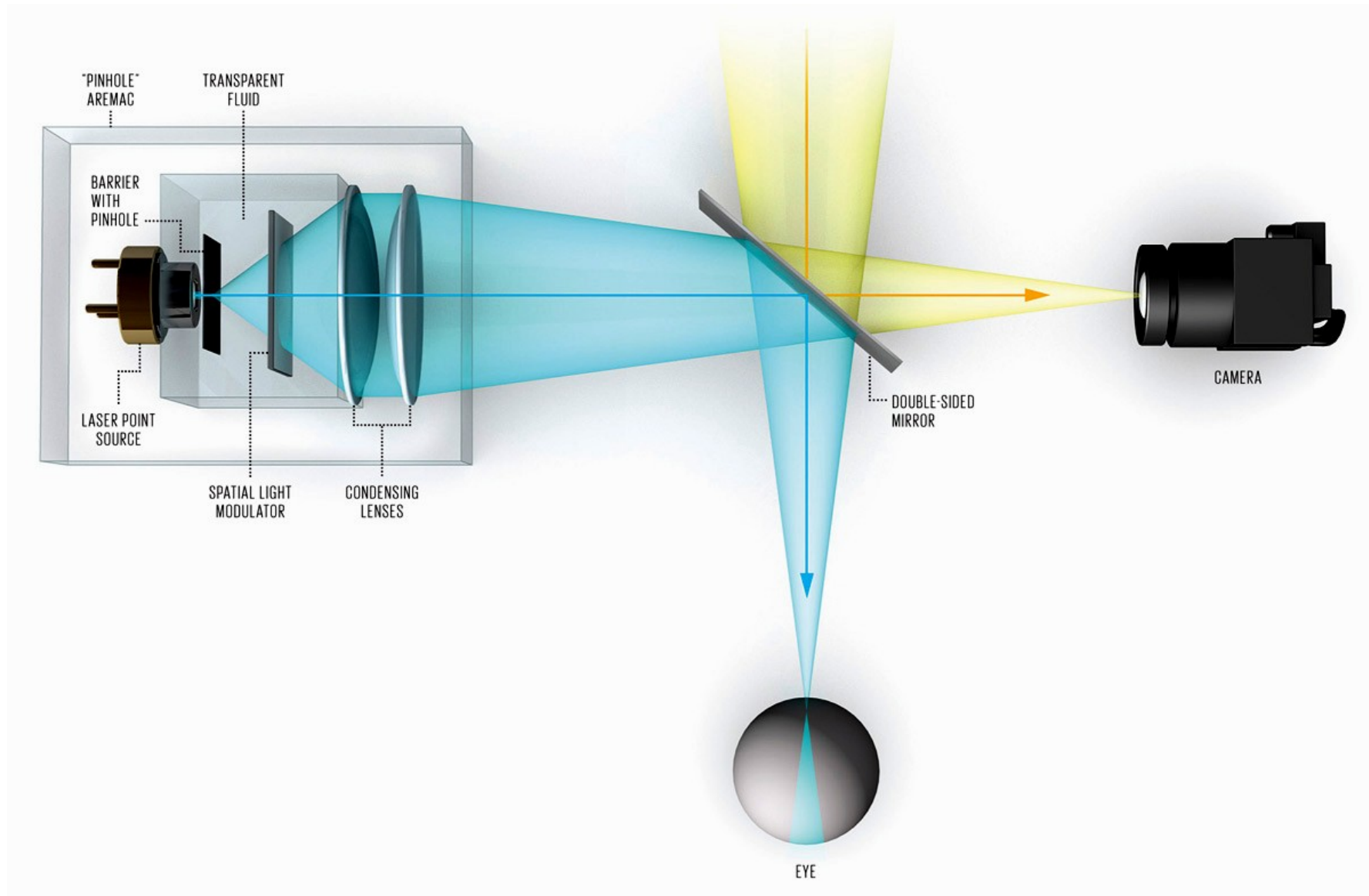
EyeTap



Mann's 1999 "EyeTap Digital Eye Glass"

[Mann 2012]

