

VR/AR Challenges

Pixar/Disney History

Conclusion

NBAY 6120
April 6, 2016
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Lecture 10

Requirements for “PRESENCE”

Need to be able to see (understand) correct DEPTH information

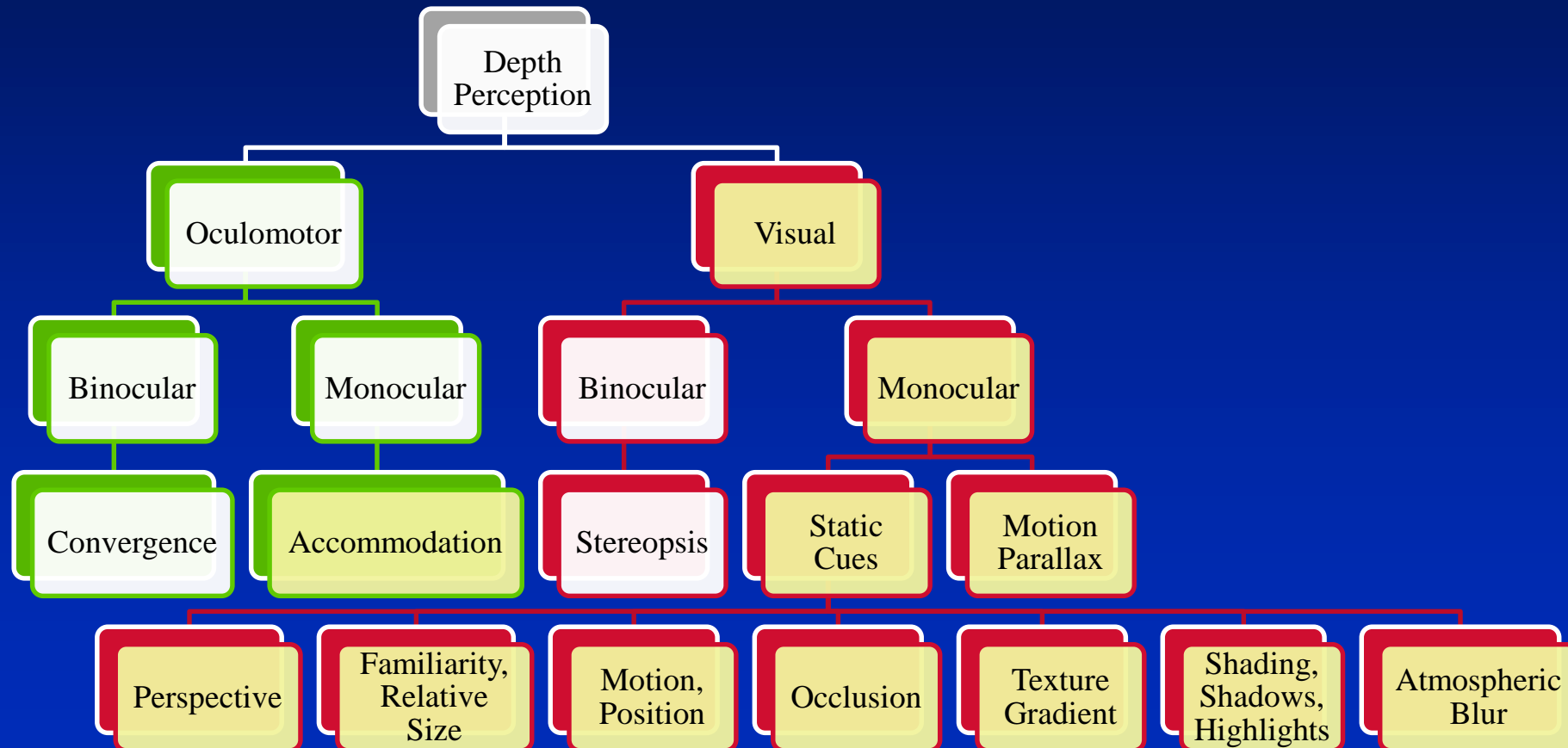
Need to have significant RESOLUTION to merge virtual and real imagery

Need to render images that are PHYSICALLY ACCURATE and
PERCEPTUALLY INDISTINGUISHABLE from real world scenes

