from e-gate to free flow

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First e-gates

First e-gate pilots with FR shows up at the early 2000's.
First operational deployment in mid-2000's with availability of the biometric e-passport.

As customs declaration process was long and passport readers were slow, many deployments used a 2 step process (Kiosk + e-gates)

As algorithms were robust to almost nothing, e-gates were designed to follow the ISO/IEC 19794-5 constraints for facial images, like passport images.

Beautiful « all blacks » e-gate in Auckland, NZ.

Design constraints

Totem with cameras in the walking direction to avoid yaw angles

3 cameras for height adjustment to avoid large pitch angles.

Screen and light signals to attract attention, to avoid large poses.

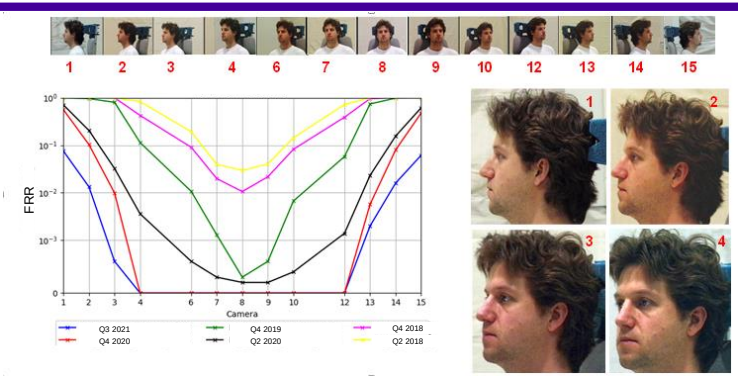
Long light tubes to help for uniform illumination while avoiding glare in glasses

Fast ticket reader

Distance subject-camera greater than 1m20 as in ISO_IEC 19794-5 recommendations to avoid distortion

Robustness to face pose

Gross, R., Matthews, I., Cohn, J., Kanade, T., & Baker, S. (2010). Multi-pie. *Image and vision computing*, *28*(5), 807-813.



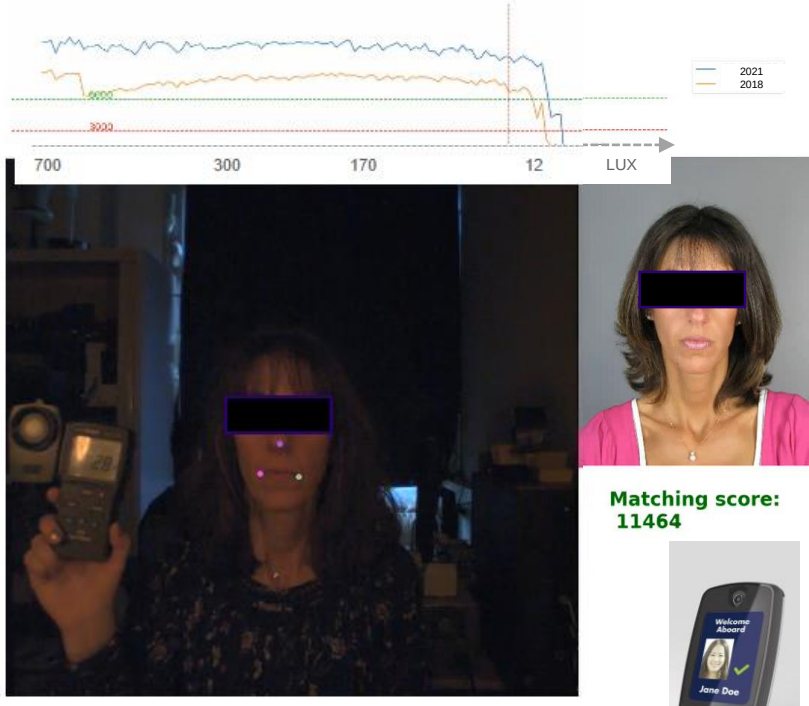
Tests from NIST FRVT confirm that it is now possible to compare frontal and profile face images with good performance.

Algorithm	Probe	Mugshot	Mugshot	Webcam	Profile 90°	Border	Kiosk	Border ΔT ≥ 10 YRS	Mugshot ΔT ≥ 12 YRS
	Date	N = 12000000	N = 1600000	N = 1600000	N = 1600000	N = 1600000	N = 1600000	N = 1600000	N = 3000000
cloudwalk_mt_001	2022-07-27	0.0021(5)	0.0018(13)	0.0116(11)	0.0637(1)	0.0019(1)	0.0496(1)	0.0173(1)	0.0032(2)
idemia_009	2022-03-01	0.0021(4)	0.0013(3)	0.0089(3)	0.1164(6)	0.0038(5)	0.0646(6)	0.0480(12)	0.0074(7)

Algorithms improvement regarding pose (yaw and pitch angles) allows to put camera at any position in e-gates.

