

# Real World Virtual Reality

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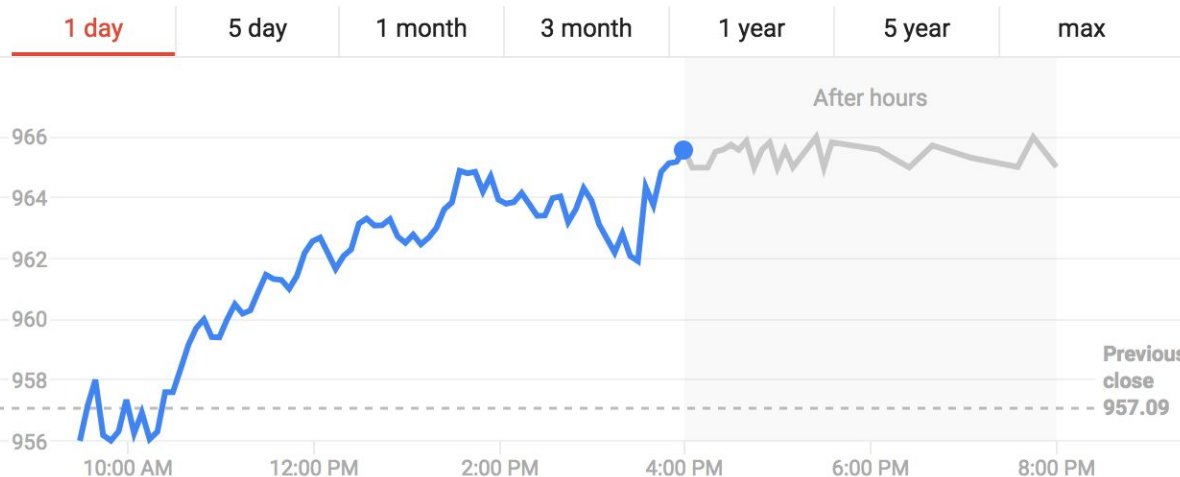
# Alphabet Inc Class C



NASDAQ: GOOG - Jun 23, 7:58 PM EDT

**965.59** USD **↑8.50 (0.89%)**

After-hours: 965.02 **↓0.06%**



Open 956.83  
High 966.00  
Low 954.20

Mkt cap 673.93B  
P/E ratio 31.12  
Div yield -

[Your stocks](#)







Daydream

# Modern CS in the Real World

Modern  
Computer  
Science

The  
Real  
World

Modern  
Computer  
Science

The  
Real  
World

Modern  
Computer  
Science

The  
Real  
World

CS + Reality

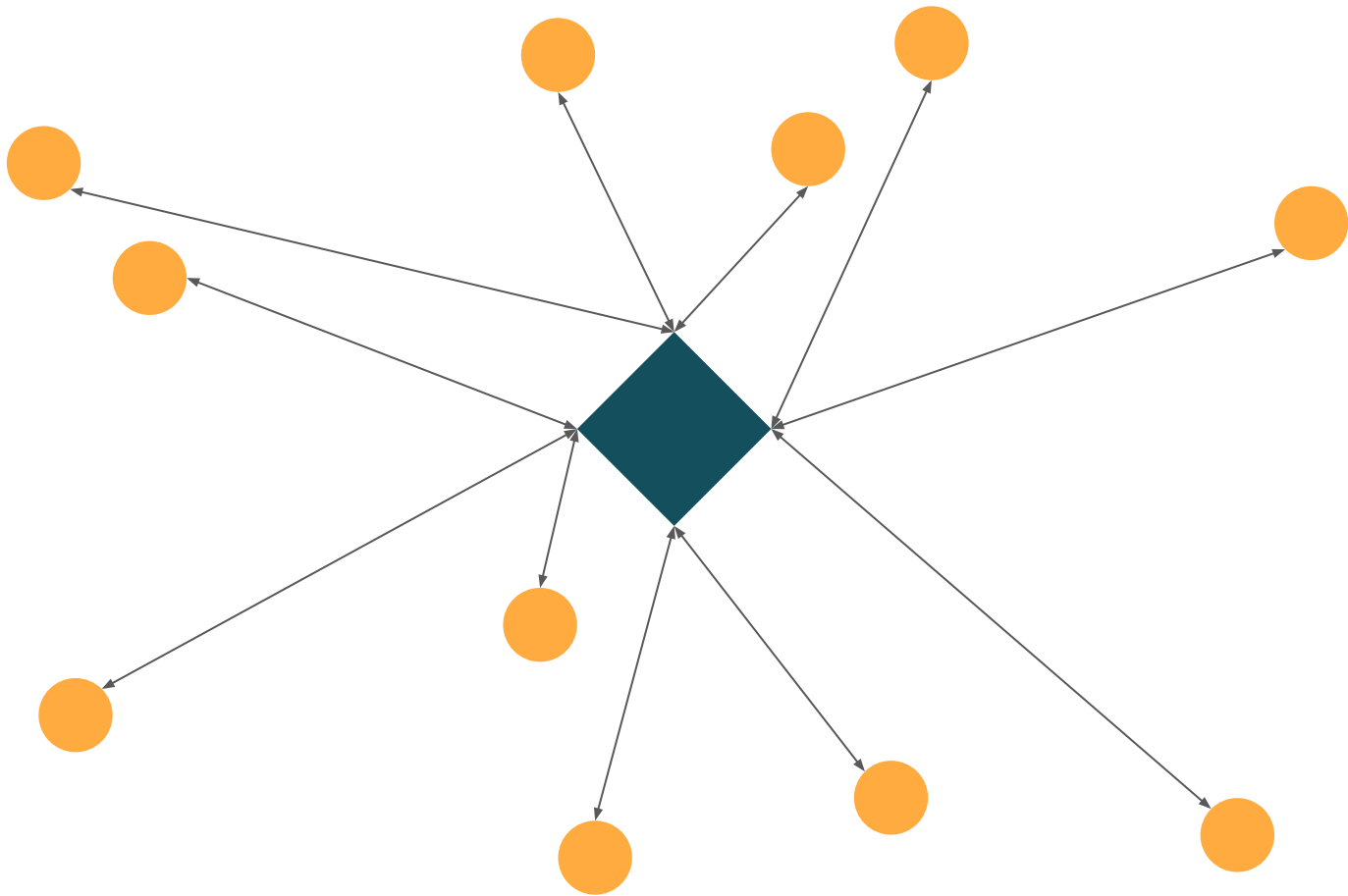
CS + Reality  
= Software Engineering

# Modern CS in the Real World



Real World Virtual Reality

What we will be covering?







JOHN J. PERSHING  
MIDDLE SCHOOL



Zeroconf Networking

DNS-SD

Interpupillary Distance (IPD)

AppleTalk

Panorama

Field of View (FOV)

NBP

Photosphere

Optical Flow

mDNS

Omnidirectional Stereo

Photo Stitching

Real World Virtual Reality

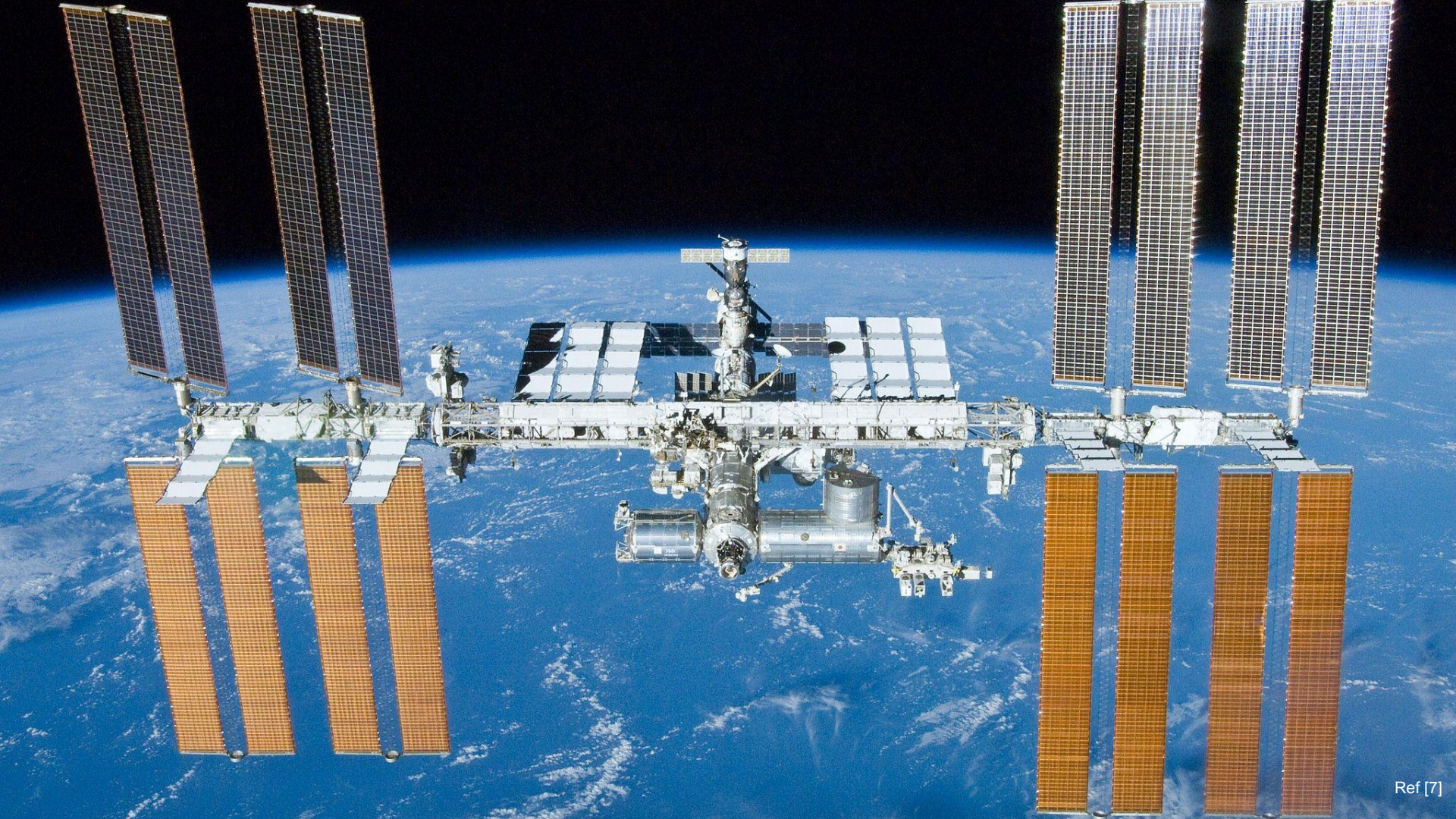


Google Expeditions

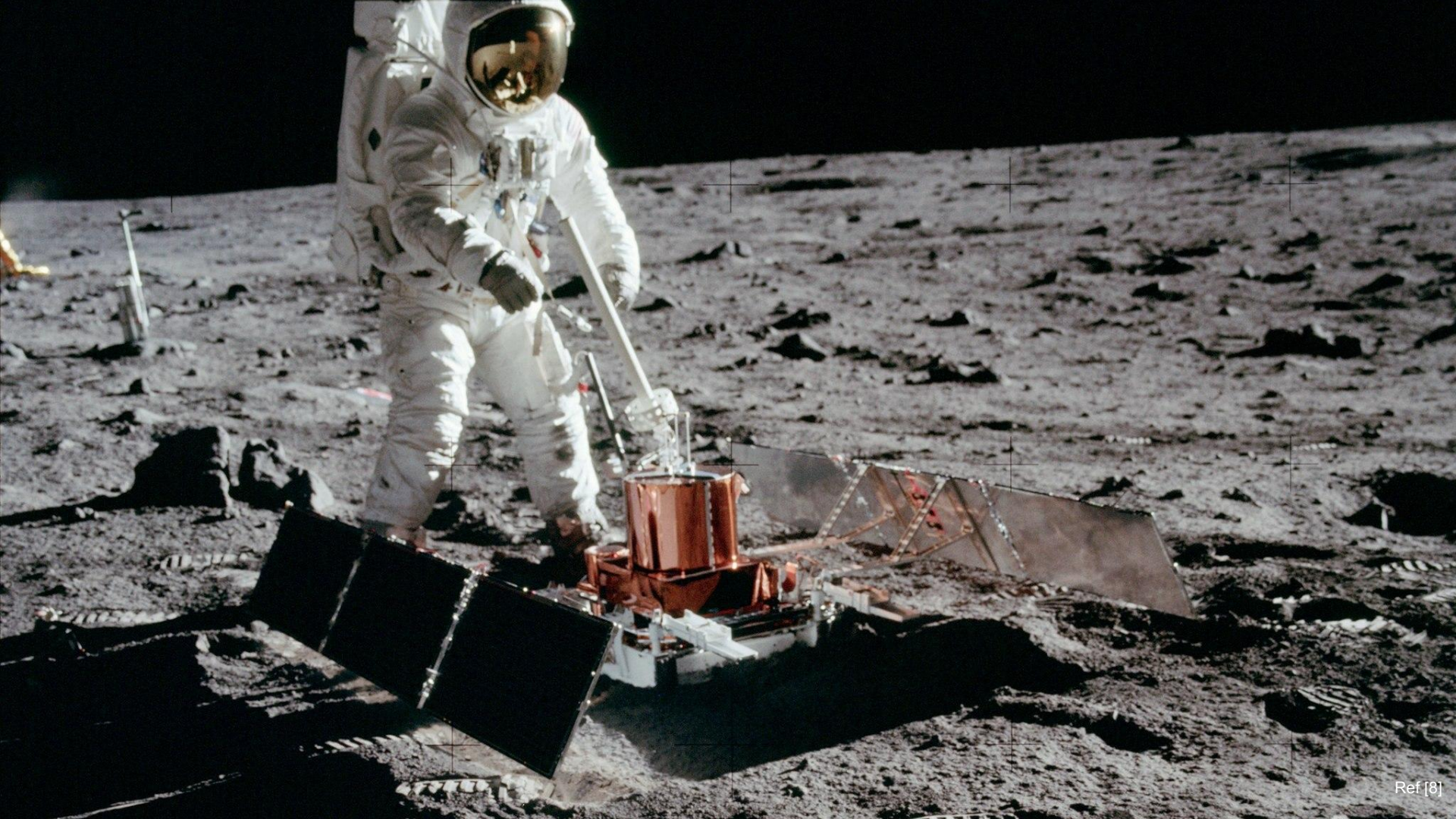














Google Expeditions









So how do we do this?

# Meet the Classroom





**Meet the Users**





How to Handle Expectations  
1. Know the rules  
2. Be on time  
3. Be on task  
4. Be on your feet  
5. Be on your feet

How to Handle Expectations  
1. Know the rules  
2. Be on time  
3. Be on task  
4. Be on your feet  
5. Be on your feet

Classroom Expectations  
1. Know the rules  
2. Be on time  
3. Be on task  
4. Be on your feet  
5. Be on your feet

Scheduling the Day  
1. Know the rules  
2. Be on time  
3. Be on task  
4. Be on your feet  
5. Be on your feet

Often No Internet

One Teacher + Thirty Students

# Existing Social Dynamics

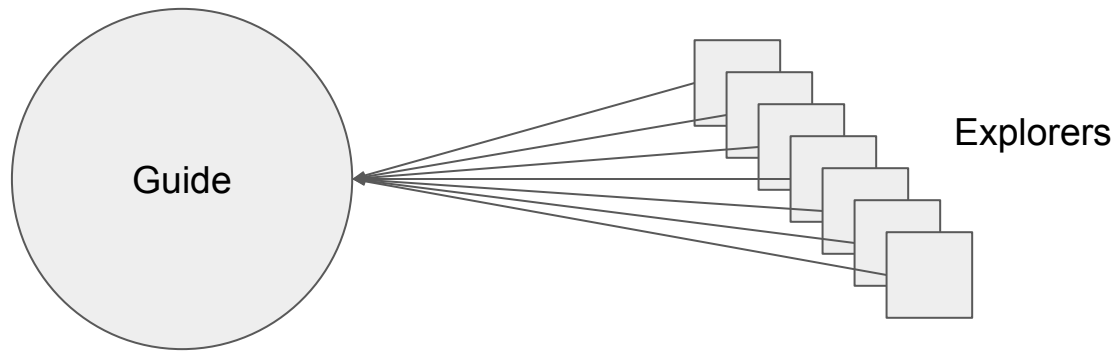
Schools are Cost Sensitive

# The Problem



One Unified Experience

31 Devices





# What options are available now

- Service Location Protocol (SLP)
- NetBIOS
- Web Services Dynamic Discovery (WS-Discovery)
- Universal Plug and Play (UPnP) / SSDP
- mDNS + DNS-SD (Bonjour)

Our Choice...

Our Choice = mDNS + DNS-SD

# Some Context


Foundational Events Through Time





# Some Context

1974 - TCP/IP Spec



# Some Context




1974 - TCP/IP Spec

1982 - US DoD Standardizes on TCP/IP

A horizontal arrow pointing to the right, representing a timeline, is located at the bottom of the slide.

# Some Context



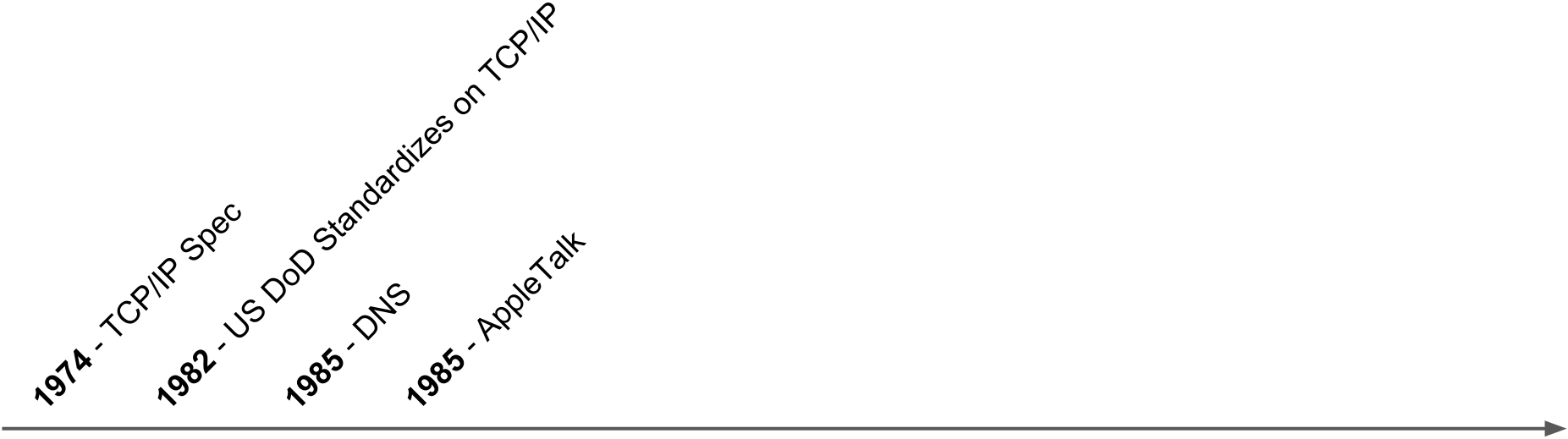
A horizontal timeline arrow pointing to the right, with three text labels positioned above it, each rotated diagonally. The labels are: '1974 - TCP/IP Spec', '1982 - US DoD Standardizes on TCP/IP', and '1985 - DNS'.