and

all of this must be done fast enough to imply motion

Human Depth Perception



Monoscopic Depth Cues

Perspective

Depth from Motion, Relative
Size, Position, Familiarity

Occlusion

Texture Gradient

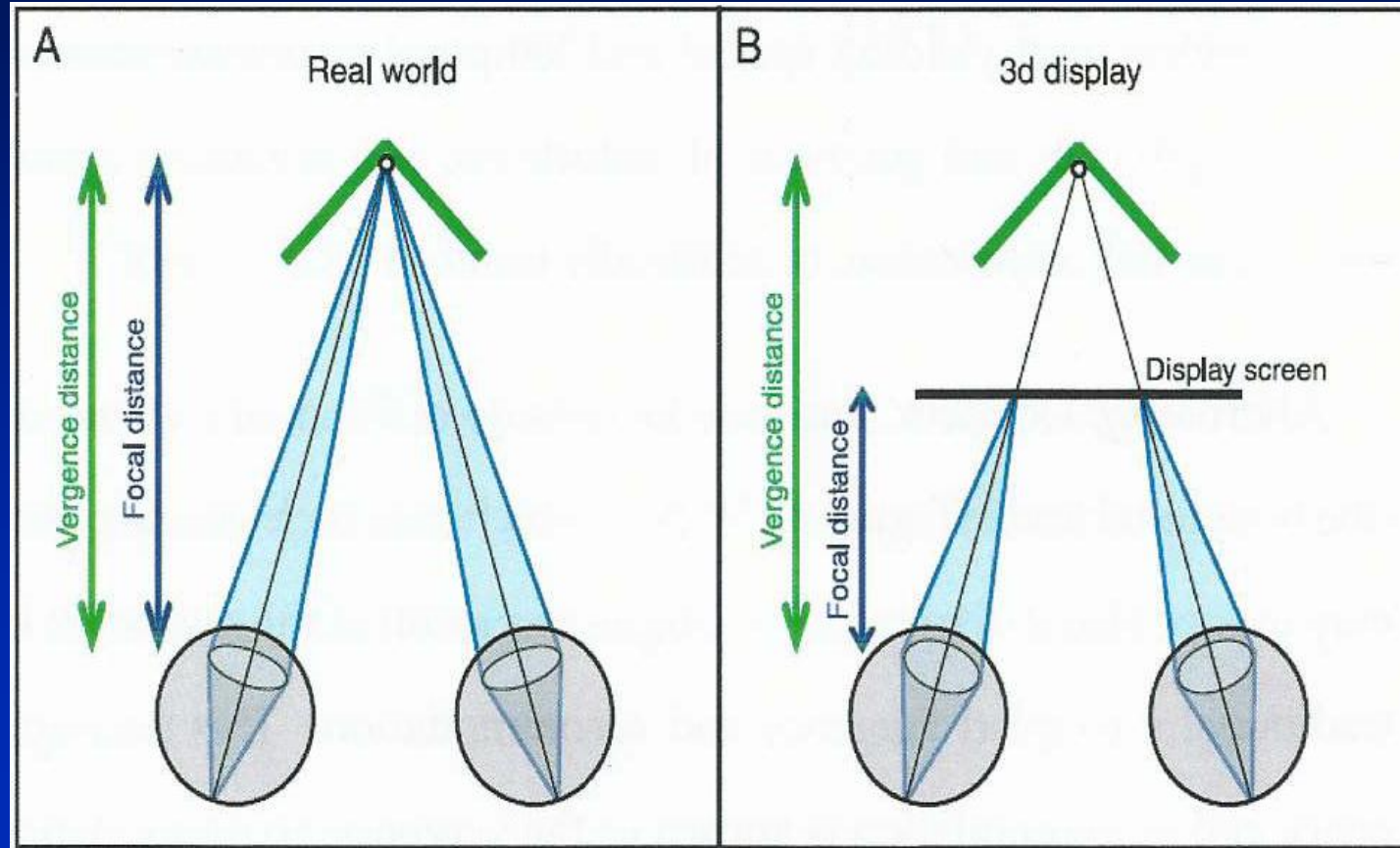
Parallax from Motion

Shadows and Specular Highlights

Atmospheric Blur



Vergence Accommodation Conflict



Components of the Human Eye

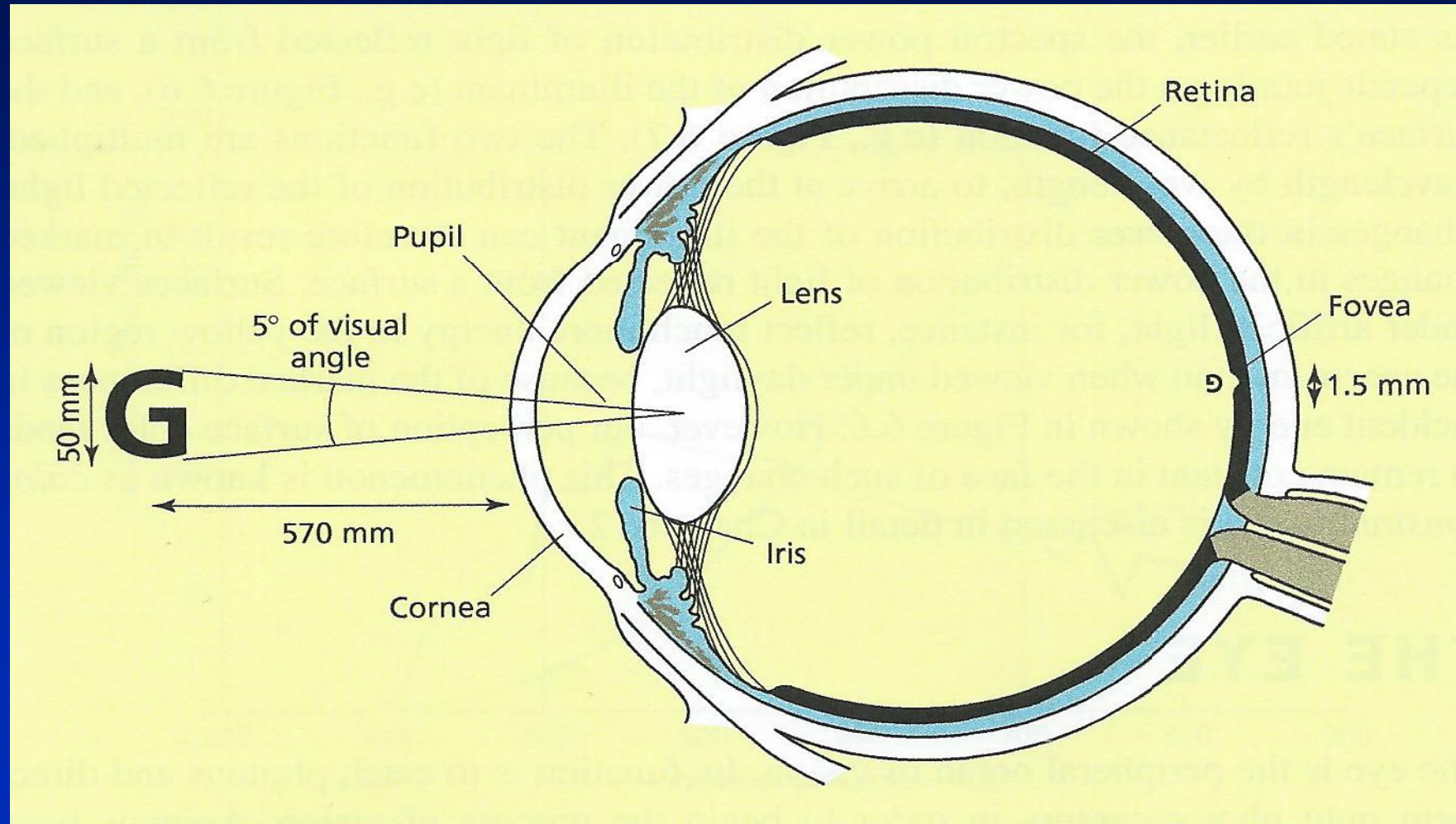
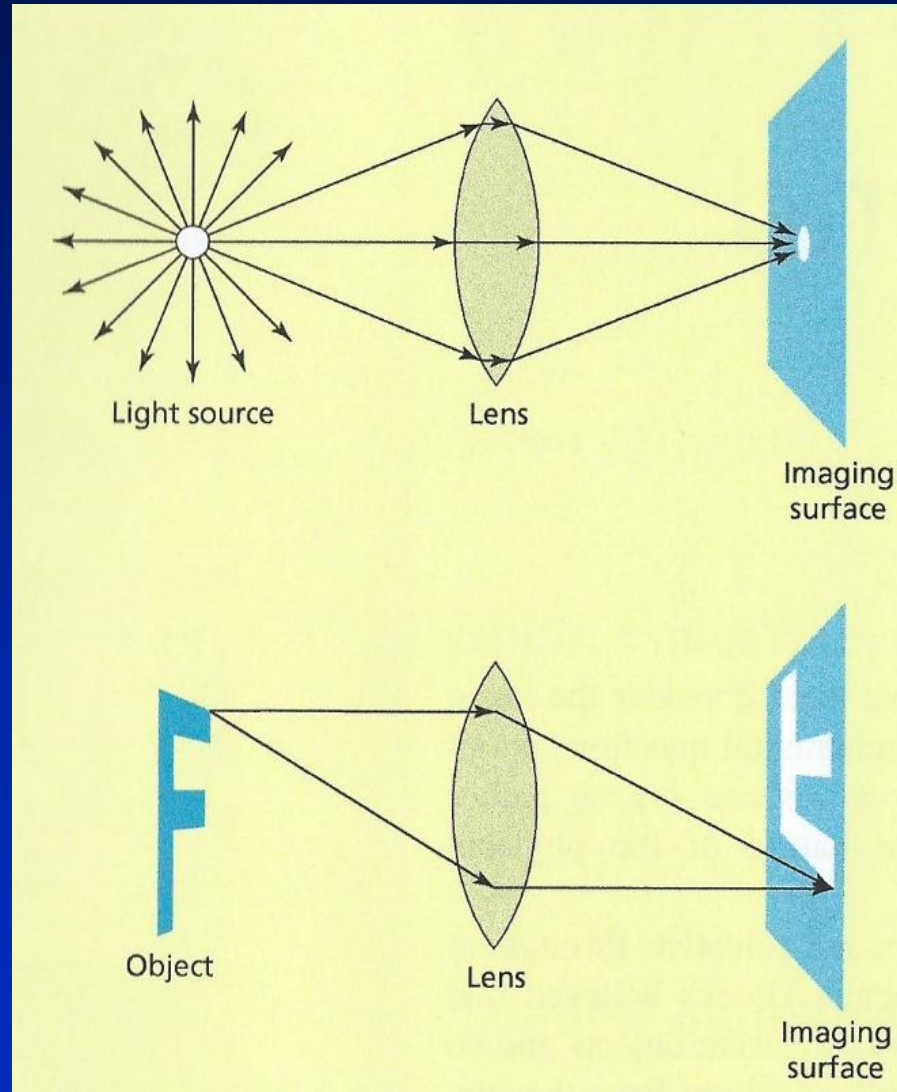
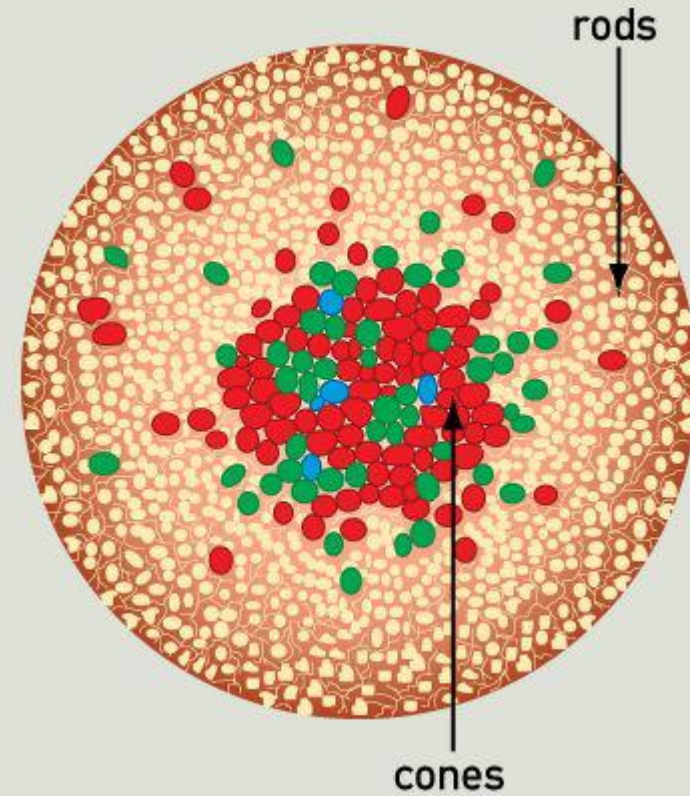
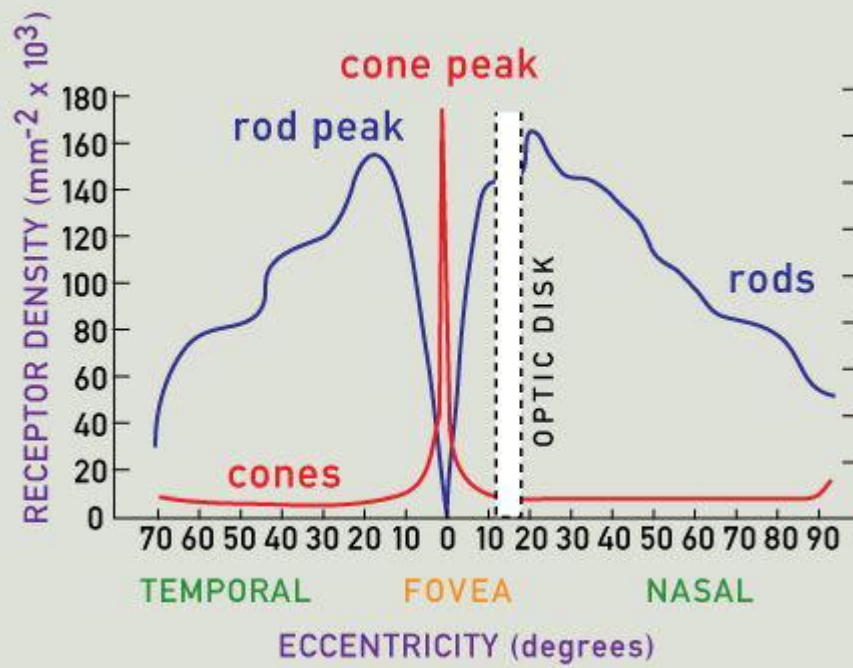