Robustness to ambient light

- Improvement regarding face detection allows stable automatic gain control of cameras, centered on faces.



- With algorithms improvement regarding illumination, this allows to remove additional illuminations in e-gates.

Current deployment

All these improvements at algorithmic side have reduced deployment constraints.

- No device above more than 1m40
- Acquisition in few seconds
- 1:N for boarding.
- Reuse of acquired images for enrollment

However today, passenger are still processed one by one, and they have to stop at some point.

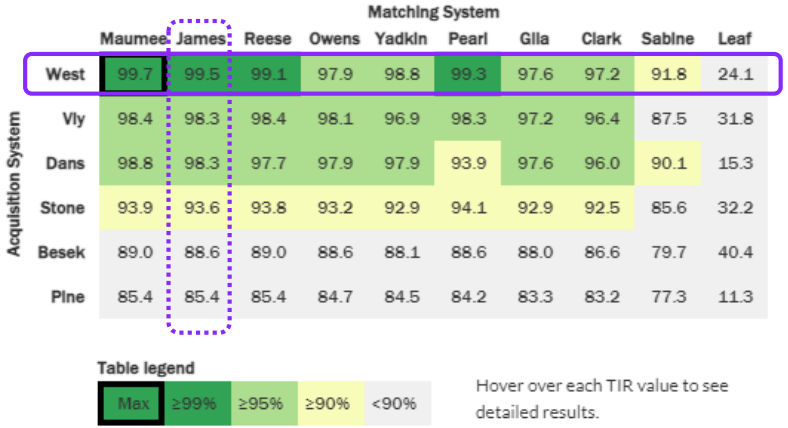
Acquisition on the move

Idemia acquisition system

Idemia matching system

Acquisition on the move has been doable for a while, but for most airport applications, almost 100% success is needed for cooperative subjects.
DHS biometric technology rally evaluated this for few years.

A good acquisition system allows all matching systems to perform better.

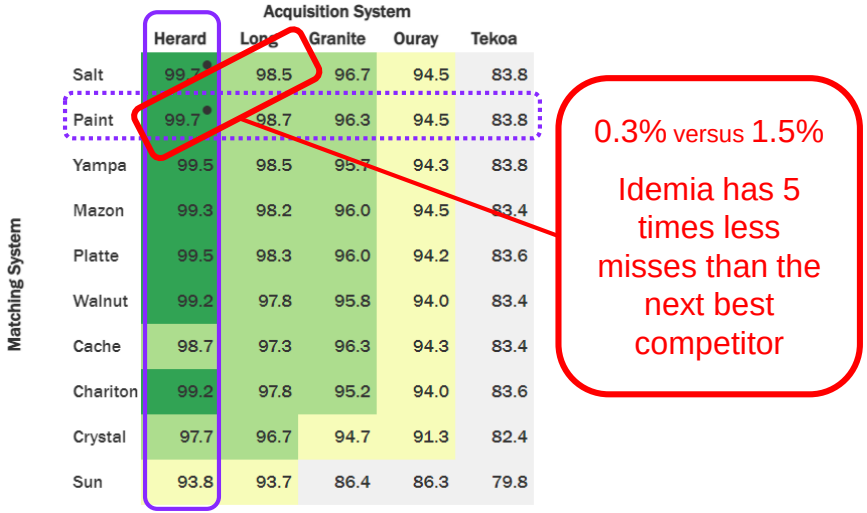


Acquisition System \ Matching System	Maumee	James	Reese	Owens	Yadkin	Pearl	Gila	Clark	Sabine	Leaf
West	99.7	99.5	99.1	97.9	98.8	99.3	97.6	97.2	91.8	24.1
Vly	98.4	98.3	98.4	98.1	96.9	98.3	97.2	96.4	87.5	31.8
Dans	98.8	98.3	97.7	97.9	97.9	93.9	97.6	96.0	90.1	15.3
Stone	93.9	93.6	93.8	93.2	92.9	94.1	92.9	92.5	85.6	32.2
Besek	89.0	88.6	89.0	88.6	88.1	88.6	88.0	86.6	79.7	40.4
Pine	85.4	85.4	85.4	84.7	84.5	84.2	83.3	83.2	77.3	11.3

Table legend: Max | ≥99% | ≥95% | ≥90% | <90%

Hover over each TIR value to see detailed results.

