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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UNIVERSITY CHICAGO

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

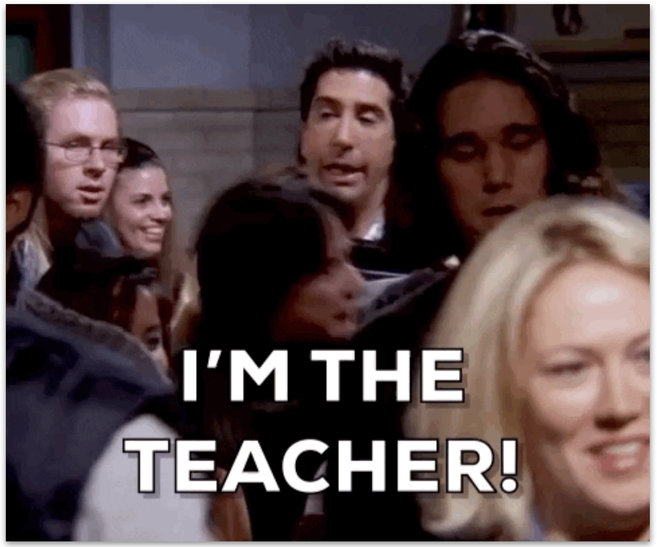
Daniel Moreira (Instructor)
Contact: dmoreira1@luc.edu
Office: 310 Doyle Center

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/

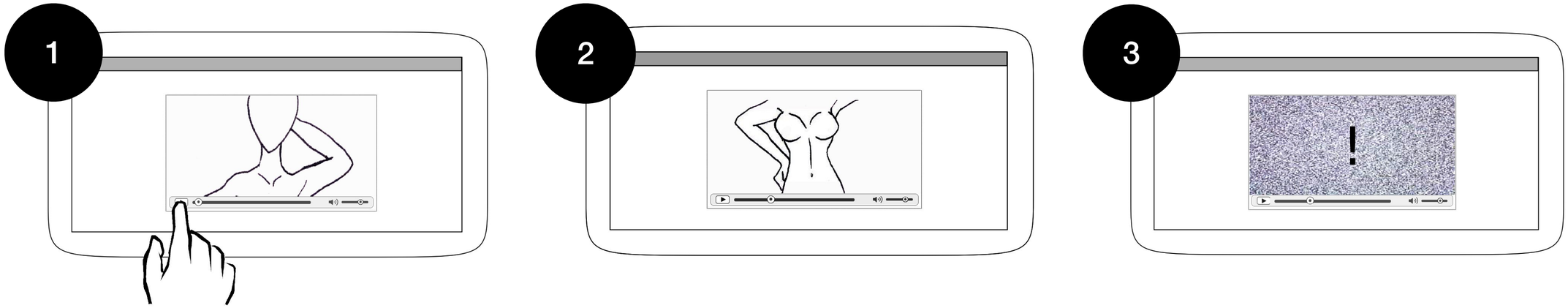
The Problem


The Intersect
The Washington Post
A 12-year-old girl live-streamed her suicide. It took two weeks for Facebook to take the
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 M
Man shot, killed while live-streaming
CNN
CNN BUSINESS
Markets Tech Media Success Perspectives Video
U.S. Edition +
Seven weeks later, videos of New Zealand attack still circulating on Facebook and Instagram

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?



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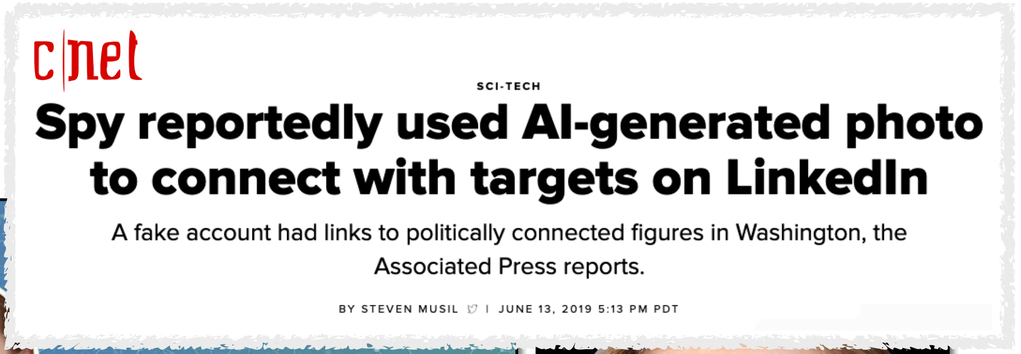
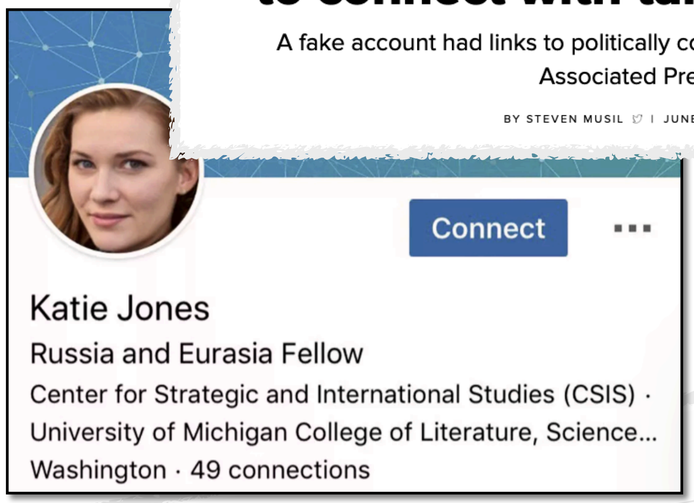
The Notorious B.I.G.
NY scene rapper
Media Forensics
https://danielmoreira.github.io/project/medifor/
Kurt Cobain
Grunge scene musician

The Problem





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

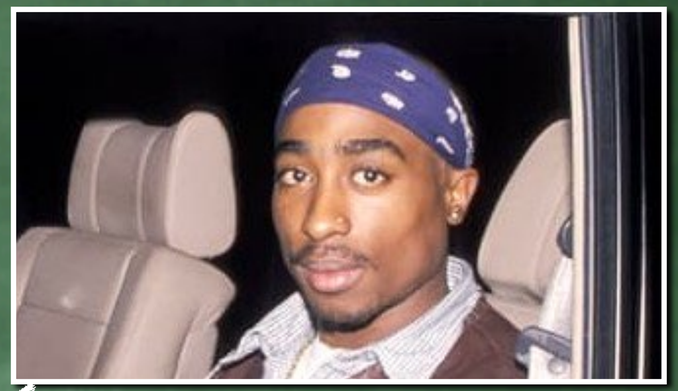
Adobe

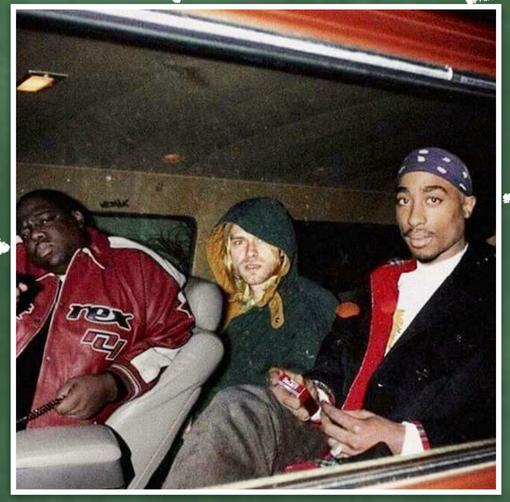
Crafting new images with photo manipulation.


The Notorious B.I.G.
NY scene rapper
HANGING OUT?
Kurt Cobain
Grunge scene musician