Image Formation by Lenses





Resolution of the Human Eye

Humans can tell visual details at distances larger than 0.3 arc minutes

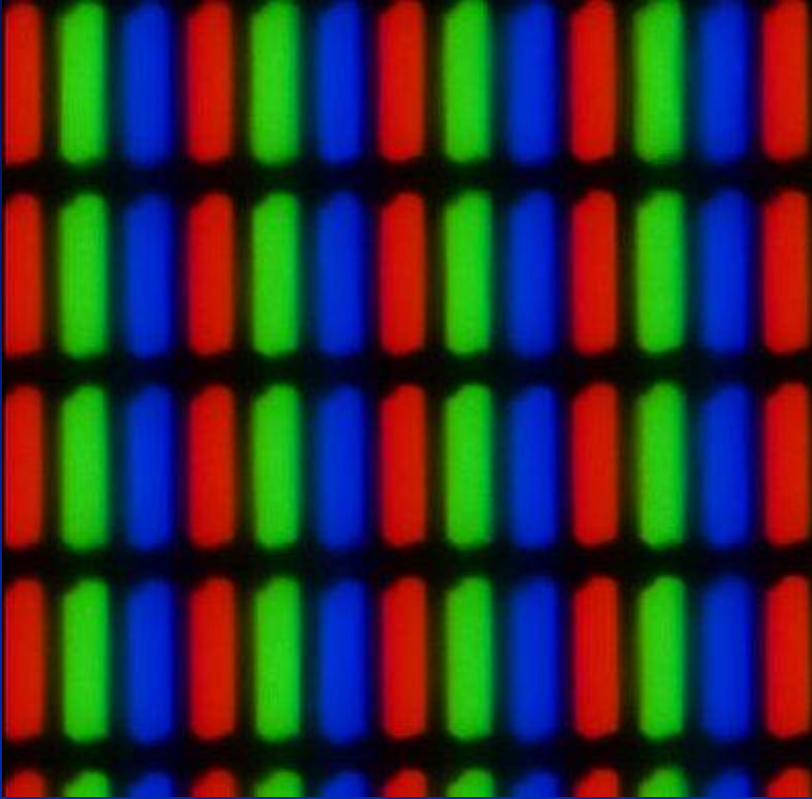
The Field of View (FOV) of the human eye can be generously estimated as
120 by 90 degrees

Resolution of the Human Eye

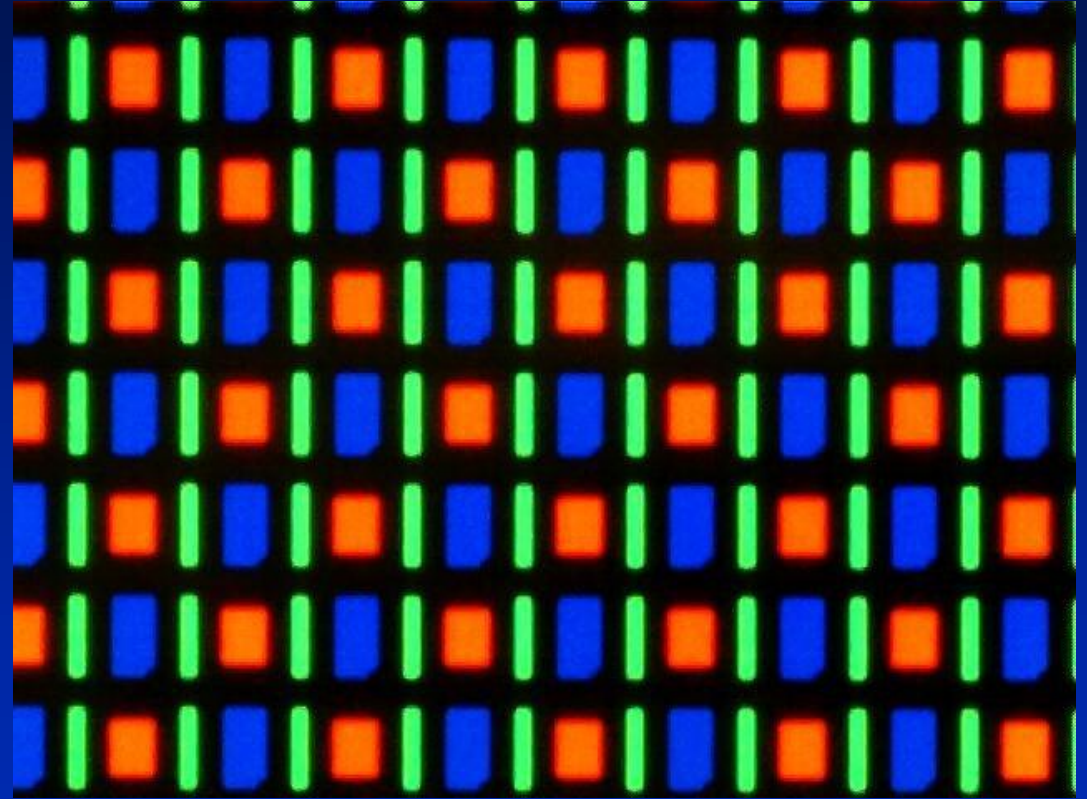
$(120 \text{ degrees} \times 60 \text{ arcminutes} / \text{degree} \times 1 \text{ pixel} / 0.3 \text{ arcminutes}) \times (90 \text{ degrees} \times 60 \text{ arcminutes} / \text{degree} \times 1 \text{ pixel} / 0.3 \text{ arcminutes})$

431,568,000 pixels; 432 MegaPixels. A 1080p display is 2.1 megapixels.

Samsung AMOLED Displays



Standard LCD RGB Display



PenTile Display

Refresh vs. Update Rate

The “refresh rate” is the number of times per second the entire image is drawn. To avoid flicker, the image must be refreshed approximately 50 cycles per second

The “update rate” is the number of times per second the image is changed. To perceive motion, the image must be updated approximately 20-30 frames per second.

Material Accuracy

Cook-Torrance



1979

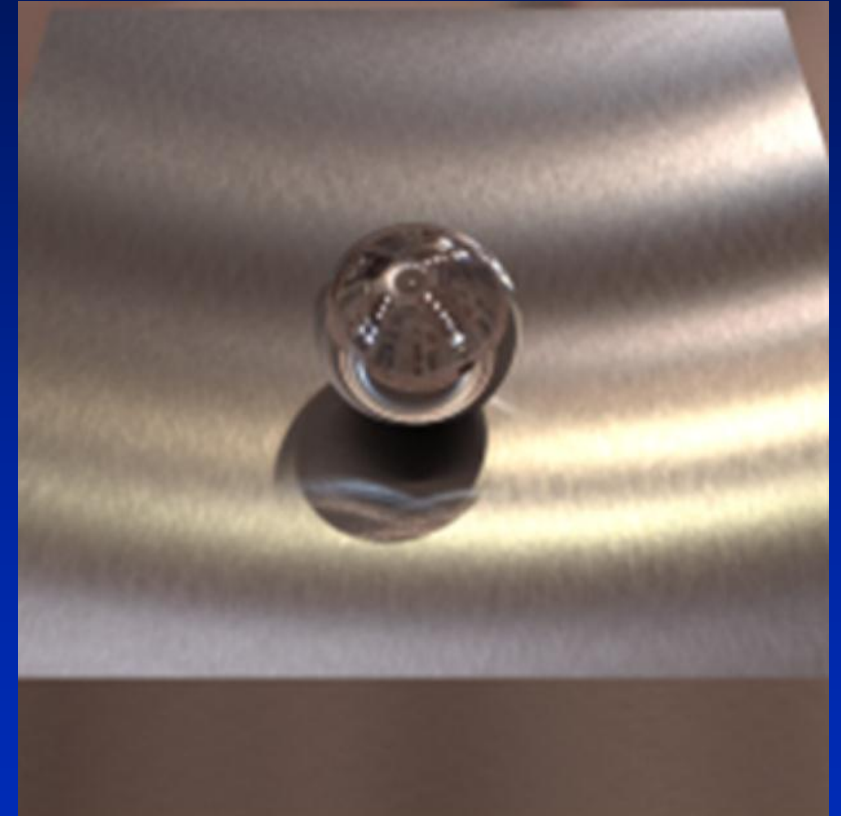
Material Accuracy

Marschner



2012

P. of C. G.



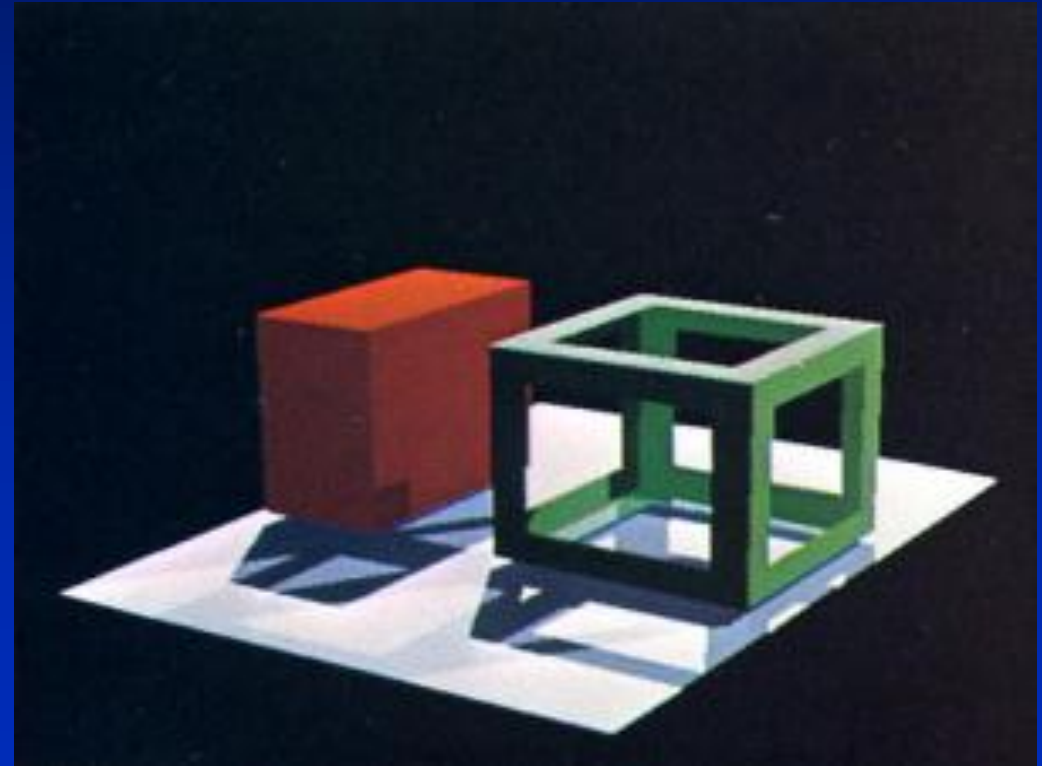
2016

Rendering Accuracy

Direct Illumination



Direct Illumination with shadows



Sufficient Physical and Perceptual Accuracy

Global Illumination



Eames Chair

Pixar's Renderman



Technology Challenges

- Modeling Complexity
- Tracking Accuracy
- Display Resolution
- Material Representation
- Rendering Accuracy
- Rendering Speed
- Limited Latency
- Sufficient Bandwidth

