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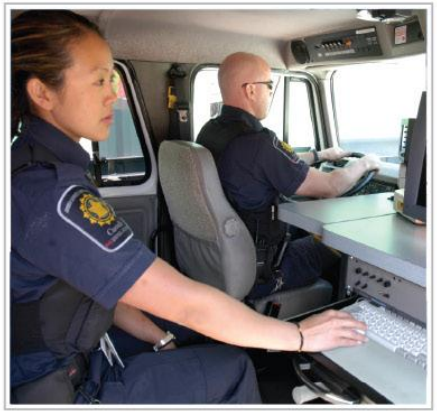
PROVE-IT(FRiV): framework and outcomes




Dmitry O. Gorodnichy
Science and Engineering Directorate

Eric Granger
Ecole de technologie superieure, Universite du Quebec

Other contributors:
CBSA: J.-P. Bergeron, D. Bissessar, E. Choy, T. Mungham
uOttawa: R. Laganiere, S. Matwin, E. Neves
ETS: C. Pagano, M. De la Torre, P. Radtke

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2. Dmitry Gorodnichy et al. "*PROVE-IT(FRiV): framework and outcomes*" (NIST IBPC 2014)

Outline

- Background
- PROVE-IT() framework:
  - Taxonomy of surveillance setups types
  - Taxonomy of technology applications
  - Grading scheme
- PROVE-IT(FRiV) results:
  - Literature review results
  - Off-line evaluation results
    - Datasets to simulate operational environment
    - Face resolution in surveillance video
    - Target-based design/evaluation for dealing with low face resolution
    - Multi-level performance evaluation of COTS products
  - Live system evaluation results
- Technology Readiness assessment results

3. Dmitry Gorodnichy et al. "*PROVE-IT(FRiV): framework and outcomes*" (NIST IBPC 2014)

Background

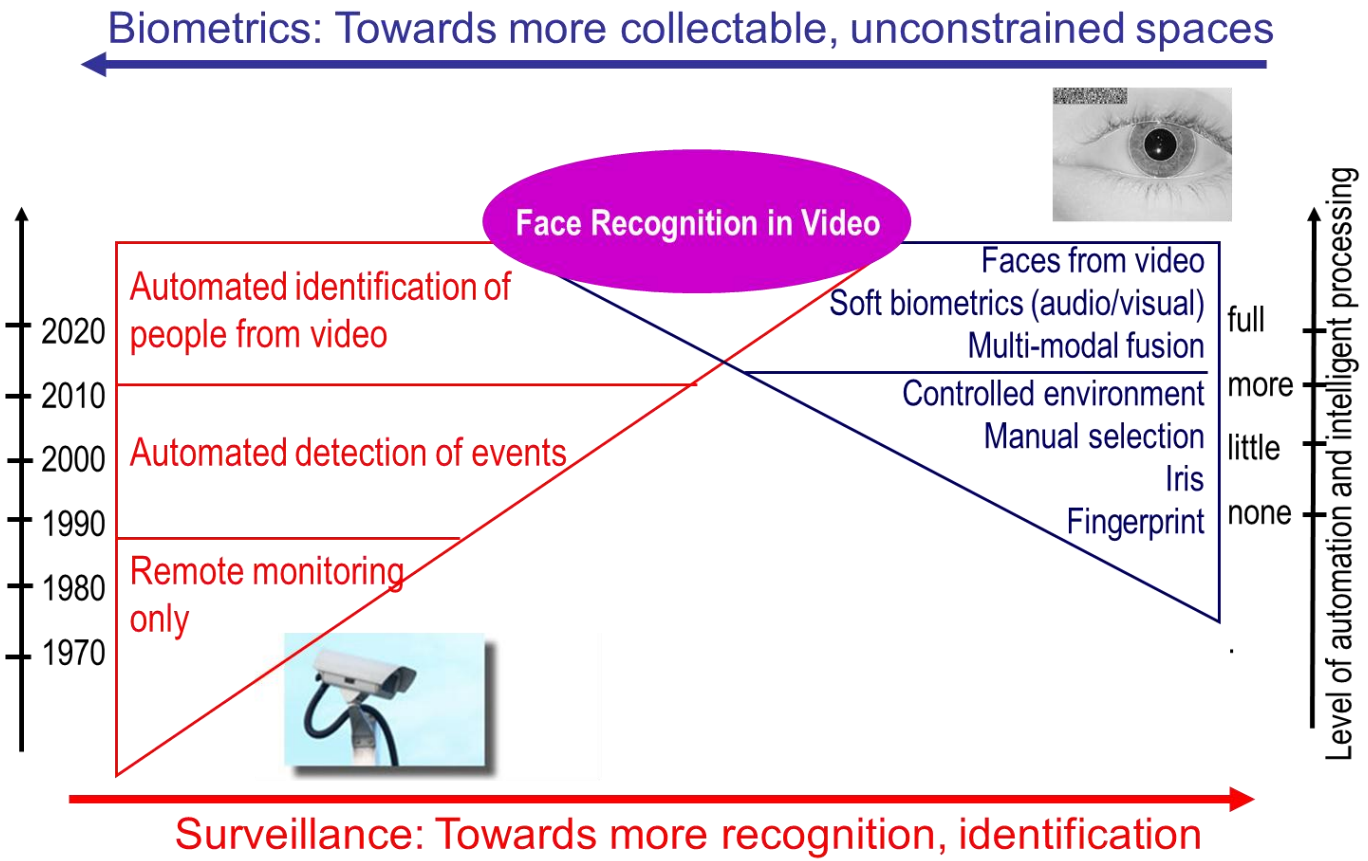
- IBPC 2012:
  - Methodology on testing FRiV systems for real-time open-set applications, such as Watch-List Screening
  - Taxonomy of Surveillance Setups
  - Survey of Public Datasets
  - Survey of Academic Solutions
  - Survey of Commercial technologies
  - Preliminary TRL assessment results

- Since then:
  - Three state-of-art COTS systems tested using the methodology
  - New CCTV system in Ottawa Airport spec-ed by the same team
  - PROVE-IT(FRiV) project concluded with recommendations
  - PROVE-IT() framework established, opened for public discussion and contribution

4. Dmitry Gorodnichy et al. "*PROVE-IT(FRiV): framework and outcomes*" (NIST IBPC 2014)

FRiV

- Where Solutions from one Community of Practice (CoP) are applied to a different CoP:
  - Different business requirements and constraints
  - E.g.: State-of-art cameras deployed in Ottawa Intern. Airport in 2012



5. Dmitry Gorodnichy et al. "*PROVE-IT(FRiV): framework and outcomes*" (NIST IBPC 2014)

PROVE-IT()

- Approach for proving (or disproving) the claims about the readiness of technologies for deployments and pilots
- Specifically, for Video Surveillance applications

- Practical tool for providing recommendations related to
  i. technology deployment, and ii. R&D investment opportunities

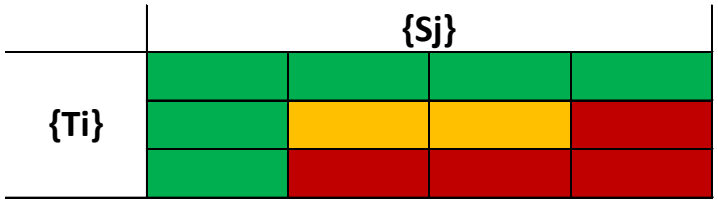
- Consists of three steps:
  1. Define taxonomy of possible setups {Sj}
  2. Define taxonomy of technology applications {Ti}
  3. Assign readiness colour for each { Ti I Sj }

By CoP (users)

By SME (experts)

PROVE(T|S) = {Green, Yellow, Red}

for all technology applications {Ti} and for all scenarios {Sj}



- Community-driven effort

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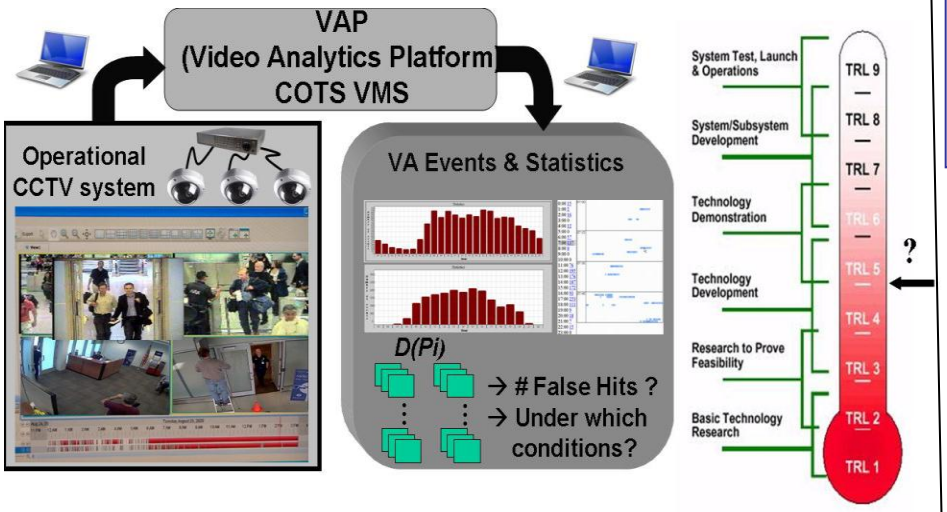
Project number: PSTP 03-401BIOM



PROVE-IT (FRiV)

Pilot and **R**esearch on **O**perational **V**ideo-based **E**valuation of **I**nfrastructure and **T**echnology:
Face Recognition in Video

Lead: CBSA and uQuébec (ÉTS)
Partners: RCMP, DRDC, DFAIT, CATSA, TC, PCO; uOttawa, FBI, HomeOffice, NIST
Dates: April 2011 – March 2013
Funding: DRDC Public Safety Technology Program
Synergy project: **PROVE-IT (VA)** wrt face tracking

Outputs:

- Evaluation of Real-Time FR Technologies for Video Surveillance Applications (NIST IBPC 2012)

- Survey of academic research and prototypes for face recognition in video
- Survey of commercial technologies for face recognition in video
- Methodology for evaluation of FR technologies in video surveillance applications
- Results from evaluation of three COTS FR systems on Chokepoint dataset

- Using smooth ROC method for evaluation and decision making in biometric systems,
- 3D face generation tool Candide for better face matching in surveillance video
- Evaluation of different features for face recognition in video
- TRL Assessment of People Tracking technologies for Video Surveillance applications”
- Video Analytics technology: market analysis and demonstrations” (inc. face tracking/detection)