Sept 2020 : Results without Mask



Matching System \ Acquisition System	Herard	Long	Granite	Ouray	Tekoa
Salt	99.7	98.5	96.7	94.5	83.8
Paint	99.7	98.7	96.3	94.5	83.8
Yampa	99.5	98.5	95.7	94.3	83.8
Mazon	99.3	98.2	96.0	94.5	83.4
Platte	99.5	98.3	96.0	94.2	83.6
Walnut	99.2	97.8	95.8	94.0	83.4
Cache	98.7	97.3	96.3	94.3	83.4
Chariton	99.2	97.8	95.2	94.0	83.6
Crystal	97.7	96.7	94.7	91.3	82.4
Sun	93.8	93.7	86.4	86.3	79.8

0.3% versus 1.5%

Idemia has 5 times less misses than the next best competitor

Sept 2021 : Results without Mask

https://mdtf.org/Rally2021/Results2021

Sanitary Mask

Idemia acquisition system

Idemia matching system

Due to covid, questions arise about robustness of face recognition and face acquisition with mask.

2020 DHS rally focuses on mask, then we have upgraded all algorithms :

- Detection
- Tracking
- Quality assessment for BI selection

… and Fray (Idemia) was the only acquisition system able to handle mask.

Acquisition System \ Matching System	Alan	Wolf	Taff	Osage	Pond	Cedar	Mayo	Nolan	Sandy	Brush
Fray	95.9	91.7	90.0	91.9	91.9	89.1	91.4	91.4	82.9	8.3
Elk	69.1	86.6	87.1	84.0	90.0	86.9	87.8	87.1	82.1	9.5
Glen	89.1	85.9	83.3	86.9	86.2	82.6	79.1	84.7	78.6	9.0
Jacks	82.9	76.7	76.9	74.8	71.4	74.5	72.2	69.0	71.9	7.4
Coosa	79.5	72.6	75.2	72.8	66.3	71.9	68.0	62.1	64.5	3.6
Round	69.2	68.5	66.4	68.3	67.5	67.0	68.5	68.2	62.1	3.8

Table legend

Max	≥99%	≥95%	≥90%	<90%

Hover over each TIR value to see detailed results.

Sept 2020 : Results with Mask

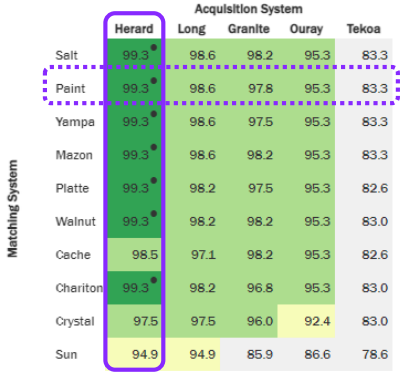
Fairness

Idemia acquisition system

Idemia matching system

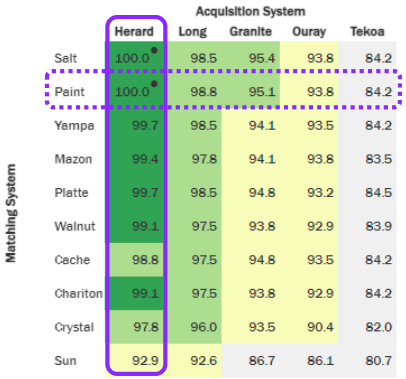
NIST FRVT has reported excellent fairness of Idemia algorithms for FPIR (1:N) and FMR (1:1)

2021 DHS rally focuses on fairness.
It completes NIST results by computing FNIR (1:N).



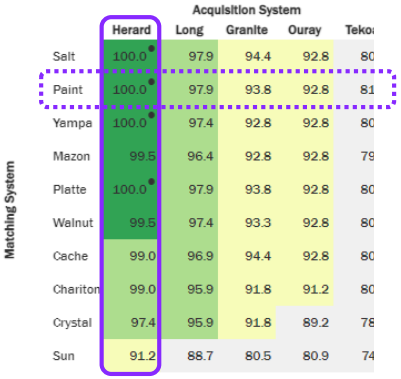
Matching System	Acquisition System: Herard	Long	Granite	Ouray	Tekoa
Salt	99.3	98.6	98.2	95.3	83.3
Paint	99.3	98.6	97.8	95.3	83.3
Yampa	99.3	98.6	97.5	95.3	83.3
Mazon	99.3	98.6	98.2	95.3	83.3
Platte	99.3	98.2	97.5	95.3	82.6
Walnut	99.3	98.2	98.2	95.3	83.0
Cache	98.5	97.1	98.2	95.3	82.6
Chariton	99.3	98.2	96.8	95.3	83.0
Crystal	97.5	97.5	96.0	92.4	83.0
Sun	94.9	94.9	85.9	86.6	78.6

