Driver Identification in SHRP2 Naturalistic Driving Study

Doug McGraw, VTTI

Driving Transportation with Technology

Virginia Tech Transportation Institute

Face Recognition using Eigenfaces

We have developed a near real-time computer system that can locate and track a subject's head, and then recognize the person by comparing characteristics of the face to those of known individuals.

Matthew Turk and Alex Pentland
Vision and Modeling Group
The Media Laboratory
Massachusetts Institute of Technology

The Journal of Cognitive Neuroscience, Volume 3, Number 1

Driver Id and its value to SHRP2

- identify trips where the primary or secondary driver is operating the vehicle
- primary drivers complete a battery of assessments and questionnaires that provide a behavioral, medical and physical profile of the driver
- a tool to help researchers understand factors that may influence specific driving behaviors.

Driver Identification relies on Face Recognition

Face Recognition is one of many biometric technologies.

Biometrics

Fingerprints	Handwriting	Voice recognition
Keystroke dynamics	Hand geometry	Vascular pattern
Gait	Retinal scan	Iris scan

Face recognition

Face Recognition 101

- Identification (1:N) vs. Verification (1:1)
- Capture a digital face image
- Detect (locate) it in the image
- Use pattern-matching techniques to prepare a model based on the detected face
- Compare the model to previously identified models
- Declare results as a "score", often in the range 0-1.

SHRP2 Face Recognition 101

- The SHRP2 face cam video is the source for all "query images" (single video frames).
- Driver "reference images" are captured at installation under bright and dark lighting conditions.
- Each vehicle will have a gallery of reference images for the primary driver (and for the secondary driver, if applicable).
- Driver Identification does not occur in real-time
- Pre-processing occurs at VT's HPC Research Data Center

Video Pre-processing

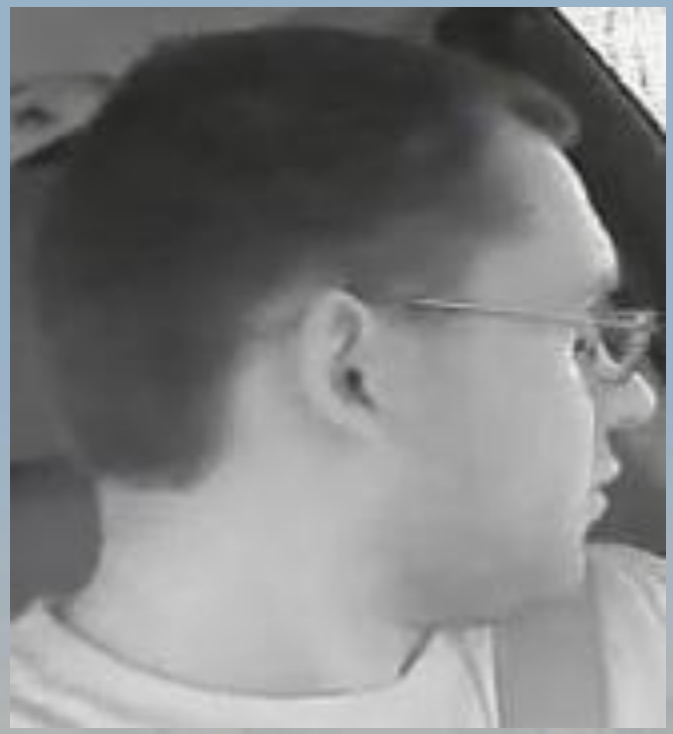
There are challenges …
Unconstrained Lighting - daylight