Technology Challenges

Product Design

Seeing your hands and feet

Allowing Eye-to-Eye Contact

SOCIAL ACCEPTANCE

Pixar/Disney History & Negotiations

George Lucas Computer Division

- With the success of Star Wars, he recognized the impact of special effects
- In 1979, set-up a computer division with three goals:
 - A digital video editing system
 - A digital audio system
 - A digital film printer
- The group ultimately became *Industrial Light & Magic*

George Lucas Computer Division

1983 - George Lucas divorce

Drop in revenue stream from Star Wars

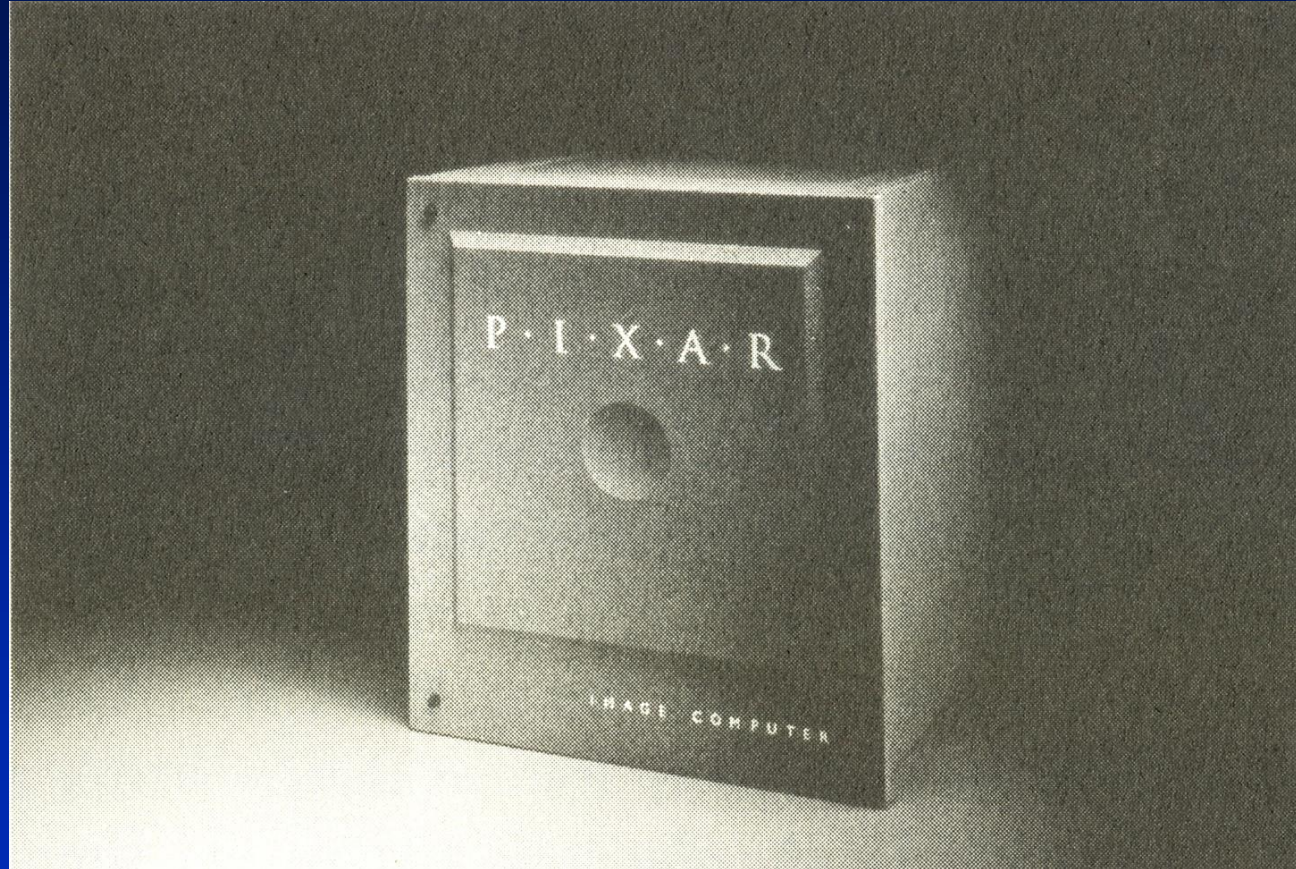
Lucas had to stop cash flow losses

1986 - Steve Jobs paid \$5M to Lucas

Steve Jobs invested \$5M in capital

Basically it was a 7 year research project associated with developing entertainment production tools

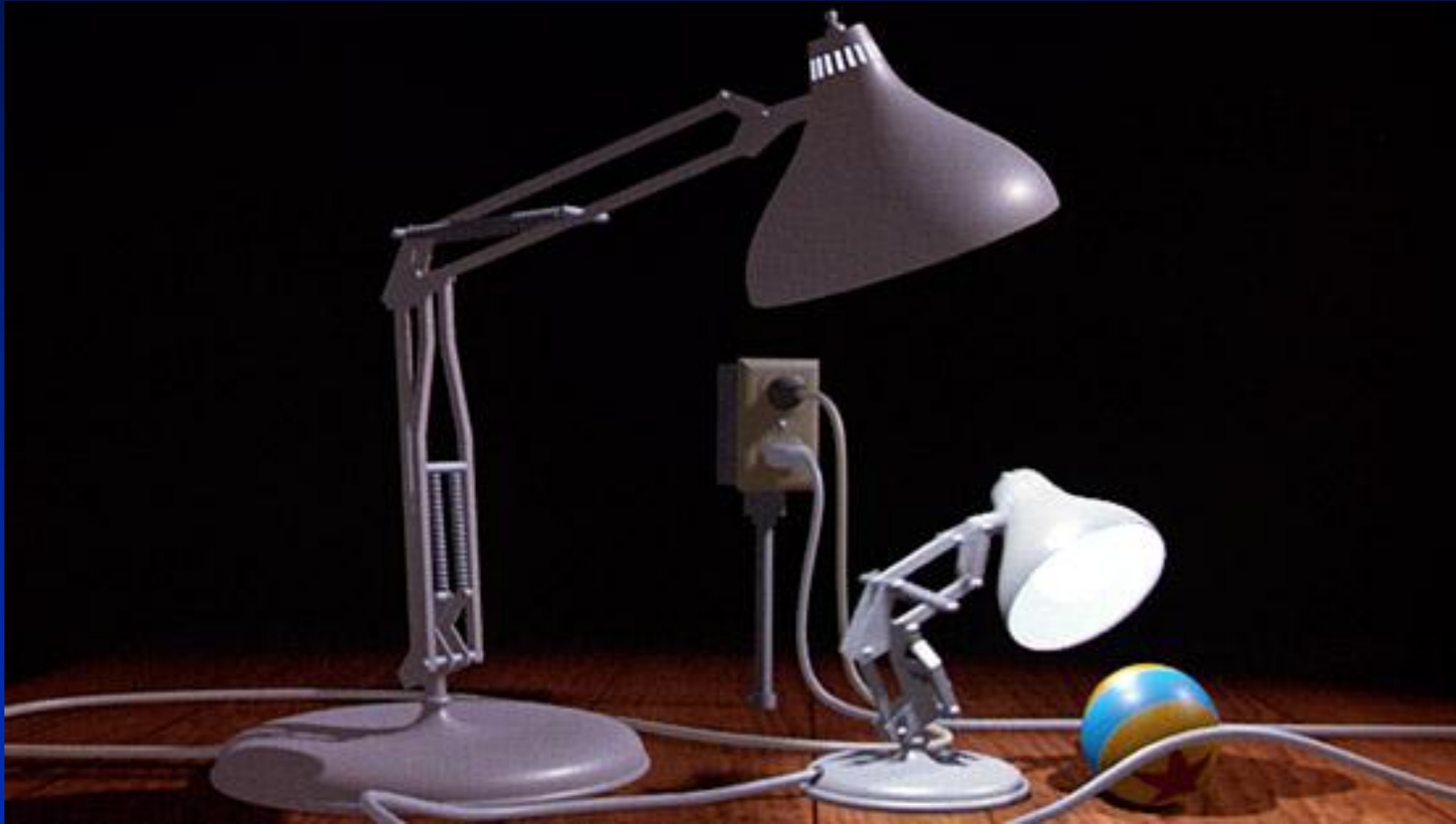
Pixar Image Computer (mid-1986)



Pixar's first production, the ill-fated Pixar Image Computer.

Luxo & Luxo Jr.

1986



Pixar History

1986-1990 Recurring revenue was generated primarily from the licensing of Renderman software, software development contracts, and animated television commercials

1991 Feature Film Agreement with Disney

The development & production of up to three animated feature films to be marketed and distributed by Disney

∴ NEW BUSINESS STRATEGY

Disney/Pixar 1991 Feature Film Agreement

- Pixar was to produce three computer-animated films for Disney through 2000. Toy Story was the first.
- Disney would pay for all film development costs (except when costs exceeded the budget).
- Disney was responsible for all marketing & distribution
- Disney kept 85% of gross revenues from the films and related products. Pixar kept the remaining 15%.

