Bayesian Data Analysis

PHY / CSI / INF 451 / 551

Fall 2020

Prof. Kevin H. Knuth

NASA Ames Research Center 2001 – 2005
UAlbany 2005 - present

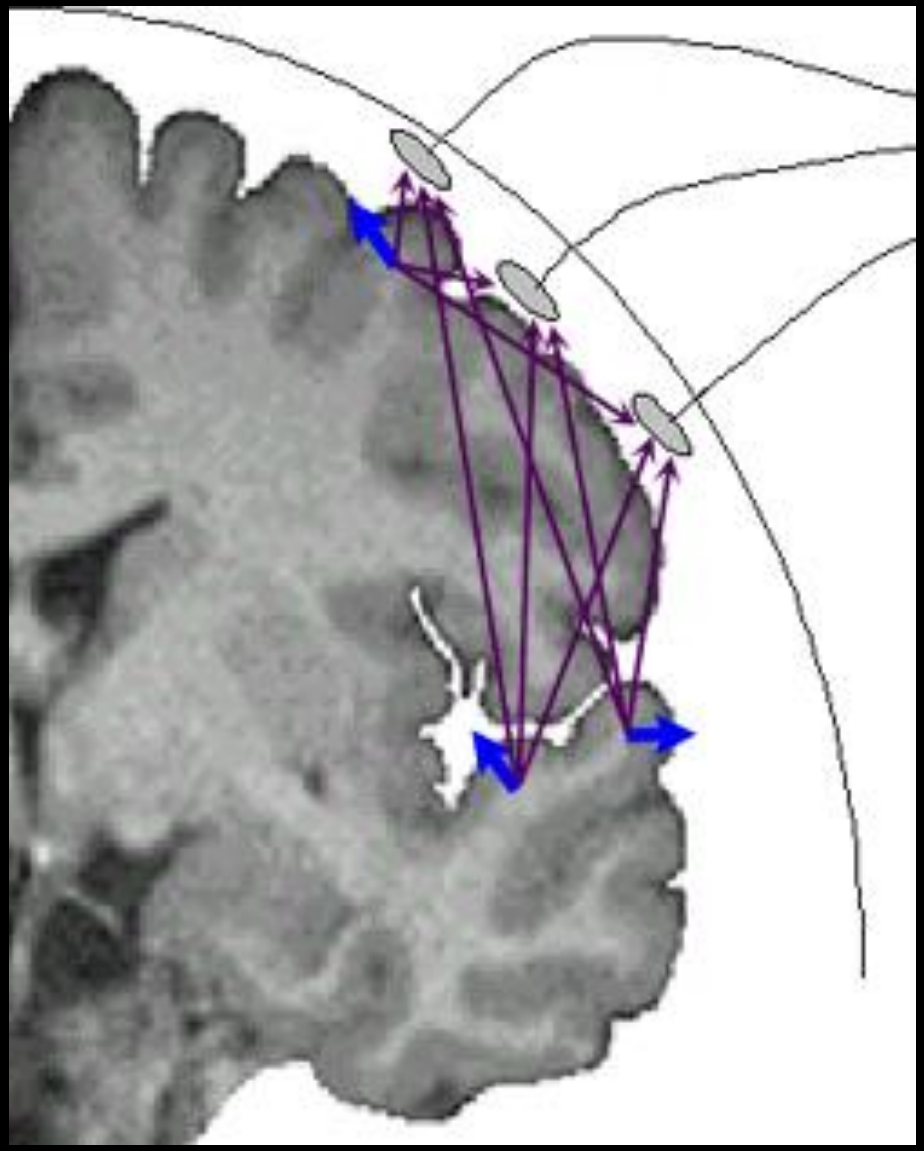
Monthly adventure-role playing aid

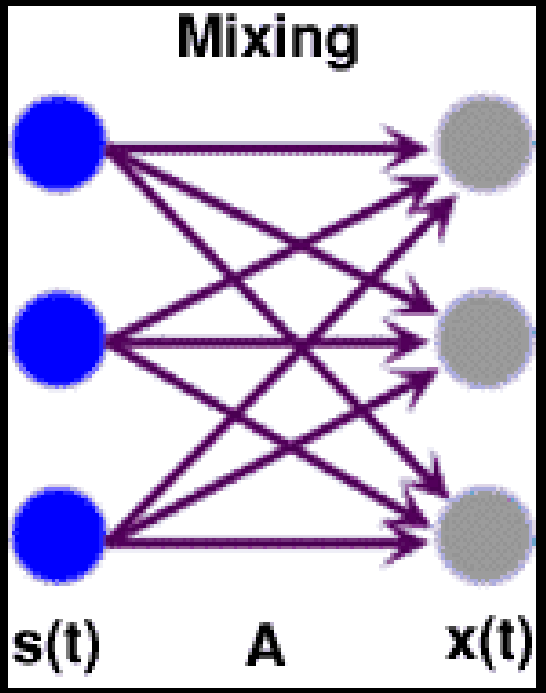
Dragon™

$3.00 #55

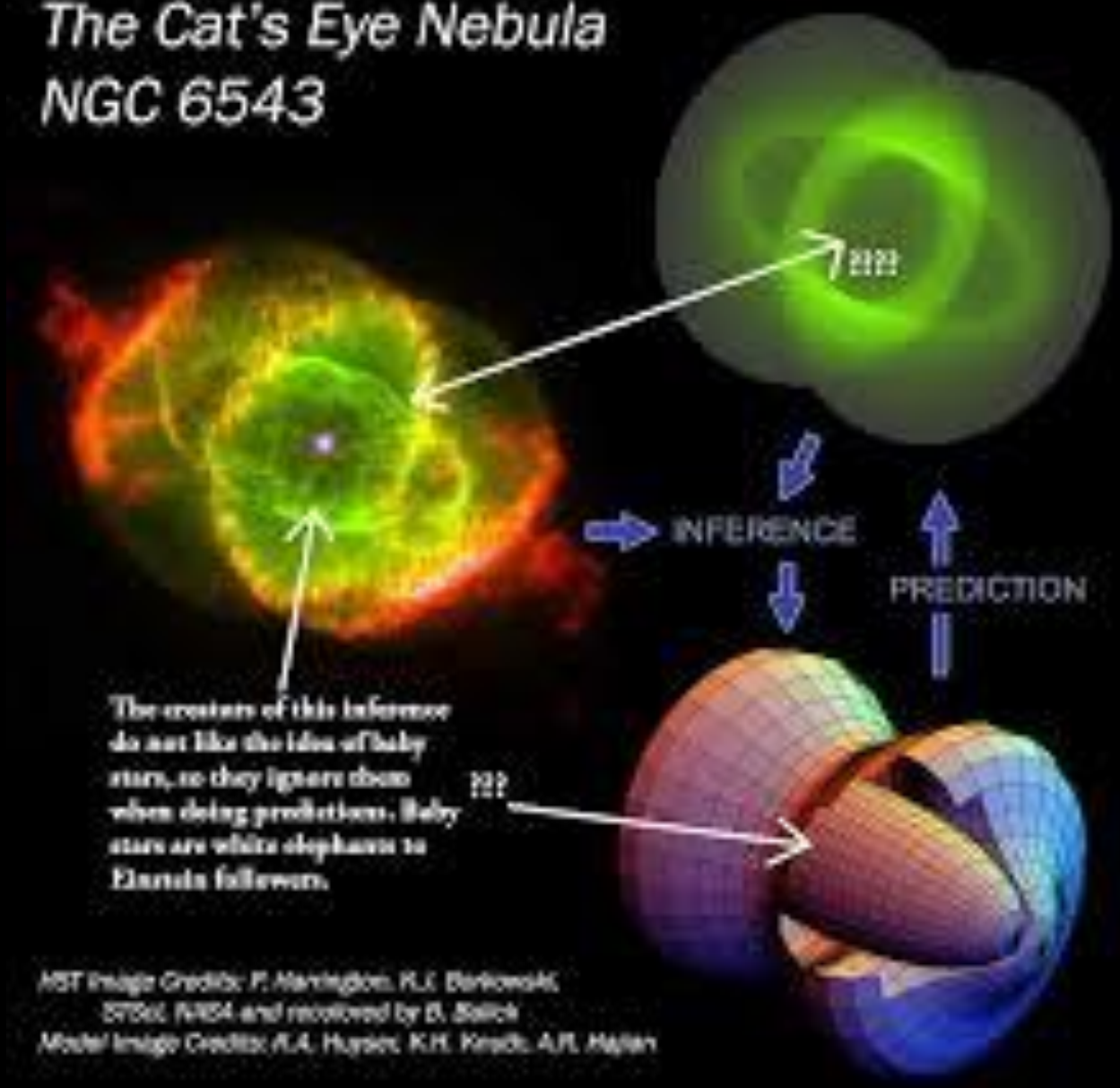
- A new D&D® adventure
- Fiction by Gardner Fox
- Dinosaurs revisited

