

Computer Vision Applications

COMP 388-002/488-002 Computer Science Topics

Daniel Moreira
Fall 2022



LOYOLA
UNIVERSITY CHICAGO

Introduction to Computer Vision

**COMP 388-002/488-002 Computer Science Topics
Computer Vision Applications**

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Today you will...

(1) Get to know what is ahead of you in the course, and (2) be introduced to Computer Vision.

Welcome

COMP 388-002/488-002 Computer Science Topics Computer Vision Applications

Daniel Moreira (Instructor)

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Office: 310 Doyle Center



Course Hours

Lectures: MON, 4:15 to 6:45 PM, 117 Cuneo Hall

Office: TUE and THR, 5 to 7 PM, 310 Doyle Center or Zoom,
by appointment (<https://bit.ly/3Tos8wx>)

Communication

Sakai: soon

Webpage: <https://danielmoreira.github.io/teaching/cvapp-aut22/>

About me

Computer Scientist

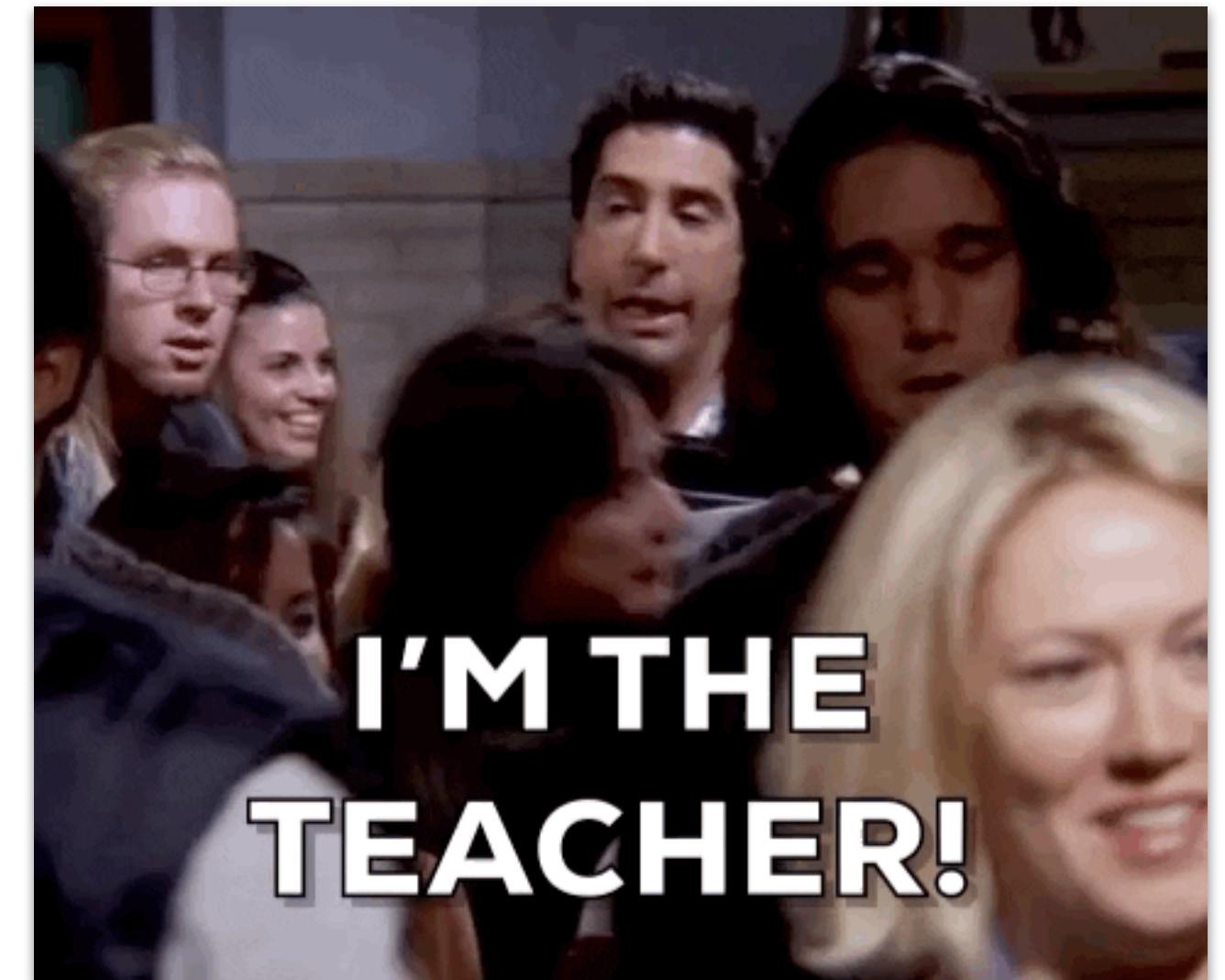
PhD from the University of Campinas (Brazil)

Theme: Sensitive-Video Analysis

Loyola University Chicago

Assistant Professor

Just joined on August 15



Research

Media Forensics, Biometrics, Computer Vision, Machine Learning

Webpage: <https://danielmoreira.github.io>

(see next slides)



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Sensitive-Video Analysis

<https://danielmoreira.github.io/project/sma/>

The Problem

The New York Times
Teenager Is Accused of Live-Streaming a Friend's Rape

SOUTH FLORIDA

Miami Herald

Another girl hangs herself while streaming it live — this time in N

CNN BUSINESS Markets Tech Media Success Perspectives Video

Seven weeks later, videos of New Zealand attack still circulating on Facebook and Instagram

The Intersect

The Washington Post

A 12-year-old girl live-streamed her suicide.
It took two weeks for Facebook to take the

Man shot, killed while live-streaming

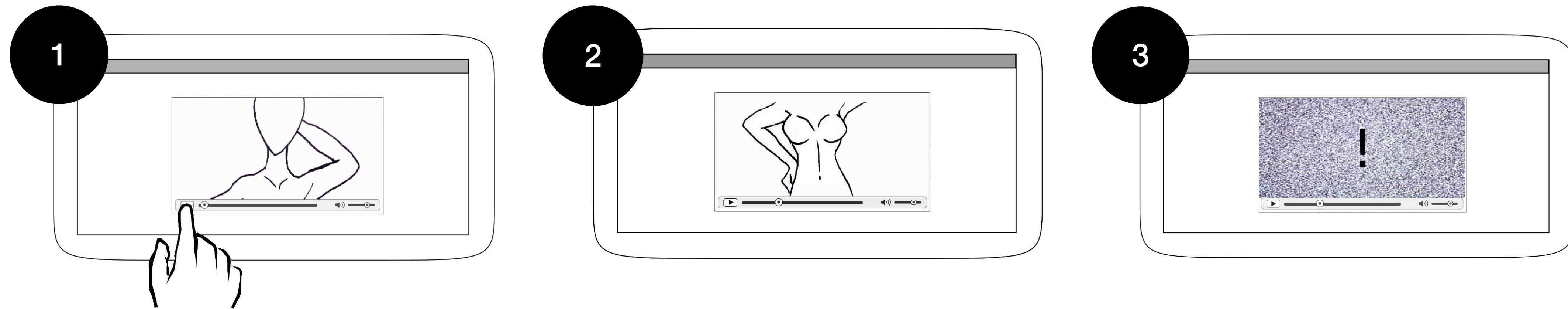


Sensitive Video

“Motion pictures whose content may inflict harm (e.g., trauma, shock, or fear) to particular audiences (e.g., children or unwary spectators), due to the inappropriateness of content.”



Can a computer localize sensitive scenes within a video timeline?





The Notorious B.I.G.
NY scene rapper

Media Forensics

<https://danielmoreira.github.io/project/medifor/>

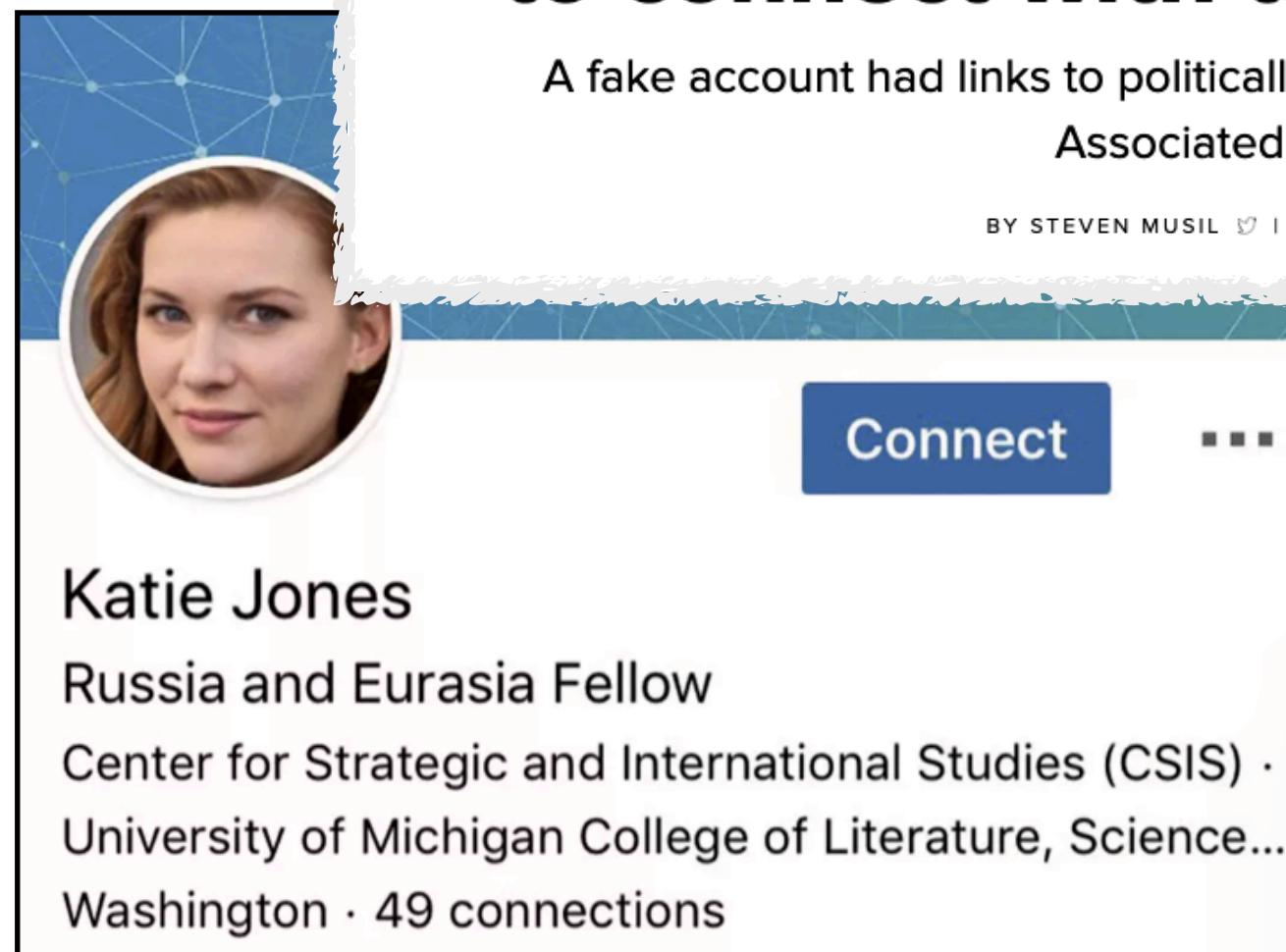
Kurt Cobain
Grunge scene musician

The Problem

CNET
SCI-TECH
Spy reportedly used AI-generated photo to connect with targets on LinkedIn

A fake account had links to politically connected figures in Washington, the Associated Press reports.

BY STEVEN MUSIL | JUNE 13, 2019 5:13 PM PDT



Katie Jones
Russia and Eurasia Fellow
Center for Strategic and International Studies (CSIS) ·
University of Michigan College of Literature, Science...
Washington · 49 connections

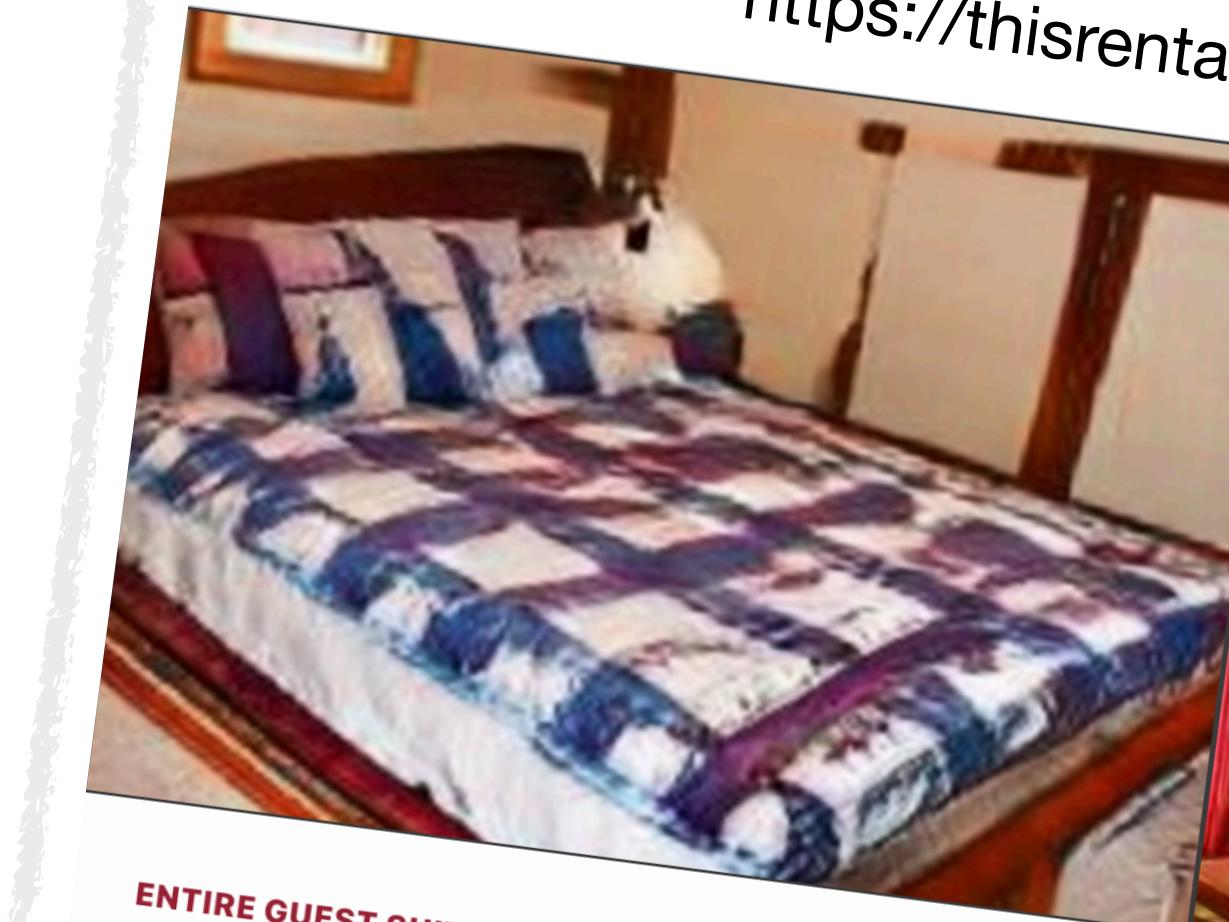
Connect ...



<https://thisrentaldoesnotexist.com/>



ENTIRE GUEST SUITE
**GRAND CANAL TOUR VIEW 3 BED 1/2
BATH**



Adobe

Crafting new images with photo manipulation.



<https://www.youtube.com/watch?v=p7-B8S734T4>

A composite image. On the left, a man wearing a red baseball cap with 'ROYAL' and 'S' on it is shown from the chest up. On the right, a portrait of Kurt Cobain, the lead singer of Nirvana, looking slightly upwards and to his right.

The Notorious B.I.G.
NY scene rapper

HANGING OUT?

Kurt Cobain
Grunge scene musician

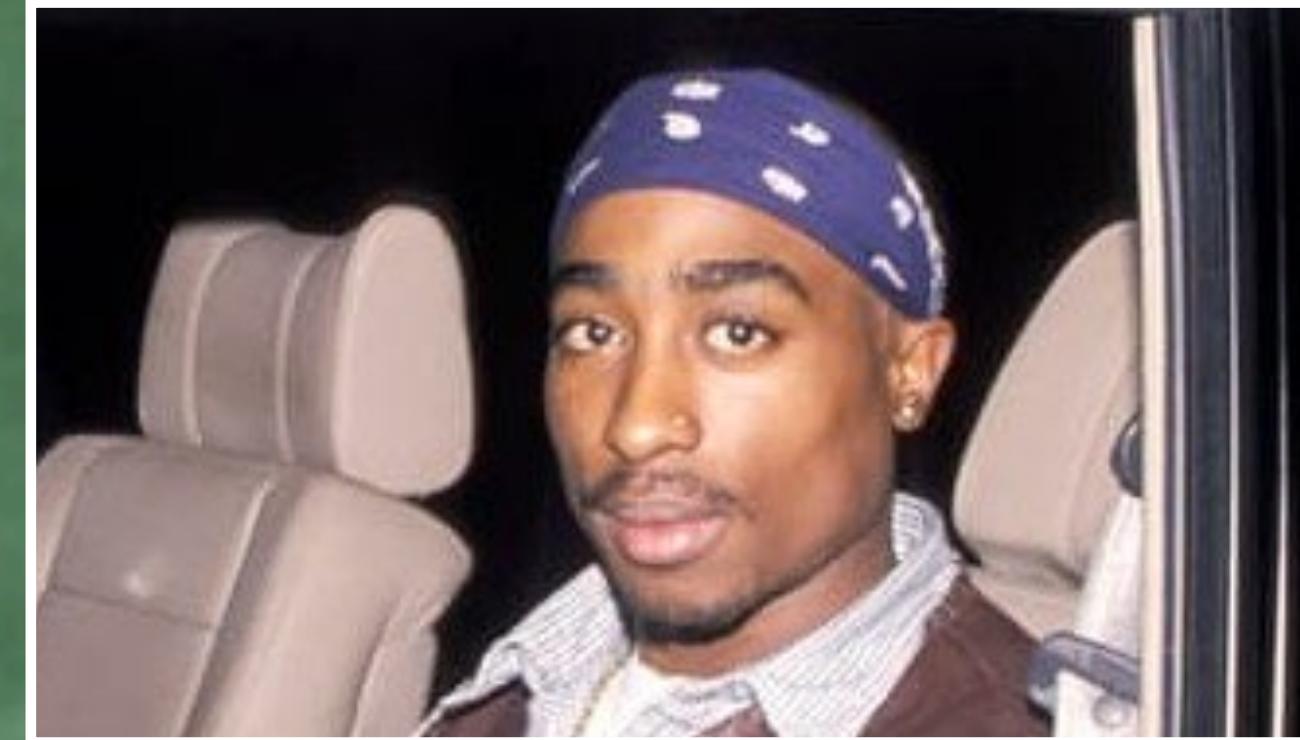
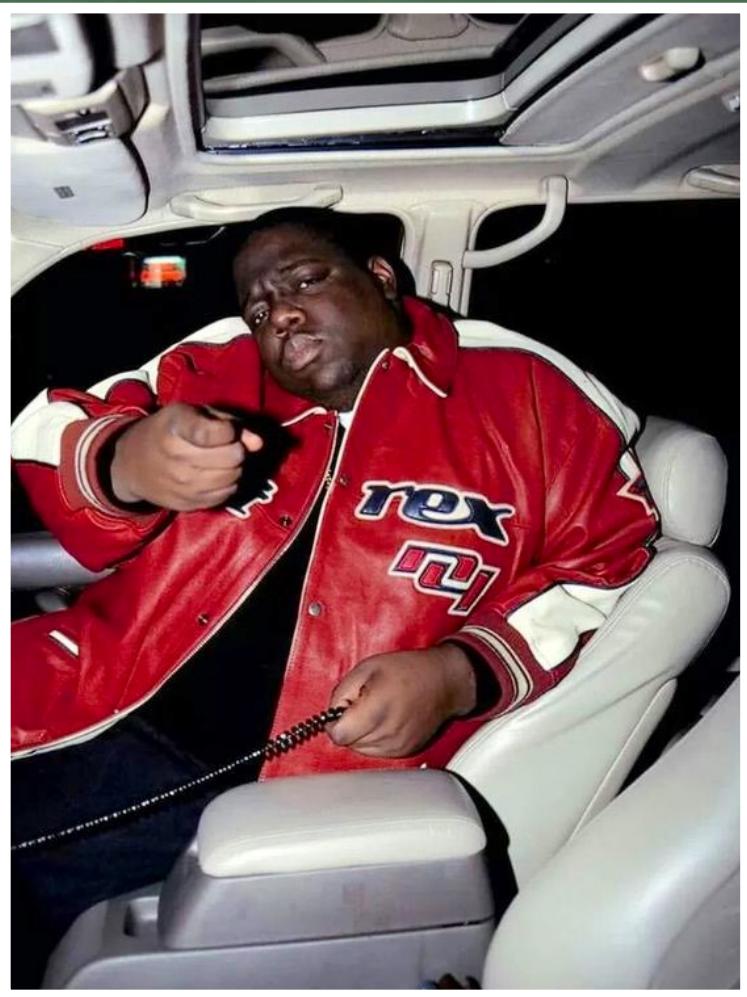


A collage of three images. On the left, a man in a red baseball cap and a red jacket with 'RED' and 'DODGERS' on it. In the center, a woman with long blonde hair wearing a green jacket. On the right, Tupac Shakur wearing a baseball cap.