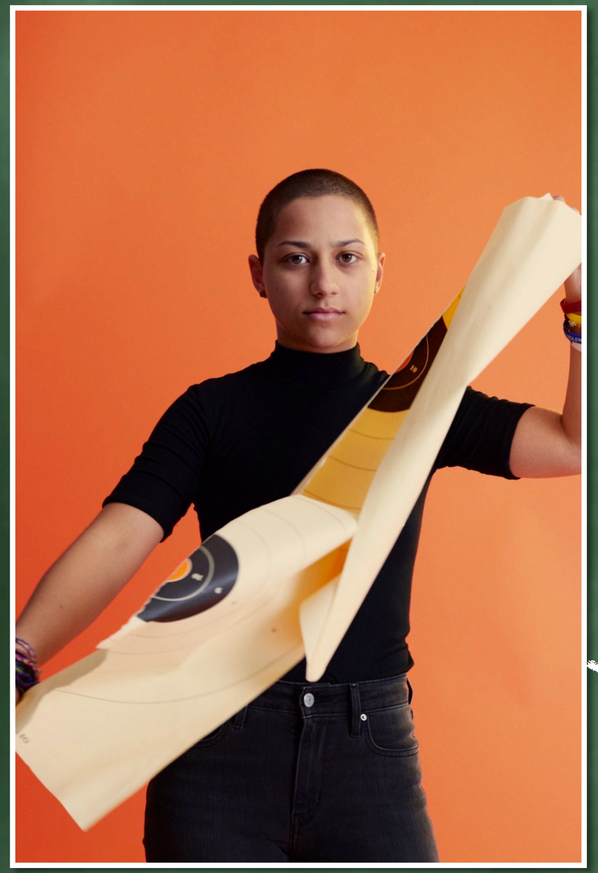

rex

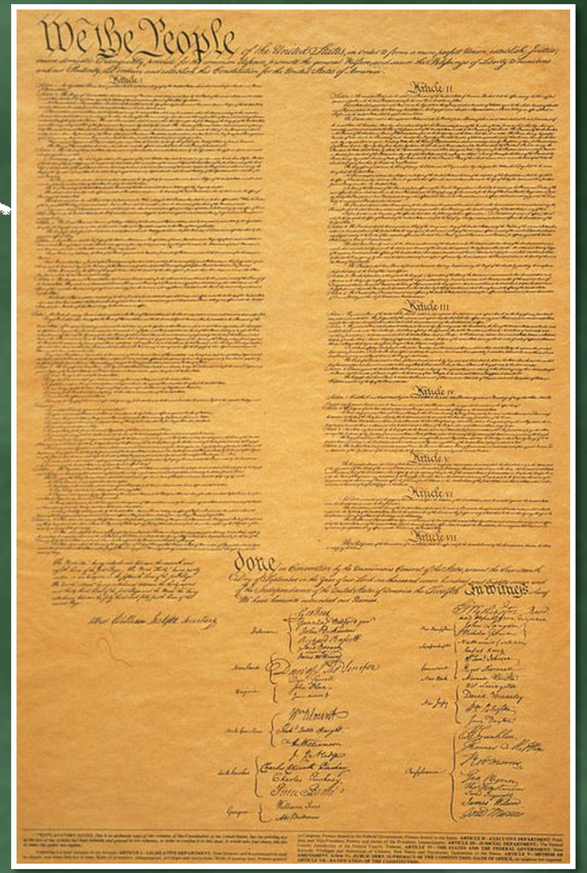

Tupac Shakur
LA scene rapper



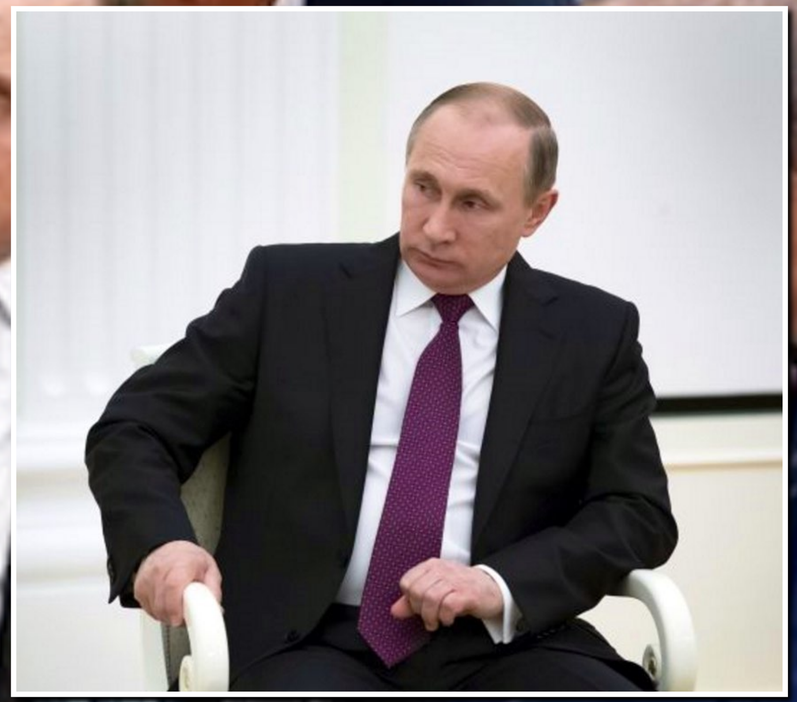


Provenance Graph




We the People
Article I
Article II
Article III
Article IV
Article V
Article VI
Article VII
Done
In Witness


Russian Federation
Turkey



Russian Federation

Turkey

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.

Richard Van Noorden

nature

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

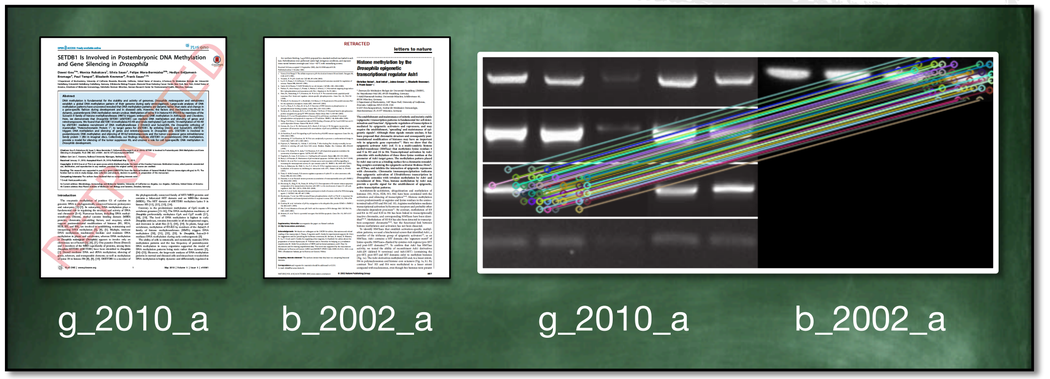
REUTERS GRAPHICS

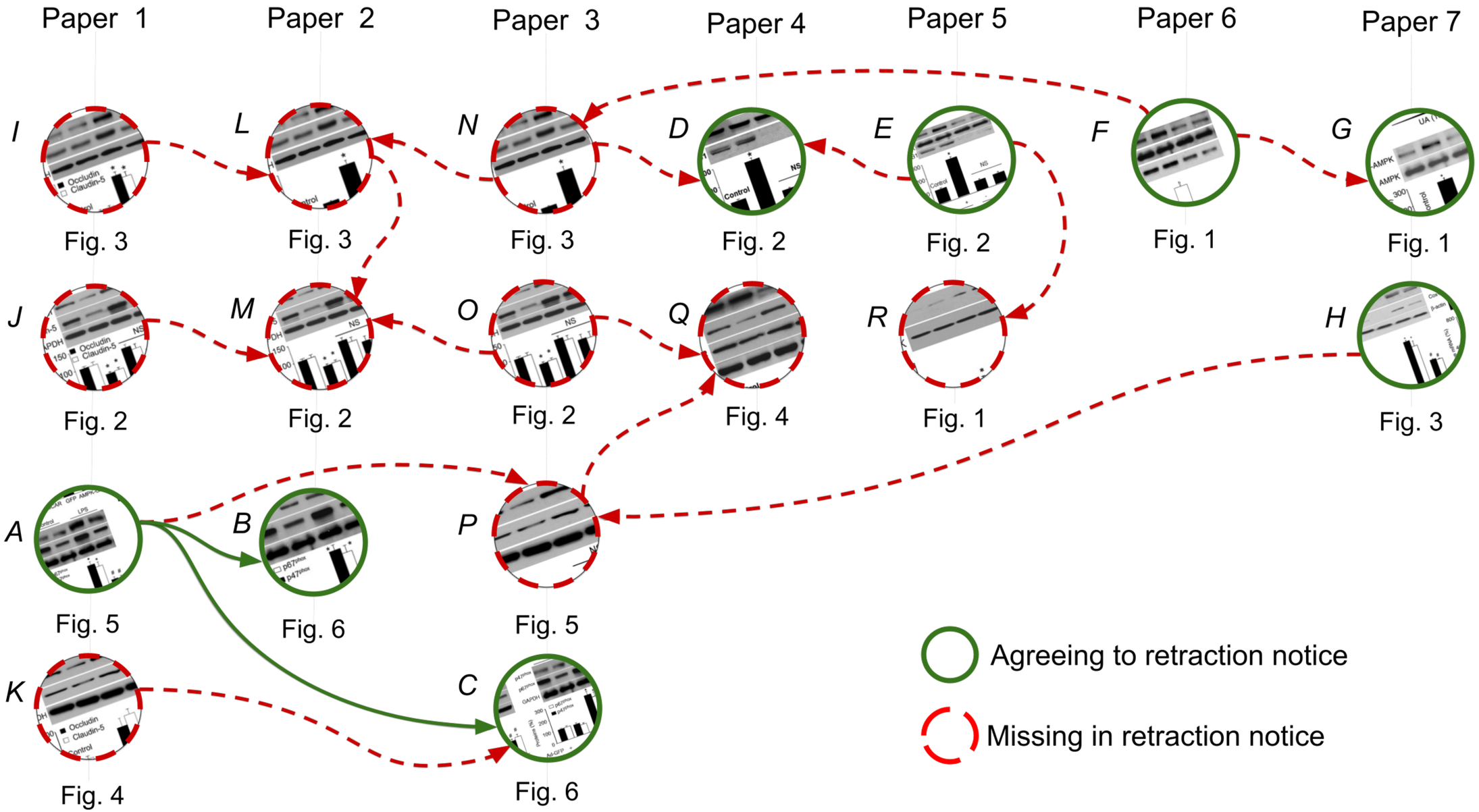
Speed Science

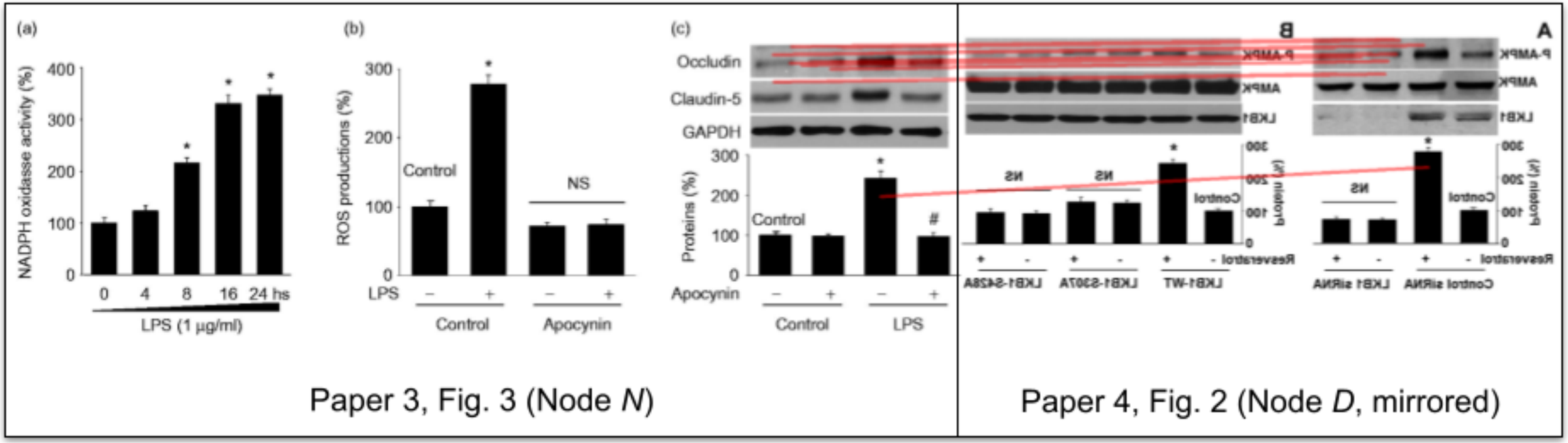
The risks of swiftly spreading coronavirus research