1974 - TCP/IP Spec

1982 - US DoD Standardizes on TCP/IP

1985 - DNS

# Some Context



1974 - TCP/IP Spec  
1982 - US DoD Standardizes on TCP/IP  
1985 - DNS  
1985 - AppleTalk

# Some Context

1974 - TCP/IP Spec

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1994 - TCP stack default included in Mac OS

# Some Context

1974 - TCP/IP Spec

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1999 - IETF Zeroconf Working Group

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2000 - mDNS draft proposal

# Some Context



1974 - TCP/IP Spec

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1985 - DNS

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2000 - mDNS draft proposal

2002 - Bonjour née Rendezvous



# Some Context



1974 - TCP/IP Spec

1982 - US DoD Standardizes on TCP/IP

1985 - DNS

1985 - AppleTalk

1994 - TCP stack default included in Mac OS

1999 - IETF Zeroconf Working Group

2000 - mDNS draft proposal

2002 - Bonjour née Rendezvous

2013 - mDNS RFC

2013 - DNS-SD RFC

# Zero Configuration Networking

# Name Binding Protocol (NBP)

Bonjour

mDNS + DNS-SD

So how does it work?

mDNS = Multicast Domain Name System

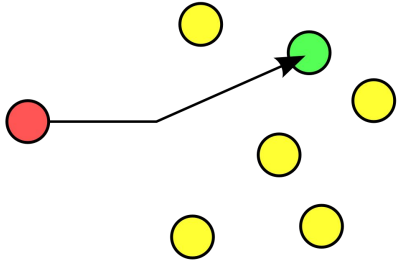
mDNS = Multicast Domain Name System



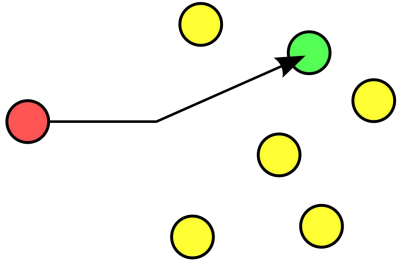
.local

mDNS = Multicast Domain Name System

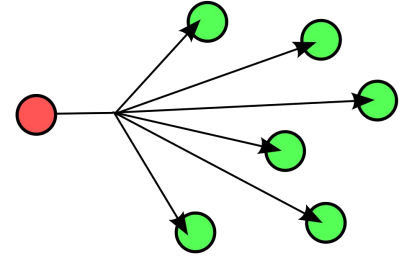
**mDNS = Multicast Domain Name System**



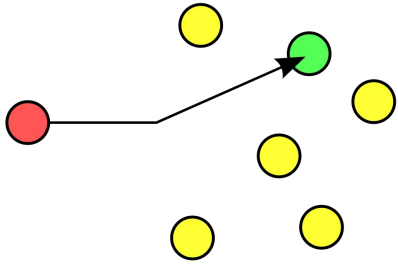
Unicast



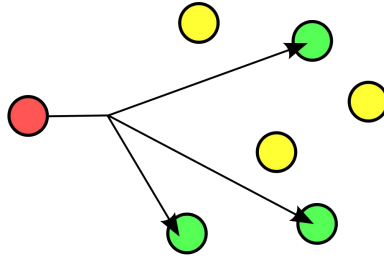
Unicast



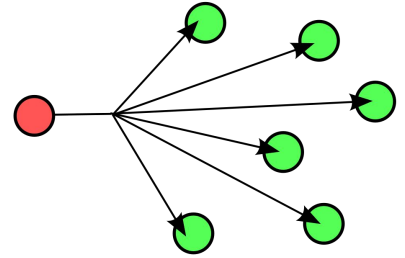
Broadcast



Unicast



Multicast



Broadcast

**224.0.0.251:5353 (IPv4) or FF02::FB:5353 (IPv6)**

# One-shot Querying in mDNS



# Responding to mDNS Queries

# Continuous Querying in mDNS

DNS-SD = DNS Service Discovery

# DNS SRV Records

```
# _service._proto.name. TTL    class rr    priority weight port target.  
_http._tcp.infoq.com.    86400 IN     SRV    10      60     5060 bigbox.infoq.com.  
_http._tcp.infoq.com.    86400 IN     SRV    10      20     5060 smallbox1.infoq.com.  
_http._tcp.infoq.com.    86400 IN     SRV    10      20     5060 smallbox2.infoq.com.  
_http._tcp.infoq.com.    86400 IN     SRV    20      0      5060 backupbox.infoq.com.
```

# DNS TXT Records

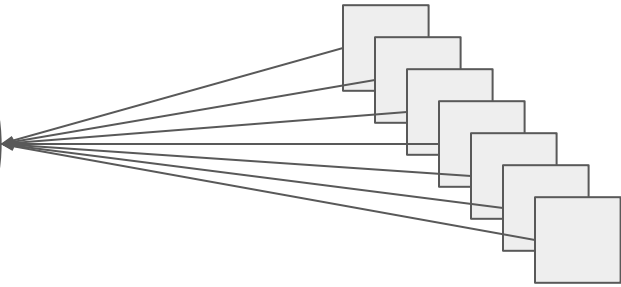
```
# name.      TTL   class rr      text.
infoq.com.  86400 IN    TXT    "QCon NYC Date=2017/06/26" "Number of Tracks=7"
```

# DNS PTR Records

```
# name.                TTL  class rr  text.
100.0.168.192.in-addr.arpa. 6230 IN    PTR  mailserver.infoq.com.
```

# DNS PTR Records

```
# name.                TTL  class rr    text.
_googexpeditions._tcp.local 6230 IN   PTR    Leif Erikson.local
_googexpeditions._tcp.local 6230 IN   PTR    Christopher Columbus.local
```



Explorers





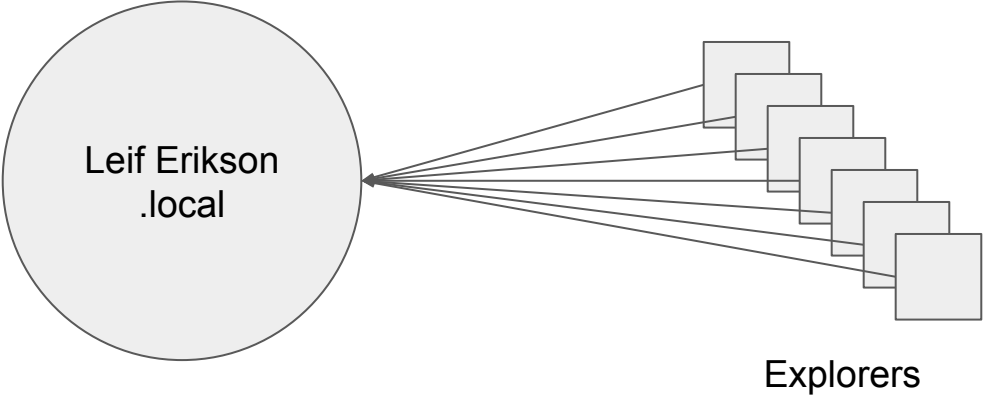
# Many Services use mDNS/DNS-SD

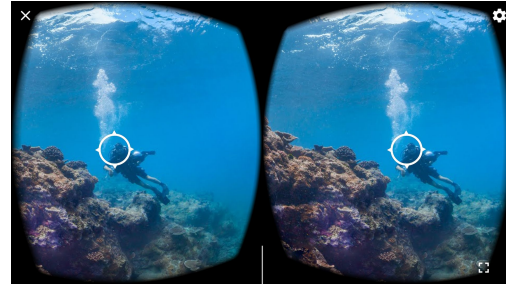
**Expeditions:** `_googexpeditions._tcp` & `_googexpeditions._udp`

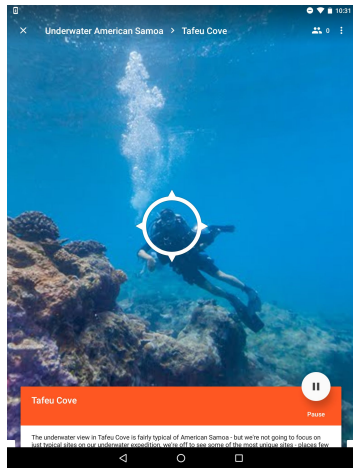
**Chromecast:** `_googlecast._tcp`

**Spotify Connect:** `_spotify-connect._tcp`

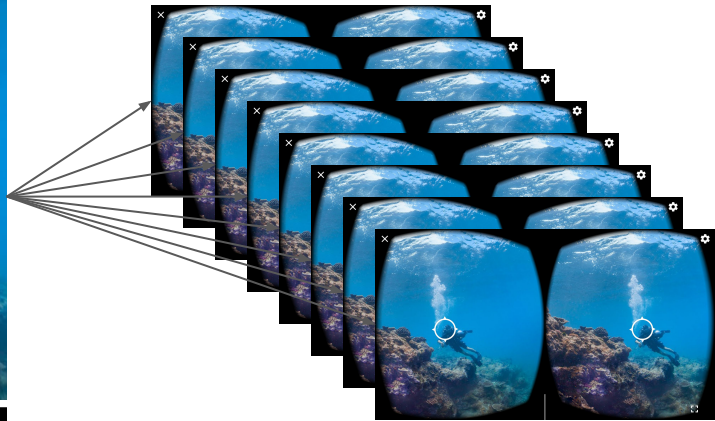
**Philips Hue:** `Philips-hue.local`, but resolves with `_hap._tcp`



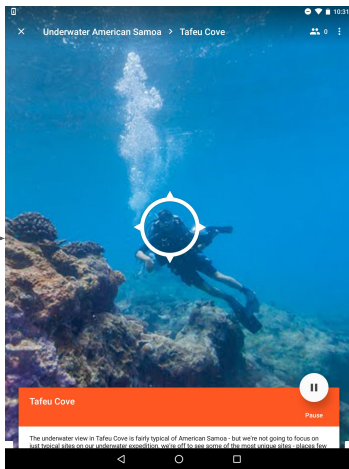
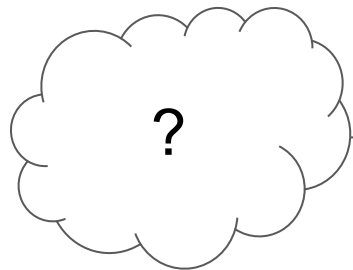




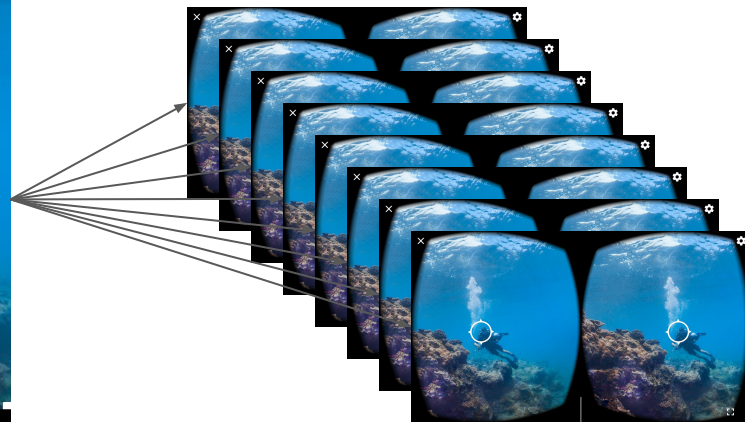
Lead



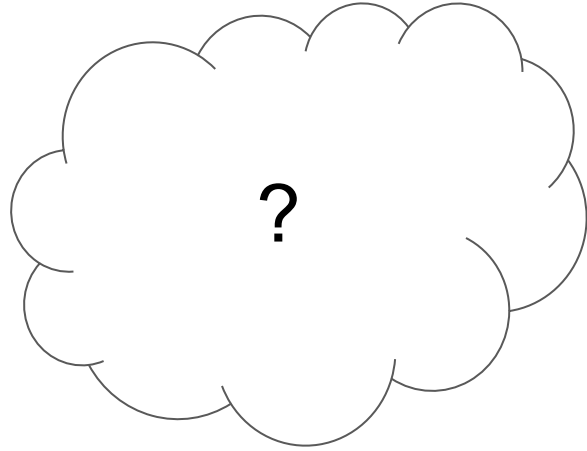
Explore



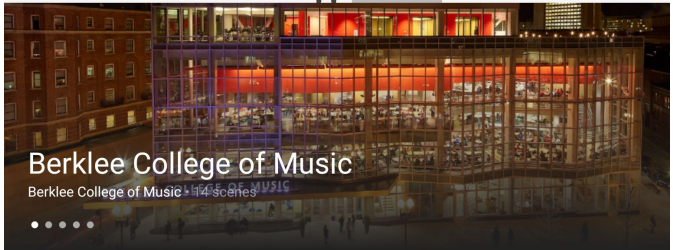
Lead



Explore



You are connected to **Midgard** Wi-Fi network.  
Hold on. Looking for explorers...



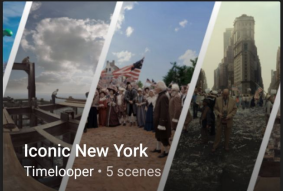
# Berklee College of Music

Berklee College of Music • 14 scenes

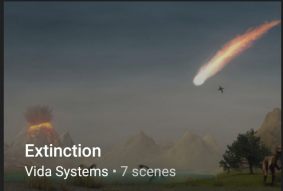


- ARTS & CULTURE
- LANDSCAPES
- SCIENCE
- ENVIRONMENT
- THE WORLD TODAY
- CAR


## New



**Iconic New York**  
Timelooper • 5 scenes



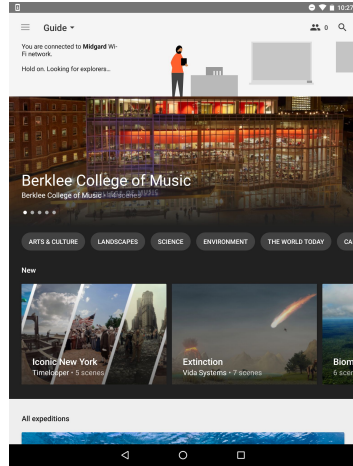
**Extinction**  
Vida Systems • 7 scenes



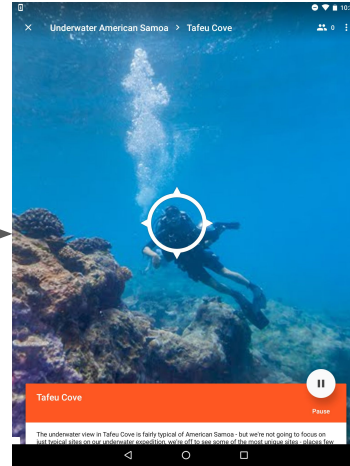
**Biome**  
6 scenes

## All expeditions



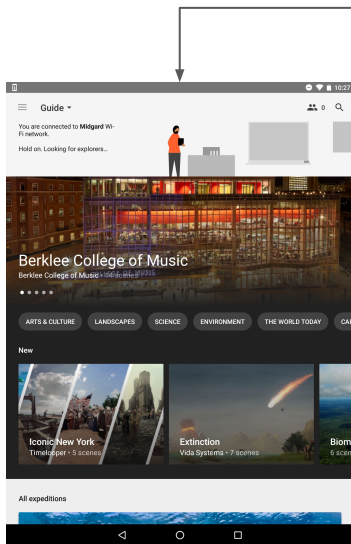
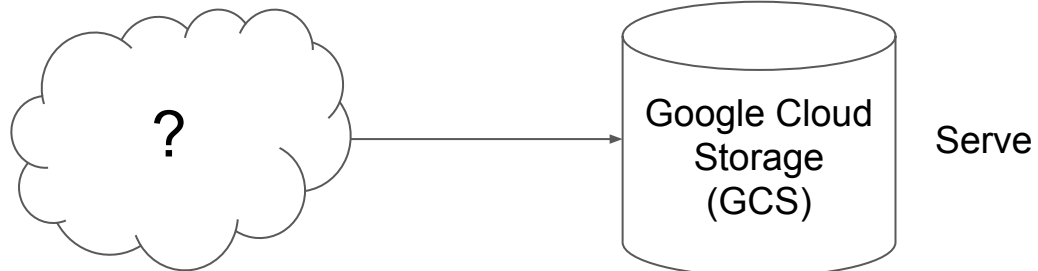


Browse /  
Download

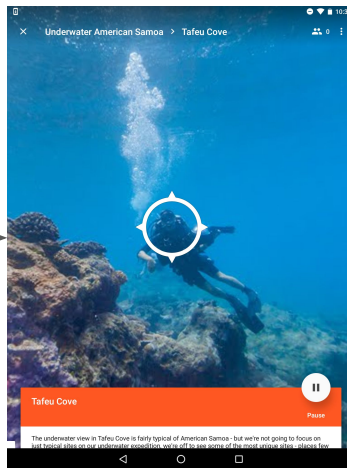


Lead

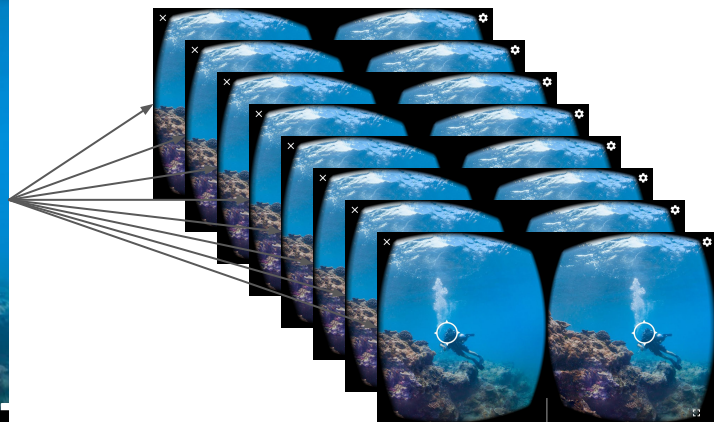




Browse /  
Download



Lead



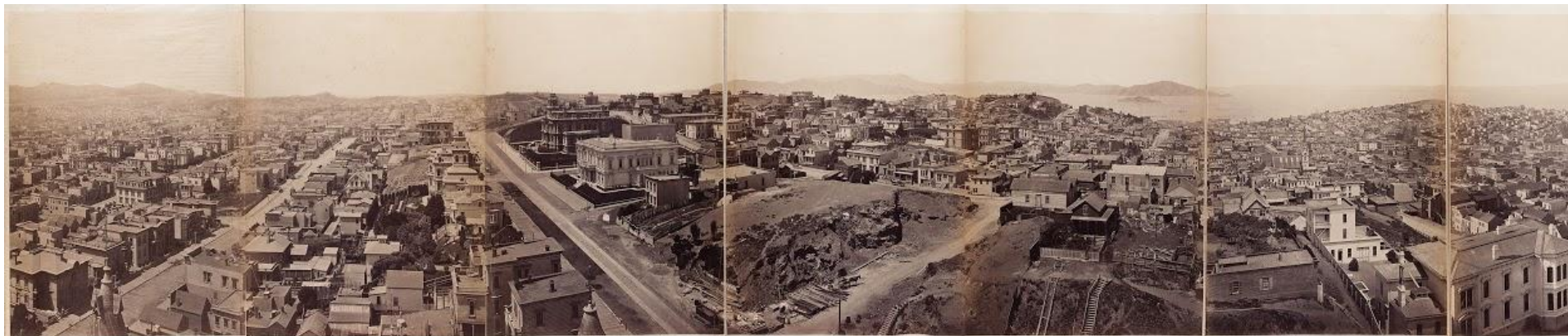
Explore













# QuickTime<sup>®</sup> VR – An Image-Based Approach to Virtual Environment Navigation

Shenchang Eric Chen

**Apple Computer, Inc.**

# Cylindrical Panorama





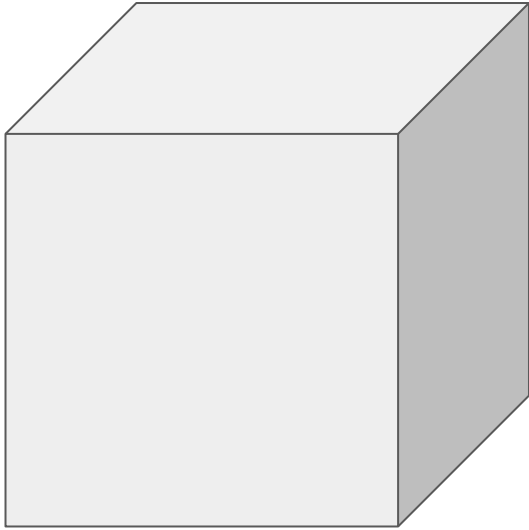




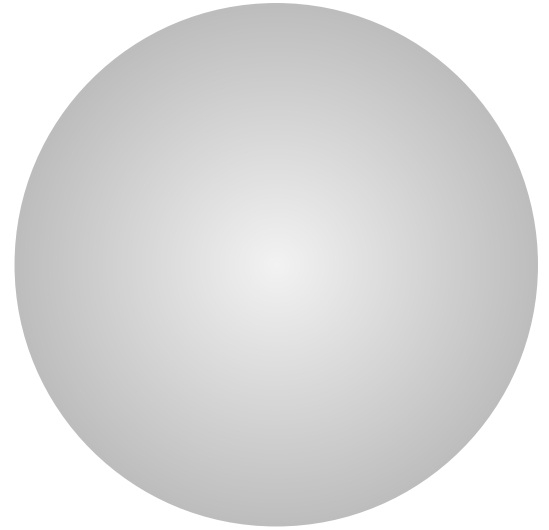
BROOKLYN  
BOTANIC GARDEN



Projection



Cube



Sphere

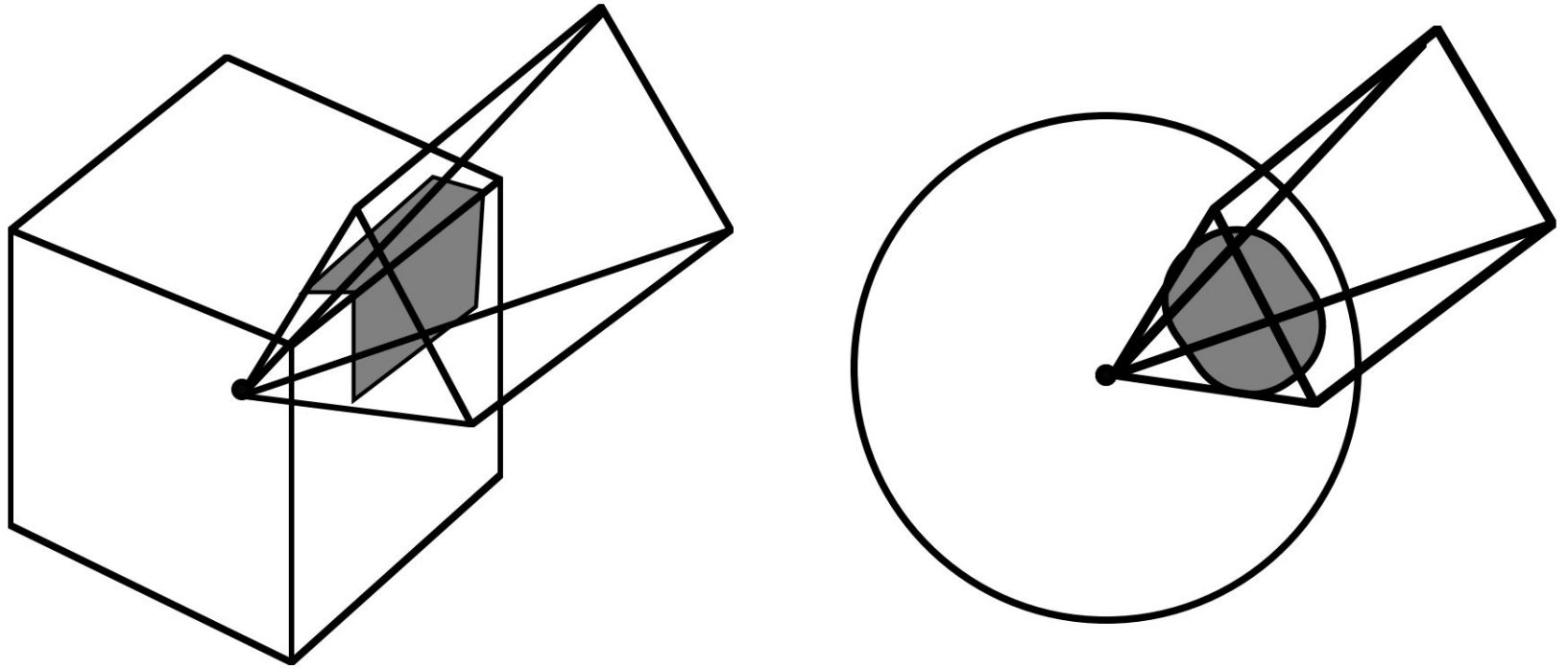


Figure 1. Reprojecting a cubic and a spherical environment map.