Schematic



How it works

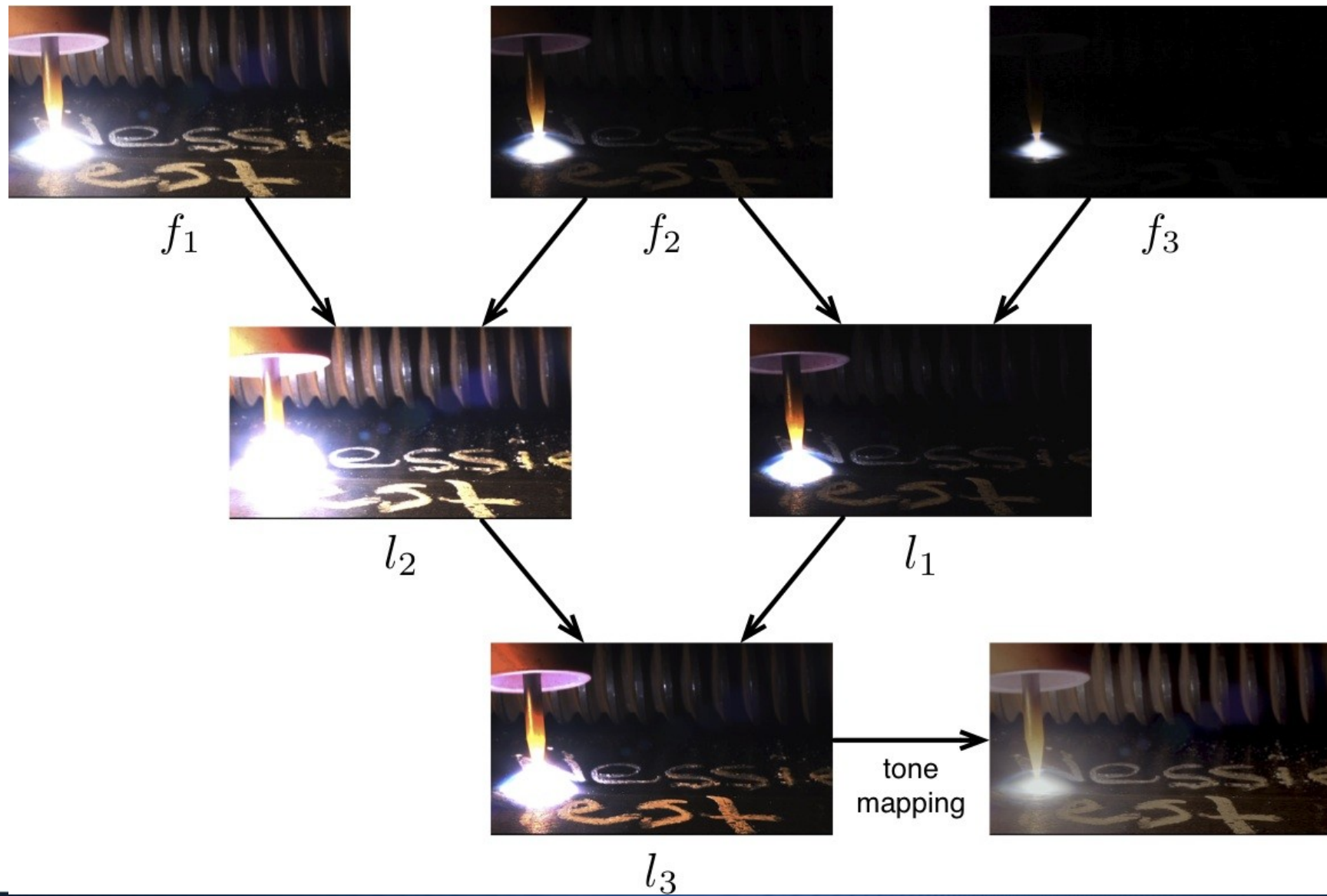
- Incoming light is diverted onto camera
- Captured image is processed
- Processed image is projected into eye

- Functionally, the eye becomes a camera
 - To the outside, the camera replaces the eye

Applications

- Lifelogging
- Capture events from exact perspective of user
- Augmented / mediated reality
 - Latency between capture and projection will disturb users (simulation sickness)
- Correction of visual impairment
 - Not just long-/shortsightedness
- Increase visual dynamic range

HDR filter



Color blindness

- About 8% of all men are red-green colorblind
- Much of our everyday life is color-coded
- EyeTap could automatically replace colors, or label colored surfaces



[<http://en.wikipedia.org/wiki/Colorblindness>]

Comparison with Glass

EyeTap

- More potential for mediated reality
- Can replace prescription glasses

Glass

- Standard smartphone functionality
- Compact enough be worn as an accessory

Future development

- Size, weight and battery life will improve through normal technical progress
- More computing power will allow for more complex applications
 - Latency is limiting factor of mediated reality
- Society's reaction to Glass will be very important
 - Broad acceptance of Glass will make EyeTap more acceptable

What if we film the user instead?