By **Manas Sharma, Simon Scarr** and **Kate Kelland**

PUBLISHED FEBRUARY 19, 2020




Paper 1
Paper 2
Paper 3
Paper 4
Paper 5
Paper 6
Paper 7
I
L
N
D
E
F
G
Fig. 3
Fig. 3
Fig. 3
Fig. 2
Fig. 2
Fig. 1
Fig. 1
J
M
O
Q
R
H
Fig. 2
Fig. 2
Fig. 2
Fig. 4
Fig. 1
Fig. 3
A
B
P
Fig. 5
Fig. 6
Fig. 5
K
C
Fig. 4
Fig. 6
Occludin
Claudin-5
Control
NS
p67phox
p47phox
AMPK
GAPDH
Agreeing to retraction notice
Missing in retraction notice



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/

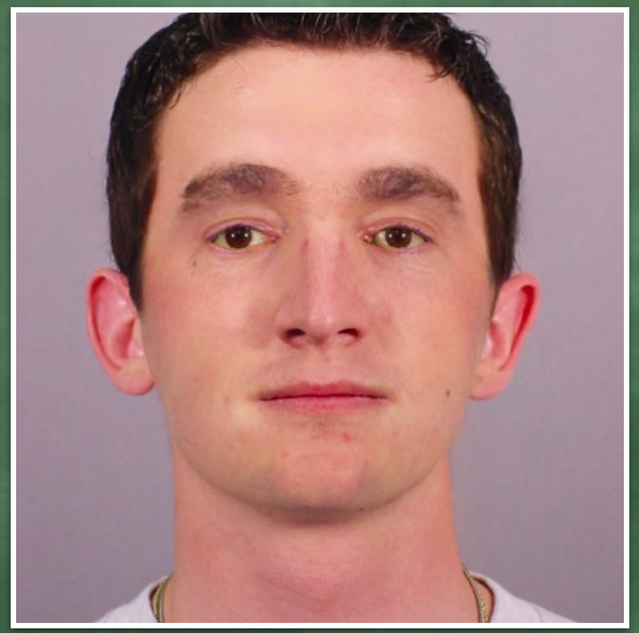
Does this person exist?

No
(nose and mouth replaced)

No
(eyes replaced)

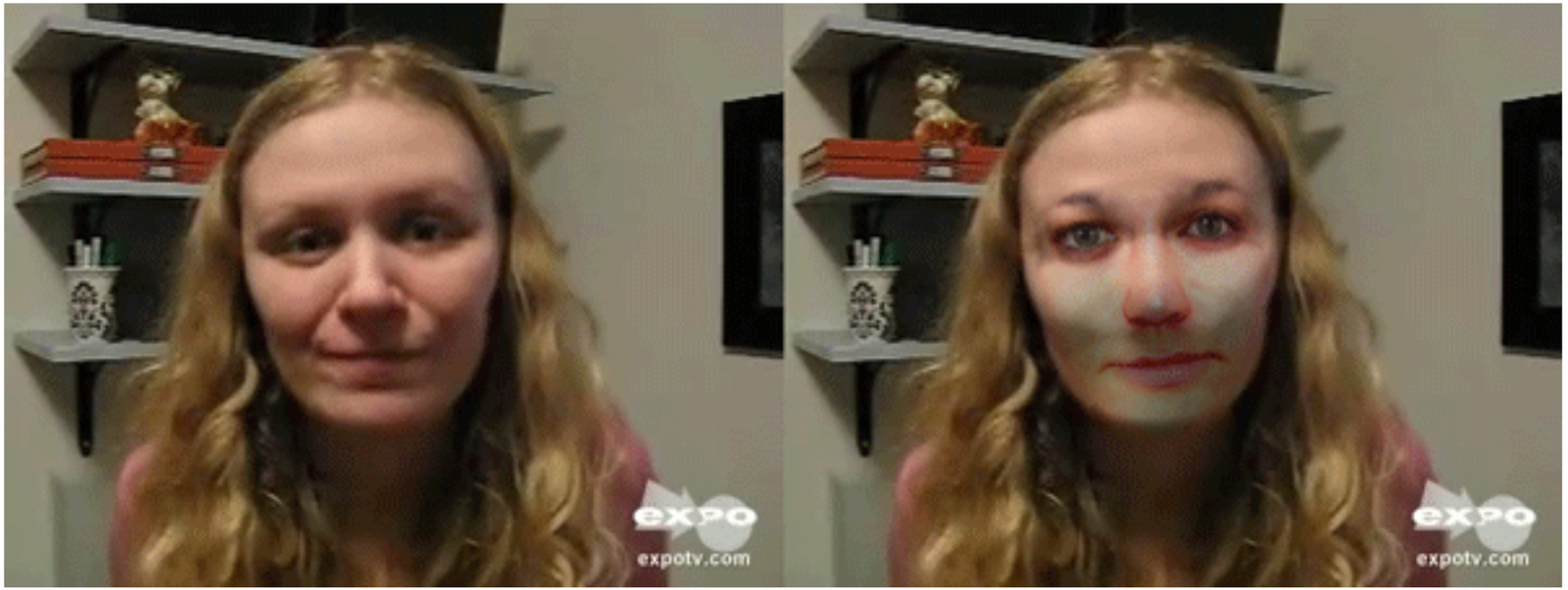
Yes
(original)

No
(eyes, nose and mouth replaced)



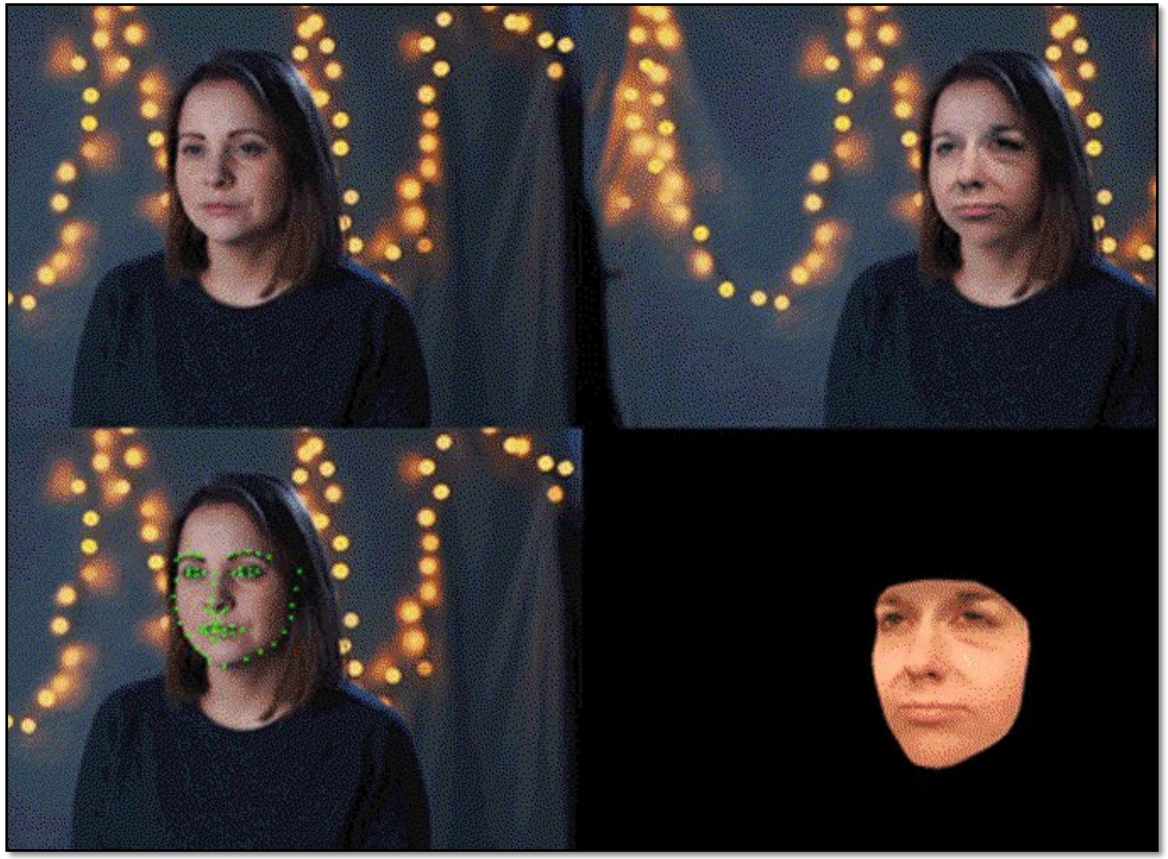
First Steps

Video Replacement



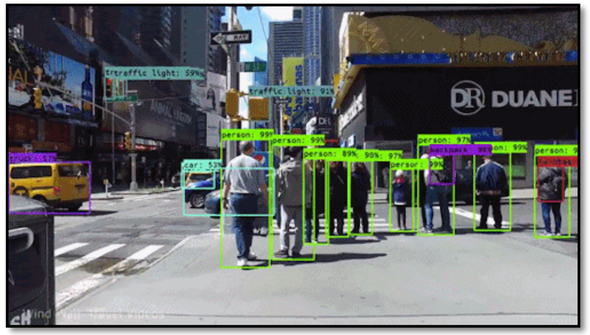
What's Next?