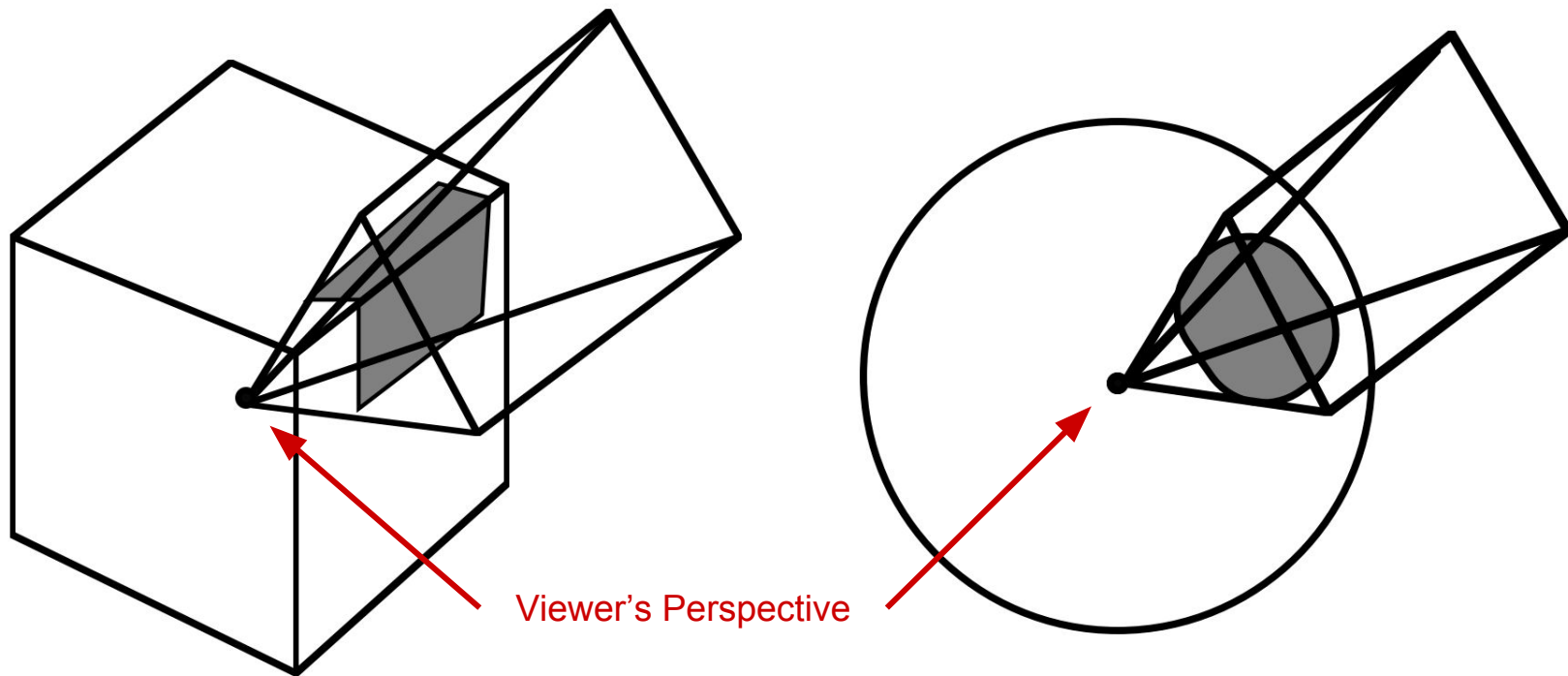


Figure 1. Reprojecting a cubic and a spherical environment map.







BROOKLYN  
BOTANIC GARDEN

















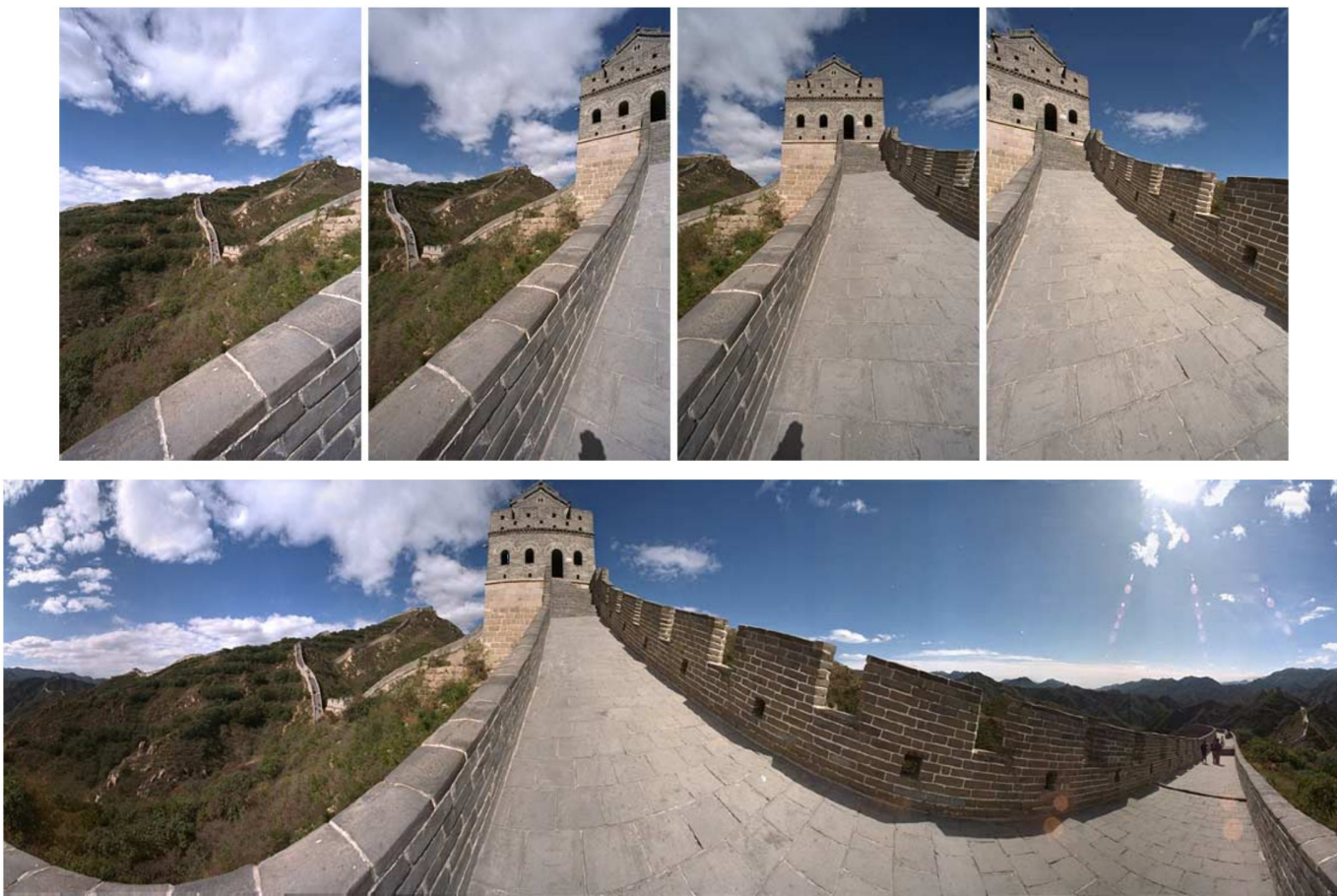


Figure 9. A stitched panoramic image and some of the photographs the image stitched from.





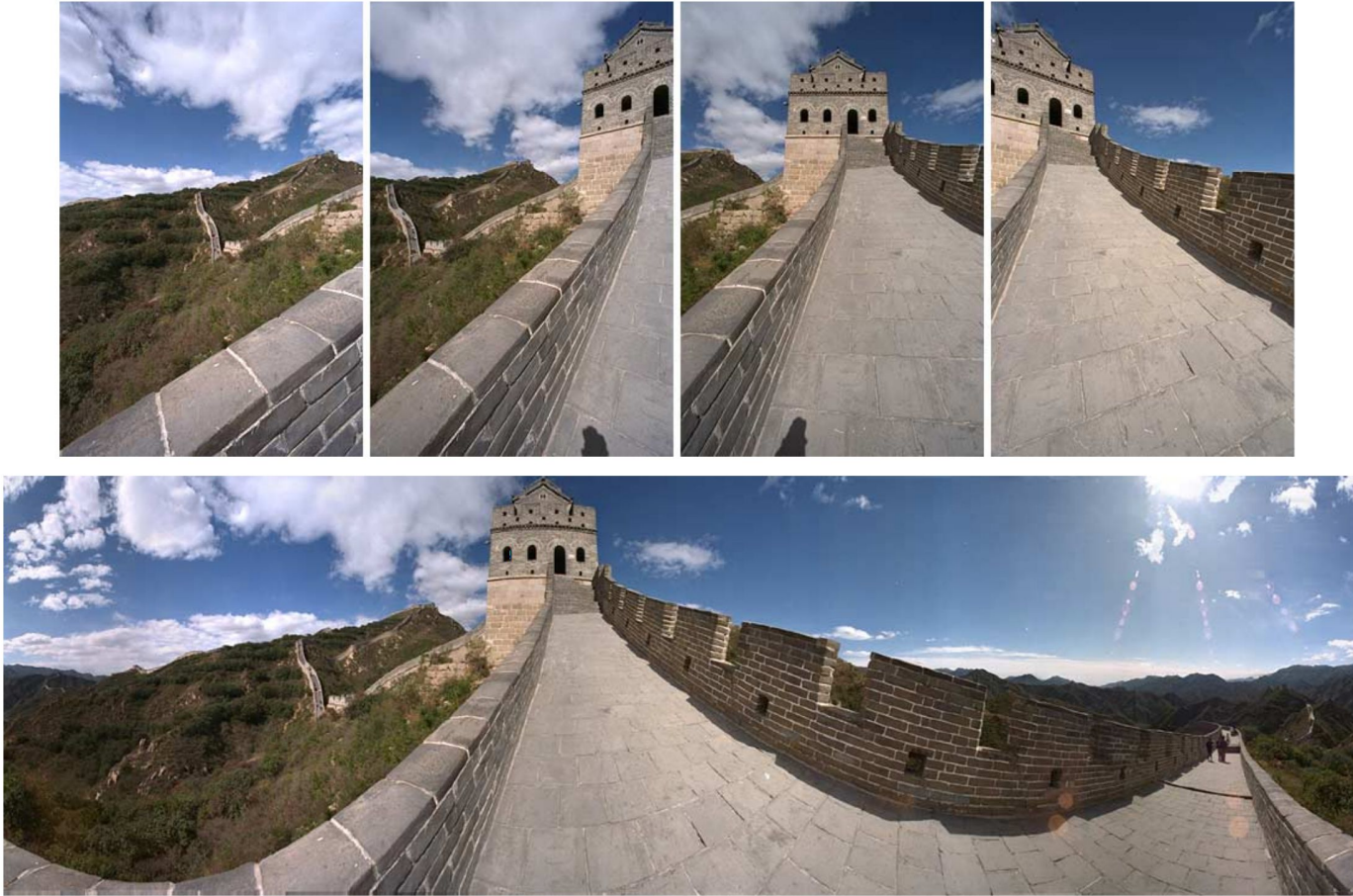
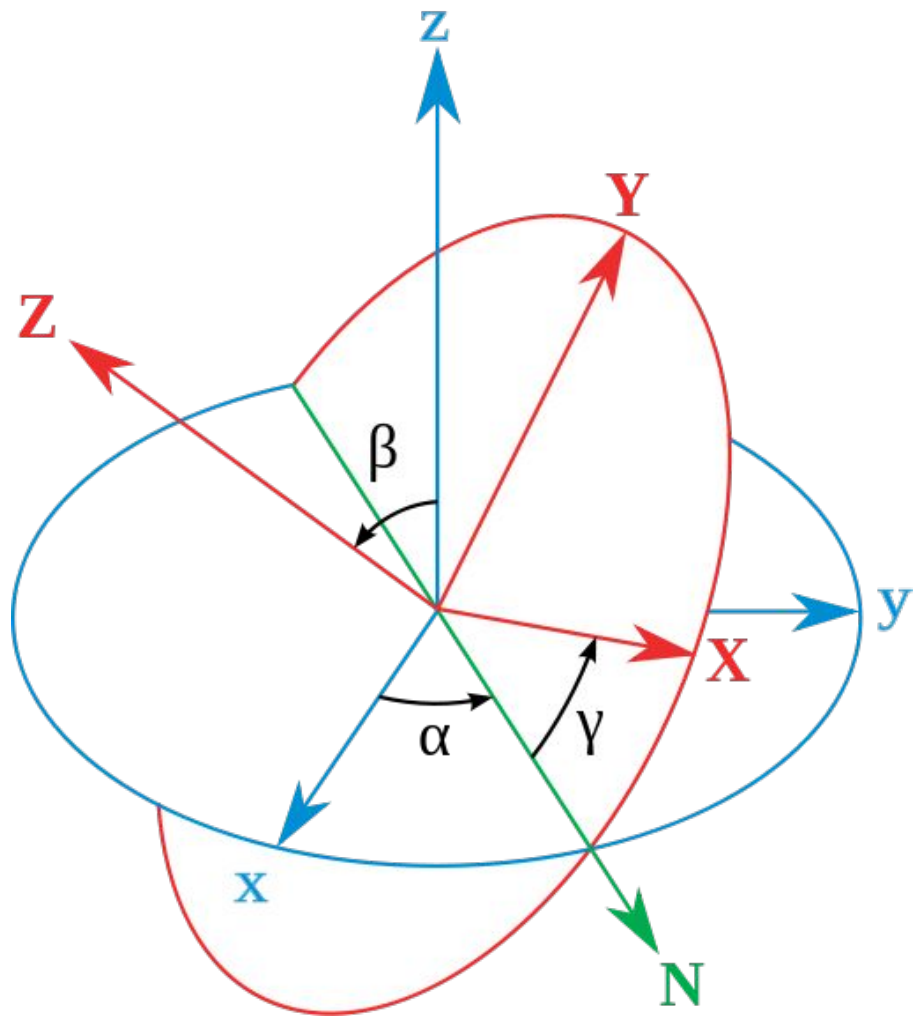


Figure 9. A stitched panoramic image and some of the photographs the image stitched from.