Motion capture



[<http://avatarblog.typepad.com/avatar-blog/2010/05/behind-the-scenes-look-at-the-motion-capture-technology-used-in-avatar.html>]

Motion capture

- We have already seen a system using body-mounted cameras for capturing full body motion
 - (April 9, talk by Antoine Kaufmann)



[Shiratori2011]

Approach

- Capture the face using one camera and multiple light sources (Photometric stereo)
 - Can be combined with other systems
 - Many systems have a normal camera pointed at the face anyway
- The actor should be able to move freely
 - Ambient light changes

Why capture the face separately?

- Face is the most expressive part of body language
- Even small mistakes will stand out
- Traditionally, artists would correct generated images by hand

How it works



[Jones 2011]

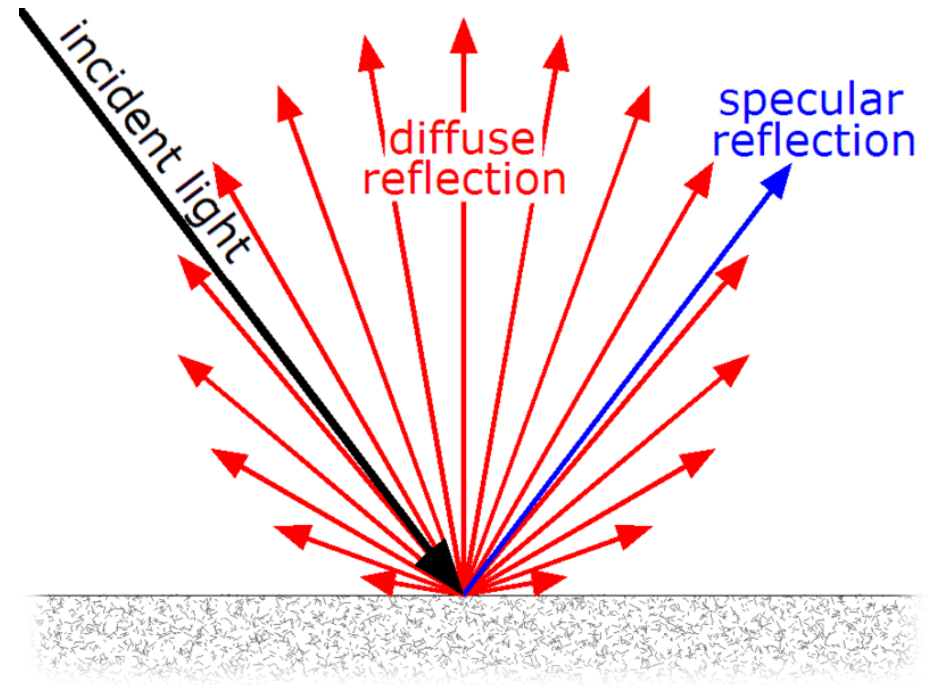
How it works



- Three different lighting directions
- One with ambient lighting only
- Capture 120 fps input for 30 fps output
 - Change lights at 360Hz to eliminate flickering

How it works

- Assumes lambertian reflectance
 - Surface will look equally bright from a range of angles



[<http://commons.wikimedia.org/wiki/File:Lambert2.gif>]

Equation

$$I = L * N A$$

- I: image intensity (measured by camera)
 - L: lighting direction (3x3 matrix, known)
 - N: surface normal (vector that we want to know)
 - A: albedo (scaling factor)
-
- Surface geometry can then be reconstructed from normals

Corrections

- Closeness of both lights and camera leads to inaccuracies
 - Lighting direction for each pixel depends on depth
- Use a generic smoothed face to initialize lighting directions



Video demonstration

“Head-Mounted Photometric Stereo for Facial Performance Capture”