Canada

TRL vs. PROVE-IT

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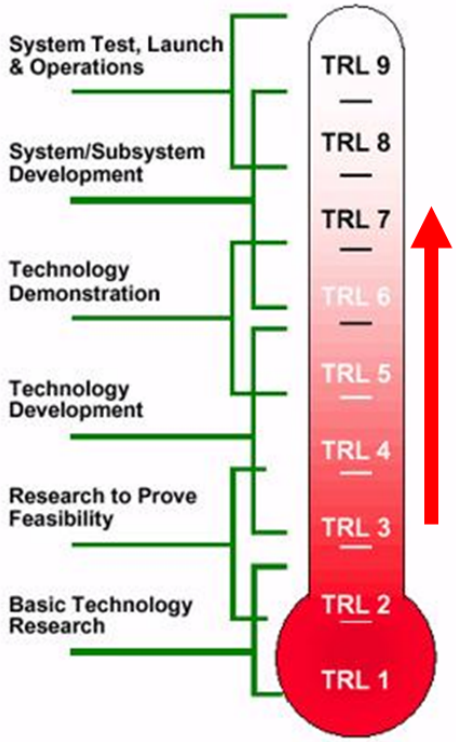
9. Actual system 'flight proven' through successful mission operations (over 30)
8. Actual system completed and 'flight qualified' through test and demonstration.
7. System prototype demonstration in operational environment. ← PILOT
6. System prototype demonstration in relevant environment. ← MOCK-UP
5. Component validation in relevant environment.
4. Component validation in laboratory environment.
3. Analytical and experimental critical function - characteristic proof of concept.
2. Technology concept / application formulated
1. Basic principles observed and reported.



GRADE	TRL	DEFINITION
++	8-9	***Operationally Ready***: Can be deployed immediately with no customization and predictable results.
+	7	***Operationally with Configuration***: Deployed within 1 year with some customization; predictable results.
oo	5-6	***Short-term Ready***: Possible within 1 to 3 years with a moderate investment in applied R&D
o	4	***Medium-term Ready***: Possible within 3 to 5 years with a significant investment in applied R&D
-	1-3	***Not Ready (Academic)***: Not possible within next 5 years; requires major academic R&D.

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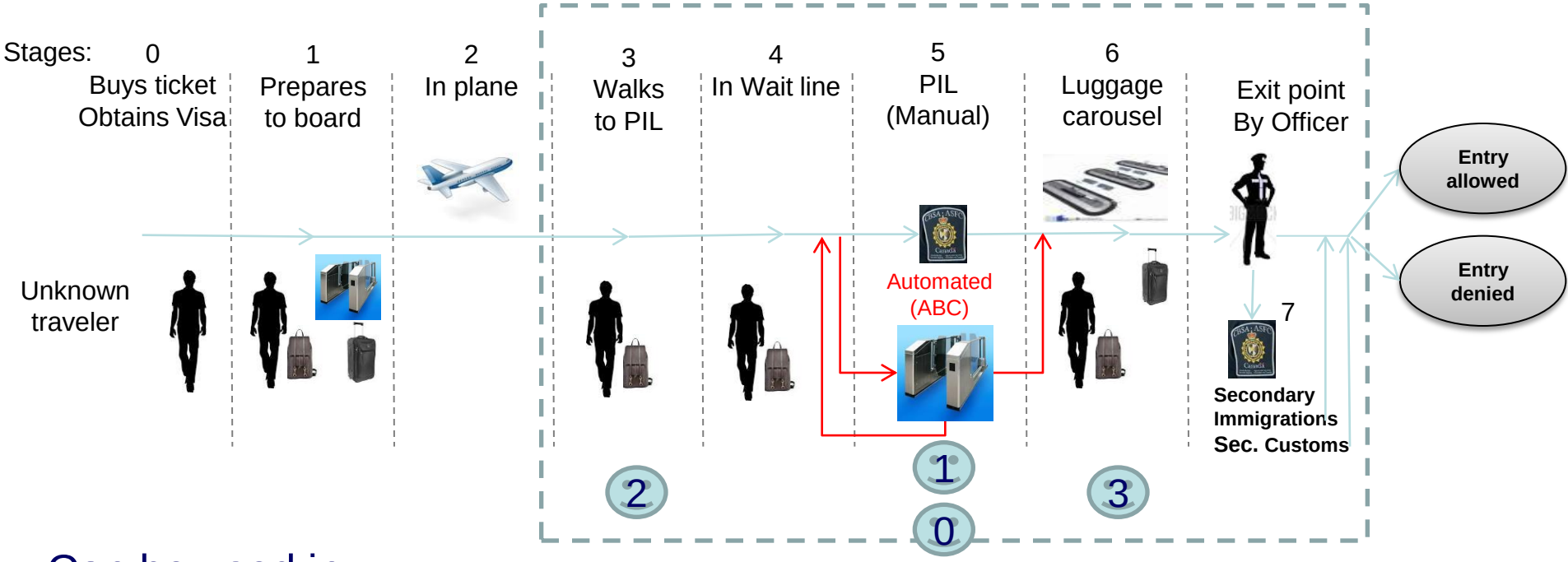
FRiV within Air Traveller Continuum



Can be used in:

- In real-time mode – for eBorder traveller screening / clearance
  - Part of these eBorder components (Ref.: "ABC as part of eBorder" IBPC 2014):
    III: automated behavior screening (AVATAR)
    IV: intelligent queuing
    V: biometric systems (ABC): Gen-1, Gen-2, Gen-3

- In investigative (off-line) mode – for search and retrieval of Evidence

9. Dmitry Gorodnichy et al. "*PROVE-IT(FRiV): framework and outcomes*" (NIST IBPC 2014)

Step 1: Taxonomy of scenarios: {Sj}

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- Defined according to “WHO-WHAT-WHERE” Factor Triangle

TYPE	PERSON FACTORS	PROCEDURE FACTORS	SETUP FACTORS	DEFINITION
0 eGate	controlled	controlled	controlled	Cooperative biometric setup as in Access Control or e-Gate:
1 Kiosk	uncontrolled	controlled	controlled	Semi-constrained setup as in passport control
2 Portal	uncontrolled	semi-controlled	controlled	Unconstrained, free-flow, one at a time as in airport chokepoint
3 Hall	uncontrolled	uncontrolled	controlled	Unconstrained, free-flow, many at a time as in airport halls
4 Outdoor	uncontrolled	uncontrolled	uncontrolled	No constraint on lighting, procedure or, person appearance

1

2

3

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Step 2: Taxonomy of applications: {Ti}

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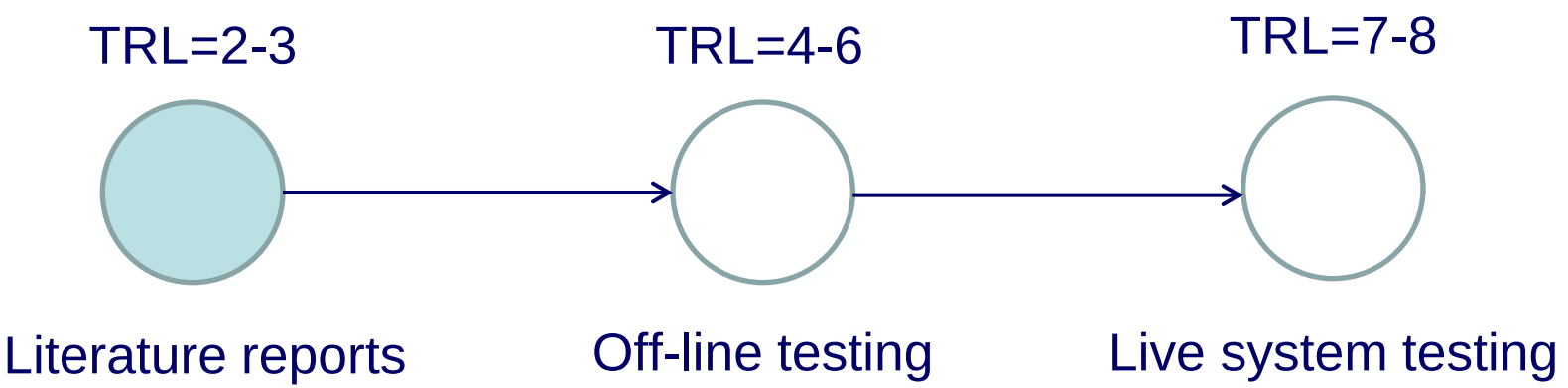
- By end-user application: mode of operation
  - Real-time mode: border control applications
  - Post-event mode: investigation applications
- By mode of operation and decision making
  - Fully-automated: Binary or Triaging decisions
  - Semi-automated: as Visual Analytic tool/filter
- By data modality
  - Still-to-video: from Gallery of still images
  - Video-to-video: re-Identification in video streams
- By level of Face Processing *
  - Face Detection, Face Tracking,
  - Face Categorization, Face Classification
  - Face Grouping, Face Identification
  - Facial Expression Recognition

11. Dmitry Gorodnichy et al. "*PROVE-IT(FRiV): framework and outcomes*" (NIST IBPC 2014)

Step 3: Assessing PROVE-IT(Ti|Sj}

Based on:

1. Literature / market review
2. Off-line performance evaluation: with bench-marking protocols and datasets
3. Live performance evaluation: technology development and demonstration on real data
   – With state-of-art COTS products



