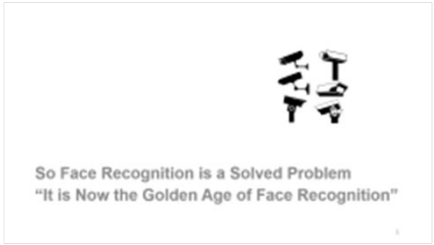
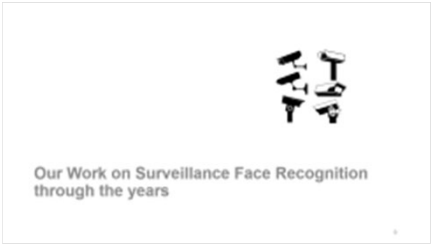
Biometrics in Surveillance Videos

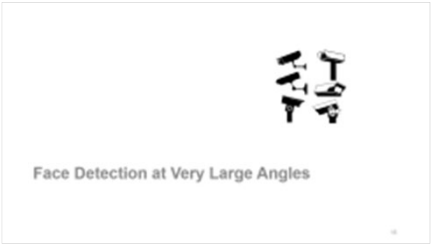
Brian Lovell

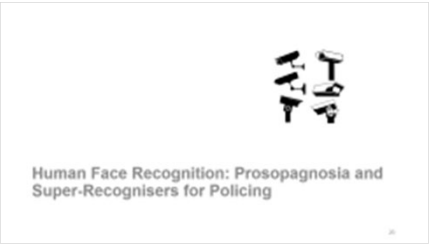
The University of Queensland

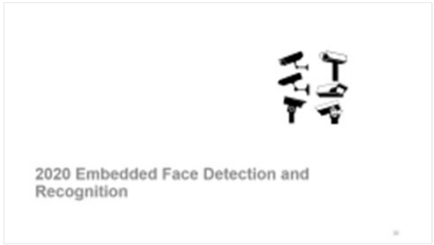
Roadmap to My Presentation

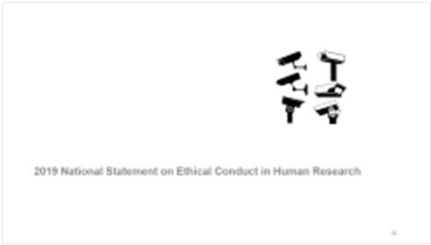


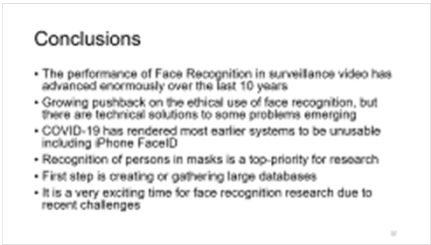












So Face Recognition is a Solved Problem
“It is Now the Golden Age of Face Recognition”

Face Recognition for Border Control

Cooperative Facial Verification

Airport smart gates, border control, access control

- Known reference image – e.g. passport photo
- Very high resolution
- Perfect artificial lighting
- Multiple high quality cameras or single height adjustable
- No movement, no glasses, no expression allowed
- One person at a time
- Photo based not video based
- Cooperative Subject – the subject wants to be recognised
- One-to-one match – verification only, not one-to-many recognition

Many Commercial Solutions available, fully tested by NIST

Australia was first in the World with Face for Border Control
Rollout in 2007 at BNE Airport

SmartGate

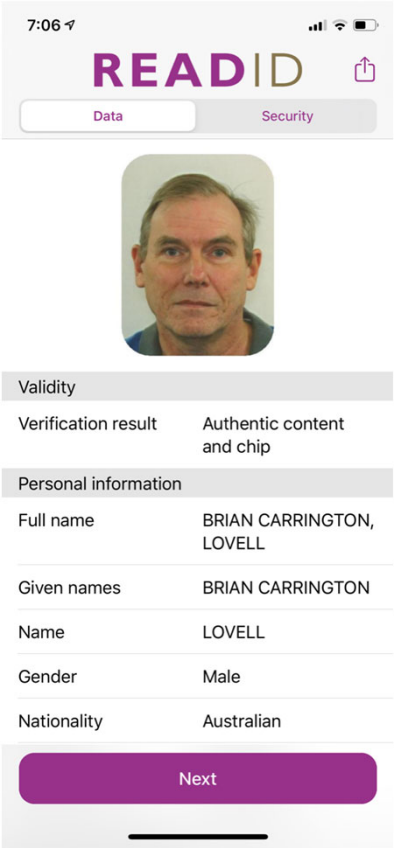
- Are these two faces the same person?
- Primarily used for passenger facilitation not security
- Now used for Australian Departures as well
- Similar Tech is in use in UK, NZ etc

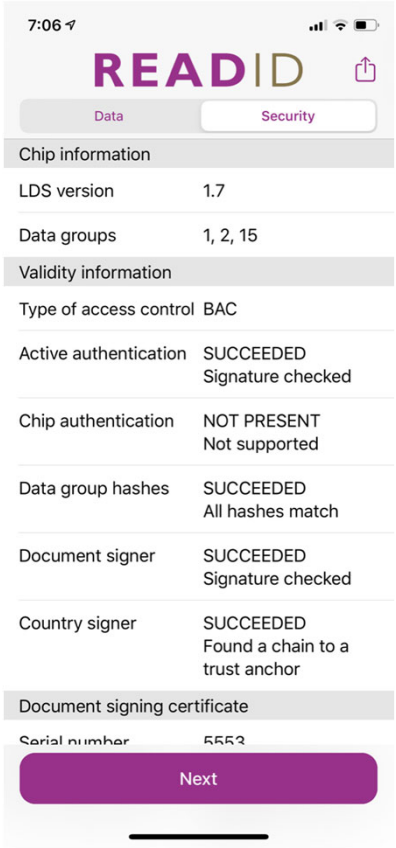
Australian Customs and Border Control is now working on Digital Passports, so passengers can cross national borders without any paperwork. (Initiative Announced at ICB2018)

Digital Passports: Photo and Passport Information is Stored in the RFID Chip

Step 1 - SCAN

To gain access to the chip in your passport, scan the Machine Readable Zone using the camera.





Apple has only allowed this access from IOS 13 released late 2019 at the request of UK government.

iPhone X 2D and 3D FaceID

- Time of flight proximity sensor
- Powers up other sensors
- IR dot projector for 3D
- IR Flood Illuminator
- IR camera
- Works at night with IR illumination

3D is mostly for anti spoofing not recognition accuracy.

Anyone know of a practical 2D Anti-spoof technique?

Digital Mobile ID with Face Recognition

- Way back in 2015, Apple Vice President Eddy Cue told us that replacing passports was one of the company's ambitions. Governments are already exploring use of Apple's devices to replace driving licenses.
- Apple in 2018 enabled use of its devices as digital ID at student campuses across the U.S.. This use of device as ID may also provide Apple with real usage data to help prove its systems work and can be trusted to do so — even by governments.

https://www.computerworld.com/article/3388300/your-iphone-will-be-your-passport.html