<http://www.youtube.com/watch?v=RGtFPLciFLQ>

Results



- Shadow artifacts show up as white albedo around nose

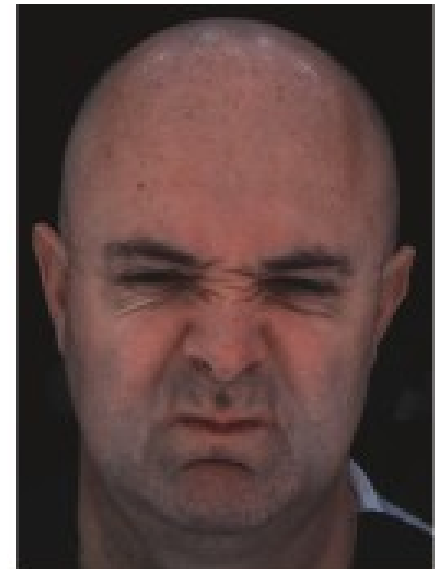
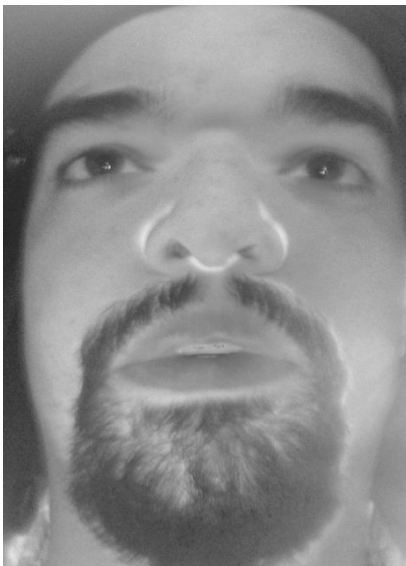
Results

- Subtle movements are captured
 - Exactly where non-camera-based approaches fail
- Using infrared light leads to more artifacts
- Computation of normals and geometry reconstruction can be done in real-time

Comparison with more detailed method

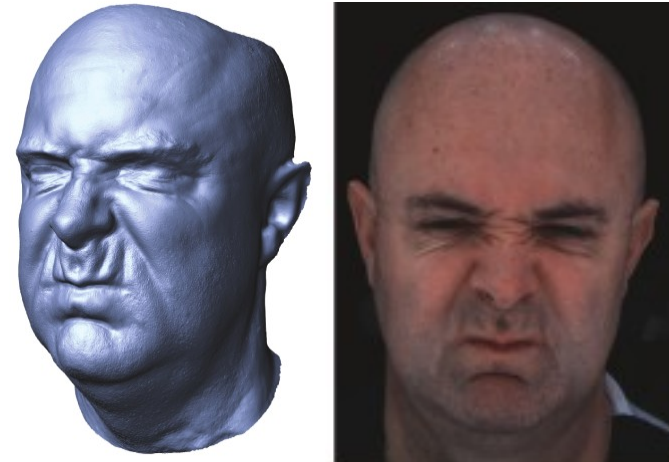
Jones et al, 2011

Beeler et al, 2011



Comparison with more detailed methods

- Actors can move freely
- Can handle changes in ambient light
- Captures even small wrinkles
- Needs multiple cameras and uniform lighting
- Actors must hold head still



Next steps

- Use a picoprojector for lighting
- Use a customized input head model
- Arrange lights further apart
- Track shaking of camera
- Try out more faces
- Combine with other methods