12. Dmitry Gorodnichy et al. "*PROVE-IT(FRiV): framework and outcomes*" (NIST IBPC 2014)

Literature / Market review

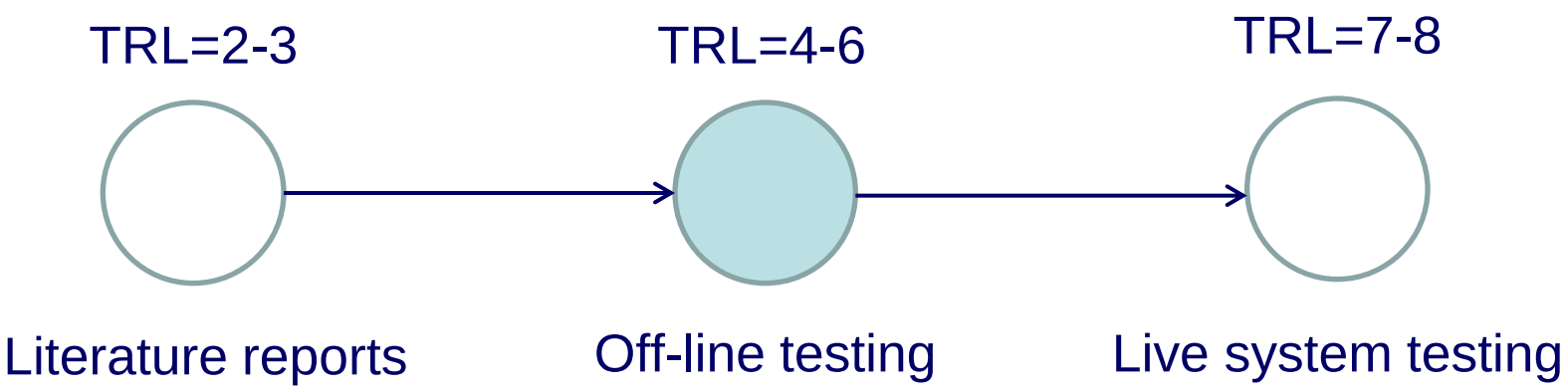
- Market analysis:
  - Many integrators, Few developers
  - Enough open-source
- Integration (pre-processing & post-processing) is key to success
- Approaches to FRIV
  - Feature-based,
  - Part-based
  - Holistic
- Video-based vs. still-based
  - COTS are mainly still-based
  - Academia working on video-based
- COTS product types:
  - High-performing (NEC, Cognitec, Morpho) for ICAO compliant faces
  - High-performing for internet tagging (PittPatt)
  - More affordable (Neurotechnology)

FR developper	Website
Acsys Biometrics	www.acsysbiometrics.com.
Animetrics	www.animetrics.com
Ayonix	www.ayonix.com
Bayometric	www.bayometric.com
Behrooz Kamgar-Parsi	http://www.biometrics.org/bc2006/presentation
Betaface	www.betaface.com
* Cognitec Systems GmbH	www.cognitec-systems.de
Cross Match Technologies, Inc.	www.crossmatch.com
Cybula Ltd.	www.cybula.com
Face.com	www.face.com
* Facial Forensic (F2), formerly Screening Assistant	www.faceforensics.com
L-1 Identity Solutions, Inc. (acquired Bioscript)	www.l1id.com
Luxand, Inc.	www.luxand.com
Morpho (acquired L1, 2011)	www.morpho.com
NeoFace - NEC	
* Neuro Technology	www.neurotechnology.com
OmniPerception	www.omniperception.com
* PittPatt: Pittsburgh Pattern Recognition	www.pittpatt.com
Sensible Vision, Inc.	www.sensiblevision.com
FR integrator	
Advanced Corp. Security Systems	www.acss.co.za
Airborne Biometrics Group	www.facefirst.com
Arti-Vision	www.arti-vision.com
Aurora	www.facerec.com
Avalon Biometrics	www.avalonbiometrics.com
Canadian Bank Note	http://www.cbnco.com
Csystems Advanced Biometrics	www.ex-sight.com
EAL	www.eal.nl
Face.com developers	www.developers.face.com
Facing-IT	www.facing-it.com
Guardia	www.guardia.dk
Herta Security	www.hertasecurity.com
ID One, Inc.	www.idoneinc.com
IITS, S.L.	www.iits.se
INO	www.ino.ca
Intelligent Security Systems	www.isscctv.com
IntelligenTek	www.intelligentek.com
Inttelix	www.inttelix.com
iView	www.iviewsystems.com
iWT	www.iwtek.net
Kee Square	www.keesquare.com
Kiwi Security	www.kiwi-security.com
NICTA	http://www.nicta.com.au/
Omron	www.omron.com
Panvista	www.panvista.com
PSP Security	www.pspsecurity.com
Quantum Signal	www.quantumsignal.com
TAB Systems	www.tab-systems.com
The Covenant Consortium (TCC)	www.tcc.us.com
XID Technologies Pte Ltd.	www.xidtech.com
IntelliVision	www.intelli-vision.com
Open Source FR codes	
CSU: Evaluation of Face Recognition	www.cs.colostate.edu/evalfacerec
CSU: FaceL: Facile Face Labeling	http://www.cs.colostate.edu/facel
CSU: Baseline 2010 Algorithms	http://www.cs.colostate.edu/facerec/algorithms
RTFTR: Real-Time Face Tracking and Recognition	http://rtftr.sourceforge.net/
Face Recognition using Associative Neural Networks	www.videorecognition.com/FRiV
OpenCV Face Recognition	http://docs.opencv.org/modules/contrib/doc/fac

13. Dmitry Gorodnichy et al. "*PROVE-IT(FRiV): framework and outcomes*" (NIST IBPC 2014)

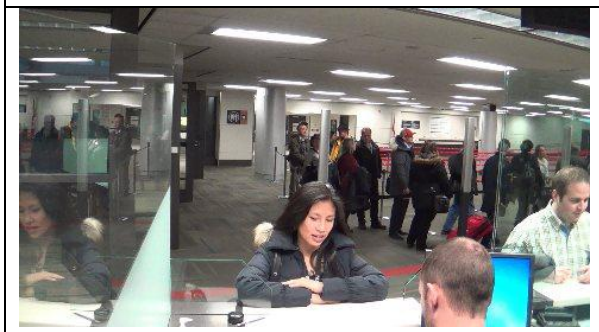
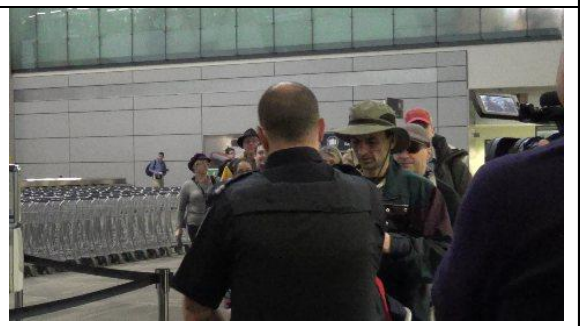
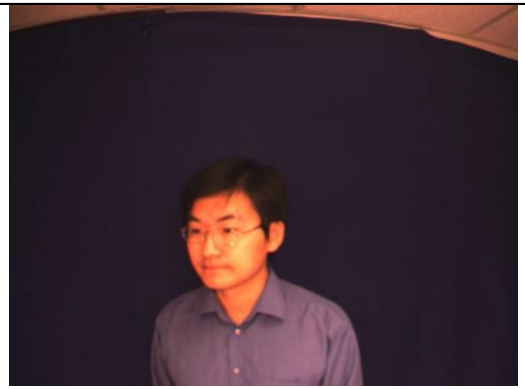
Offline evaluation of COTS products

- Three state-of-art COTS FR products (SDK of Dec. 2012)
  - Pittpatt
  - Cognitec
  - Neurotechnology
- On Chokepoint dataset
  - 10 individuals out of 29 make a Watch List
  - One sequence for tuning the parameters for each individual
  - Other sequence for testing



14. Dmitry Gorodnichy et al. "*PROVE-IT(FRiV): framework and outcomes*" (NIST IBPC 2014)

Off-line evaluation: datasets

Setup type #1 (Kiosk)	Setup type #2 (Corridor, Chokepoint)	Setup type #3 (Halls)
OPERATIONAL DATA		
 1920 x 1080	 1920 x 1080	 1920 x 1080
Public Dataset: CMU PIA	**Public Dataset: MICTA Chokepoint**	**Public Dataset:**
 640 x 480	 800 x 600	• YouTube Faces • Person identification in TV series • QMUL underGround Re-IDentification (GRID) Dataset

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“Chokepoint” dataset for Setup 2 analysis

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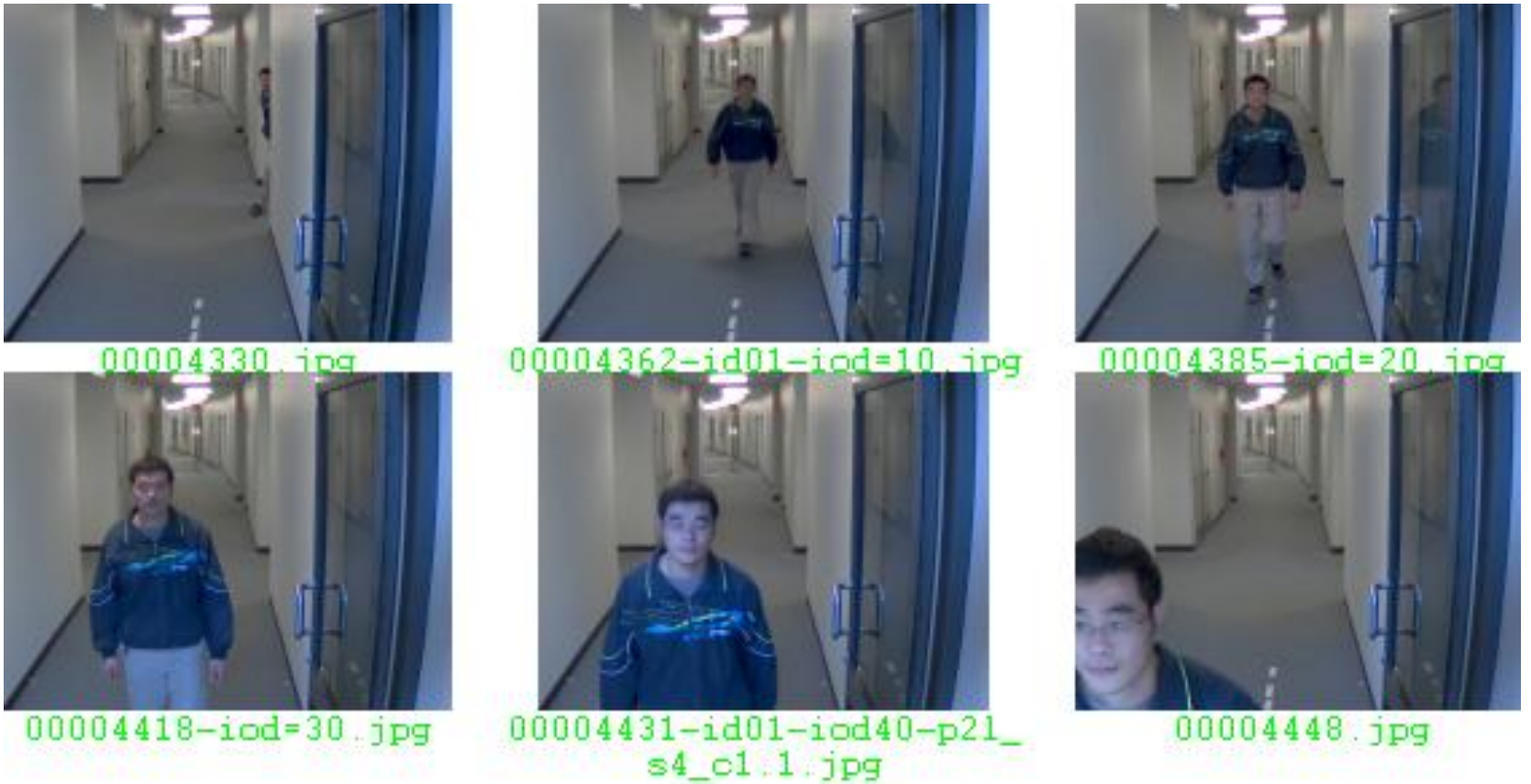
- 29 persons, 54 video sequences, 1-3 mins each, 30 fps 800x600 camera, video is stored as still .jpg images
- Settings & quality: easier / better than operational