Pixar History

1995

Toy Story released in November

First full length animated feature film.

Pixar goes public on November 29, 1995 just after Toy Story release .

6.9M shares open at \$22 and end at \$39/share.

IPO earns about \$140M for Pixar (greater than Netscape).

1995

First recognition of film revenue

Toy Story - 1995



1996

- Steve Jobs begins pressing Disney CEO Eisner a few months after the successful Toy Story release.
- Pixar now had cash (from IPO) and could co-finance film production.
- Jobs wanted a greater share of profits and Pixar name recognition.
- New co-production agreement signed February 24, 1997.

2005-2006

- Iger visits Hong Kong Disneyland in September 2005 and watches Parade
- Only new characters from the last 10 years came from Pixar
- January 24, 2006, Disney buys Pixar with stock - \$7.4B
- Jobs is biggest shareholder. His 50.1% of Pixar's stock is approximately 7% of Disney

Announcing Pixar's Purchase



Inside Out

2015



Pixar Theater Gross Revenues 9/2015

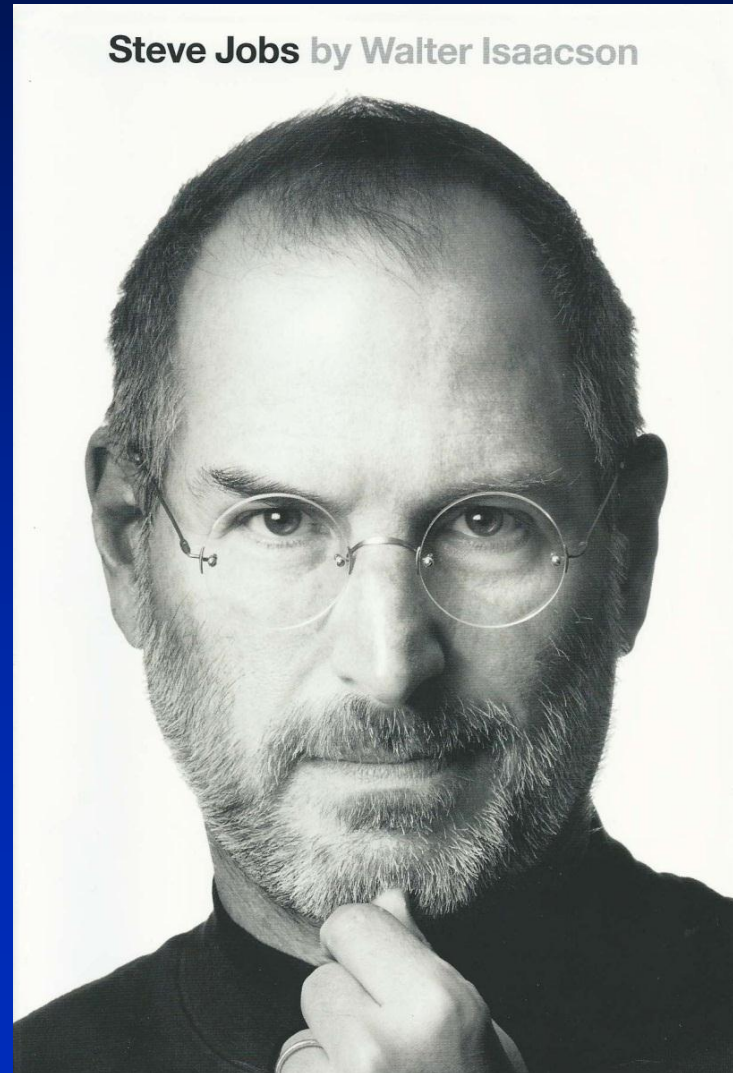
Worldwide (Unadjusted)

Rank	Title (click to view)	Studio	Worldwide	Domestic / %	Overseas / %	Year
1	Toy Story 3	BV	\$1,063.2	\$415.0 39%	\$648.2 61%	2010
2	Finding Nemo	BV	\$895.6	\$339.7 37.9%	\$555.9 62.1%	2003
3	Inside Out	BV	\$774.6	\$353.6 45.6%	\$421.0 54.4%	2015
4	Monsters University	BV	\$743.6	\$268.5 36.1%	\$475.1 63.9%	2013
5	Up	BV	\$731.3	\$293.0 40.1%	\$438.3 59.9%	2009
6	The Incredibles	BV	\$631.4	\$261.4 41.4%	\$370.0 58.6%	2004
7	Ratatouille	BV	\$623.7	\$206.4 33.1%	\$417.3 66.9%	2007
8	Cars 2	BV	\$559.9	\$191.5 34.2%	\$368.4 65.8%	2011
9	Brave	BV	\$539.0	\$237.3 44%	\$301.7 56%	2012
10	Monsters, Inc.	BV	\$528.8	\$255.9 48.4%	\$272.9 51.6%	2001
11	WALL-E	BV	\$521.3	\$223.8 42.9%	\$297.5 57.1%	2008
12	Toy Story 2	BV	\$485.0	\$245.9 50.7%	\$239.2 49.3%	1999
13	Cars	BV	\$462.0	\$244.1 52.8%	\$217.9 47.2%	2006
14	A Bug's Life	BV	\$363.4	\$162.8 44.8%	\$200.6 55.2%	1998
15	Toy Story	BV	\$362.0	\$191.8 53%	\$170.2 47%	1995
TOTAL:			\$9,284.7	\$3,890.6 41.9%	\$5,394.1 58.1%	-
AVERAGE:			\$619.0	\$259.4 41.9%	\$359.6 58.1%	-

Jobs and Wozniak in the garage, 1976



Steve Jobs



Steve Jobs

“Passion for perfection and ferocious drive
revolutionized six industries:

PCs

Phones

Animated Movies

Tablet Computing

Music

Digital Publishing”

Walter Issacson

Steve's Credo

“It’s in Apple’s DNA that technology is not enough. We believe that it’s technology married with the humanities that yields the results that makes our heart sing.”

Summary and Conclusion

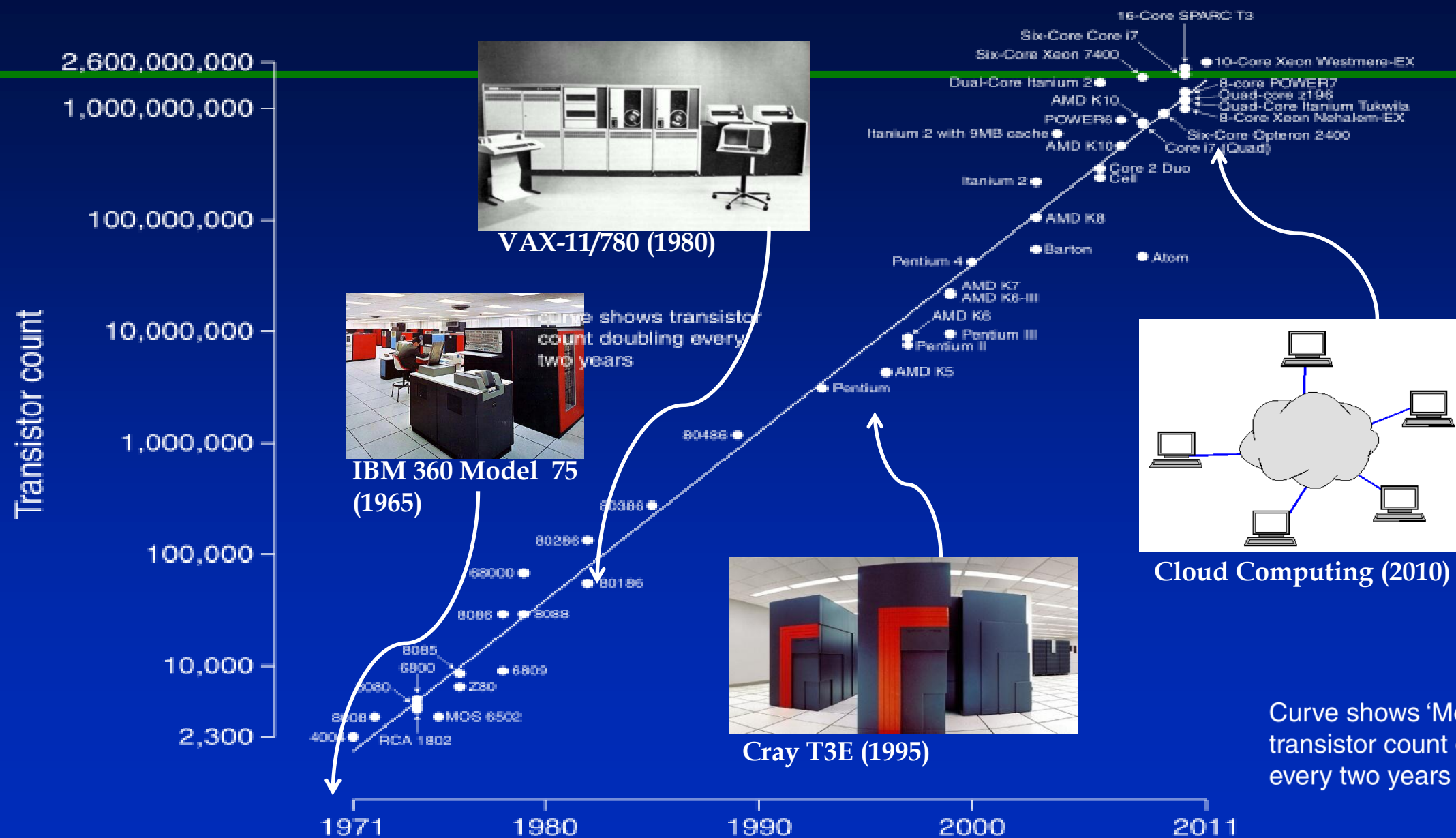
Moore's Law

“Chip density doubles every 18 months.”