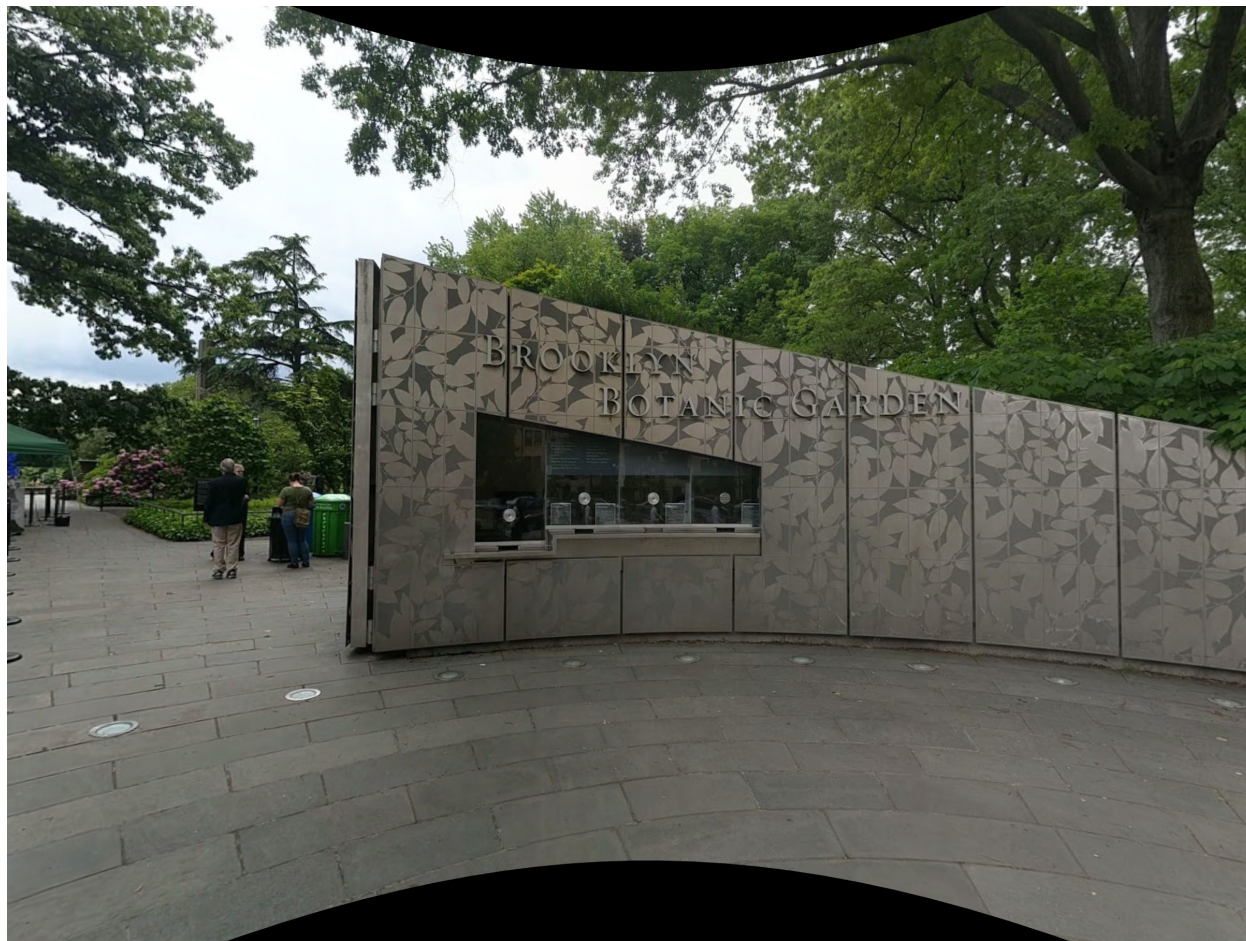


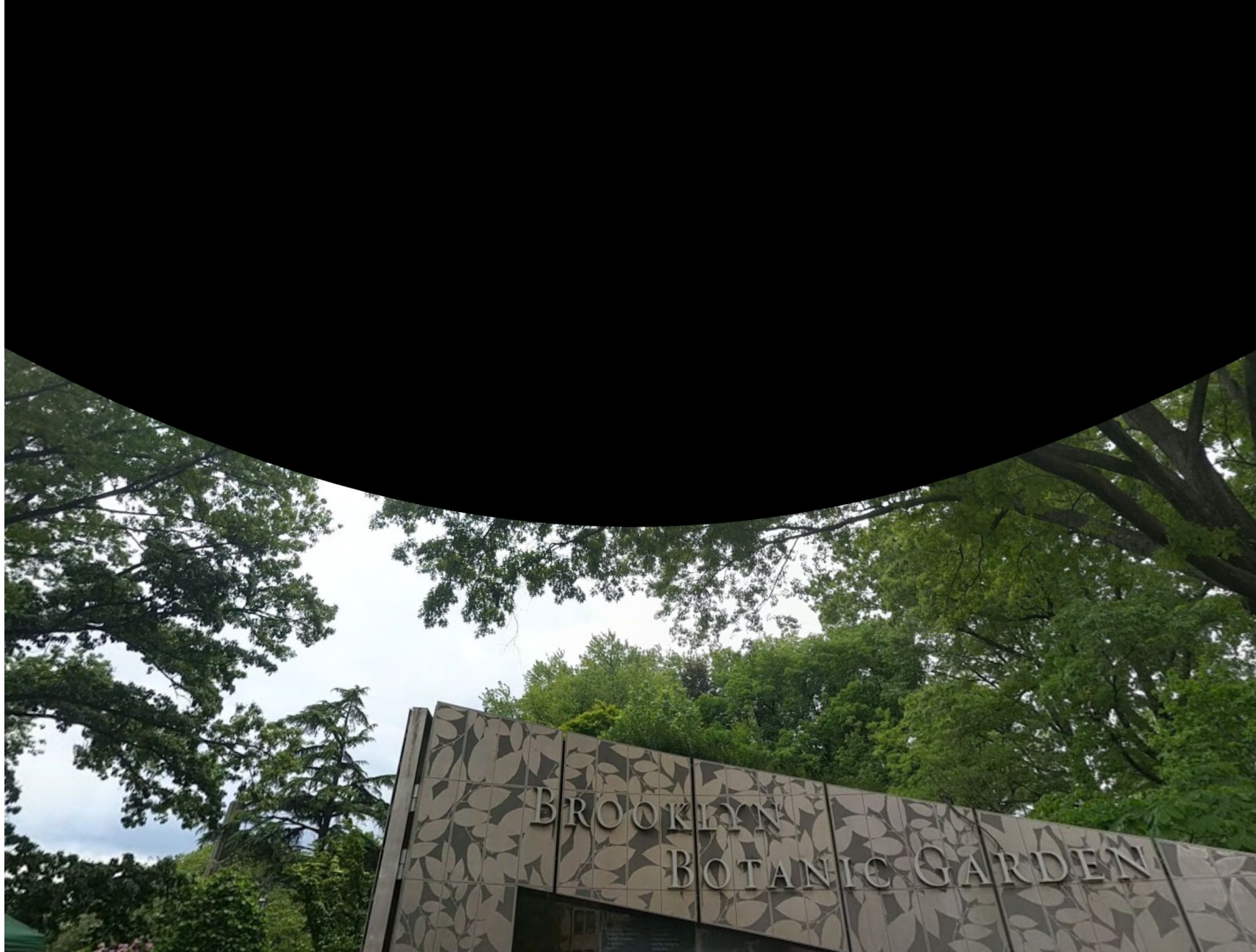
BROOKLYN  
BOTANIC GARDEN





# Perspective Projection



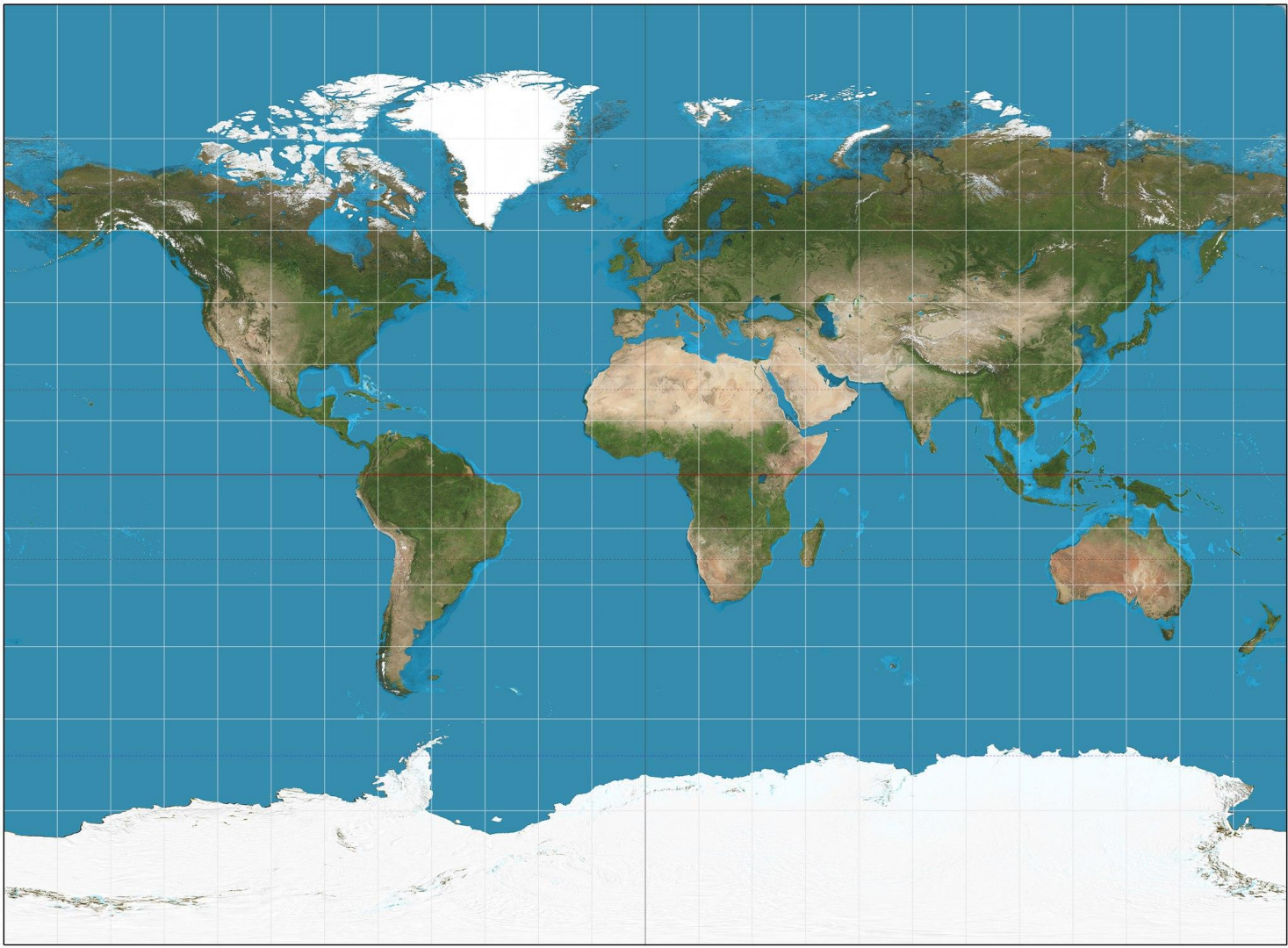


BROOKLYN  
BOTANIC GARDEN

# Spherical Panorama

Spherical Panoramas = Photospheres















# ster·e·op·sis

/,sterē'äpsəs/ 

*noun*

the perception of depth produced by the reception in the brain of visual stimuli from both eyes in combination; binocular vision.



Translations, word origin, and more definitions

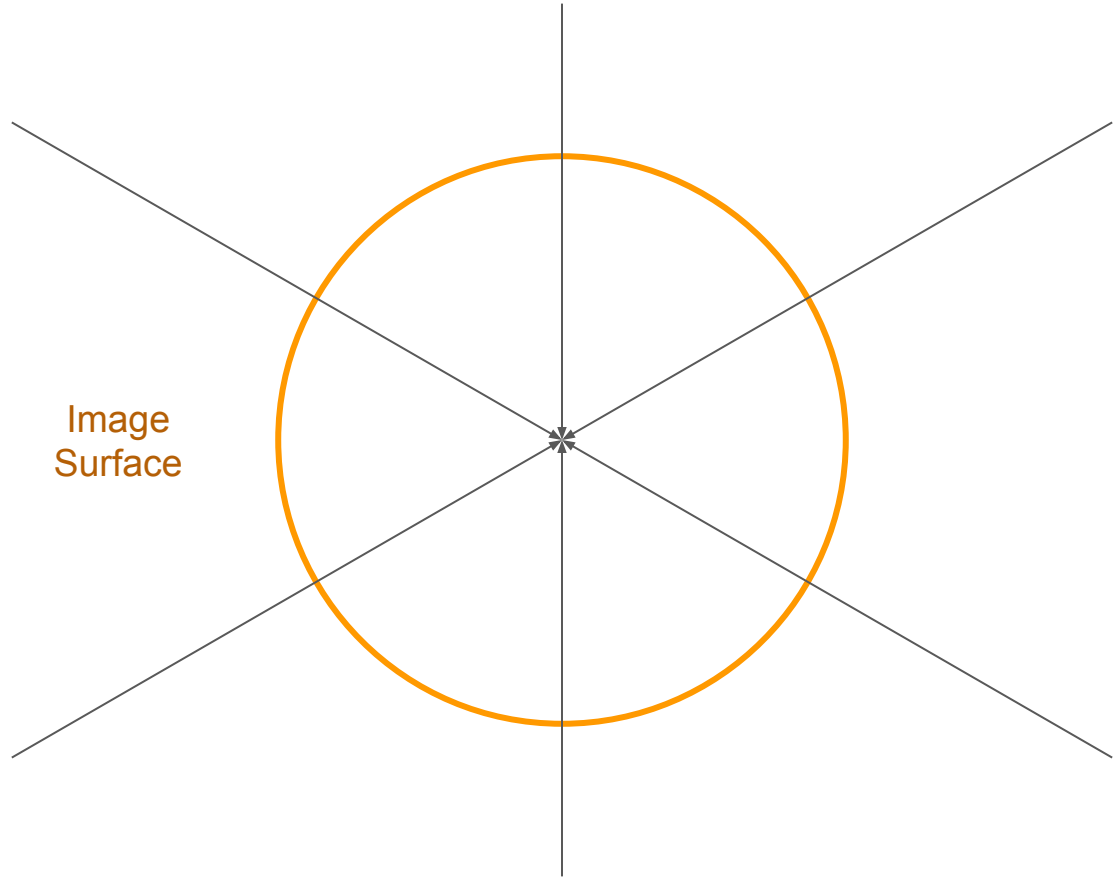
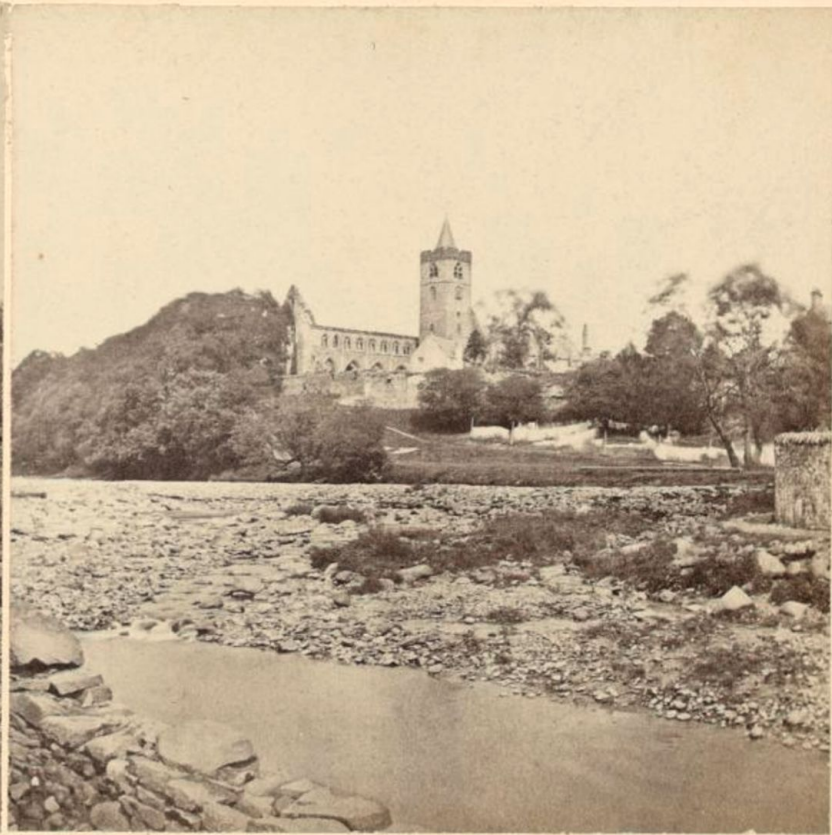
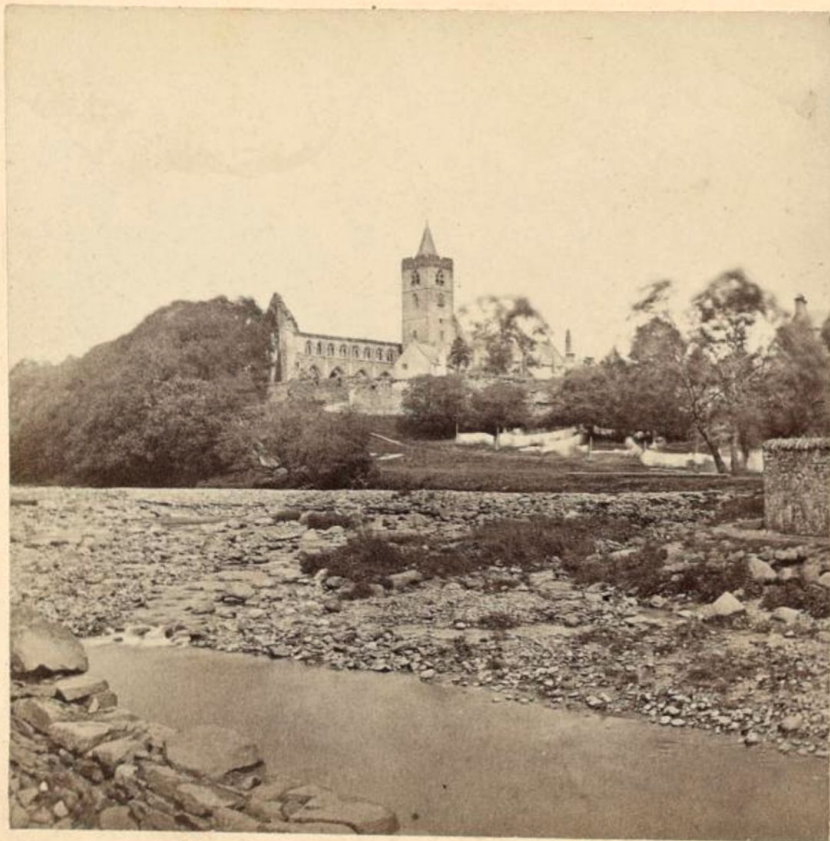
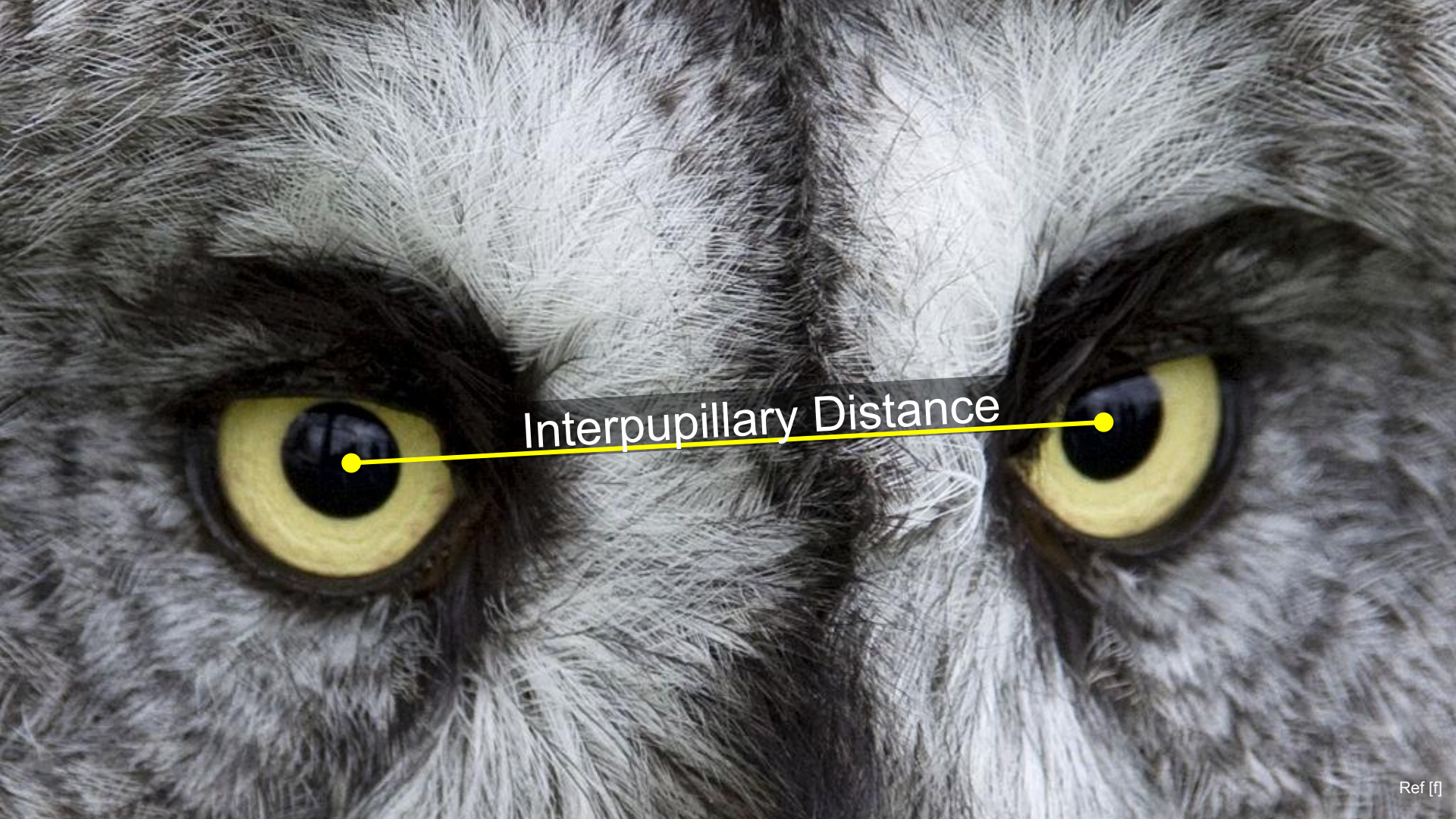


Image  
Surface



Interpupillary Distance (IPD)

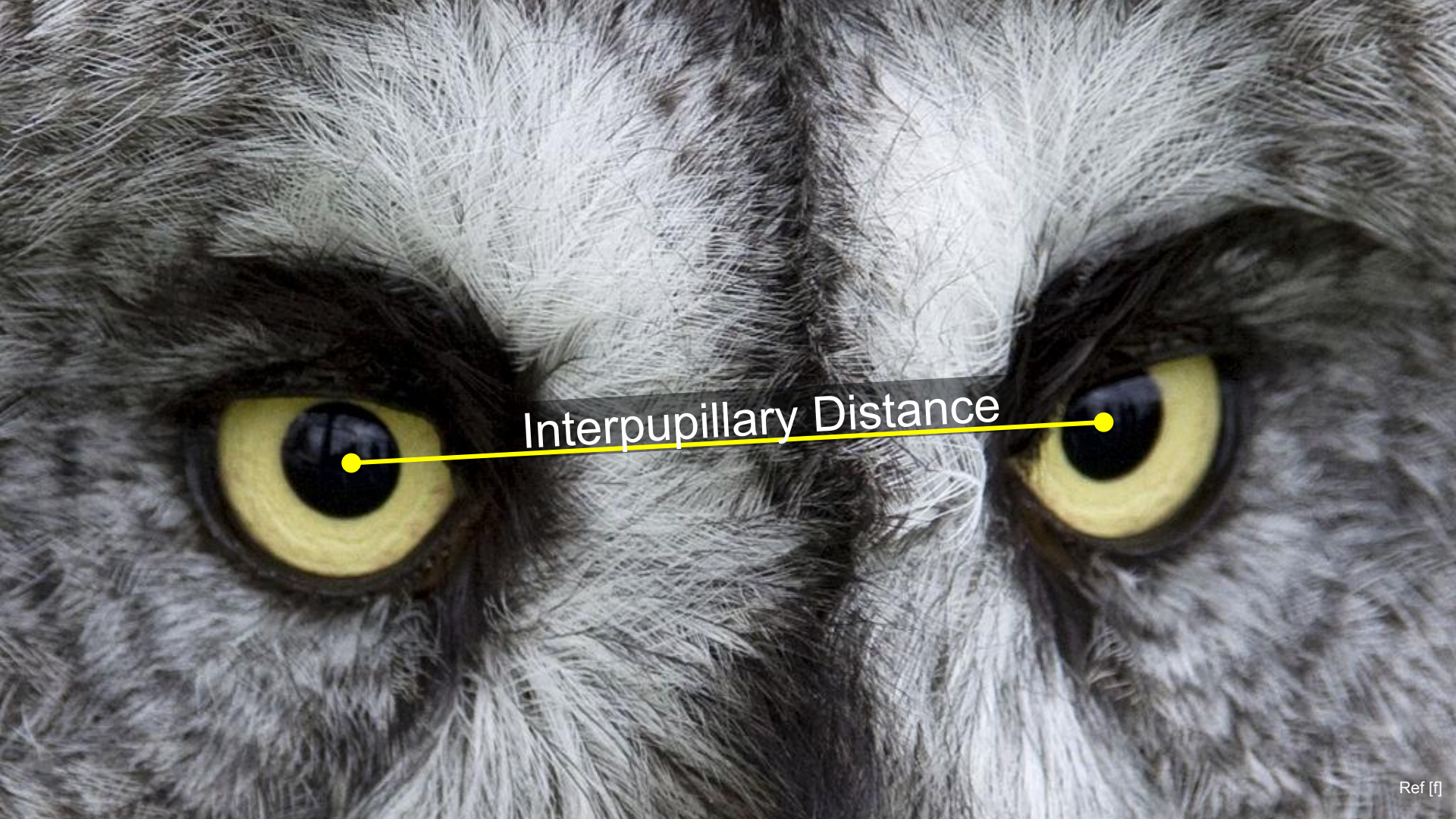


A close-up photograph of an owl's face, focusing on its two large, yellow eyes. A horizontal yellow line with small circular endpoints at each eye's pupil is drawn across the image. The text "Interpupillary Distance" is written in white, sans-serif font, centered over the line. The owl's feathers are a mix of grey and white, and its beak is partially visible in the center.

