Some research projects at the Transport and Mobility Laboratory (EPFL)

Michel Bierlaire

transp-or.epfl.ch

Transport and Mobility Laboratory, EPFL

Transport and Mobility Laboratory

- 19 members, including
  - 8 PhD students
  - 3 postdocs
- Research themes:
  - Transportation research
  - Operations Research
  - Discrete choice models
  - Other: computer vision, image analysis, hospital management, marketing.

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Two projects

- Automatic facial expression recognition: a discrete choice approach
- Exploiting mobility data from Nokia smartphones

Outline

- Facial expressions
- Data
- Variables
- Static expressions
- Dynamic expressions
- Conclusion

Facial expressions

“The face is the most extraordinary communicator, capable of accurately signaling emotion in a bare blink of a second, capable of concealing emotion equally well”

Deborah Blum

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Facial expressions

1872 Darwin: universality of facial expressions

1971 Ekman: six primary emotions, that possess each a distinctive content together with a unique facial expression:

- Happiness
- Sadness
- Fear
- Anger
- Disgust
- Surprise

1978 Ekman's Facial Action Unit Coding System (FACS)

Facial expressions

- Active field of research
- Mostly in the machine learning and computer vision communities
- Some difficulties:
  - Context dependency (time, gestures, verbal reaction, etc.)
  - Ambiguity of expressions
  - Need for a ground truth

Data: facial expressions

Cohn-Kanade database

- Testbed for research in automatic facial image analysis
- About 500 image sequences from 100 subjects
- Subjects were instructed by an experimenter to perform a series of 23 facial displays
- Expressions based on FACS action units (see later)

Data: facial expressions

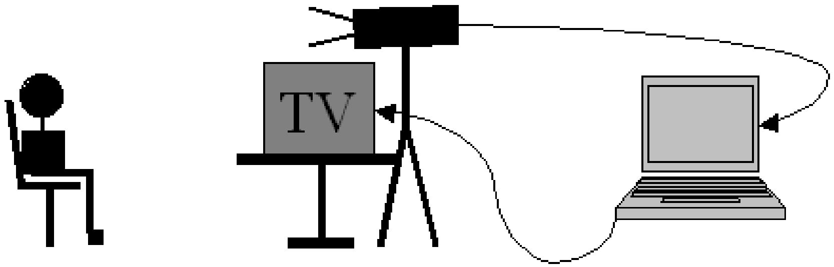
Example of recorded video:

Data: facial expressions

Example of recorded video:

Data: facial expressions

Facial Expressions and Emotion Database, TU Munich
Experimental setup:



Data: facial expressions

Example of video shown:

Data: facial expressions

Example of recorded video:

Data: facial expressions

Another example of recorded video:

Data: facial expressions

- Database: 18 different individuals
- Each individual performed all six desired actions three times.
- Additionally, three sequences doing no expressions at all are recorded.
- Total: 399 sequences.

For more information:

www.mmk.ei.tum.de/ waf/fgnet

Data: choice

Choice experiment:

- Present an image or a video sequence
- Ask the respondent to select the most appropriate expression among
  - `Happiness`
  - `Surprise`
  - `Fear`
  - `Disgust`
  - `Sadness`
  - `Anger`
  - `Neutral`
  - `Other`
  - `I don’t know`