Sequence P2L-S4-C1.1, frames 4330-4448 corresponding to individual with ID=1

(“Chokepoint” dataset site: http://itee.uq.edu.au/~uqywong6/chokepoint.html)

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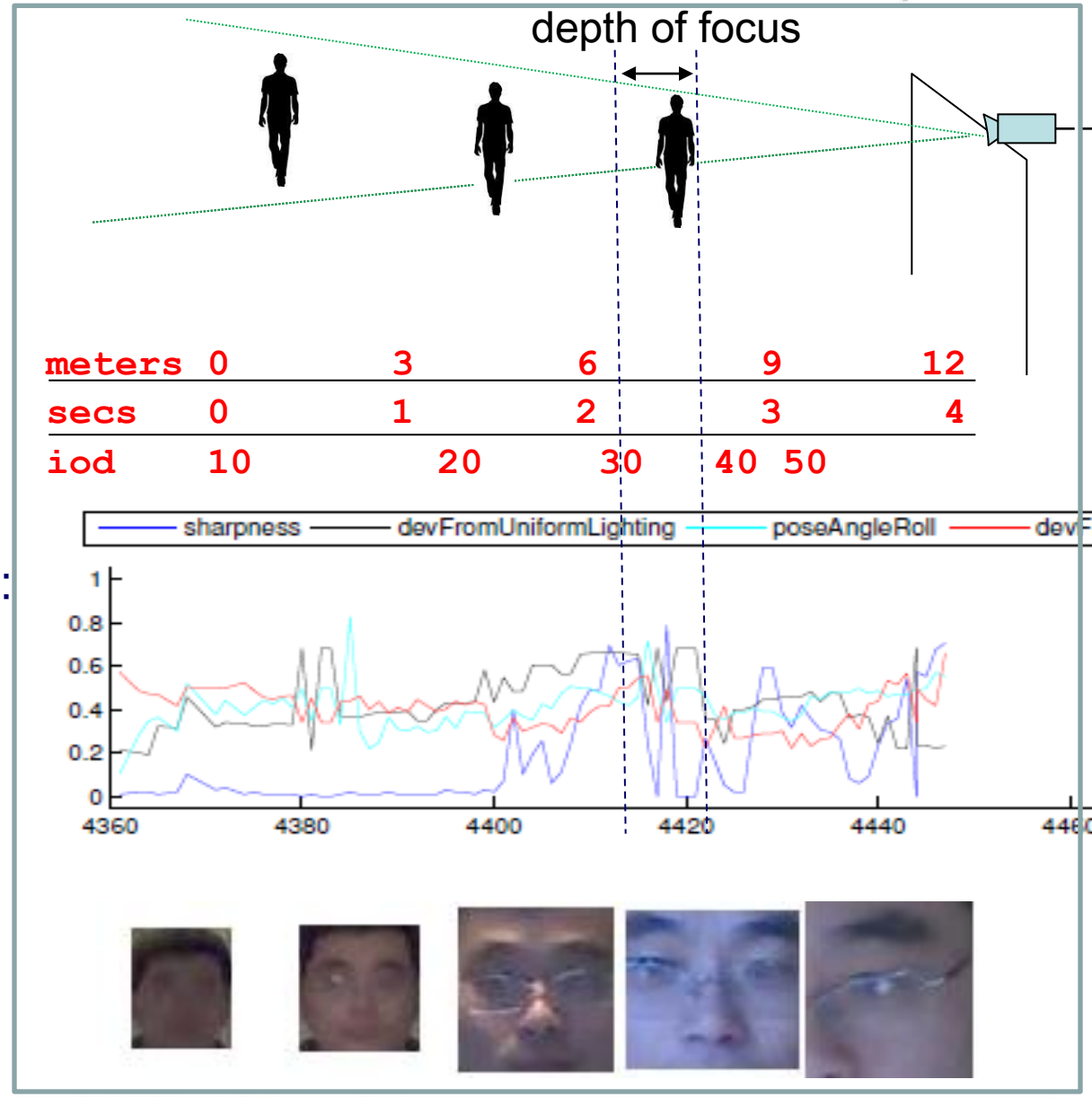
Face resolution analysis

- The image quality of the moving object depends: aperture, exposure.
- Basic photography principle: either blur or lack of focus !
- Face resolution – intra-ocular distance (iod):
  - In Sensor : 24 – 200 pixels (1/32-1/8 frame width)
  - In reality (Informative resolution): 10 – 60 pixels



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Face resolution analysis: conclusion

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…we need to appreciate the fact that facial images in video *are meant to be* of low resolution/quality, … and develop a methodology that deals with this resolution and quality.

…For it is actually not so low, if humans can easily recognize people in it!

What does that mean for
Real-Time Screening (RTS) / Instant Face Recognition (iFR) system design and evaluation ?

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Designing & evaluating RTS / iFR systems

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- If a RTS system is designed so that it processes only images that are in focus, then there is a high chance of missing a target individual.
- If, on the other hand, the system uses all facial images including those that are out-of-focus and small, then the risk of falsely matching non-target people becomes even high.

Currently used methodologies in evaluating and designing FR systems, such as those developed for offline forensic investigation and real-time access / border control applications, do not address the problem.

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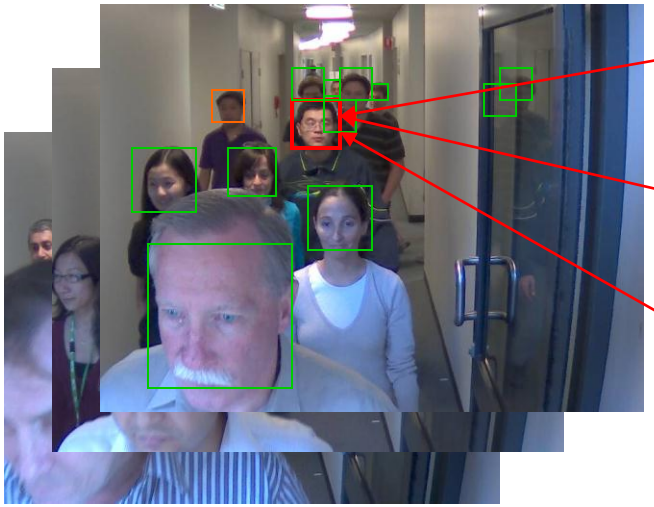
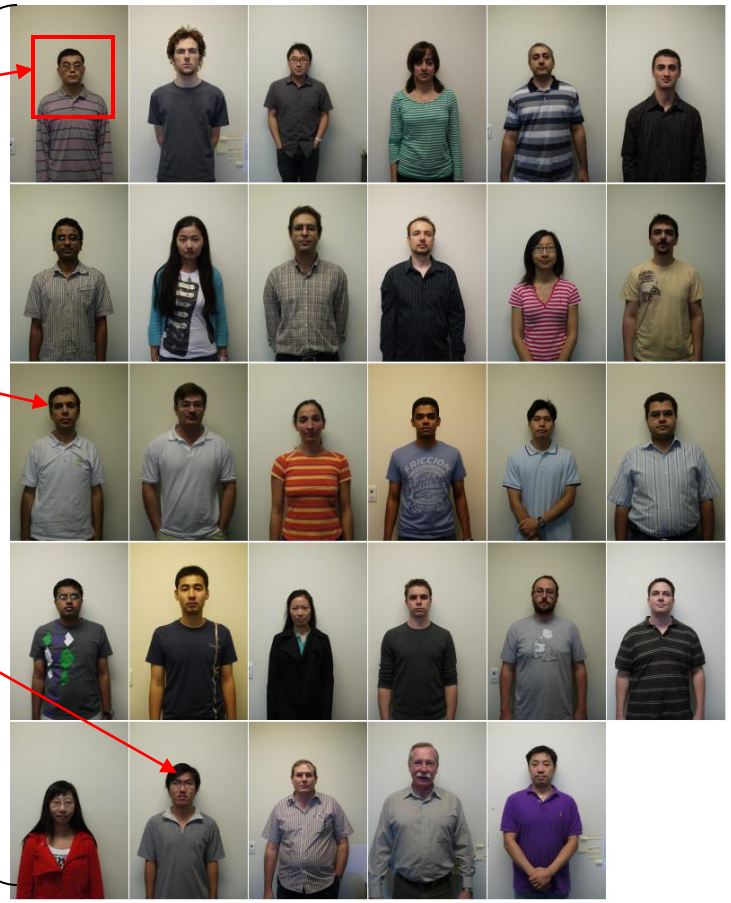
Gallery-based RTS architecture





For each detected ROI

•compare it to each “criminal” in gallery

Hard:

- to scale for large number of travellers
- to incorporate additional target details (eg. gender, race)
- to set target-specific system parameters / thresholds