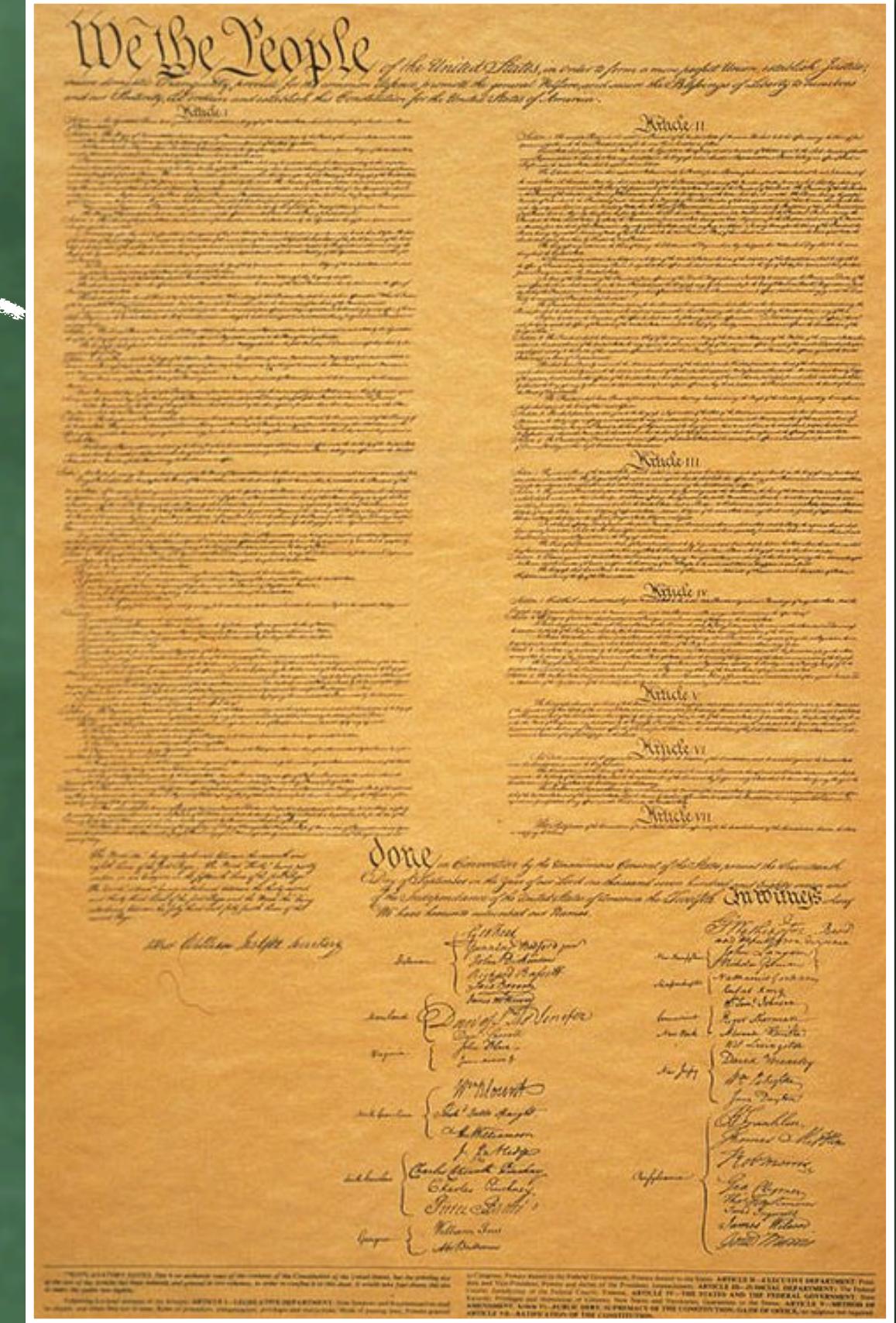
Tupac Shakur
LA scene rapper



Provenance Graph











Scientific Integrity

<https://danielmoreira.github.io/project/sciint/>

The Problem

Journals adopt AI to spot duplicated images in manuscripts

A few publishers are using automated software to catch flaws in submitted papers.

nature

Richard Van Noorden

REUTERS GRAPHICS

Speed Science

The risks of swiftly spreading coronavirus research

By Manas Sharma, Simon Scarr and Kate Kelland

PUBLISHED FEBRUARY 19, 2020

HEALTH

SEC Investigating Cassava Sciences, Developer of Experimental Alzheimer's Drug

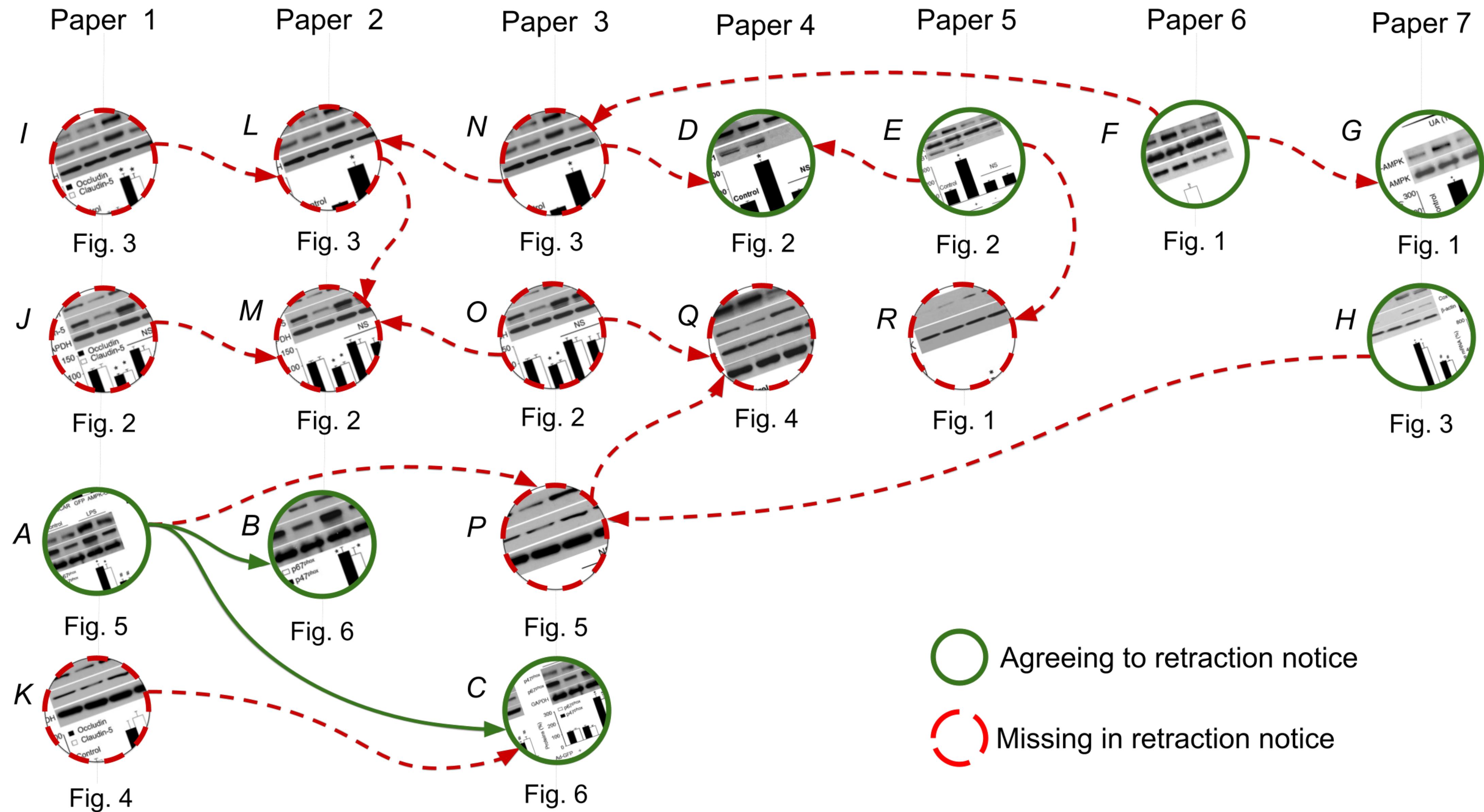
Cassava, one of best-performing U.S. stocks this year, denies claims that it manipulated research results

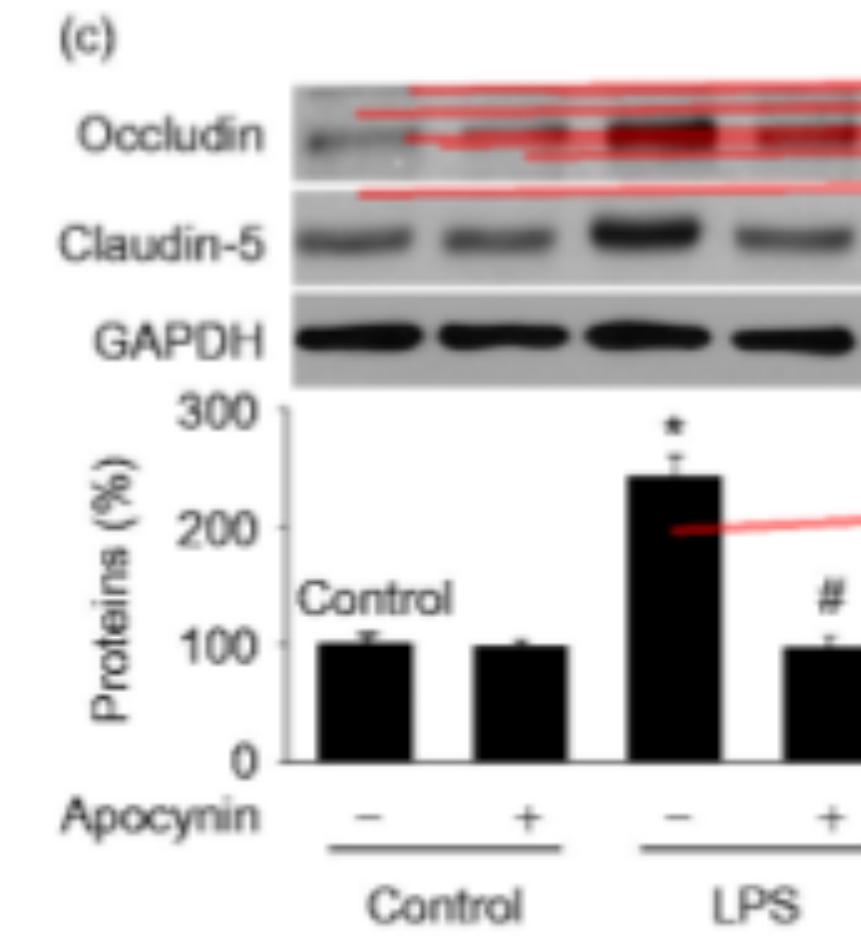
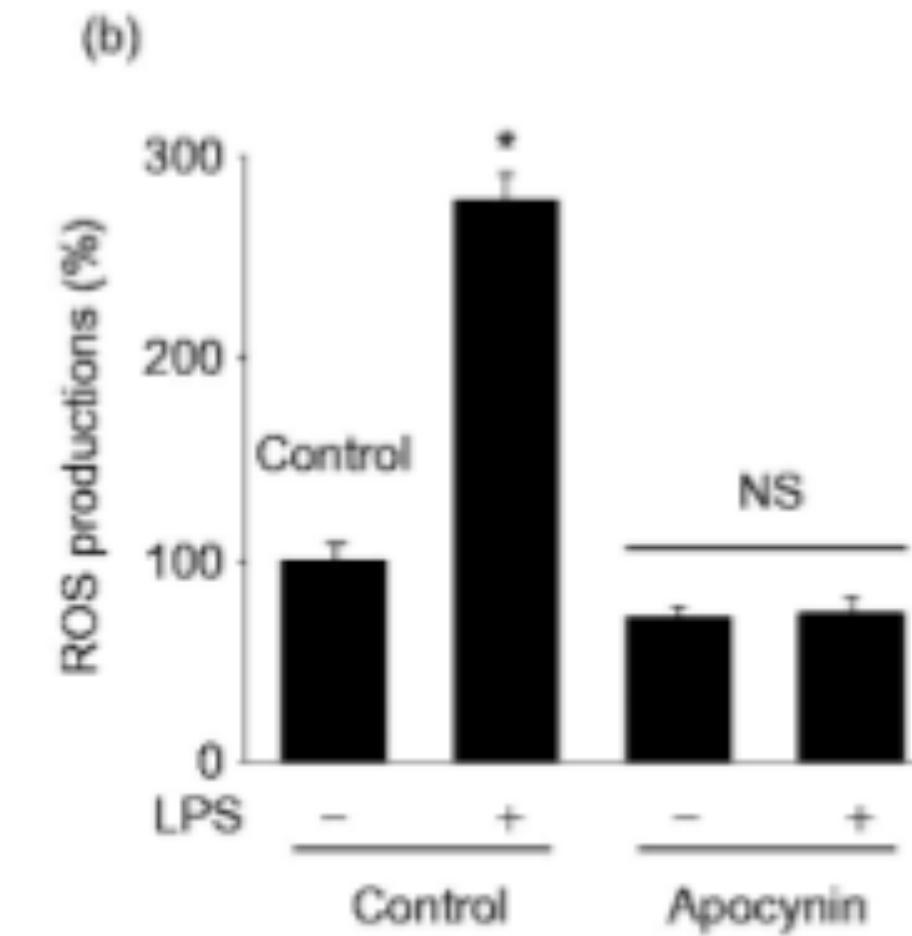
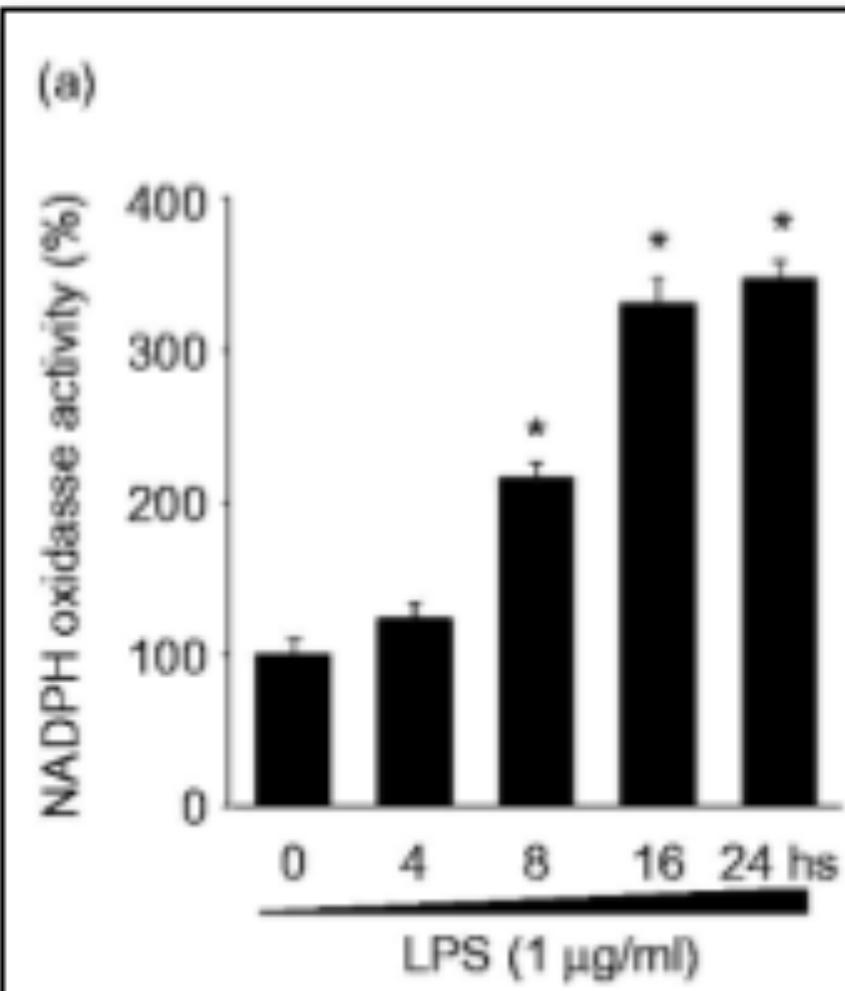
THE WALL STREET JOURNAL.

By [Dave Michaels](#) and [Joseph Walker](#)
Updated Nov. 17, 2021 4:55 pm ET

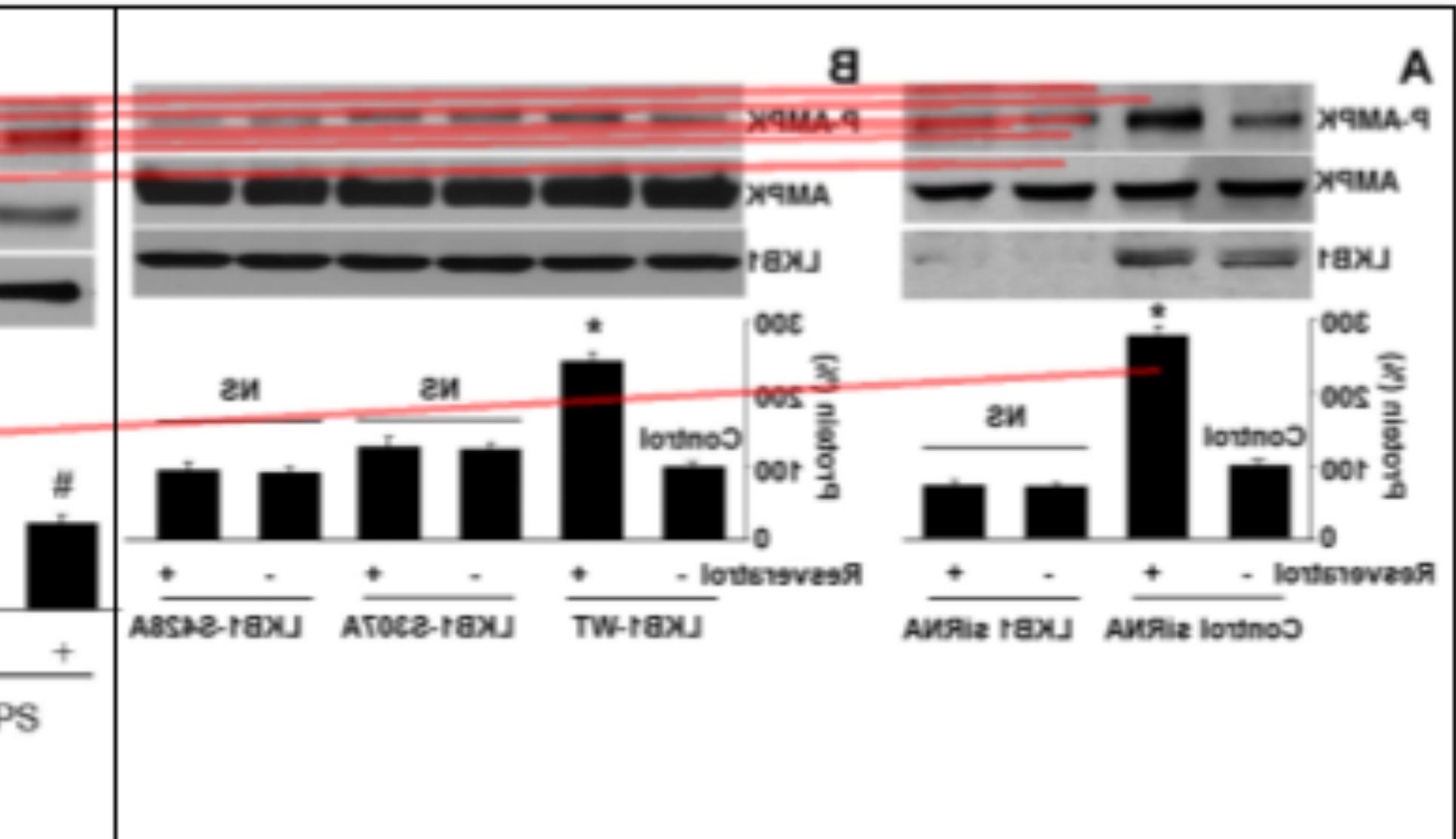
Two journal articles from Nature are shown. The first is titled 'SETDB1 Is Involved in Postembryonic DNA Methylation and Gene Silencing in Drosophila' by Paul Teng et al., published in Nature Communications. The second is titled 'Histone methylation by the Drosophila epigenetic transcriptional regulator Ahi1' by Paul Teng et al., published in Letters to Nature. Both articles have red 'RETRACTED' marks over them. To the right is a screenshot of a Wall Street Journal article titled 'SEC Investigating Cassava Sciences, Developer of Experimental Alzheimer's Drug'. The article discusses allegations of manipulated research results by Cassava Sciences, a company developing an experimental Alzheimer's drug. The WSJ logo is visible at the bottom.

g_2010_a b_2002_a g_2010_a b_2002_a





Paper 3, Fig. 3 (Node *N*)



Paper 4, Fig. 2 (Node *D*, mirrored)

DOI 10.3109/02699052.2015.1004746

DOI 10.3109/10641963.2015.1131288

Synthesis of Realistic Example Faces

<https://danielmoreira.github.io/project/srefv/>

Does this person
exist?