Synthetic Controlled Diversity



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

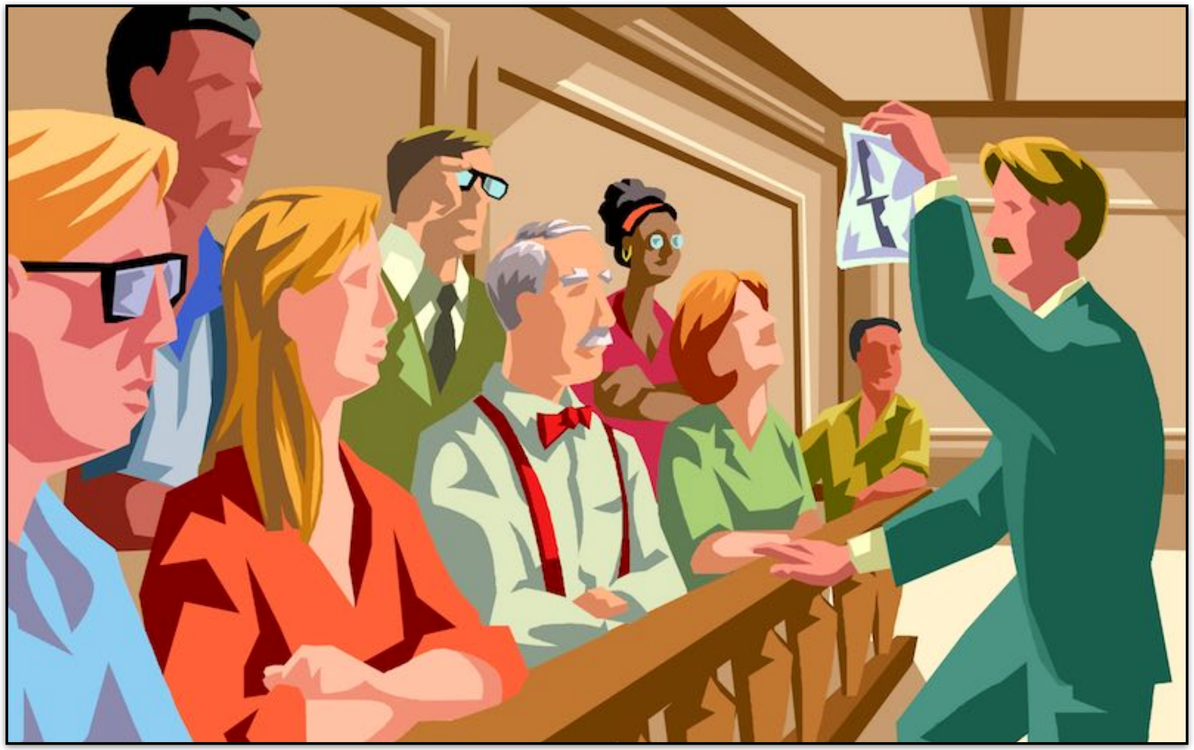
Challenge: keep everything (e.g., emotions, sentiments, reactions) but identity.



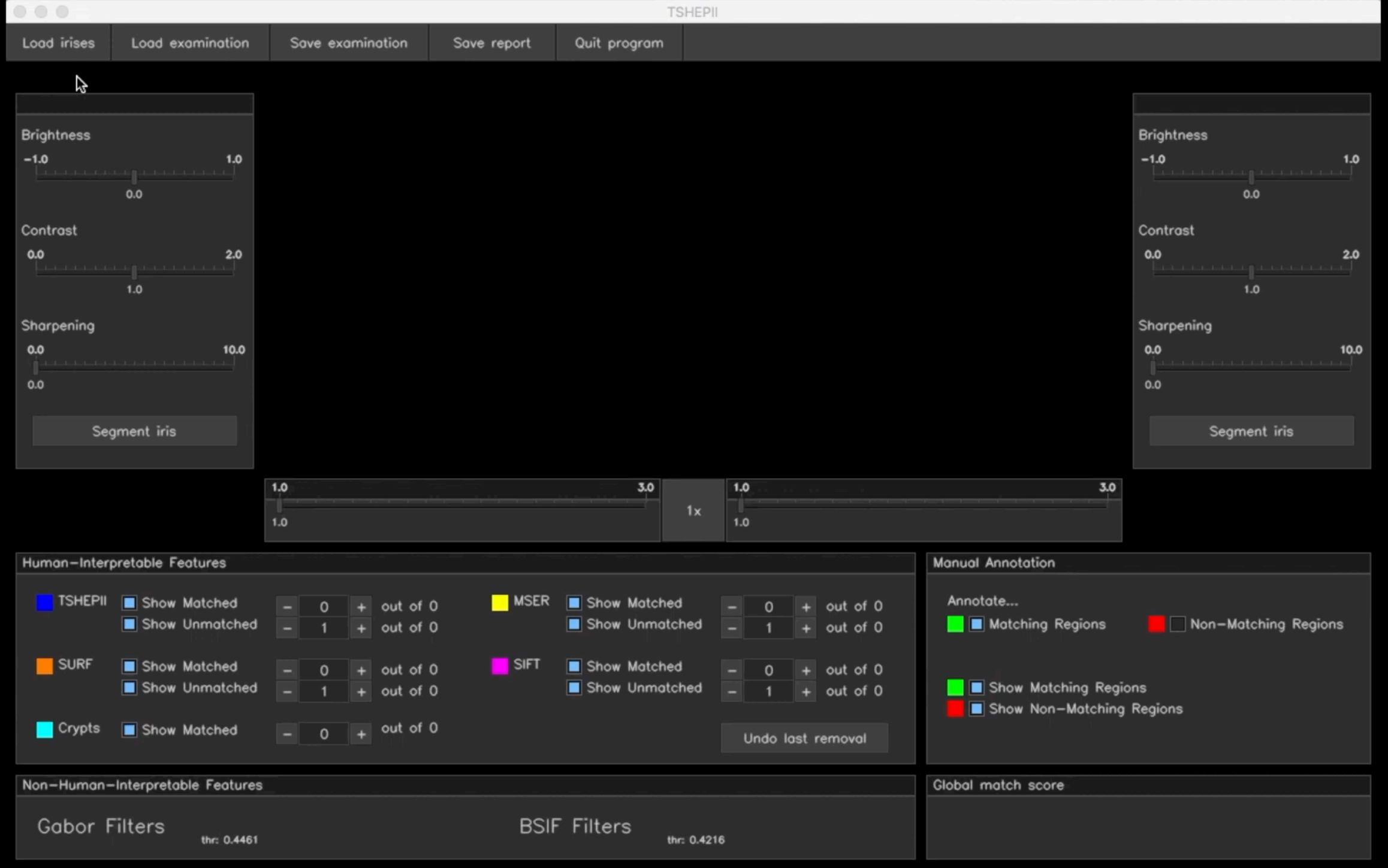

TSHEPII
Load irises
Load examination
Save examination
Save report
Quit program
0008_R_2_1.png
Brightness
−1.0
1.0
Contrast
0.0
2.0
1.1
Sharpening
0.0
10.0
1.0
0008_R_3_1.png
Brightness
−1.0
1.0
Contrast
0.0
2.0
1.0
Sharpening
0.0
10.0
2.0
Tool Supporting the Human Examination of Post-Mortem Iris Images
https://danielmoreira.github.io/project/tshepii/
WARNING
Manual Annotation
Annotate...
out of 3
Non-Human-Interpretable Features
Gabor Filters
0.4585
impostor
genuine
9/11

The Problem

Interpretable Iris Recognition



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


TSHEPII
Load irises
Load examination
Save examination
Save report
Quit program
Brightness
−1.0
1.0
0.0
Contrast
0.0
2.0
1.0
Sharpening
0.0
10.0
0.0
Segment iris
Brightness
−1.0
1.0
0.0
Contrast
0.0
2.0
1.0
Sharpening
0.0
10.0
0.0
Segment iris
1.0
3.0
1.0
1x
1.0
3.0
1.0
Human−Interpretable Features
TSHEPII
Show Matched
Show Unmatched
0
out of 0
1
out of 0
SURF
Show Matched
Show Unmatched
0
out of 0
1
out of 0
Crypts
Show Matched
0
out of 0
MSER
Show Matched
Show Unmatched
0
out of 0
1
out of 0
SIFT
Show Matched
Show Unmatched
0
out of 0
1
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 preferredprogramming 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

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What is Computer Vision?

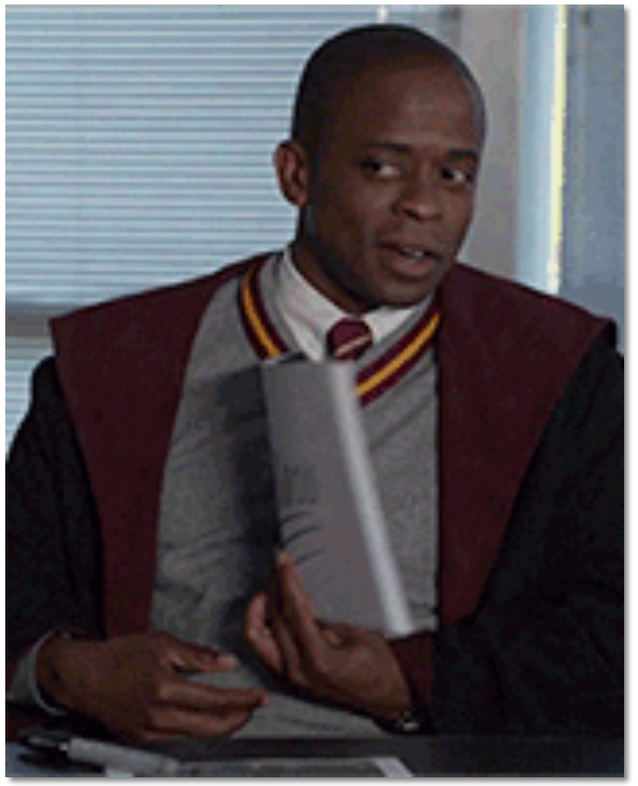
Computer Science Subfield
It aims at developing computer systems
that mimic the human visual system.

Reference

Objective

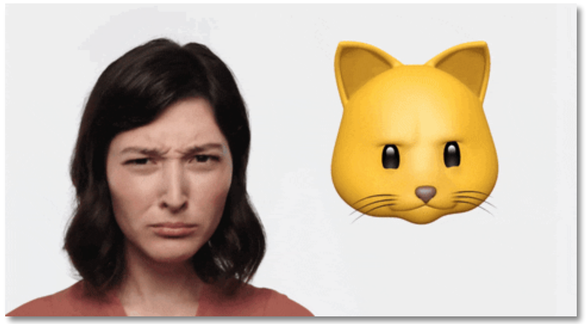
What is Computer Vision?

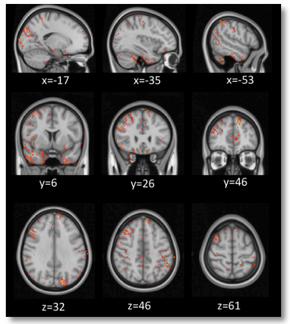
Humans
By relying on images:
Reason about the world.
Navigate through the space.
Interact and communicate.