Bayesian Separation of EEG Signals

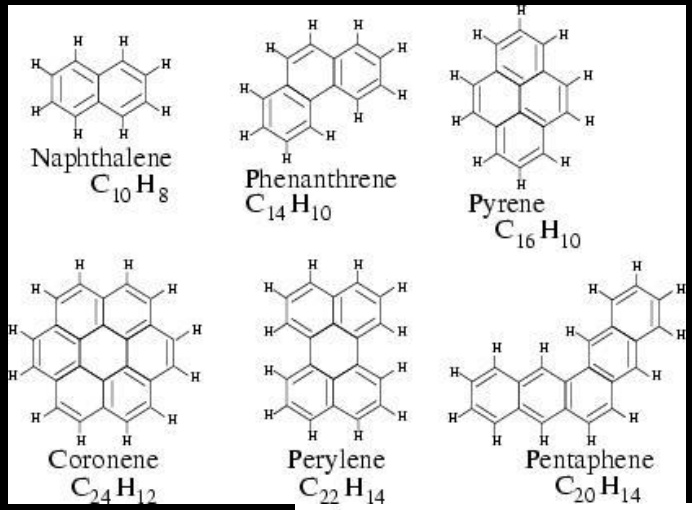


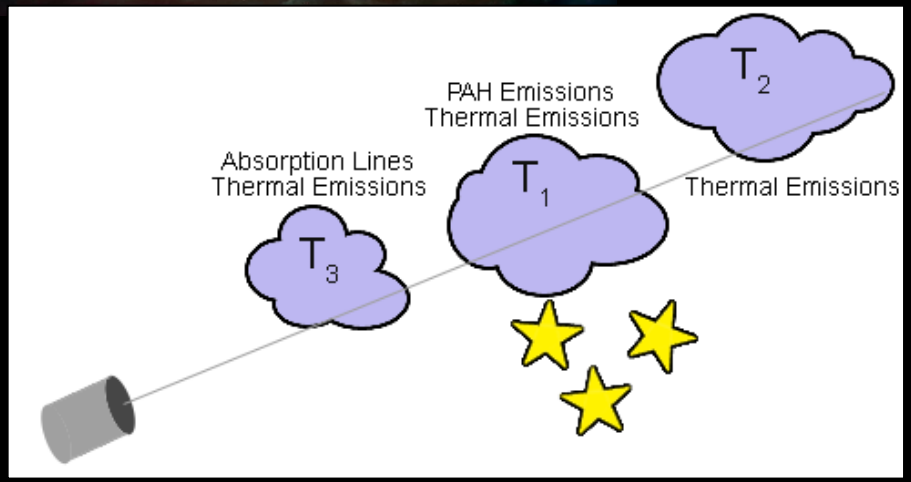


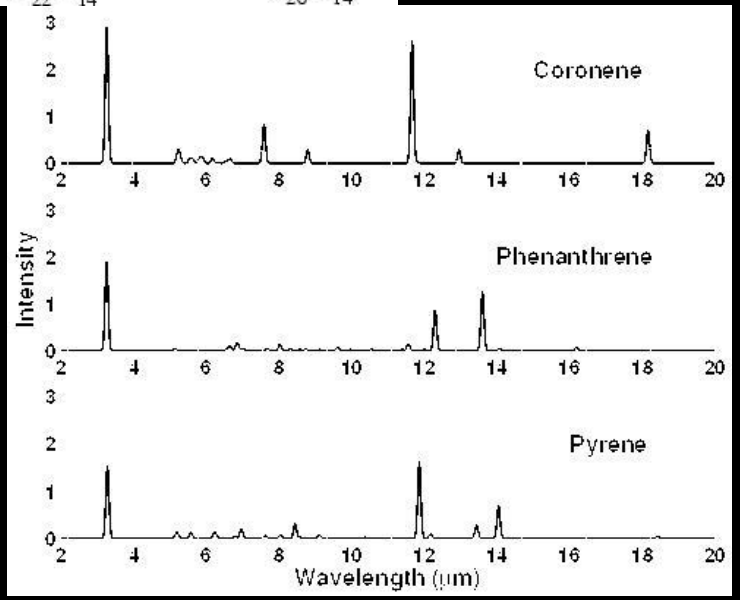
Planetary Nebula Modeling



Interstellar Organic Molecules







Bayesian Vision-Based Navigation

Calibrate Accelerometer and Gyro signals

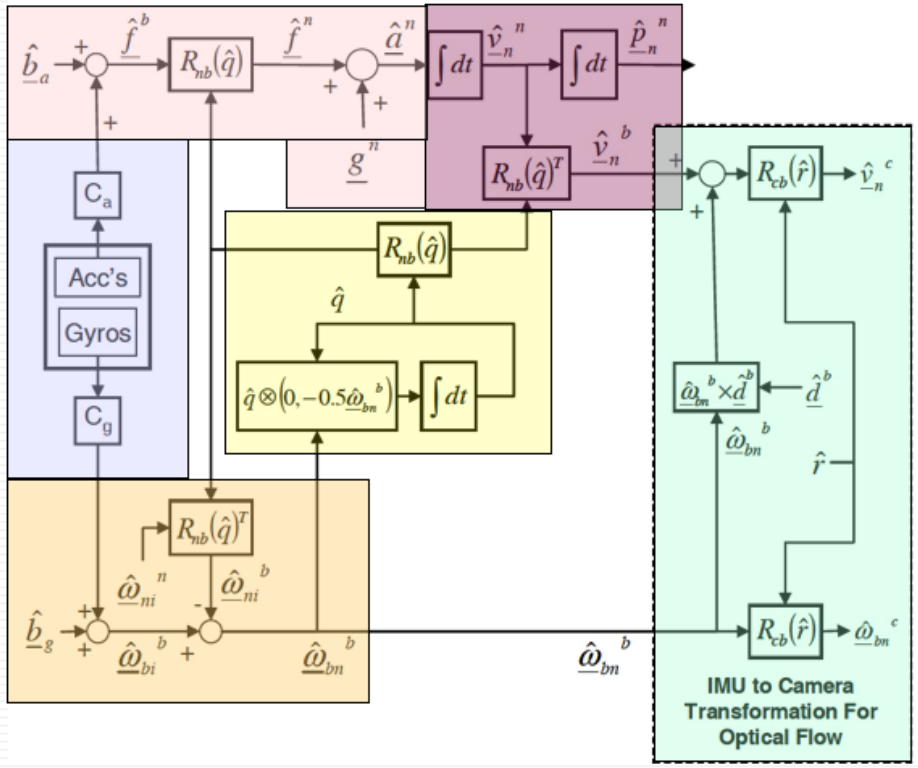
F = ma with flat earth

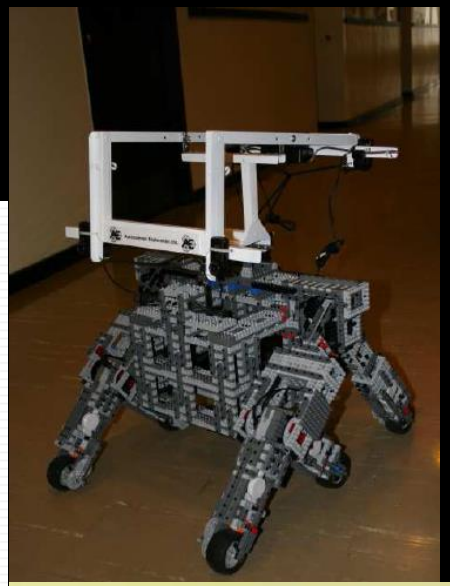
Obtain angular velocities

Quaternion orientation update

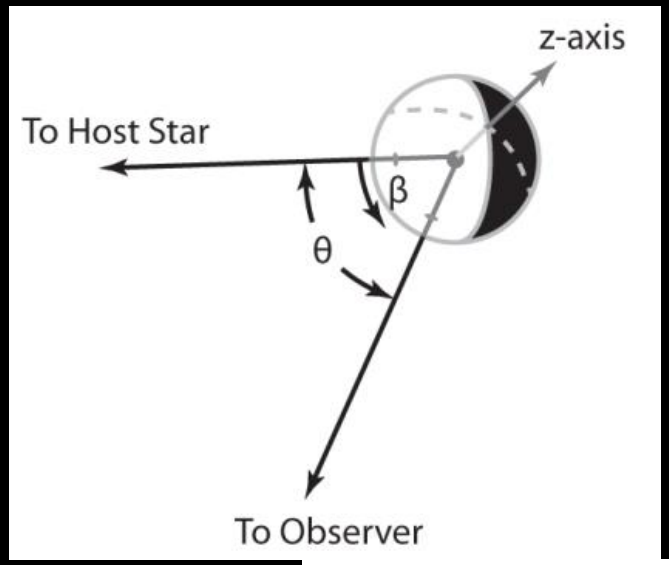
Integrate to get velocity & position

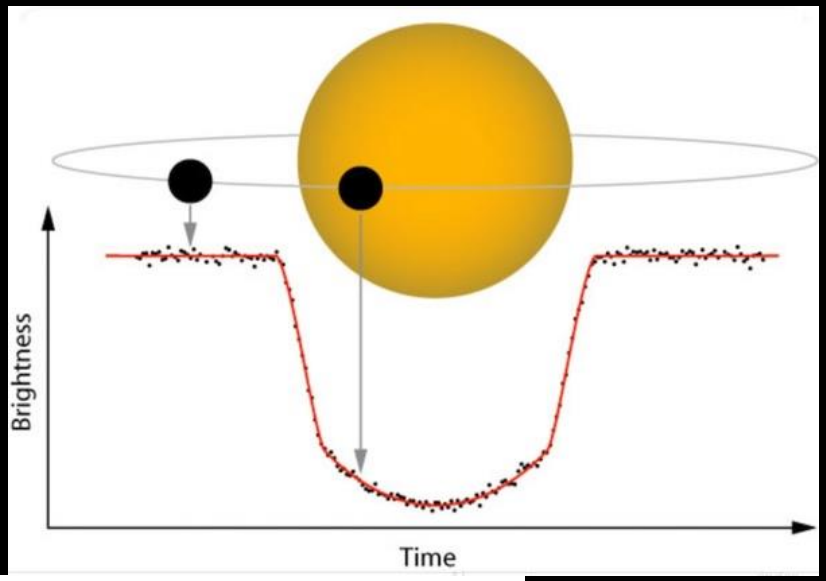
Resolve into camera frame

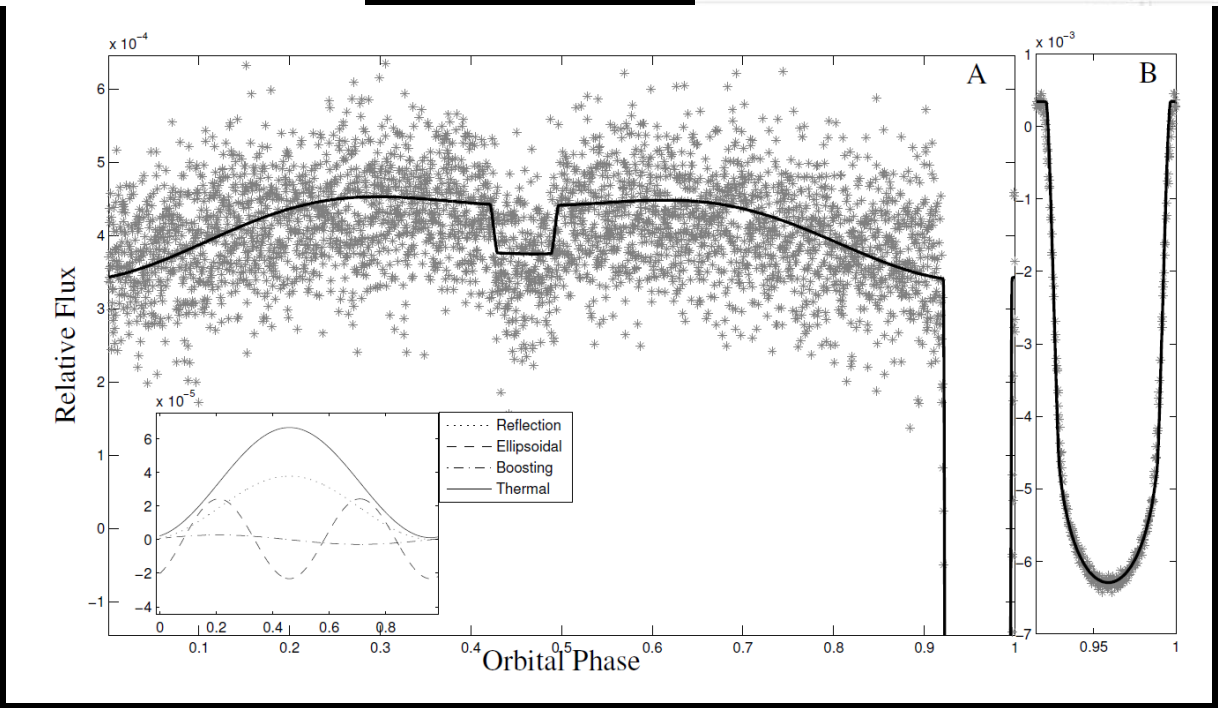


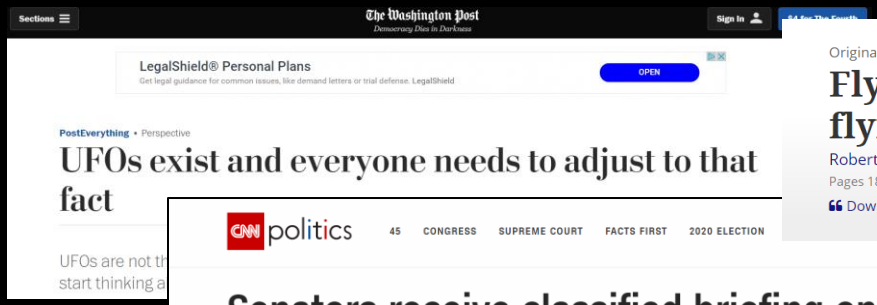


Exoplanet Detection and Characterization





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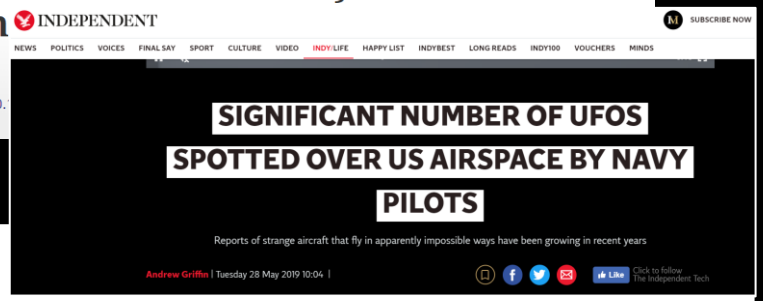
By Veronica Stracqualursi and Zachary Cohen, CNN
Updated 2014 GMT (0414 HKT) June 20, 2019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Reports of strange aircraft that fly in apparently impossible ways have been growing in recent years
Andrew Griffin | Tuesday 28 May 2019 10:04 |
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U.S. MILITARY
US Navy introducing guidelines report UFO sightings
By Barbara Starr, CNN Pentagon Correspondent
Updated 1834 GMT (0234 HKT) April 24, 2019


US
Pentagon Confirms It Does In Fact Investigate Reports Of UFOs