Male



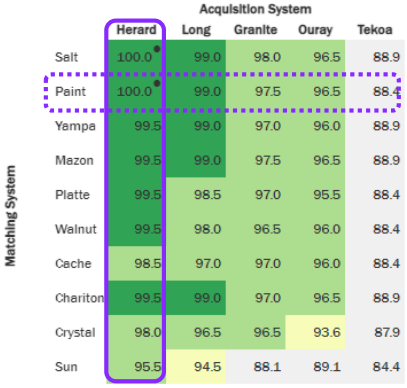
Matching System	Acquisition System: Herard	Long	Granite	Ouray	Tekoa
Salt	100.0	98.5	95.4	93.8	84.2
Paint	100.0	98.8	95.1	93.8	84.2
Yampa	99.7	98.5	94.1	93.5	84.2
Mazon	99.4	97.8	94.1	93.8	83.5
Platte	99.7	98.5	94.8	93.2	84.5
Walnut	99.1	97.5	93.8	92.9	83.9
Cache	98.8	97.5	94.8	93.5	84.2
Chariton	99.1	97.5	93.8	92.9	84.2
Crystal	97.8	96.0	93.5	90.4	82.0
Sun	92.9	92.6	86.7	86.1	80.7

Female



Matching System	Acquisition System: Herard	Long	Granite	Ouray	Teko
Salt	100.0	97.9	94.4	92.8	80
Paint	100.0	97.9	93.8	92.8	81
Yampa	100.0	97.4	92.8	92.8	80
Mazon	99.5	96.4	92.8	92.8	79
Platte	100.0	97.9	93.8	92.8	80
Walnut	99.5	97.4	93.3	92.8	80
Cache	99.0	96.9	94.4	92.8	80
Chariton	99.0	95.9	91.8	91.2	80
Crystal	97.4	95.9	91.8	89.2	78
Sun	91.2	88.7	80.5	80.9	74

Darker Skin



Matching System	Acquisition System: Herard	Long	Granite	Ouray	Tekoa
Salt	100.0	99.0	98.0	96.5	88.9
Paint	100.0	99.0	97.5	96.5	88.4
Yampa	99.5	99.0	97.0	96.0	88.9
Mazon	99.5	99.0	97.5	96.5	88.9
Platte	99.5	98.5	97.0	95.5	88.4
Walnut	99.5	98.0	96.5	96.0	88.4
Cache	98.5	97.0	97.0	96.0	88.4
Chariton	99.5	99.0	97.0	96.5	88.9
Crystal	98.0	96.5	96.5	93.6	87.9
Sun	95.5	94.5	88.1	89.1	84.4

Lighter Skin

No strong difference between groups. And on this dataset, the female demographic group exhibits slightly better performance than the male group.

Qualities for face

There are different usage of “quality” for face image.

- assess if an image represent a face
- is compliant with ISO-IEC
- can be use for biometric matching (1:1 or 1:N), for enrollment or only for verification
- can be use to editing an ID-document
- select the best image in a video stream

All quality assessments have progressed during past years, as show in NIST quality benchmark. Here, by removing only 1% of the worst images, we reduce biometric misses by a factor of 2.

Quality Algorithm	Submission Date	FNMR after removal of 1% lowest quality. Initial FNMR = 0.01. Lower is better.	Efficiency after removal of 1% lowest quality. Higher is better.	FNMR after removal of 5% lowest quality. Initial FNMR = 0.01. Lower is better.	Efficiency after removal of 5% lowest quality. Higher is better.
intema_000	2022-08-16	0.0051(1)	48.9	0.0034(1)	13.2
idemia_001	2022-08-22	0.0051(2)	48.5	0.0034(2)	13.1
rankone_000	2019-06-03	0.0061(5)	39.5	0.0036(3)	12.8

On static acquisition systems, Image selection is less critical.