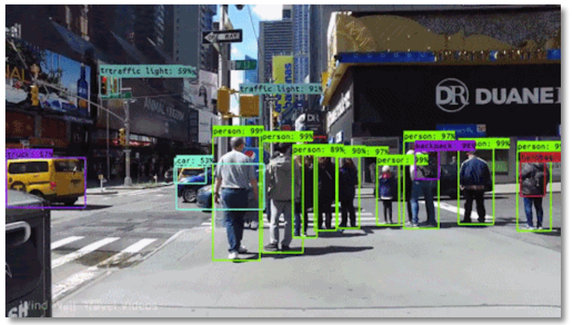


What is Computer Vision?

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

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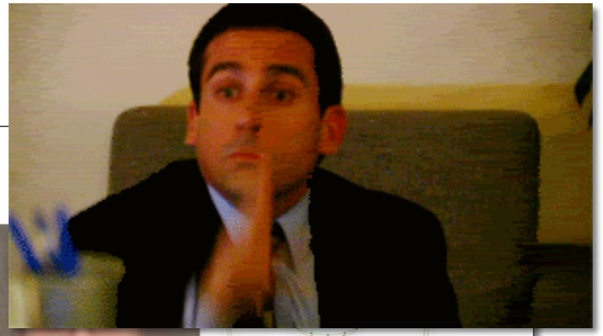
What is Computer Vision?

And to make things worse…



BBC

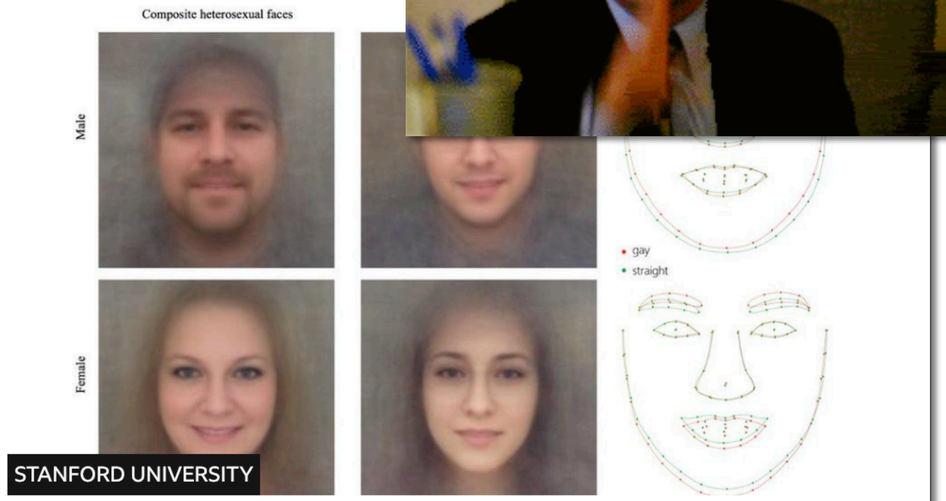
NEWS

Menu

Tech

Row over AI that 'identifies gay faces'

11 September 2017



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

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

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What is Computer Vision?

Digital Image
Foundation

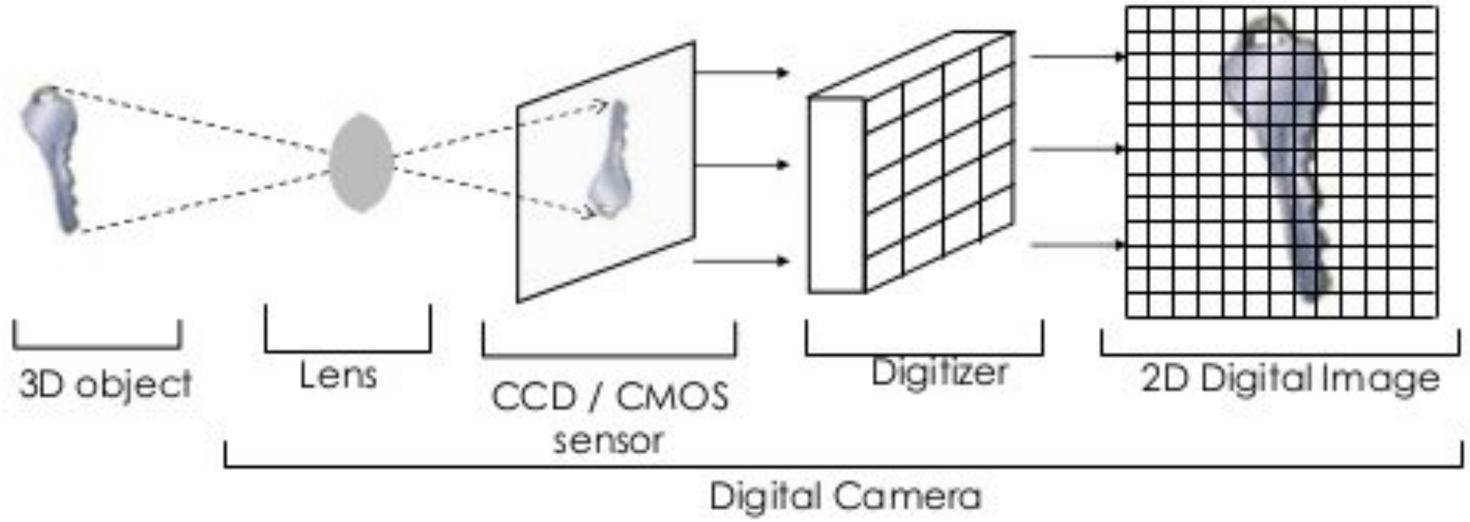
Digital Image

Matrix of pixels

What is Computer Vision?

Digital Image

Acquisition Process



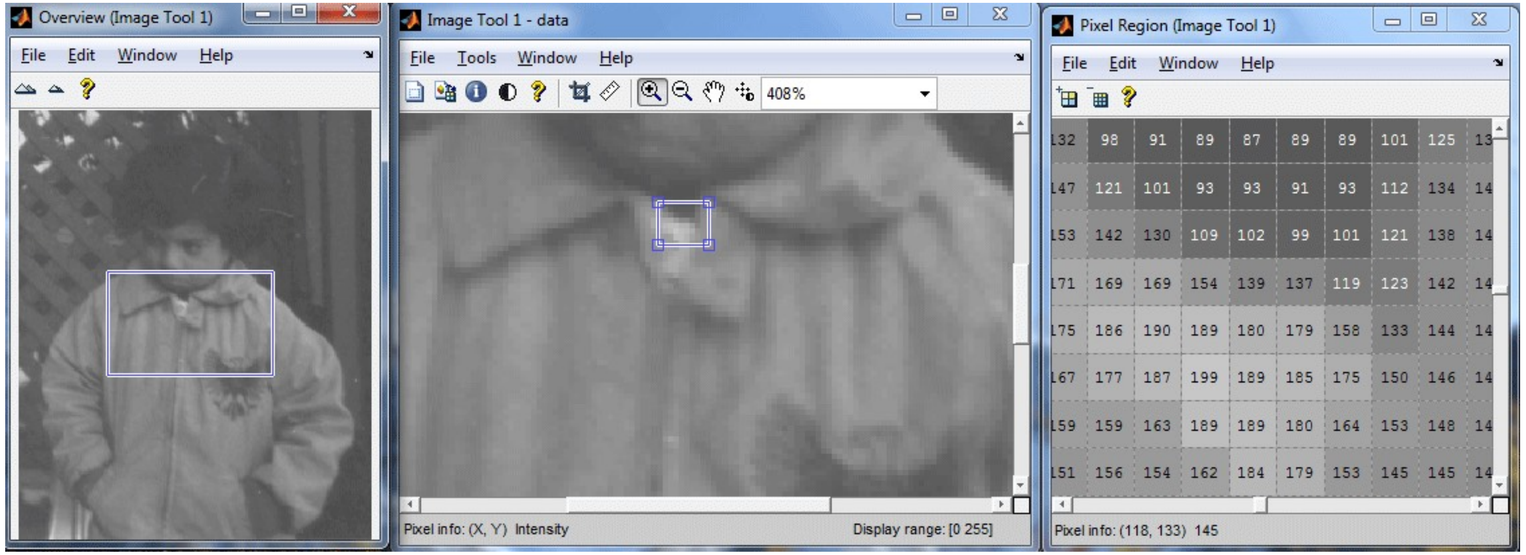
CCD: charged coupled device (old technology)
CMOS: complementary metal-oxide semiconductor (current technology)

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

What is Computer Vision?

Digital Image

Data Structure
Matrix of pixels



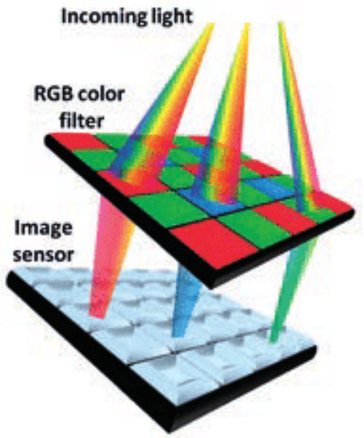
Sharma, N. *What is an image and how images are made?* Quora, 2018

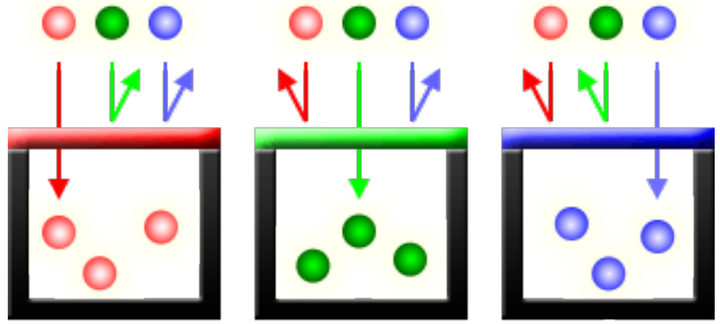
What is Computer Vision?