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Recent UFO Encounters With Navy Pilots Occurred Constantly Across Multiple Squadrons
exclusive details about the incidents off the east coast in 2014 and 2015, including that the


UFOS · Published May 27
Multiple pilots have reported encounters with UFOs, Navy says


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Frustrated pilots got Navy to stop dismissing UFO sightings
by Deanna Paul, Washington Post, Updated: April 24, 2019

Gimbal USAF Footage

Go Fast USAF Footage

2004 Nimitz USAF Footage

“I have no idea what I saw.

It had no plumes, wings or rotors and outran our F-18s.

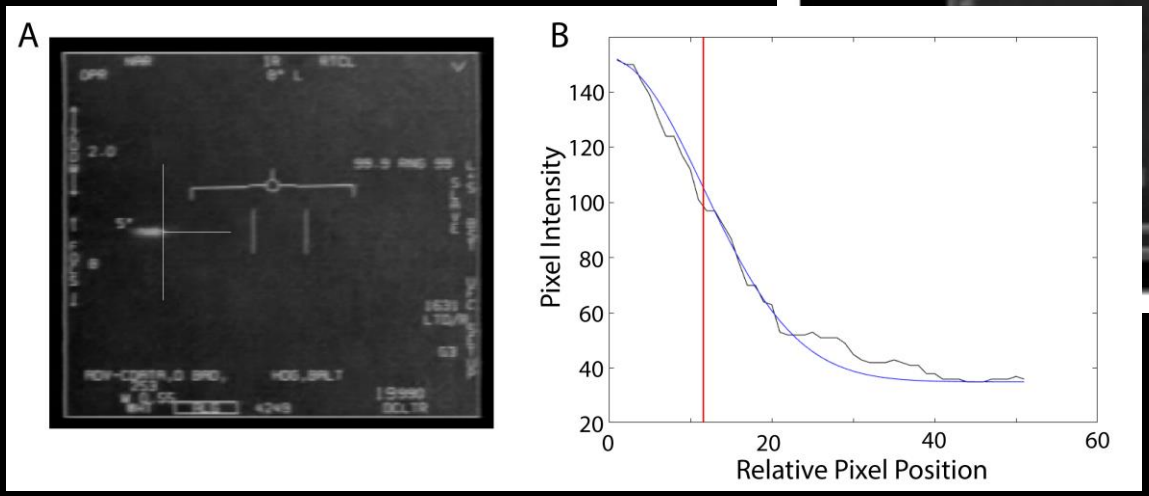
But I want to fly one.”

— *Cdr. David Fravor*

Nimitz Encounter (USS Princeton/Nimitz 2004)
Nov 2004
off Southern California USA

Tracking the Object

A Gaussian is fit to the right-edge intensity profile.



Nimitz Encounter (USS Princeton/Nimitz 2004)
Nov 2004
off Southern California USA

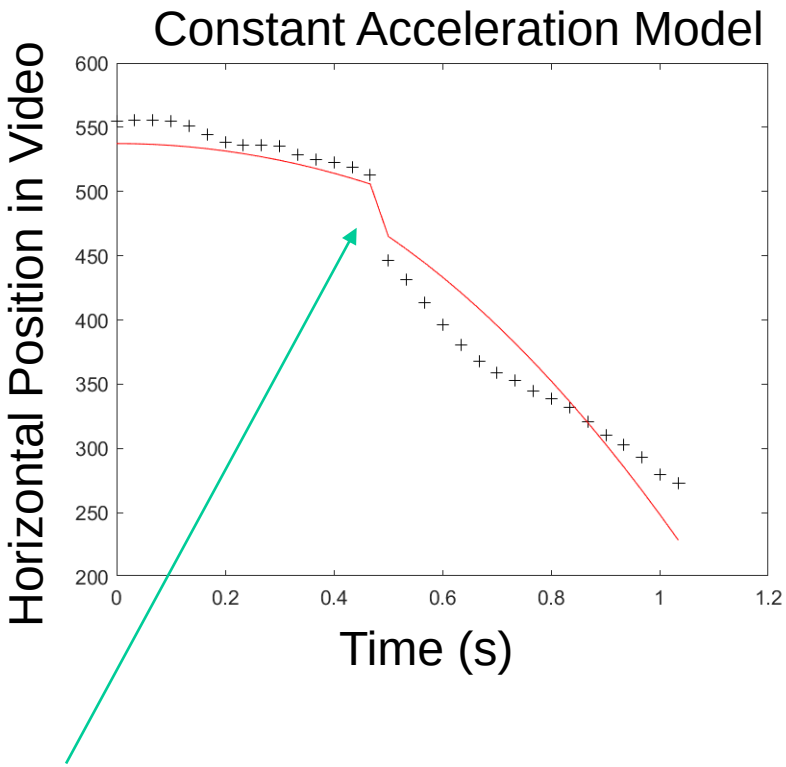
Constant Acceleration Model

$$x = \frac{1}{2}\, a_x\, t^2 + \, x_o$$

Nested Sampling

$a_x = -33.7\ g \pm \ \ 0.85\ g$

$\log Z = -245000$



The targeting computer changes its magnification

Nimitz Encounter (USS Princeton/Nimitz 2004)
Nov 2004
off Southern California USA

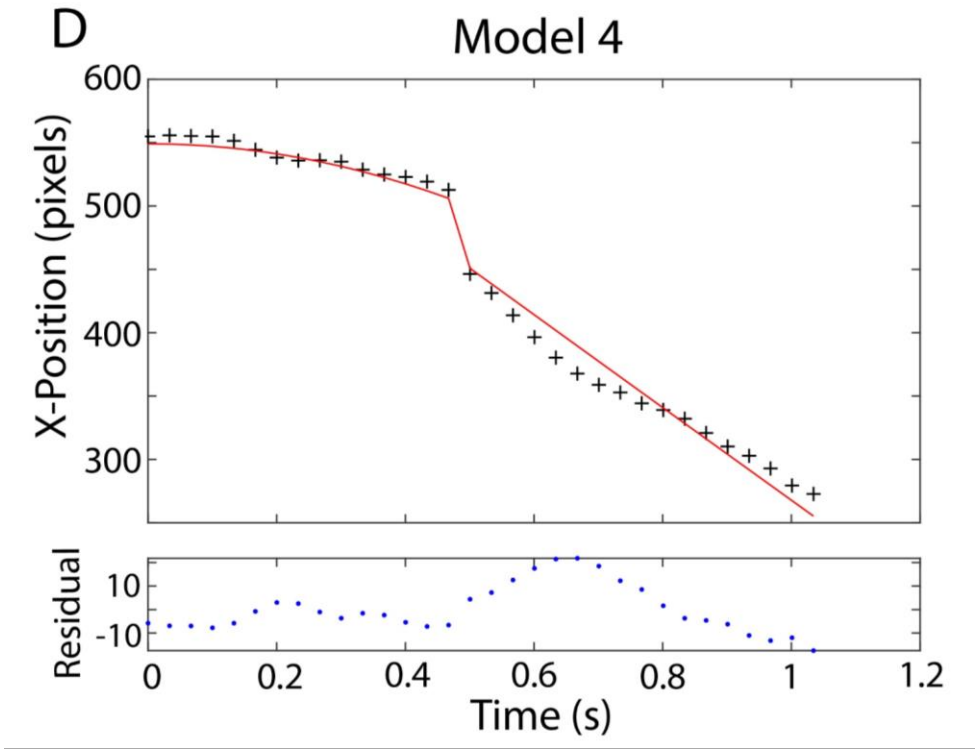
Constant Acceleration + Constant Speed Model

The UAV accelerates to the left and away from the F-18.