Lifelogging

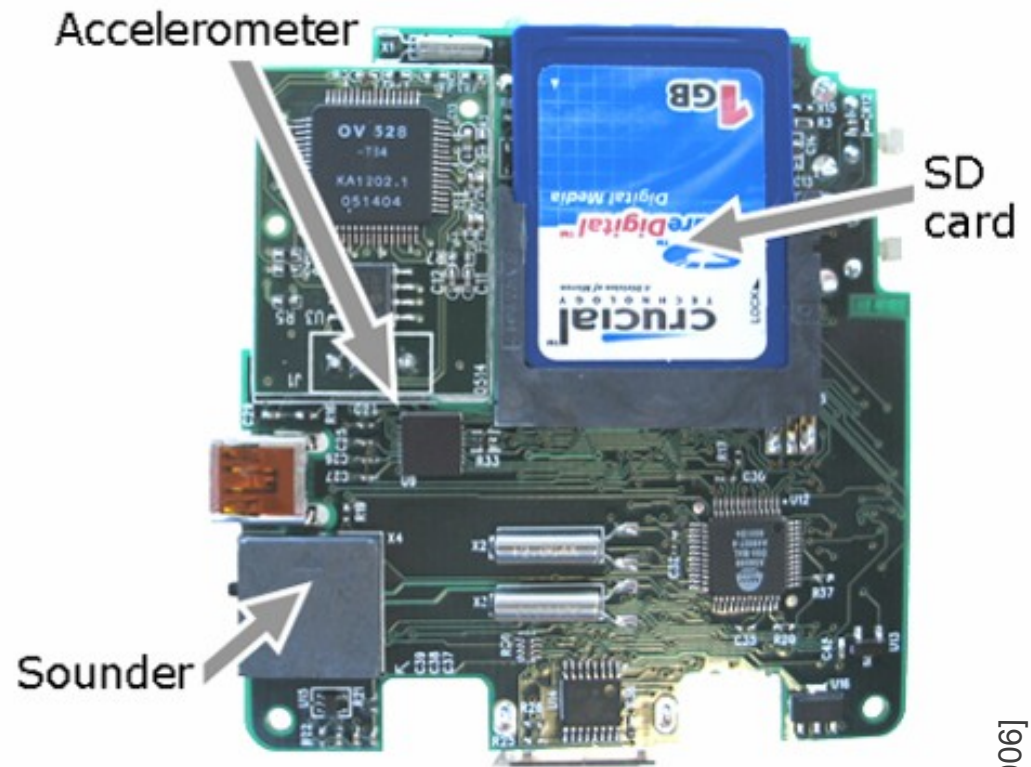
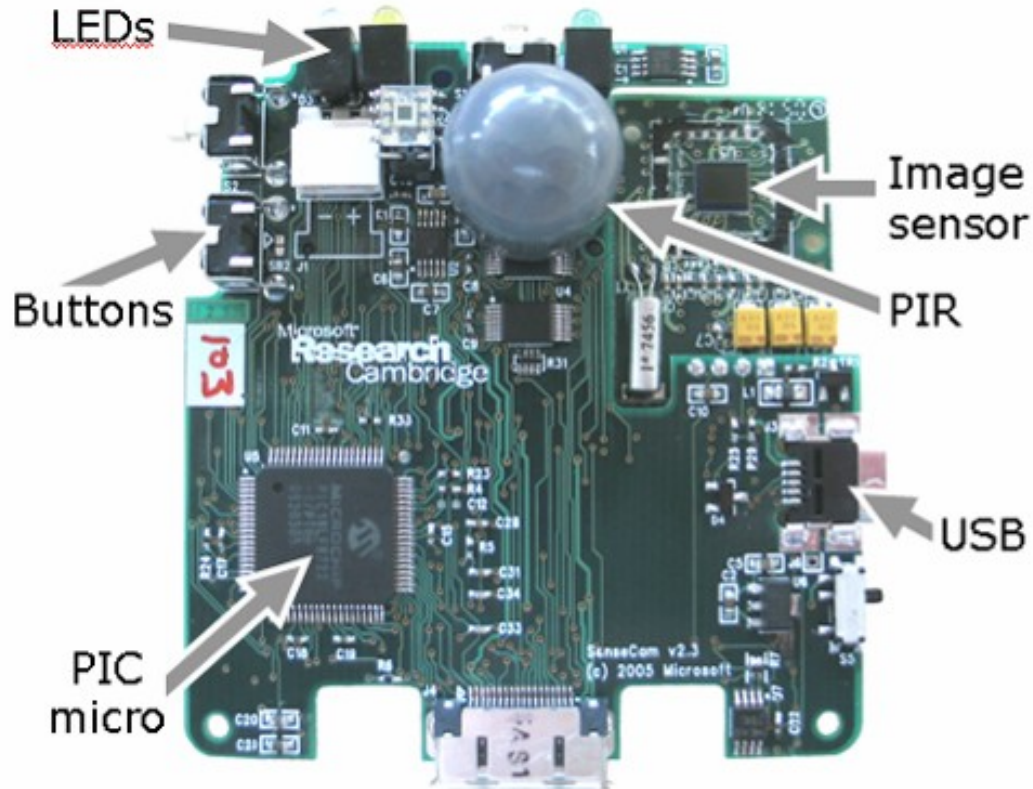


[<http://www.viconrevue.com/images/000000903.jpg>]

SenseCam

- Automatically triggered camera
- Lightweight
- Unobtrusive
- Battery life of at least 12 hours
- Capture interesting moments