Our Work on Surveillance Face Recognition through the years

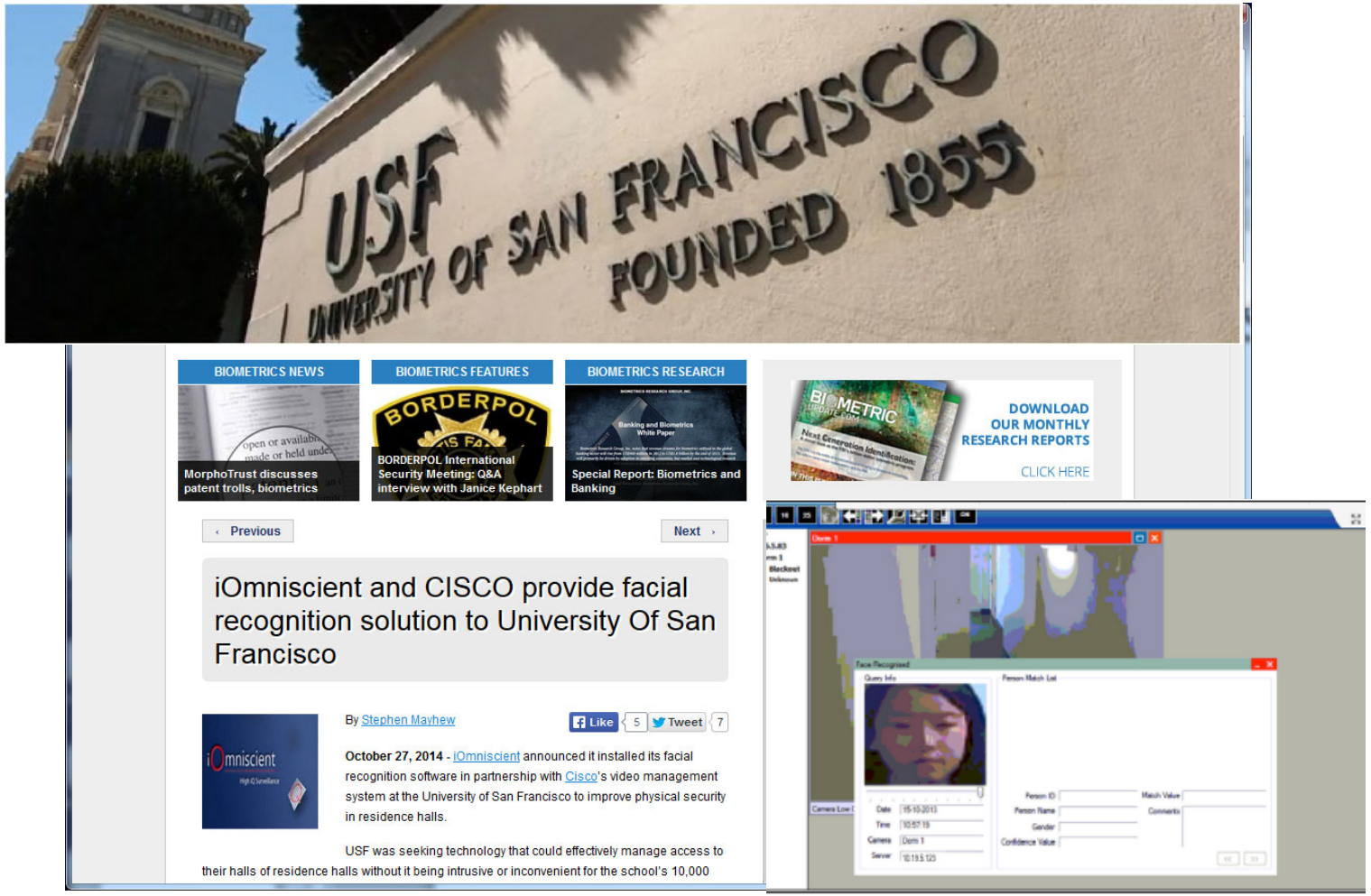
2011: Chokepoint Identification

Notes

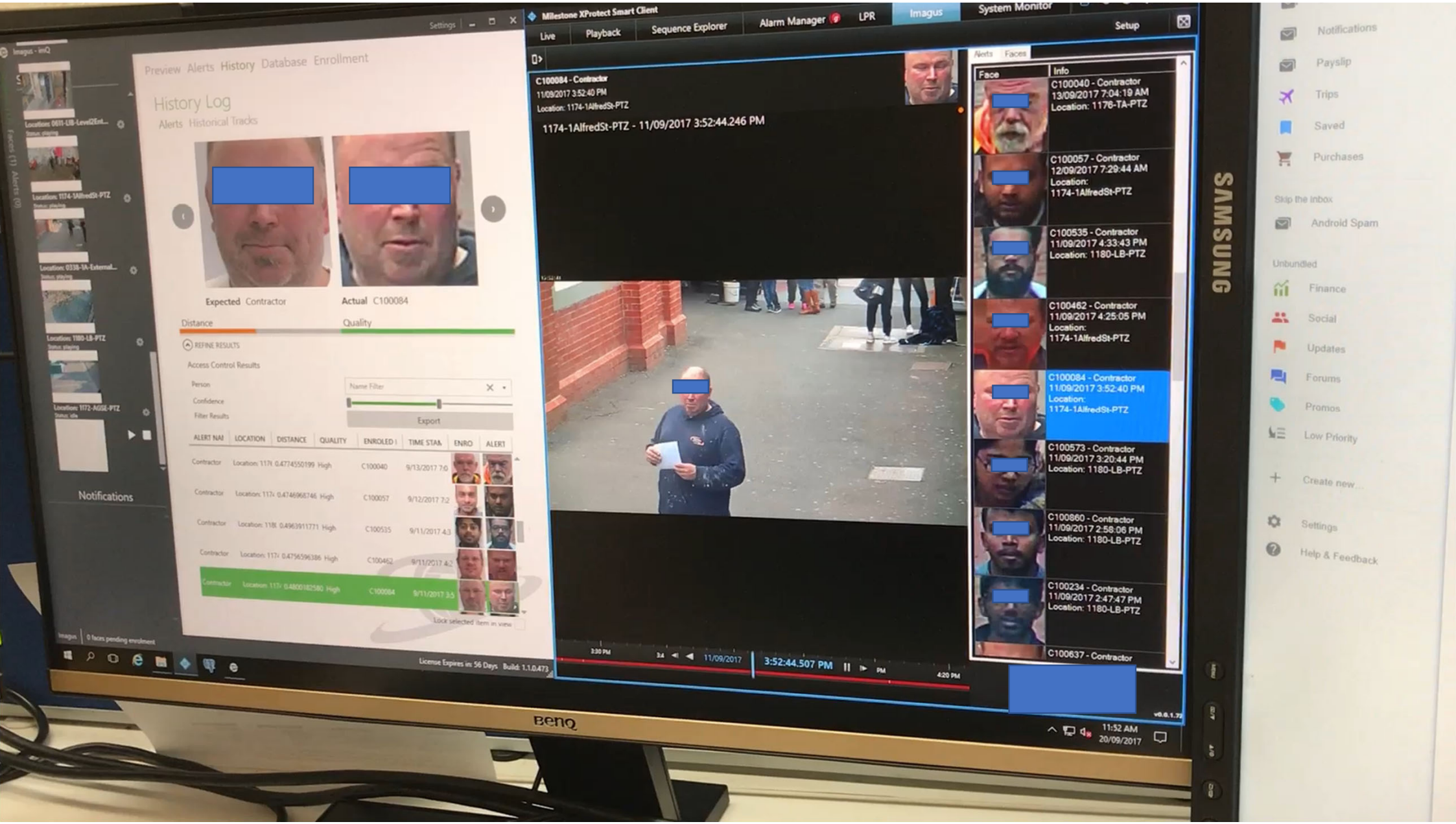
- Detection is Viola-Jones Cascade based (Pittpatt)
- Recognition is Bag of Words based
- No CNNs
- Multiprocessed using GPUs and Robot Operating System (ROS)
- We won the IFSEC Major Category of **CCTV System of the Year** for **Face Recognition in a Crowd in 2011** in Birmingham
- Chokepoint simulates persons walking down an Aerobridge and was intended to address the Undocumented Passenger Problem.
- Chokepoint Dataset released to community.