Nested Sampling

$a_x = -79.5\ g \pm\ \ 0.2\ g$

$\log Z = -52084$

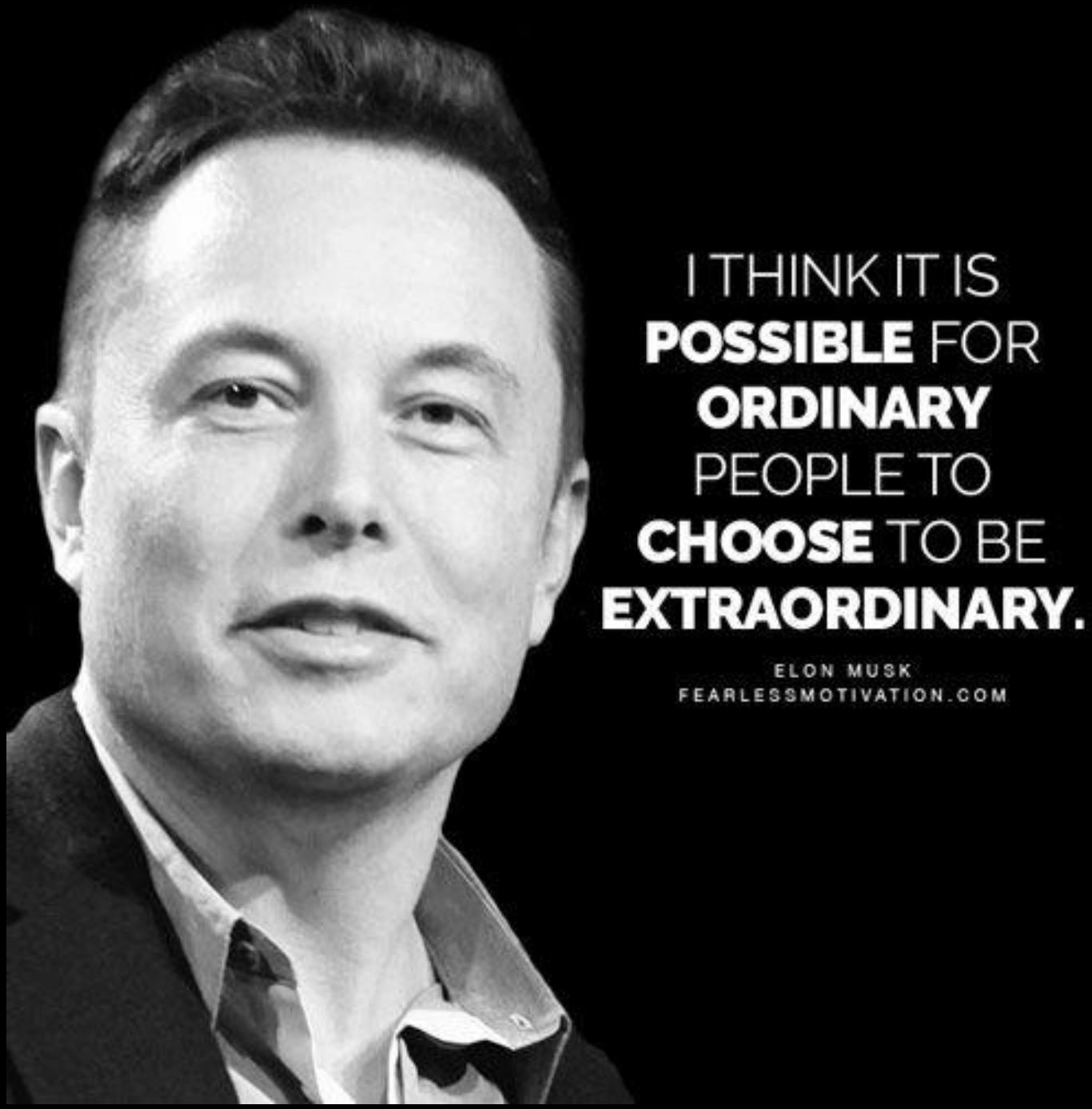


We estimate accelerations ranging from $68\ g$ to $\sim 5300\ g$

An acceleration of $25g$ would kill most living things!
The F-35 fighter jet cannot withstand more than about $13.5\ g$
The Crotale NG VT1 Missile can withstand 50 g
and maintain maneuverability up to 35 g

These are indeed “impossible” accelerations.

Encounter	Dimensions	Acceleration
Bethune (1951) over Atlantic Ocean off Nova Scotia		
Bethune (1951)	300 ft	$\sim 1700\ g$
JAL 1648 (1986) over Alaska (40 min encounter!)		
JAL 1648 Linear Motion	1000 ft	$68 \pm 7\ g$
JAL 1648 Circular Motion	1000 ft	$84 \pm 8\ g$
Nimitz Carrier Strike Group (2004) off Southern CA		
Day (2004)		$\sim 5300\ g$
Fravor (2004)	40 – 50 ft	$\sim 150\ g$
Nimitz FLIR (2004)	40 – 50 ft	$79.5 \pm 0.2\ g$

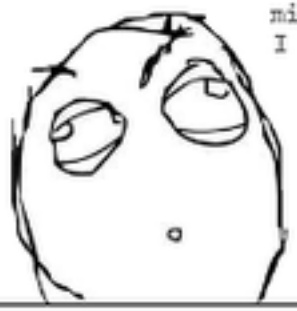

I THINK IT IS
POSSIBLE FOR
ORDINARY
PEOPLE TO
CHOOSE TO BE
EXTRAORDINARY.
ELON MUSK
FEARLESSMOTIVATION.COM

Doing math homework when you don't know exactly how to do a problem:

Elementary

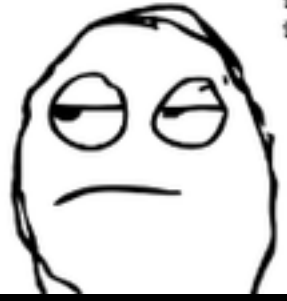
Don't know how to do this, but I think I can figure it out...

Algebra



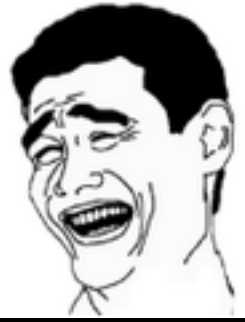
hmm....this is hard...I might be able to do it if I ask a friend for help

Trigonometry



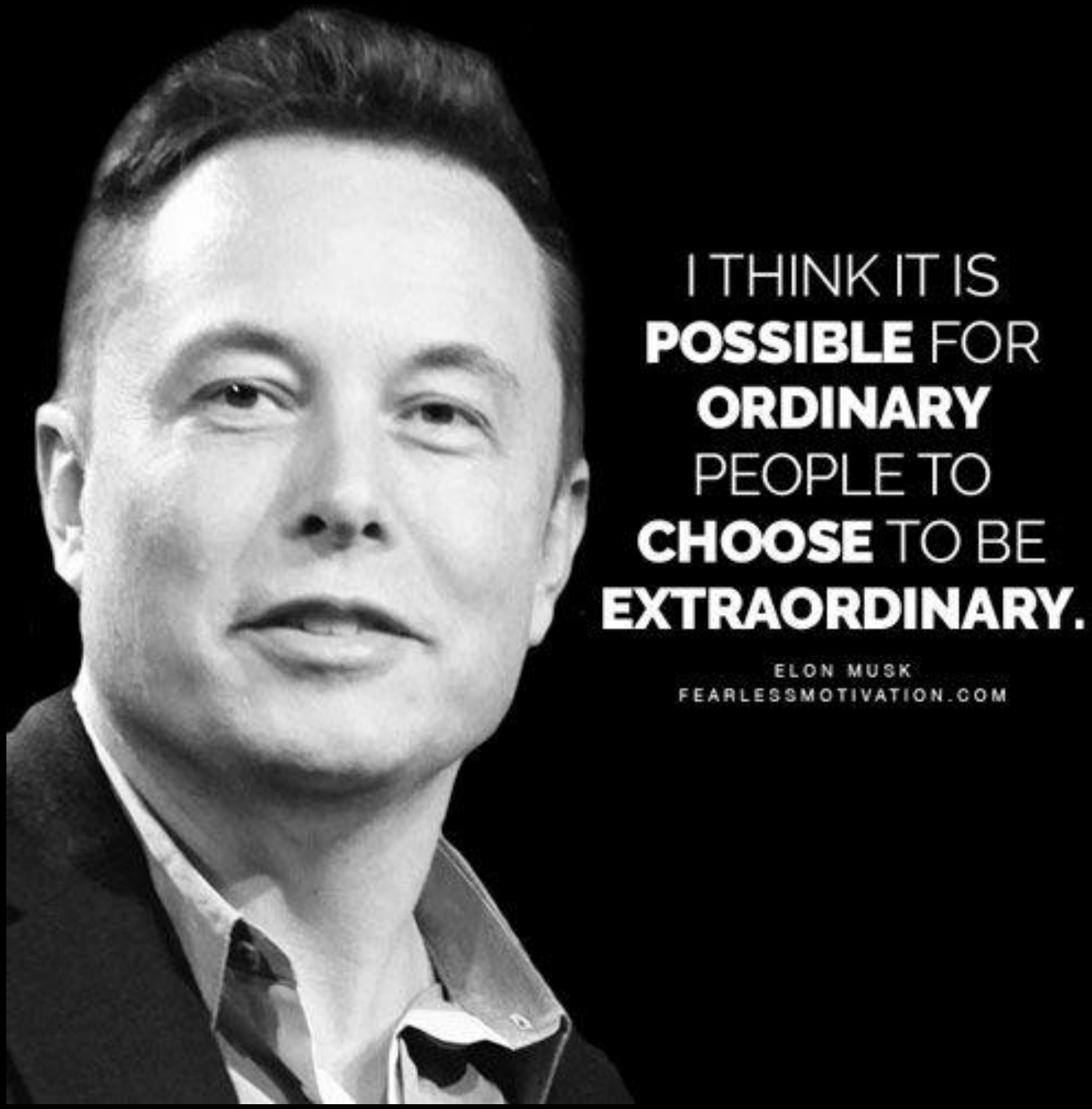
Whatever I'll just ask the teacher in class tomorrow how to do it