No
(nose and
mouth
replaced)



Yes
(original)

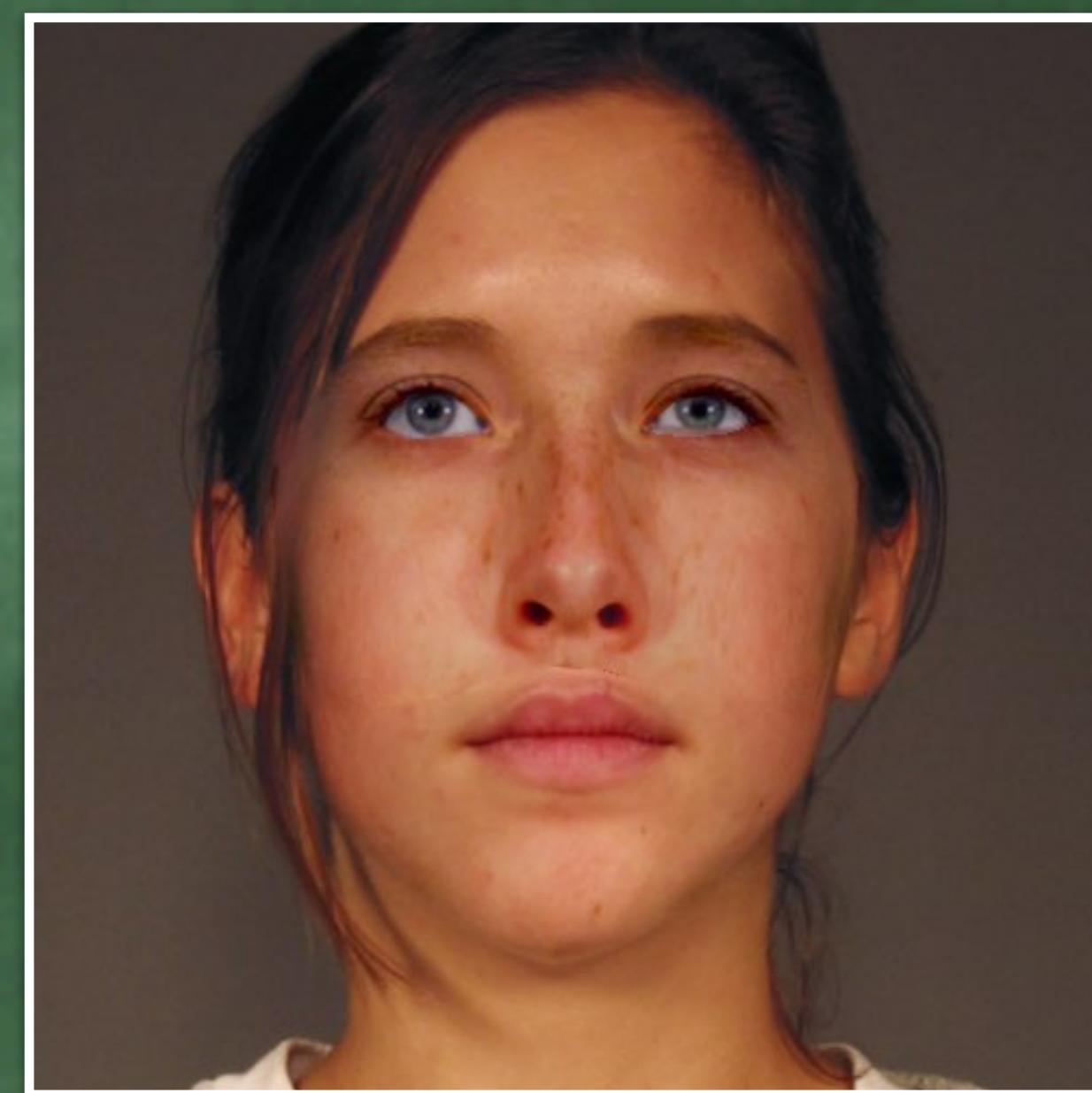
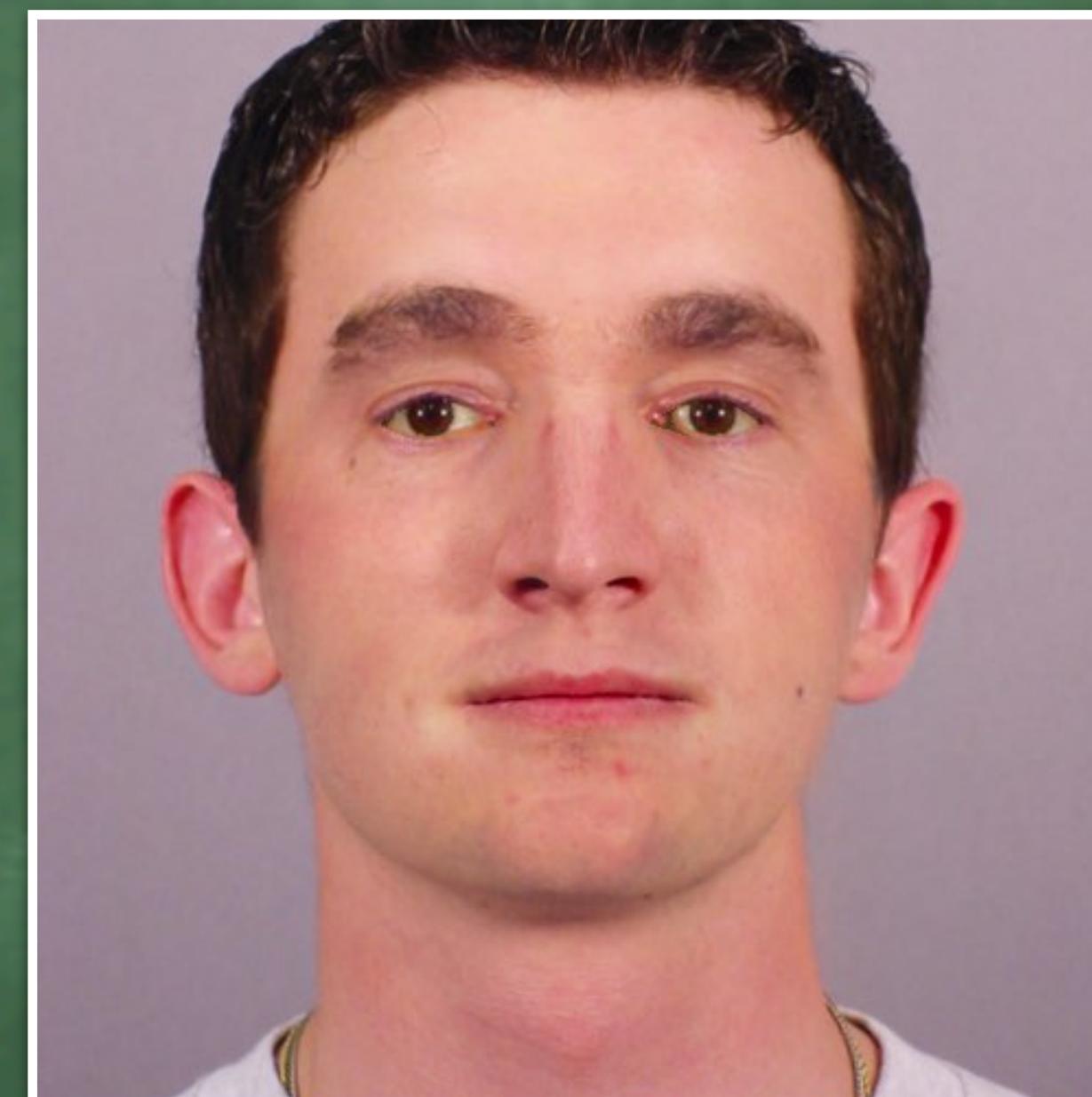


No
(eyes
replaced)



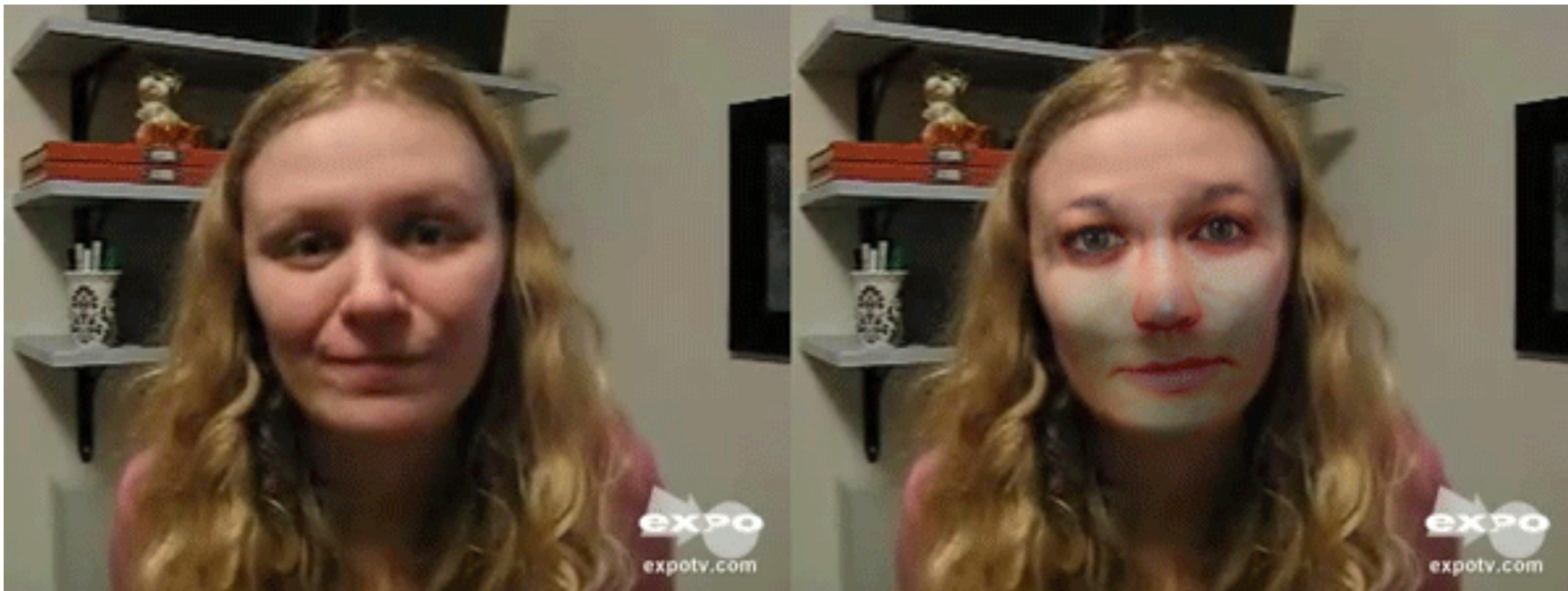
No
(eyes, nose
and mouth
replaced)





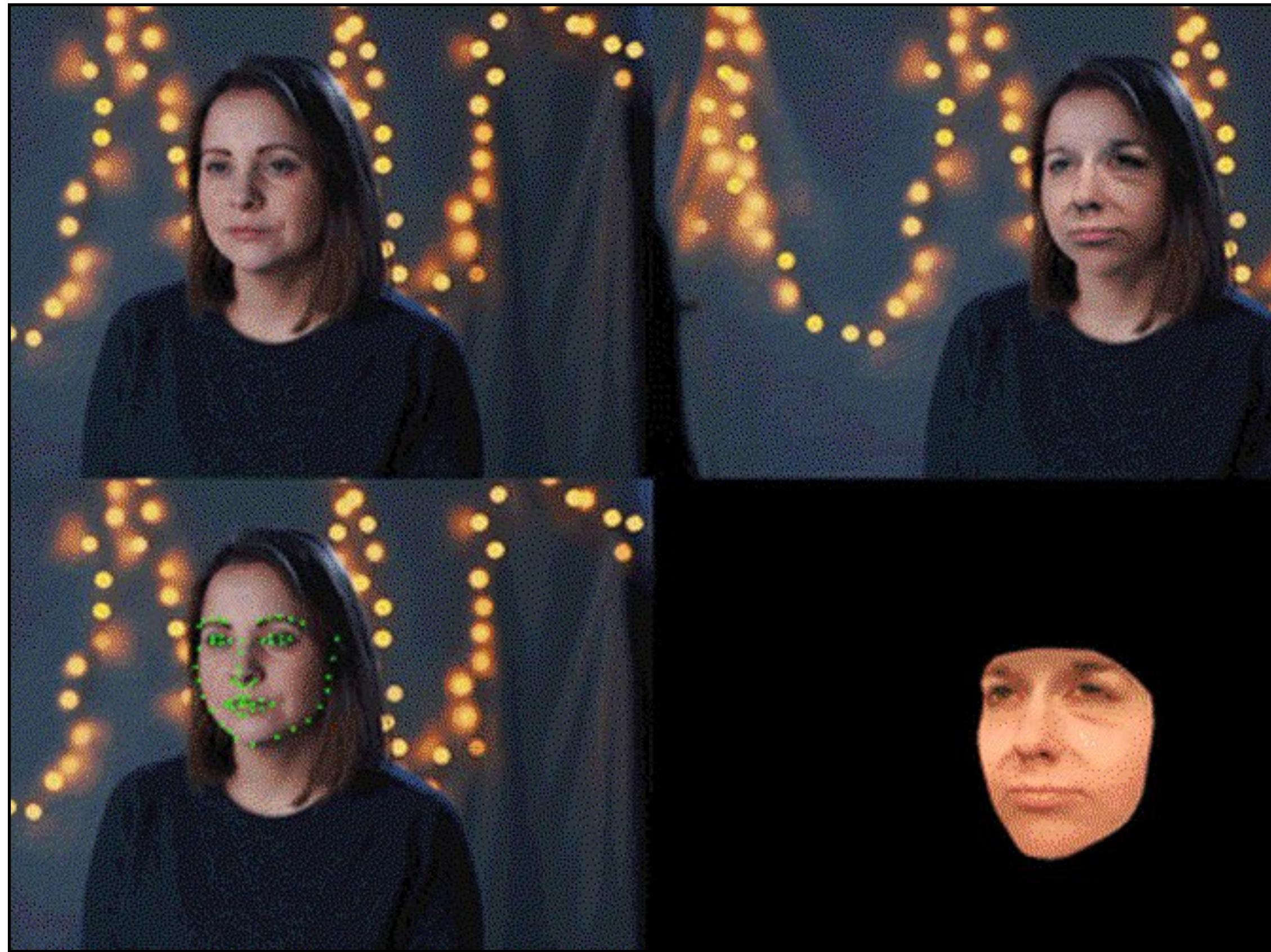
First Steps

Video Replacement



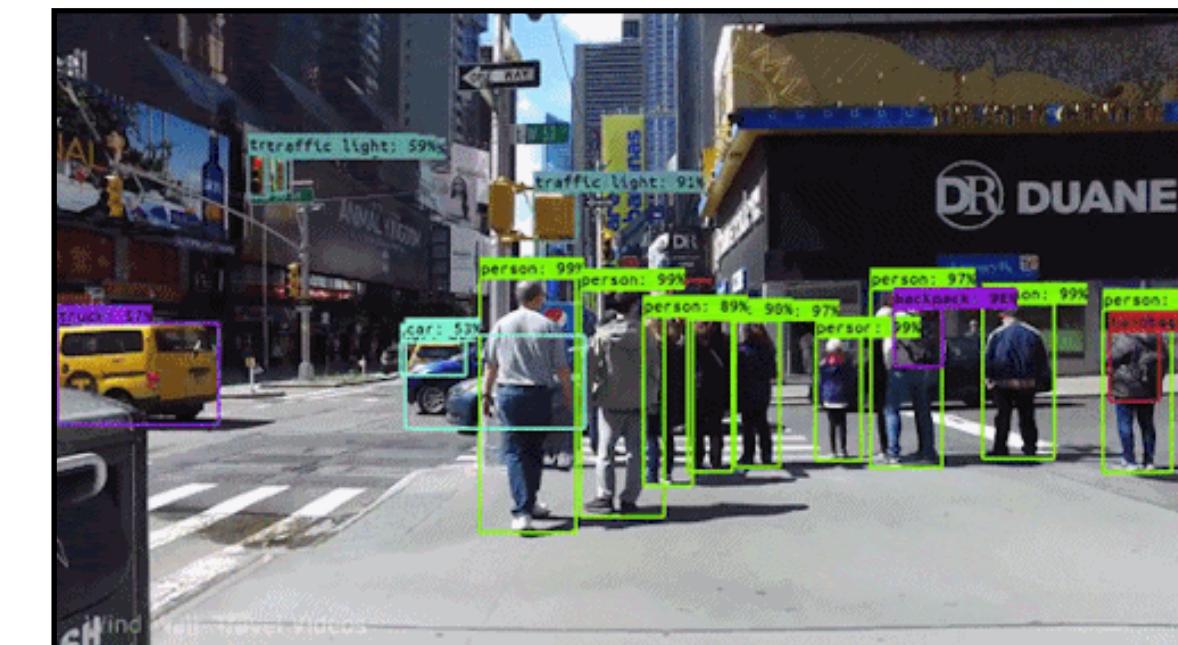
What's Next?

Synthetic Controlled Diversity



Controlled replacements of gender, age, and ethnicity, with synthetic identities (to ensure privacy).

Challenge: keep everything (e.g., emotions, sentiments, reactions) but identity.



Load irises

Load examination

Save examination

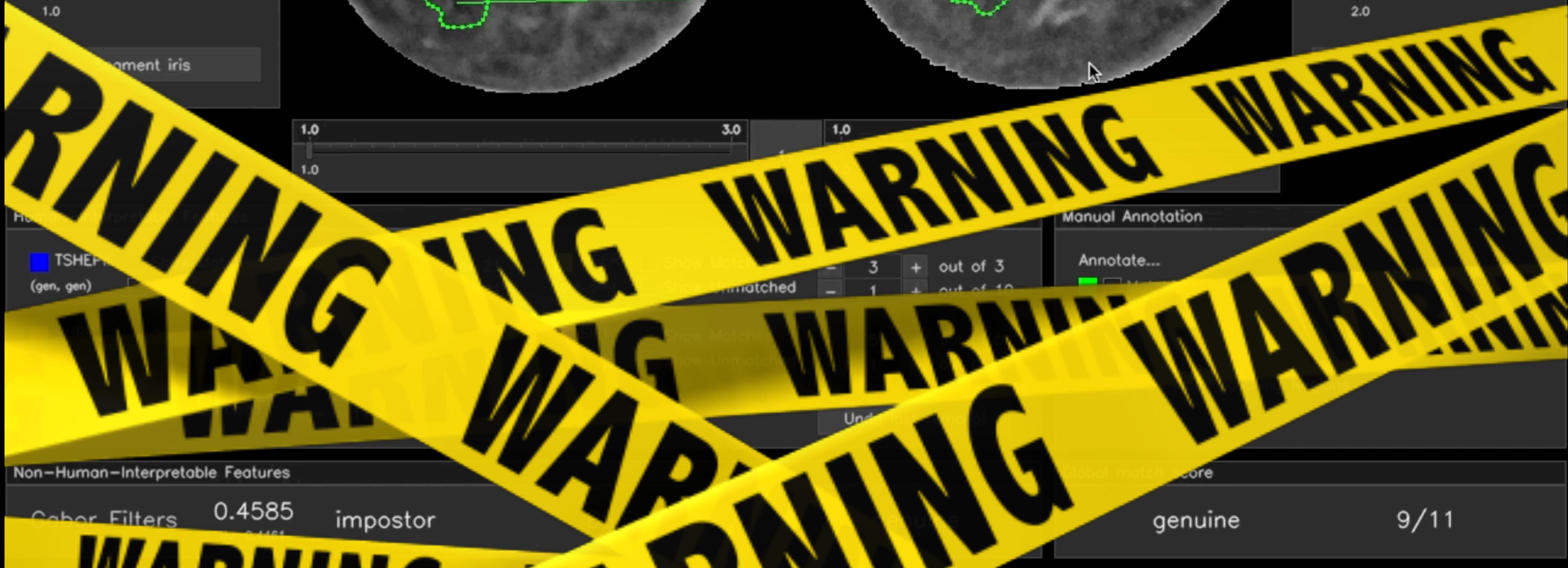
Save report

Quit program



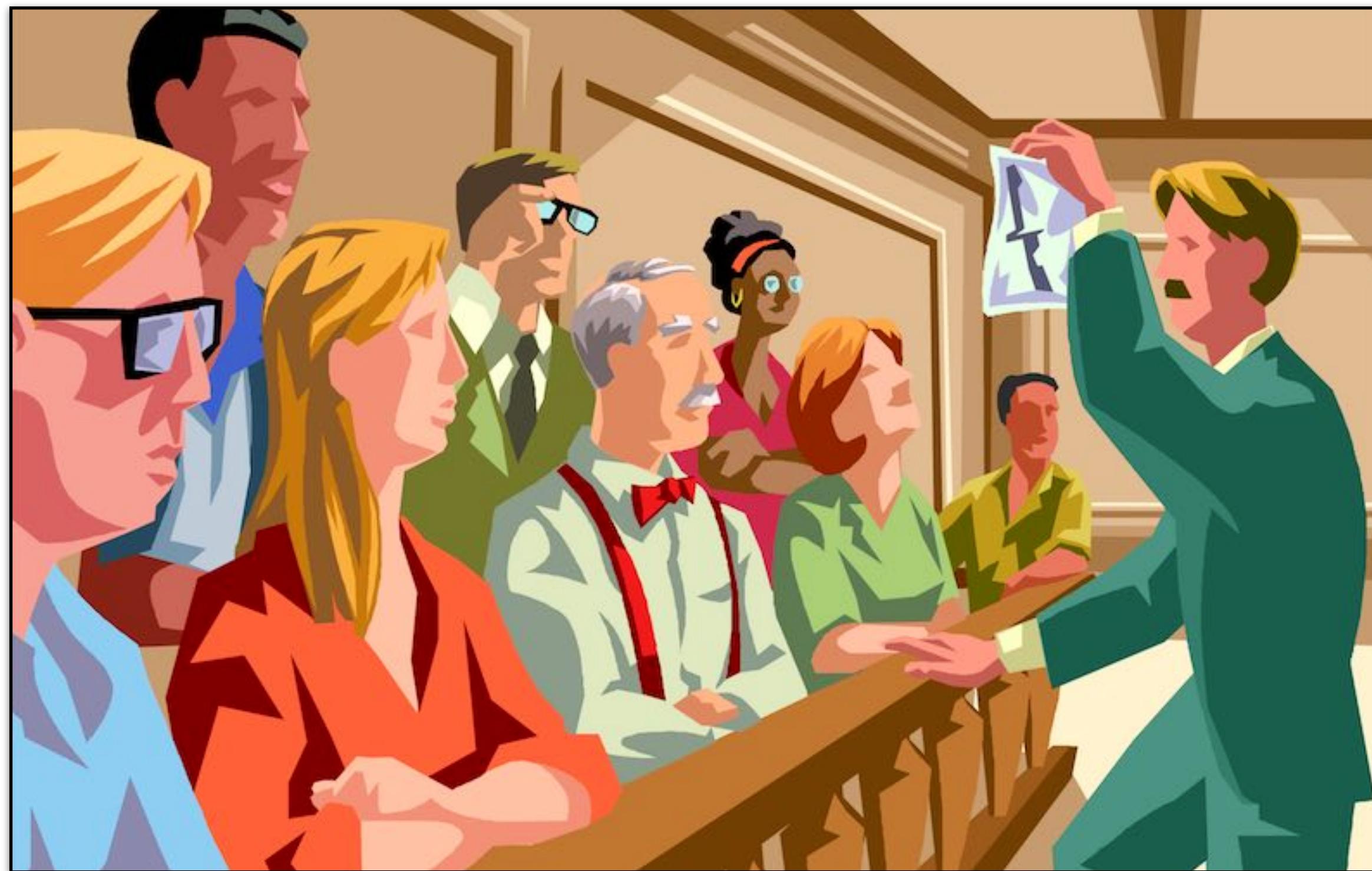
Tool Supporting the Human Examination of Post-Mortem Iris Images

<https://danielmoreira.github.io/project/tshepii/>



The Problem

Interpretable Iris Recognition



How to convince people who do not possess image processing expertise?