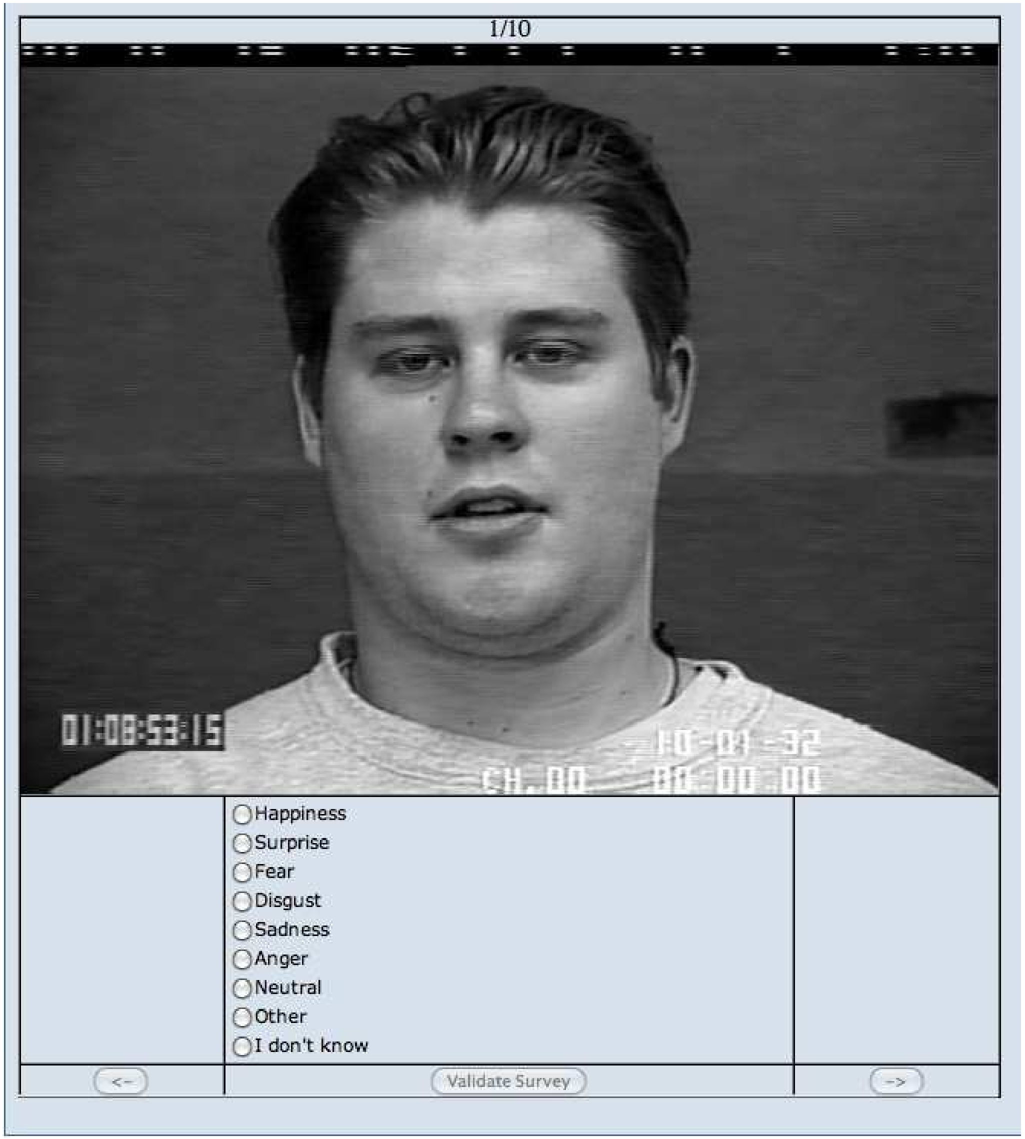
Data: choice

Survey for static images:

`lts5www.epfl.ch/face`

Designed by Matteo Sorci

Data: choice


1/10
01:08:53:15
Happiness
Surprise
Fear
Disgust
Sadness
Anger
Neutral
Other
I don't know
<-
Validate Survey
->

Data: choice

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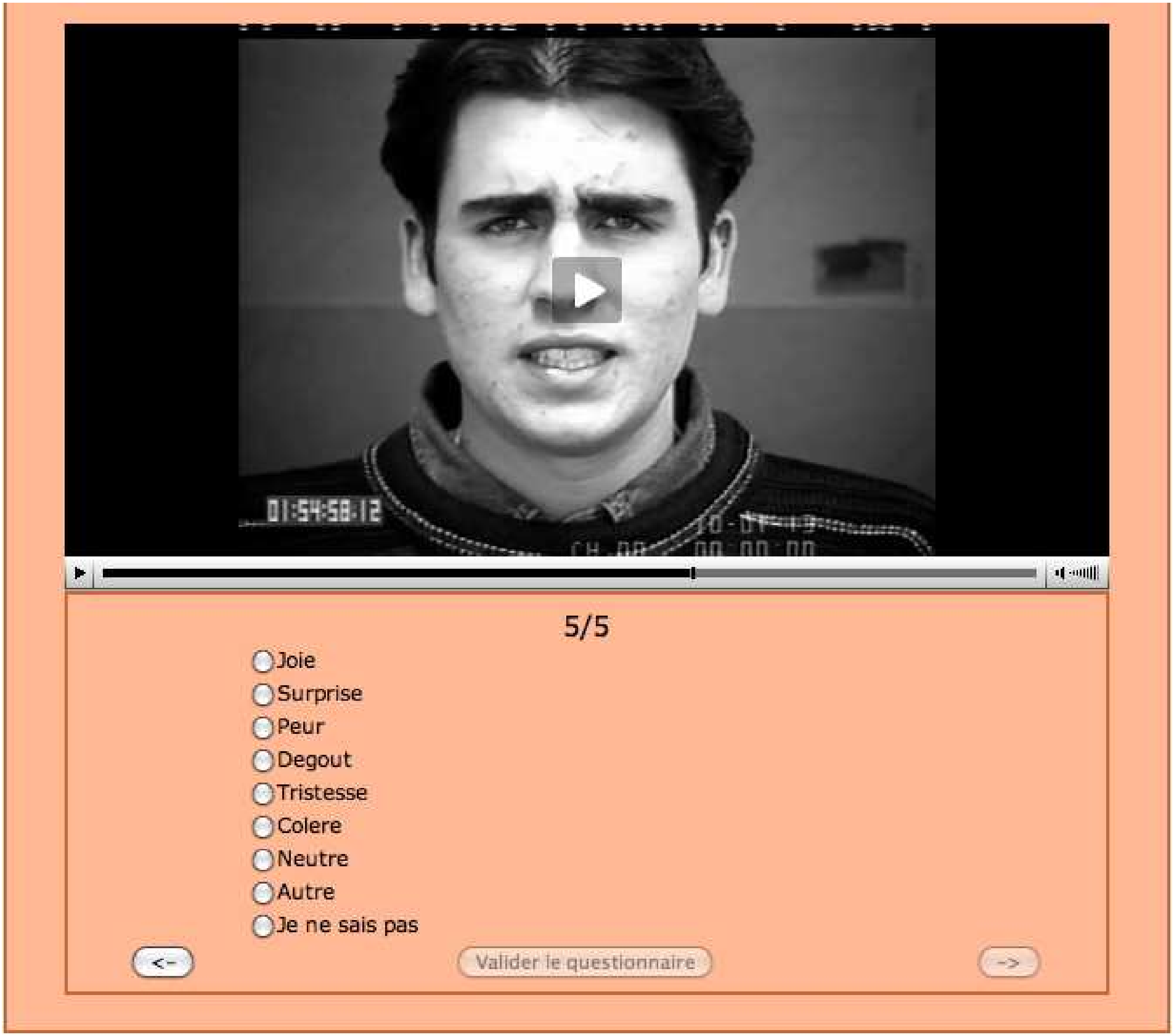
Data: choice