Calculus



Fuck it! I'll just copy my friend's answers


NO. YOU MAY NOT OUTSOURCE YOUR HOMEWORK TO INDIA.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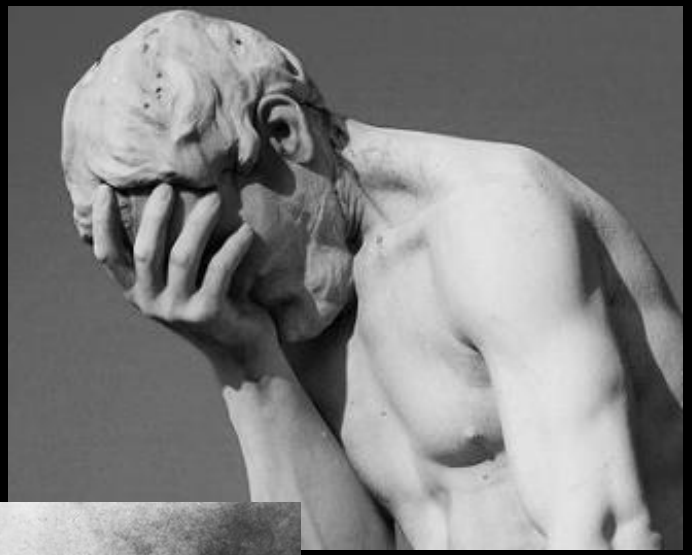
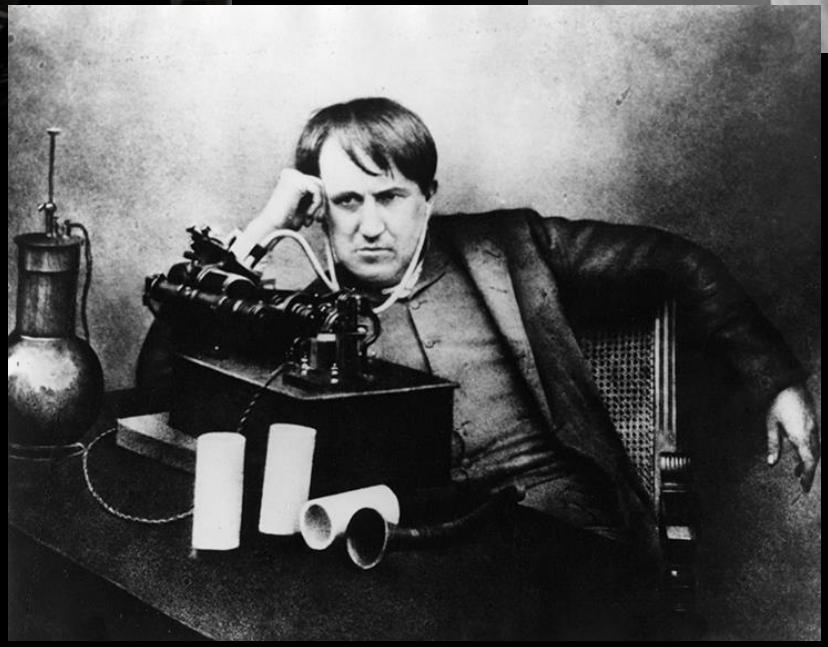
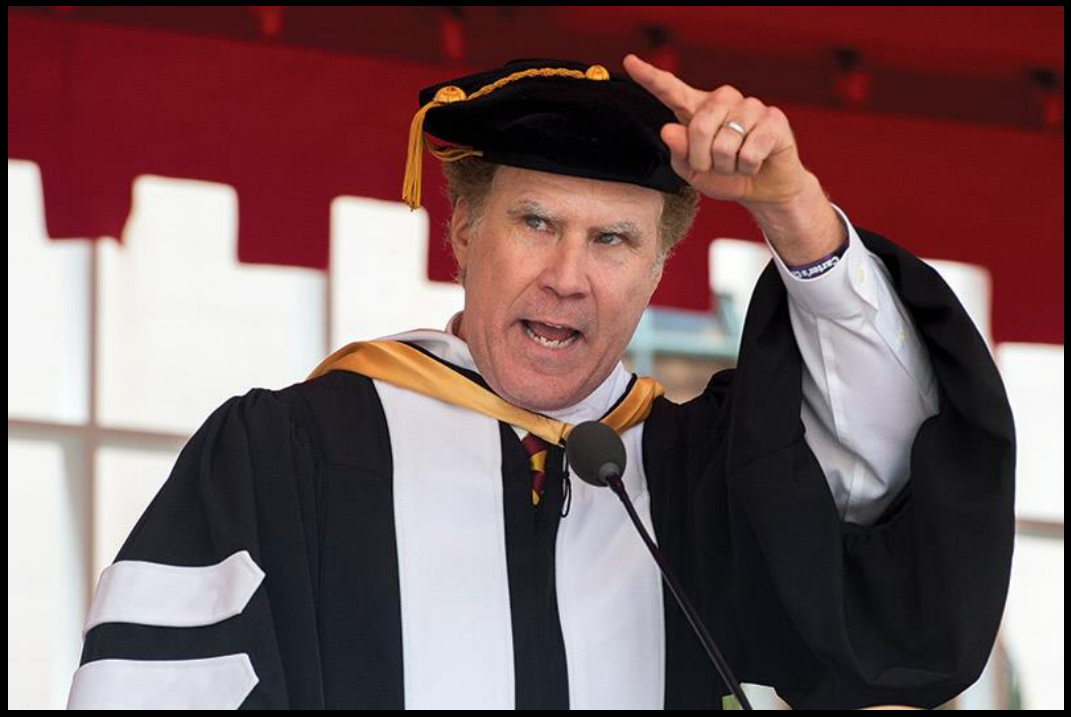


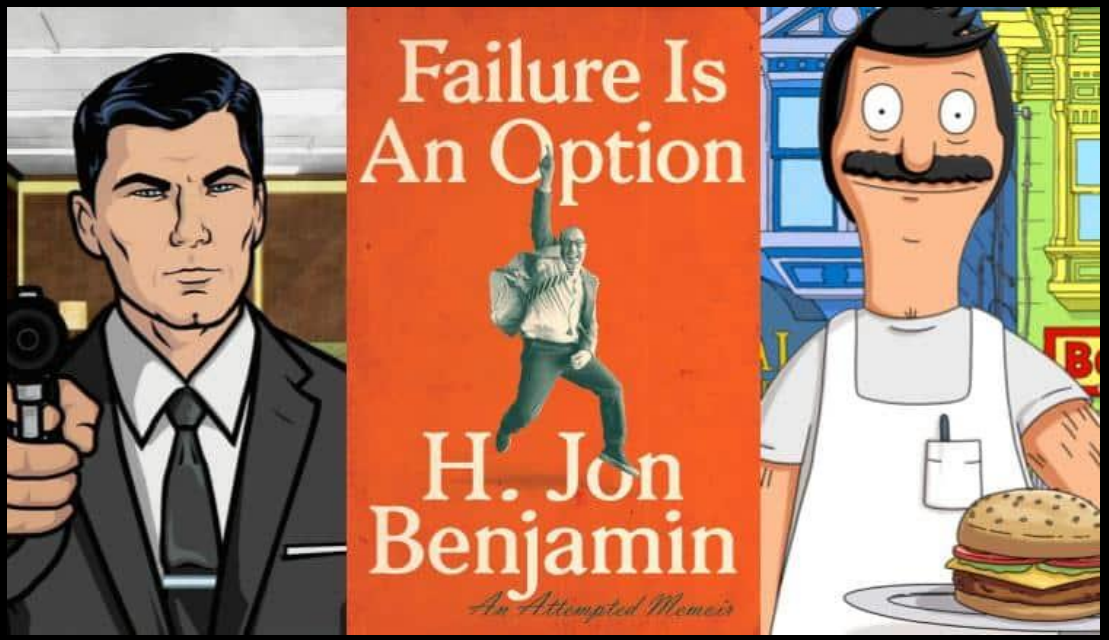




“You're never not afraid”

“My fear of failure never approached in magnitude my fear of ‘what if ’: What if I never tried at all?”

- Will Farrell



I've never worked for a show or was on a show that I didn't have a lot of control creatively, but then again, I haven't worked on a lot of shows.

- H. Jon Benjamin


adult
swim

CHAPTER 22

How I Failed at Differentiating My Two Characters of Bob and Archer

I did the same voice. The end.


"Failure is an option here. If things are not failing, you are not innovating enough."
Elon Musk

We learn from our mistakes

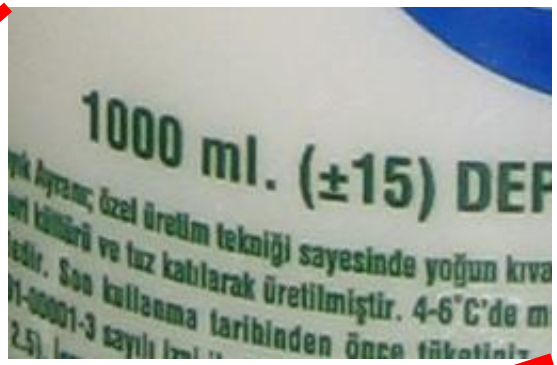
We learn from our mistakes

“The job of a theoretical physicist is to make mistakes as fast as possible”

- John Archibald Wheeler


Cam Şişede Daha Sağlıklı
YAYIK AYRANI
eker
1000 ml. (±15) DEPOZİTOSUZ TS. 3810

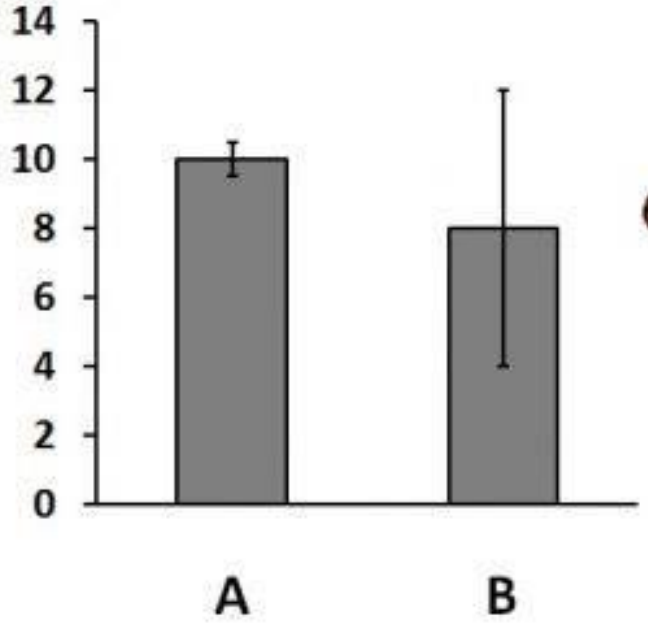

Cam Şişede
YAYIK AYRANI
eker
1000 ml. (±15)


1000 ml. (±15) DEP

Quantifying Uncertainty Is Critical

MR T TEST

"THAT AIN'T SIGNIFICANT, FOOL!"

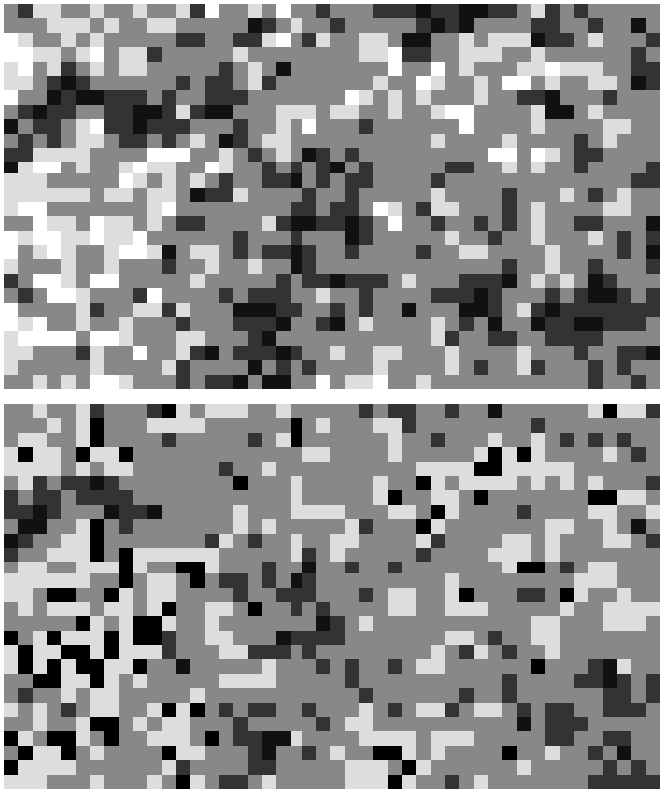


Non-Invertible Transformations Destroy Information!