For acquisition on the move, the quality for selection is now able to handle the trade-off between pose, motion blur, expression, resolution ...

E-gate for family

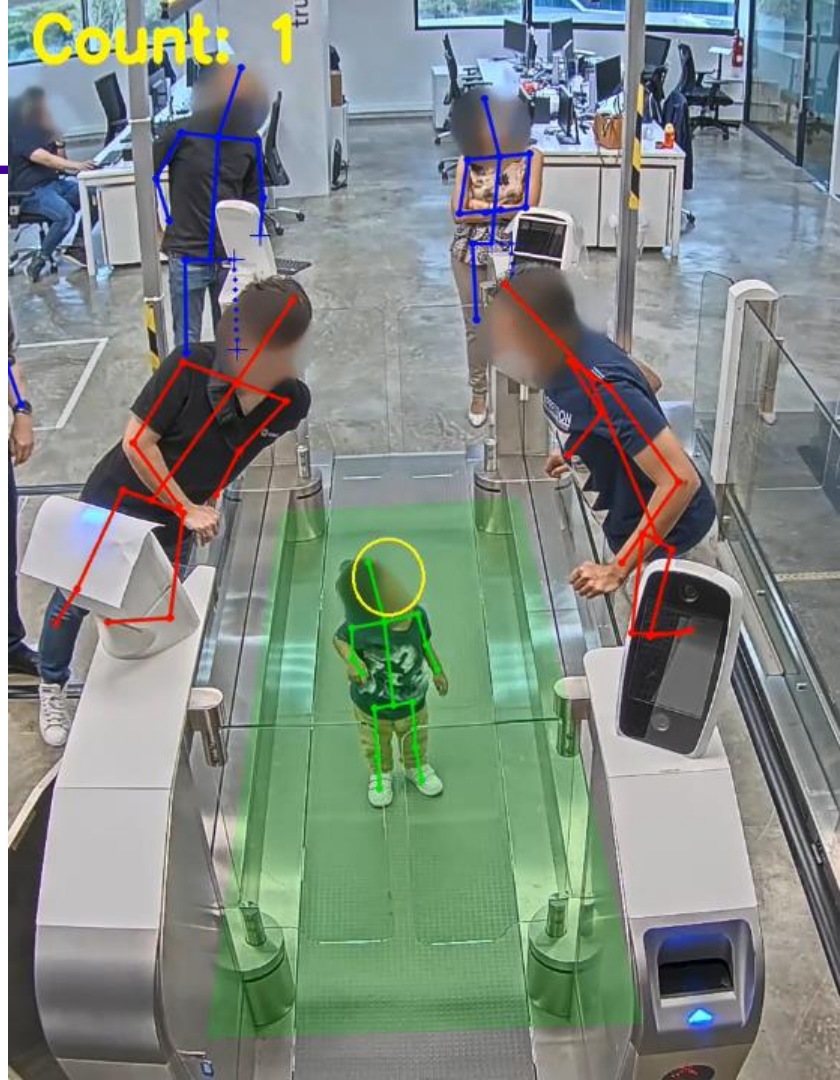
Another option to increase the throughput is to handle multiple subjects in a single “family” e-gate.

With a calibrated sensor, and with face and pedestrian tracking, we can detect and count people that are in the gate, even in complex scenario (infant in arms).

3D security

Tracking precisely face and pedestrian allows also to increase security of fully automatic e-gate by detecting people crossing the gate by the side.

Here the system raise an alarm when the face in front of the sensor do not belong to someone in the gate.