Load irises

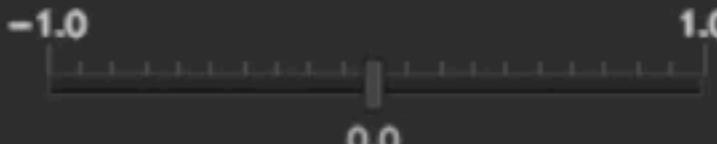
Load examination

Save examination

Save report

Quit program

Brightness



Contrast

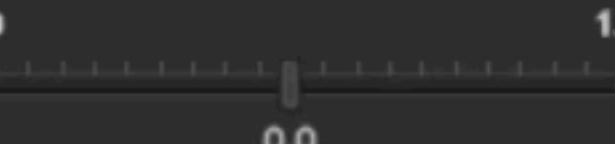


Sharpening



Segment iris

Brightness



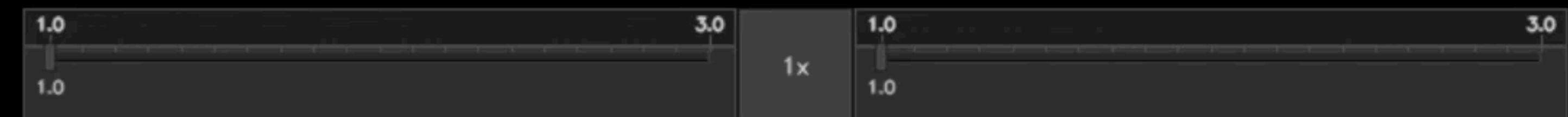
Contrast



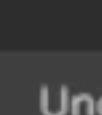
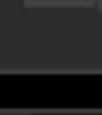
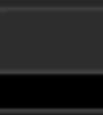
Sharpening



Segment iris



Human-Interpretable Features

<input checked="" type="checkbox"/> TSHEPII	<input type="checkbox"/> Show Matched		0		out of 0	<input checked="" type="checkbox"/> MSER	<input type="checkbox"/> Show Matched		0		out of 0
	<input type="checkbox"/> Show Unmatched		1		out of 0		<input type="checkbox"/> Show Unmatched		1		out of 0
<input checked="" type="checkbox"/> SURF	<input type="checkbox"/> Show Matched		0		out of 0	<input checked="" type="checkbox"/> SIFT	<input type="checkbox"/> Show Matched		0		out of 0
	<input type="checkbox"/> Show Unmatched		1		out of 0		<input type="checkbox"/> Show Unmatched		1		out of 0
<input checked="" type="checkbox"/> Crypts	<input type="checkbox"/> Show Matched		0		out of 0						

Undo last removal

Manual Annotation

Annotate...

Matching Regions Non-Matching Regions

Show Matching Regions Show Non-Matching Regions

Non-Human-Interpretable Features

Gabor Filters

thr: 0.4461

BSIF Filters

thr: 0.4216

Global match score

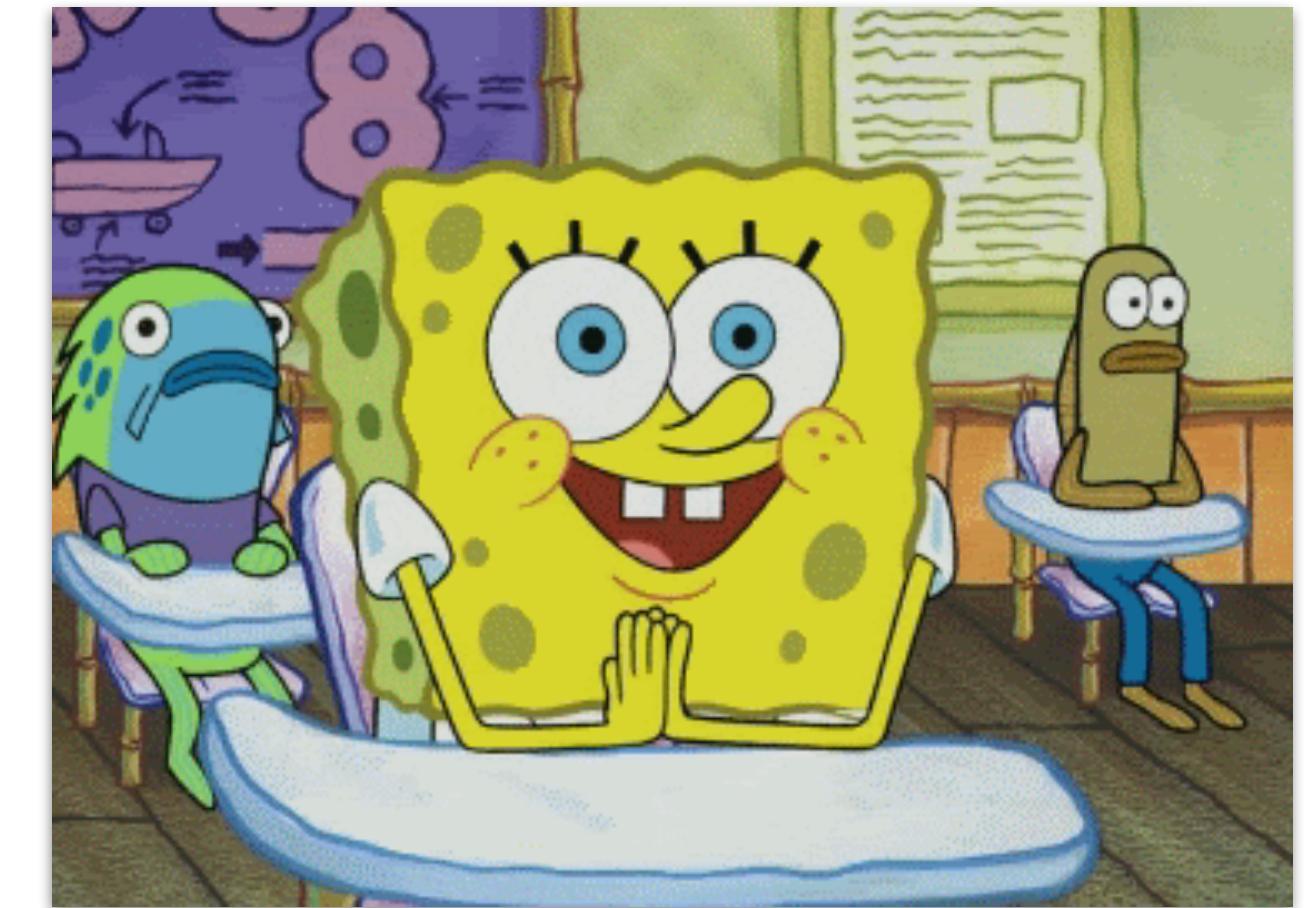
How about you?

Background

What is your career?

Can you code?

What is your preferred programming language?



Accommodation Needs

Please reach out to me in private ASAP.

We'll make things work.

What is Computer Vision?

What comes to your mind?



<https://bit.ly/3TqZdlg>



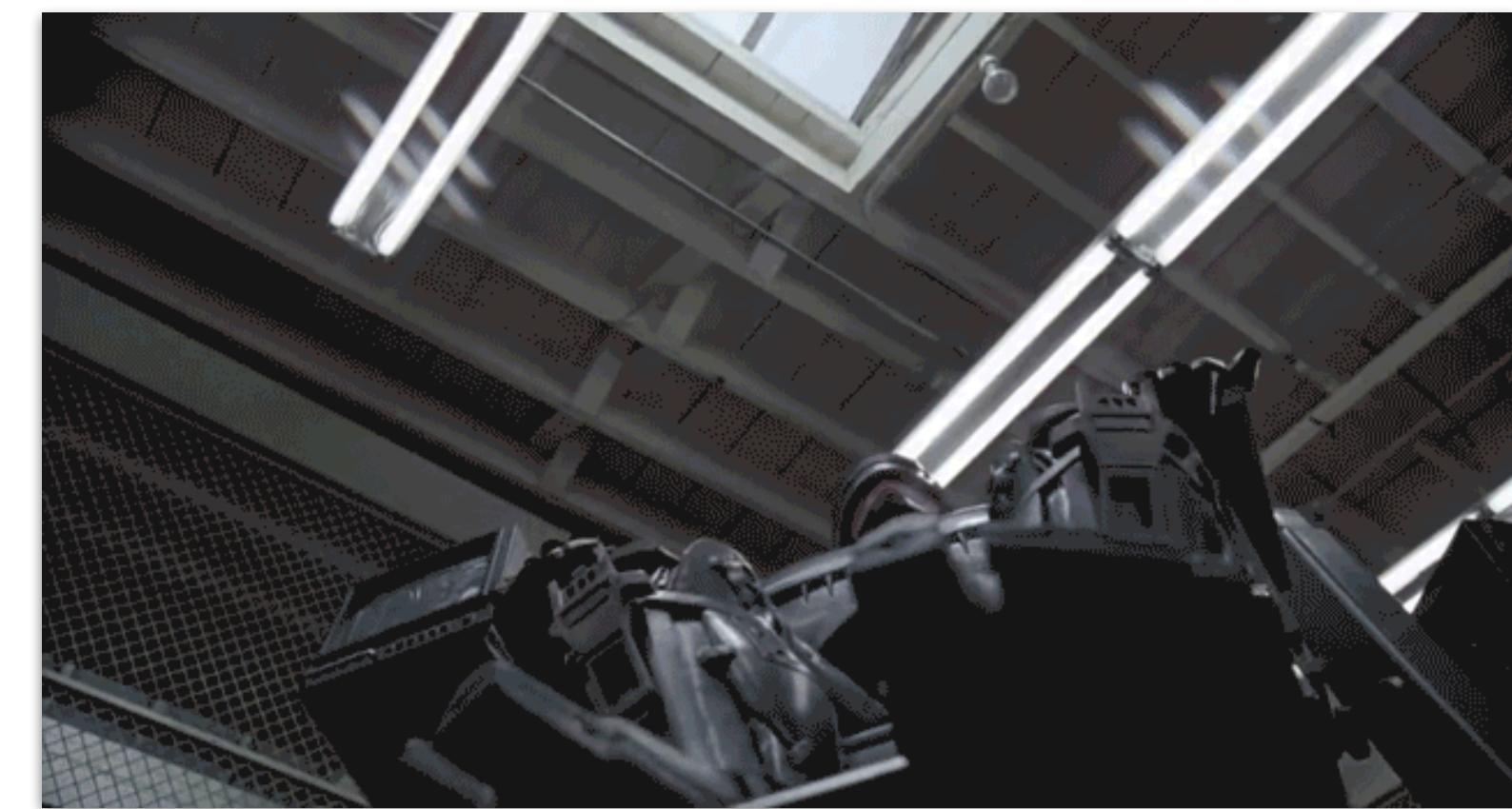
What is Computer Vision?

Computer Science Subfield

It aims at developing computer systems that mimic the human visual system.



Reference



Objective

What is Computer Vision?

Humans

By relying on images:

Reason about the world.

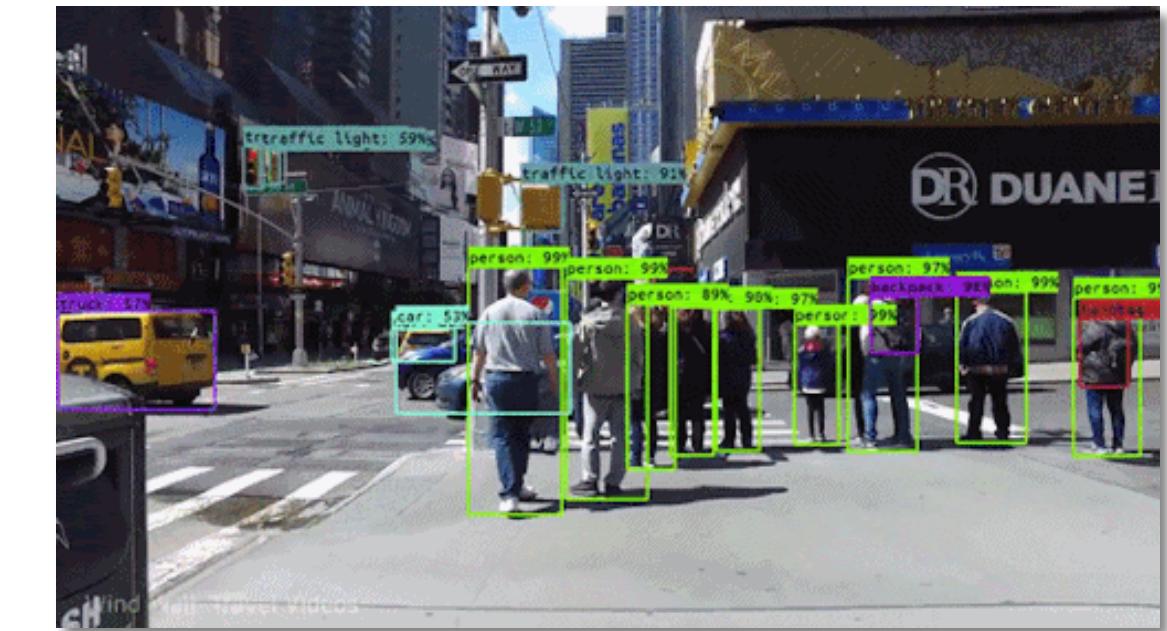
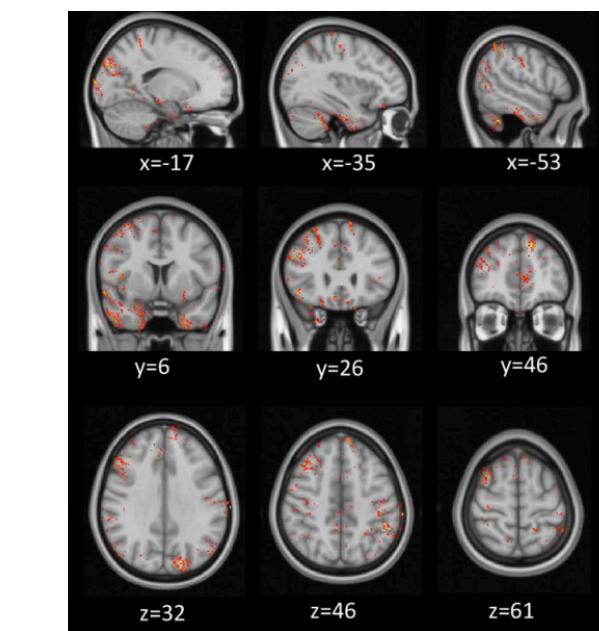
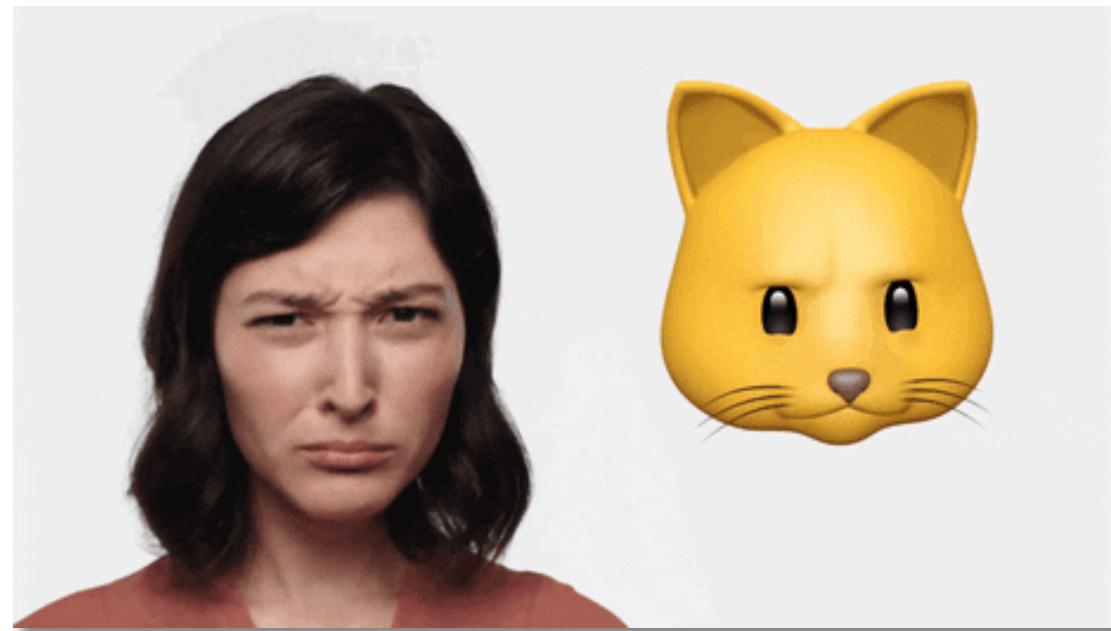
Navigate through the space.

Interact and communicate.



What is Computer Vision?

Computers
Are we quite there?



[1]

[1] Folego et al., Alzheimer's Disease Detection Through Whole-Brain 3D-CNN MRI
Frontiers in Bioeng. and Biotech.

What is Computer Vision?



<https://www.wired.com/story/10-year-old-face-id-unlocks-mothers-iphone-x/>



<https://youtu.be/tpOg87AQvbo>

What is Computer Vision?

And to make things worse...



The BBC News website features a story titled "Row over AI that 'identifies gay faces'". The article is dated 11 September 2017. To the right of the news article is a graphic titled "Composite heterosexual faces" showing four composite faces (two male, two female) and a diagram illustrating facial feature analysis, specifically focusing on differences between gay and straight faces.

BBC NEWS

Tech

Row over AI that 'identifies gay faces'

11 September 2017

STANFORD UNIVERSITY

The study created composite faces judged most and least likely to belong to homosexuals

<https://www.bbc.com/news/technology-41188560>

What is Computer Vision?

Digital Image Foundation

Digital Image

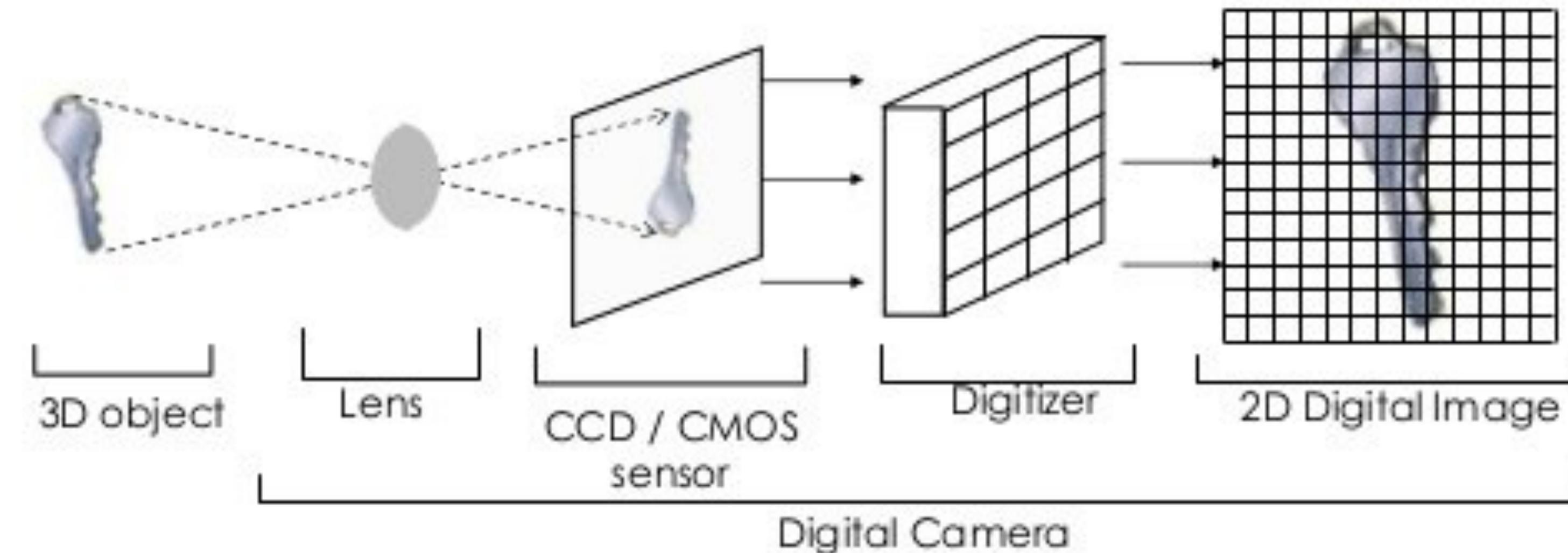
*Matrix of
pixels*



What is Computer Vision?