Internals



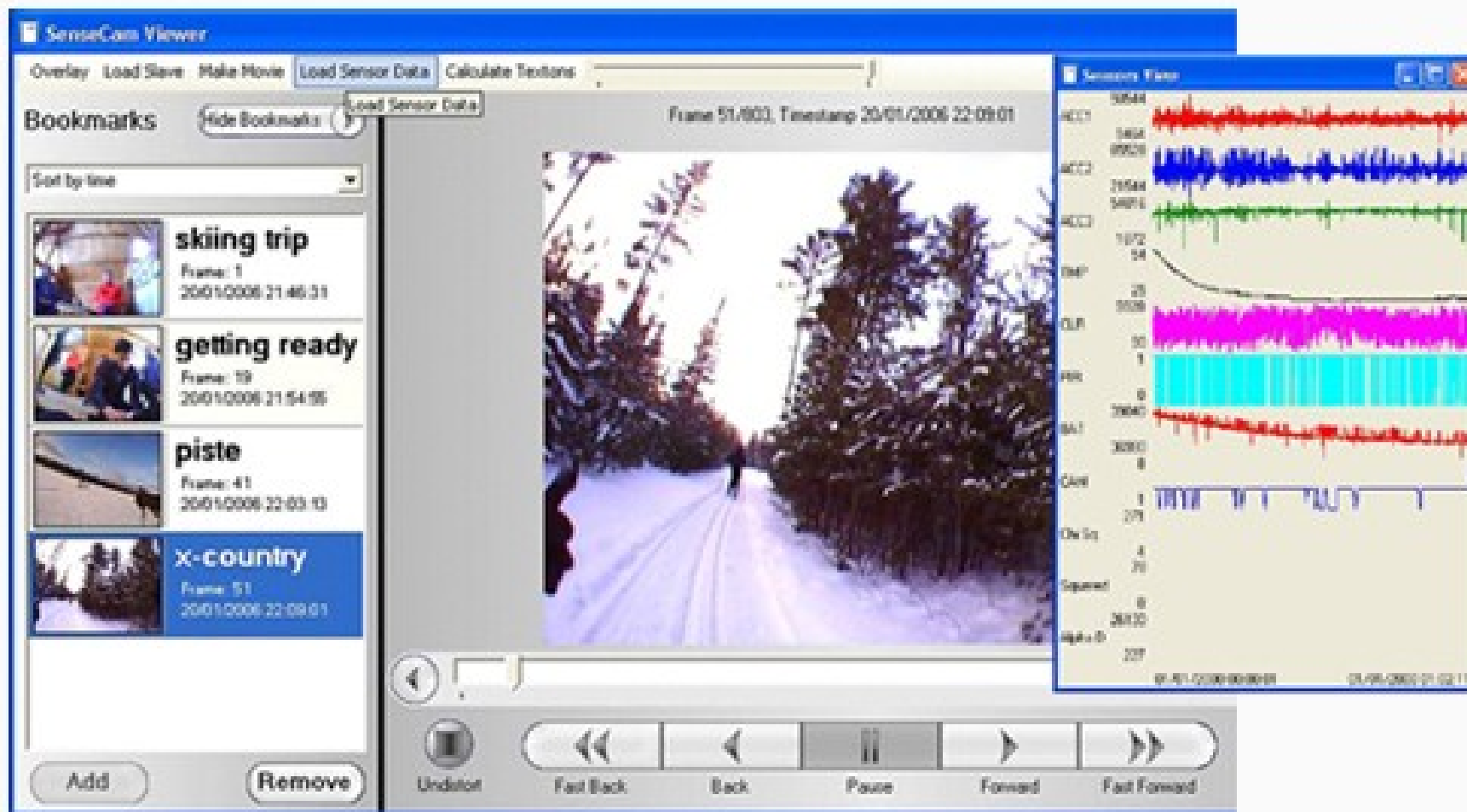
How it works

- Sensors judge if situation is interesting
 - If yes, take picture
- Take picture after timeout
- Log reason why picture was taken
- Battery lasts over 24 hours when taking a picture every 30 seconds



[Hodges 2006]

Viewer application



The Microsoft Research Cambridge SenseCam viewer application allows playback and review of Sensecam images and associated sensor readings.