Driving Transportation with Technology

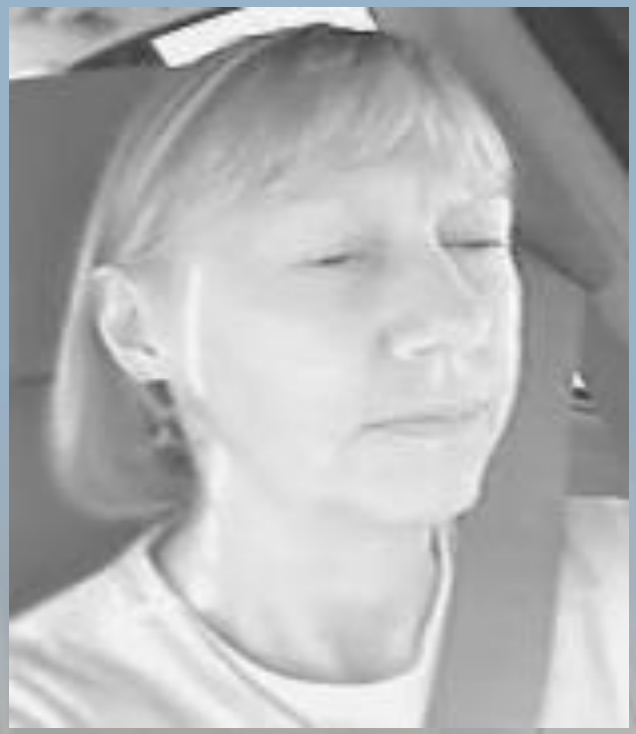
Virginia Tech
Transportation
Institute

Unconstrained Lighting – IR/night-time

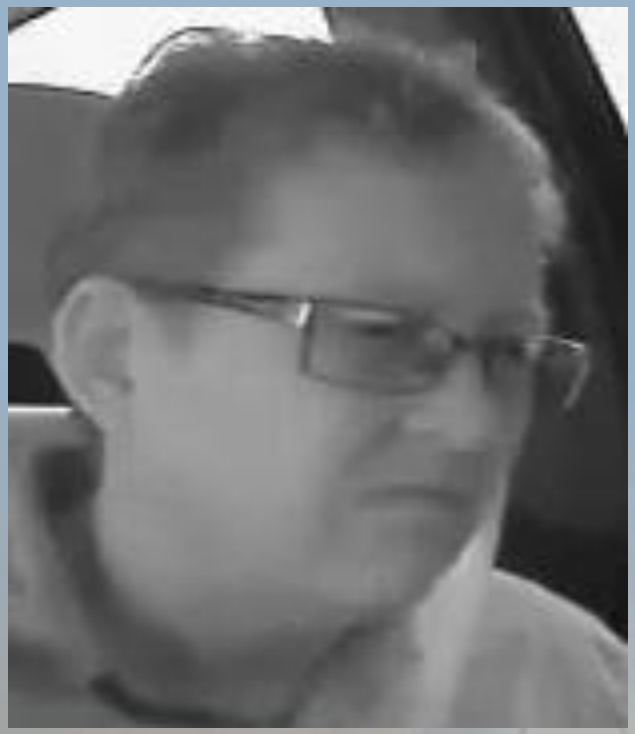
Unconstrained Head Pose



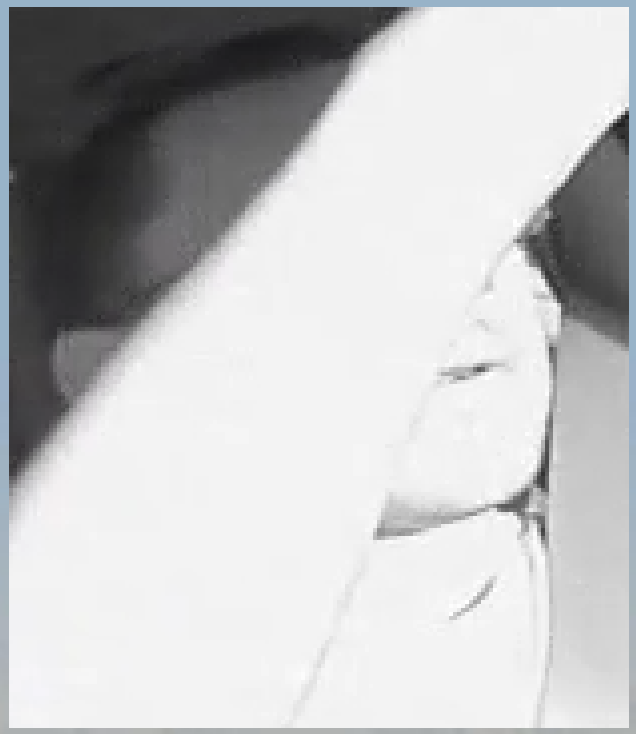
Unconstrained Facial Expression



Low Resolution/Blurred Image



Occluded Face



Advances in Face Recognition

- Federal government is supporting Biometrics research
  - NIST leads a very active Biometrics research program
  - DOD, FBI and a host of other 3-letter agencies
- vendors are adapting to unconstrained environments
- social media and photo-tagging
  - facebook
  - Faces
  - FaceR
  - RECOGNIZR
- face "detection" is built into many digital cameras/phones
- face recognition is becoming ubiquitous

Unconstrained Lighting - daylight

Unconstrained Facial Expression

Low Resolution/Blurred Image

Unconstrained Head Pose

Vendors: systems, apps, SDKs or APIs

- The Biometrics Consortium
- Pittsburgh Pattern Recognition (PittPatt) SDK (software development kit)
- Star Technologies - STARFace SDK
- face.com API (application programming interface)
- Animetrics SDK

Which end of this do we pick up?

- Incremental programming to understand and exercise the SDK
- Wrap functionality around it that we can "see".
- Ended up with an interactive application and a batch application

Driver ID application development

- Interactive application
  - provides gallery management
  - user control:
    - stop/start video play
    - move fwd/back by frame
    - request detection/recognition
    - add slider control to move through video
  - clearly demonstrated the need for day & night reference images

Driver Id app development, cont'd

- Batch mode application
  - provide gallery management (in database)
  - set time interval (ms) to operate detection/match
  - results stored in a database for later analysis
  - similar to the approach that will be taken on a large scale.