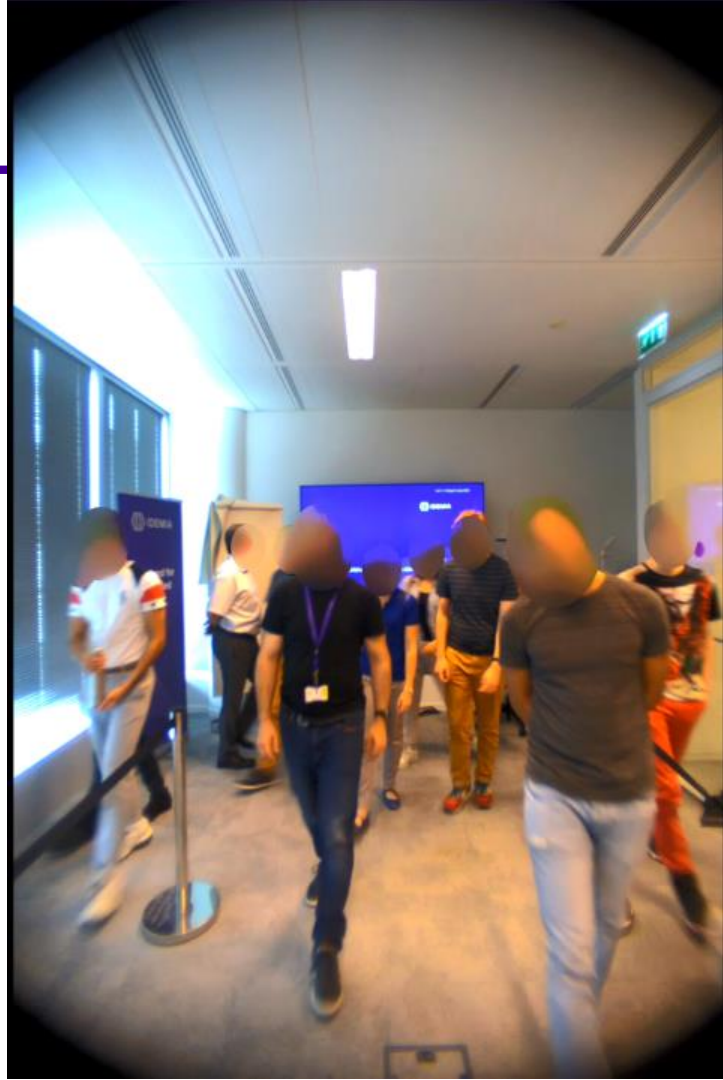
Free flow : detection

Public Presentation

Multiple object detection and tracking has greatly progress during the recent years.

Most of partially occluded, small and non-frontal faces are detected, in real time, from a single RGB camera.

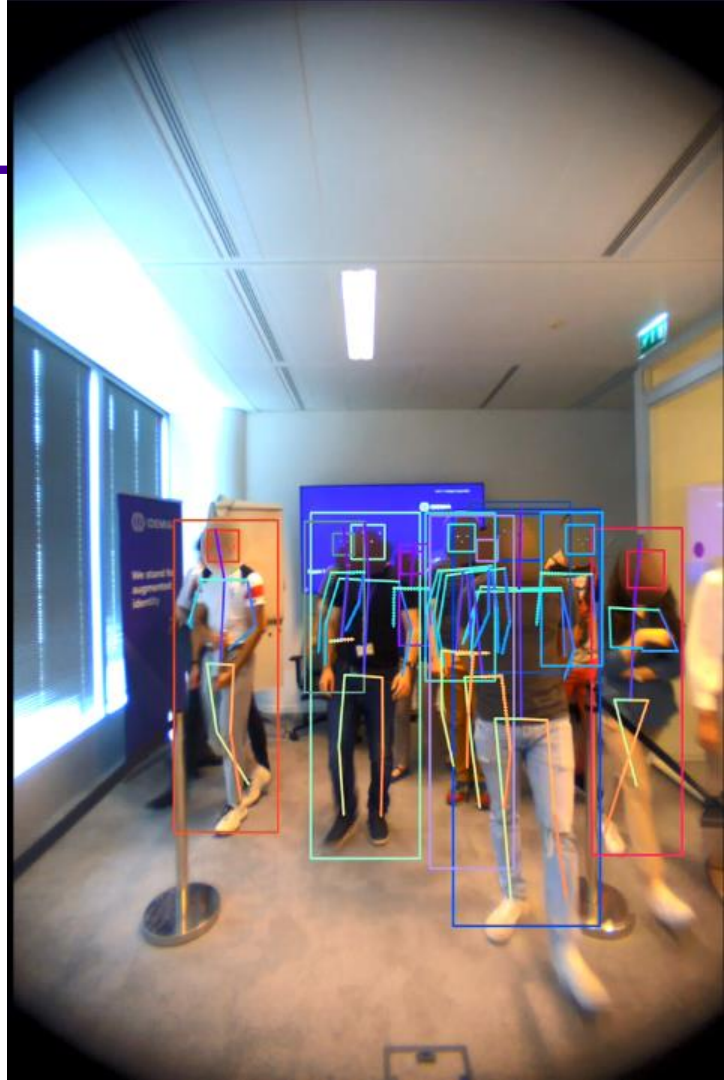
The 100% of face detection accuracy that is achieved for one face per image is now available for multiple faces.



Free flow : pedestrian tracking

In conjunction with face detection, pedestrian detection allows for greater consistency of Identity tracks.