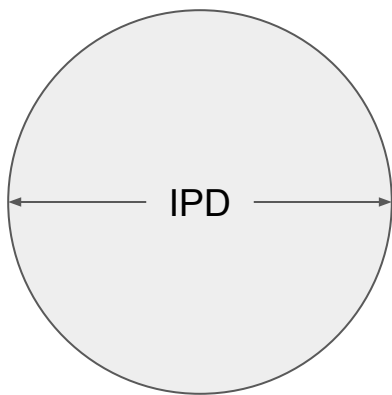
Interpupillary Distance

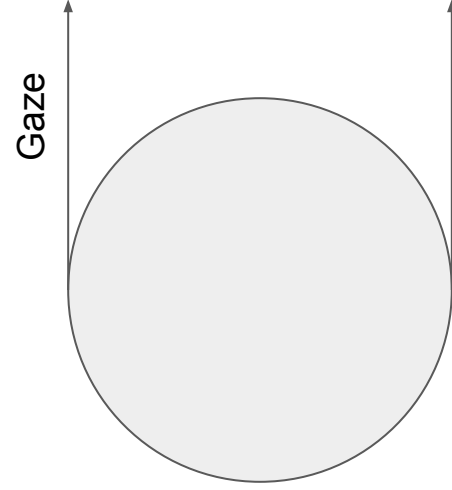


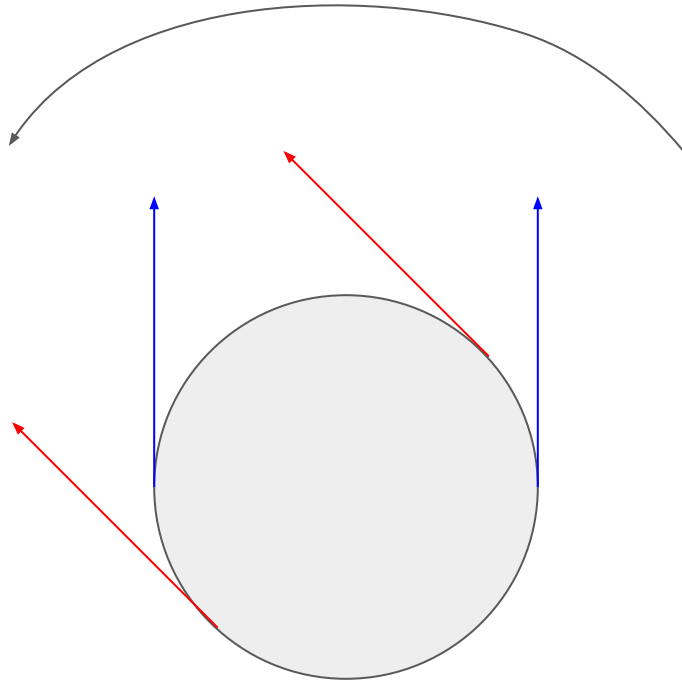


A close-up photograph of an owl's face, focusing on its two large, yellow eyes. A horizontal yellow line with small circular endpoints at each eye's pupil is drawn across the image. The text "Interpupillary Distance" is written in white, sans-serif font, centered over the line. The owl's feathers are grey and white, and its beak is visible in the center between the eyes.

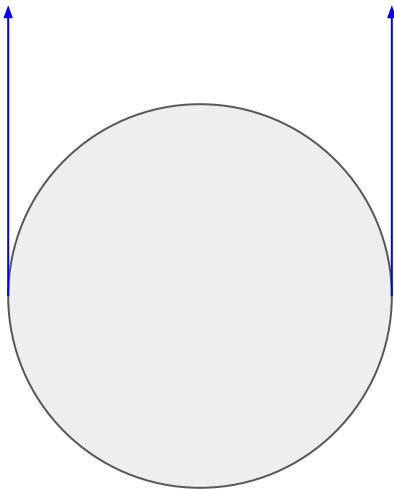
Interpupillary Distance

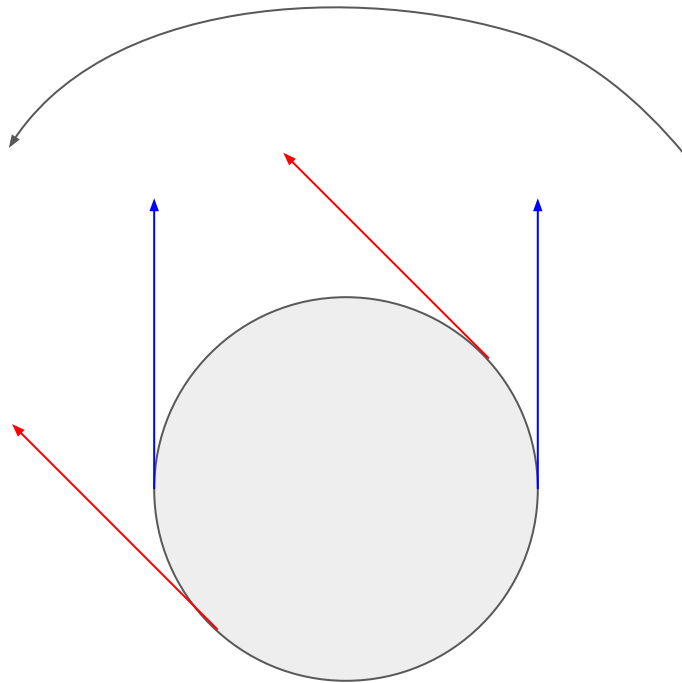




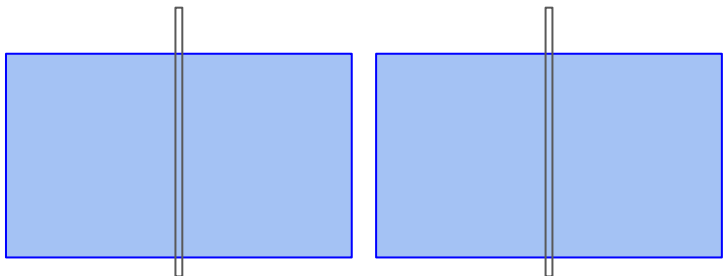




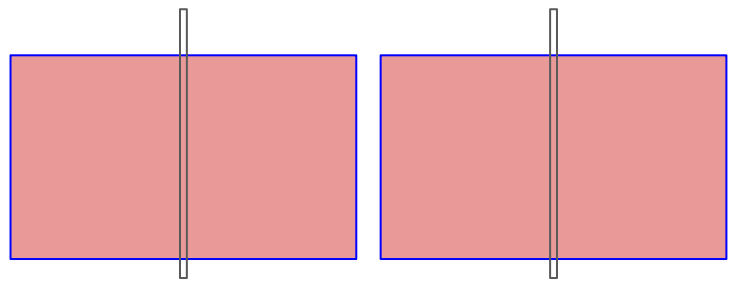


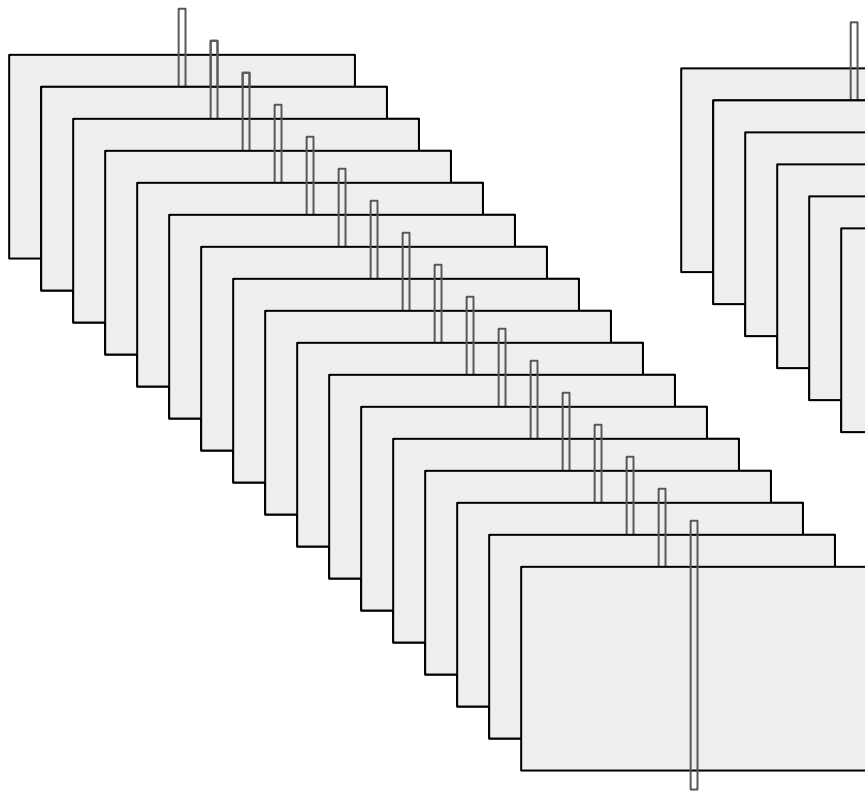


Time 1

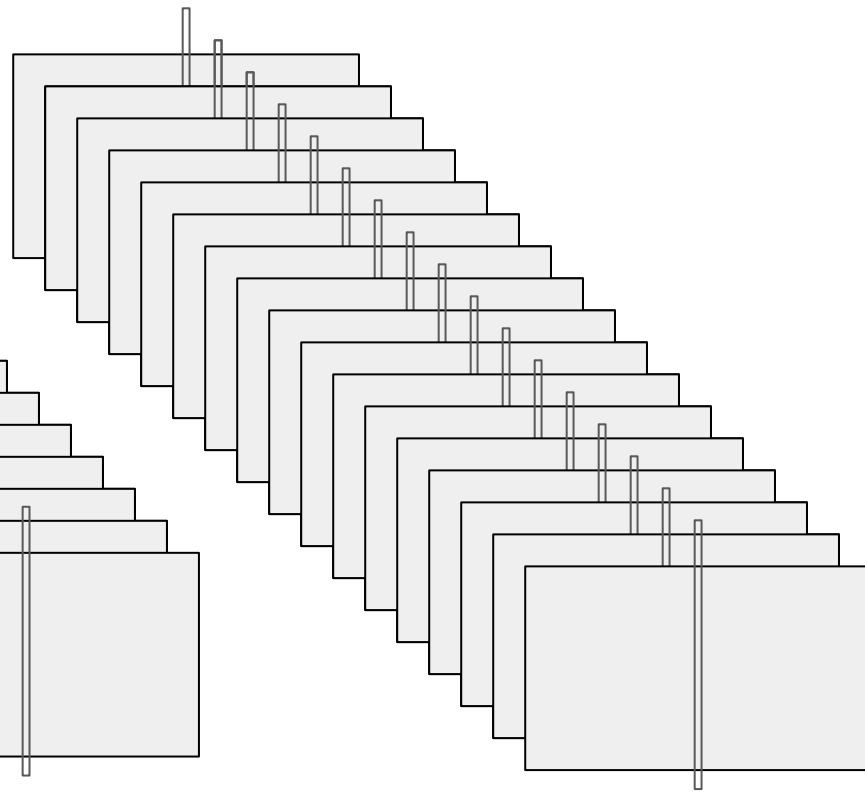


Time 2

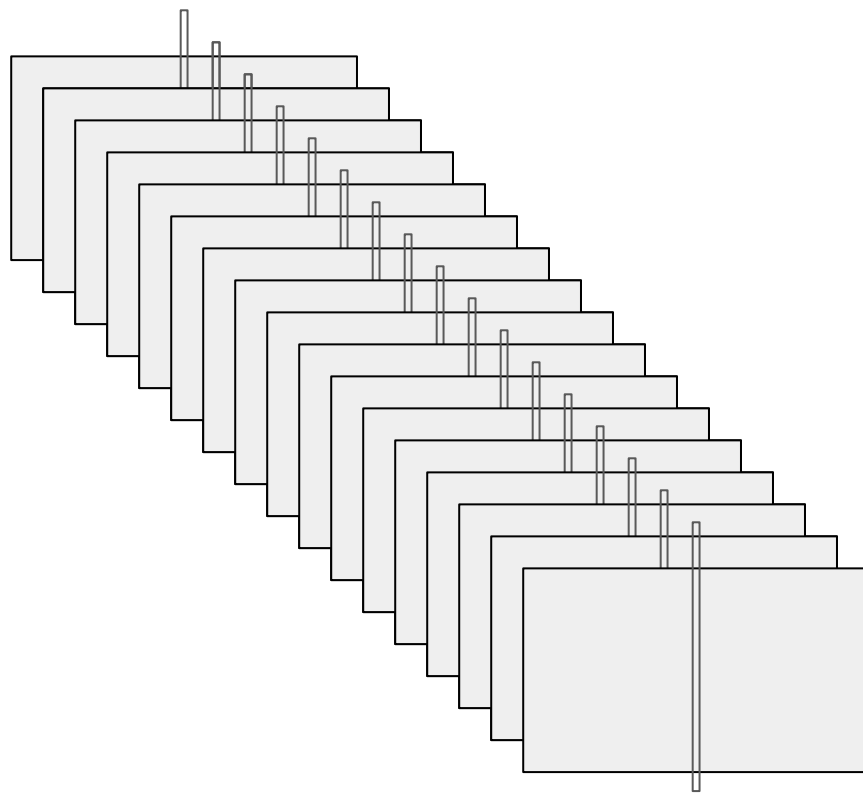
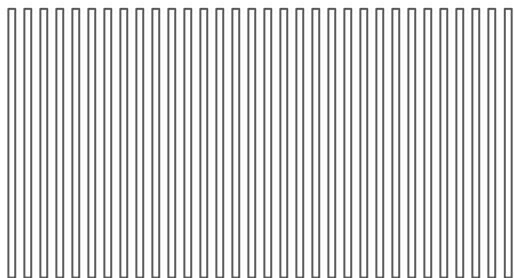




Left Eye



Right Eye

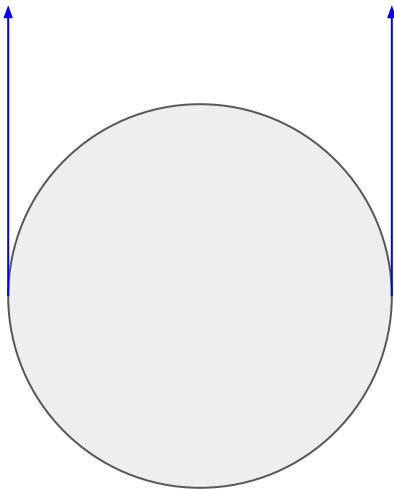


Right Eye









**OMNI-DIRECTIONAL STEREO  
FOR  
MAKING GLOBAL MAP**

**Hiroshi Ishiguro, Masashi Yamamoto and Saburo Tsuji**

**Department of Control Engineering  
Osaka University**

**Toyonaka, Osaka 560, Japan**

**Email:ishiguro@tsuji-lab.ce.osaka-u.ac.jp**

# Omnistereero: Panoramic Stereo Imaging

Shmuel Peleg, *Member, IEEE*, Moshe Ben-Ezra, and Yael Pritch

**Abstract**—An Omnistereero panorama consists of a pair of panoramic images, where one panorama is for the left eye and another panorama is for the right eye. The panoramic stereo pair provides a stereo sensation up to a full 360 degrees. Omnistereero panoramas cannot be photographed by two omnidirectional cameras from two viewpoints, but can be constructed by mosaicing together images from a rotating stereo pair. A more convenient approach to generate omnistereero panoramas is by mosaicing images from a single rotating camera. This approach also enables the control of stereo disparity, giving larger baselines for faraway scenes, and a smaller baseline for closer scenes. Capturing panoramic omnistereero images with a rotating camera makes it impossible to capture dynamic scenes at video rates and limits omnistereero imaging to stationary scenes. We, therefore, present two possibilities for capturing omnistereero panoramas using optics without any moving parts. A special mirror is introduced such that viewing the scene through this mirror creates the same rays as those used with the rotating cameras. A lens for omnistereero panorama is also introduced. The designs of the mirror and of the lens are based on curves whose caustic is a circle. Omnistereero panoramas can also be rendered by computer graphics methods to represent virtual environments.