Super-Resolution Imaging

by Peter Cheeseman, Bob Kanefsky, Robin Hanson, and John Stutz
NASA Ames Research Center

Sample Input Images



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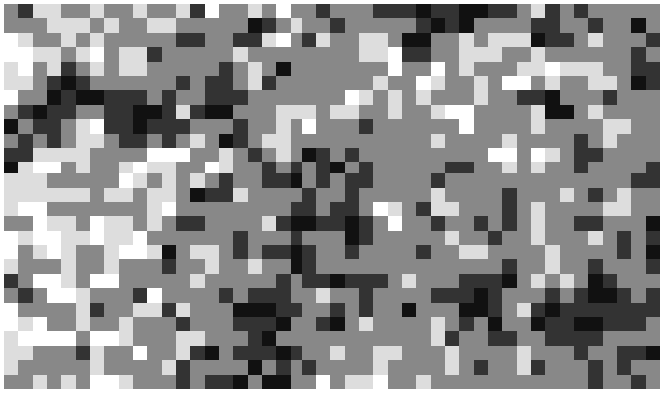

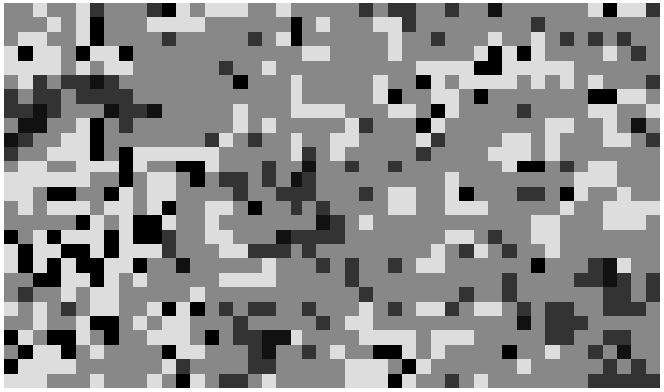

Average Image

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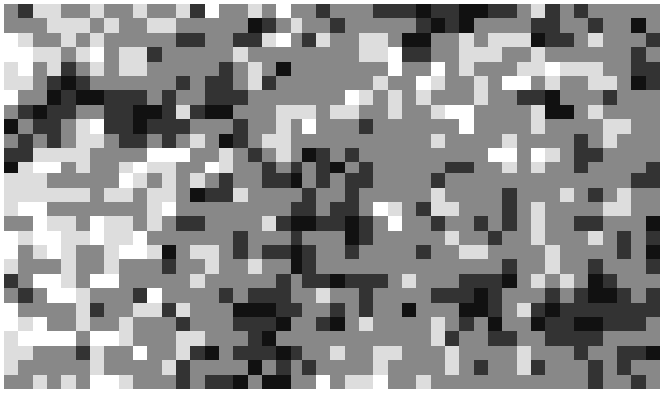

Average Image

Output Image

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Sample Input Image

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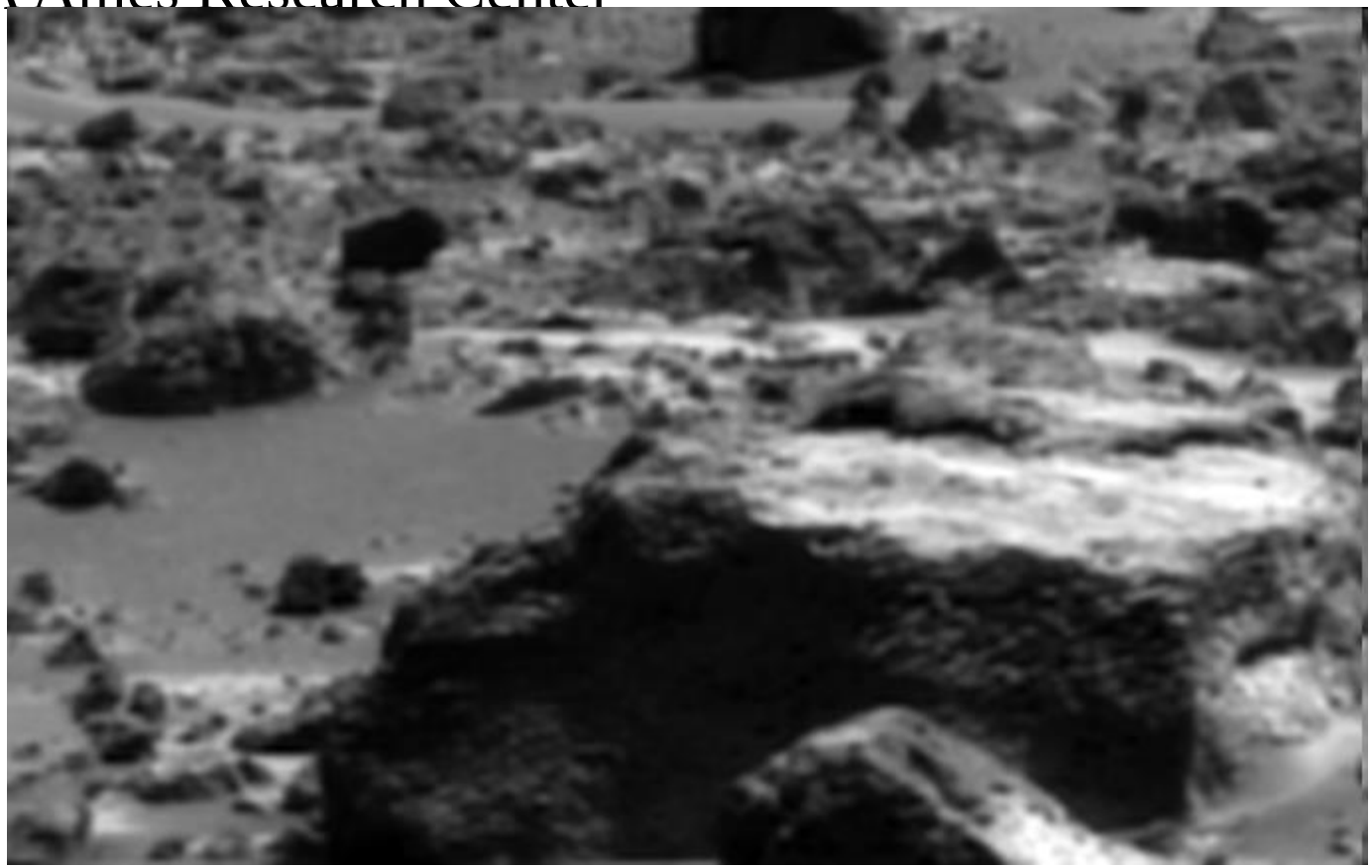

Output Image

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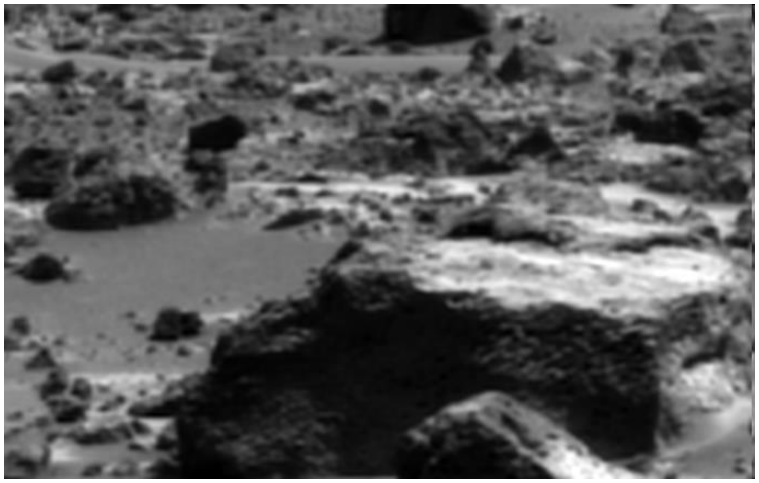


Output Image

Image and Depth from a Conventional Camera with a Coded Aperture

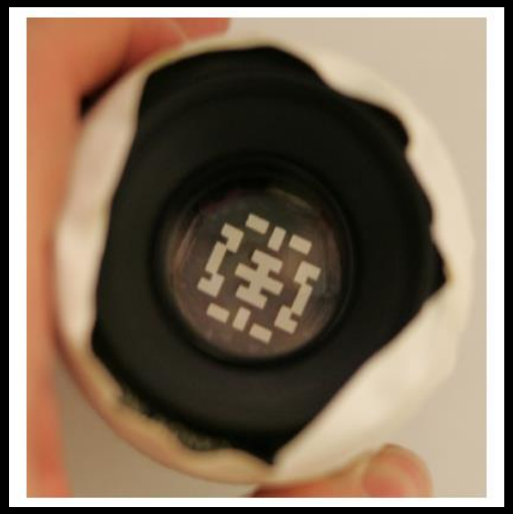
Anat Levin, Rob Fergus,
Frédo Durand, William Freeman

MIT CSAIL

Idea 2: Coded Aperture

- **Mask (code) in aperture plane**
  - **make defocus patterns different from natural images and easier to discriminate**