Processing Power (P) in 15 years:

$$\begin{aligned} P &= P_{\text{today}} (2)^{\frac{15 \text{ years}}{18 \text{ months}}} = P_t (2)^{\frac{15}{1.5}} \\ &= P_t (2)^{10} = 1000 P_t \end{aligned}$$

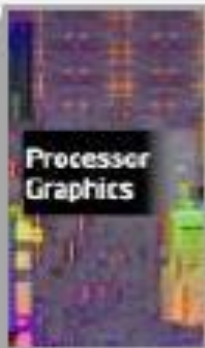
Microprocessor Transistor Counts 1971-2011 & Moore's Law



Intel – Integrated Graphics

2013

“SANDY BRIDGE”



17%
GPU*



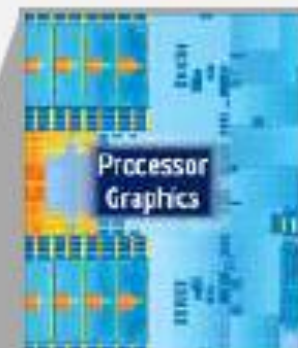
“IVY BRIDGE”



27%
GPU*



“HASWELL”
Estimated



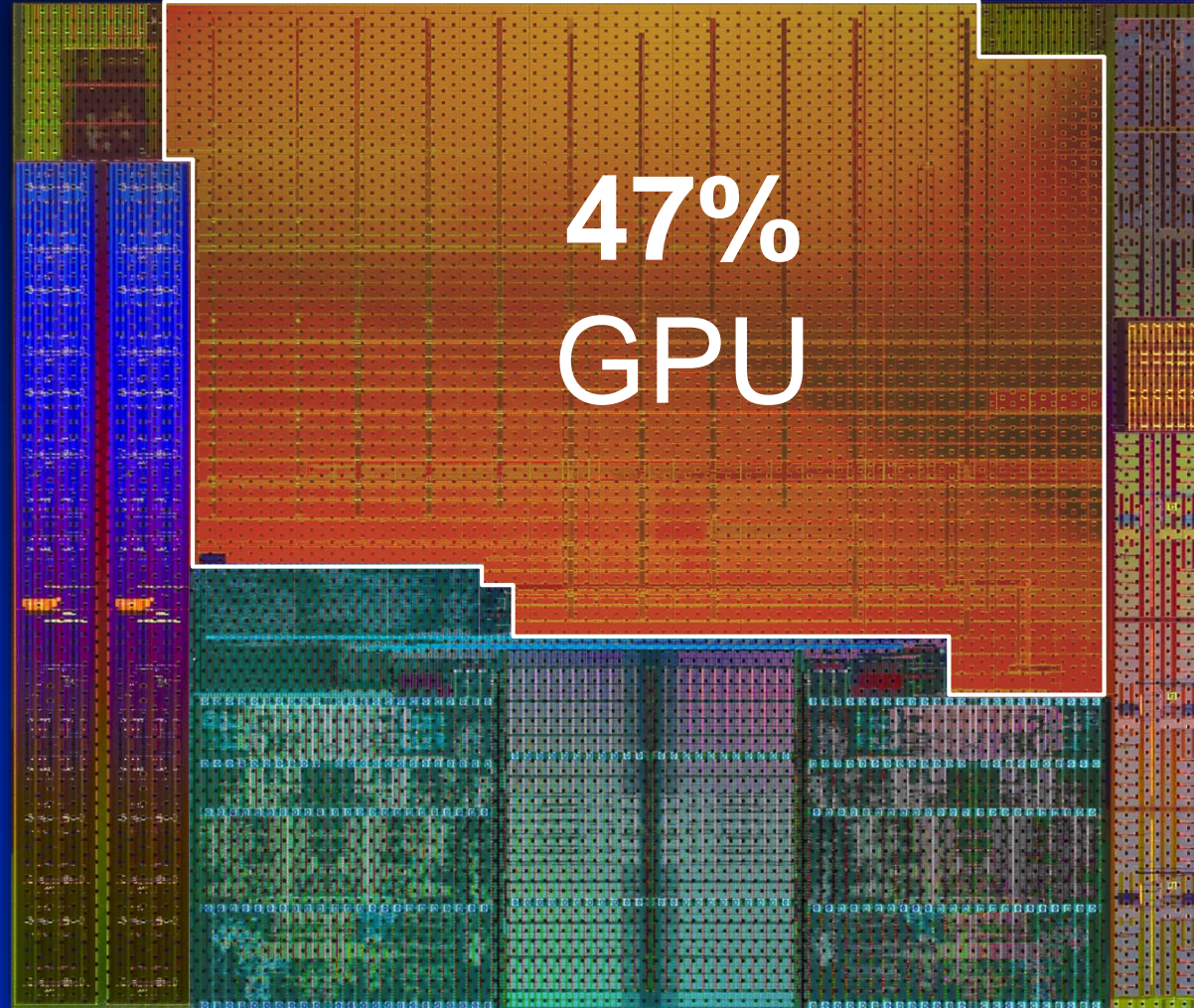
31%
GPU*



AMD – Integrated Graphics

2014

- “Kaveri”
- 28 nm
- 47% GPU



Samsung Galaxy S6

2016

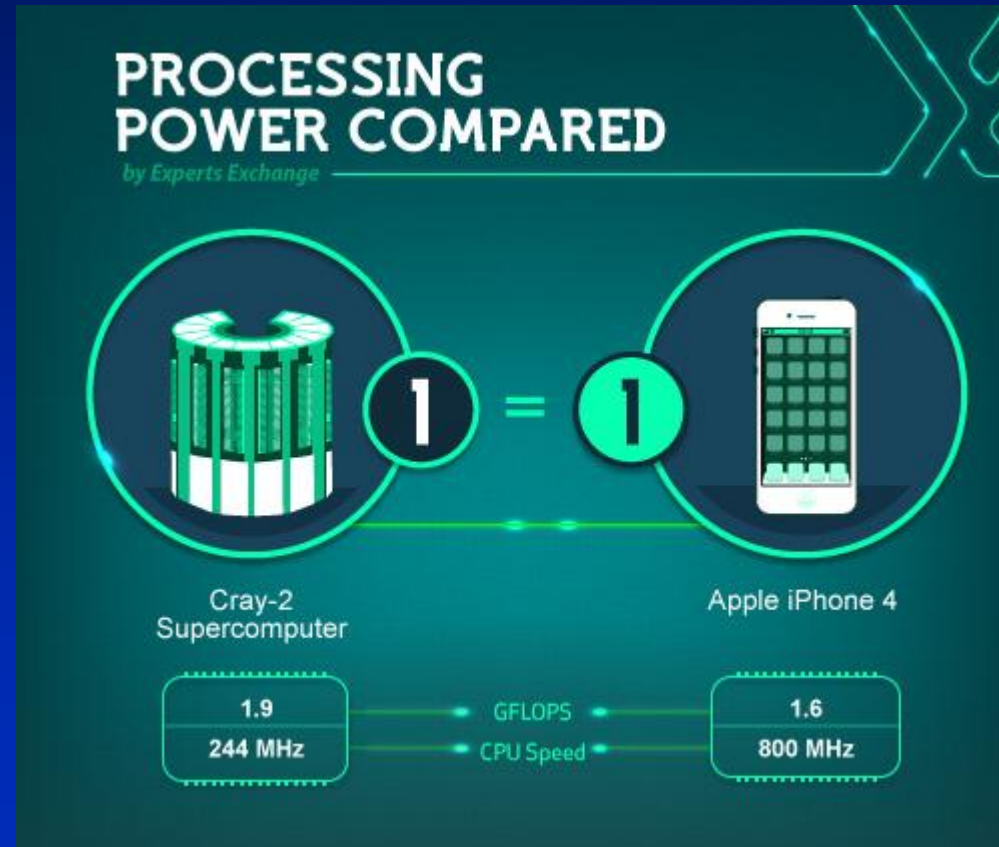
- Screen Size: 5.1 inch screen
- Screen Resolution: 1440 x 2560 pixels (~577 ppi)
- Battery Life: 23 hour talk time
- Feature: 4G LTE
- Operating System: Android
- Camera Resolution: 16 MP
- Weight: 4.9 ounce
- Memory: 32 GB
- 64-bit Exynos 7420 Processor
- 8 core processor, Cortex-A53/Cortex-A57, Exynos 7420 processor
- 14 nm FinFET technology