**Index Terms**— Stereo imaging, panoramic imaging, image mosaicing.



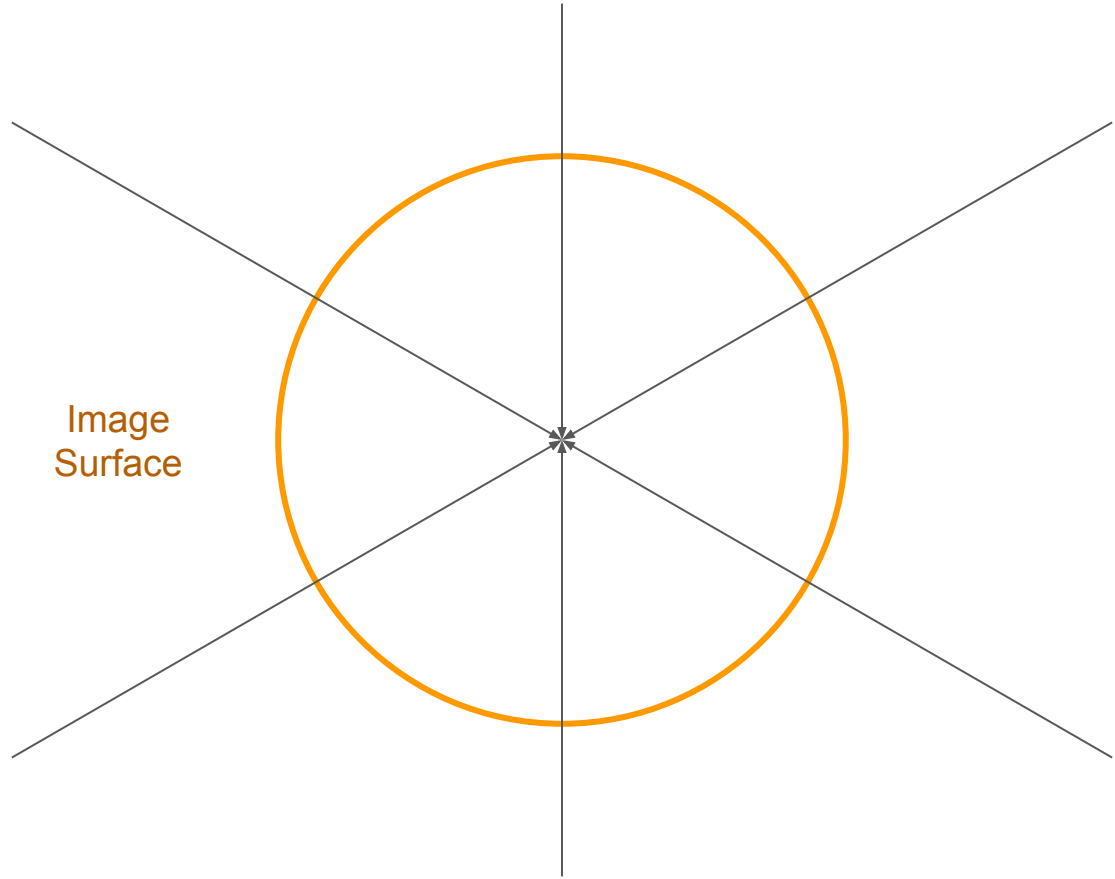
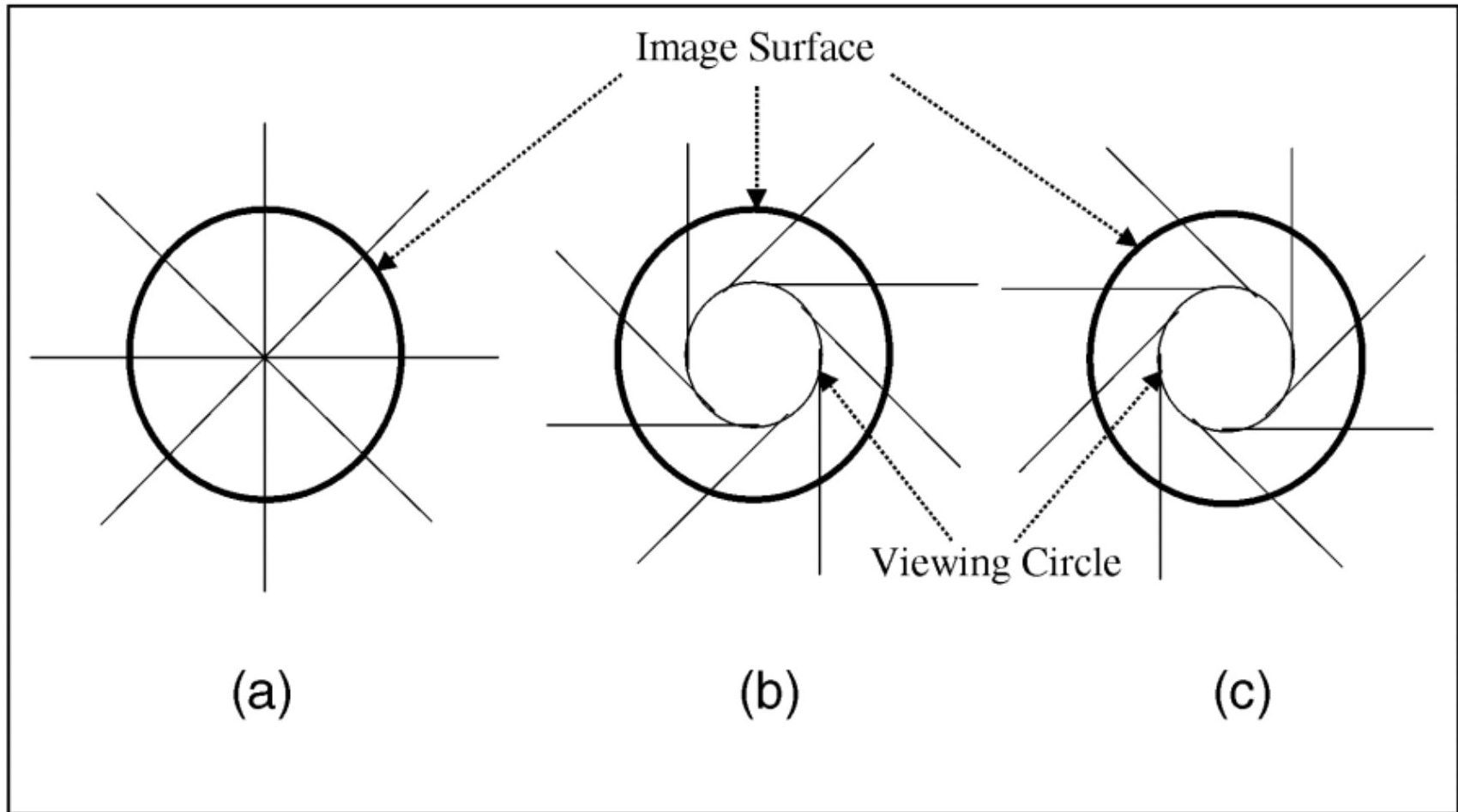
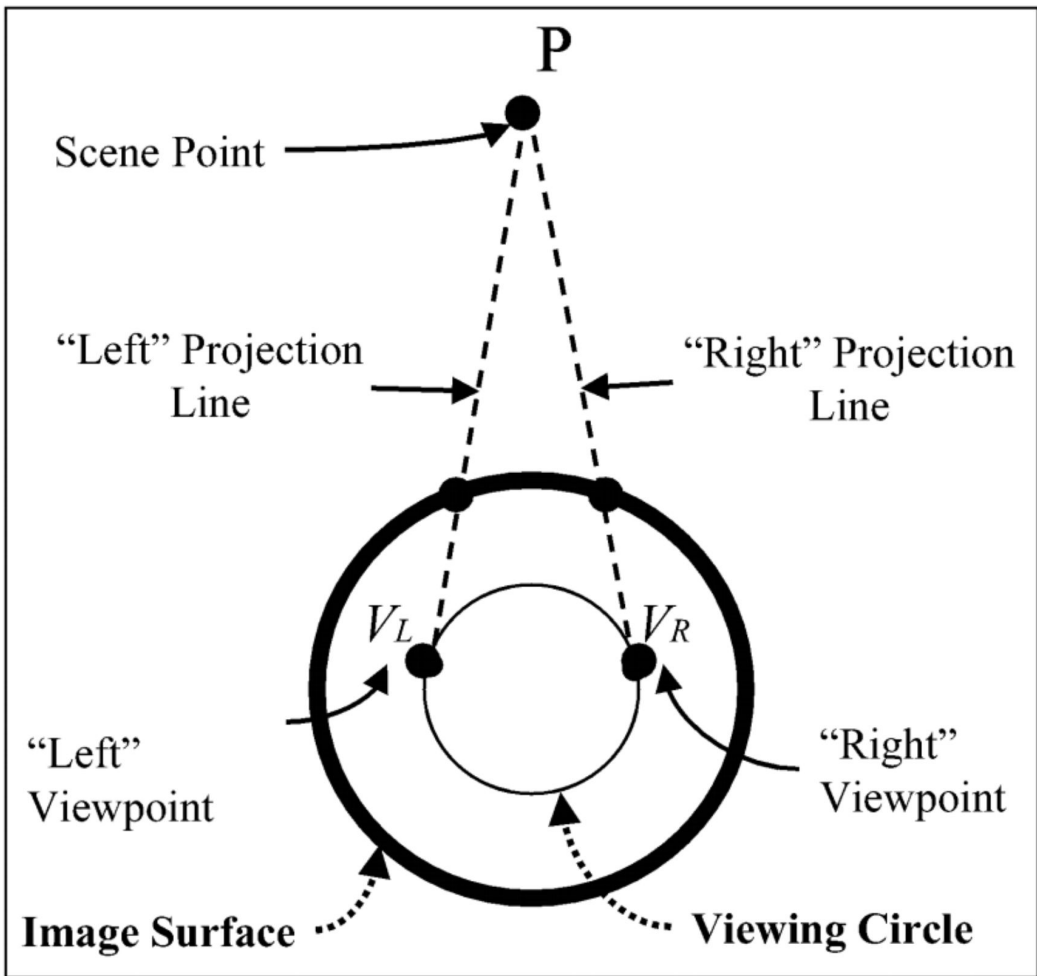
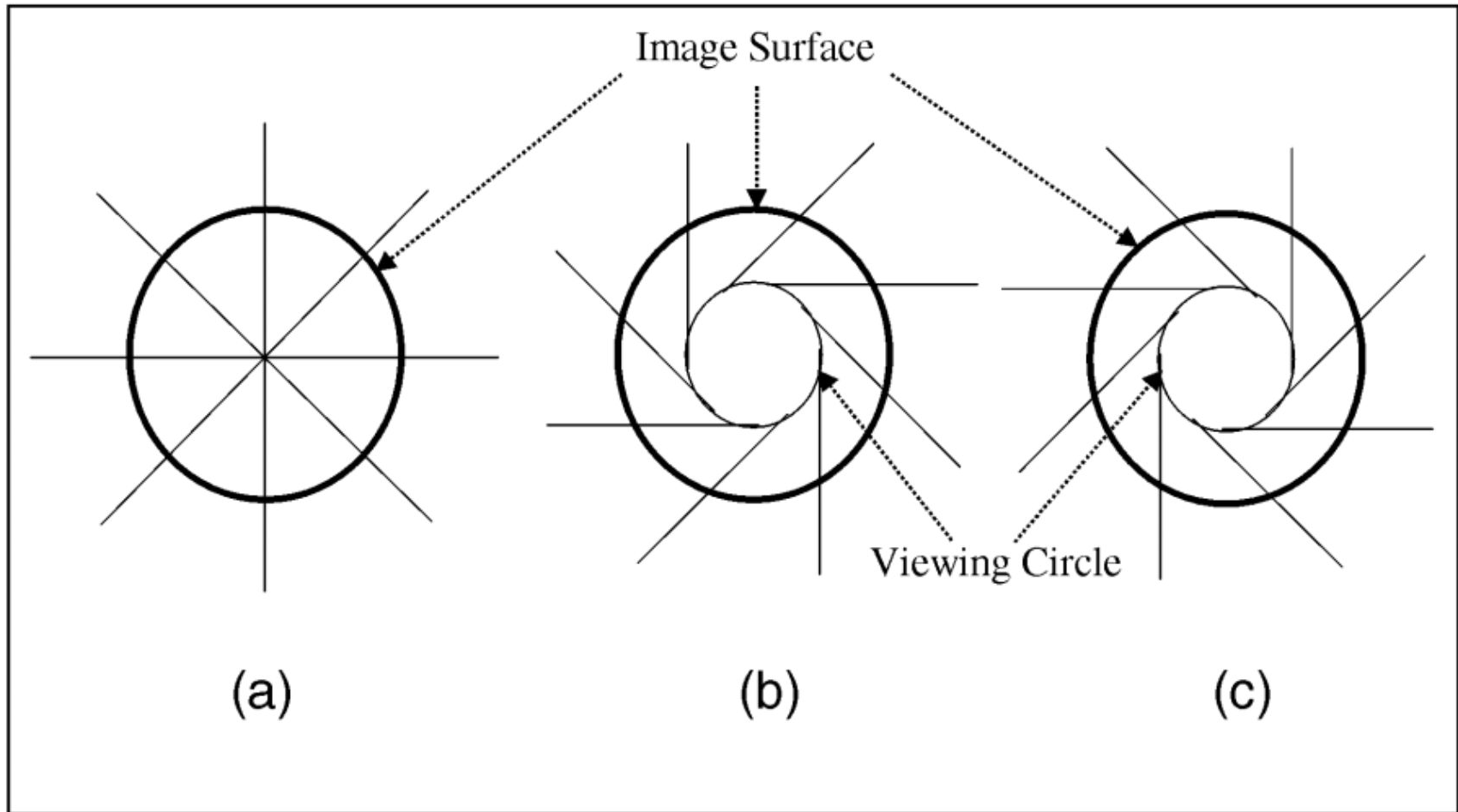