https://zenodo.org/record/815657#.XhP2nPxS-Uk

2011 System Deployed Commercially



2017 Accuracy Greatly Increased by Using DNNs for Face Recognition


Milestone XProtect Smart Client
Live
Playback
Sequence Explorer
Alarm Manager
LPR
Imagus
System Monitor
Setup
Preview Alerts History Database Enrollment
History Log
Alerts Historical Tracks
Expected Contractor
Actual C100084
Distance
Quality
REFINE RESULTS
Access Control Results
Person
Name Filter
Confidence
Filter Results
Export
ALERT NAI
LOCATION
DISTANCE
QUALITY
ENROLED I
TIME STAN
ENRO
ALERT
Notifications
C100084 - Contractor
11/09/2017 3:52:40 PM
Location: 1174-1AlfredSt-PTZ
1174-1AlfredSt-PTZ - 11/09/2017 3:52:44.246 PM
Alerts
Faces
Face
Info
C100040 - Contractor
13/09/2017 7:04:19 AM
Location: 1176-TA-PTZ
C100057 - Contractor
12/09/2017 7:29:44 AM
Location:
1174-1AlfredSt-PTZ
C100535 - Contractor
11/09/2017 4:33:43 PM
Location: 1180-LB-PTZ
C100462 - Contractor
11/09/2017 4:25:05 PM
Location:
1174-1AlfredSt-PTZ
C100084 - Contractor
11/09/2017 3:52:40 PM
Location:
1174-1AlfredSt-PTZ
C100573 - Contractor
11/09/2017 3:20:44 PM
Location: 1180-LB-PTZ
C100860 - Contractor
11/09/2017 2:58:06 PM
Location: 1180-LB-PTZ
C100234 - Contractor
11/09/2017 2:47:47 PM
Location: 1180-LB-PTZ
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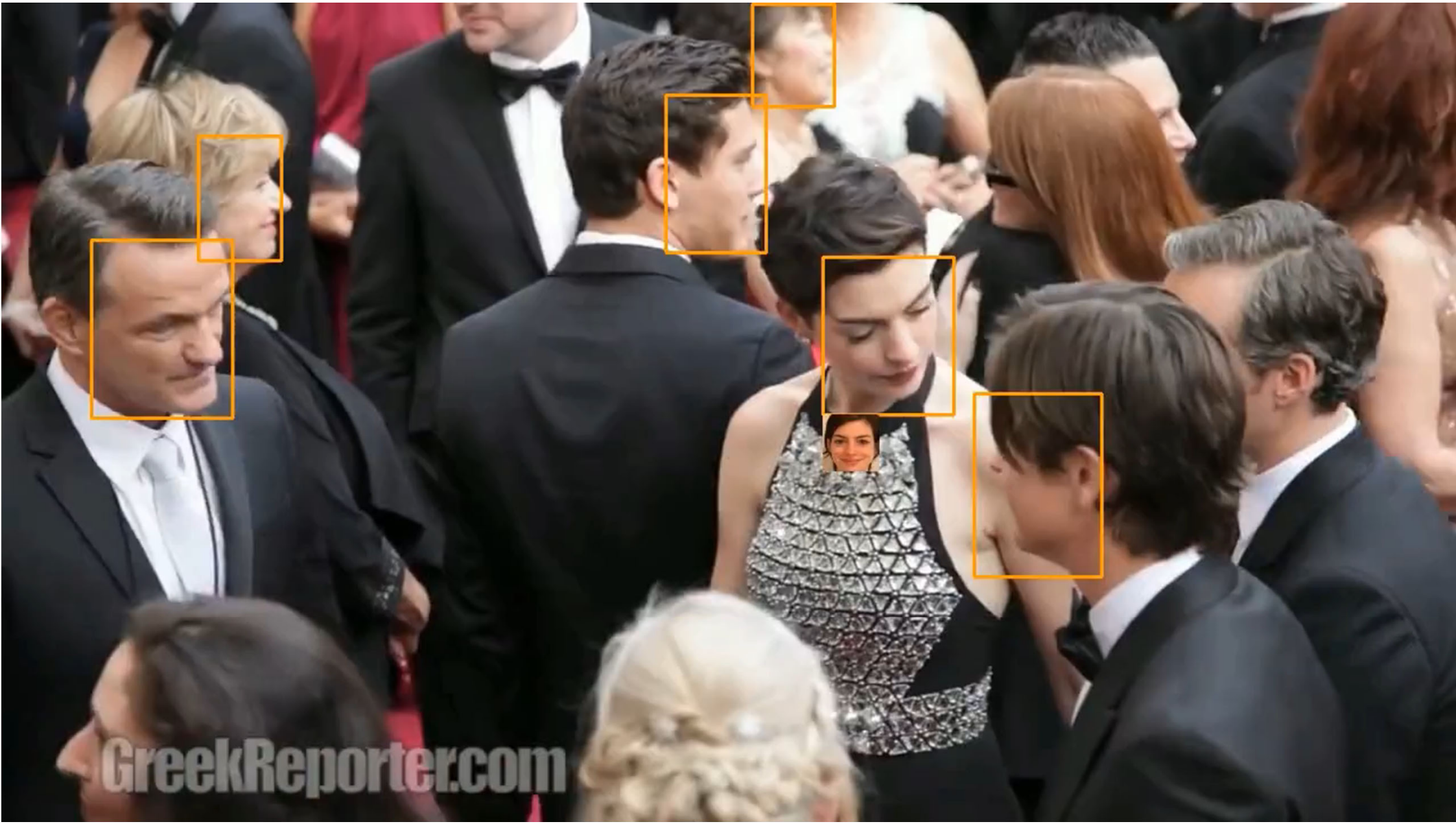
Forums
Promos
Low Priority
Create new...
Settings
Help & Feedback
SAMSUNG
BenQ