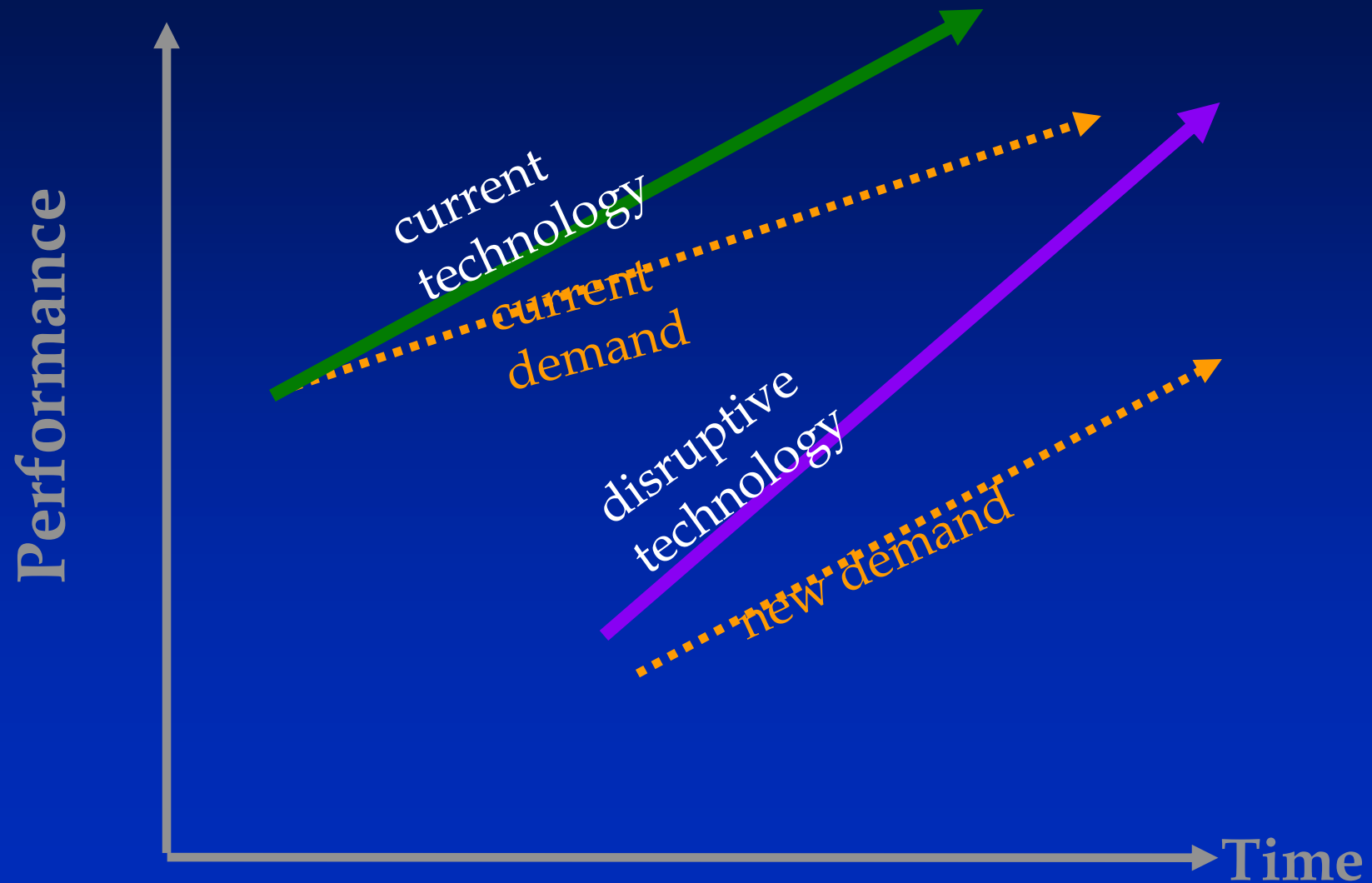
Processing Power Compared

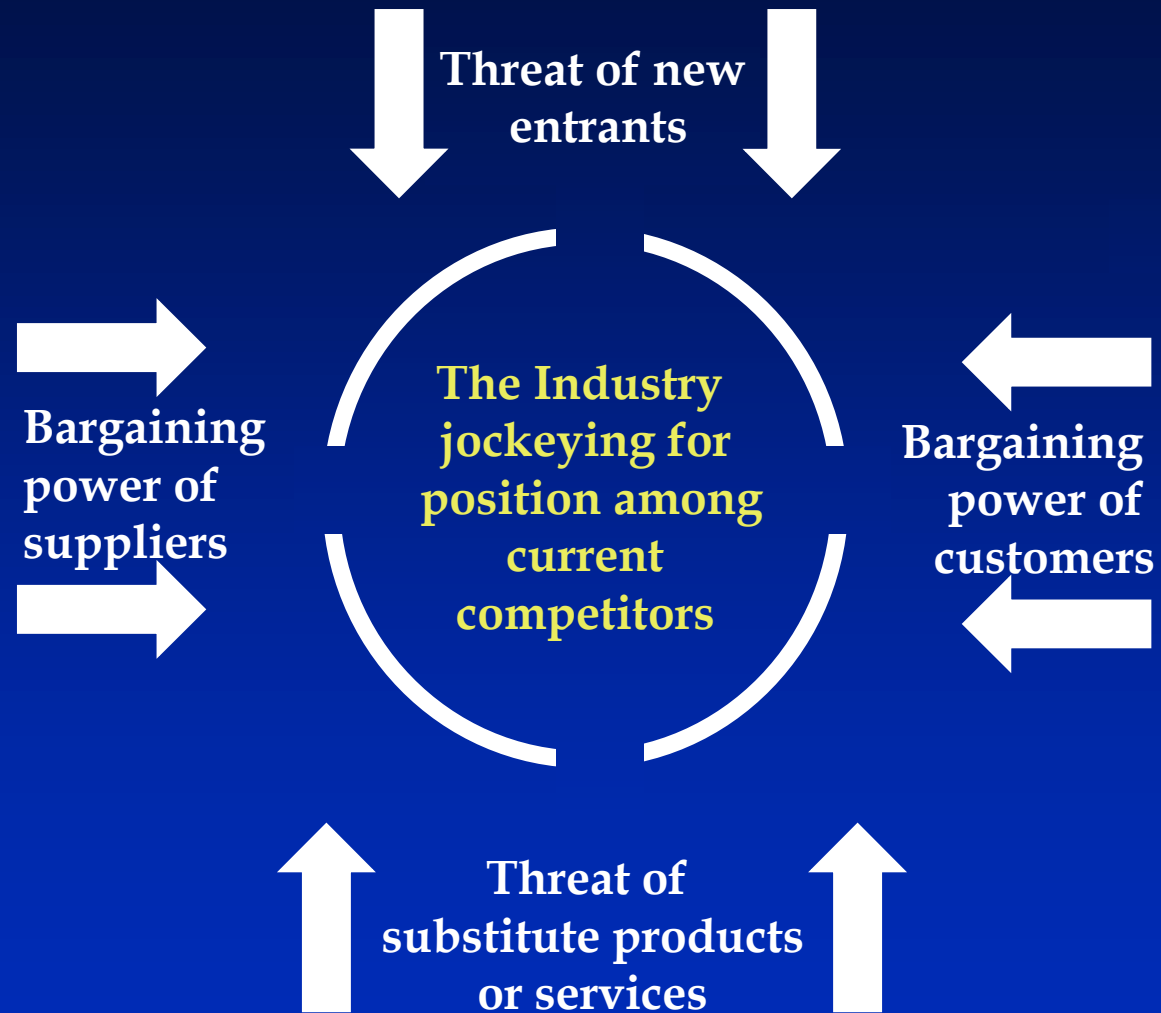
- 2015: iPhone 5 > 1985 Cray-2

(2.7x)



Typical Disruptive Technology





Samsung 110-inch 4K UHD TV 2014



LG press-on 'wallpaper' TV

2015

Less than
1 mm thick



Motorola: Spotlight Stories



Lytro Camera



Sensors on Google's ADV

VIDEO CAMERA

Mounted near the rear-view mirror, the camera detects traffic lights and any moving objects.

LIDAR

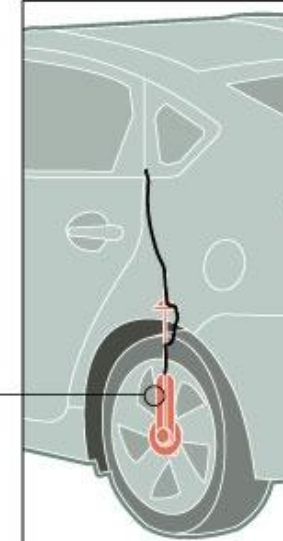
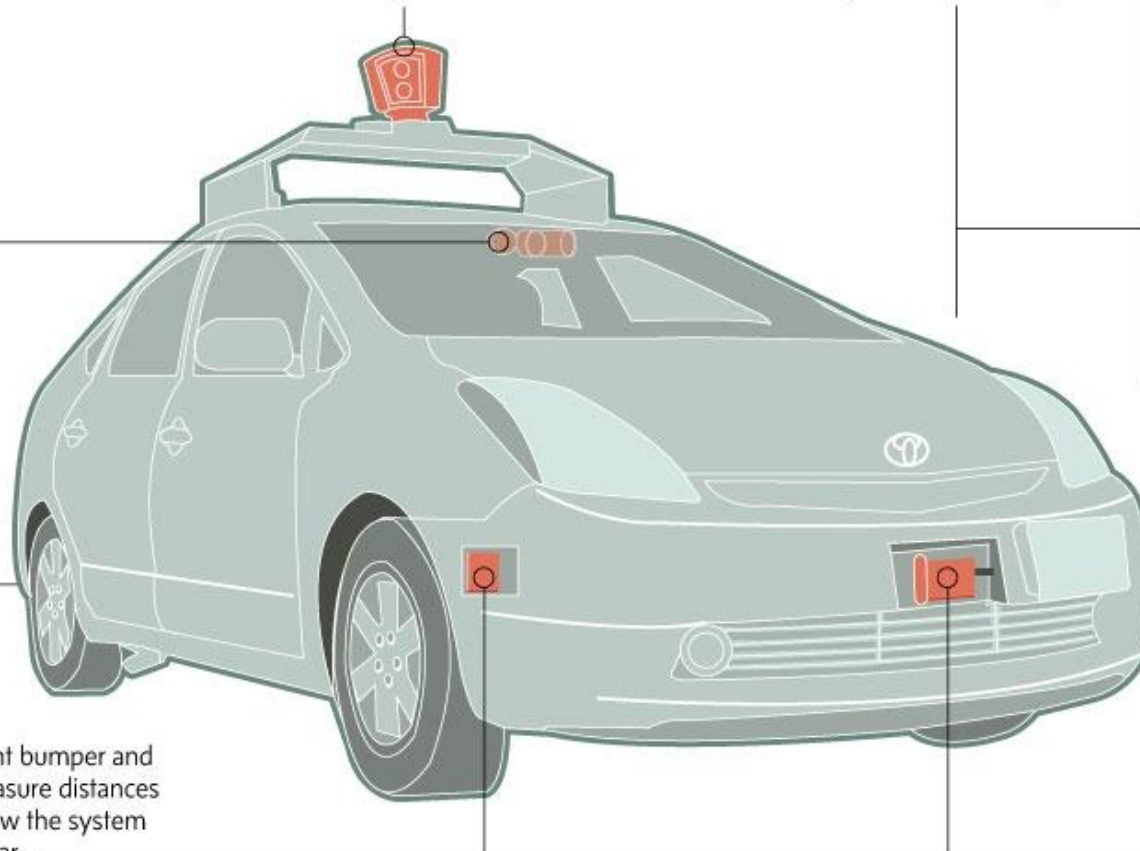
A rotating sensor on the roof scans the area in a radius of 60 metres for creation of a dynamic, three-dimensional map of the environment.