Digital Image

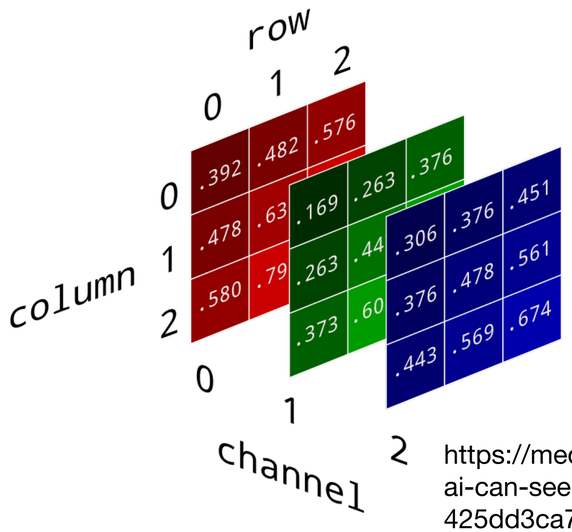
Multiple Channels

Red, Green, Blue (RGB)





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

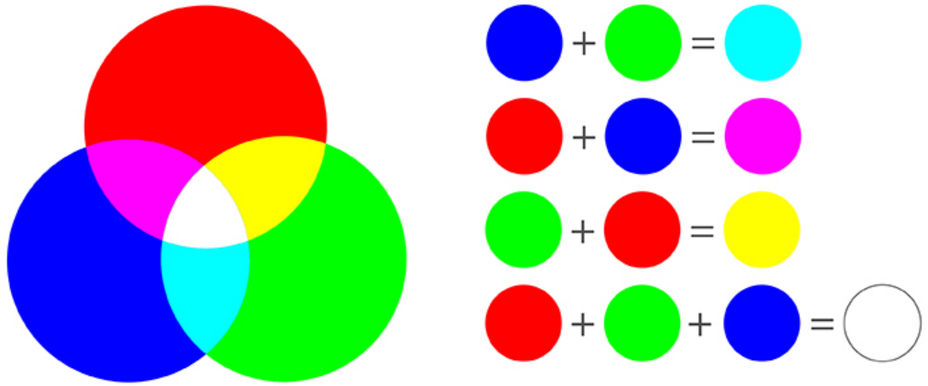


https://medium.com/swlh/ai-can-see-you-heres-how-425dd3ca7322

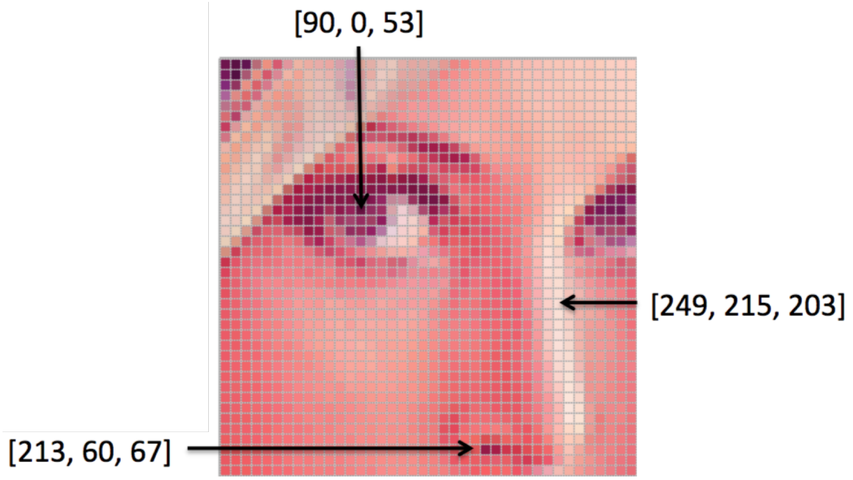
What is Computer Vision?

Digital Image

Multiple Channels
Red, Green, Blue (RGB)

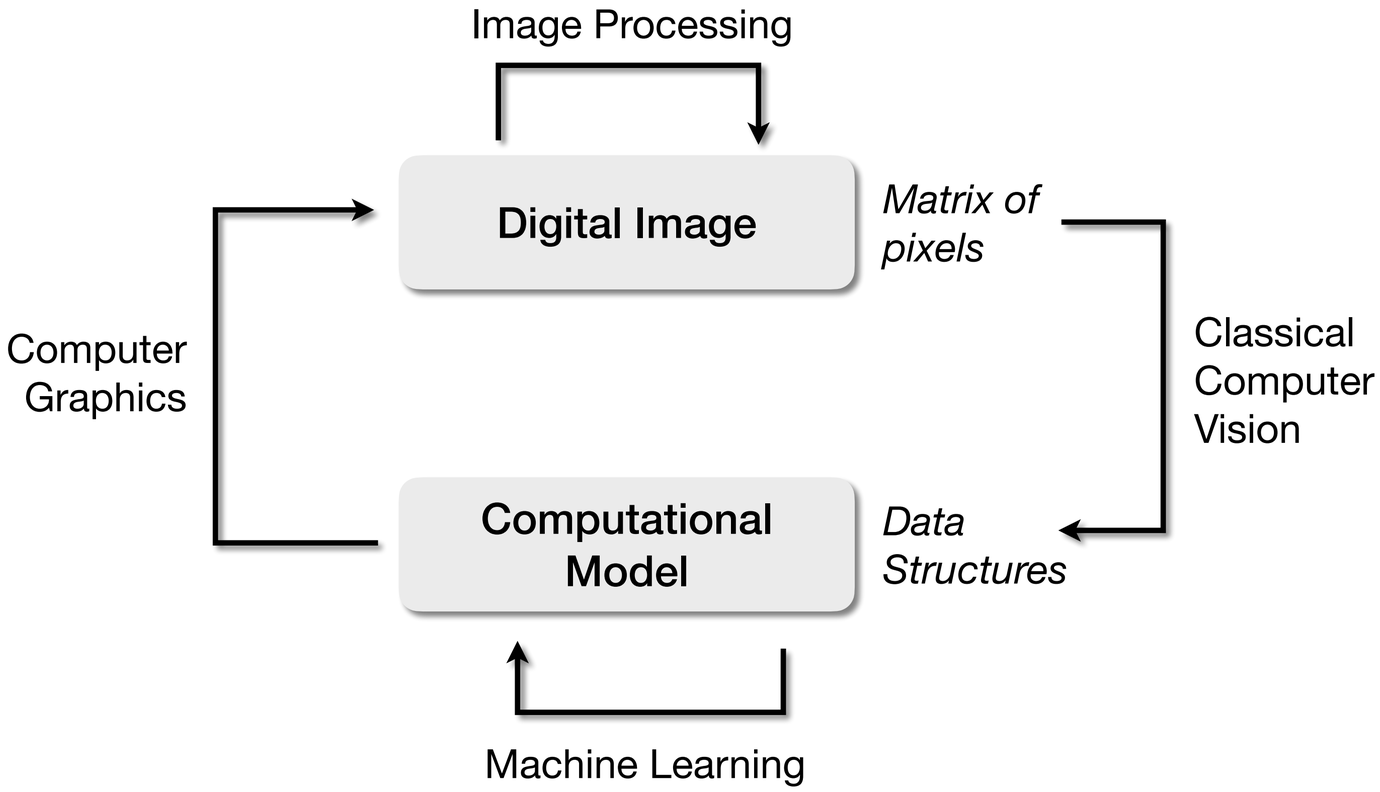


https://br24.com/en/rgb-cmyk-differences/



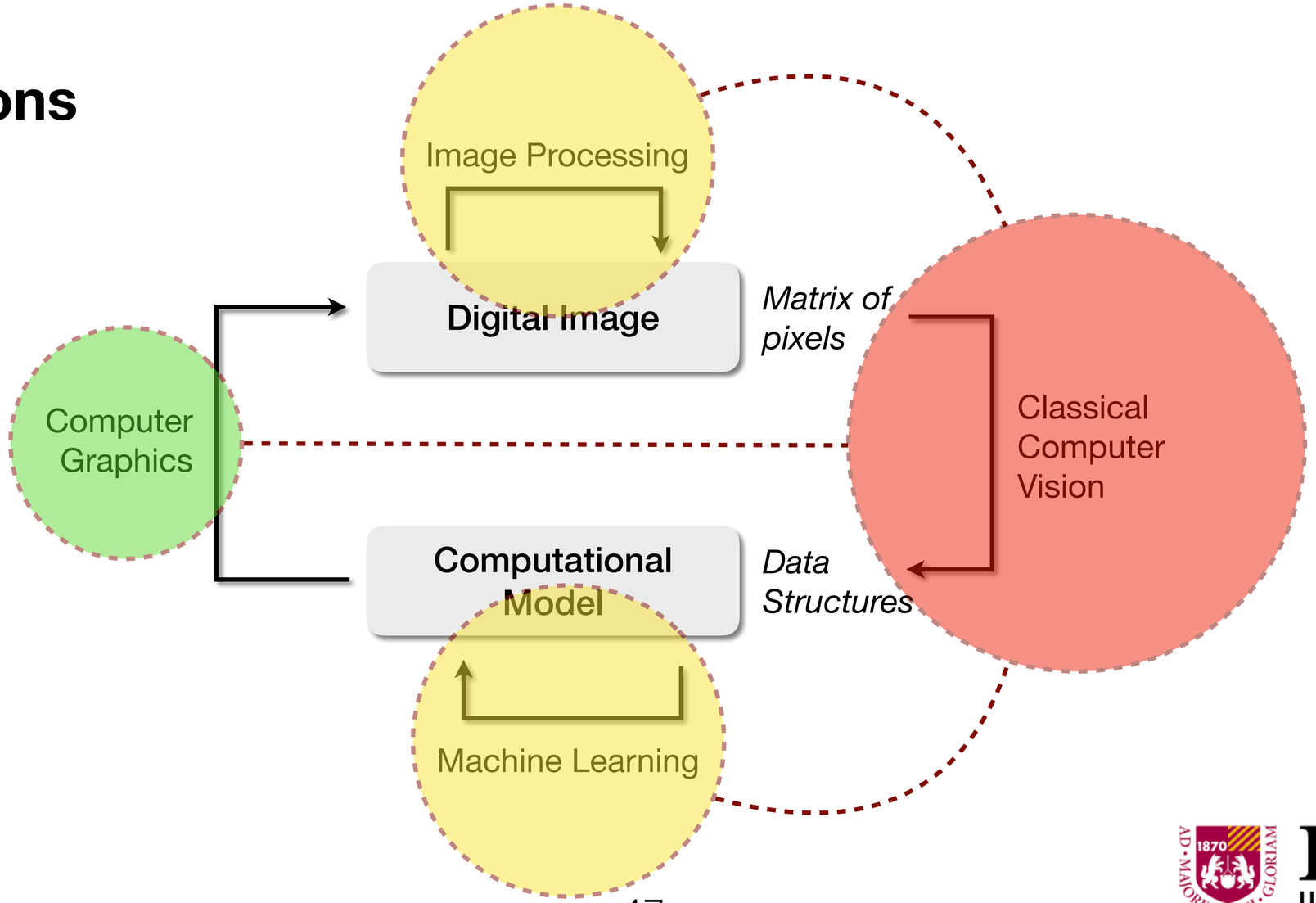
https://ai.stanford.edu/~syyeung/cvweb/tutorial1.html

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

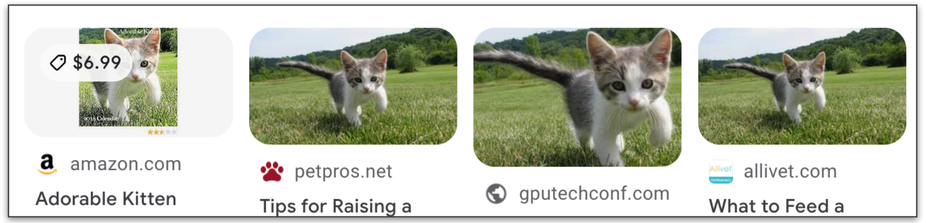
What is Computer Vision?