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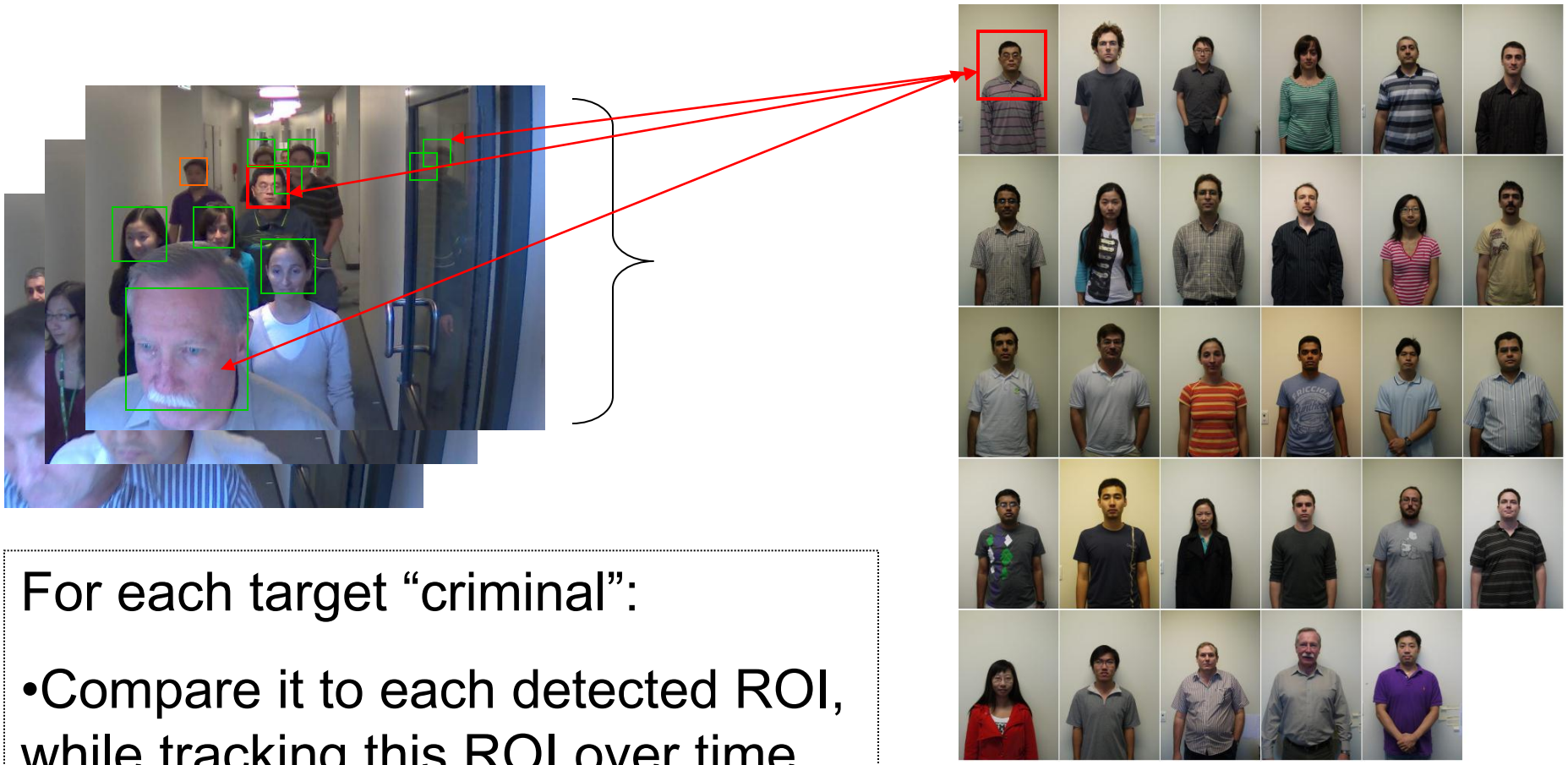
Target-based RTS architecture



For each target “criminal”:

•Compare it to each detected ROI, while tracking this ROI over time

- This is how humans do, when looking for someone in a crowd. Decision can be used in a combination with manual decision by a human.

-Scores can be updated continuously over time as more data is captured.

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Target-based RTS architecture (cntd)

For each target “criminal”:

•Compare it to each detected ROI, while tracking this ROI over time

- Also scalable to other video-based face recognition applications, such as:
  - person re-identification (tracking across multiple cameras)
  - video summarization

22. Dmitry Gorodnichy et al. “*PROVE-IT(FRiV): framework and outcomes*” (NIST IBPC 2014)

Evaluation methodology: key stages

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Using a FR marcher that can match faces in low resolution (iod<60), start with easiest surveillance type (Type 1-2)

- Use public video dataset which simulates the chosen type
- Divide dataset on training and testing subsets

STAGE 1: Designing target recognition system

- Use training subset to tune decision thresholds for each target at several face resolutions

STAGE 2: Evaluation of the designed system

- **Examine risks by applying multi-level performance evaluation**
  - I. wrt low-quality of faces: FTA, FDR - Level 0
  - II. wrt unbalanced target vs. non-target distributions: PROC - Level 1
  - III. wrt existing bad-performing face types : subject-based analysis (% of “goats” vs. “sheep”) - Level 2
  - IV. wrt low-resolution of faces - by accumulation over time: time-based decision analysis - Level 3

If no issues uncovered, proceed to the setup of higher difficulty (Type 2-3)

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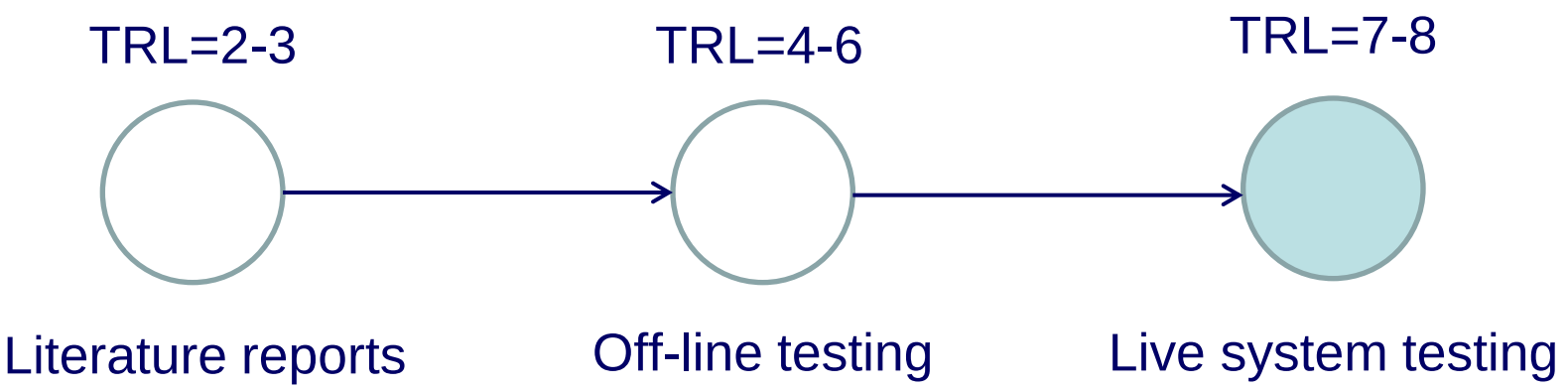
Live system evaluation

How?

- Continuously over substantially long period of time
- In real settings, with real IP-Surveillance camera network

Why ?

- Because of human and many other factors, performance of deployed system is worse than the performance reported for a component or on limited off-line



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Technology demonstrations

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With COTS SDK (most recent releases as of Dec 2012):

- Cognitec
- PittPatt

Embedded into in-house developed Video Analytic Platform (VAP*) connected to operational CCTV IP video surveillance network

For Real-Time applications:

- Measuring processing time and counting people (no FR)
- Still-to-video watch-list screening: binary decision
- Still-to-video watch-list screening: **triaging** (using temporal accumulation, quality, matching scores)
- Video-to-video face recognition (Re-Identification in Video)

For Investigation applications:

- Post-event FR tools: face search and retrieval

* "VAP/VAT: Video Analytics Platform and Testbed for testing" Proceedings of SPIE Conference on Defense, Security, and Sensing, 2010

Conclusions: PROVE-IT(FRiV) assessment

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As of September 2013:

FACE RECOGNITION IN VIDEO APPLICATION	TYPE 0 (EGATE)[1]	TYPE 1 (KIOSK)	TYPE 2 (PORTAL)	TYPE 3 (HALLS)
Detection (no Face Recognition)				
1. Face Detection in Surveillance Video	++	++	+	oo
Tracking (no Face Recognition)				
2. Face Tracking across a Single Video	+	+	+	-
3. Face Tracking across Multiple Videos	+	+	o	-
Fully-automated Recognition: for real-time border or access control applications				
Still to Video				
4. Instant FR for Watch List Screening – Triaging	+	oo	o	-
5. Instant FR for Watch List Screening – Binary	+	o	-	-
Video to Video (Re-Identification)				
6. Instant FR in single camera	+	oo	o	-
7. Instant FR from multiple cameras	+	o	o	-
Semi-automated Recognition: for post-event investigation (search and retrieval) applications				
Still to Video				
8. Face Grouping to aid forensic examination	+	oo	oo	-
Video to Video (Re-Identification)				
9. Face Tagging / Tracking across multiple videos	+	oo	oo	o
Micro-facial feature recognition				
10. Facial Expression analysis: for emotion / intent recognition	+	oo	o	-
Face Classification, Soft biometrics				
11. Human type recognition (gender, age, race)	+	oo	o	-
12. Personal metrics (eg. height, weight, eye/hair colour)	+	o	o	-

Regular updates recommended. Community feedback and participation welcome!

26. Dmitry Gorodnichy et al. "*PROVE-IT(FRiV): framework and outcomes*" (NIST IBPC 2014)

Acknowledgements

- Eric Granger is with École de Technologie Supérieure de Université du Québec, Laboratoire d'imagerie, de vision et d'intelligence artificielle (LIVIA), on Sabbatical leave with CBSA-S&E.
- uQuebec – ETS (Lead: Eric Granger): FR literature/ market review, video-based FR techniques, methodology and off-line evaluation
- uOttawa - VIVA group (Lead: Robert Laganiere): pre-processing algorithms for Face Tracking, and best-quality face selection
- uOttawa - TAMALE group (Lead: Stan Matwin): post-processing algorithms for decision fusion and Order 2-3 analysis (smROC);
- DRDC-CSS: Networking, logistical, and financial support

All findings and technology demonstrations presented for stakeholders at VT4NS'13 (federal department meetings on Video technology for National Security), Ottawa, March 2013

27. Dmitry Gorodnichy et al. "*PROVE-IT(FRiV): framework and outcomes*" (NIST IBPC 2014)

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Off-line testing:

Multi-order performance analysis of COTS FR systems for real-time Watch List screening applications

28. Dmitry Gorodnichy et al. "*PROVE-IT(FRiV): framework and outcomes*" (NIST IBPC 2014)

Level 0: Face Detection / Quality

Measure	Cognitec	PittPatt
Failure to acquire rate	30.42%	33.97%
Falsely detected faces	11.65%	1.10%
Low quality faces	11.72%	0.00%