Face Detection at Very Large Angles

The Practical Problem In a Nutshell

- Due to computational requirements, face recognition from surveillance video has mainly used the Viola-Jones Cascade Face Detector on the Front End
- If we want to recognize faces in video at extreme angles, we must use CNN based detectors which are much slower and cannot easily handle the huge camera resolutions (5Mp or more) and multiple streams
- All decoding and detection must take place in the GPU
- We now do face detection with CNNs at 500 fps on small edge devices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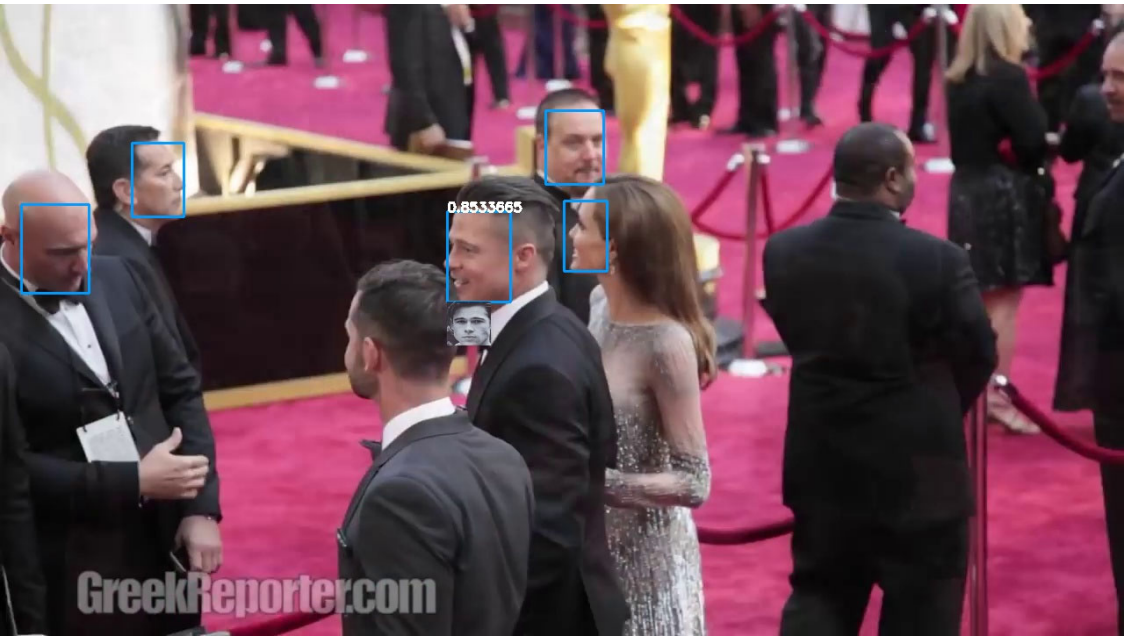
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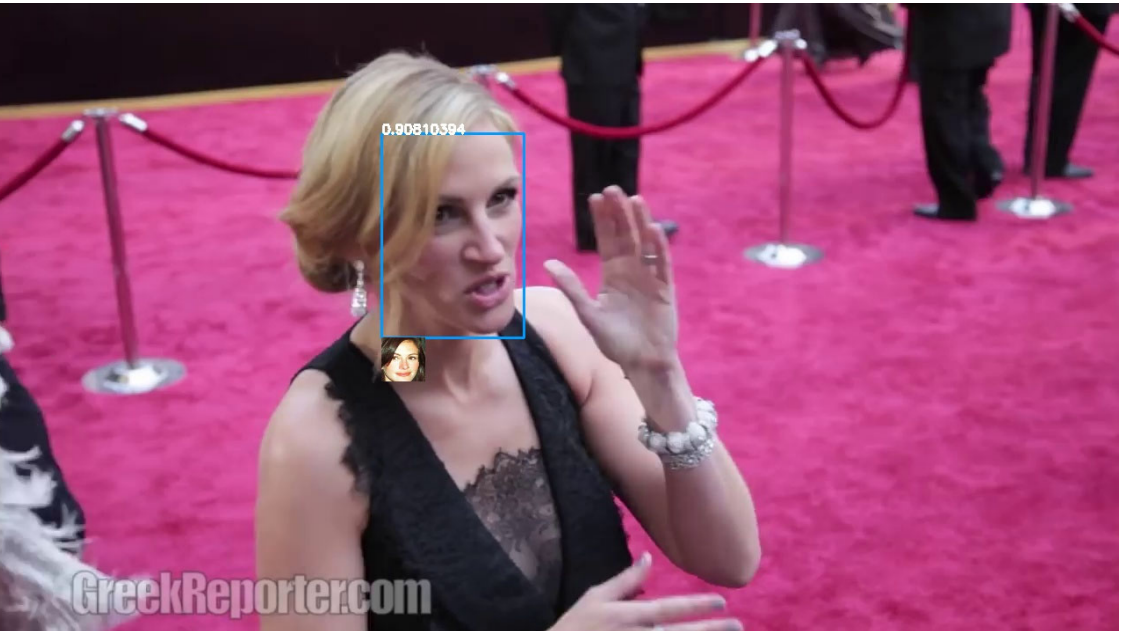
GreekReporter.com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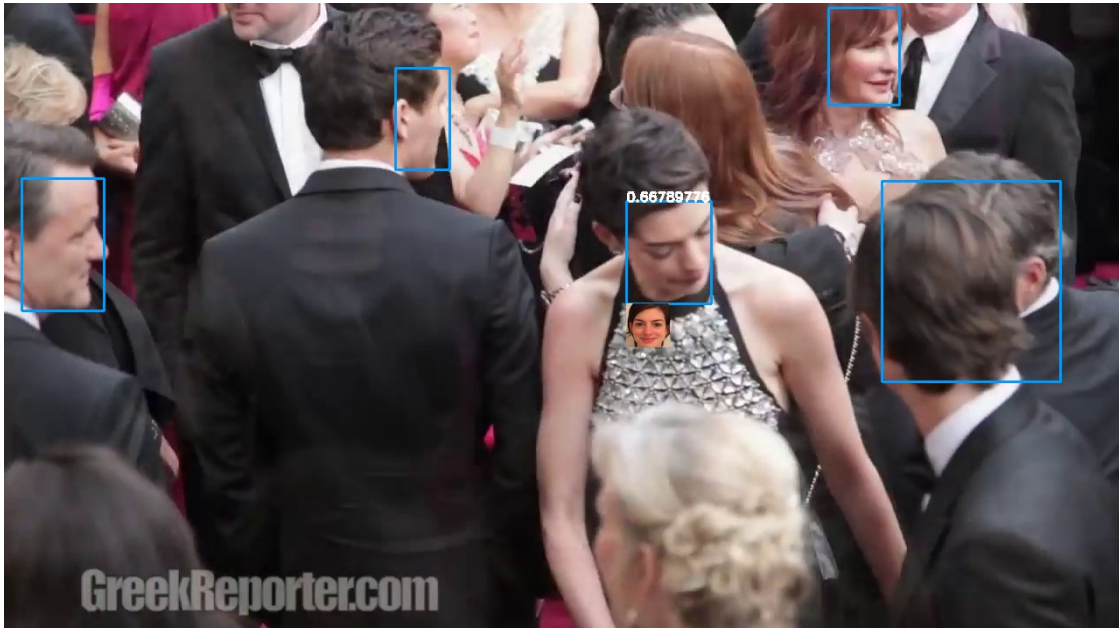
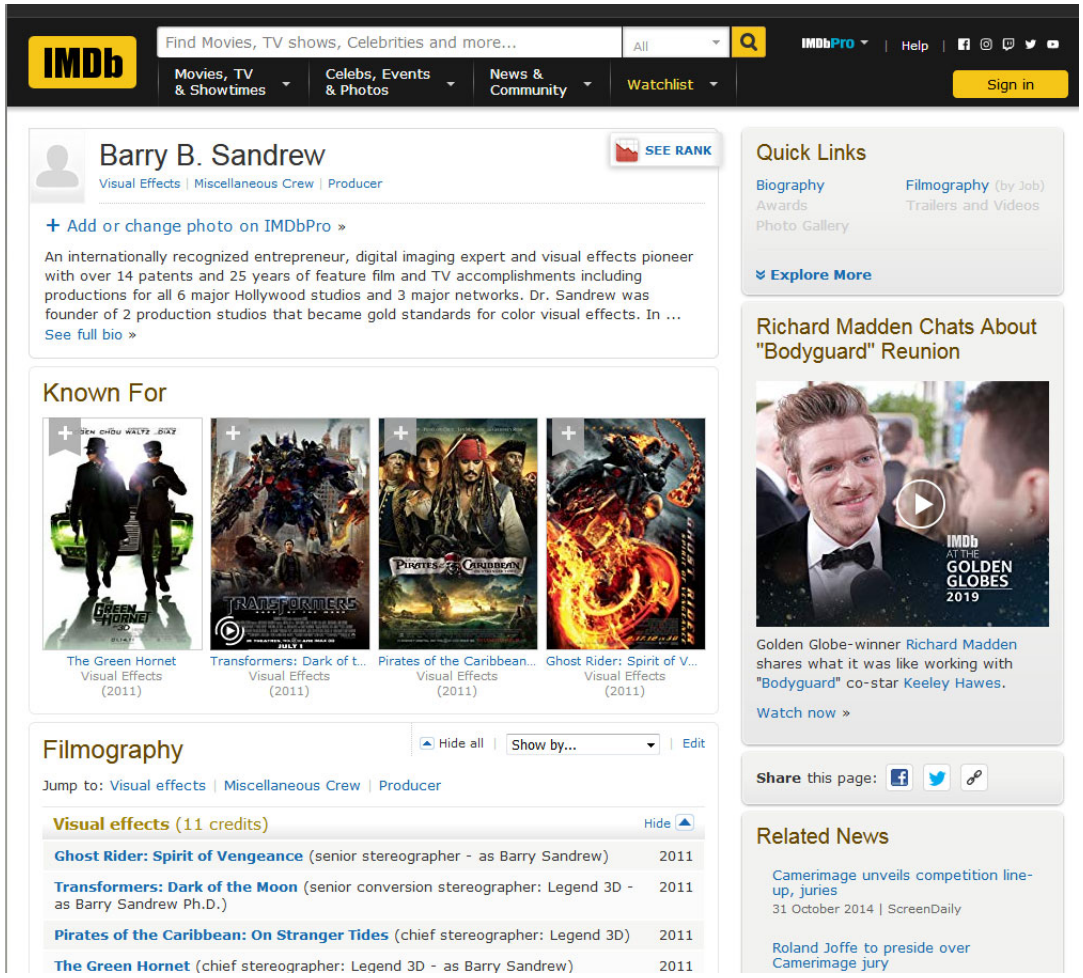

GreekReporter.com

Faces in a Milling Crowd

- The problem with CCTV face recognition in many common situations is that people simply do not look at the camera, but we would still like to identify them.
- The Chokepoint scenario addresses this issue because people tend to look straight ahead when walking in a crowd
- This assumption applies to aerobridges, borders, concierge situations, but not to cocktail parties, conferences, shopping centres, check in areas.
- We would like to have much better performance under common non-cooperative conditions where people do not look at the camera.

Human Face Recognition: Prosopagnosia and Super-Recognisers for Policing

Dr Barry Sandrew (Prosopagnosiac)



Prosopagnosia

Prosopagnosia (*prosopon* = face, *agnosia* = unknowing)—also known as *face blindness*—is a medically recognized neuro-cognitive disorder that can be extremely debilitating in social situations. An estimated 2.5 percent of the population—some 8.2 million people in the United States alone—is affected. While many people with a mild case of face blindness may simply conclude they, “are not good with faces,” in reality, they might very well fall within the prosopagnosia spectrum.