Typical Tasks

Image Retrieval
Provide an image (query).
Receive **related** images (gallery).

Related (depending on the application)
Near-duplicates
(same imaging pipeline)

query



gallery

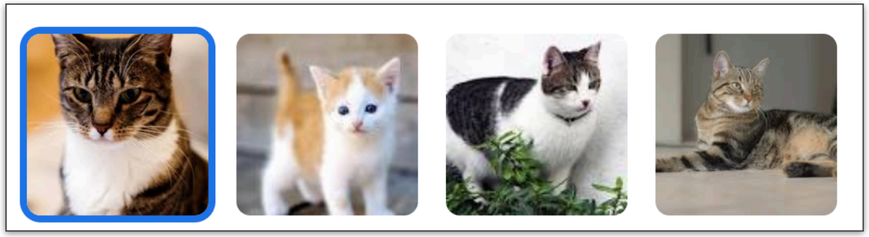
What is Computer Vision?

Typical Tasks

Image Retrieval
Provide an image (query)
Receive **related** images (gallery)

Related (depending on the application)
Near-duplicates
Semantically similar

query

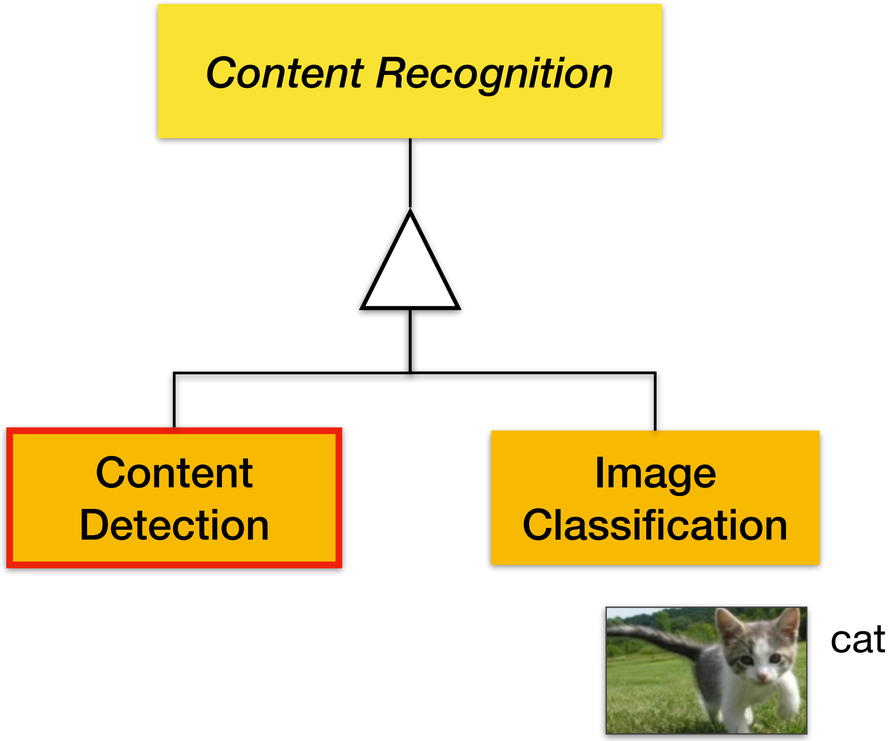


gallery

What is Computer Vision?

Typical Tasks

Content Recognition
Image Classification
Content Detection/Localization



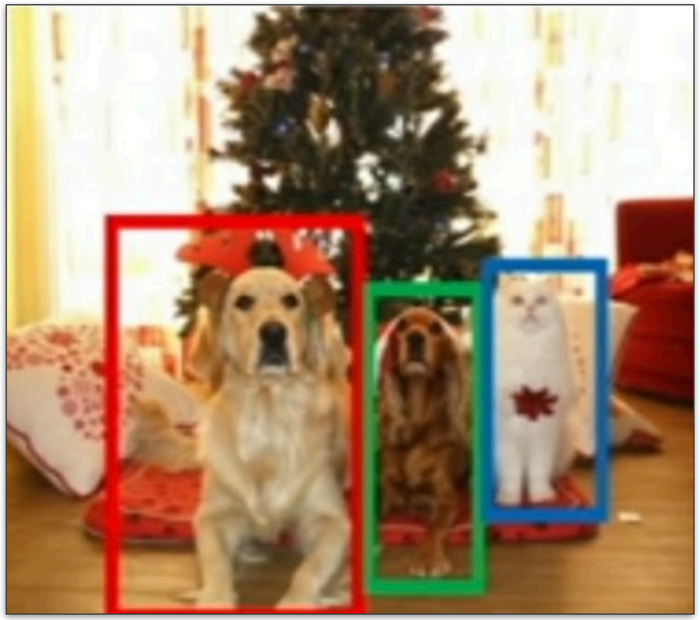
What is Computer Vision?

Typical Tasks

Content Recognition

Image Classification

Content Detection/Localization



dog dog Cat

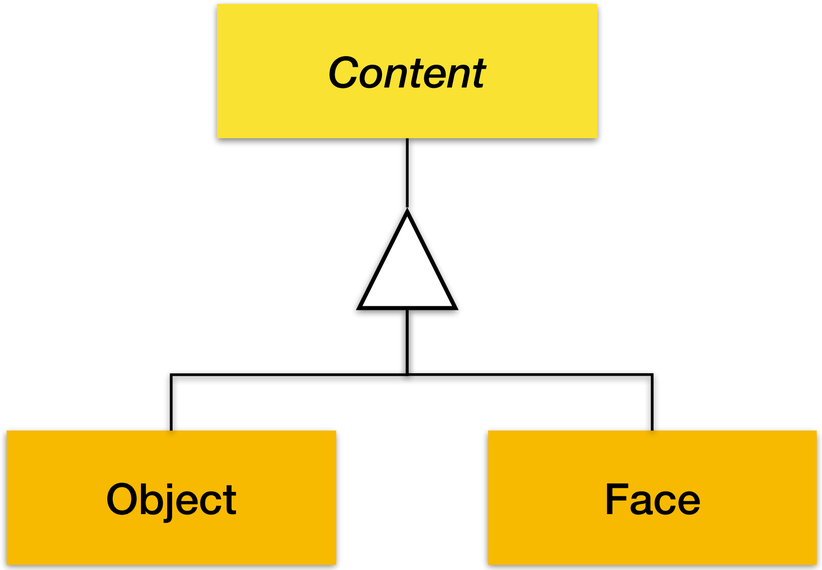
Li, F-F., Johnson, J., and Yeung, S. *Detection and Segmentation*. Stanford University, 2017

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?

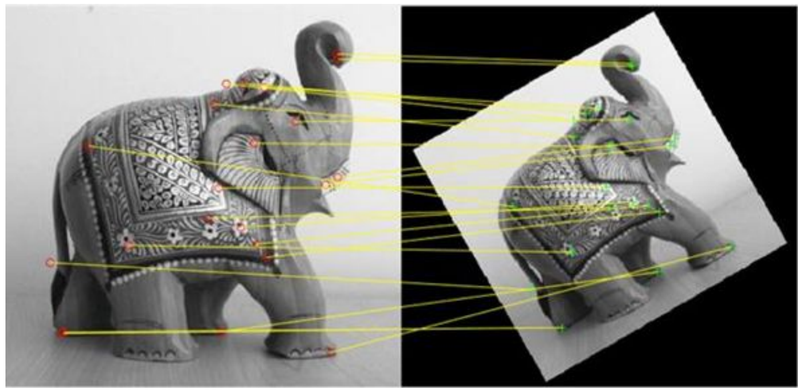
Typical Tasks

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

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Semantic Gap

Level 0 Level 1 Level 2 Level 3 Task

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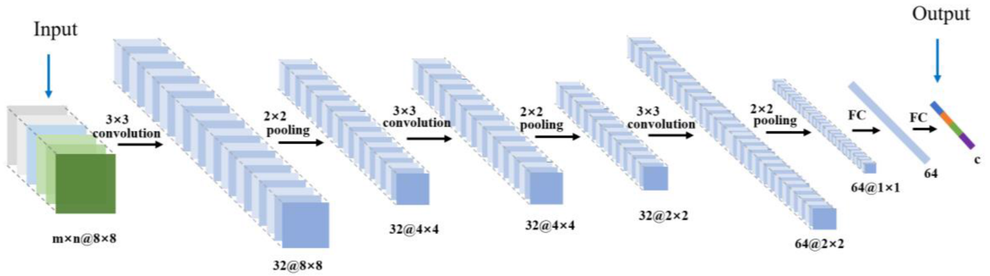
Semantic Gap