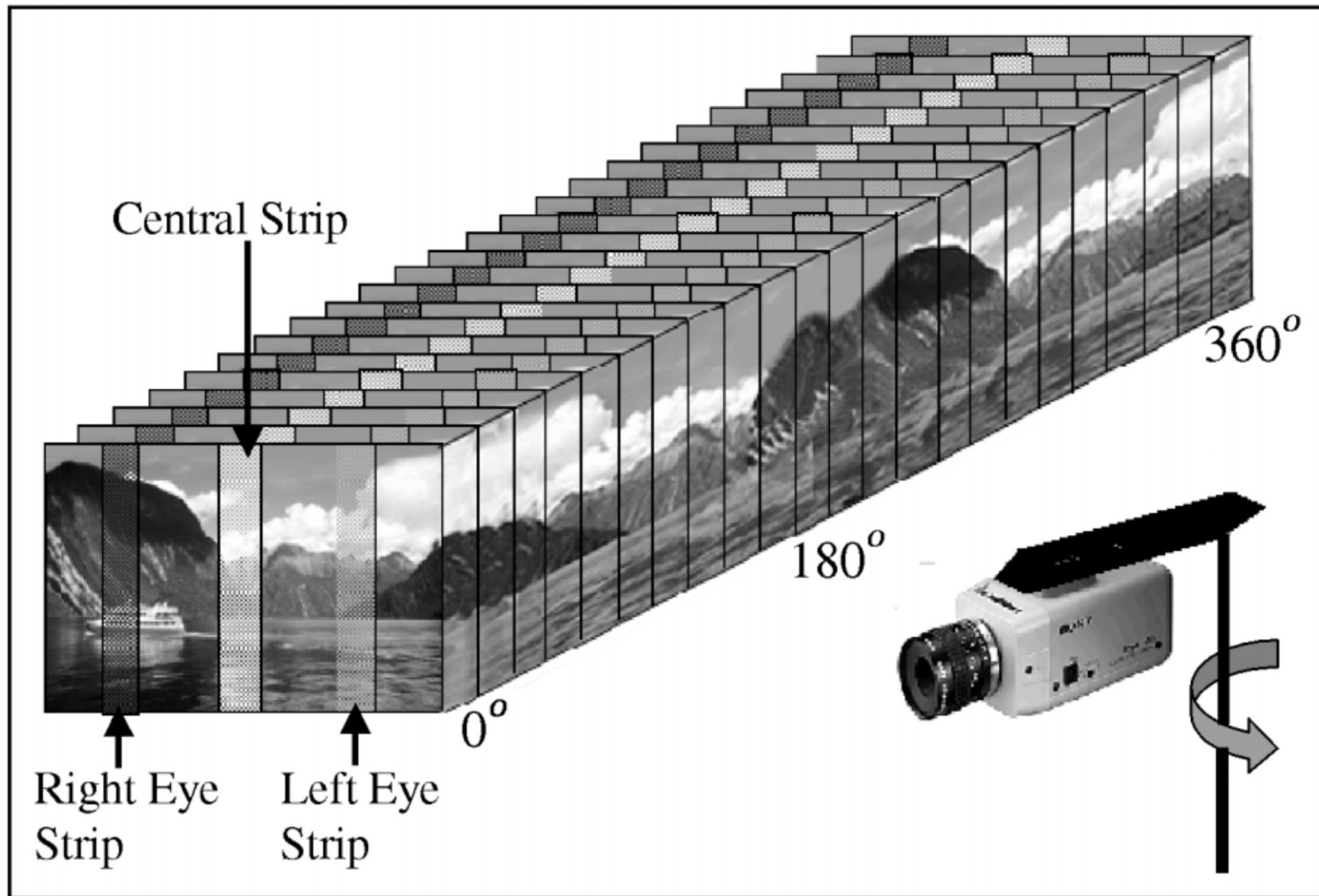
Image  
Surface

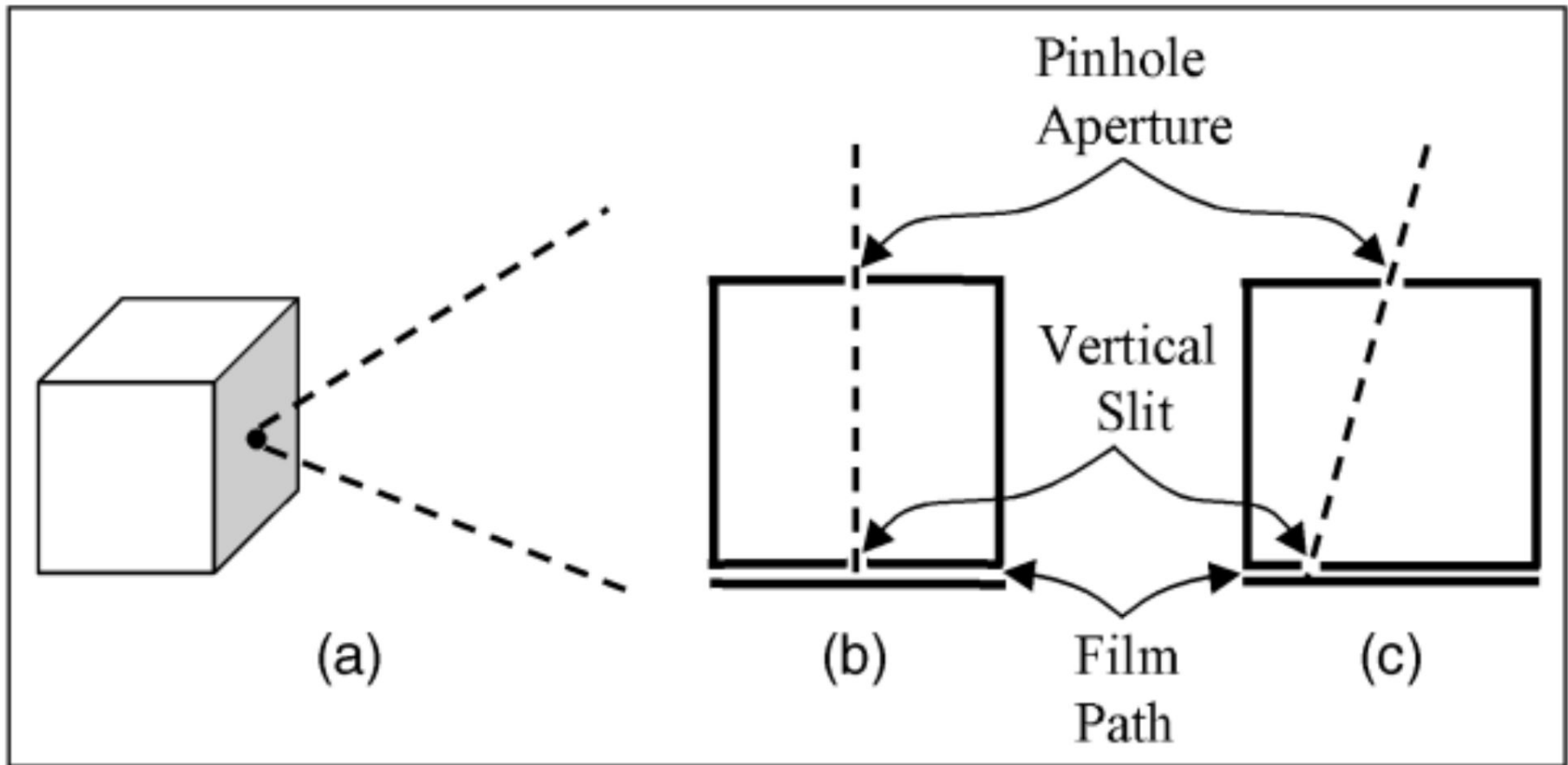


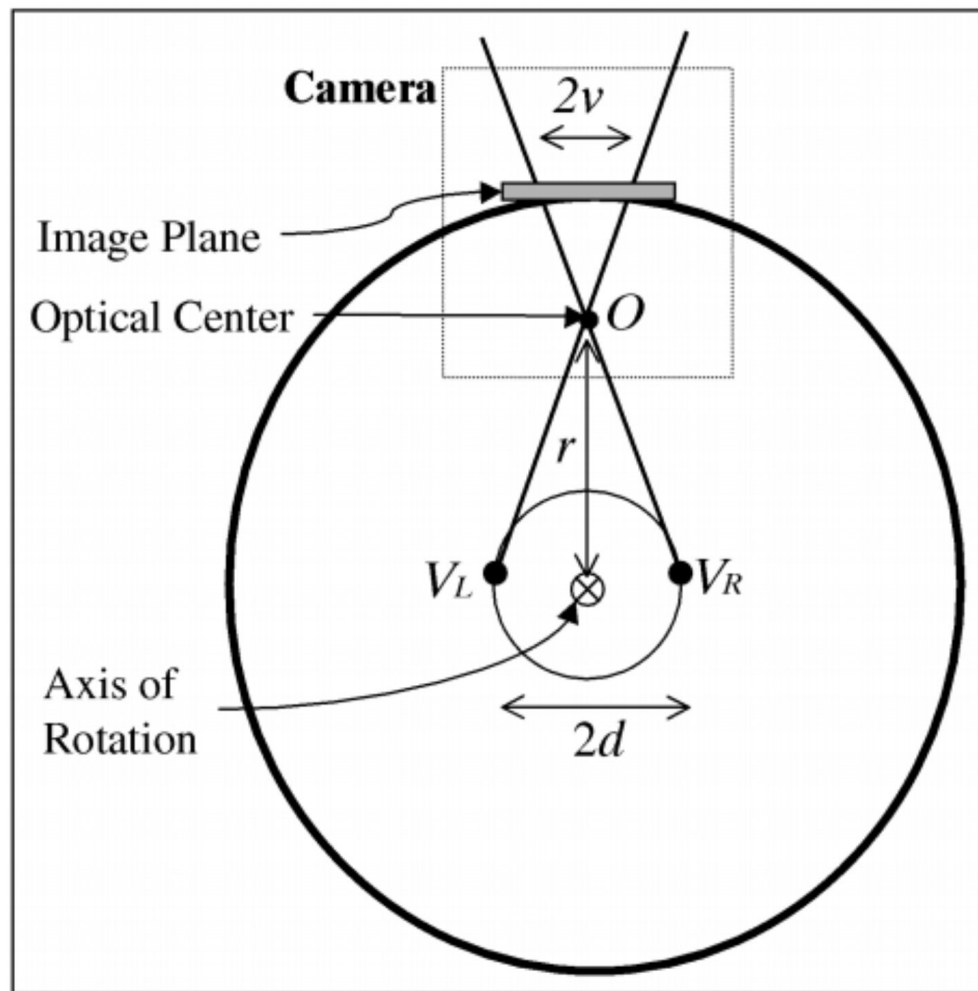


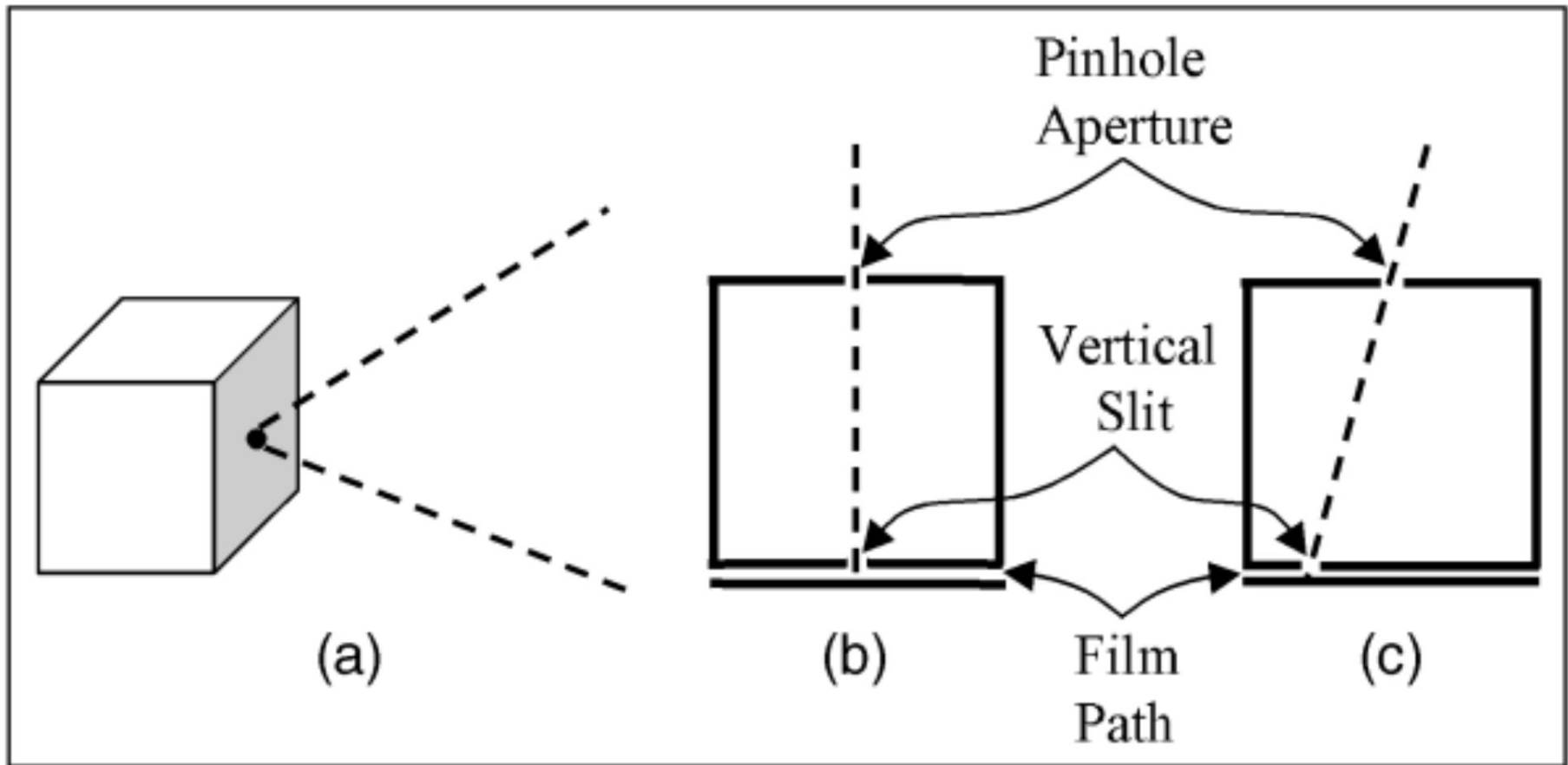


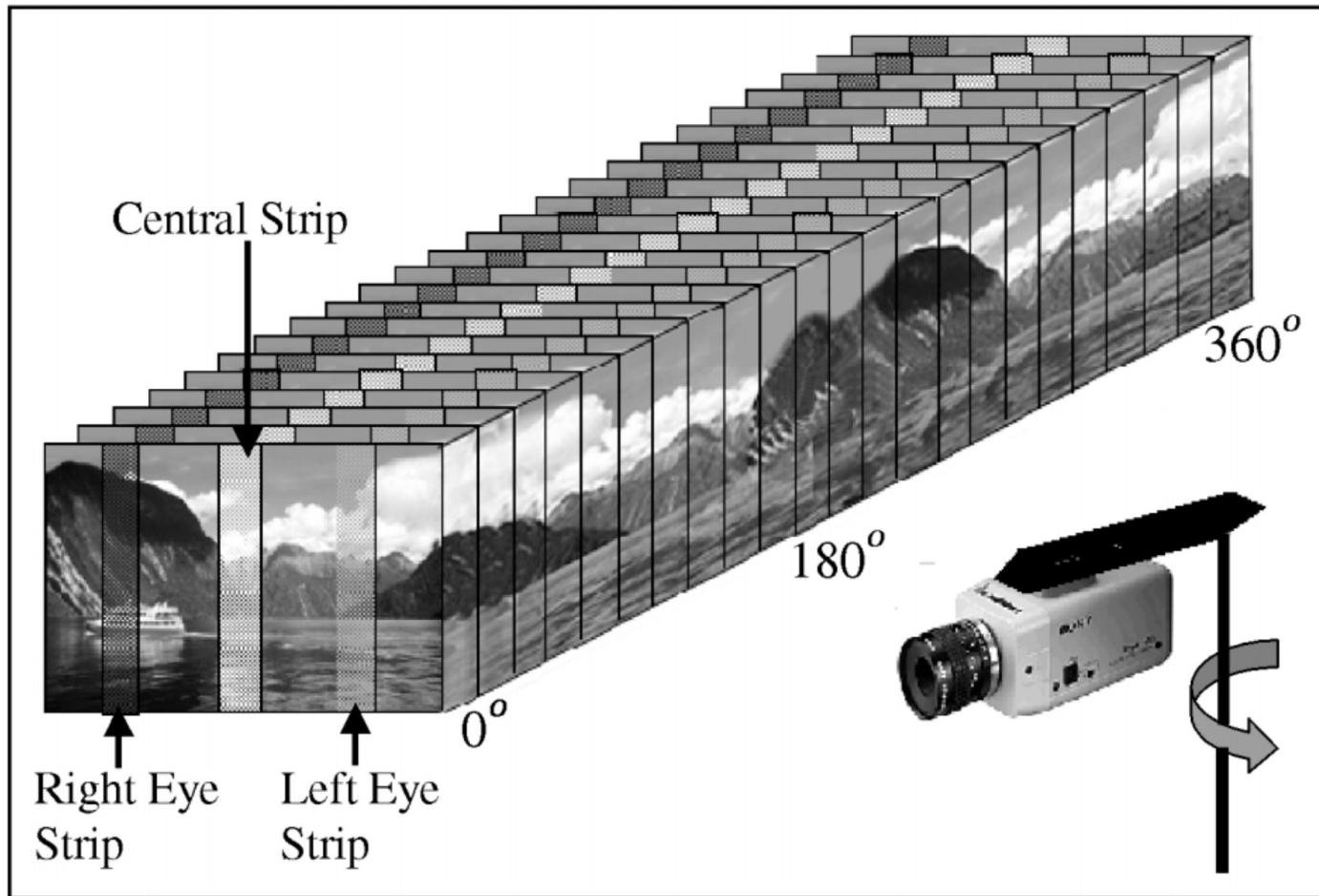




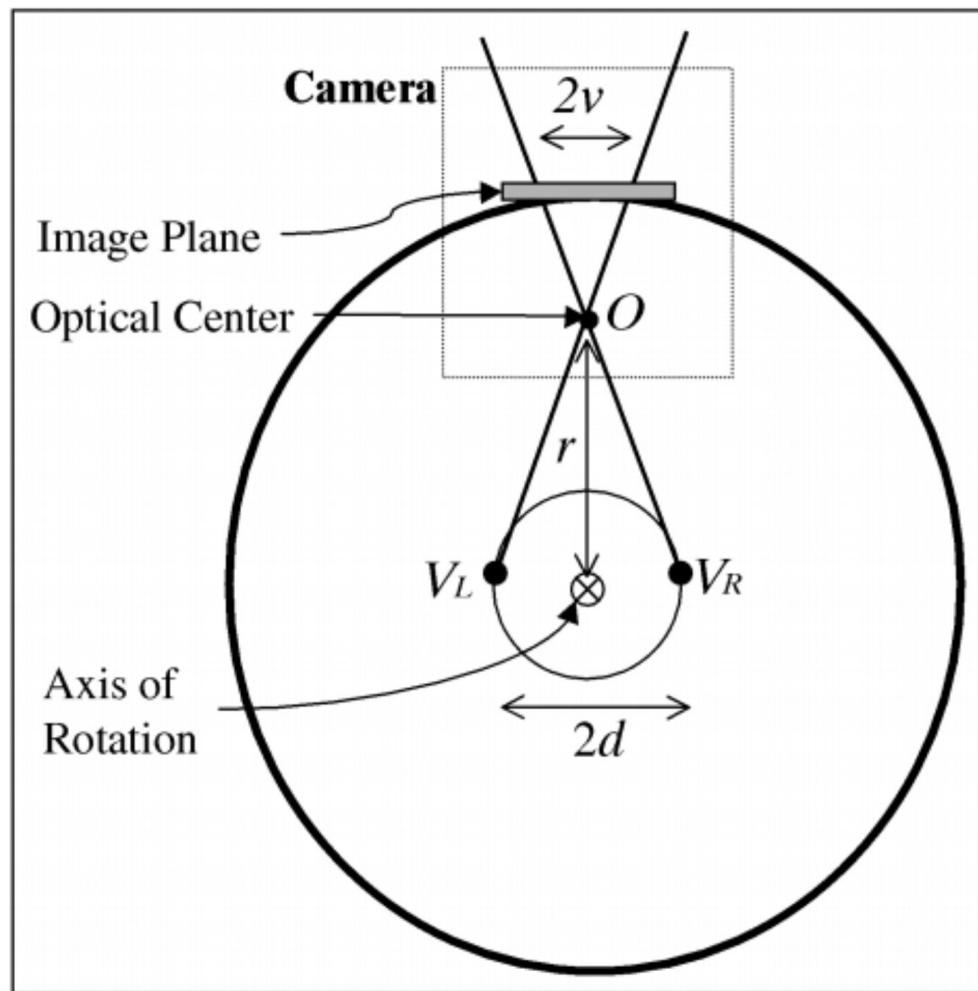












The Right Image



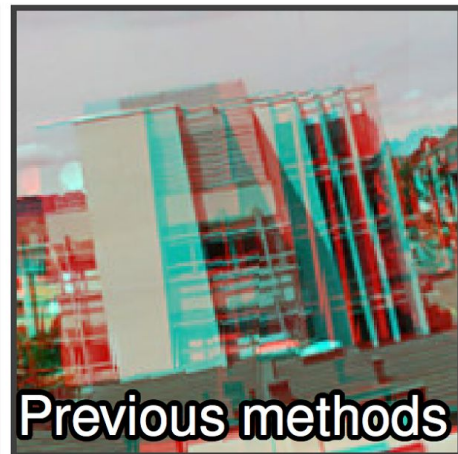
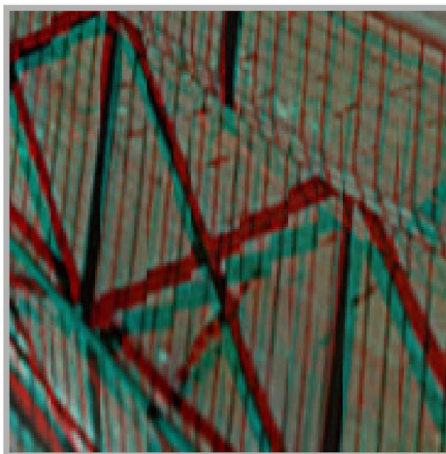
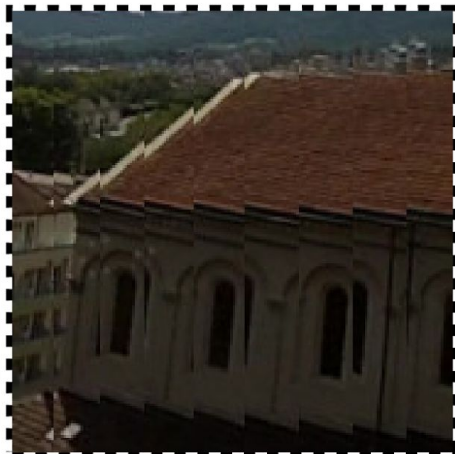
The Left Image



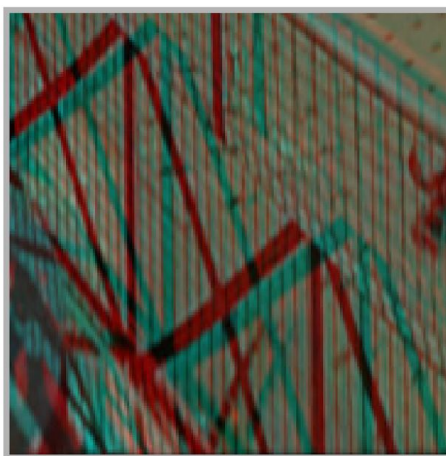
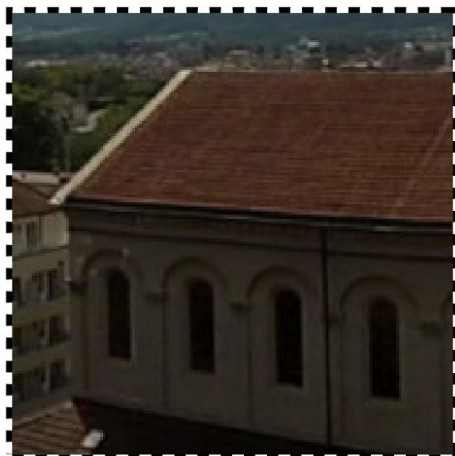
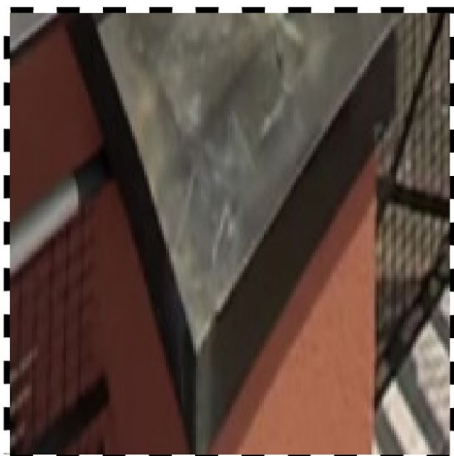
# Megastereo: Constructing High-Resolution Stereo Panoramas

Christian Richardt <sup>1,2</sup>    Yael Pritch <sup>1</sup>    Henning Zimmer <sup>1,3</sup>    Alexander Sorkine-Hornung <sup>1</sup>

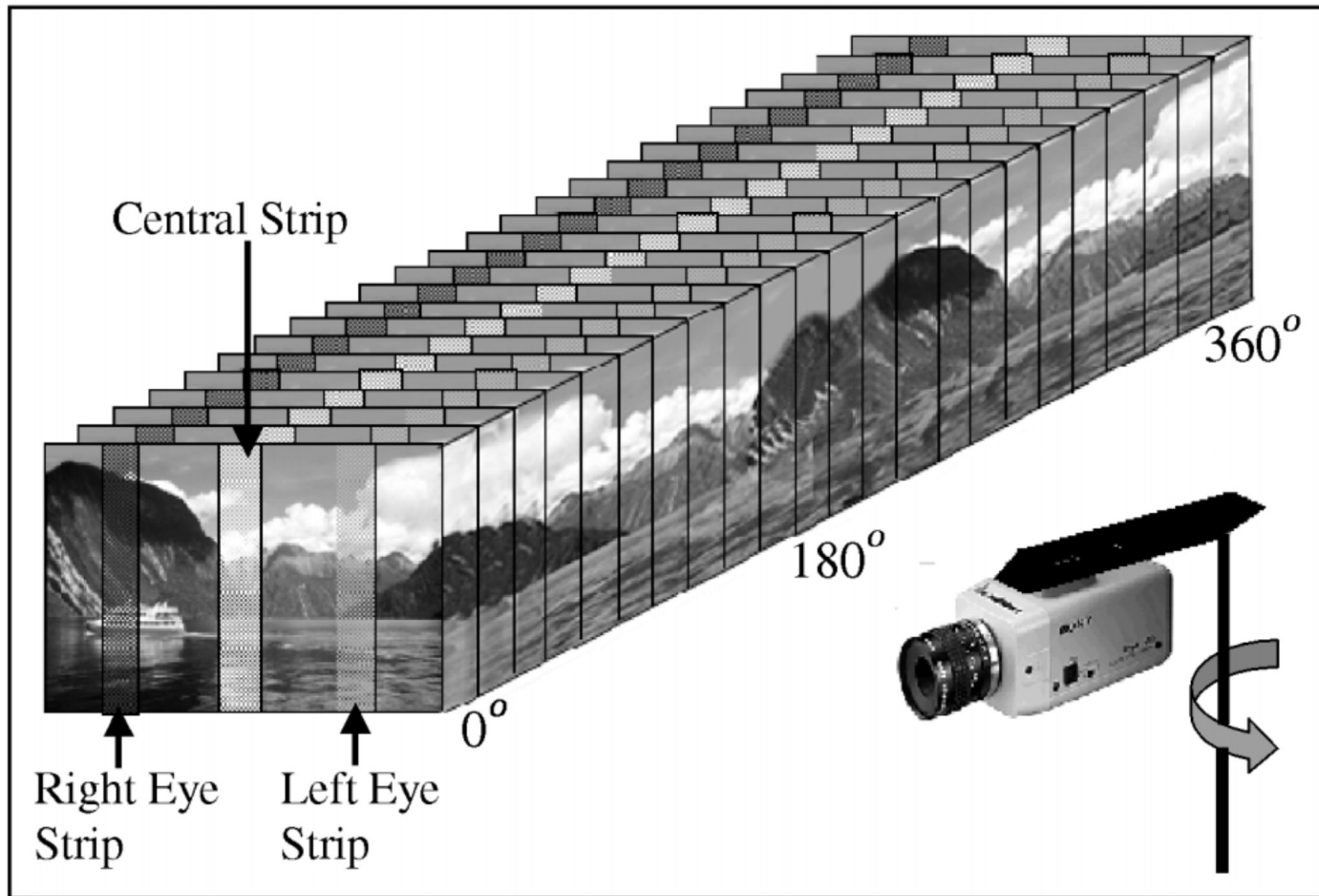
<sup>1</sup> Disney Research Zurich    <sup>2</sup> REVES/INRIA Sophia Antipolis    <sup>3</sup> ETH Zurich



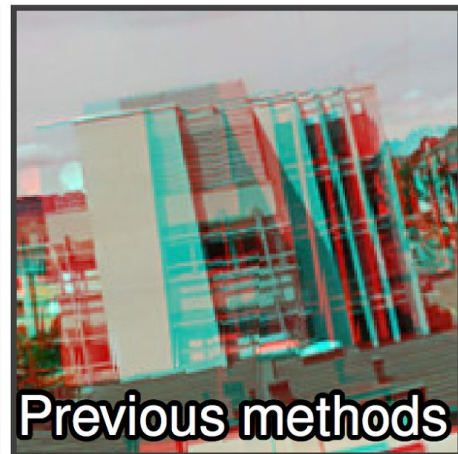
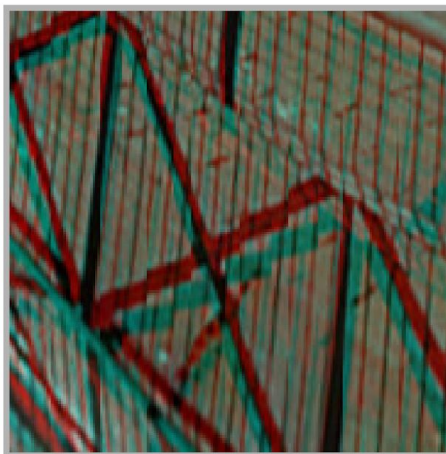
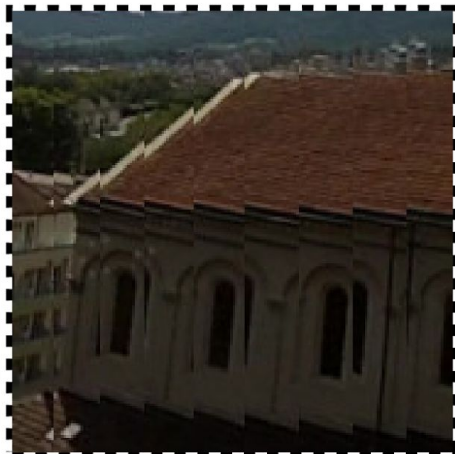
Previous methods



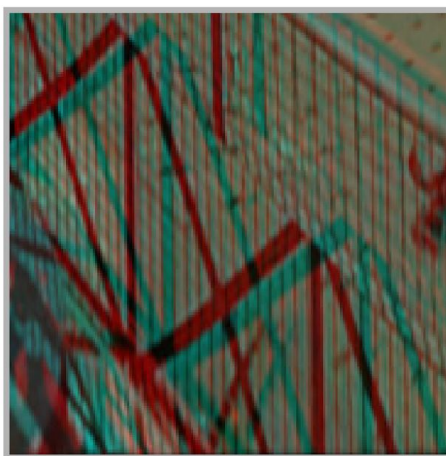
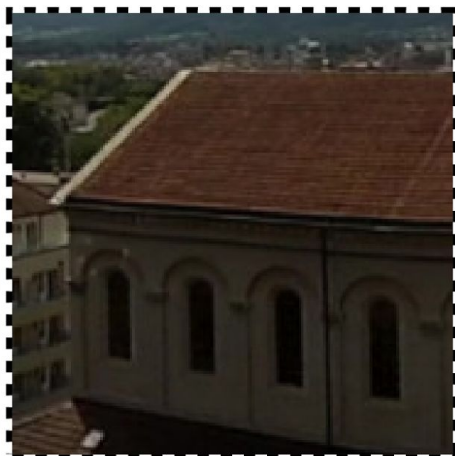
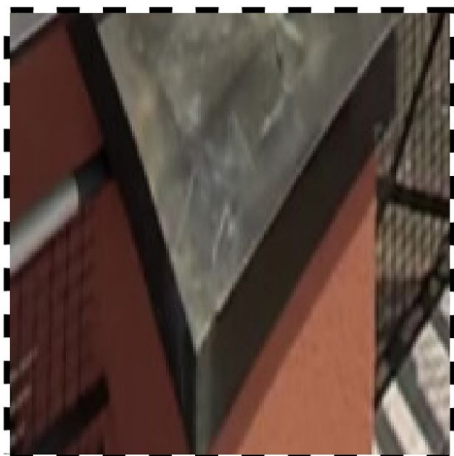
Our result







Previous methods



Our result

First, some terminology...



# pho·to·gram·me·try

/ˌfōdəˈgramət̩rē/ 

*noun*

the use of photography in surveying and mapping to measure distances between objects.