Survey for video sequences:

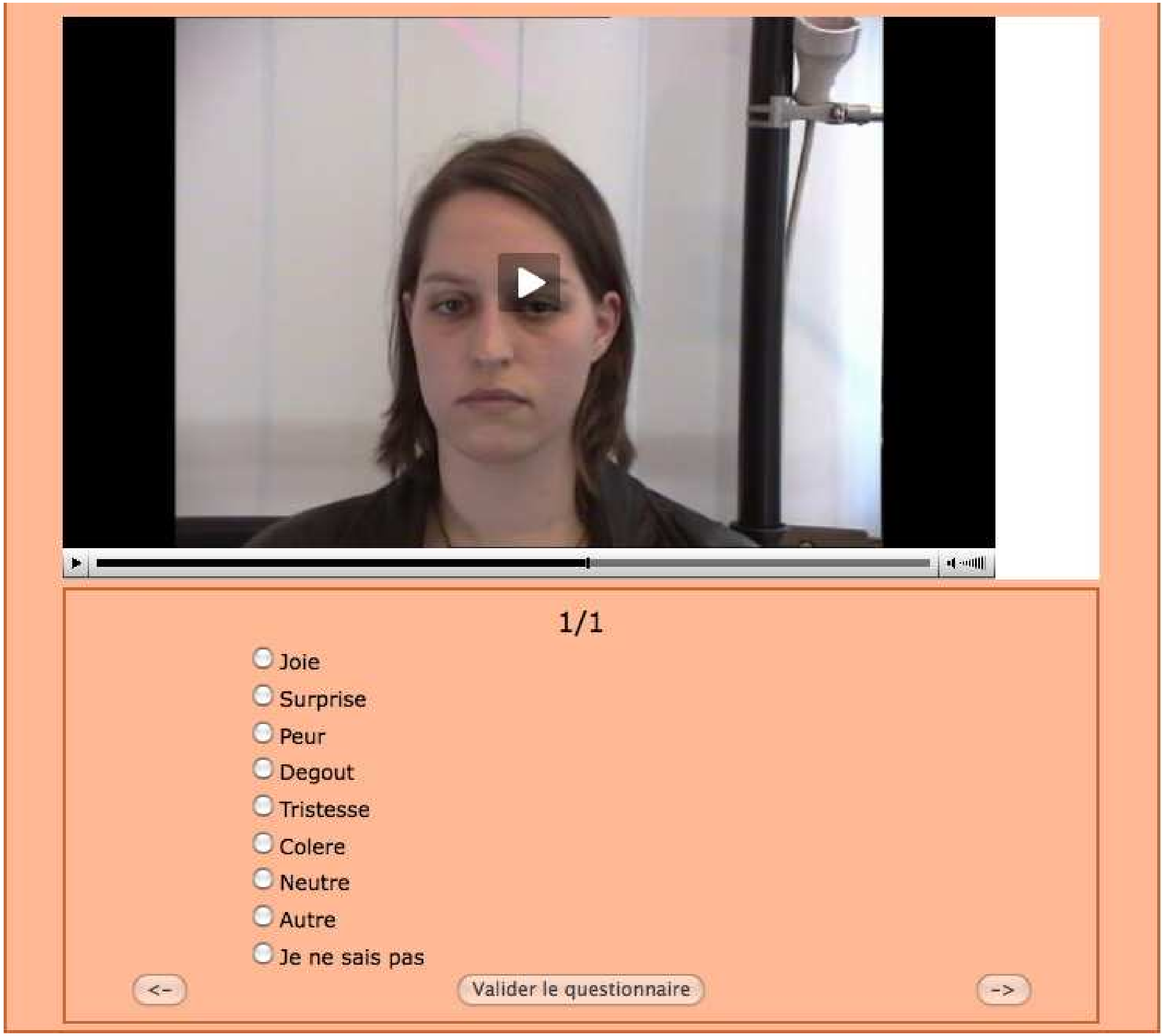
`transp-or2.epfl.ch/videosurvey`

Designed by Thomas Robin and Javier Cruz

Data: choice


5/5
Joie
Surprise
Peur
Degout
Tristesse
Colere
Neutre
Autre
Je ne sais pas
<-
Valider le questionnaire
->

Data: choice


1/1
Joie
Surprise
Peur
Degout
Tristesse
Colere
Neutre
Autre
Je ne sais pas
<-
Valider le questionnaire
->

Variables

- Objective: explain the choice of an expression using variables describing the face
- Require image analysis techniques
- Cootes, Edwards and Taylor (2001) *Active Appearance Models* PAMI, 23, 681-685.
  - Statistical models of shape and texture
  - Shape and texture are often correlated
  - Correlation learned from PCA
  - Another PCA is used combining the previous two

Data extraction

Shape:

- Automatic extraction of a list of points

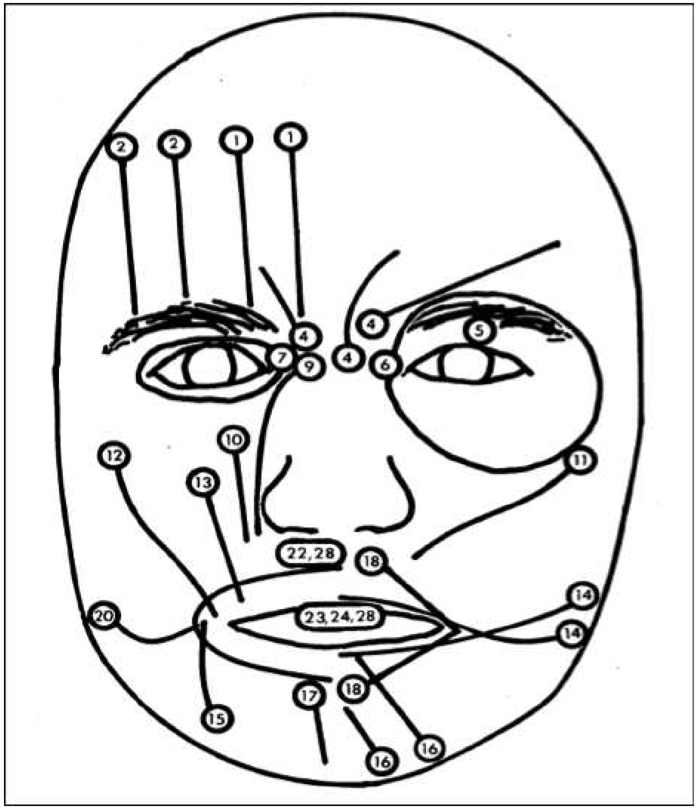
- $x = (x_1, y_1, \ldots, x_n, y_n)'$

Explanatory variables

- FACS Action Units
- Expression Descriptive Units
- Active Appearance Model

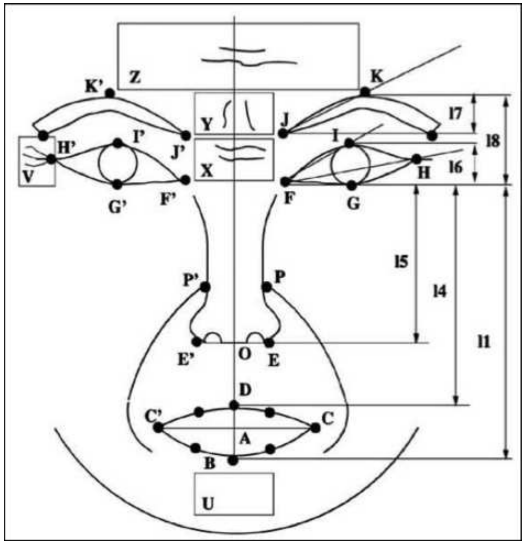
FACS Action Units

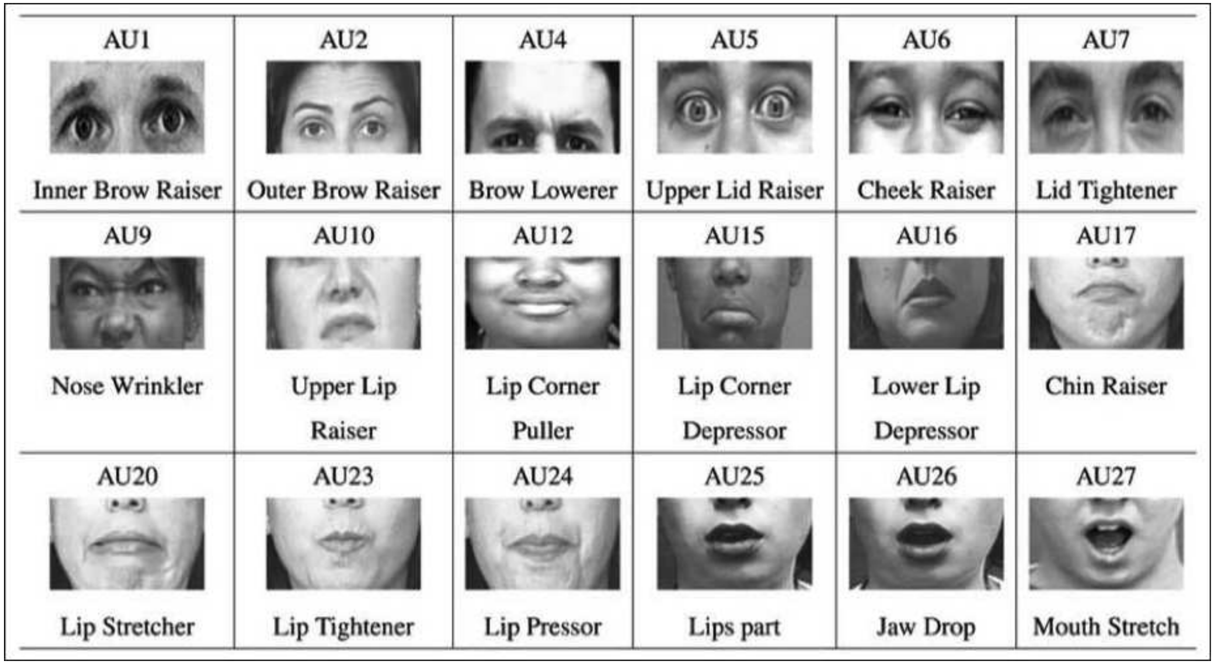
- 1978: Ekman & Friesen proposed the Facial Action Coding System
- Measurement units called *Action Units* (AUs)
- AUs are contraction or relaxations of one or more muscles
  - 46 AUs account for changes in facial expression
  - 12 AUs describe changes in gaze direction and head orientation