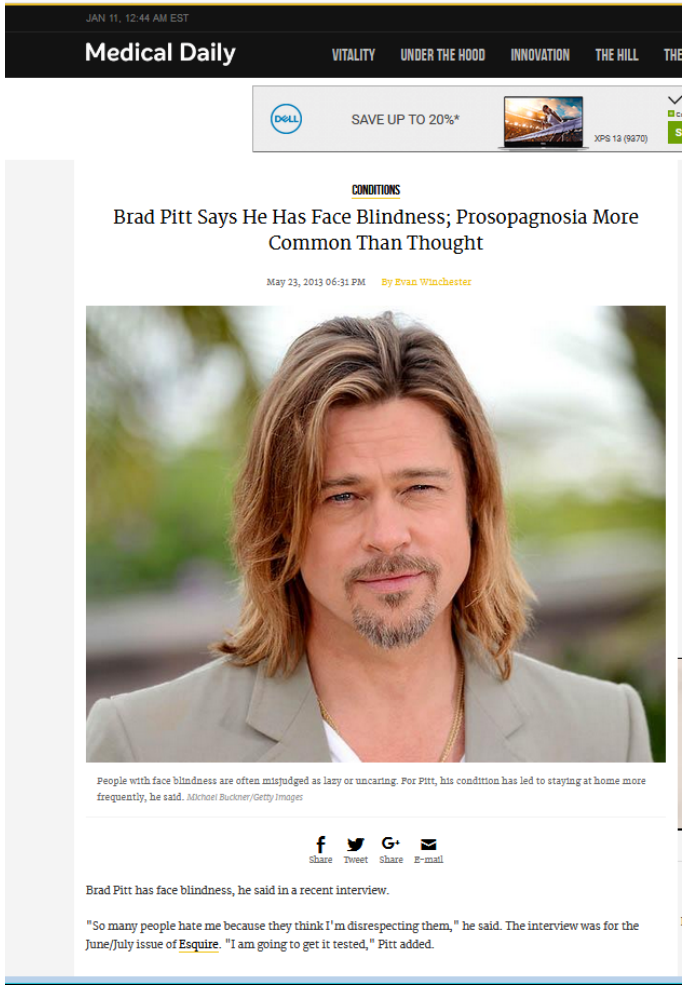
- Barry Sandrew

Notable People

- A number of notable people, including the actor, **Brad Pitt**; famed primatologist, **Jane Goodall**; and co-founder of Apple, **Steve Wozniak** suffer to some degree from clinically relevant face blindness
- The social interchange and friendly banter that average people manage innately throughout the day become a huge challenge for those with facial blindness

- Barry Sandrew

Brad Pitt



JAN 11, 12:44 AM EST

Medical Daily VITALITY UNDER THE HOOD INNOVATION THE HILL THE

SAVE UP TO 20%* XPS 13 (9370)

CONDITIONS

Brad Pitt Says He Has Face Blindness; Prosopagnosia More Common Than Thought

May 23, 2013 06:31 PM By Evan Winchester

People with face blindness are often misjudged as lazy or uncaring. For Pitt, his condition has led to staying at home more frequently, he said. *Michael Buckner/Getty Images*

Share Tweet Share E-mail

Brad Pitt has face blindness, he said in a recent interview.

"So many people hate me because they think I'm disrespecting them," he said. The interview was for the June/July issue of Esquire. "I am going to get it tested," Pitt added.

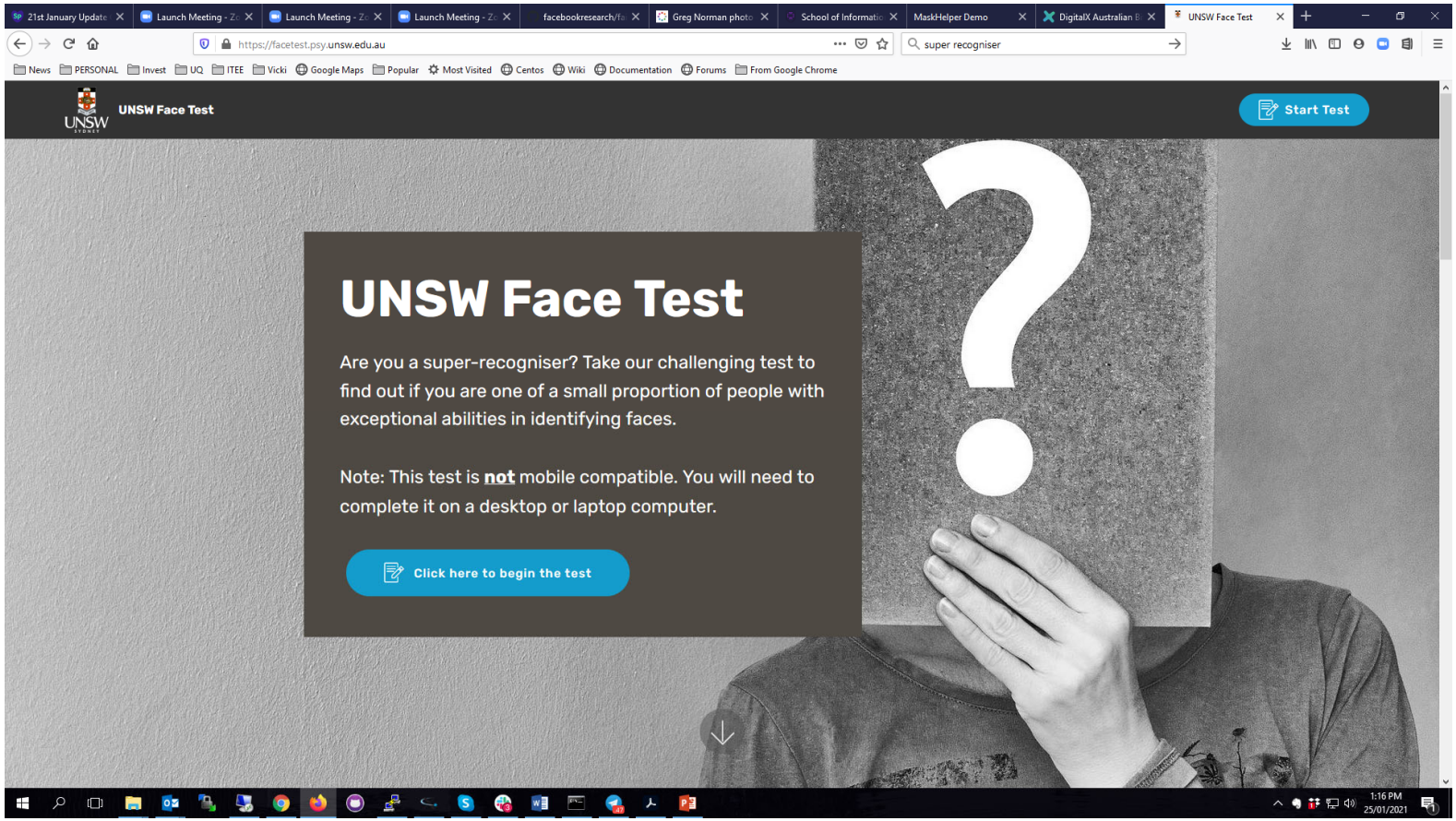
"I swear to God, I took one year where I just said, This year, I'm just going to cop to it and say to people, 'Okay, where did we meet?' But it just got worse. People were *more* offended," said the 49-year-old star of the zombie movie *World War Z. "*Every now and then, someone will give me context, and I'll say, 'Thank you for helping me.' But I piss more people off. You get this thing, like, 'You're being egotistical. You're being conceited.' But it's a mystery to me, man. I can't grasp a face and yet I come from such a design/aesthetic point of view."