Digital Image

Acquisition Process



CCD: charged coupled device (old technology)

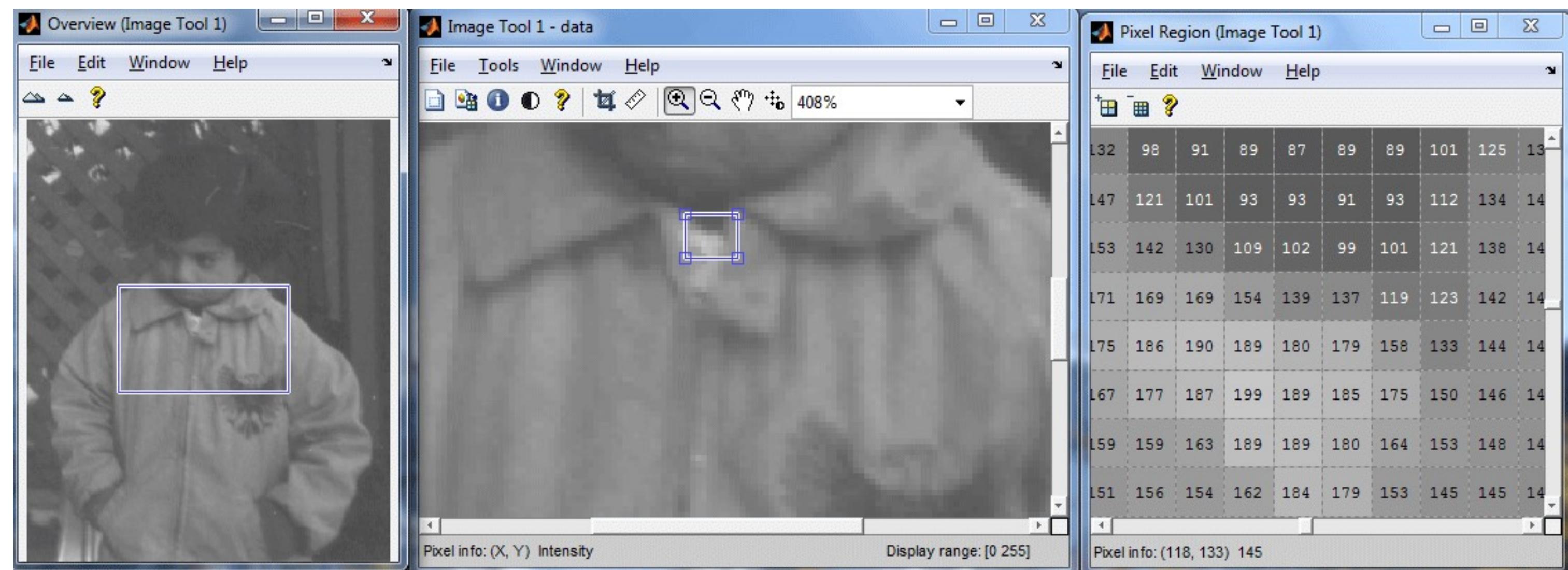
CMOS: complementary metal-oxide semiconductor (current technology)

Sharma, N. *What is an image and how images are made?* Quora, 2018

What is Computer Vision?

Digital Image

Data Structure
Matrix of pixels

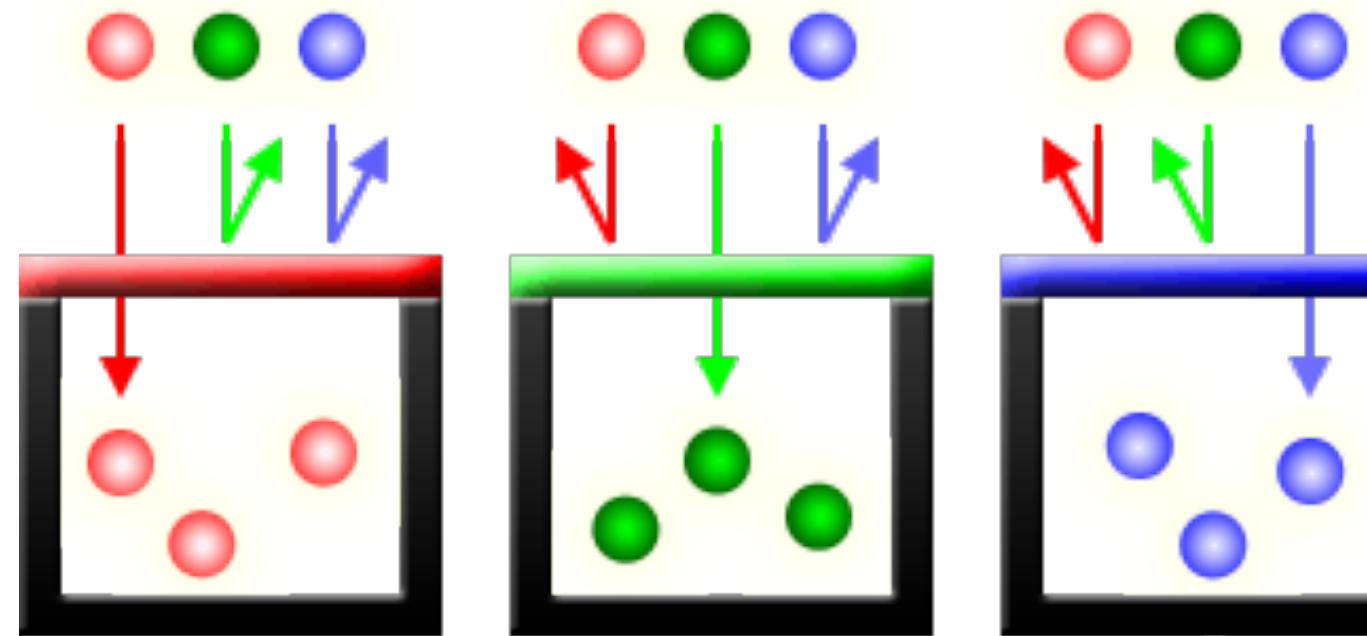
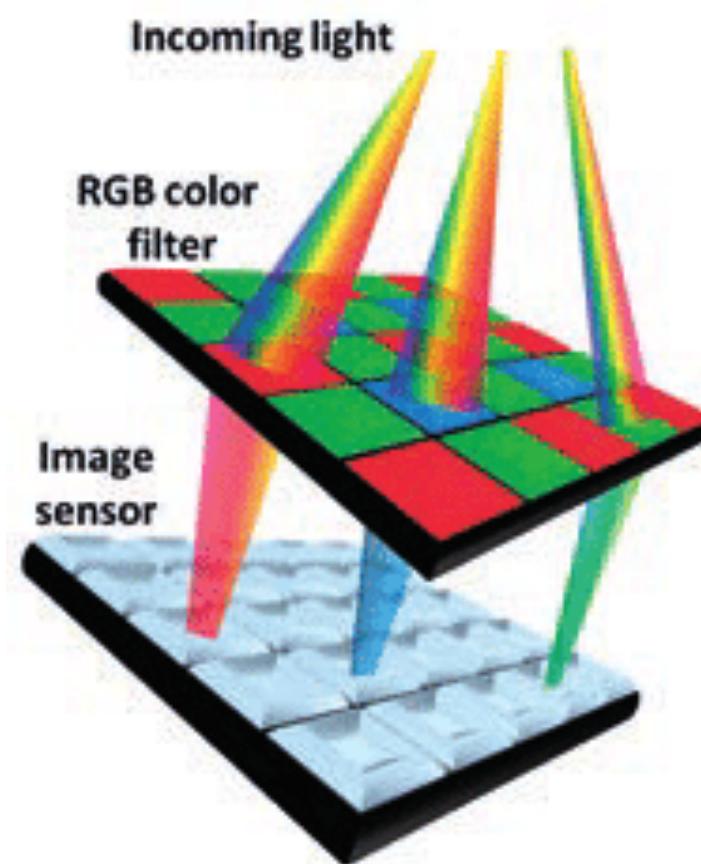


Sharma, N. *What is an image and how images are made?* Quora, 2018

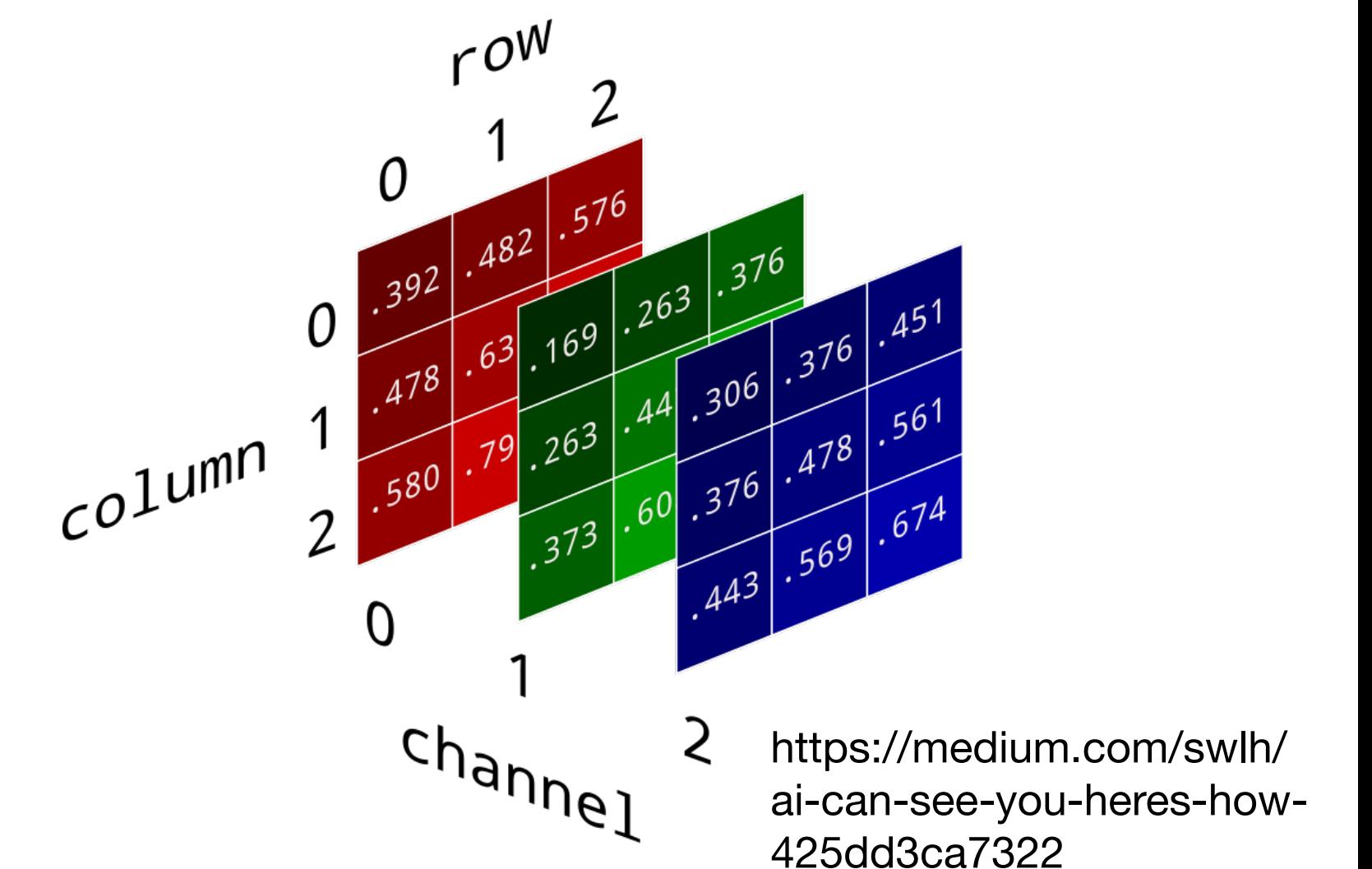
What is Computer Vision?

Digital Image

Multiple Channels
Red, Green, Blue (RGB)



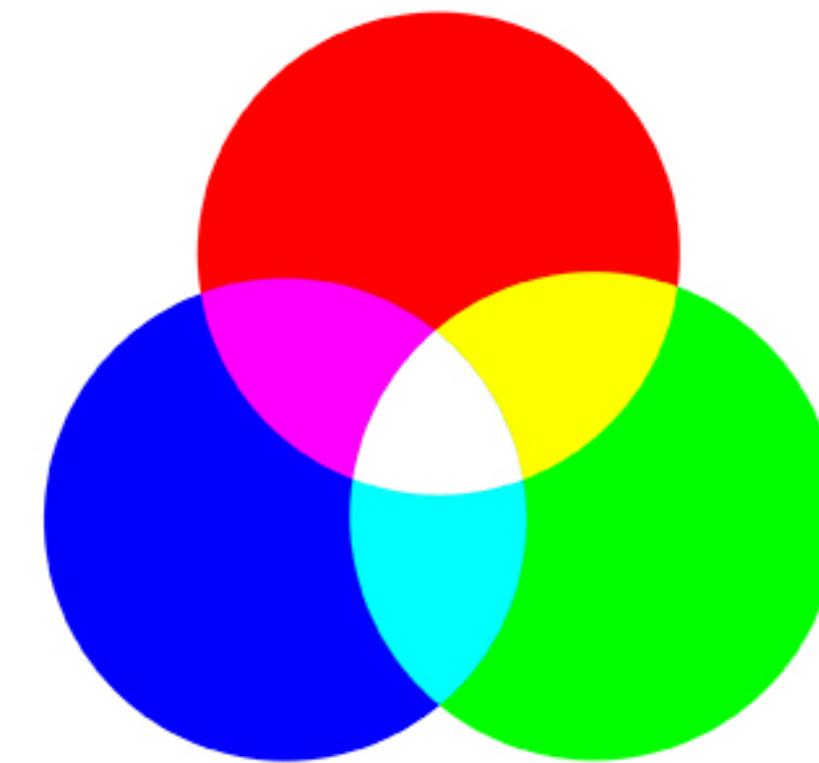
<https://www.red.com/red-101/bayer-sensor-strategy>



What is Computer Vision?

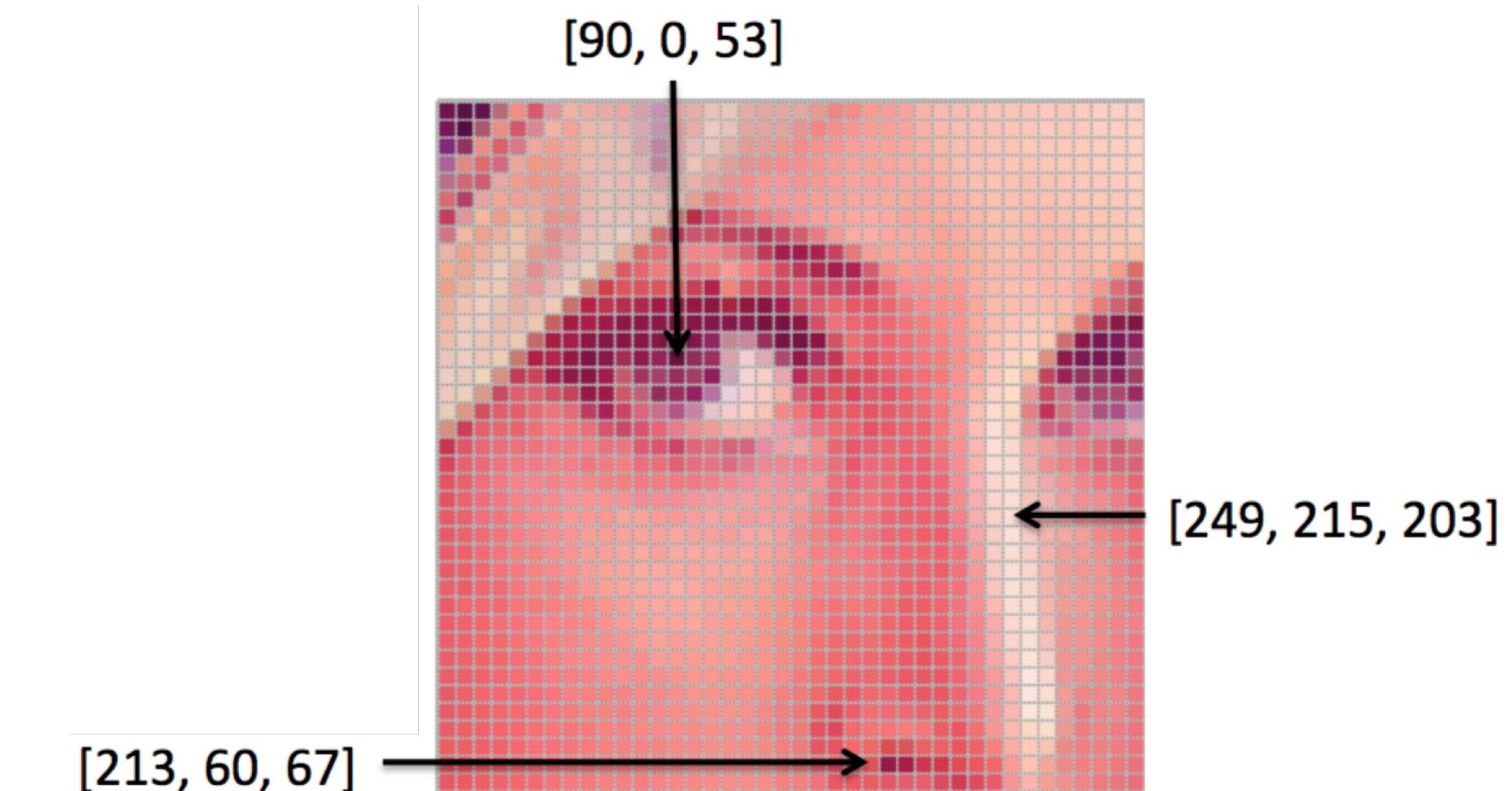
Digital Image

Multiple Channels
Red, Green, Blue (RGB)



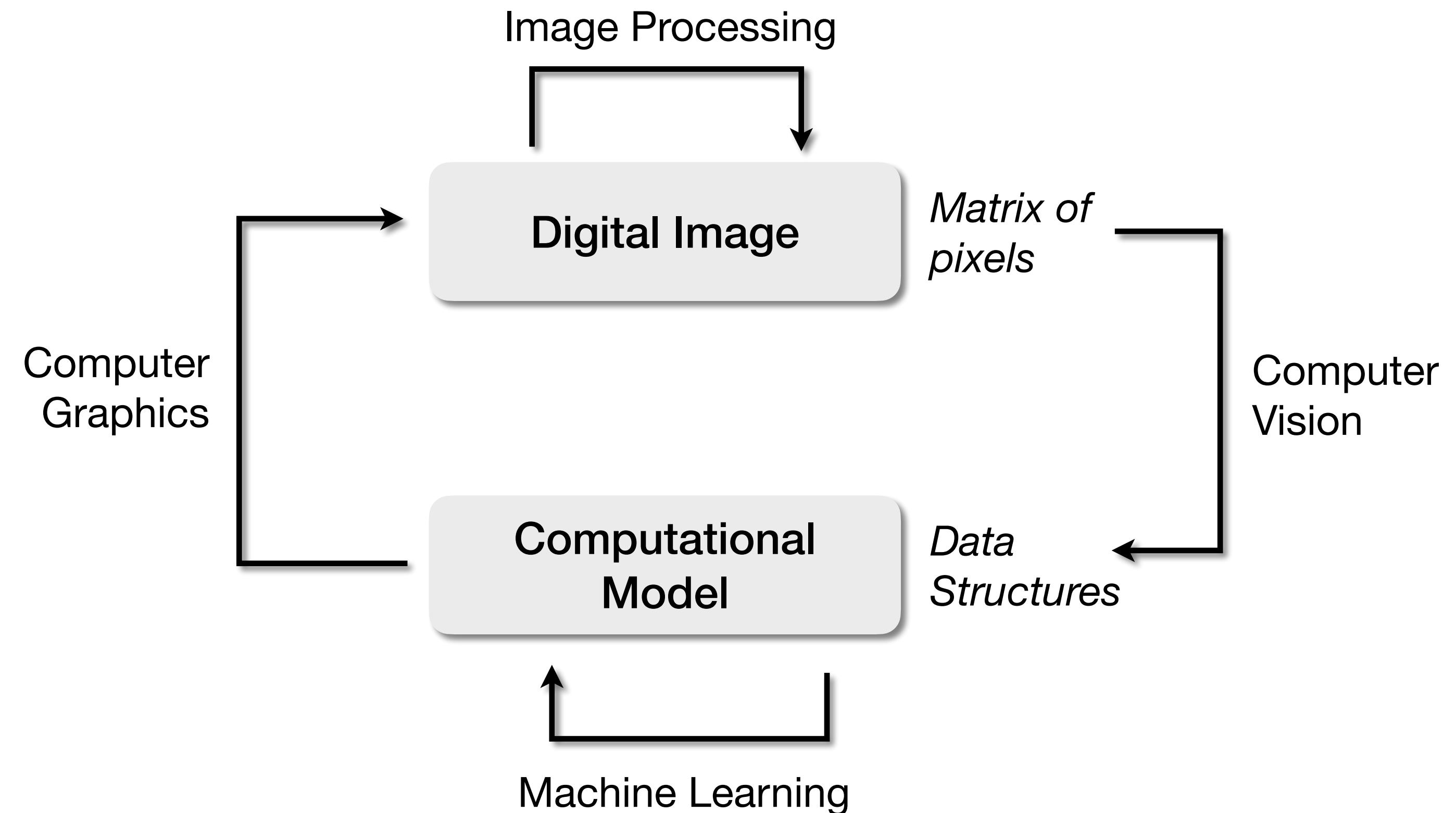
$$\begin{array}{l} \text{Blue} + \text{Green} = \text{Cyan} \\ \text{Red} + \text{Blue} = \text{Magenta} \\ \text{Green} + \text{Red} = \text{Yellow} \\ \text{Red} + \text{Green} + \text{Blue} = \text{White} \end{array}$$