FACS: leading standard for measuring facial expressions

FACS Action Units



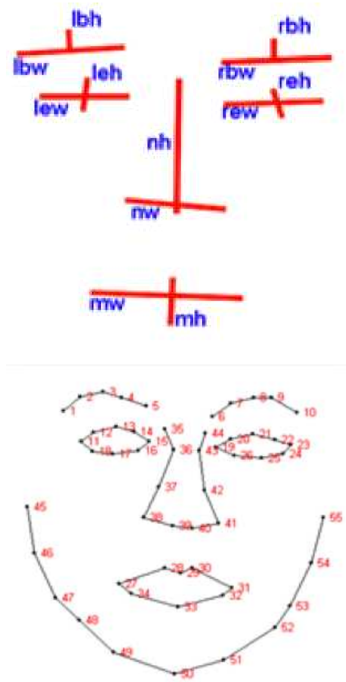


www.bk.isy.liu.se/candide

Expression Descriptive Units

EDU Measures	Measures definition
EDU1	$\frac{1}{2}(\frac{leh}{lew} + \frac{reh}{rew})$
EDU2	$\frac{lbh}{lbw}$
EDU3	$\frac{rbh}{rbw}$
EDU4	$\frac{mh}{mw}$
EDU5	$\frac{nh}{nw}$
EDU6	$\frac{lew}{mw}$
EDU7	$\frac{leh}{mh}$
EDU8	$\frac{leh+reh}{lbh+rbh}$
EDU9	$\frac{lew}{nw}$
EDU10	$\frac{nw}{mw}$
EDU11	$\frac{EDU2}{EDU4}$
EDU12	$\frac{EDU3}{EDU4}$
EDU13	$\frac{EDU2}{EDU10}$
EDU14	$\frac{EDU3}{EDU14}$

Proposed by Antonini, Sorci, Bierlaire and Thiran (2006)

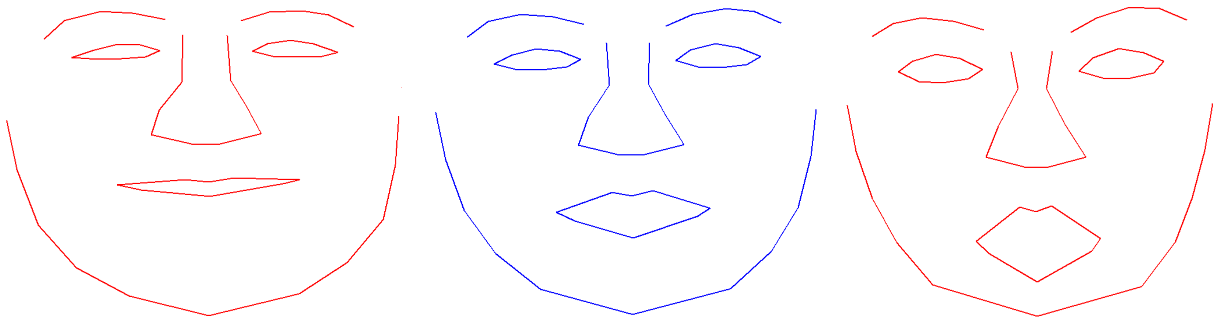


Active Appearance Model

Shape:

- $x = (x_1, y_1, \ldots, x_n, y_n)'$
- Apply PCA

$$x = \bar{x} + P_s b_s$$



Active Appearance Model

Texture:

$\Longrightarrow$ warp to mean shape $\Longrightarrow$

Texture is represented by a vector g

Active Appearance Model

Texture: Apply PCA

$$g = \bar{g} + P_g b_g$$

Finally, apply PCA on b_s and b_g

$$b = \begin{pmatrix} W b_s \\ b_g \end{pmatrix} = Qc = \begin{pmatrix} Q_s \\ Q_g \end{pmatrix} c$$

Varying c changes both shape and texture (demo using AAM lab...)

Static expressions

Discrete choice model:

Decision maker : a person evaluating an expression

Choice set : happiness, surprise, etc. (see surveys)

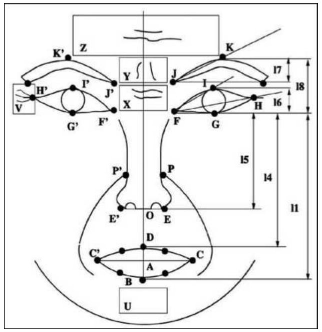
Attributes : FACS, EDU, AAM

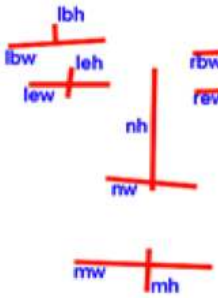
Characteristics : possibility to account for heterogeneity of perceptions and interpretations (not done here)

Model : up to now, logit model

The model

$$V_i = \text{ASC}_i \quad + \sum_k I_{ik}\beta_{ik}^{\text{FACS}}\text{AU}_k \quad + \sum_h I_{ih}\beta_{ih}^{\text{EDU}}\text{EDU}_h \quad + \sum_\ell I_{i\ell}\beta_{i\ell}^{\text{AAM}}\text{AAM}$$