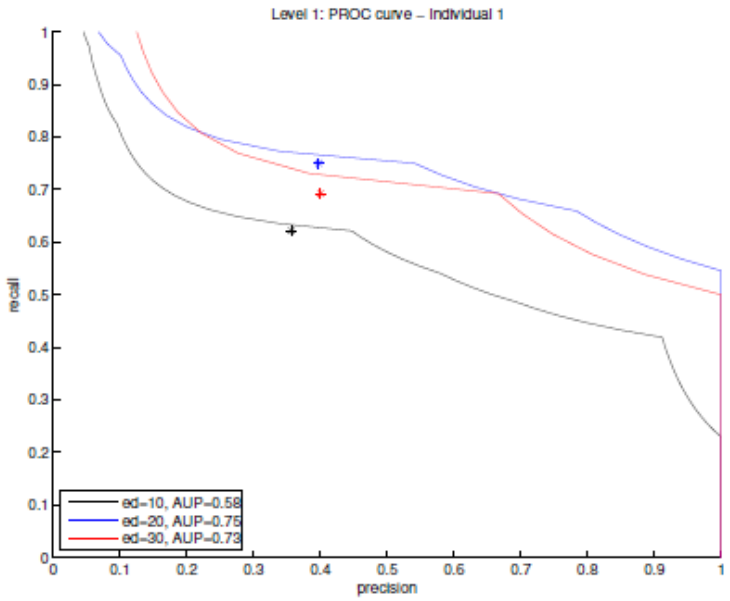
ID#1.	iod>10	iod>20	iod>30		iod>50
Detection / Level 0 results					
Target faces detected	74	44	30		8
Non-target faces detected	1632	1162	638		181
Falsely detected regions	39.42%	11.65%	18.74%		42.06
Failure to Acquire	2.25%	30.42%	60.96		
Matching (Level 1) results					
Low quality regions	6.57	11.72%	19.20%		43.39%
False Positive rates	5.09%	4.30%	4.23%		
Precision rate		39.76%			
True Positive (Recall) rate	62.16%	75.00%	69.23%		
Operational threshold fpr=5%	0.1383	0.1315	0.1294		0.1146

29. Dmitry Gorodnichy et al. "*PROVE-IT(FRiV): framework and outcomes*" (NIST IBPC 2014)

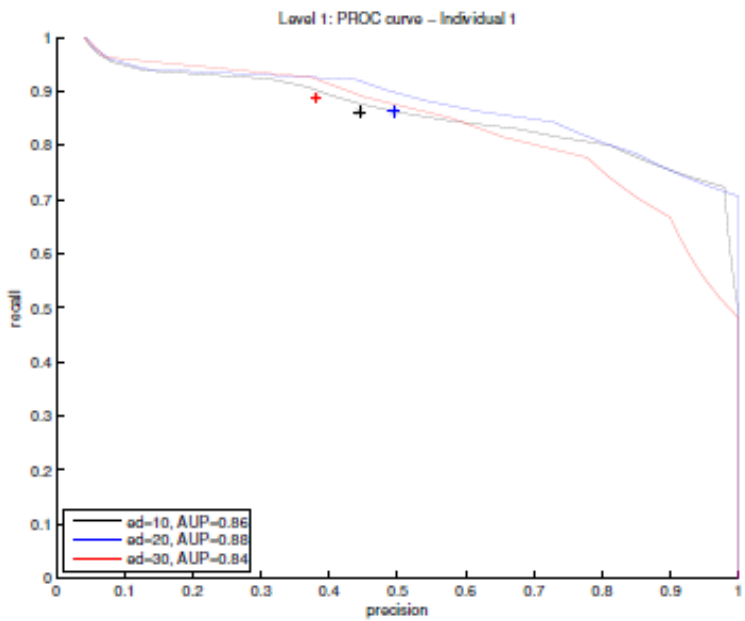
Level 1 (transaction-based) analysis

- PROC Curves For all IDs in Watch List on entire video sequence

Product	Measure	Ind01	Ind04	Ind05	Ind07	Ind09	Ind10	Ind11	Ind12	Ind16	Ind29	AVG	STD
Cognitec	fpr	4.30%	3.77%	4.05%	3.84%	5.14%	3.81%	3.73%	5.43%	3.34%	3.10%	4.05%	0.007
	tpr	75.00%	47.37%	68.89%	70.49%	71.05%	62.00%	75.00%	95.56%	43.24%	97.67%	70.63%	0.166
	$prec$	39.76%	29.03%	39.74%	49.43%	31.03%	41.33%	47.56%	40.57%	29.09%	53.85%	40.14%	0.081
	$F1$	0.520	0.360	0.504	0.581	0.432	0.496	0.582	0.570	0.348	0.694	0.509	0.101
	AUC	0.944	0.908	0.936	0.946	0.944	0.941	0.951	0.994	0.945	0.997	0.951	0.025
	$AUC_{0.05}$	0.719	0.443	0.589	0.636	0.567	0.549	0.686	0.885	0.414	0.953	0.644	0.165
PittPatt	fpr	4.01%	3.43%	0.62%	4.48%	1.68%	6.04%	3.30%	11.00%	2.21%	1.75%	3.85%	0.028
	tpr	86.27%	72.22%	91.67%	87.50%	92.11%	48.94%	21.15%	100.00%	84.21%	89.29%	77.34%	0.230
	$prec$	49.44%	40.00%	86.27%	49.49%	64.81%	25.27%	22.92%	26.63%	56.14%	55.56%	47.65%	0.188
	$F1$	0.629	0.515	0.889	0.632	0.761	0.333	0.220	0.421	0.674	0.685	0.576	0.193
	AUC	0.956	0.852	0.968	0.946	0.985	0.725	0.600	0.997	0.916	0.946	0.889	0.123
	$AUC_{0.05}$	0.852	0.613	0.929	0.796	0.945	0.407	0.184	0.948	0.762	0.884	0.732	0.244



vs.



Level 2 (subject-based) analysis

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According to Doggington's zoo terminology:

- yellow- "goats" (difficult to predict),
- blue- "lambs" (can be impersonated by someone else),
- red – "wolfs" (who can impersonate another user

For ID# 1:

Distance	Ind. 1	Ind. 2	Ind. 3	Ind. 4	Ind. 5	Ind. 6	Ind. 7	Ind. 8	Ind. 9	Ind. 10	Ind. 11	Ind. 12	Ind. 13	Ind. 14	Ind. 15
10 px.	62.16%	0.00%	0.00%	1.61%	8.20%	1.18%	14.47%	0.00%	3.39%	3.03%	1.35%	3.03%	7.78%	6.33%	0.00%
20 px.	75.00%	0.00%	0.00%	2.63%	4.44%	1.69%	19.67%	0.00%	0.00%	4.00%	0.00%	0.00%	3.08%	5.66%	0.00%
30 px.	69.23%	0.00%	0.00%	0.00%	8.33%	0.00%	12.50%	0.00%	0.00%	3.57%	0.00%	0.00%	5.13%	6.67%	0.00%

(a)

Distance	Ind. 16	Ind. 17	Ind. 18	Ind. 19	Ind. 20	Ind. 21	Ind. 22	Ind. 23	Ind. 24	Ind. 25	Ind. 26	Ind. 27	Ind. 28	Ind. 29	Ind. 30
10 px.	5.00%	3.08%	4.23%	2.78%	7.55%	0.00%	0.00%	14.75%	6.17%	3.90%	11.11%	1.37%	3.23%	3.45%	5.63%
20 px.	2.70%	0.00%	5.66%	2.00%	9.52%	0.00%	0.00%	12.50%	5.26%	1.79%	2.78%	2.04%	4.00%	4.65%	6.52%
30 px.	5.26%	0.00%	6.25%	3.70%	12.50%	0.00%	0.00%	14.29%	3.23%	3.12%	0.00%	3.85%	3.57%	7.69%	0.00%

(b)

vs.

Distance	Ind. 1	Ind. 2	Ind. 3	Ind. 4	Ind. 5	Ind. 6	Ind. 7	Ind. 8	Ind. 9	Ind. 10	Ind. 11	Ind. 12	Ind. 13	Ind. 14	Ind. 15
10 px.	86.15%	0.00%	0.00%	0.00%	18.03%	14.10%	35.82%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.41%	0.00%
20 px.	86.27%	0.00%	0.00%	0.00%	16.67%	5.08%	42.86%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	7.41%	0.00%
30 px.	88.89%	0.00%	0.00%	0.00%	25.00%	0.00%	72.73%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	6.67%	0.00%

(a)

Distance	Ind. 16	Ind. 17	Ind. 18	Ind. 19	Ind. 20	Ind. 21	Ind. 22	Ind. 23	Ind. 24	Ind. 25	Ind. 26	Ind. 27	Ind. 28	Ind. 29	Ind. 30
10 px.	0.00%	1.61%	1.54%	4.35%	3.64%	0.00%	0.00%	5.17%	1.28%	0.00%	0.00%	0.00%	0.00%	0.00%	14.52%
20 px.	0.00%	0.00%	1.96%	5.66%	2.44%	0.00%	0.00%	0.00%	1.72%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
30 px.	0.00%	3.33%	3.33%	3.45%	0.00%	0.00%	0.00%	5.56%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	7.69%

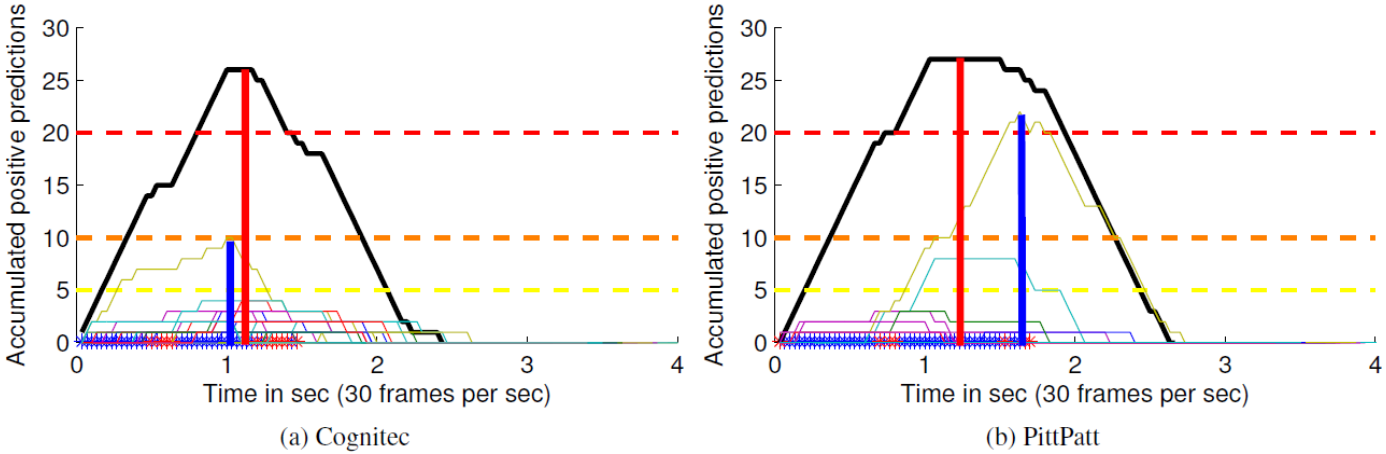
(b)

