from e-gate to free flow

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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.

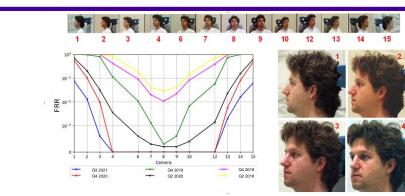
Long light tubes to help for uniform illumination while avoiding glare in glasses

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 ∆T ≥ 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⁾
					\square				



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

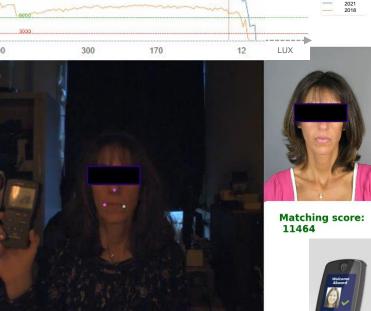


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Robustness to ambient light

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





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



^{Dublic Presentation}

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 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.

						Matching	System						
		Maumee	James	Reese	Owens	Yadkin	Pearl	Glla	Clark	Sabine	Leaf		
	West	99.7	99.5	99.1	97.9	98.8	99.3	97.6	97.2	91.8	24.1		
tem	Vly	98.4	98.3	98.4	98.1	96.9	98.3	97.2	96.4	87.5	31.8		
on Sys	Dans	98.8	98.3	97.7	97.9	97.9	93.9	97.6	96.0	90.1	15.3		
Acquisition System	Stone	93.9	93.6	93.8	93.2	92.9	94.1	92.9	92.5	85.6	32.2		
Acq	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 leg	end										
		Max	≥99%	≥95%	≥90%	<90%	Hover over each TIR value to see detailed results.						

Granite Ourav Herard Tekoa 98.5 96.7 94.5 83.8 Salt 98.7 Paint 96.3 94.5 83.8 0.3% versus 1.5% ••••• 98.5 94.3 83.8 Yampa 95. Idemia has 5 Mazon 99.3 98.2 96.0 94.5 83.4 times less Matching System 99.5 94.2 Platte 98.3 96.0 83.6 misses than the next best Walnut 99.2 97.8 95.8 94.0 83.4 competitor Cache 98.7 97.3 96.3 94.3 83.4 95.2 Chariton 97.8 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

Acquisition System

Sept 2021 : Results without Mask

Sept 2020 : Results without Mask

https://mdtf.org/Rally2021/Results2021



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

Acquisition System

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.

						Matching	g 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			
2	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 leg	end											
		Max	≥99%	≥95%	≥90%	<90%		each TIR value to see ults.						

Sept 2020 : Results with Mask

Public Presentation



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).