Data: 39000 observations from 1718 respondents

Model	Nbr of parameters	LL
AU only	93	-57121
AU + EDU	120	-55027
AU + EDU + AAM	145	-54657

Some parameters

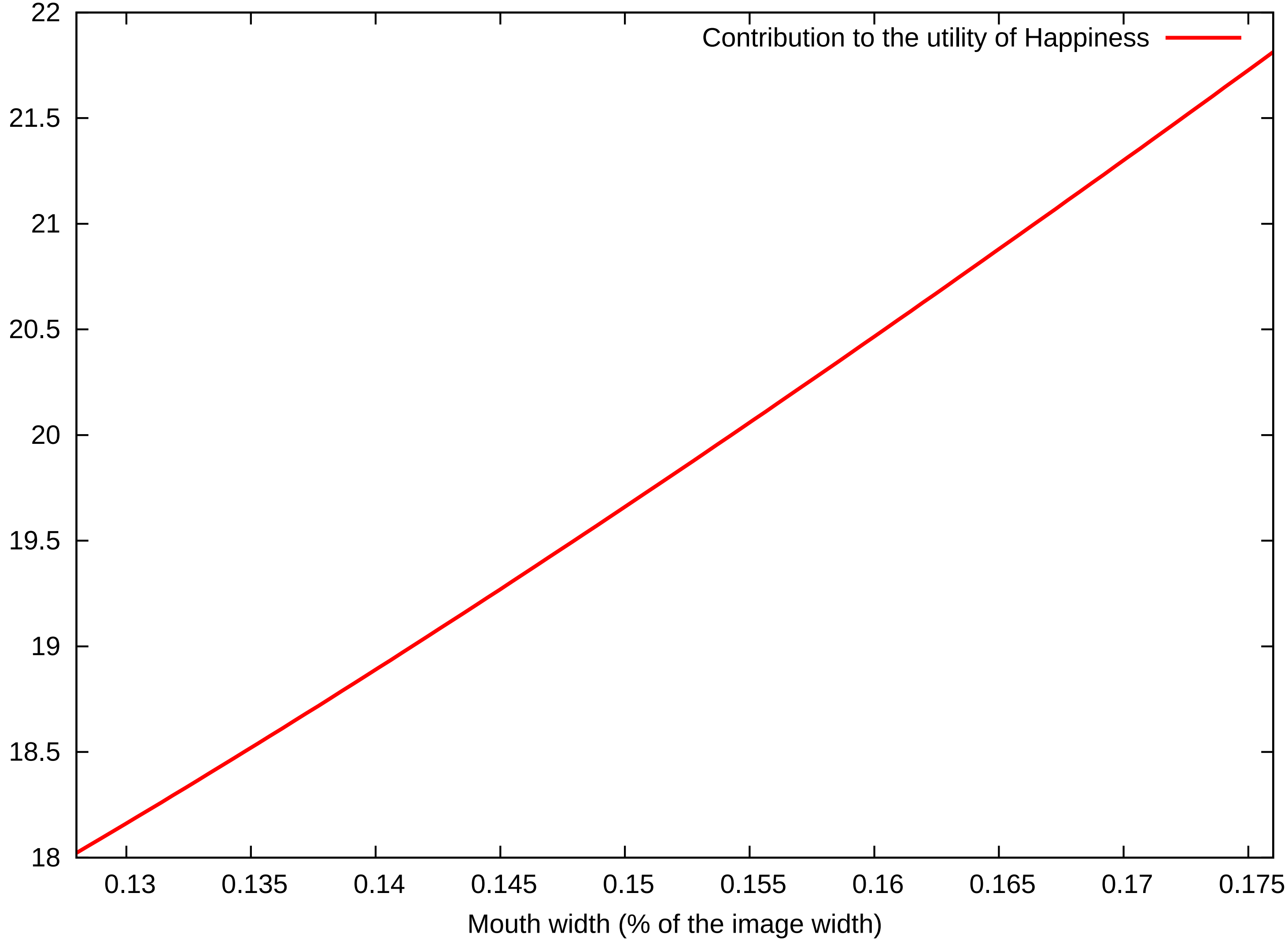
Effects of mouth width on utility of “happiness”

$$U_{\text{happiness}} = \cdots + \beta_1 \frac{\text{mouth height}}{\text{mouth width}} + \beta_2 \text{mouth width} + \cdots$$

	Estimate	t-test
β_1	8.38	8.25
β_2	105	37.64

The wider the mouth, the happier...