[<http://research.microsoft.com/en-us/um/cambridge/projects/sensecam/review.htm>]

Applications

- Lifelogging
- Monitoring behavior (e.g. for scientific studies)
- Measuring typical environment
 - Replace laboratory settings
- Memory aid
- Therapeutic tool for mental & cognitive disorders

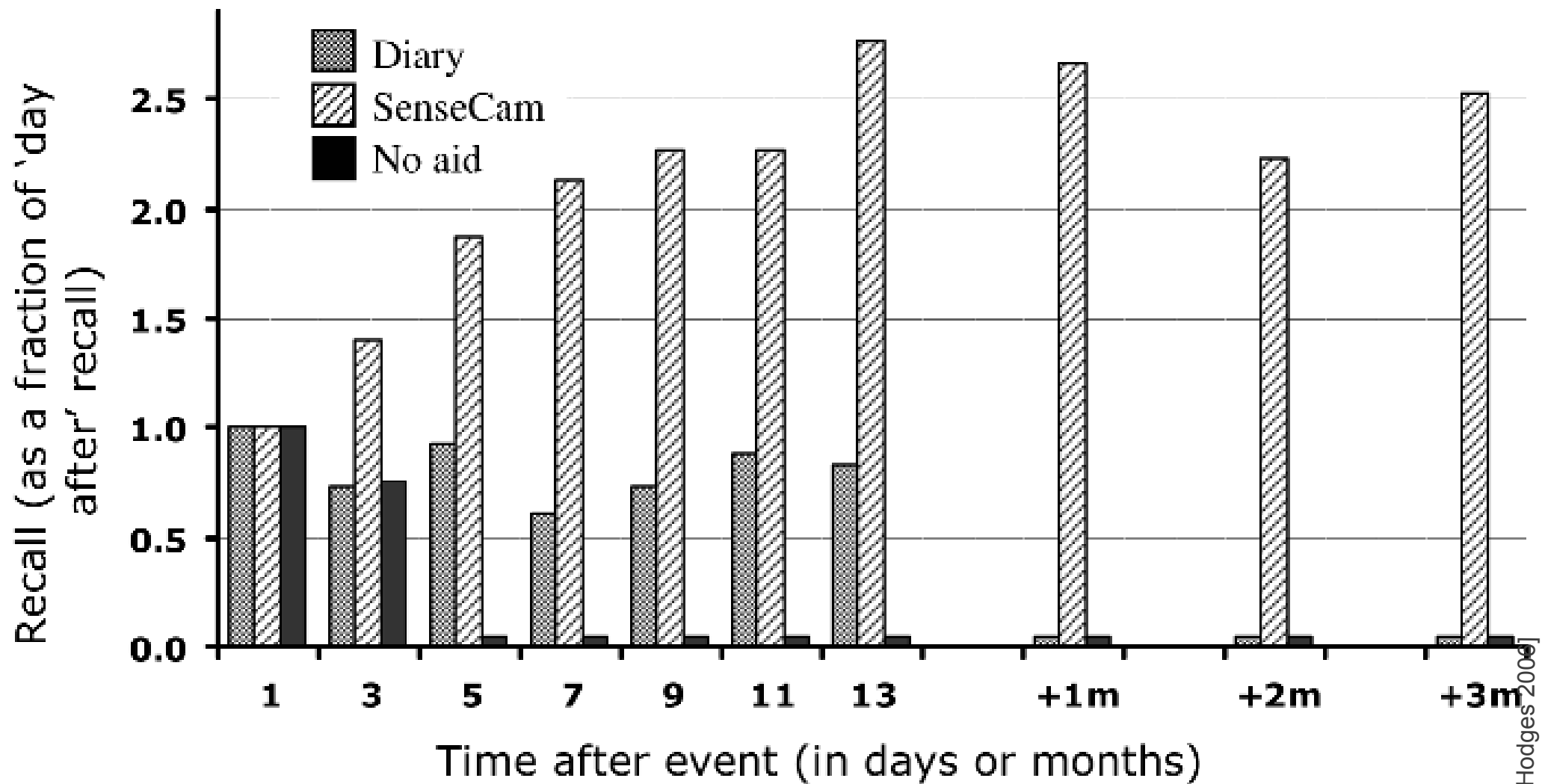
Treatment for memory disorders

- Many patients benefit from reading a diary or looking at pictures of events they witnessed
- But they are the least reliable group to write diaries and take pictures
- SenseCam does not need any attention during the event it captures

Case study

- 63 year old married woman
- Memory loss after illness
 - Limbic encephalitis (brain inflammation)
- Forgets events completely after a week

Results



[Hodges 2006]