31. Dmitry Gorodnichy et al. "*PROVE-IT(FRiV): framework and outcomes*" (NIST IBPC 2014)

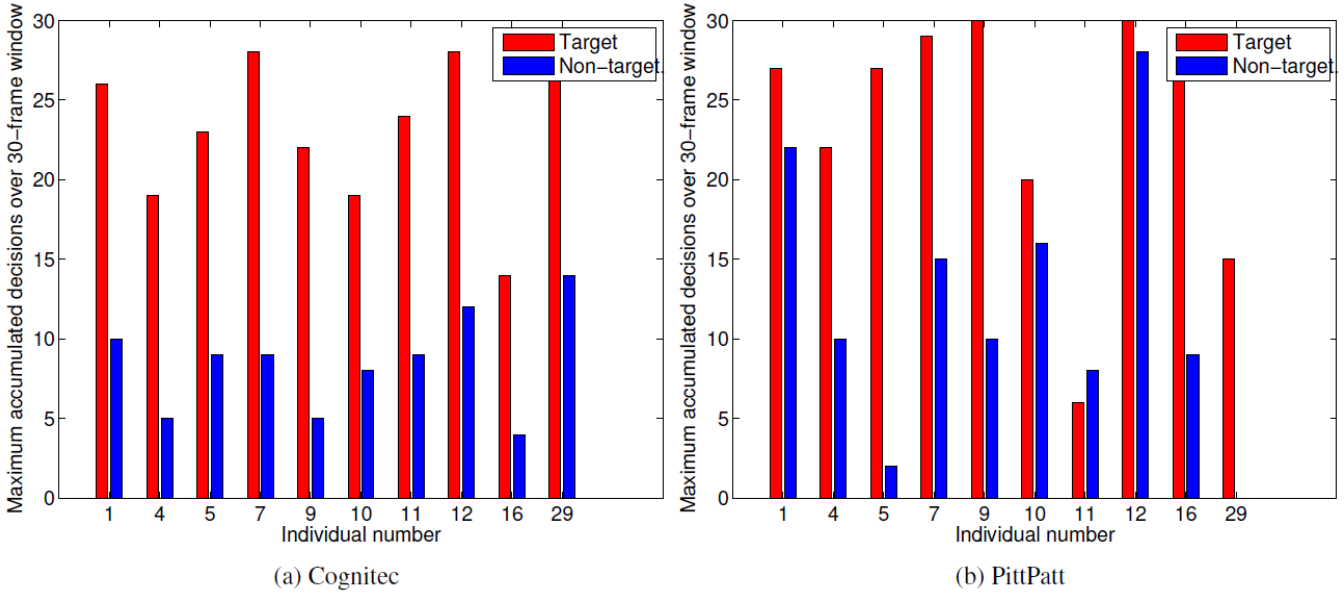
Level 3 (time-based) analysis

- Accumulation of “hits” over time: for target vs. non-target individuals

For ID#1:



For all IDs in Watch List:



32. Dmitry Gorodnichy et al. “*PROVE-IT(FRiV): framework and outcomes*” (NIST IBPC 2014)

Annex B

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Live system testing:

Technology demonstration and live testing on real data

33. Dmitry Gorodnichy et al. "*PROVE-IT(FRiV): framework and outcomes*" (NIST IBPC 2014)

Testing using Mock-up settings

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- Camera positions / lighting as in airports
- Cameras and VMS identical to the ones used in the field
- Type 1 (“at Kiosk”): people are asked questions for ~20 secs observed by BEST POSSIBLE face capture camera

  3 Mp AXIS P1346: 2012x1507
  H.264 compression (70%,1700kps)

- Types 2-3 (“Airport corridor”): people walking for ~ 2 min observed by 2 cameras

  1.5Mp AXIS Q1755: 1440x1080
  H.264 compression (60%,1700kps)

  2Mp Panasonic P1346: 1600x1200
  H.264 compression (65%,2000kps)

34. Dmitry Gorodnichy et al. “*PROVE-IT(FRiV): framework and outcomes*” (NIST IBPC 2014)

1. FR Triaging for real-time application

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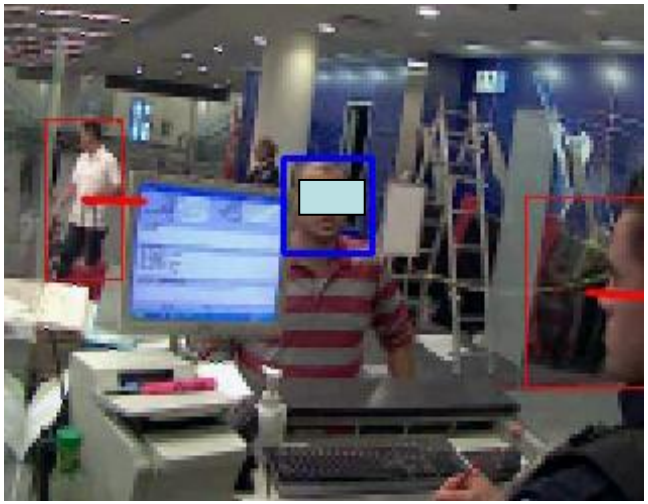
Potential Application for Border Officer :



- "Red" – refer to Secondary Inspection Lane
- "Yellow" – ask more questions
- "Green" – no additional questions required

Testing scenario:

"Watch List" Photo Gallery:

- 60 "Wanted by the CBSA": http://www.cbsa-asfc.gc.ca/wc-cg/menu-eng.html
- 6 (group members)

"Regular travellers": 5 (other group members)

- With operational IP-Cameras, in (similar to) operational setups
- Several state-of-art COTS FR used

35. Dmitry Gorodnichy et al. "*PROVE-IT(FRiV): framework and outcomes*" (NIST IBPC 2014)

“Watch-List”: 60 (CBSA Wanted) + 6 (CBSA staff)

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36. Dmitry Gorodnichy et al. “*PROVE-IT(FRiV): framework and outcomes*” (NIST IBPC 2014)

Watch-List Screening: Type 1 Setup

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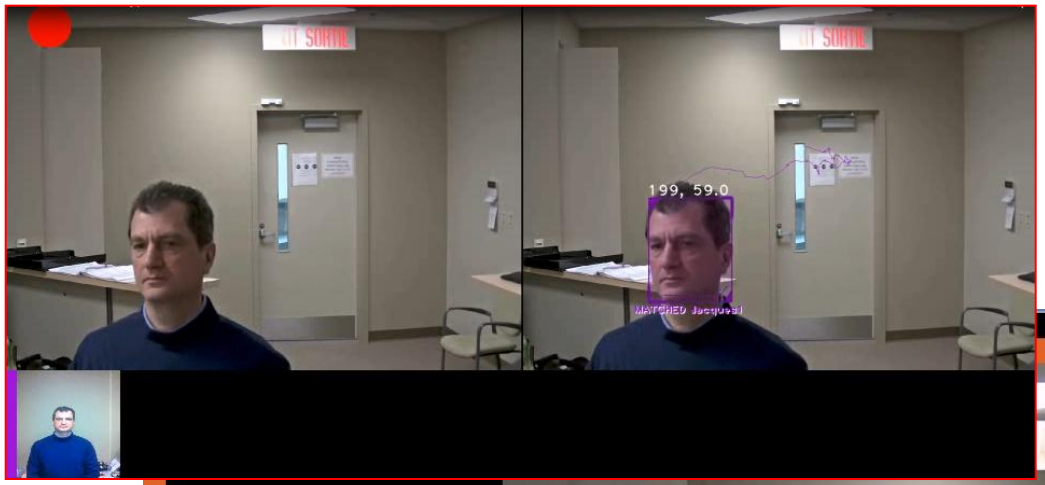
- Includes Face Tracking and processing time

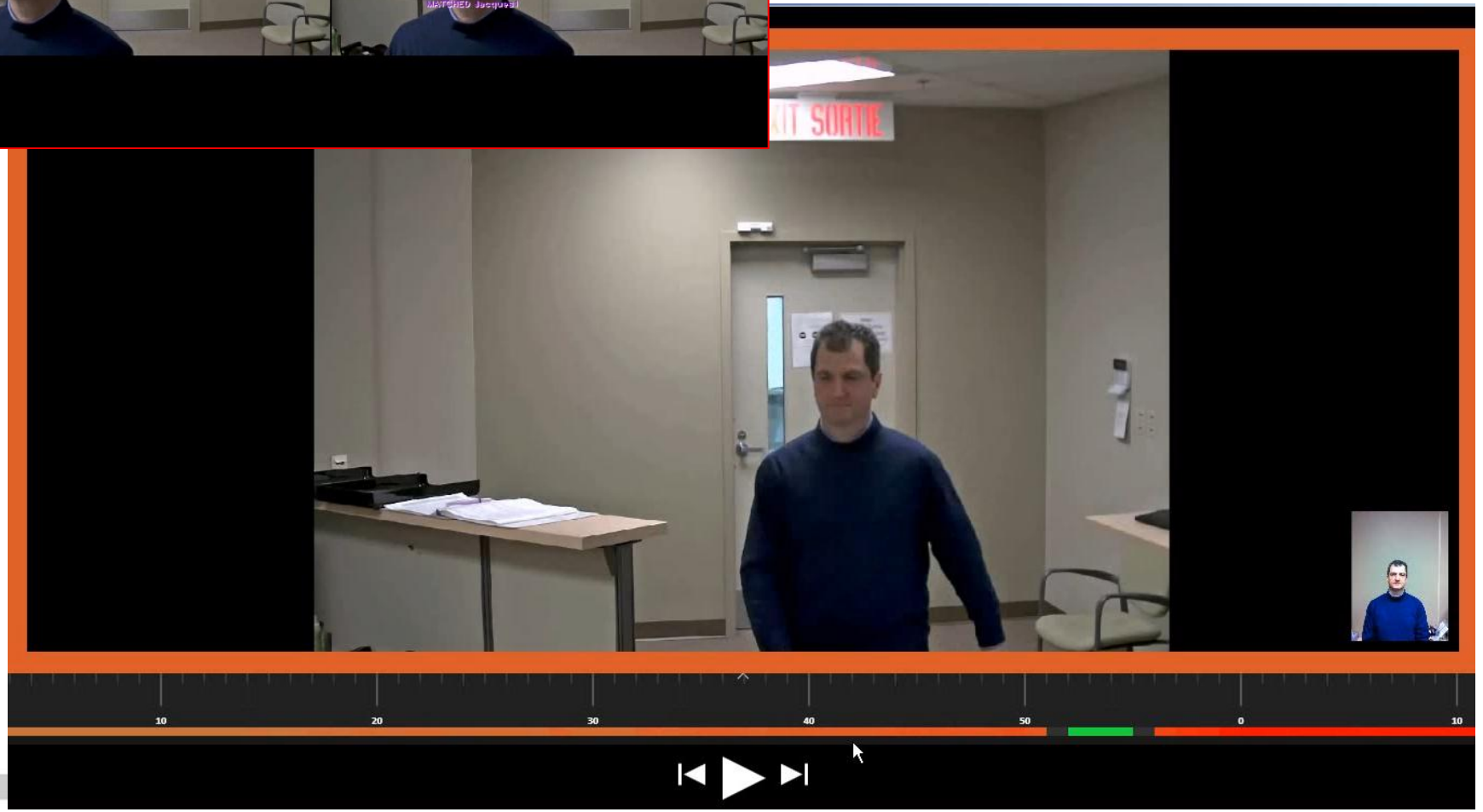
37. Dmitry Gorodnichy et al. "*PROVE-IT(FRiV): framework and outcomes*" (NIST IBPC 2014)