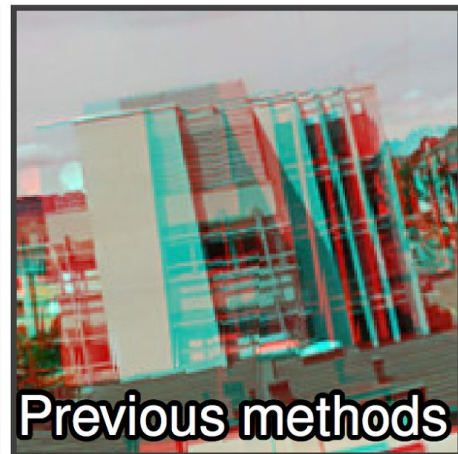
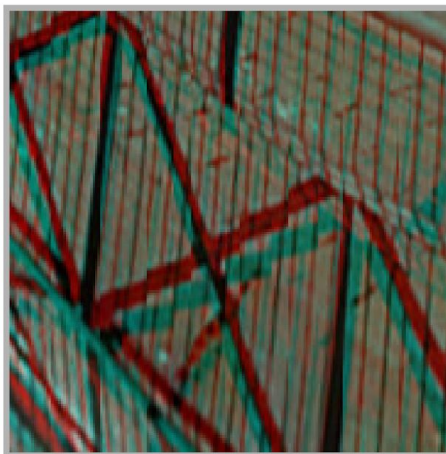
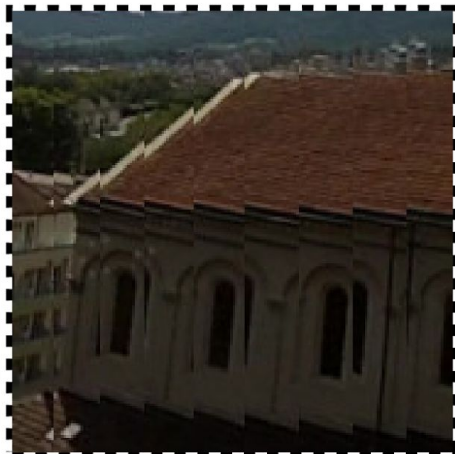
Translations, word origin, and more definitions

“““**Structure from motion (SfM)** is a *photogrammetric range imaging* technique for estimating three-dimensional structures from two-dimensional image sequences that may be coupled with local *motion signals*. ”””

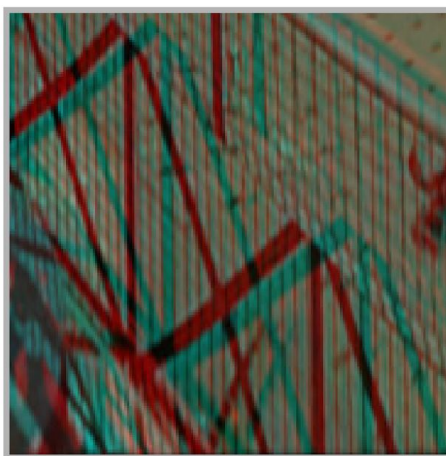
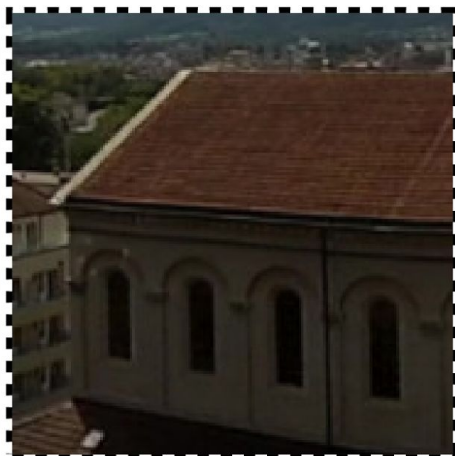
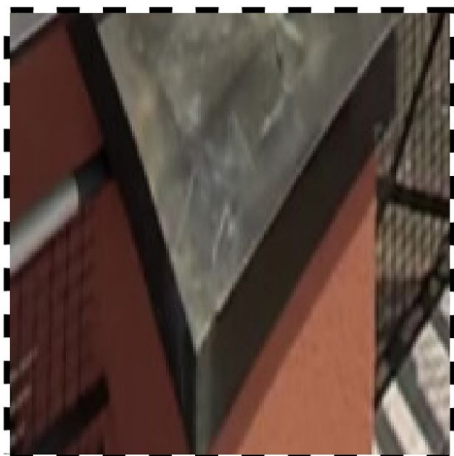
~Wikipedia







Previous methods



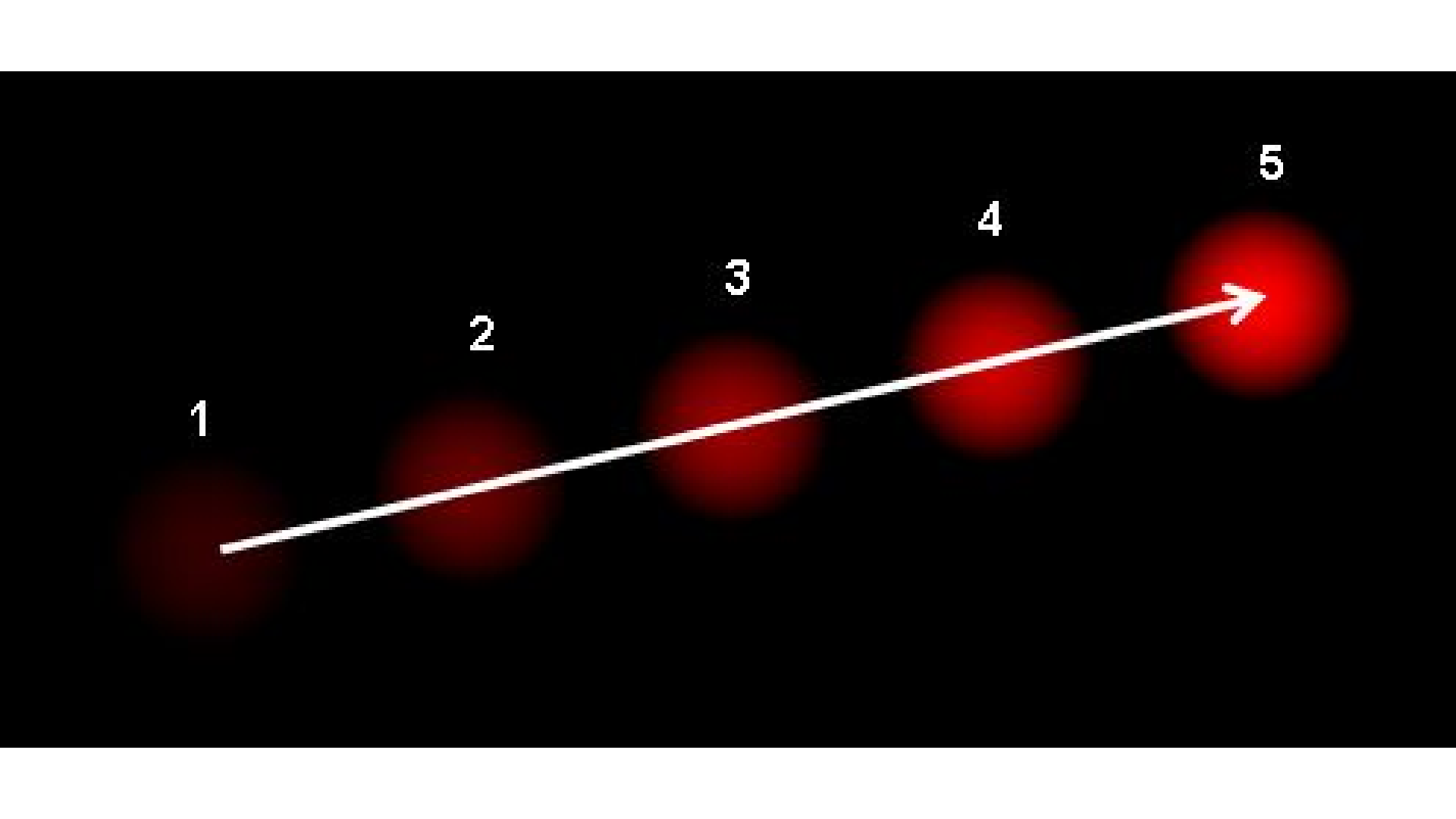
Our result

And, some more terminology...

“““**Optical flow** or **optic flow** is the pattern of apparent *motion* of objects, surfaces, and edges in a visual scene caused by the *relative motion* between an observer and a scene. ”””

~Wikipedia





First section of Figure 12 -- Jump: Virtual Reality Video



**(a)**

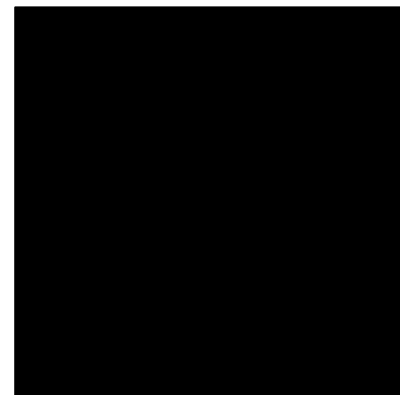
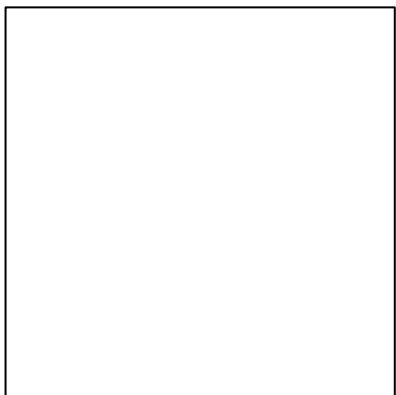


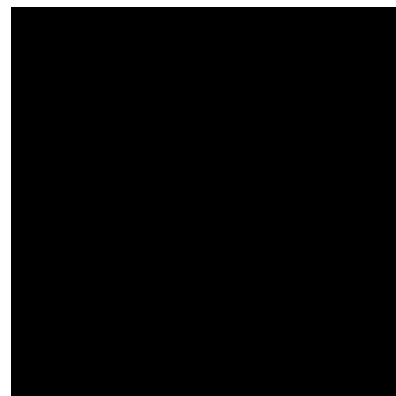
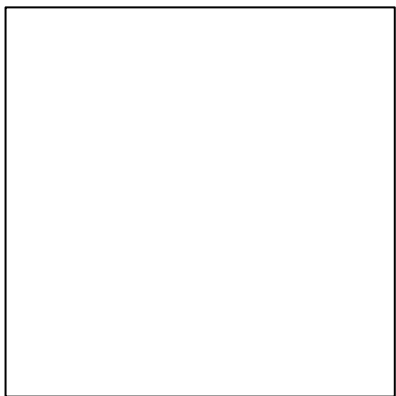
**(b)**



**(c)**









Blending test:



**Nearest neighbour**

Blending test



**Linear**

Blending test:



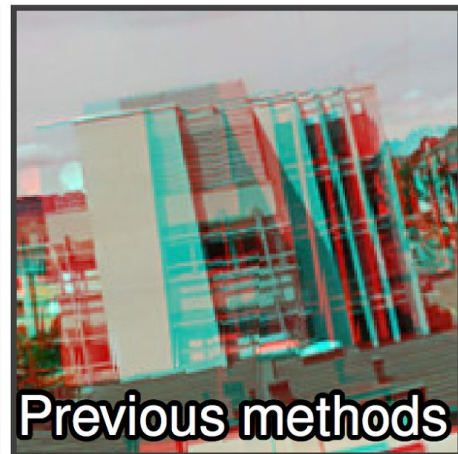
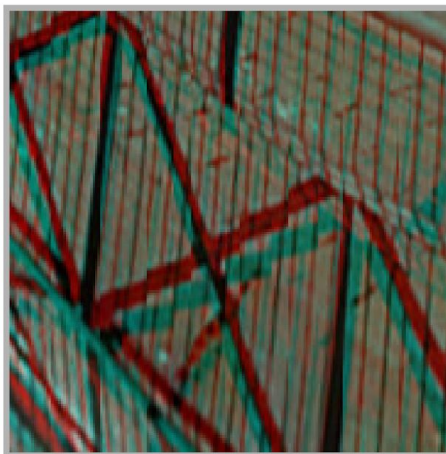
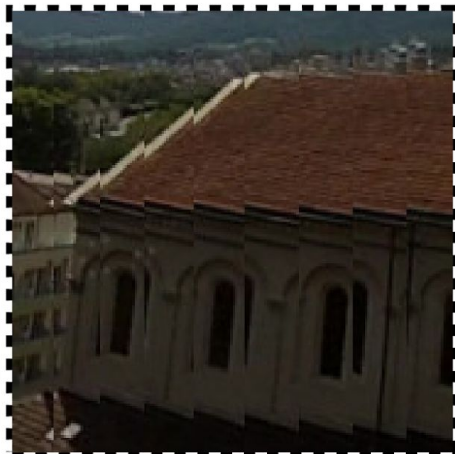
**Pyramid-based**

Blending test

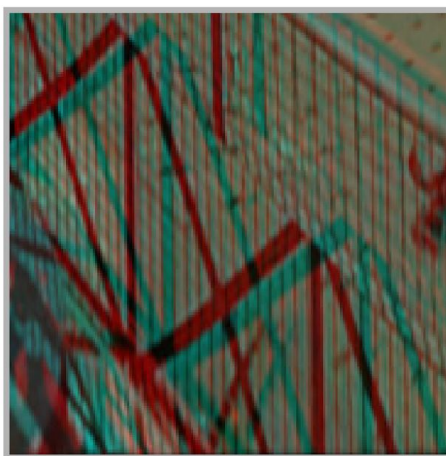
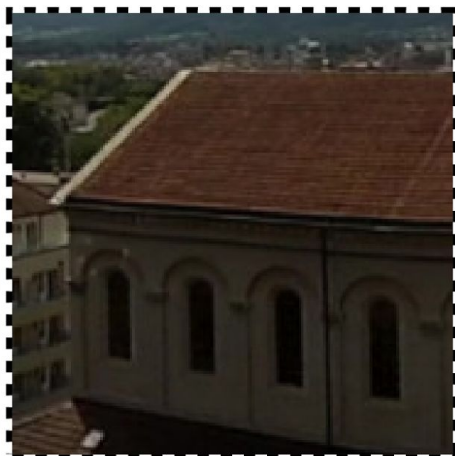
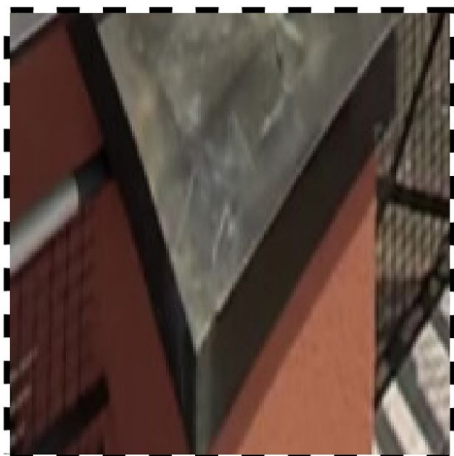


**Flow-based (ours)**

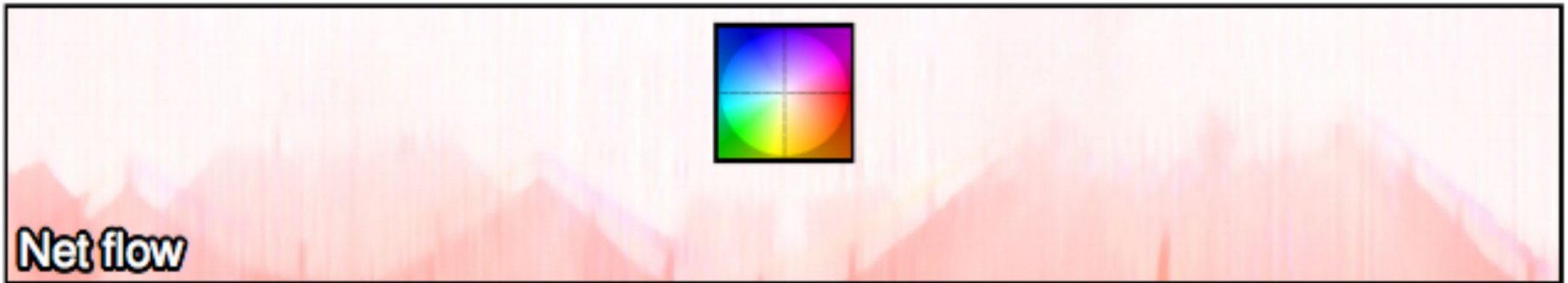




Previous methods



Our result

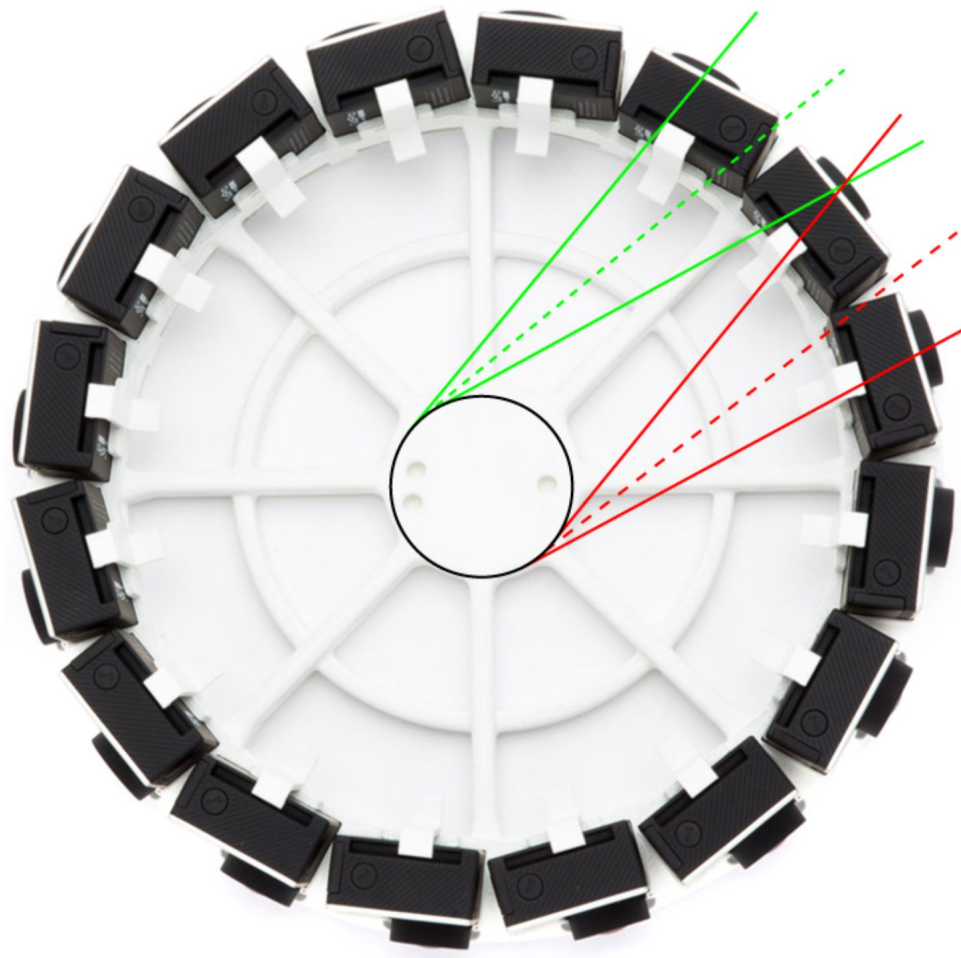


# Jump: Virtual Reality Video

Robert Anderson    David Gallup    Jonathan T. Barron    Janne Kontkanen  
Noah Snavely    Carlos Hernández    Sameer Agarwal    Steven M. Seitz

Google Inc.









**(a)**



**(b)**



**(c)**



**(a)**



**(b)**



**(c)**







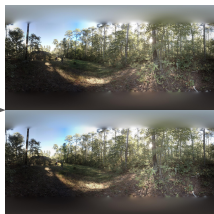








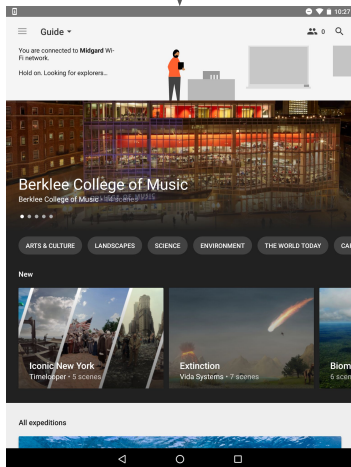
Capture



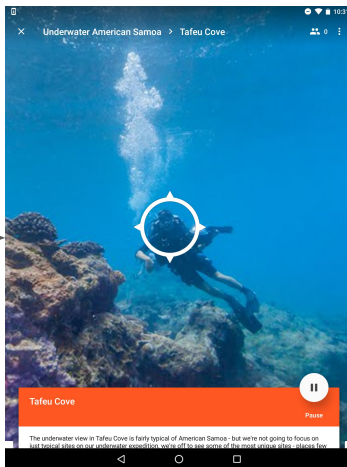
Stitch

Google Cloud  
Storage  
(GCS)

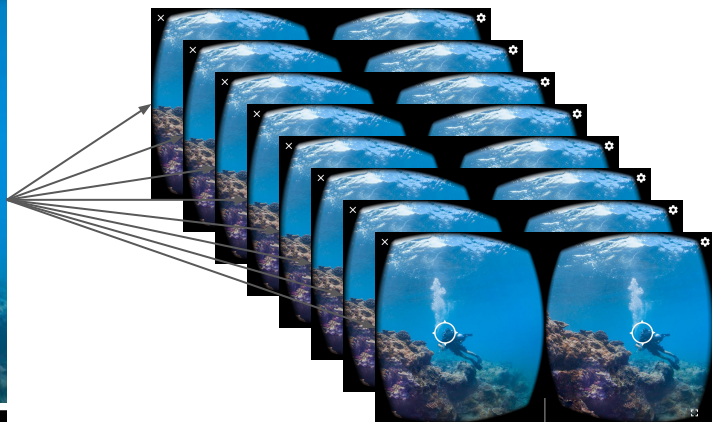
Serve



Browse /  
Download



Lead



Explore



Zeroconf Networking

DNS-SD

Interpupillary Distance (IPD)

AppleTalk

Panorama

Field of View (FOV)

NBP

Photosphere

Optical Flow

mDNS

Omnidirectional Stereo

Photo Stitching

# Sources

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3. See page for author [Public domain], via Wikimedia Commons -- <https://commons.wikimedia.org/wiki/File%3AQuicktime-Logo.svg>
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Real World Virtual Reality

**Real World** in Virtual Reality

Questions?





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 Alex.Kesling@gmail.com

 <http://linkedin.com/in/alexkesling>