<https://br24.com/en/rgb-cmyk-differences/>



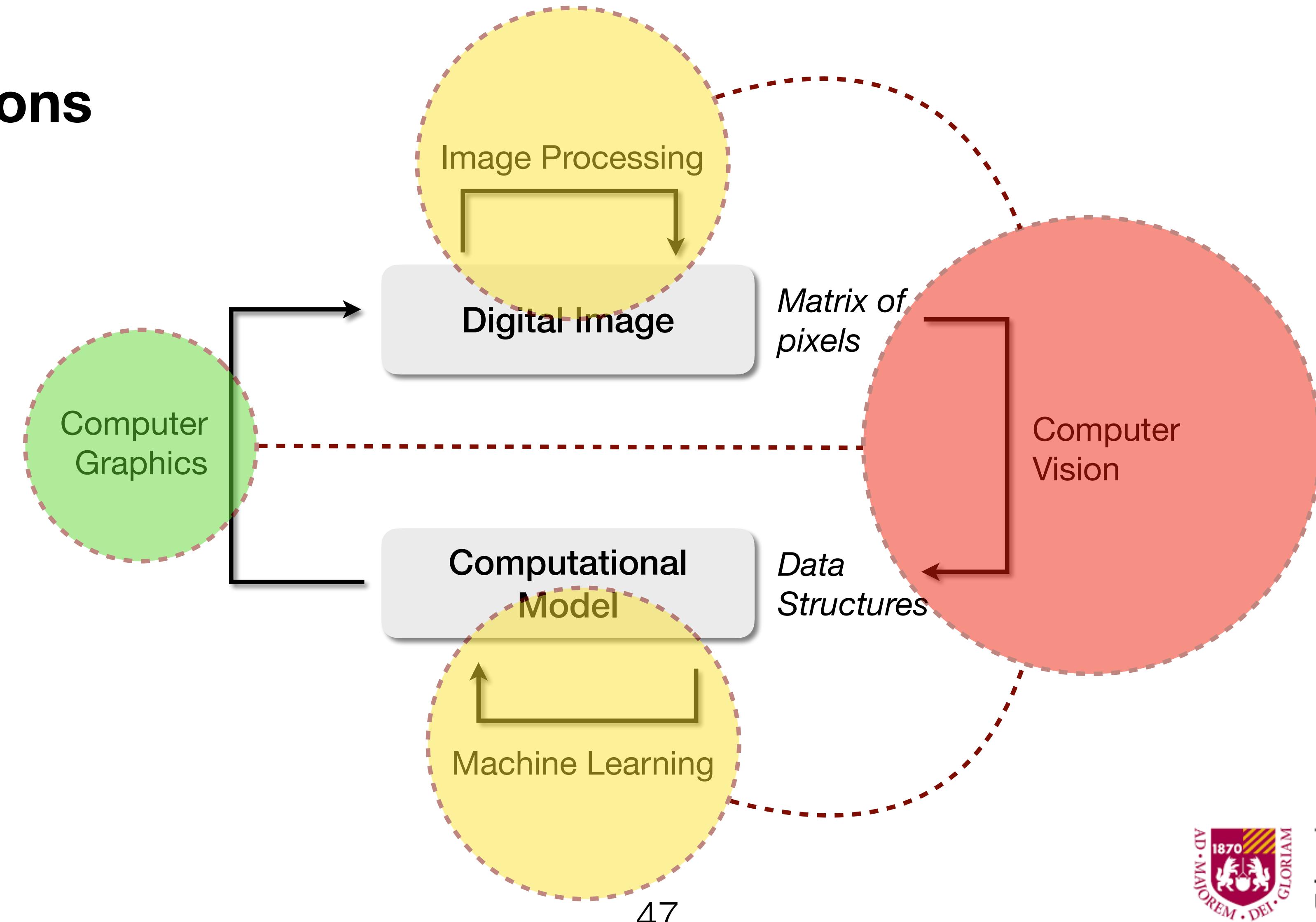
<https://ai.stanford.edu/~syyeung/cvweb/tutorial1.html>

What is Computer Vision?



What is Computer Vision?

Applications



What is Computer Vision?

Typical Tasks

Image Classification

Assign label to an entire image.



cat, 0.95

What is Computer Vision?

Typical Tasks

Image Retrieval

Provide an image (query).

Receive **related** images (gallery).



query

What is Computer Vision?

Typical Tasks

Image Retrieval

Provide an image (query).

Receive **related** images (gallery).

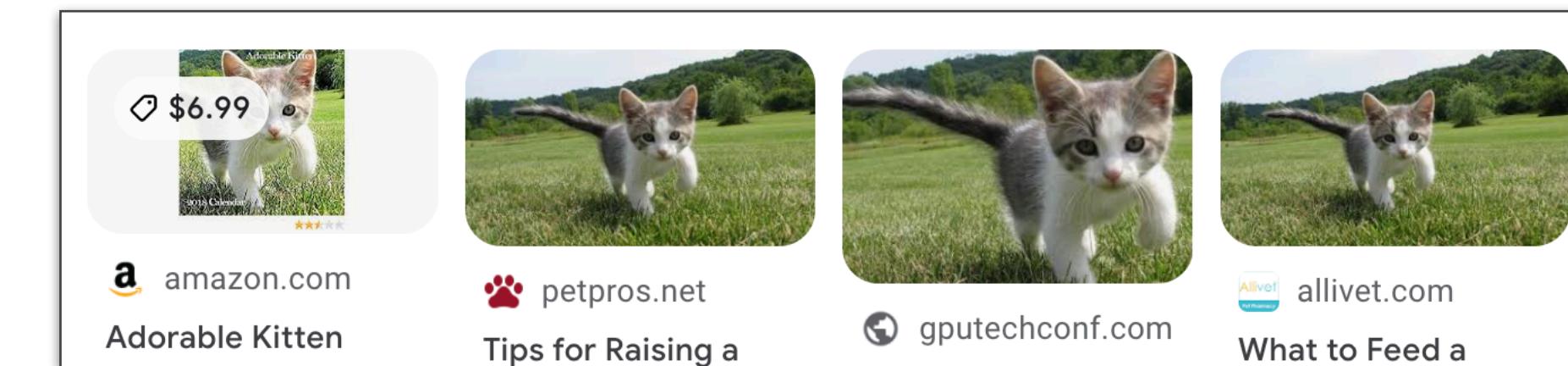


query

Related (depending on the application)

Near-duplicates

(same imaging pipeline)



gallery

What is Computer Vision?

Typical Tasks

Image Retrieval

Provide an image (query)

Receive **related** images (gallery)

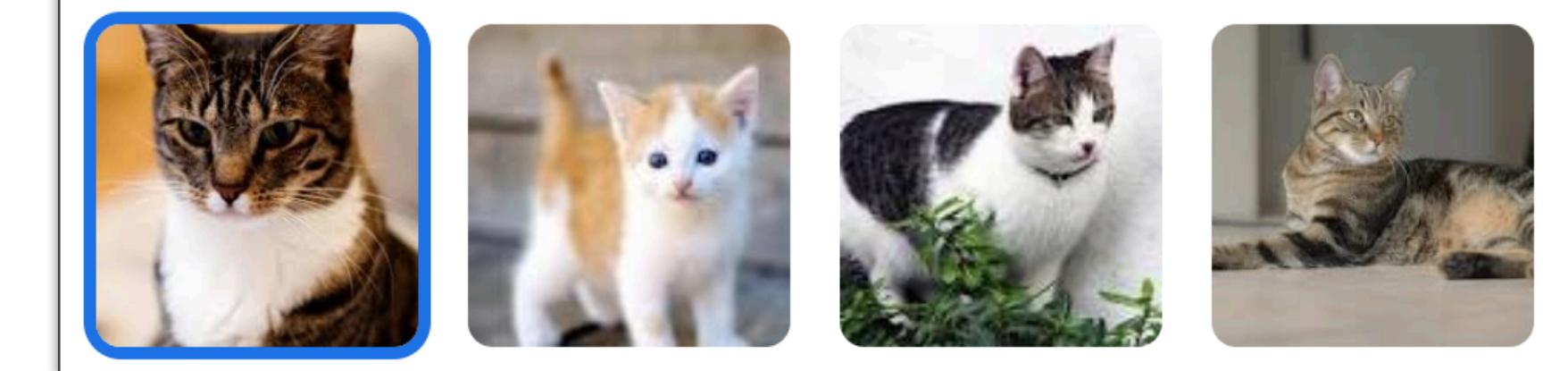


query

Related (depending on the application)

Near-duplicates

Semantically similar



gallery

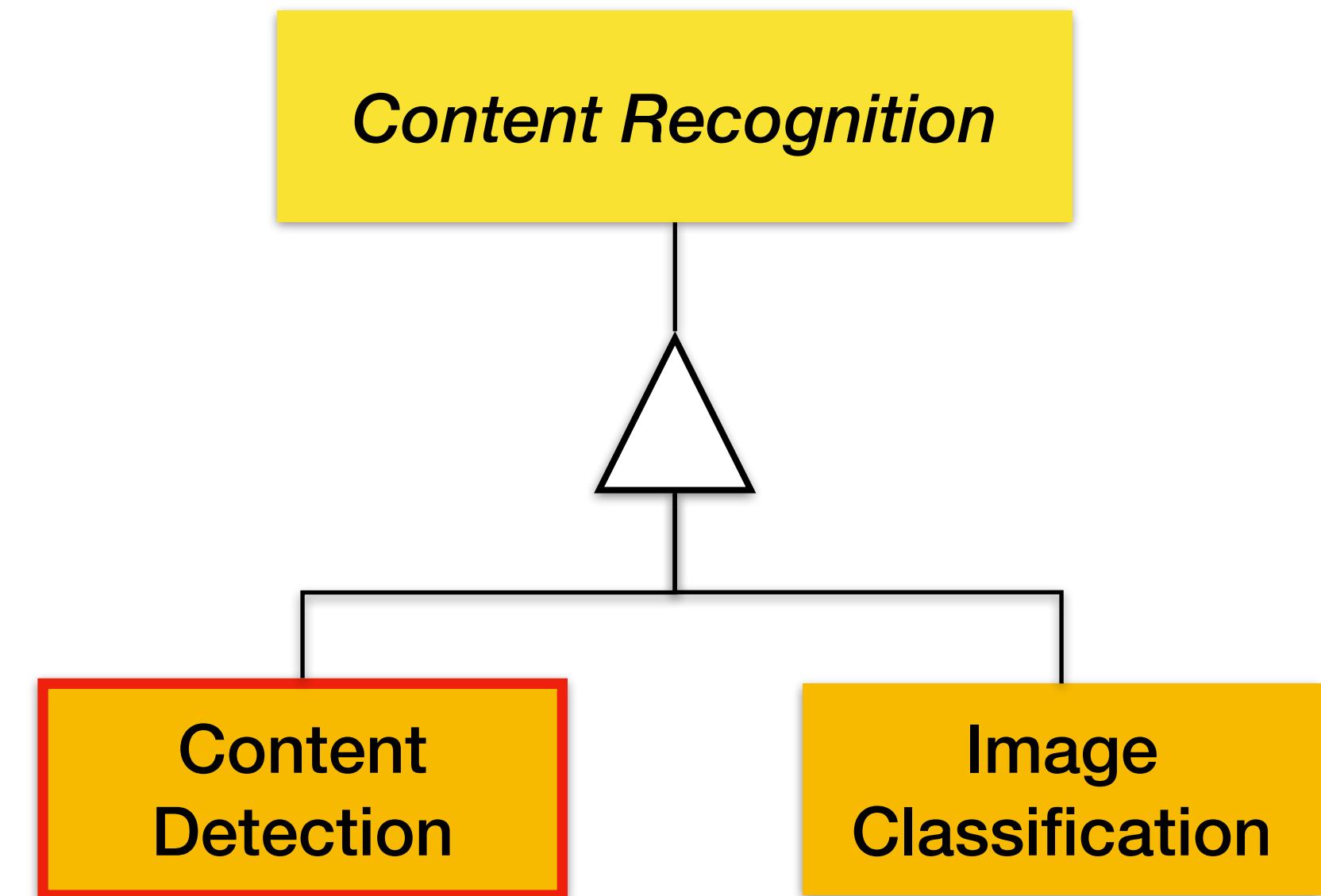
What is Computer Vision?

Typical Tasks

Content Recognition

Image Classification

Content Detection/Localization



cat

What is Computer Vision?

Typical Tasks

Content Recognition

Image Classification

Content Detection/Localization



dog

dog

Cat

Li, F-F., Johnson, J., and Yeung, S. *Detection and Segmentation*.
Stanford University, 2017



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What is Computer Vision?

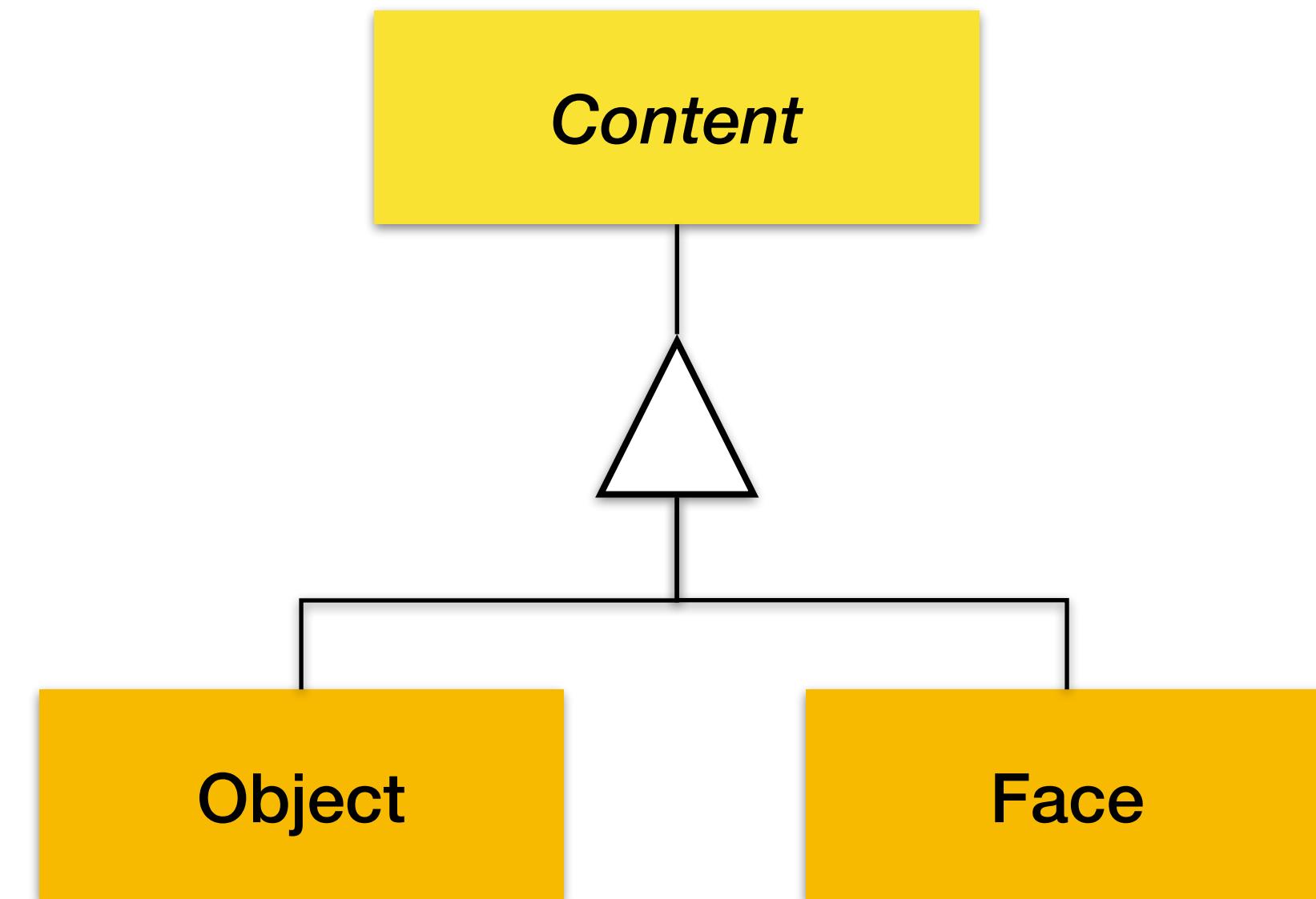
Typical Tasks

Content Recognition

Image Classification

Content Detection/Localization

Focus is mostly on the **label**
rather than the **instance**
(e.g., *this is a cat* rather than
this is my cat).



What is Computer Vision?

Typical Tasks

Image Segmentation



Li, F-F., Johnson, J., and Yeung, S. *Detection and Segmentation*.
Stanford University, 2017

What is Computer Vision?

Typical Tasks

Image Segmentation

Semantic Segmentation

(each pixel receives a label)



Arnab, A., et al. *Conditional Random Fields Meet Deep Neural Network for Semantic Segmentation...* IEEE Signal Processing Magazine 35 (1), 2018

What is Computer Vision?