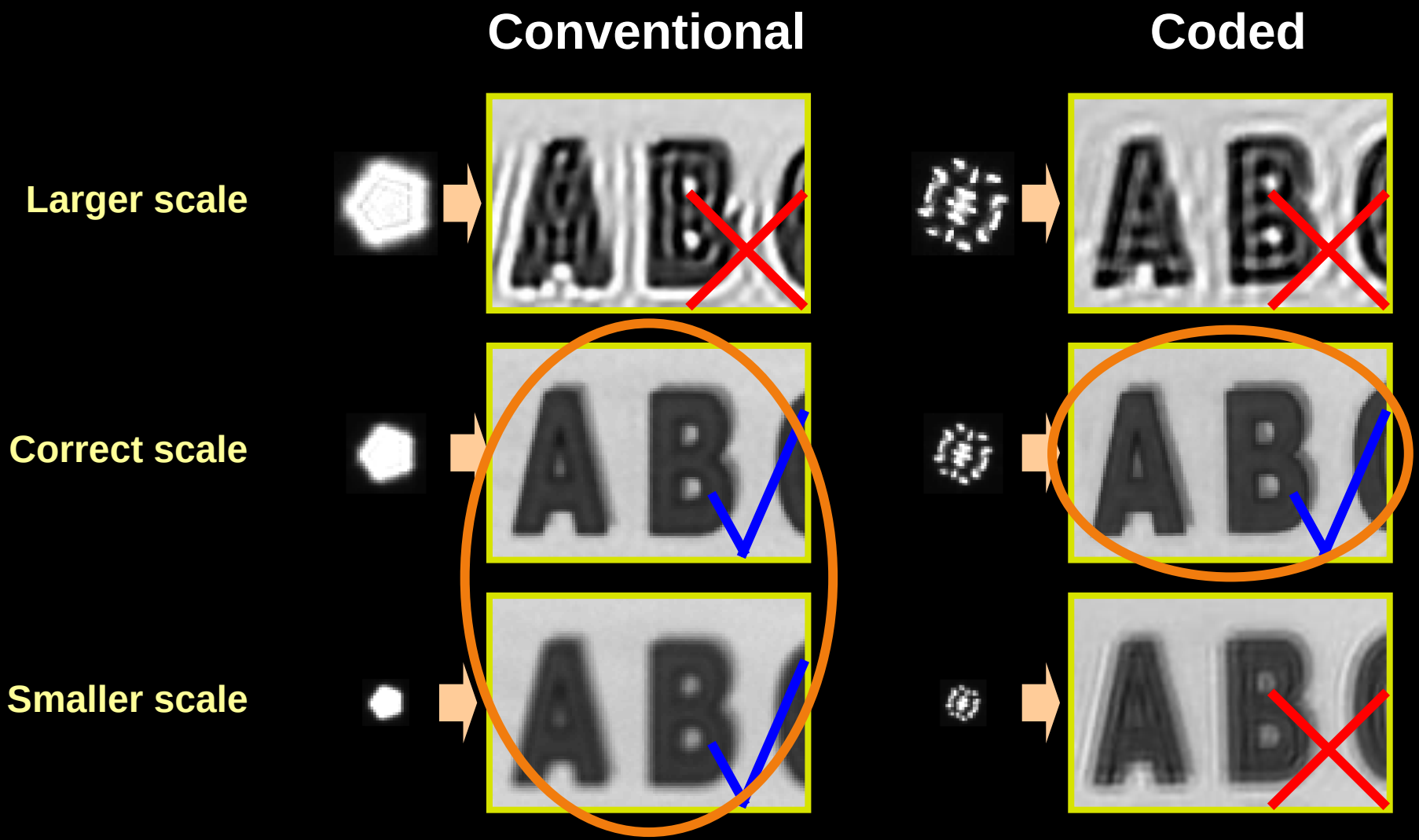
Conventional aperture



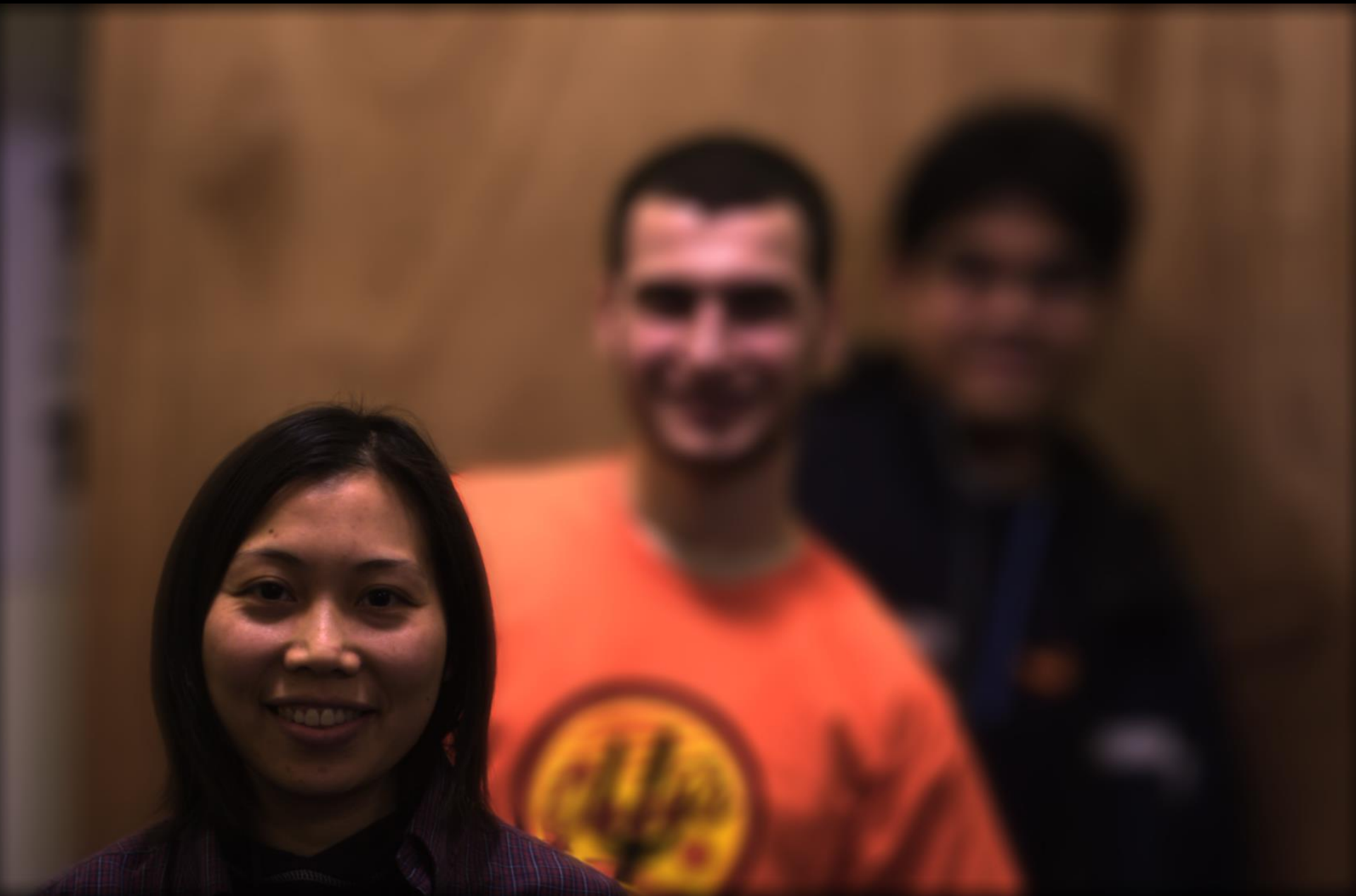
Our coded aperture

Why coded?

Coded aperture- reduce uncertainty in scale identification



Application: Digital refocusing from a single image



Application: Digital refocusing from a single image

Application: Digital refocusing from a single image

Application: Digital refocusing from a single image

How Do We Function?

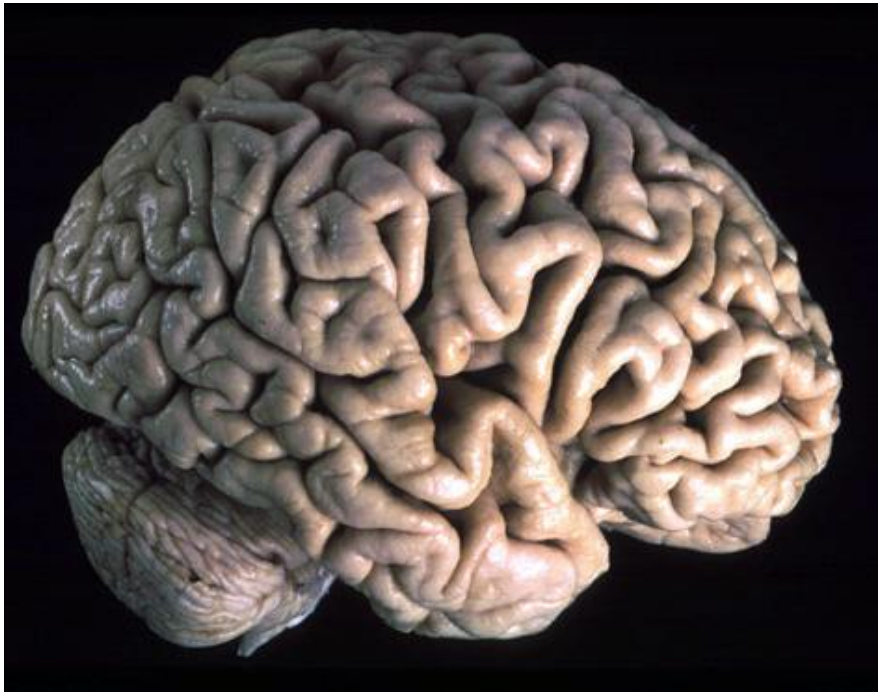
The Brain: The Living State of Matter

10^{11}-10^{12} Neurons

10^{4}-10^{5} Connections per Neuron

Maximum Firing Rate: 1 ms

1kHz massively parallel computer



The Virtual Hospital, Ch 5, Williams, Gluhbegovic, and Jew

Information Processed on order of 100s ms

MUST use **Prior Information**

A Powerful Computer

Hree is an ecxlelnet eaxmlpe of how yuor wnodreful mnid can raed tihs txet eevn touhgh its all jmbuled.

Sounds and Prior Information

Listen to these sounds…

Sounds from Haskins Laboratories, Rubin, Remez, Pardo

Sounds and Prior Information

Now listen to this one…





Sounds from Haskins Laboratories, Rubin, Remez, Pardo

Sounds and Prior Information

And now go back to this one…





Sounds from Haskins Laboratories, Rubin, Remez, Pardo

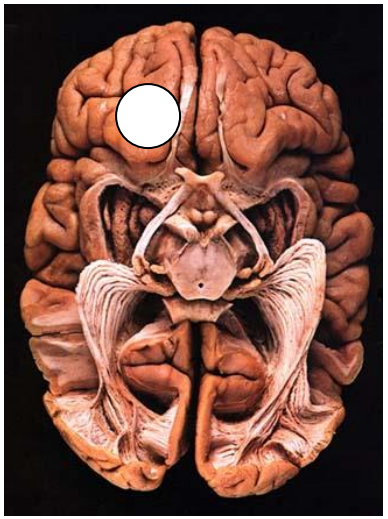
Sounds and Prior Information

What about the rest?

Sounds from Haskins Laboratories, Rubin, Remez, Pardo

Prior Information is Key

Only 10% of the inputs into primary visual cortex come from the retina via the lateral geniculate nucleus. The rest come from higher visual and frontal areas.



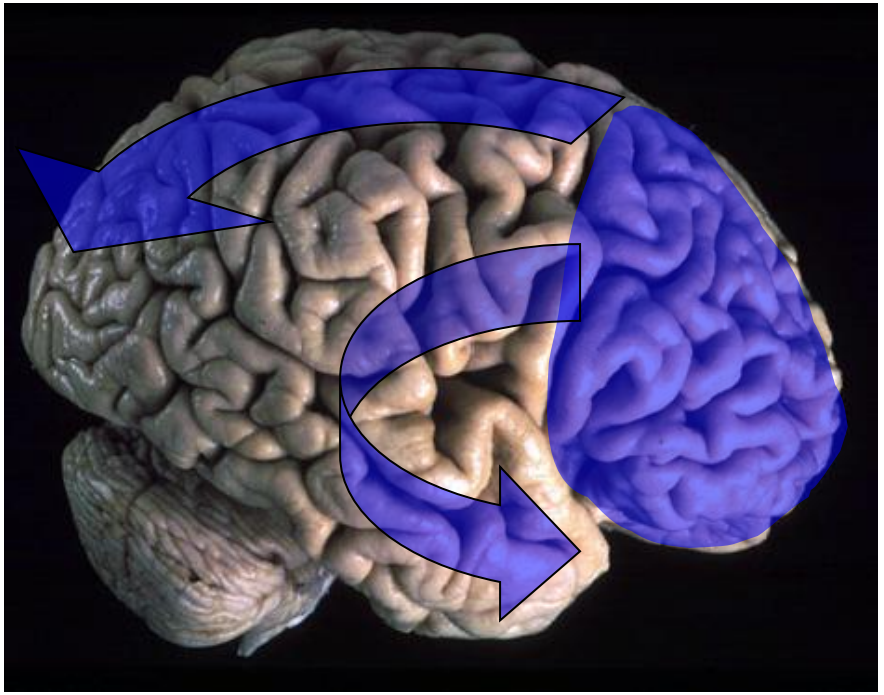
Human Brain: basal view (front at top)
The Virtual Hospital, Ch 5, Williams, Gluhbegovic, and Jew

Perception can also be modified by attention.