PittPatt SDK

- PittPatt could not accommodate the off-axis angles that result from the location of the camera.
- Rejected

Star Technologies – STARFace SDK

- Star Technologies' SDK (STARFace) yields a "score" that indicates how closely a query image maps to each reference image in the gallery.
- Their recommended "threshold" score for declaring a match is >= 0.53
- Biometric thresholds for face recognition are fuzzy because there are generally no "exact" matches between a query image and a reference image.
- STARFace SDK judged adequate, but processing intensive.

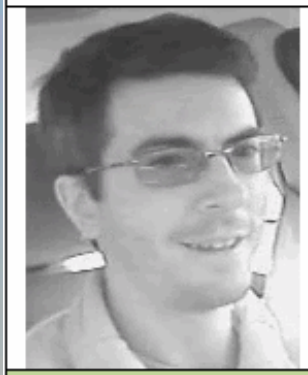
How does one a product based on "fuzzy" logic?

- Does it work in an unconstrained environment?
- How does one observe the impact of "threshold"?
- Does the product IDENTIFY the driver?
- Does the product DISCRIMINATE between drivers within a gallery?

Impact of Threshold
(Reference Image selectivity)

gallery filenames	gallery ImageID	count(*) winners threshold >= 0.70		count(*) winners threshold >= 0.60		count(*) winners threshold >= 0.55		count(*) winners threshold >= 0.53		count(*) winners threshold >= 0.50	
20100401DjbFw d01.png	148	3	2%	42	6%	314	18%	414	19%	495	20%
20100401DjbFw d02.png	149	1	1%	12	2%	79	5%	115	5%	161	6%
20100401DjbFw d03.png	150	4	2%	23	3%	162	9%	234	11%	266	10%
20100401DjbFw d04.png	151	3	2%	39	6%	121	7%	152	7%	181	7%
20100401DjbFw d05.png	152	3	2%	18	3%	47	3%	62	3%	93	4%
20100401DjbFw d06.png	153	7	4%	136	20%	353	20%	399	19%	425	17%
20100401DjbFw d07.png	154	28	17%	136	20%	209	12%	241	11%	263	10%
20100401DjbFw d08.png	155	26	16%	60	9%	68	4%	76	4%	84	3%
20100401DjbFw d09.png	156	67	40%	127	18%	162	9%	176	8%	187	7%
20100401DjbRearView 01.png	157	1	1%	5	1%	28	2%	60	3%	94	4%
20100401DjbRearView 02.png	158	2	1%	6	1%	25	1%	42	2%	76	3%
20100401DjbRearView 03.png	159	2	1%	22	3%	29	2%	33	2%	37	1%
20100401DjbRearView 04.png	160	3	2%	8	1%	30	2%	38	2%	50	2%
20100401DjbRearView Glance05.png	161	17	10%	63	9%	103	6%	111	5%	123	5%
		167		**697**		**1730**		**2153**		**2535**	
# of intervals:	**3546**										
% matches at an interval:		**5%**		**20%**		**49%**		**61%**		**71%**	

Reference Image Selection

				
20100401DjbFwd01.png	20100401DjbFwd02.png	20100401DjbFwd03.png	20100401DjbFwd04.png	20100401DjbFwd05.png
				
20100401DjbFwd06.png	20100401DjbFwd017.png	20100401DjbFwd08.png	20100401DjbFwd09.png	20100401DjbRearViewGlance05.png

Driving Transportation with Technology

Virginia Tech Transportation Institute

Discrimination Testing

threshold = 0.53, 100% success

	tm			jb				rz					sw			dm										
	360 - tmFwdD03.png	361 - tmFwdD04.png	362 - tmFwdD07.png	363 - jbFwd03.png	364 - jbFwd04.png	365 - jbFwd05.png	366 - jbFwd06.png	367 - rzFwdD03.png	368 - rzFwdD04.png	369 - rzFwdD05.png	370 - rzRearViewGlanceD01.png	371 - rzRearViewMirrorD01.png	372 - swFwdD06.png	373 - swFwdD07.png	374 - swRVglanceD02.png	375 - dmFwdD01.png	376 - dmFwdD02.png	377 - dmFwdD03.png	378 - dmFwdD04.png	379 - dmFwdD05.png	385 - dmRearVMD01.png	386 - dmRearVMD02.png	387 - dmRearVMD03.png	matches (@ 0.53)	# of time intervals	% success
rzDay.avi								45	18	28	70	8												169	1416	12%
jbDay.avi				394	242	165	554																	1355	2777	49%
swDay.avi													211	217	359									787	1666	47%
tmDay.avi	448	371	240																					1059	2242	47%

(demo)

Performance Optimizations

- 8000 trips/day
- minimize the number of frames evaluated
- pre-process video to identify good candidate query images
- take advantage of the naturally-occurring epochs within a trip
- raise the threshold level as conditions permit

VTTI High Performance Research Computing Infrastructure