Super-Recognisers

- While prosopagnosia has been recognised for some time, it was thought that it was an on-off condition – either you have it or you don't
- Recent studies have shown that face recognition ability is on a continuum and ability varies between individuals
- Testing has demonstrated this and research shows that face recognition is an innate skill that you are born with
  - Does not appear to improve with training or experience
- Scotland Yard (London Met) have tested many people and have assembled a team of super-recognizers with extraordinary ability.
- Mick Neville's Team recognized and prosecuted 300 people from London Riots in 2011.

https://www.newyorker.com/magazine/2016/08/22/londons-super-recognizer-police-force

UNSW Super Recogniser Test



https://facetest.psy.unsw.edu.au/

My Score ☹

On the UNSW Face Memory Test you scored 22 out of 40.

On the UNSW Face Sorting Test you scored 44 out of 80.

Your overall score on the UNSW Face Test was 55%.

For your information, based on the first 6300 participants on the UNSW Face Test:

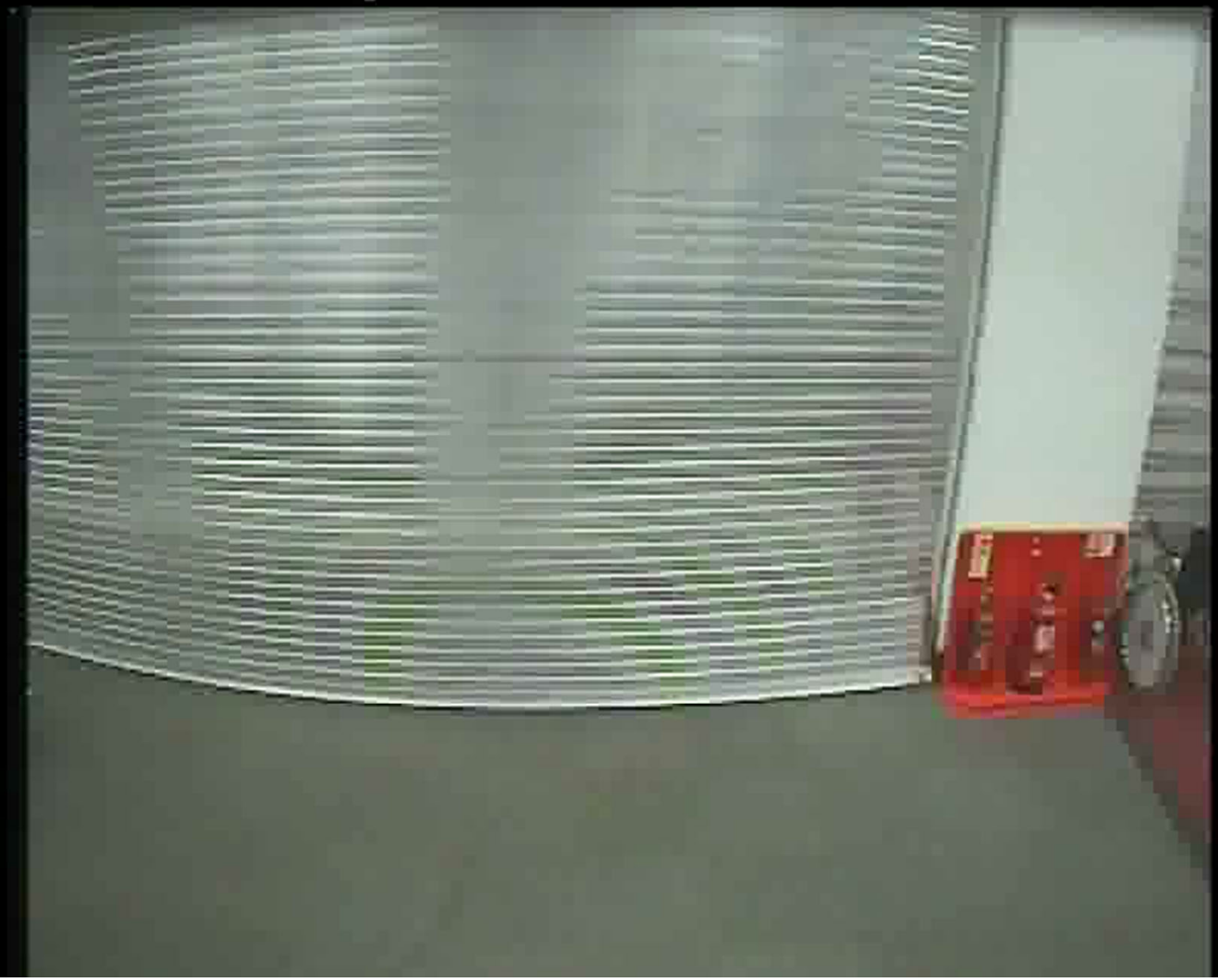
Top 5% scored 72% and above

Top 10% scored 69% and above

Top 25% scored 65% and above

Top 50% scored 61% and above

Think about placement of cameras.



How do We Recognise a Person Now?

- People are moving, blurred, wearing balaclavas and masks
- They do not look at the camera
- For such challenging videos, super recognizers can make reliable matches
- Super recognisers are often assisted by computer databases to narrow the search space – usually just text based queries
- While computer face searching is fast, a super recogniser is still the best.

2020 Embedded Face Detection and Recognition

Move Face Detection to the Edge

- Embedded System based on NVIDIA Nano
- 600 FPS Face Detection
- Conversion to 512d feature vector
- Recognition performed on Secure Server
- Currently being deployed in the UK through AR Live Systems/Facewatch

Recognition to Deter Low Level Crime

Stop Crime
Before it happens

FACEWATCH

Home | Sectors | Privacy | Contact Us | Facewatch Blog | Accredited Partners

The UK's leading facial recognition security system

Facewatch is one of the UK's leading facial recognition companies. Facewatch's cloud-based facial recognition security system safeguards businesses against crime. Our facial recognition technology sends you

It is the ONLY shared national facial recognition watchlist. Simple, secure and affordable, we are the premier choice of retail security companies in the UK. Facewatch is proven to stop crime before it happens. It's time for

Looking good. So what could possibly go wrong?

2019 National Statement on Ethical Conduct in Human Research

Ethics in AI

NHMRC BUILDING A HEALTHY AUSTRALIA

Funding | Health advice | Research policy | About Us

ABOUT US › PUBLICATIONS › NATIONAL STATEMENT ON ETHICAL CONDUCT IN HUMAN RESEARCH (2007) - UPDATED 2018

National Statement on Ethical Conduct in Human Research (2007) - Updated 2018

The *National Statement on Ethical Conduct in Human Research (2007)* (National Statement (2007) consists of a series of guidelines made in accordance with the *National Health and Medical Research Council Act 1992*.

Public consultation on National Statement content

The public consultation on the revised draft Section 4 and Section 5 of the National Statement is now open. The closing date for submissions is Friday 30 October 2020.

Further information is available from NHMRC's Online Services portal.

Publication Data

Reference number: E72
ISBN: 1864962755

2018 | Current

Go to downloads

National Statement - In a Nutshell

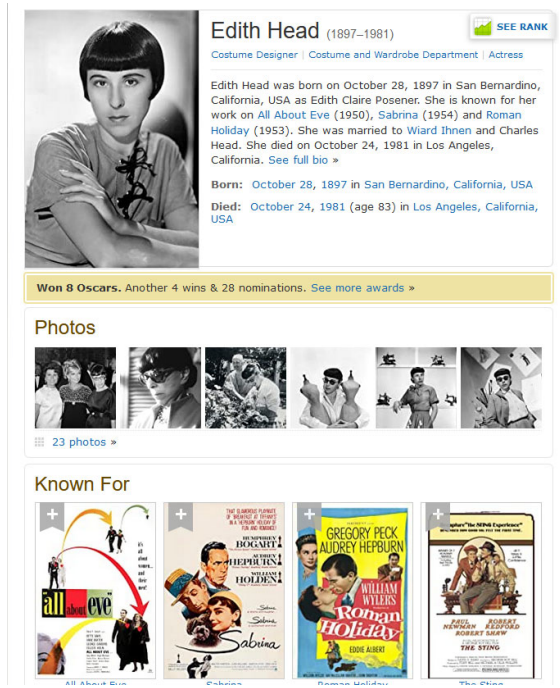
- All databases collected off the internet require ethical approval
- No ability to use datasets that do not have ethical approval
- All datasets of faces must have fully informed consent of persons concerned to use for face recognition research
- No usage of international datasets that do not comply

- **So how do we continue to research and test face recognition systems?**
- **Need to find a way to create databases with full consent or no requirement for consent**

2019 IDEA 1: EDITH Ethical Face Recognition Database using 3D Heads

Development of EDITH Database

- Ethical Database of Interactive Training Heads
  - Edith Head was a famous Hollywood Costume Designer
- Idea – Capture 3D Heads instead of Images
- Generate thousands of images from each head
- Add masks glasses etc
- Greatly reduces burden of obtaining consent
- Only release projected images and not heads themselves
- Generate photos to order



3D Head Database including Masked Faces

2019 IDEA 2: EDITH Synthetic Face Database

Faces à la Carte: Text-to-Face Generation via Attribute Disentanglement

Tianren Wang, Teng Zhang, Brian Lovell

The University of Queensland

Issues

Text-to-face tasks (TTF)

- Natural language contains high dimensional information which is often less specific but also much more abstract than images.
- The linkage between face images and their text descriptions is much looser than for popular text-to-image tasks, e.g. birds and flower images.
- Addressing emerging issues of data scarcity arising from the growing ethical concerns regarding informed consent for the use of faces scraped from the internet in modern biometrics research.