Some parameters



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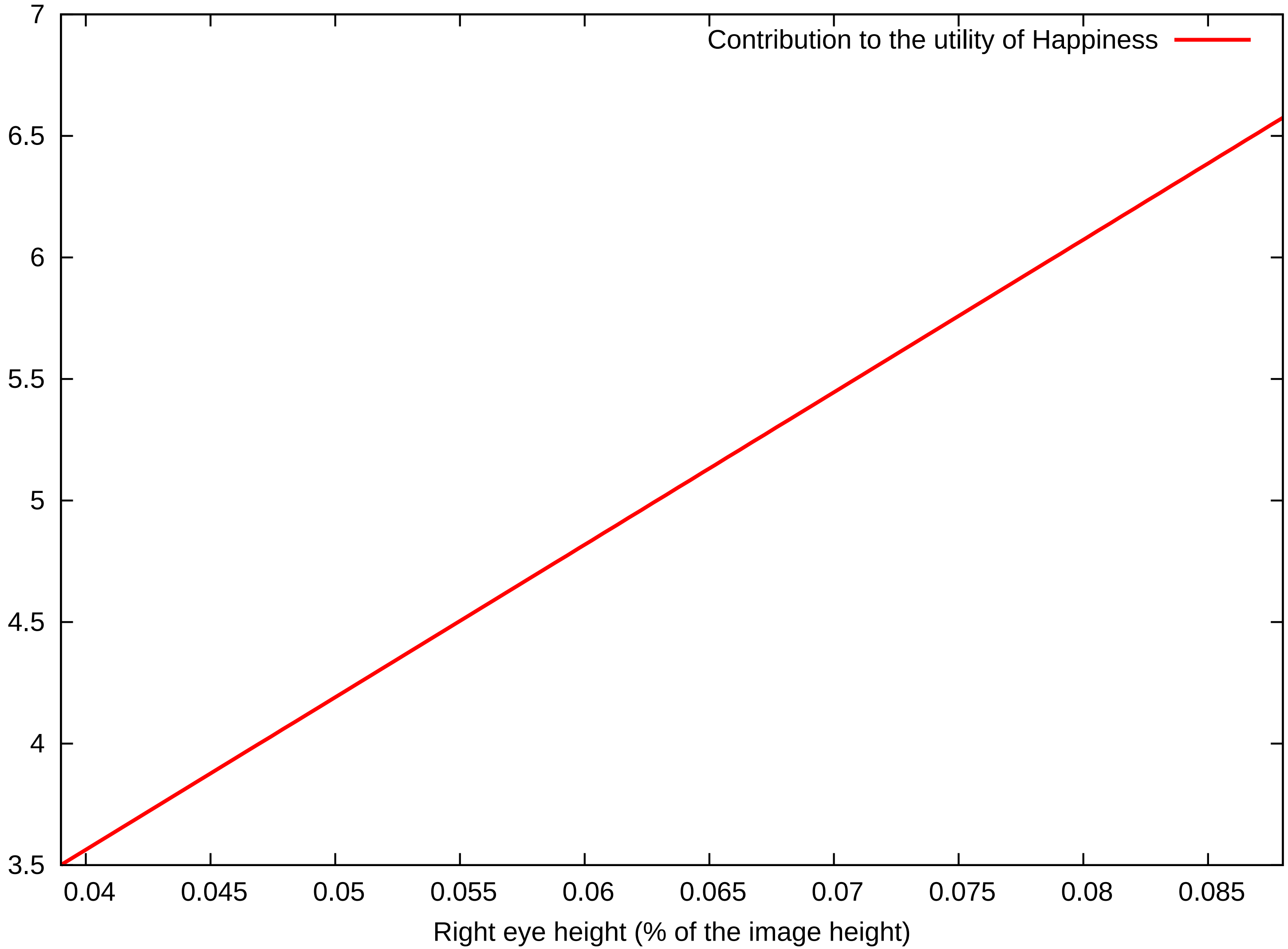
Some parameters

Effects of the height of the right eye on happiness

$$
\begin{aligned}
U_{\text{happiness}} = \; & \cdots + \\
& \beta_1 \frac{1}{2}\left(\frac{\text{left eye height}}{\text{left eye width}} + \frac{\text{right eye height}}{\text{right eye width}}\right) + \\
& \beta_2 \frac{\text{left eye height}+\text{right eye height}}{\text{left eyebrow height}+\text{right eyebrow height}} + \\
& \beta_3 \text{right eye height} + \cdots
\end{aligned}
$$

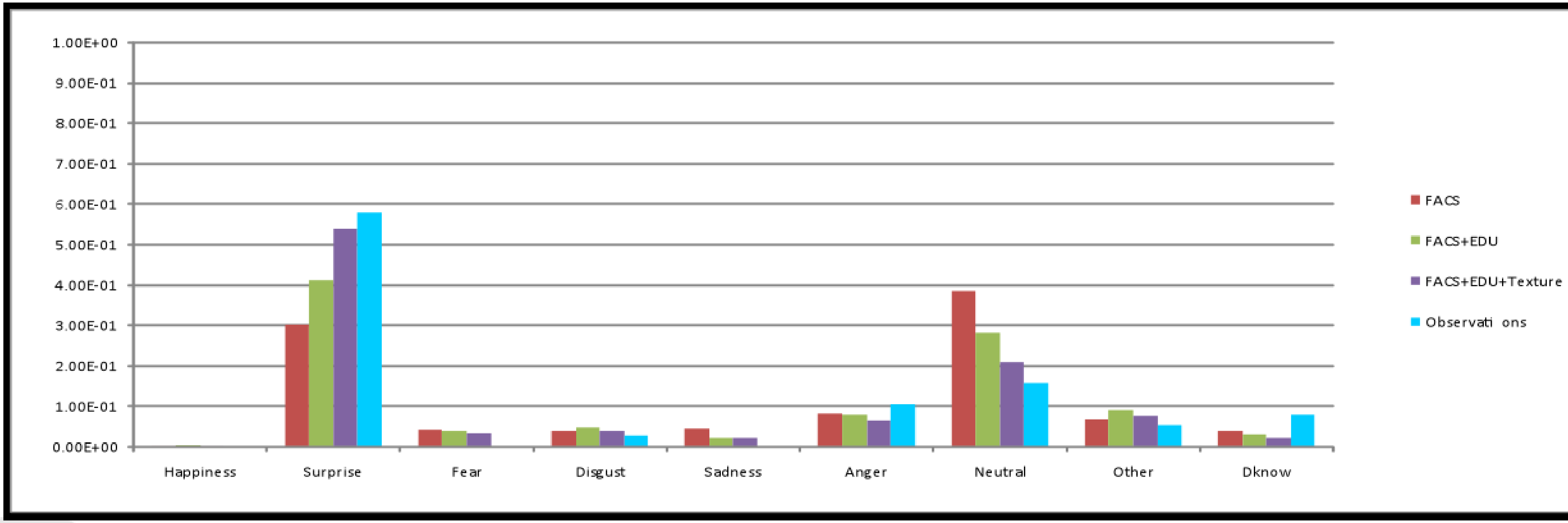
	Estimate	t-test
β_1	-4.61	-5.54
β_2	6.15	8.89
β_3	36	3.95