The position and trajectory of subjects are maintained, even if faces are occluded or bodies are partially visible.



Free flow : distance estimation

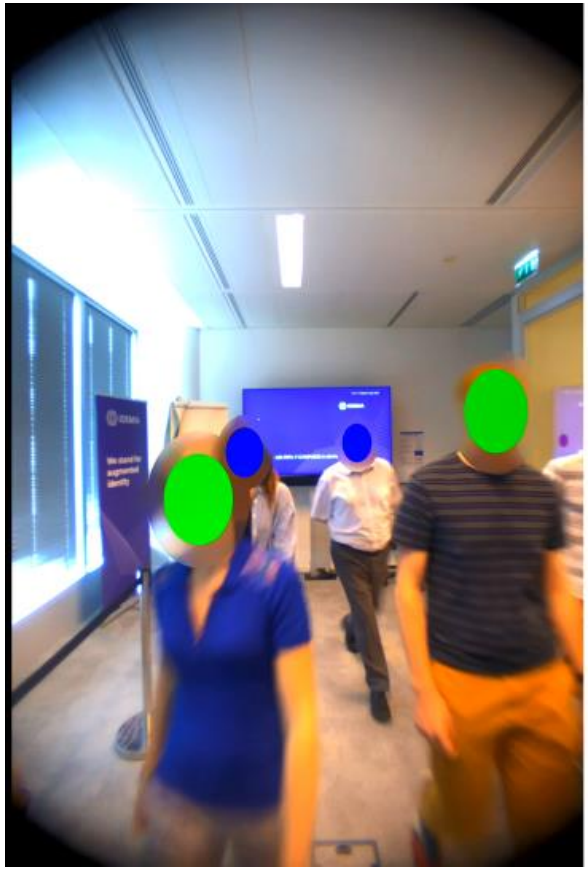
Another field of research is 3D inference of depth map from RGB stream.

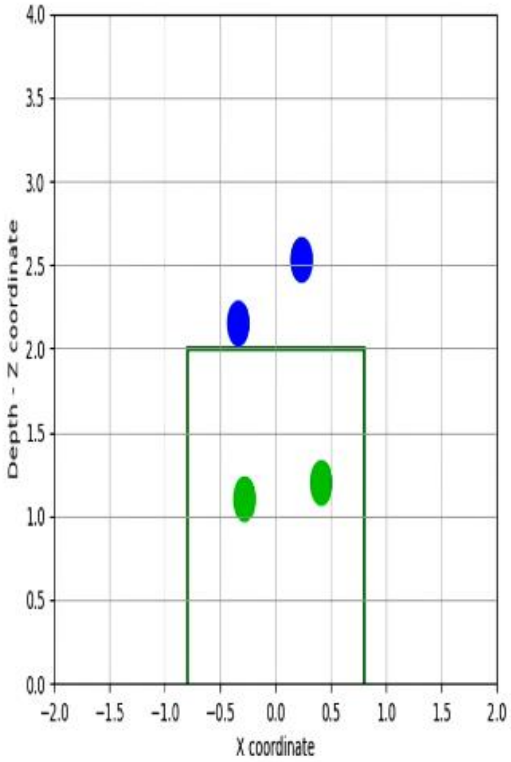
This is based on deep learning and can help to fully understand the 3D position of subject in the scene.

Free flow : area of interest

By integrating 3D information into the tracking process, we can compute the position of each identity in the real world.

Thus, we can precisely determine who enters an area of interest and who does not.