Contributions

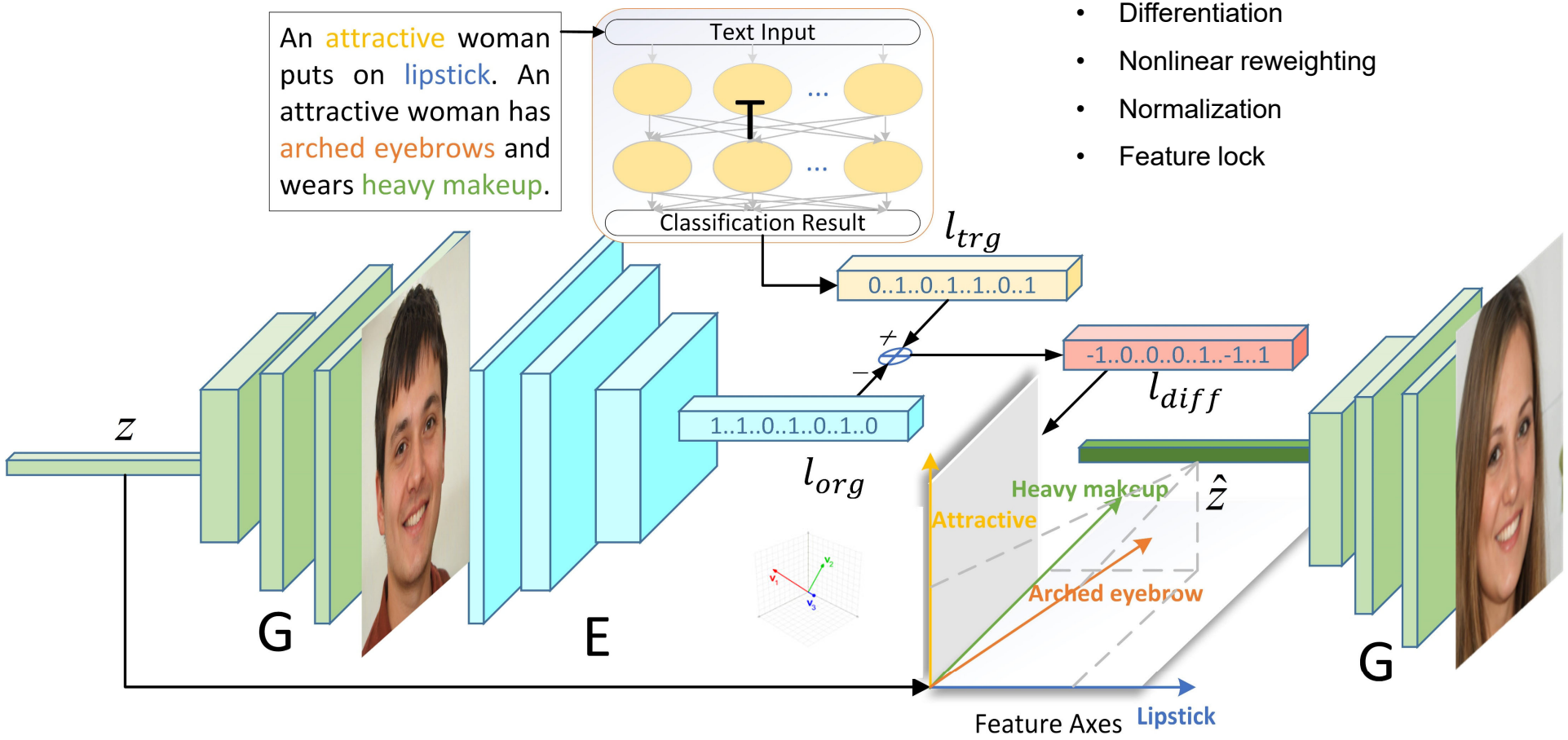
- Propose a novel TTF-HD framework comprising a multi-label text classifier, an image label encoder, and a feature disentangled image generator to generate high-quality faces with a wide range of variation.

- Add a novel 40-label orthogonal coordinate system to guide the trajectory of the input noise vectors.

- Use state-of-the-art StyleGAN2[1] as the generator to map the manipulated noise vectors into the disentangled feature space to generate 1024*1024 high-resolution images.

1. Karras, Tero, et al. "Analyzing and improving the image quality of stylegan." *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*. 2020.

Model



- Differentiation
- Nonlinear reweighting
- Normalization
- Feature lock

https://commons.wikimedia.org/wiki/File:Gram-Schmidt_orthonormalization_process.gif

Results & Evaluation

Methods	*IS*	*CS**	*LPIPS*
TTF-HD (ours)	**1.117±0.127**	**0.664**	0.583±0.002
AttnGAN	1.062±0.051	0.511	——

*Maximum for each group.

Single-sentence output

An woman has an oval face and wears heavy makeup with a smile.

The attractive man has a pointy nose.

The old woman has gray hair with a smile.

The man has a big nose and gray hair.

All faces are Synthetic!