		Acquisition System						Acquisition System										Acquisition System				
- L	Herard	Long	Granite	Ouray	Tekoa		Herard	Long	Granite	Ouray	Tekoa				ulsition Sys				Herard	Long	Granite	Ouray
alt	99.3 [●]	98.6		95.3	83.3	Salt	100.0 [●]	98.5	95.4	93.8	84.2	Self	Herard	Long	Granite	Ouray 92.8	Teko	Salt	100.0 [●]	99.0	98.0	96.5
Paint	99.3 [•]			95.3	83.3	Paint	100.0 [●]	98.8	95.1	93.8	84.2			•••••			81	Paint	100.0 [●]	99.0	97.5	96.5
'ampa	99.3 [●]	98.6	97.5	95.3	83.3	Yampa	99.7	98.5	94.1	93.5	84.2						·····			99.0	97.0	96.0
/lazon	99.3 [●]	98.6	98.2	95.3	83.3	E Mazon	99.4	97.8	94.1	93.8	83.5					92.8	79	e Mazon	99.5	99.0	97.5	96.5
Platte	99.3 [®]	98.2	97.5	95.3	82.6	Platte	99.7	98.5	94.8	93.2	84.5	Platte	100.0 [●]			92.8	80	System Statte	99.5	98.5	97.0	95.5
Valnut	99.3 [●]	98.2	98.2	95.3	83.0	Walnut Walnut	99.1	97.5	93.8	92.9	83.9	o Walnu	t 99.5	97.4	93.3	92.8	80	Walnut	99.5	98.0	96.5	96.0
ache	98.5	97.1	98.2	95.3	82.6	E Cache	98.8	97.5	94.8	93.5	84.2	Cache	99.0	96.9	94.4	92.8	80	Cache	98.5	97.0	97.0	96.0
hariton	99.3 [●]	98.2	96.8	95.3	83.0	Chariton	99.1	97.5	93.8	92.9	84.2	Charite	on 99.0	95.9	91.8	91.2	80	Charito	n 99.5	99.0	97.0	96.5
rystal	97.5	97.5	96.0	92.4	83.0	Crystal	97.8	96.0	93.5	90.4	82.0	Crysta	97.4	95.9	91.8	89.2	78	Crystal	98.0	96.5	96.5	93.6
iun	94.9	94.9	85.9	86.6	78.6	Sun	92.9	92.6	86.7	86.1	80.7	Sun	91.2	88.7	80.5	80.9	74	Sun	95.5	94.5	88.1	89.1
		Ma	ale					Fe	ema	ale			Da	rke	er S	Skir	ו		Liał	nte	r S	kin
	aint ampa lazon latte /alnut ache hariton rystal	aint 993° ampa 993° lazon 993° latte 993° latte 993° ache 985 hariton 993°	aint 993 986 ampa 993 986 lazon 993 986 latte 993 982 /alnut 993 982 ache 985 97.1 hariton 993 982 rystal 975 97.5 un 94.9 94.9	aint 99.3 998.6 97.8 ampa 99.3 98.6 97.5 lazon 99.3 98.6 97.5 latte 99.3 98.2 97.5 value 99.3 98.2 97.5 ache 98.5 97.1 98.2 hariton 99.3 98.2 96.8 ystal 99.3 98.2 96.8	eint 99.3 98.6 97.8 95.3 ampa 99.3 98.6 97.5 95.3 lazon 99.3 98.6 97.5 95.3 latte 99.3 98.2 97.5 95.3 latte 99.3 98.2 98.2 95.3 ache 98.5 97.1 98.2 95.3 hariton 99.3 98.2 96.8 95.3 ystal 97.5 96.6 95.3 95.3 ystal 99.3 98.2 96.8 95.3 ystal 99.5 97.5 96.6 92.4 yn 94.9 94.9 85.9 86.6	eint 99.3 98.6 97.8 95.3 83.3 ampa 99.3 98.6 97.5 95.3 83.3 lazon 99.3 98.6 98.2 95.3 83.3 latte 99.3 98.2 95.2 95.3 83.0 ache 99.3 98.2 96.2 95.3 83.0 ache 99.5 97.1 98.2 95.3 83.0 aysta 97.5 97.5 96.0 92.4 83.0 aysta 97.5 97.5 96.0 92.4 83.0 aysta 94.9 85.9 86.6 78.6	aint 99.3 98.6 97.8 95.3 83.3 ampa 99.3 98.6 97.5 95.3 83.3 lazon 99.3 98.6 97.5 95.3 83.3 latte 99.3 98.2 95.3 83.3 Mazon alatte 99.3 98.2 95.3 83.0 Platte valuet 99.3 98.2 95.3 83.0 Cache ache 98.5 97.1 98.2 95.3 82.0 Cache hariton 99.3 98.2 96.8 95.3 83.0 Chariton rystal 97.5 97.5 96.0 92.4 83.0 Crystal un 94.9 94.9 85.9 86.6 78.6 Sun	aint 99.3 98.6 97.8 95.3 83.3 Paint 100.0 ampa 99.3 98.6 97.5 95.3 83.3 Yampa 99.7 lateo 99.3 98.6 97.5 95.3 83.3 Mazon 99.4 lateo 99.3 98.2 97.5 95.3 83.0 Mazon 99.4 latte 99.3 98.2 97.5 95.3 83.0 Mazon 99.4 latte 99.3 98.2 95.3 83.0 Mazon 99.1 ache 98.5 97.1 98.2 95.3 83.0 Cache 98.8 hariton 99.3 98.2 96.8 95.3 83.0 Chariton 99.1 rystal 97.5 96.0 92.4 83.0 Caystal 97.8 un 94.9 94.9 85.9 86.6 78.6 Sun 92.9	eint 99.3 98.6 97.8 95.3 83.3 ampa 99.3 98.6 97.5 95.3 83.3 lateo 99.3 98.6 97.5 95.3 83.3 lateo 99.3 98.6 97.5 95.3 83.3 lateo 99.3 98.2 97.5 95.3 82.6 alutt 99.3 98.2 95.3 83.0 Platte 99.7 ache 98.5 97.1 98.2 95.3 83.0 Platte 99.1 97.5 ache 98.5 97.1 98.2 95.3 83.0 Cache 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83.3 Yampa 99.7 98.5 94.1 93.5 84.2 lato 99.3 98.6 98.2 95.3 83.3 Mazon 99.4 99.7 98.5 94.1 93.5 84.2 lato 99.3 98.2 95.3 83.3 Mazon 99.4 97.8 94.4 93.8 83.5 lato 99.3 98.2 95.3 83.3 Mazon 99.4 99.7 98.6 94.8 93.2 84.5 lato 99.3 98.2 95.3 83.0 Platte 99.7 96.6 94.8 93.6 84.2 94.4 92.8 92.8 lato 98.5 97.1 98.2 95.3 83.0 Platte 99.7</td> <td>init 99.3 98.6 97.8 95.3 83.3 init 99.3 98.6 97.7 95.3 83.3 Paint 1000 98.8 95.1 93.8 84.2 init 99.3 98.6 97.5 95.3 83.3 Paint 1000 98.8 95.1 93.8 84.2 init 99.3 98.6 97.5 95.3 83.3 Paint 1000 98.6 94.4 92.8 84.2 init 99.3 98.6 98.2 97.5 95.3 83.3 Paint 1000 98.6 94.4 92.8 84.2 initit 99.3 98.6 98.2 97.5 96.3 83.3 Paint 99.7 98.6 94.4 93.8 83.5 initit 99.3 98.2 97.5 96.3 83.0 97.5 96.3 83.0 97.5 97.6 98.8 92.8 93.8 92.8 83.5 initit 99.3 98.2 96.3 83.0 97.5 96.6 97.4 93.8 92.8</td> <td>init 993 98.6 97.8 95.3 83.3 Paint 1000 98.8 95.1 93.8 84.2 ampa 99.3 98.6 97.5 95.3 83.3 Yampa 99.7 94.5 94.5 94.4 92.8</td> <td>anna 993 986 978 963 833 Paint 1000 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No strong difference between groups. And on this dataset, the female demographic group exhibits slightly better performance than the male group.