POSITION ESTIMATOR

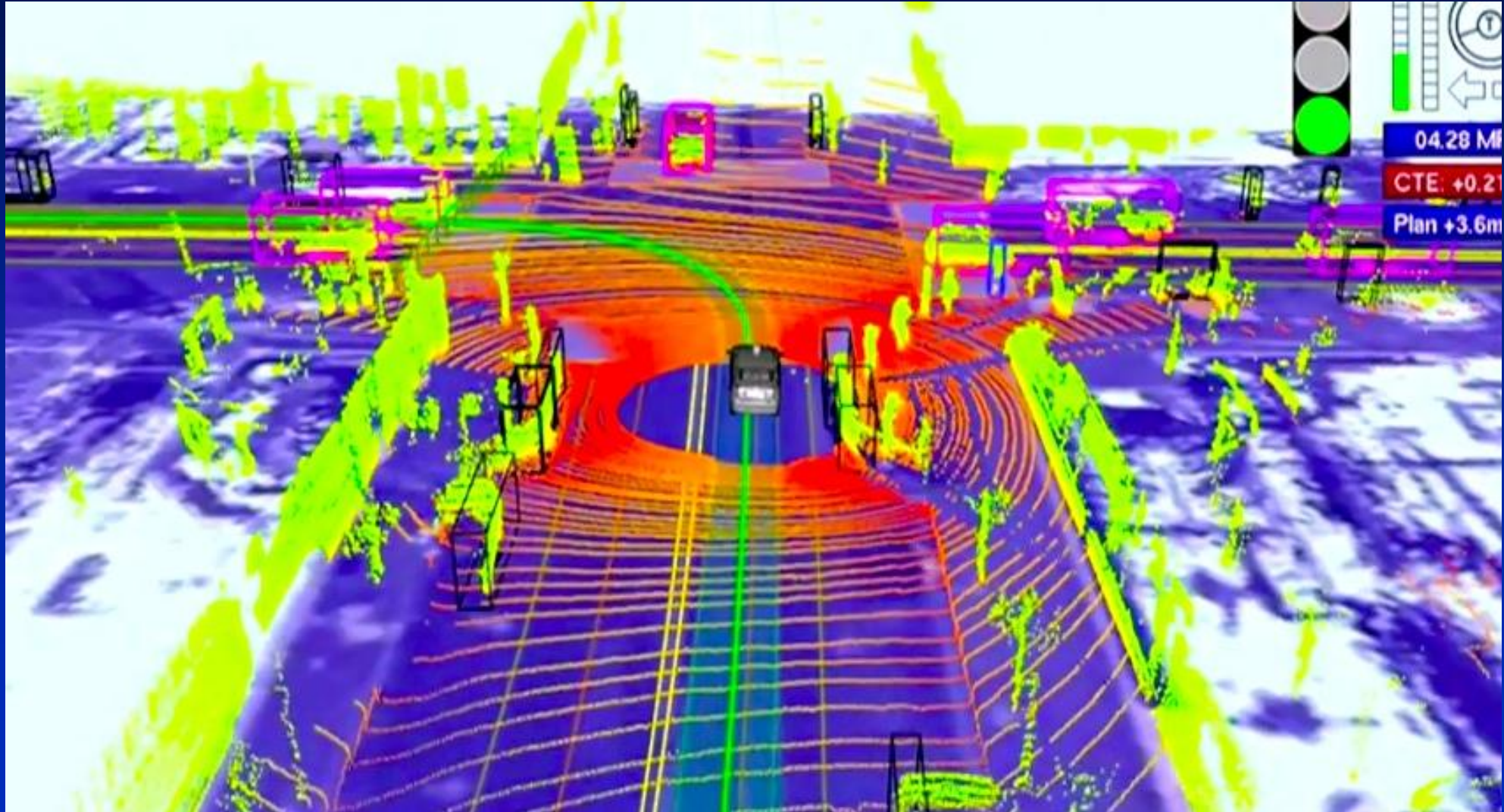
A sensor mounted on the left rear wheel measures lateral movements and determines the car's position on the map.

DISTANCE SENSORS

Four radars, three in the front bumper and one in the rear bumper, measure distances to various obstacles and allow the system to reduce the speed of the car.



Sensors on Google's ADV



Magic Leap



Microsoft's Hololens



Potential Dangers

Privacy and Security: Challenges of the new Internet Regulations

- Freedom of Speech vs. Security vs. Privacy?
- Maintenance of net neutrality and a free Internet?

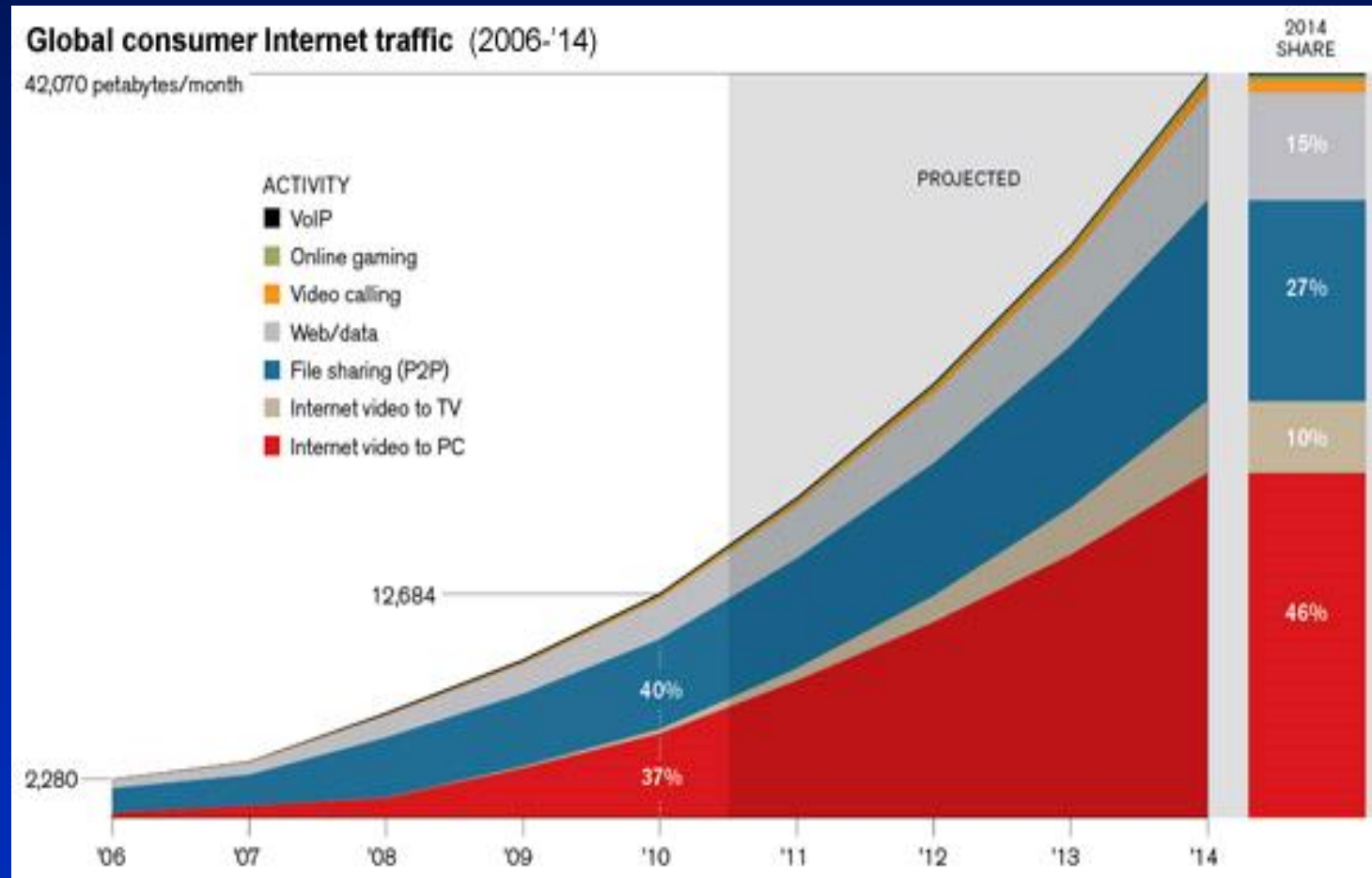
The First Amendment

“Congress shall make no law respecting an establishment of religion, or prohibiting the free exercise thereof; or abridging the freedom of speech, or of the press, or the right of the people peaceably to assemble, and to petition the Government for a redress of grievances.”

The Fourth Amendment

“The right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures, shall not be violated, and no warrants shall issue, but upon probable cause, supported by oath or affirmation, and particularly describing the place to be searched, and the persons or things to be seized.

Global Consumer Internet Traffic



END...