Ablation Study

A: Full setup

B: w/o feature lock

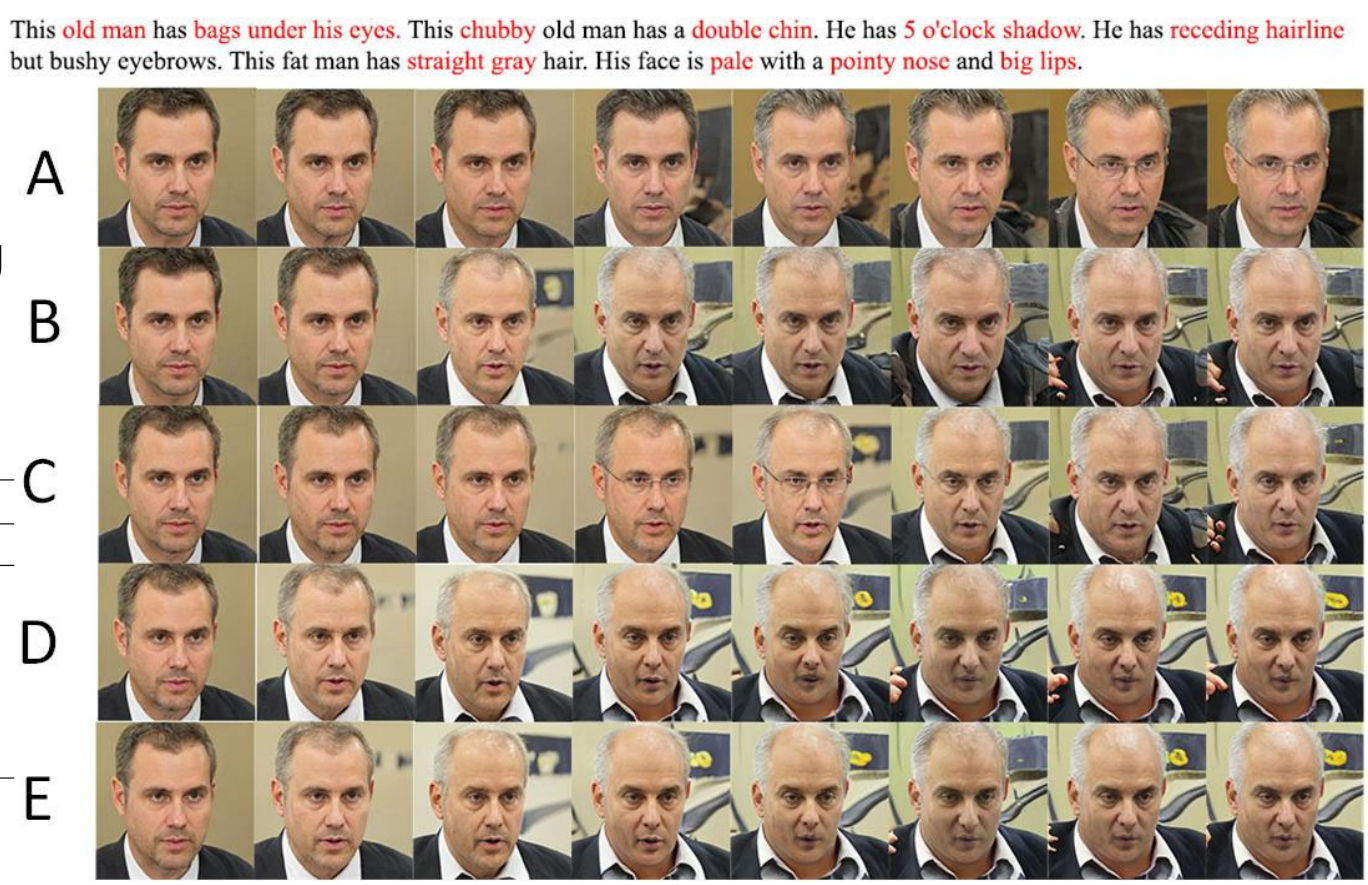
C: B + w/o normalization

D: C + w/o nonlinear reweighting

E: Blank group

Exp. Settings	Evaluation Metrics		
	IS	*CS**	*LPIPS*
Group A	1.122±0.043	0.754	**0.634±0.005**
Group B	1.116±0.080	0.739	0.608±0.005
Group C	**1.187±0.062**	**0.762**	0.603±0.005
Group D	1.101±0.095	0.683	0.521±0.006
Group E	1.102±0.033	0.706	0.532±0.005

*Maximum for each group



Status

- The text-to-feature accuracy in each image batch needs improvement.
  - The image encoder *E* is the bottle neck which needs to be improved in accuracy.

- Features in the latent space are still not well disentangled.
  - Inspired by GANSpace[1], establish feature axes in intermediate space of StyleGAN2[2] (*W* space), rather than the noise vector space extracted from normal distribution.

1. Härkönen, Erik, et al. "GANSpace: Discovering Interpretable GAN Controls." arXiv preprint arXiv:2004.02546 (2020). 2. Karras, Tero, et al. "Analyzing and improving the image quality of stylegan." Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition. 2020.

Covid 19 World Pandemic

All Face Recognition Systems developed to date are useless.

Need to handle masks at high angles for both detection and recognition stages.

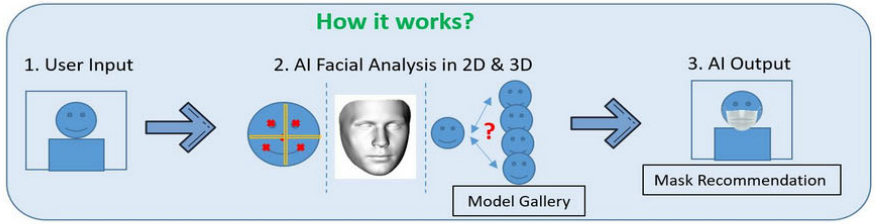
10-26-2020 Mon 10:11:49
Raw Input
Camera 01
10-26-2020 Mon 10:11:49
MTCNN
Camera 01
10-26-2020 Mon 10:11:49
RetinaFace+Large Backbone
Camera 01
MaskRetinaFace+Tiny Backbone
Camera 01

Fully Synthetic Faces at Various Angles with and without Masks

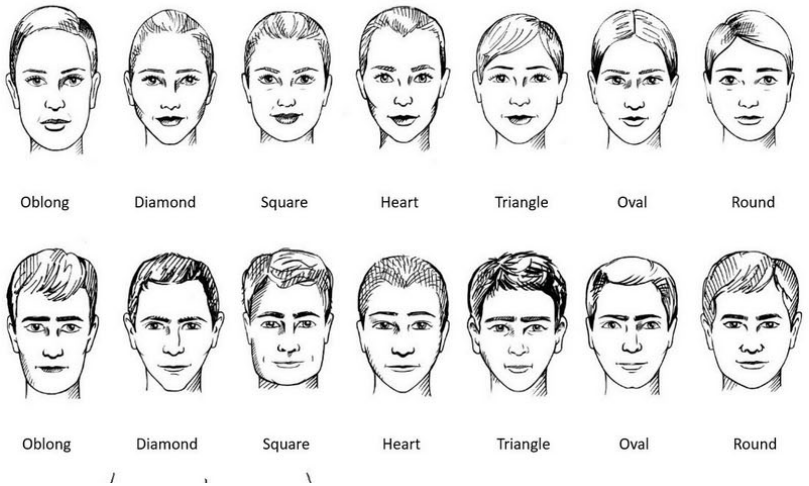
Touch Free Mask Fitting for Covid19

Mask Helper App

Tips: How to wear a mask correctly

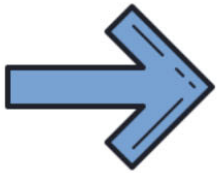


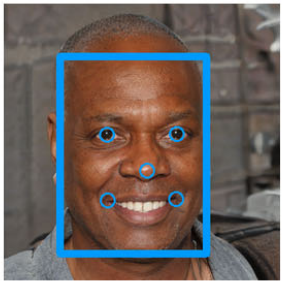
(Required) Frontal Photo :	Browse... 159994_0.png
(Required) A codename :	Random User
(Required) Face shape :	• ○ Oblong • ◉ Diamond • ○ Square • ○ Heart • ○ Triangle • ○ Oval • ○ Round
(Required) Nose shape :	• ○ Downturned • ◉ Upturned • ○ Hooked or Beaked • ○ Straight
	• ○ Short

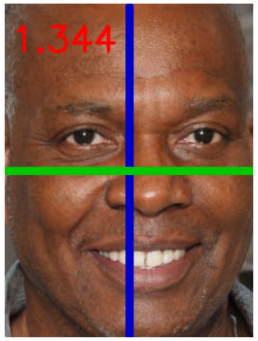


3D Reconstruction and Mask Fit

<- Delete user data and go back



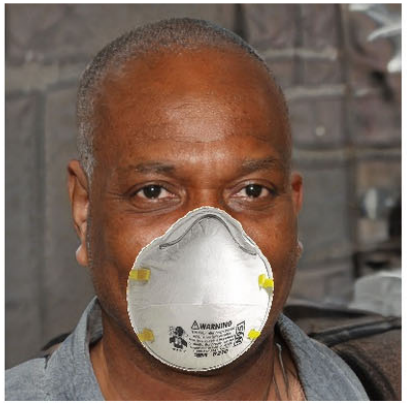




---------- Prediction Result Below----------

Face Analysis: Random User, Face Ratio:1.344, Contour: Check, 3D Landmarks: Chec

Mask Ranking: Proshield_Duckbill_Medium; System confidence [0~1] is: 0.5



Interesting Results

- We believe that this is the first time that a realistic 3D reconstruction has been made from a synthetic face
- Leads to the possibility of generating fully synthetic 3D heads
- Good progress towards the ultimate aim of creating fully synthetic ethical face databases

Conclusions

- The performance of Face Recognition in surveillance video has advanced enormously over the last 10 years
- Growing pushback on the ethical use of face recognition, but there are technical solutions to some problems emerging
- COVID-19 has rendered most earlier systems to be unusable including iPhone FaceID
- Recognition of persons in masks is a top-priority for research
- First step is creating or gathering large databases
- It is a very exciting time for face recognition research due to recent challenges