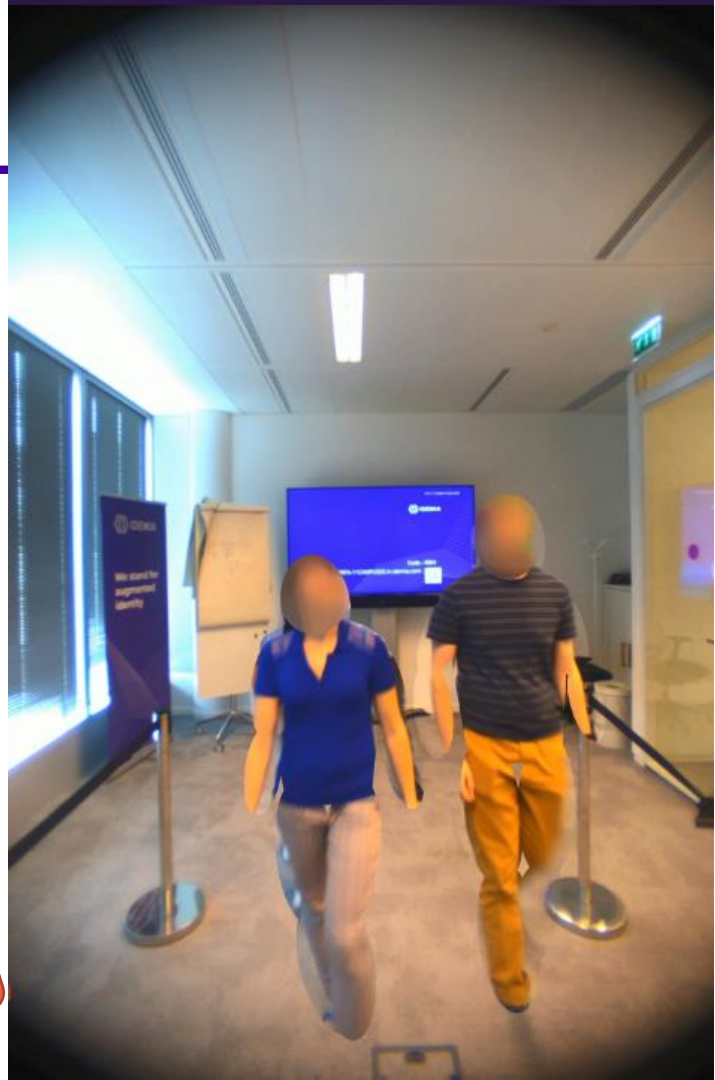


Free flow : privacy

One application of those recent technologies is a full anonymization of the scene.

Only subjects in the area of interest are displayed on the screen.
All people in the background are simply not displayed.

This leads to a stronger privacy guaranty than simply “blurring” the detected faces.
If the algorithm fails to detect faces, this will not trigger any privacy or legal issues.

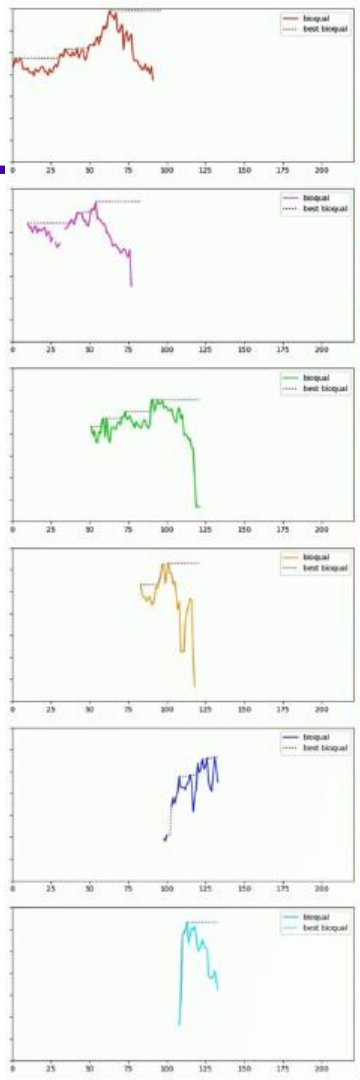


Work in progress

Free flow : Image Selection

Finally, for each person in the area, we compute one and only one face image that will be used for matching.

This image is selected with a quality dedicated to find the best image for biometric purposes.



Conclusions

- Acquisition algorithms also benefit from Deep Learning revolution.
  They are not as exposed and as tested as Feature Extraction and matching is.
  Live (Detection, Tracking and Quality assessment) have improved in precision, robustness and speed.

- Acquisition algorithms do matter a lot.
  Once a good image is selected, most of modern matching algorithms perform reasonably well.
  This extra performance allows for a more flexible and cost effective acquisition system design.

- Recent improvements enable high throughput acquisition
  Multiple subjects can be tracked continuously and one image per subject can be provided.
  This acquisition can ensure privacy and security (inside a 3D area).

Perspectives

- Alarm management in these scenarios is currently an unexplored area in its operational aspects.

- How to deal with true alarms and remaining false alarms ?
  - Stop the flow ?
  - Run after and catch the subject that triggered the alarm ?
  - Wait for him later ?
  - Manage people by group (family) in closed e-gate ?
  - …

- Will we have, one day, a fully hand-free and frictionless border crossing ?

not sure, but we are doing experiments and pilots to move forward
… and are happy to do more.

Questions ?

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