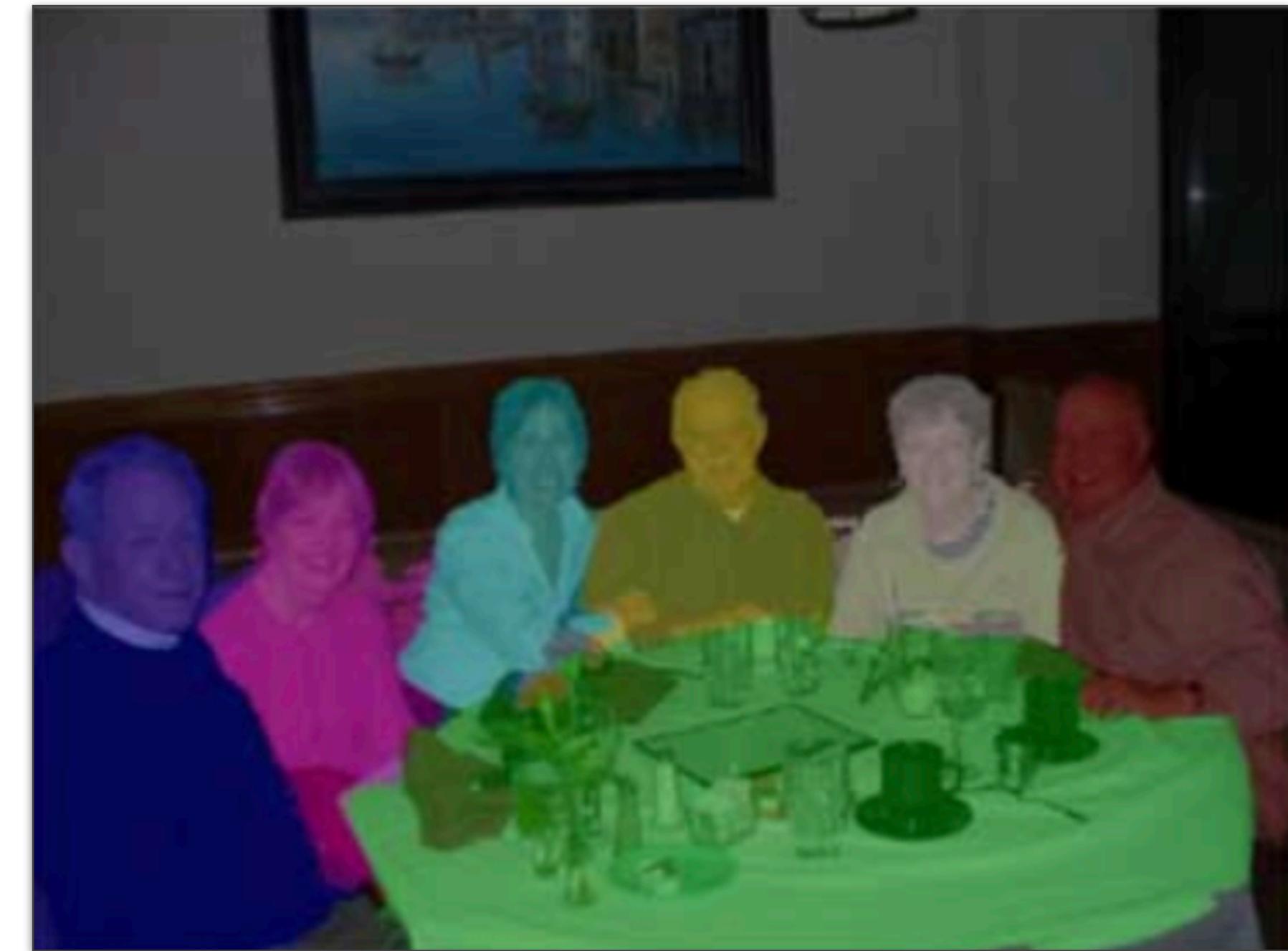
Typical Tasks

Image Segmentation

Semantic Segmentation

Instance Segmentation

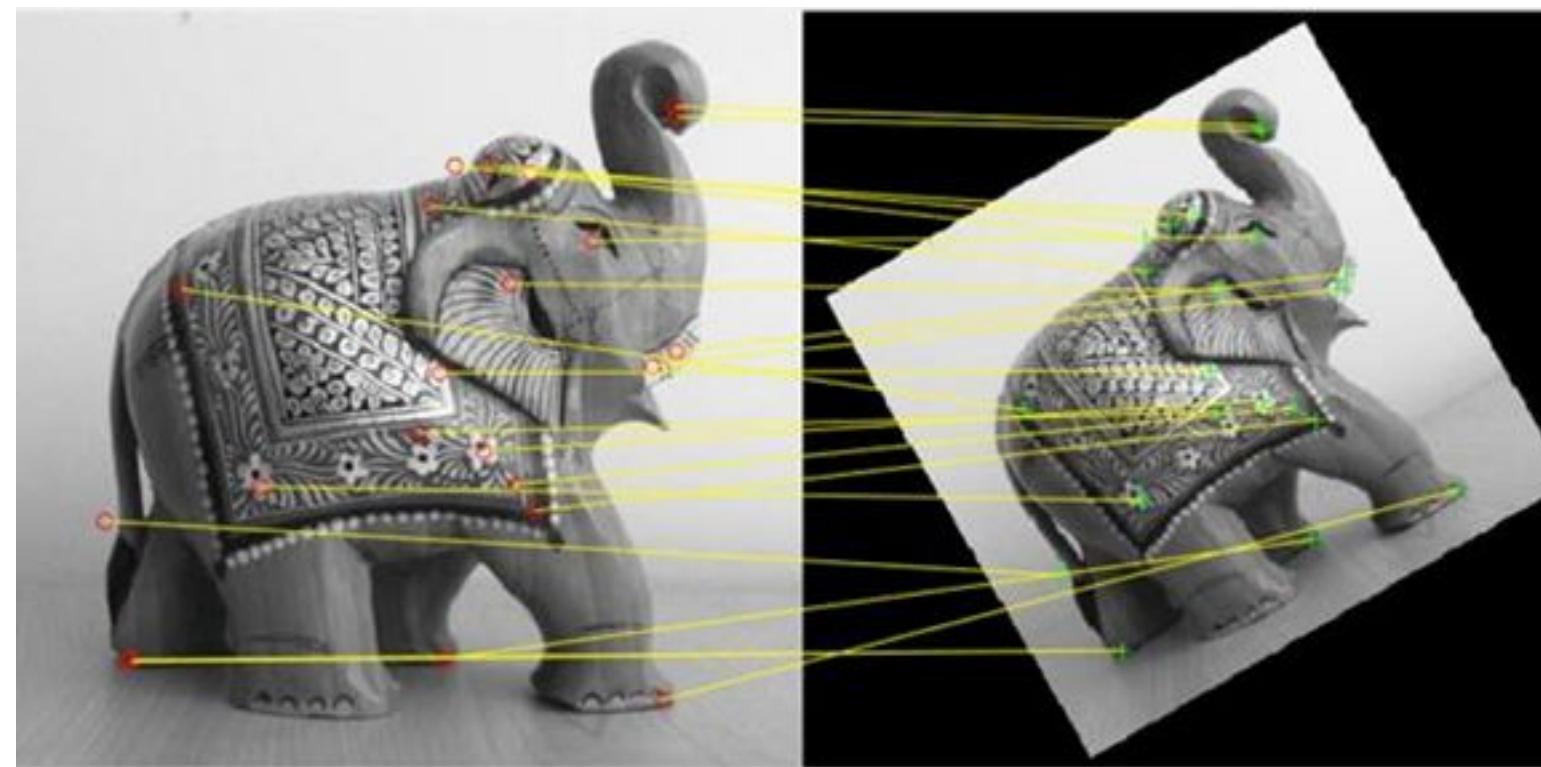
(individual objects are segmented)



Arnab, A., et al. *Conditional Random Fields Meet Deep Neural Network for Semantic Segmentation...* IEEE Signal Processing Magazine 35 (1), 2018

Computer Vision Tasks

Image Registration



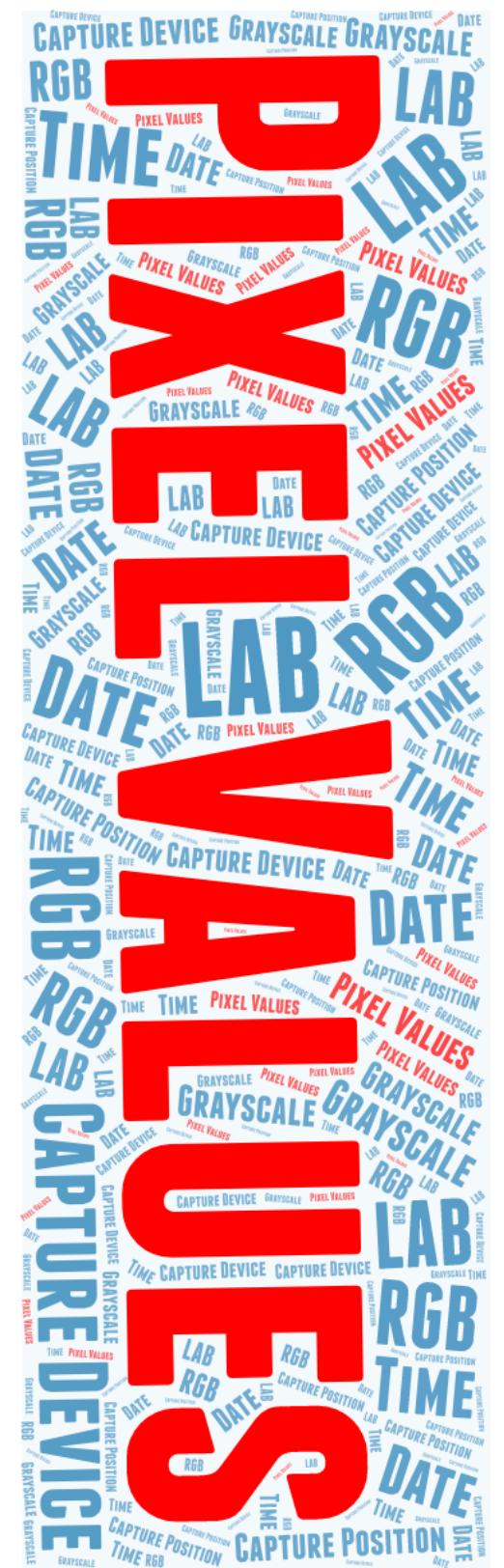
Interest-point Matching



Registration

<https://www.mathworks.com/discovery/image-registration.html>

Semantic Gap



Level 0



Task

Semantic Gap



Level 0

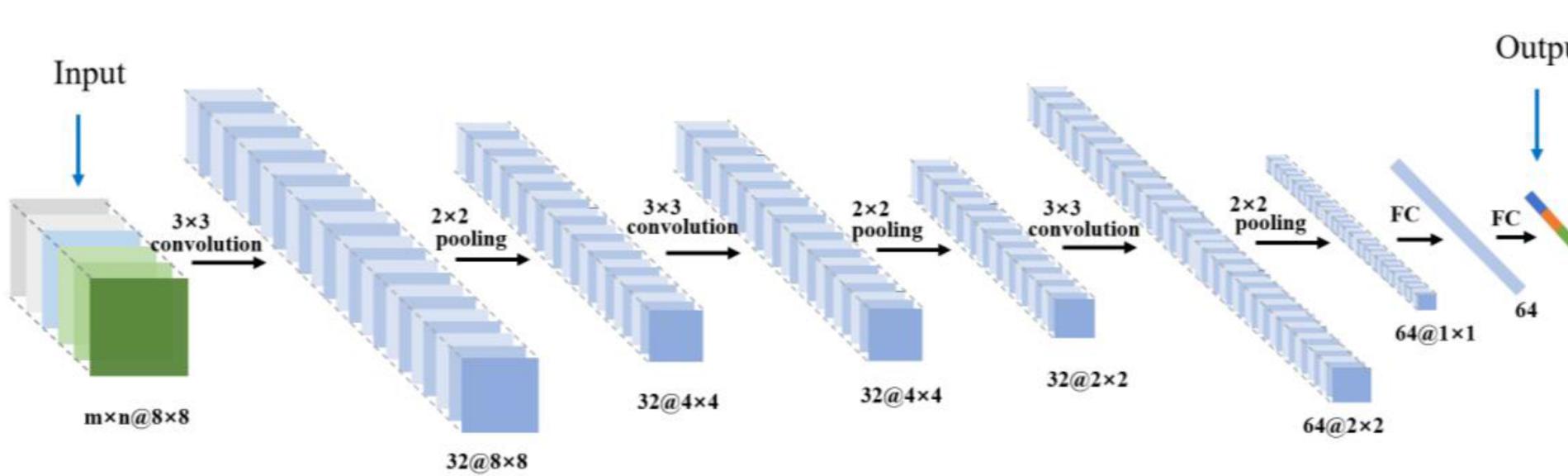
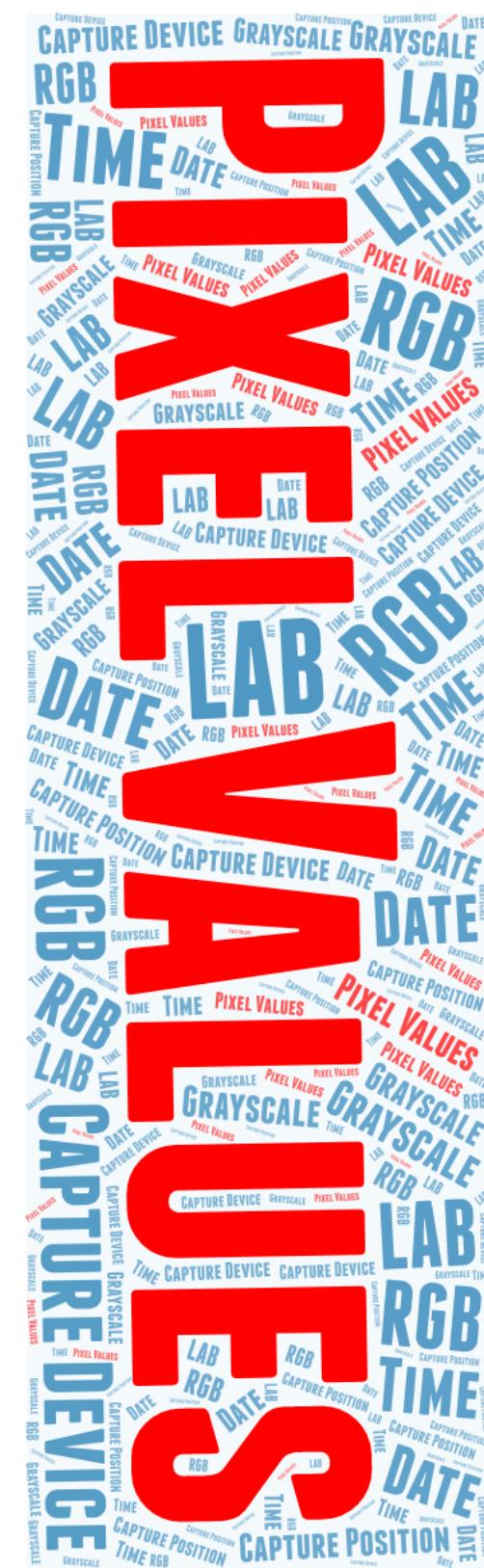
Level 1

Level 2

Level 3

Task

Semantic Gap



Deep Learning

Level 0



Task

Be Careful

August 14, 2019

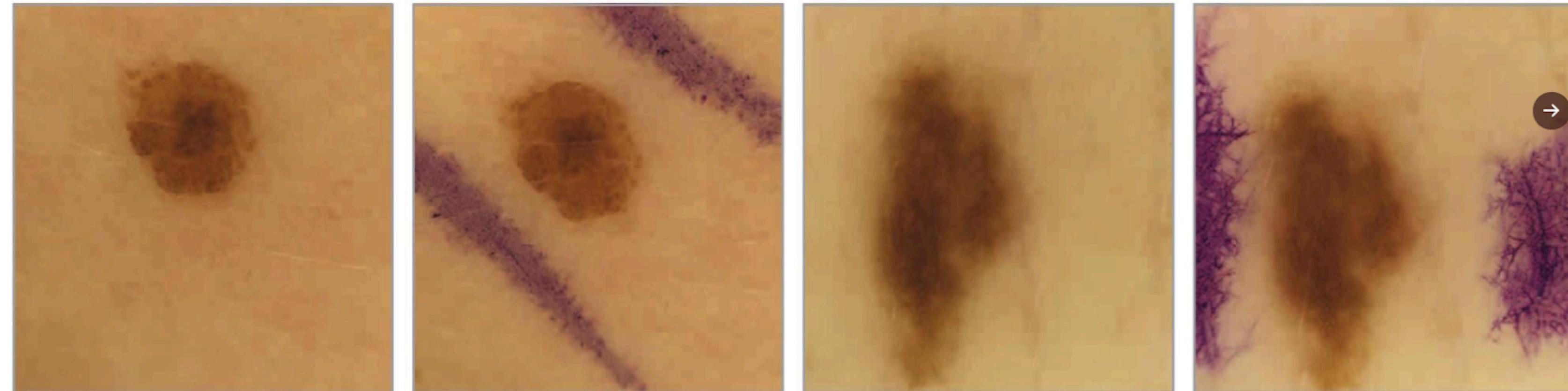
Association Between Surgical Skin Markings in Dermoscopic Images and Diagnostic Performance of a Deep Learning Convolutional Neural Network for Melanoma Recognition

Julia K. Winkler, MD¹; Christine Fink, MD¹; Ferdinand Toberer, MD¹; [et al](#)

[» Author Affiliations](#) | [Article Information](#)

JAMA Dermatol. 2019;155(10):1135-1141. doi:10.1001/jamadermatol.2019.1735

What is the network learning?



Course Overview

What are your expectations?



<https://bit.ly/3pRwcYM>



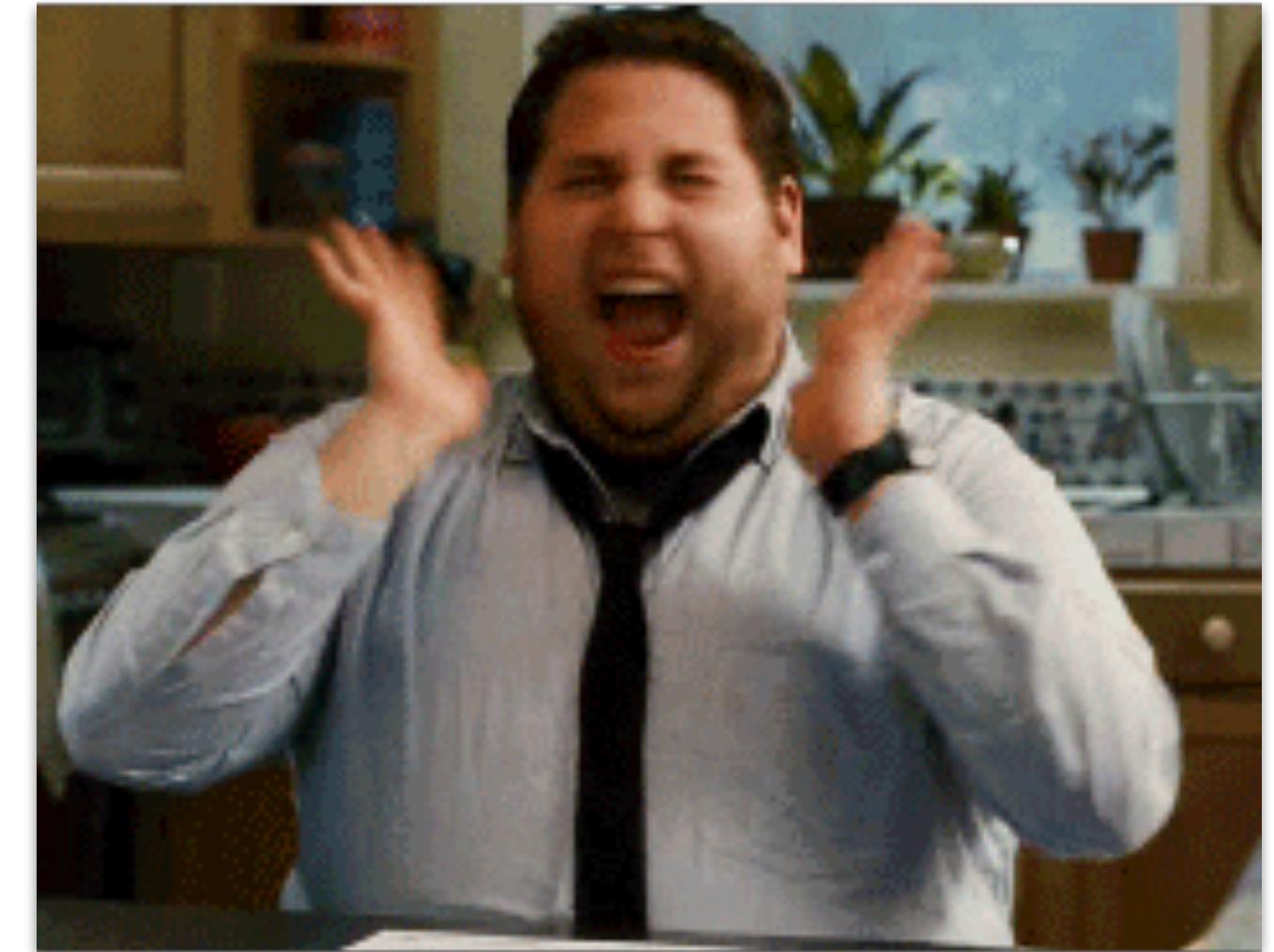
Course Overview

Structure

12 lectures in seminar format.
Presentation of scientific articles
and further discussion.

Workload

8/10 assignments (article summarization).
2 topic presentations.
1 exam (final in oral quiz format).



Course Overview

Assignments

Article Summarization

Pick one from the group.
No limit of pages.

Roadmap (suggested)

What is the problem addressed in the article?

Why is it important to address this problem?

How do the authors address the problem?

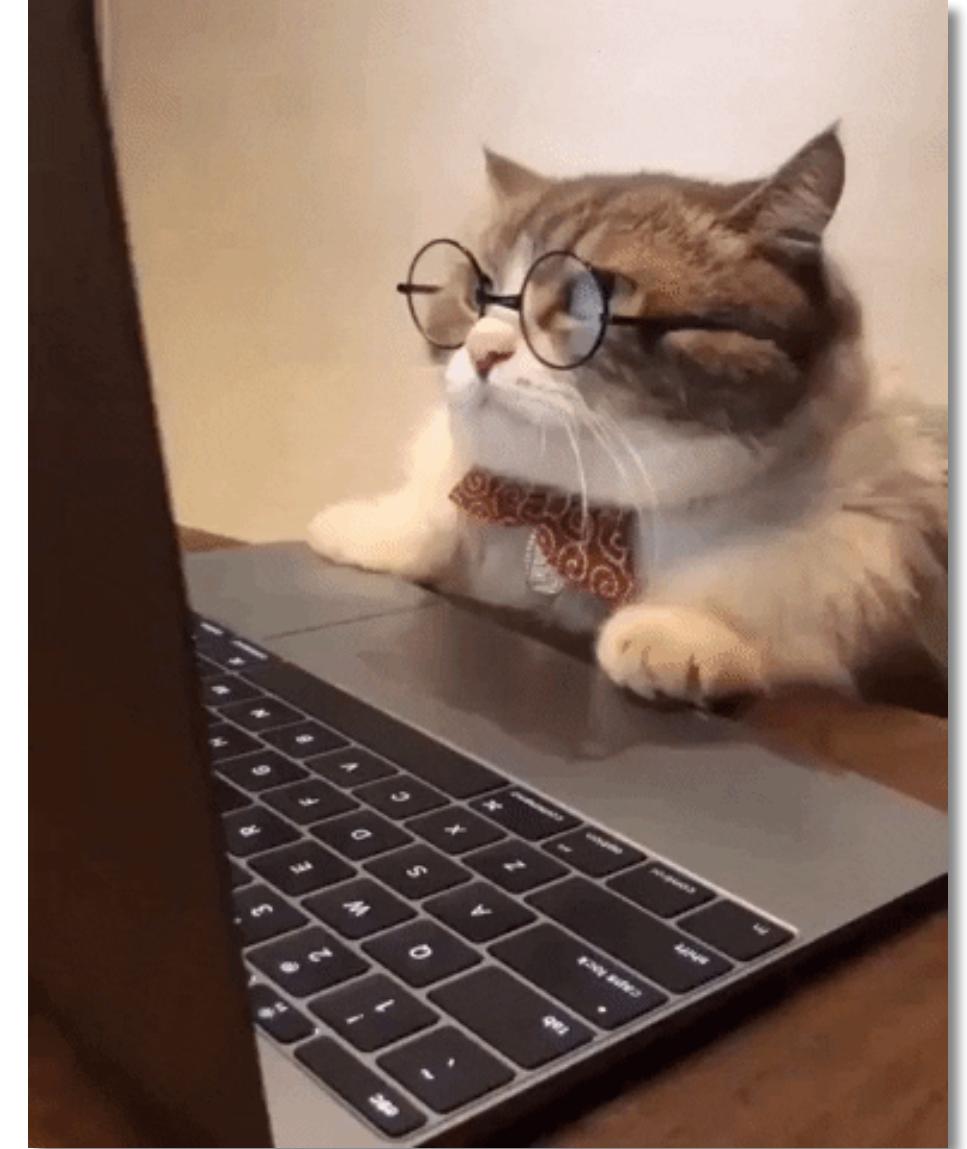
What are the authors' **claims**?

What **methodology** did they adopt (e.g., datasets, metrics, experiments)?

Do you agree with the authors' claims?

How can you leverage this work in your research?

What open questions do you have about the article?



Course Overview

Seminars

Topic Presentation and Discussion Leadership

1.5-hour presentation.