Thus the brain can actively focus on **relevant information**.

The Brain Models its Environment

The frontal regions of the brain create models of the world based on prior experience. These models affect perception and attention.



The Virtual Hospital, Ch 5, Williams, Gluhbegovic, and Jew

In addition, the brain models itself.

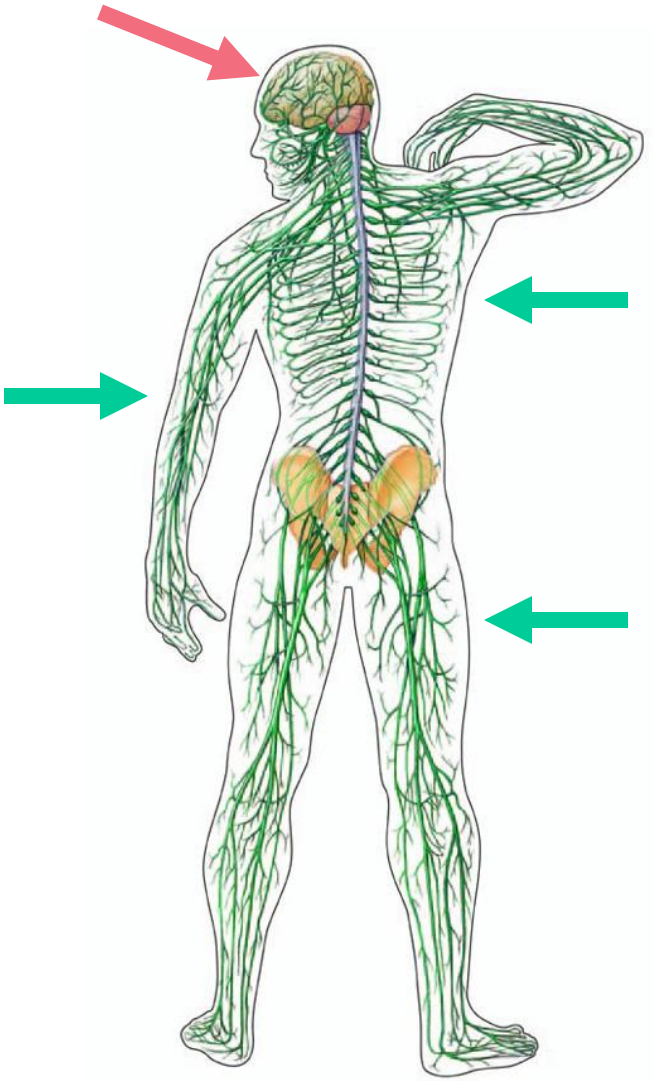
Experiments in multi-sensory processing has shown that the information processing is consistent with Bayes Theorem

Thinking Machines

Your **frontal lobes** carry a model of yourself that is continually updated from data received from a **dense sensor network**. This implements both 'Instrument Health Monitoring' and 'Calibration'

You **learn** from new data by updating your model of the world.

You actively seek new data by **asking relevant questions**.



Body and Brain form a Symbiotic Unit

Perception
and
Relevant Questions

Relevance and Perception

A. L. Yarbus, Eye Movements and Vision, Plenum, New York, 1967
(Originally published in Russian 1962)

Free Examination

Three minute recording

A. L. Yarbus, Eye Movements and Vision, Plenum, New York, 1967
(Originally published in Russian 1962)

Estimate Ages of the People

Three minute recording

A. L. Yarbus, Eye Movements and Vision, Plenum, New York, 1967
(Originally published in Russian 1962)

Remember their Clothes

Three minute recording

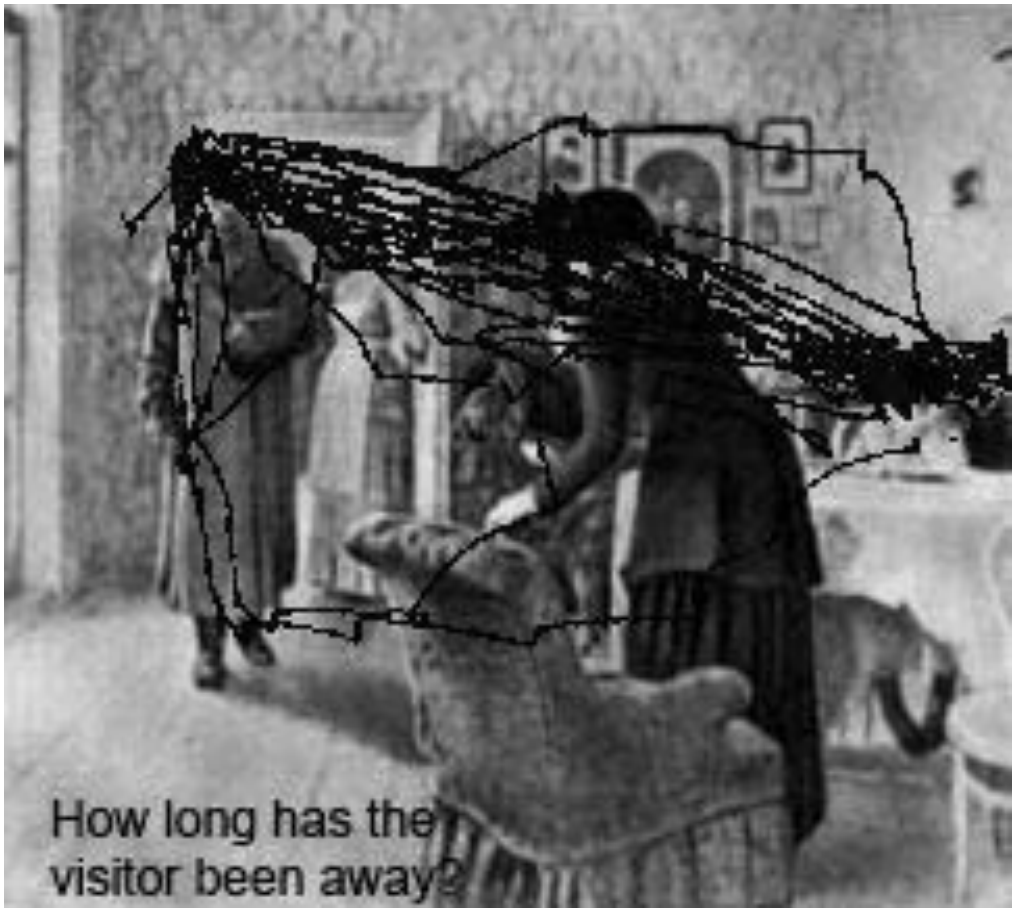
A. L. Yarbus, Eye Movements and Vision, Plenum, New York, 1967
(Originally published in Russian 1962)

Estimate Material Circumstances

Three minute recording

A. L. Yarbus, Eye Movements and Vision, Plenum, New York, 1967
(Originally published in Russian 1962)

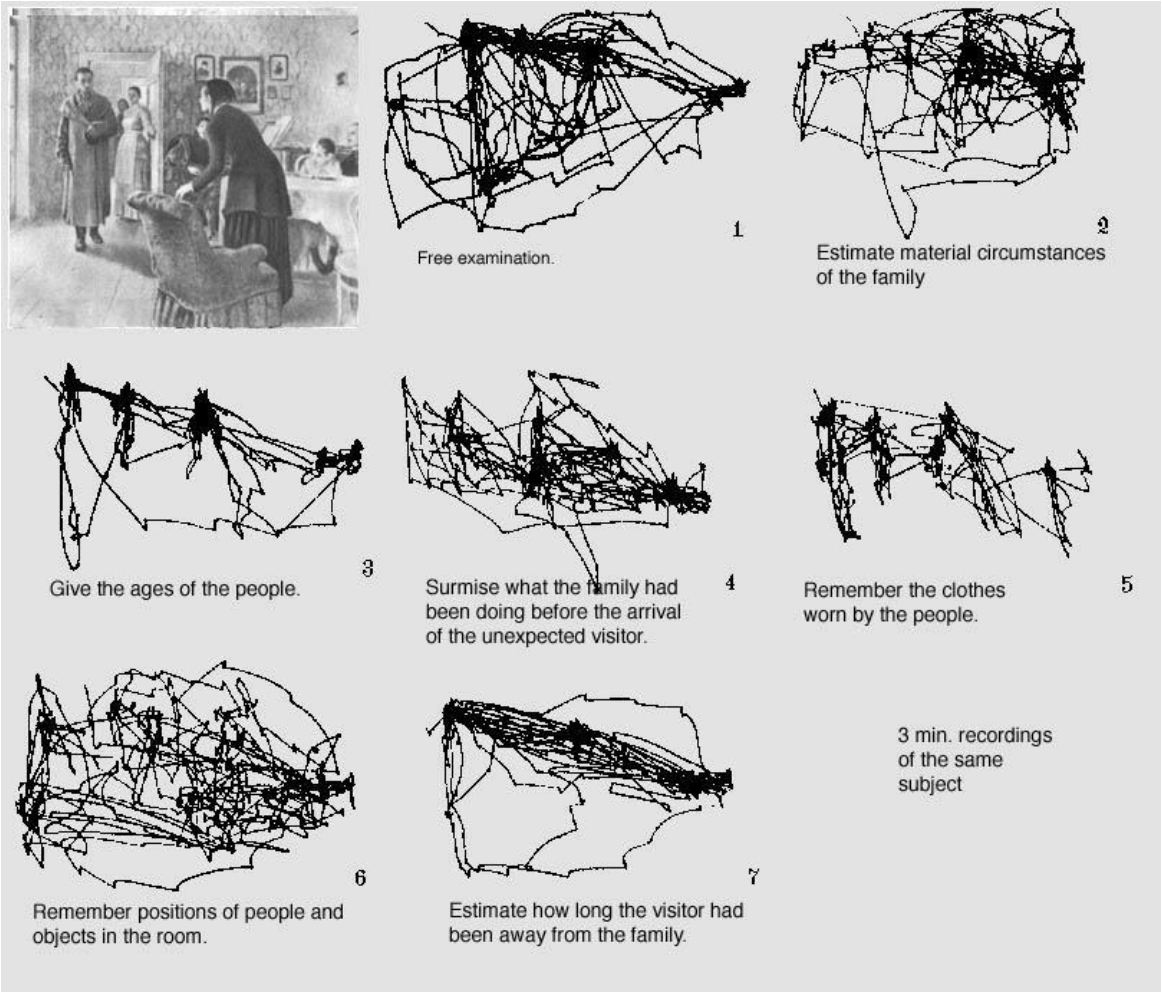
How Long has the Visitor been away?



Three minute recording

A. L. Yarbus, Eye Movements and Vision, Plenum, New York, 1967
(Originally published in Russian 1962)

Relevance and Perception



A. L. Yarbus, Eye Movements and Vision, Plenum, New York, 1967
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Do We Analyze Everything?