Impact

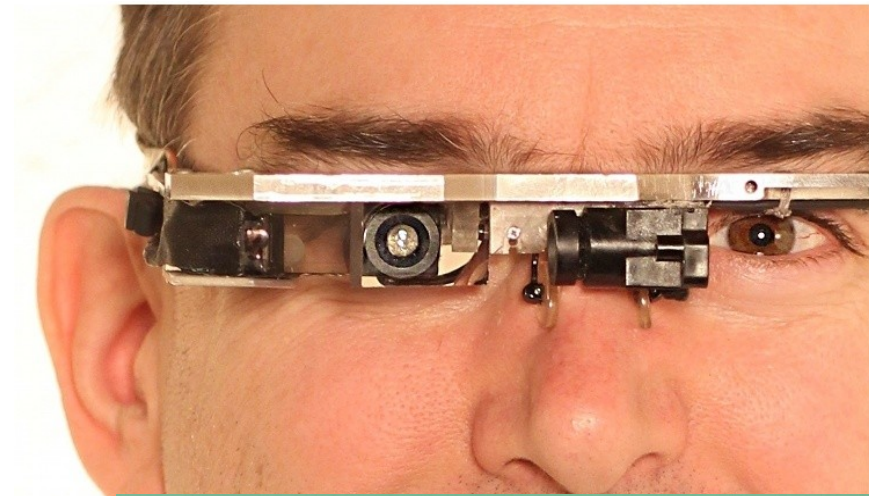
- Sparked interdisciplinary interest in memory aids
- Original paper was cited over 300 times
- Vicon manufactured a commercial version for researchers
- There is a conference just about SenseCam

Future

- There will be more research on lifelogging and its effects
- SenseCam devices will become broadly available to normal consumers
- Will become a standard gear for scientific studies
- Many applications in therapy

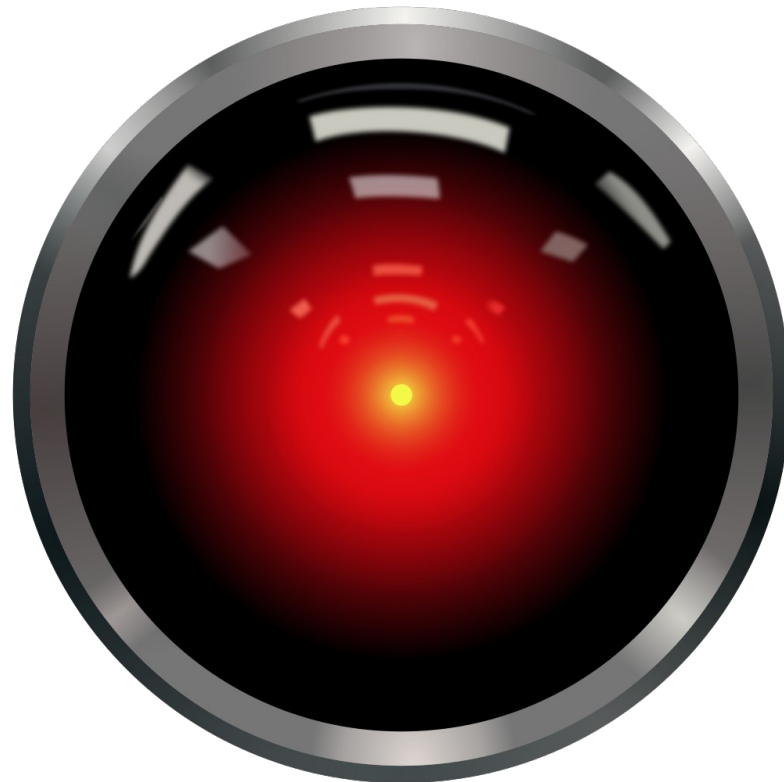
Recap

- We have seen three very different uses of cameras
 - EyeTap replaces your eye with a camera
 - SenseCam automatically takes pictures for you
 - One camera is enough for motion capture of faces



Outlook

- We already all have a camera with us all the time
- Soon, we will also have a camera ready all the time
- And soon after, we will be recording all the time



Questions?



Sources

- “Continuous Lifelong Capture of Personal Experience with EyeTap”, Steve Mann, CARPE'04, October 15, 2004
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- “SenseCam: A Retrospective Memory Aid”, Steve Hodges et al, Ubicomp 2006, Pages 177-193, 2006

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- “High-Quality Passive Facial Performance Capture using Anchor Frames”, Thabo Beeler et al, ACM Trans. Graph. 30, 4, Article 75 (July 2011)
- “Physical assault by McDonald's for wearing Digital Eye Glass”, Steve Mann, July 2012
<http://eyetap.blogspot.ca/2012/07/physical-assault-by-mcdonalds-for.html>