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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

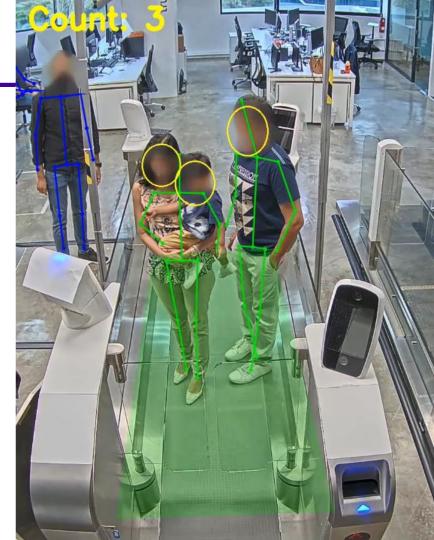
- On static acquisition systems, Image selection is less critical.
- For acquisition on the move, the quality for selection is now able to handle the trade-off between pose, motion blur, expression, resolution ...

E-gate for family

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

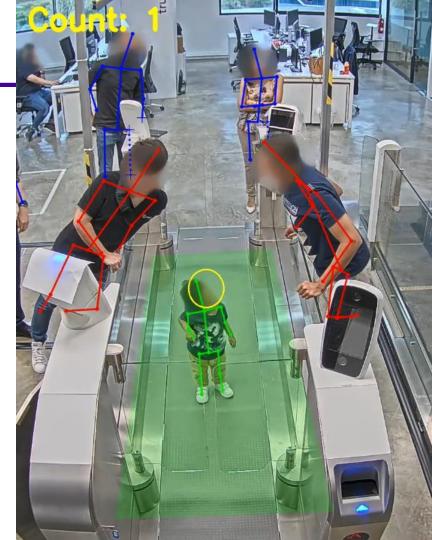
With a calibrated sensor, and with face and pedestrian tracking, we can detect and count people that are in the gate, even in complex scenario (infant in arms).





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.



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Free flow : detection

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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

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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

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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.

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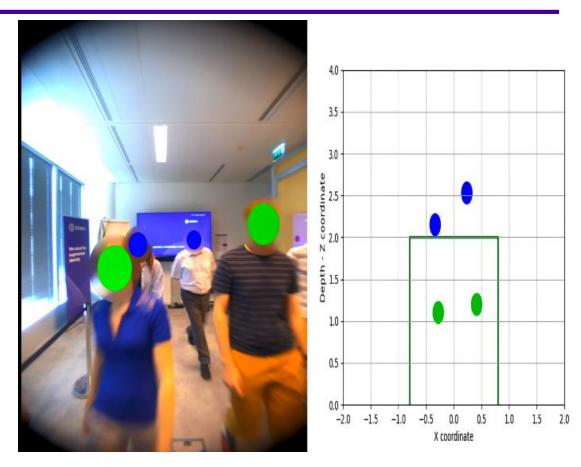
15

Free flow : area of interest

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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.





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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.





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.





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 - 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).



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- 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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21