One to many articles.



Work in groups

(preferably one graduate and one undergraduate folk).

Early access to other students' article summaries
and questions.

Free format.

Bringing demonstration will give special points.



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Course Overview

Content

Date	Topic	Leader	Assignment
08/29	Introduction to CV	Instructor	N.A.
09/05	<i>Labor Day</i>	N.A.	A01, due on 09/13
09/12	Letter Soup: AI, ML, NN, and DL	Instructor	A02, due on 09/20
09/19	Local and Global Descriptors	Instructor	A03, due on 09/27
09/26	CBIR and Indexing	TBD (students)	A04, due on 10/04
10/03	Image Classification	TBD (students)	A05, due on 10/18
10/10	<i>Fall Break</i>	N.A.	N.A.

Date	Topic	Leader	Assignment
10/17	Object Detection	TBD (students)	A06, due on 10/25
10/24	Image Segmentation	TBD (students)	A07, due on 11/01
10/31	Face Detection	TBD (students)	A08, due on 11/08
11/07	Face Verification	TBD (students)	A09, due on 11/15
11/14	GANs and Generative DL	TBD (students)	A10, due on 11/29
11/21	Deep and Cheap Fakes	Instructor	N.A.
11/28	Sensitive Media Analysis	Instructor	N.A.
12/05	Provenance Analysis	TBD (students)	N.A.
12/12	<i>Final Exam</i>	N.A.	N.A.

Course Overview

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12/12	<i>Final Exam</i>	N.A.	N.A.

Course Overview

Grading

Total: 100 points

Class presence and participation: 6 points (x13)

Assignments: 1 point (x8)

Seminar: 3 points (x2)

Final exam: 8 points

CV on the news: 1 point (extra)

Demonstration: 5 points (extra)

Late assignments: -1 point per day

Concepts

A [94, 100]

B+ [88, 89]

C+ [78, 79]

D [60, 69]

A- [90, 93]

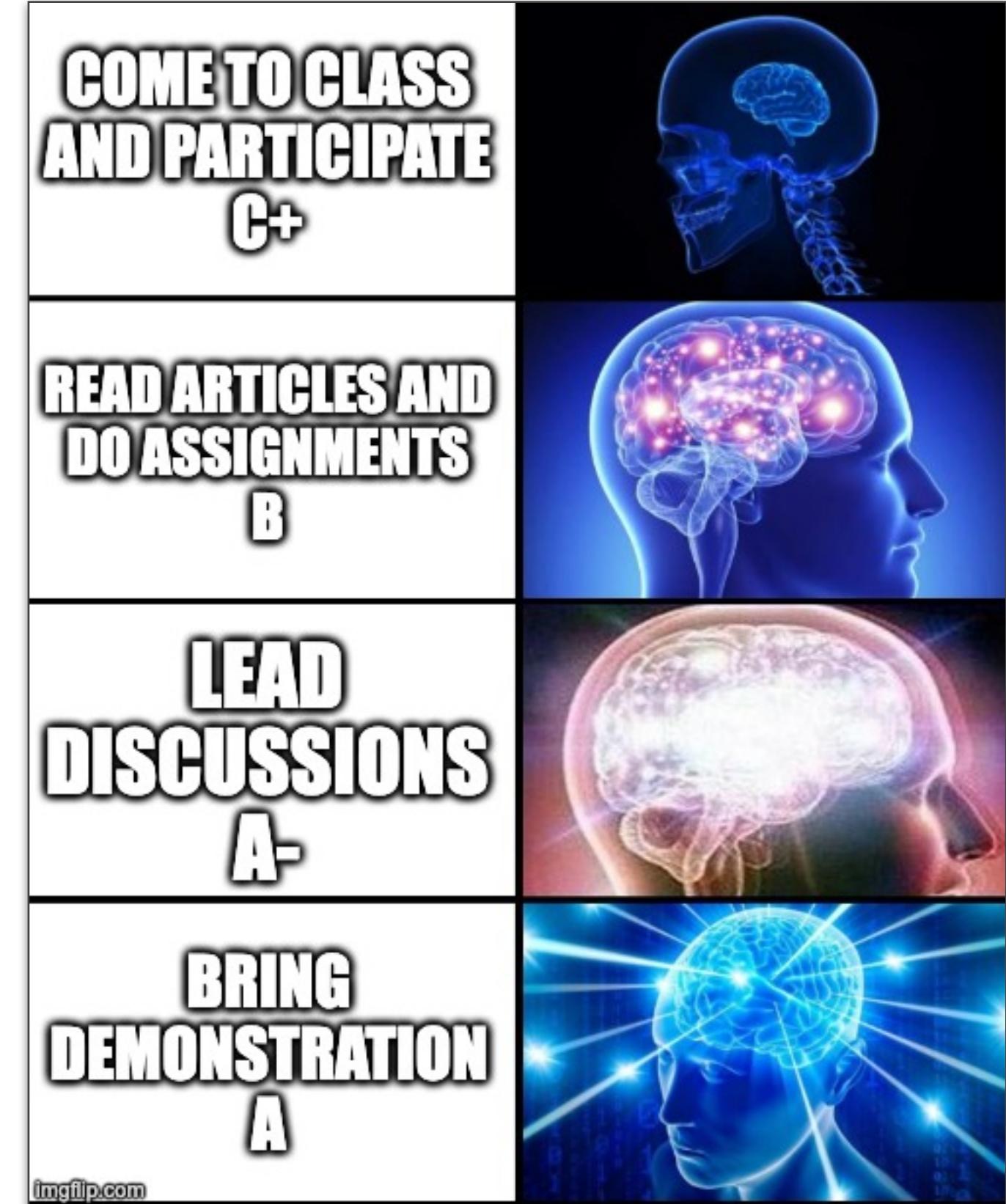
B [84, 87]

C [74, 77]

F [0, 59]

B- [80, 83]

C- [70, 73]



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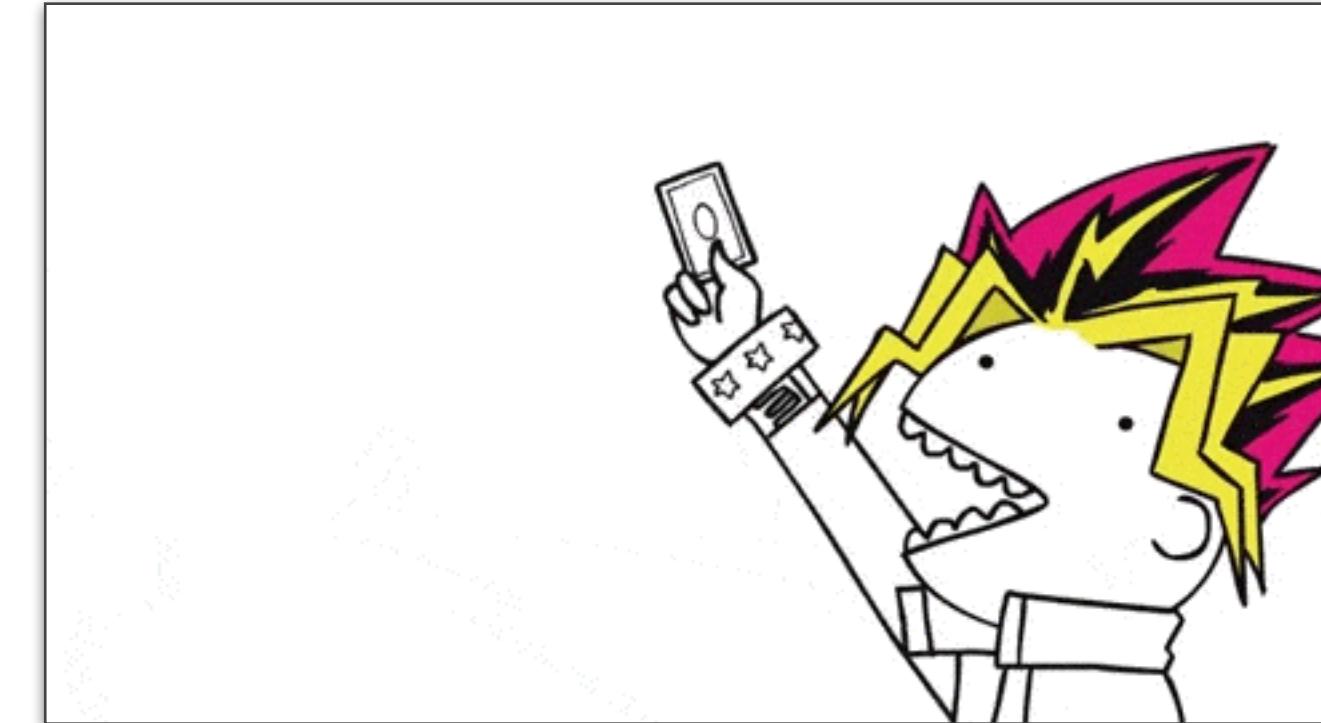
CV on the news: 1 point (extra)

Demonstration: 5 points (extra)

Late assignments: -1 point per day

Concepts

A [94, 100]	B+ [88, 89]	C+ [78, 79]	D [60, 69]
A- [90, 93]	B [84, 87]	C [74, 77]	F [0, 59]
	B- [80, 83]	C- [70, 73]	



Oopsie cards (OC)

Each student has 2 OCs.

Use it in case you need more time or do not want to lose points due to absence.

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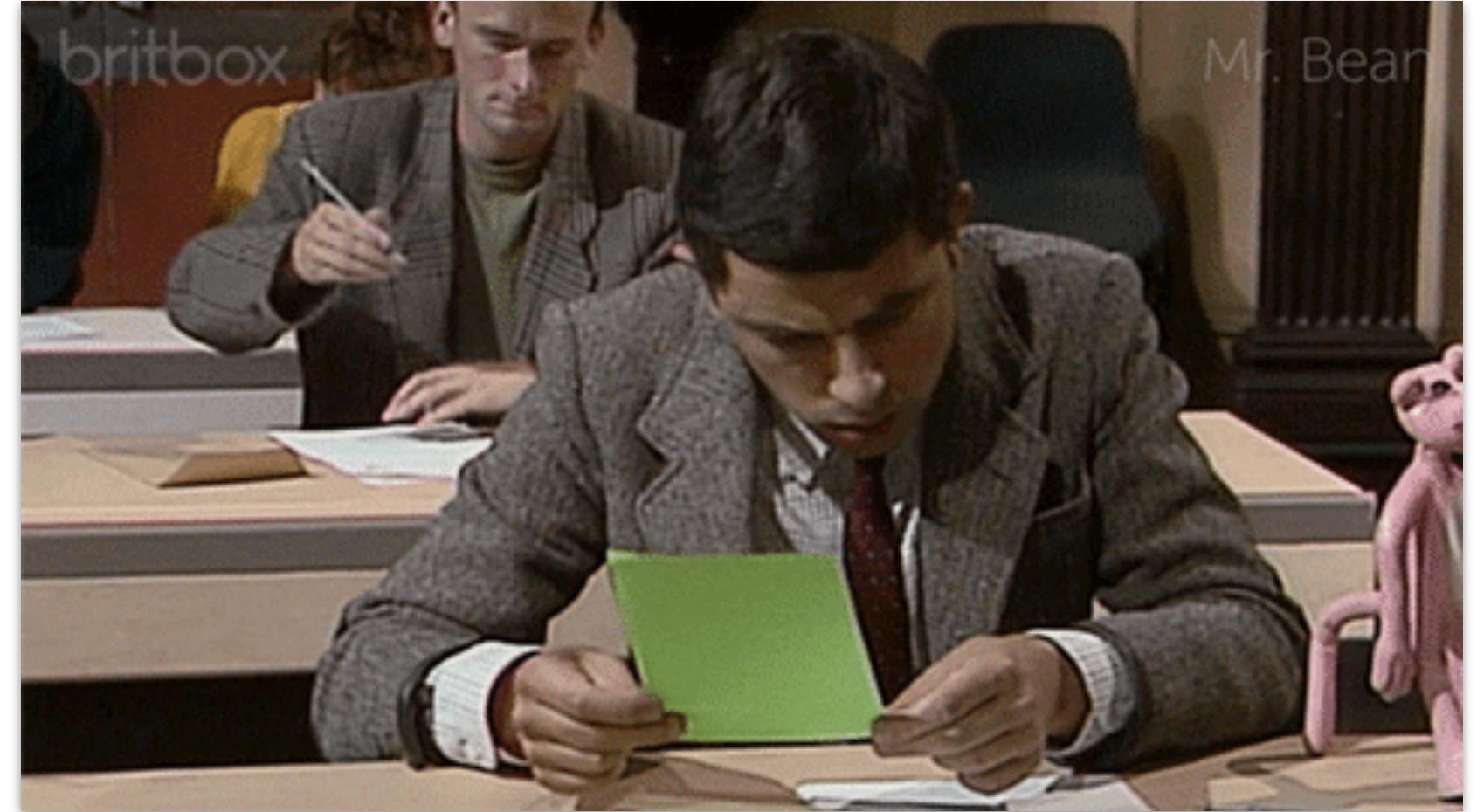
B [84, 87]

C [74, 77]

F [0, 59]

B- [80, 83]

C- [70, 73]



Code of Honor

Break it and get 0 points.

Do it again and get an F.

Please refer to <https://bit.ly/3TmiQkQ>

Course Overview

Prerequisites

Essential

Programming, basic prob & stats,
and data structures

Team work



Desired

Python, numpy, OpenCV

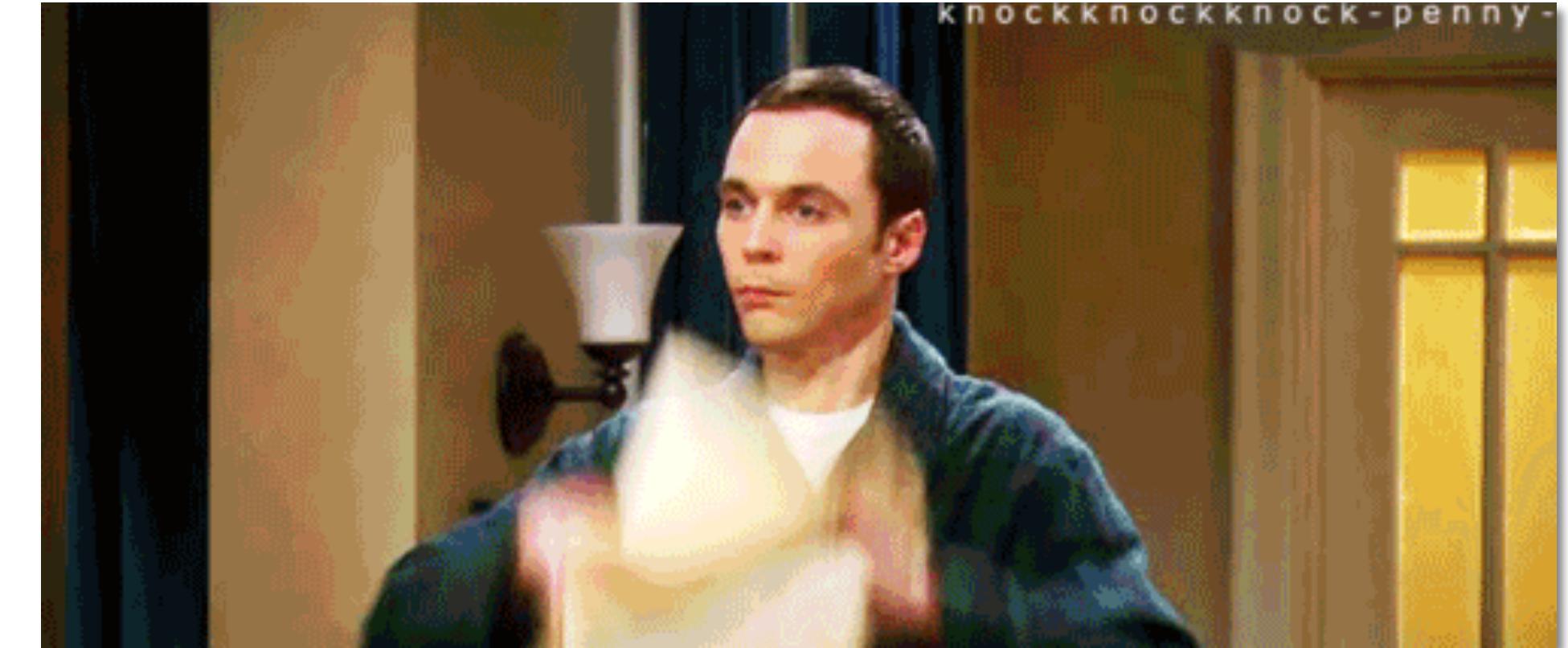
Not sure?

Please talk to me in private.

Course Overview

Bibliography

Scientific Articles will be posted on Sakai.



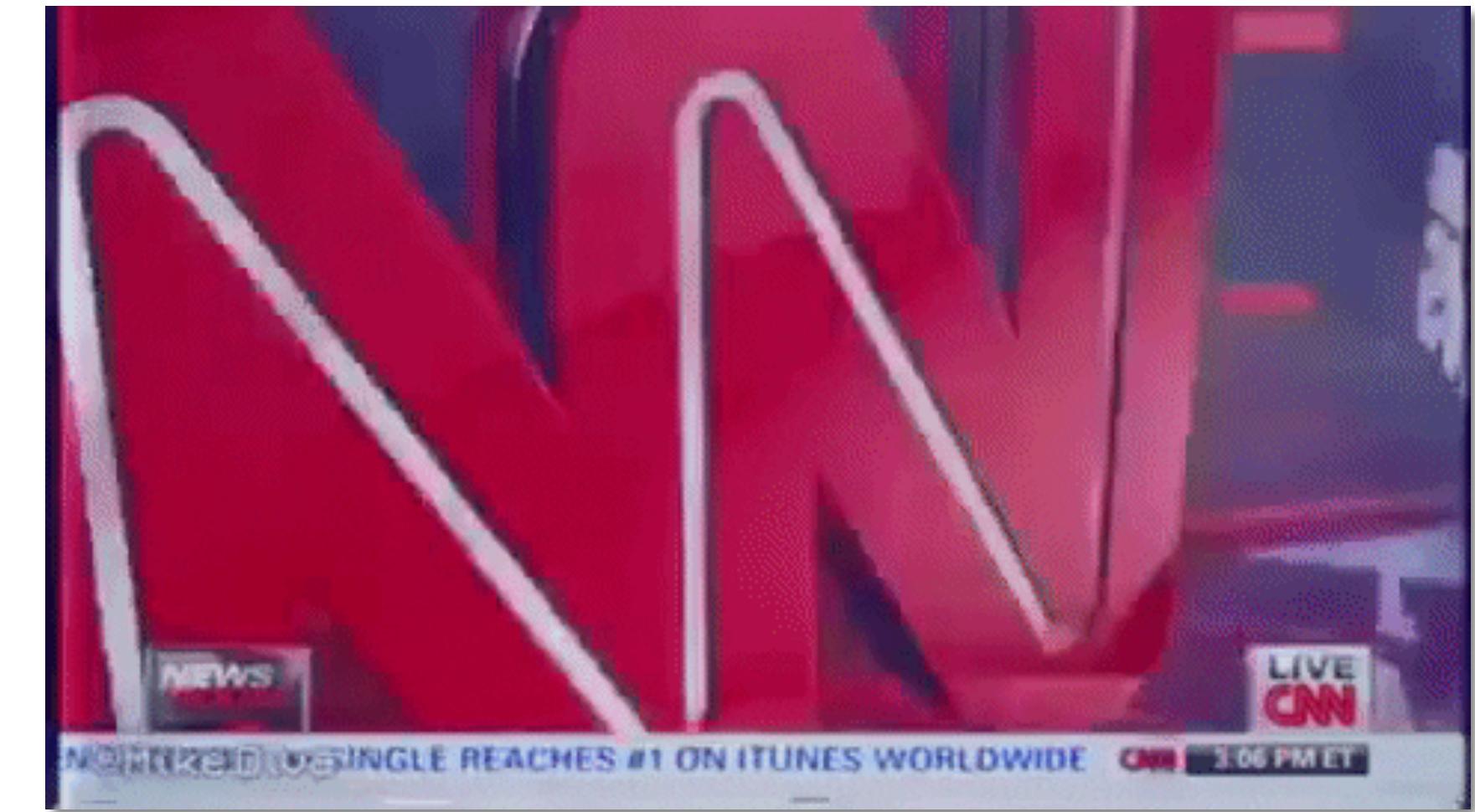
Announcements will help you to track them down.

Course Overview

CV on the News

Share with us any news you find that are related to Computer Vision.

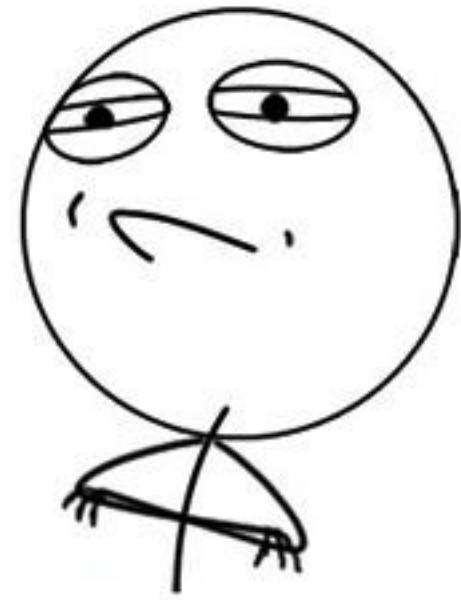
Get extra points for doing that.



Your next tasks

Relax

Any issues? Please come and talk to me.



Sakai will be up soon

Please visit it as soon as you get the notification.

Start thinking about your 2 seminars

What topics would you like to take?

Heads up: I'll set up a poll to collect your preferences.



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