Level 0



Deep Learning

Task

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Be Careful

August 14, 2019

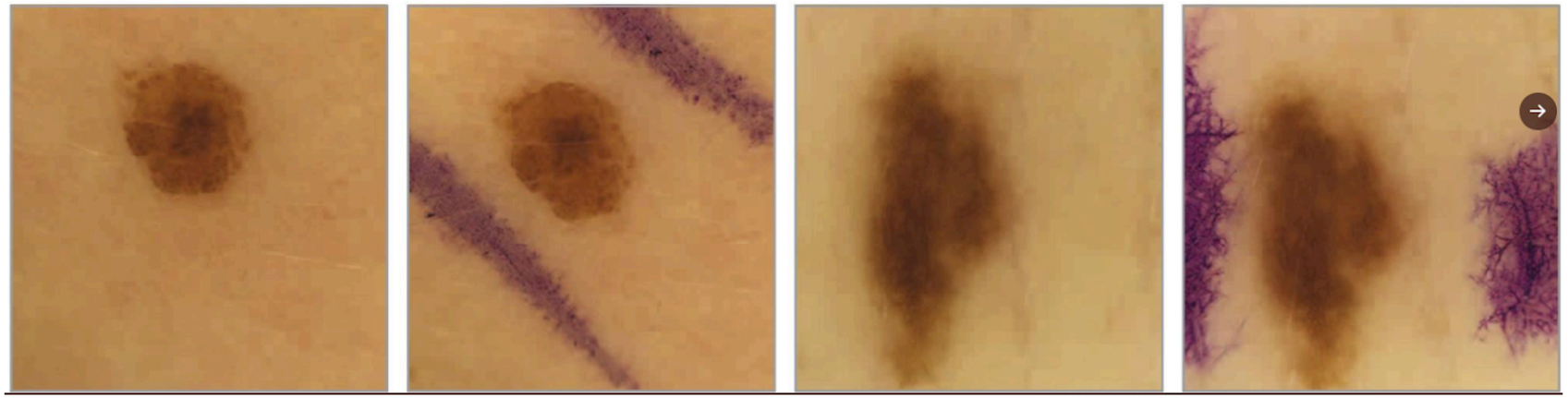
Association Between Surgical Skin Markings in Dermoscopic Images and Diagnostic Performance of a Deep Learning Convolutional Neural Network for Melanoma Recognition

Julia K. Winkler, MD[1]; Christine Fink, MD[1]; Ferdinand Toberer, MD[1]; et al

» Author Affiliations | Article Information

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

What is the network learning?



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Course Overview

What are your expectations?

https://bit.ly/3pRwcYM

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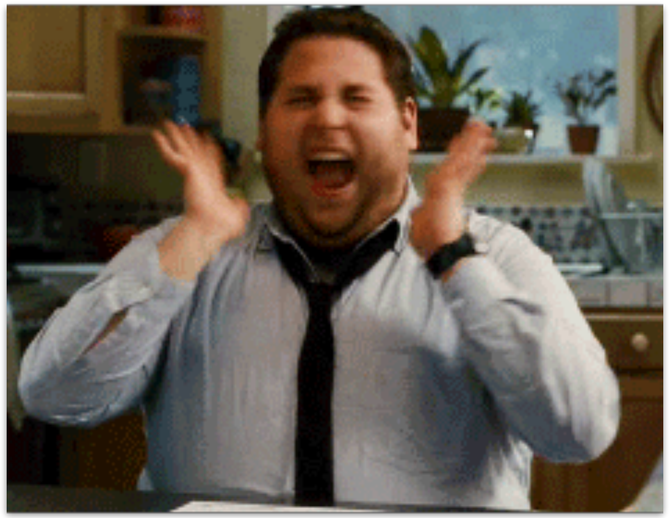
Course Overview

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

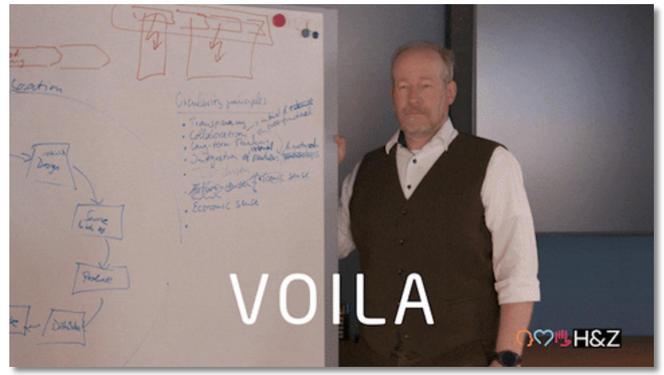
Article Summarization
Pick one from the group.
No limit of pages.

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.

Course Overview

Content

Date	Topic	Leader	Assignment
08/29	Introduction to CV	Instructor	N.A.
09/05	*Labor Day*	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	*Fall Break*	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	*Final Exam*	N.A.	N.A.

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Course Overview

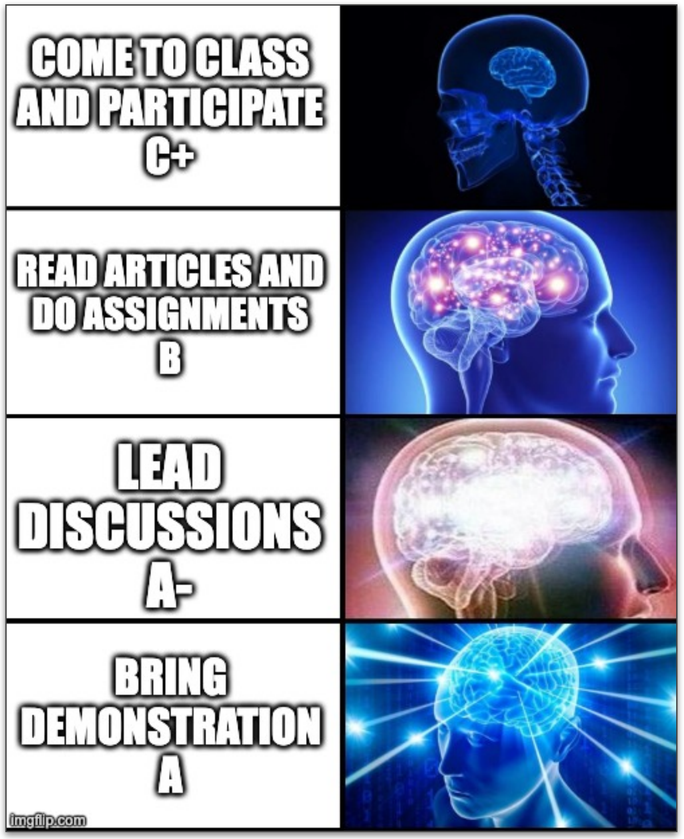
Grading
Total: 100 points

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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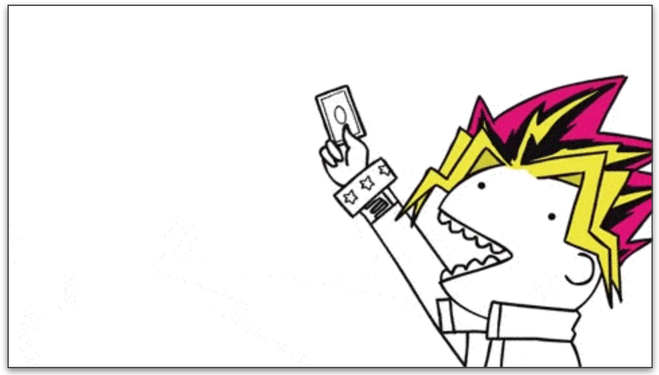

Oopsie cards (OC)
Each student has 2 OCs.
Use it in case you need more time or do not want to lose points due to absence.

Course Overview

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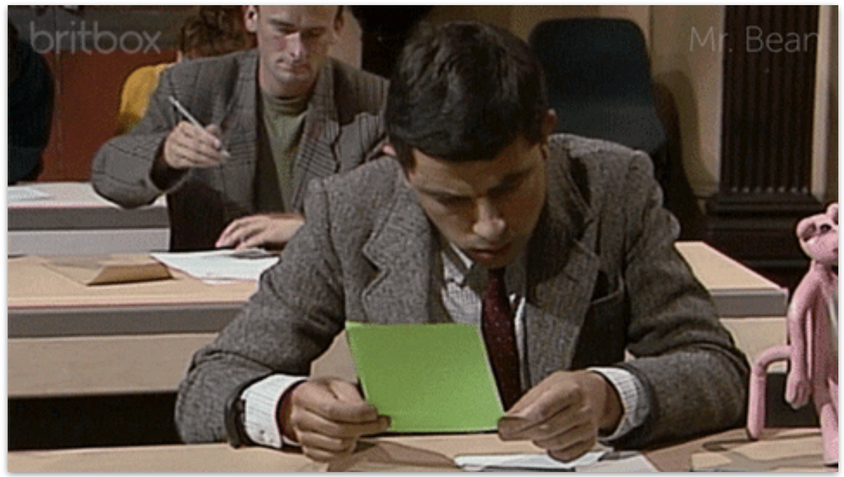

Code of Honor
Break it and get 0 points.
Do it again and get an F.
Please refer to https://bit.ly/3TmiQkQ

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Course Overview

Prerequisites

Essential
Programming, basic prob & stats,
and data structures
Team work

Desired
Python, numpy, OpenCV

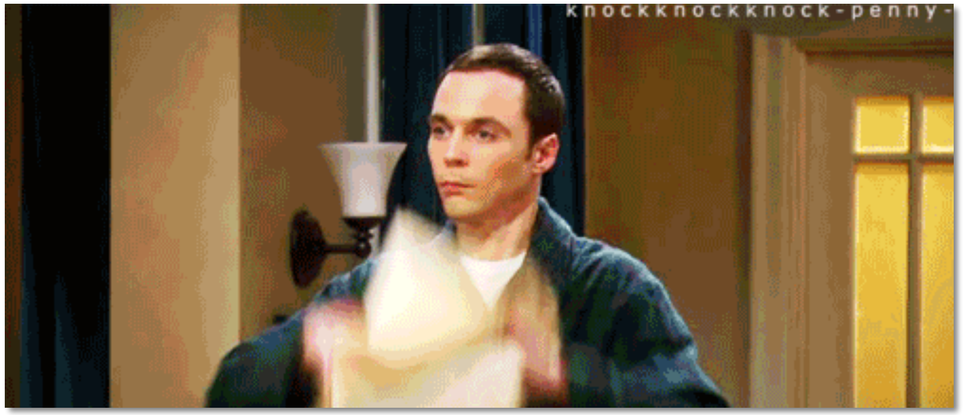
Not sure?
Please talk to me in private.

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.

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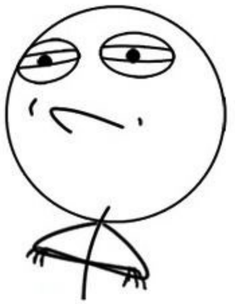
Your next tasks

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.