Watch-List Screening: Type 2 Setup



- Binary vs. Triaging

(Triaging based on image quality)



38. Dmitry Gorodnichy et al. "*PROVE-IT(FRiV): framework and outcomes*" (NIST IBPC 2014)

2. FR tools for post-event search and retrieval

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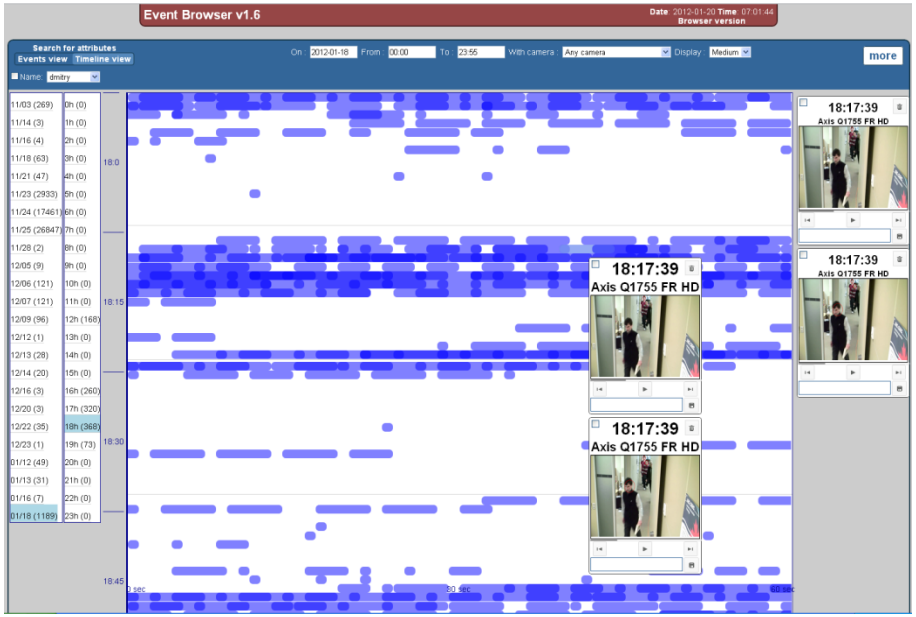
Potential Application:

- Faciltate Human Analyst in finding and retrieving evidence from large quantities of video data



Testing scenario:

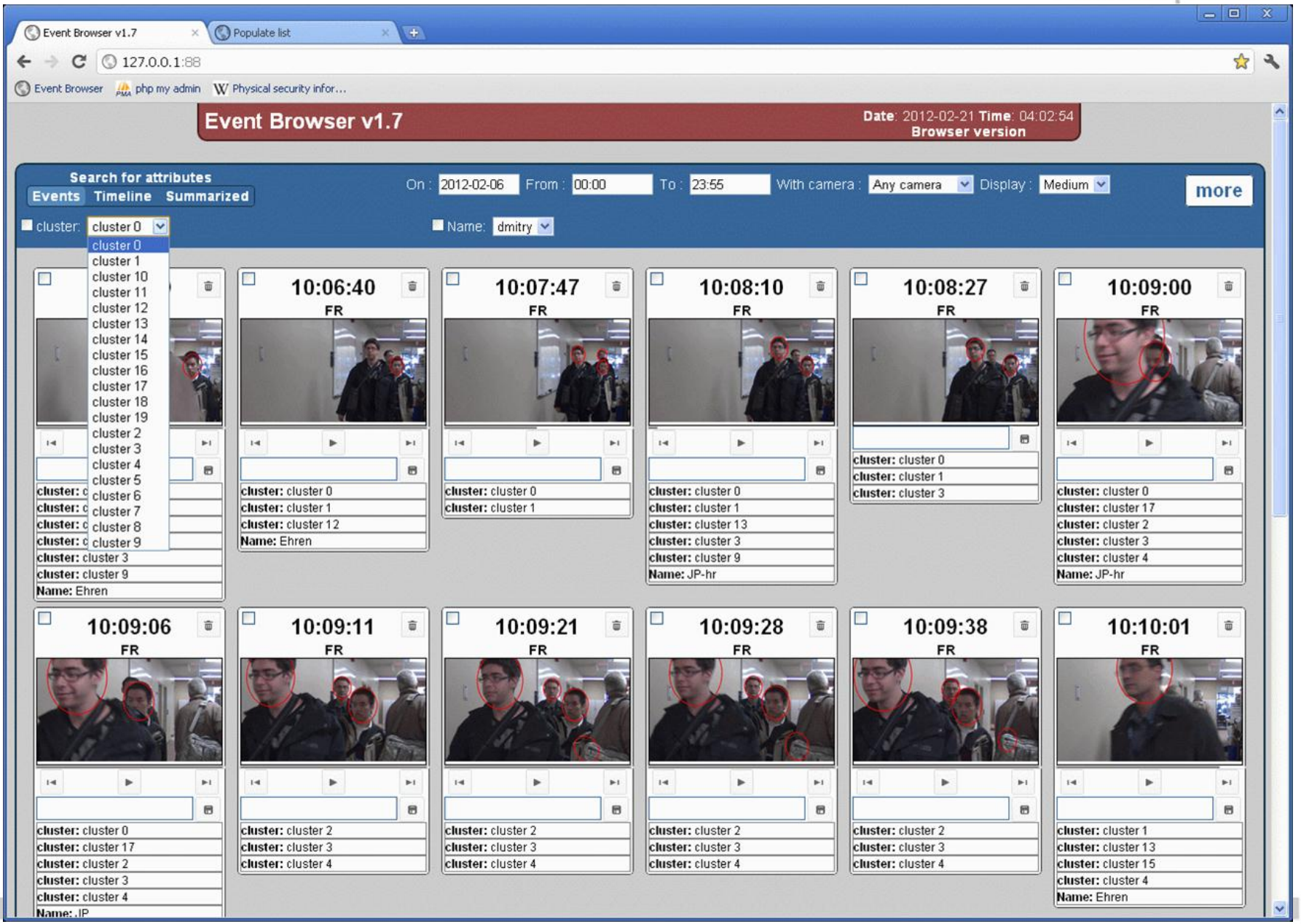
- *Visual Analytic* tool combined with Face Detection, Face Grouping and Tracking

- All frames with detected faces are colour-marked (Face Detection)
- All consecutive frames containing the same person are linked in a segment (Face Tracking)

- Filter by resemblance to “Watch List” photos (1-to-M Face Screening)
- Find “Similar” - by clicking on a selected “facial event” segment, find all segments with similar faces (Face Tagging)

39. Dmitry Gorodnichy et al. “*PROVE-IT(FRiV): framework and outcomes*” (NIST IBPC 2014)

2. FR tools for post-event search (cntd)



40. Dmitry Gorodnichy et al. "*PROVE-IT(FRiV): framework and outcomes*" (NIST IBPC 2014)

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PROVE-IT(VA)
technology readiness assessment

41. Dmitry Gorodnichy et al. "*PROVE-IT(FRiV): framework and outcomes*" (NIST IBPC 2014)

PROVE-IT(VA) assessment

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Video Analytics Application	Type 1 (Kiosk)	Type 2a (Portal)	Type 2b (Portal)	Type 3 (Halls)	Type 4 outdoor
1. Person Detection and Tracking (without Face Recognition)					
a. Person detection	++	+	oo	o	o
b. Person tracking in single camera	++	+	oo	o	o
c. Person matching in single camera	oo	o	o	-	-
d. Person matching in multiple cameras	o	o	-	-	-
2. Person Event Detection					
a. Opposite flow detection	++	++	oo	o	o
b. Running detection	++	++	oo	-	-
c. Tail-gating detection	++	++	oo	-	-
d. Loitering detection	++	+	-	-	-
e. Fall detection	++	oo	-	-	-
3. Crowd Analysis					
a. Density estimation	n/a		oo	oo	oo
b. Rapid dispersion			oo	oo	oo
c. Crowd formation			oo	oo	oo
d. Crowd Splitting			o	-	-
e. Crowd Merging			o	-	-
3. Baggage Detection and Tracking					
a. Static Object (>n sec)	+	+[1]	o[1,2]	-	-
b. Object removal	o[2]	o[2]	-	-	-
c. Dropping Object	o[2]	o[2]	-	-	-
d. Abandoned Object	o[2]	o[2]	-	-	-
e. Unattended Object	o[2]	o[2]	-	-	-
f. Carried Object	-	-	-	-	-
2. Person-Baggage Association Analysis					
a. Person-Baggage Association	o	-	-	-	-
b. Owner change	-	-	-	-	-
3. Camera Tampering Detection					
Occlusion | Focus moved | Camera moved	++	++	++	++	++

Type 2a: one at time
Type 2b: many at time

[1]Low traffic only
[2] Large objects only

42. Dmitry Gorodnichy et al. "*PROVE-IT(FRiV): framework and outcomes*" (NIST IBPC 2014)