Some parameters

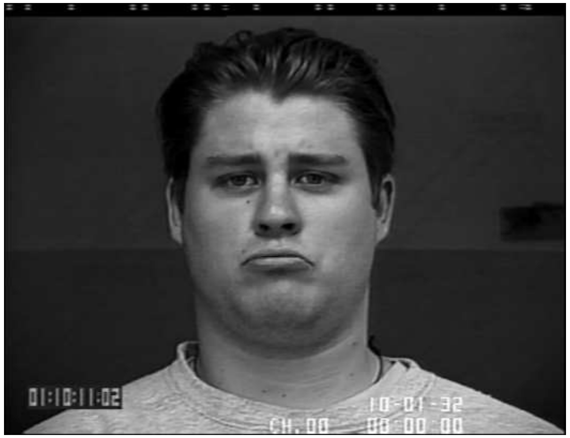


Simulation: good

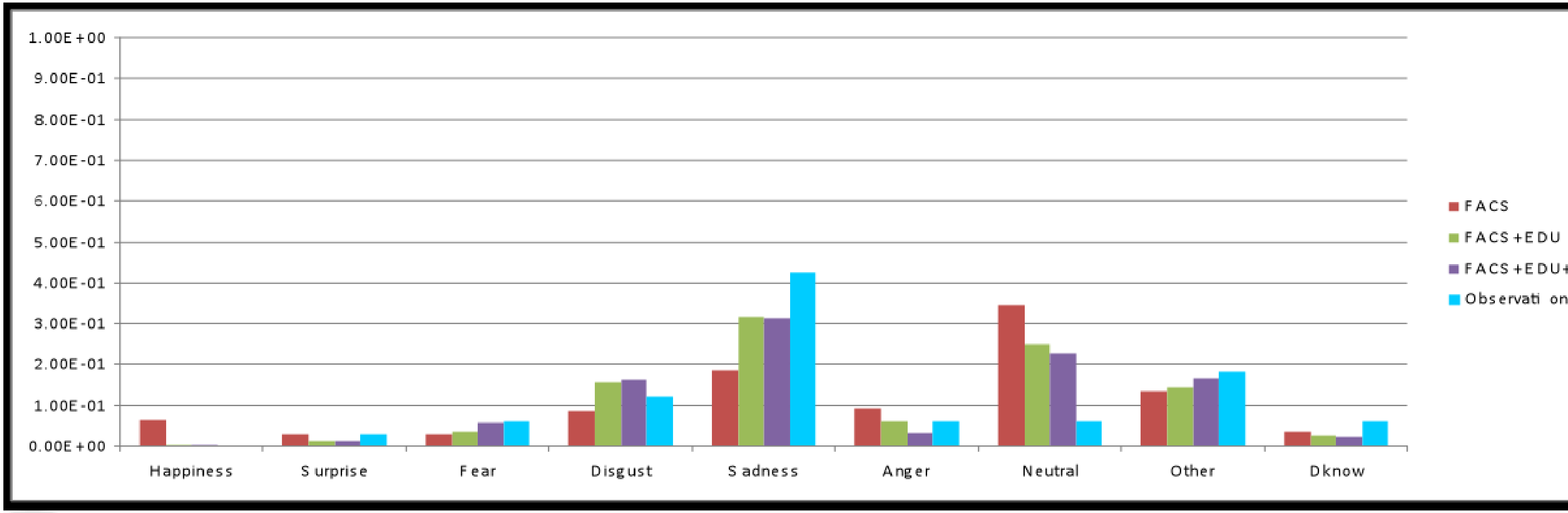
38 observations



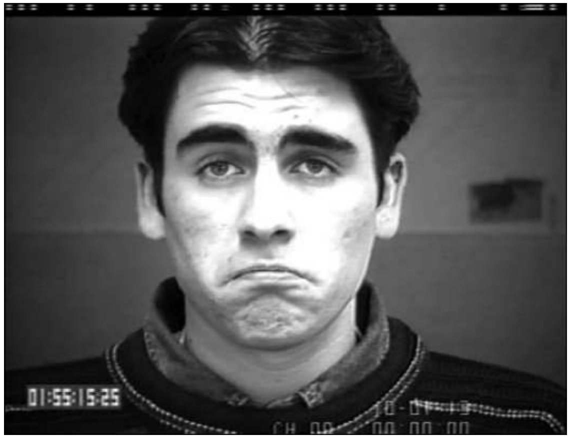
Simulation: not too bad



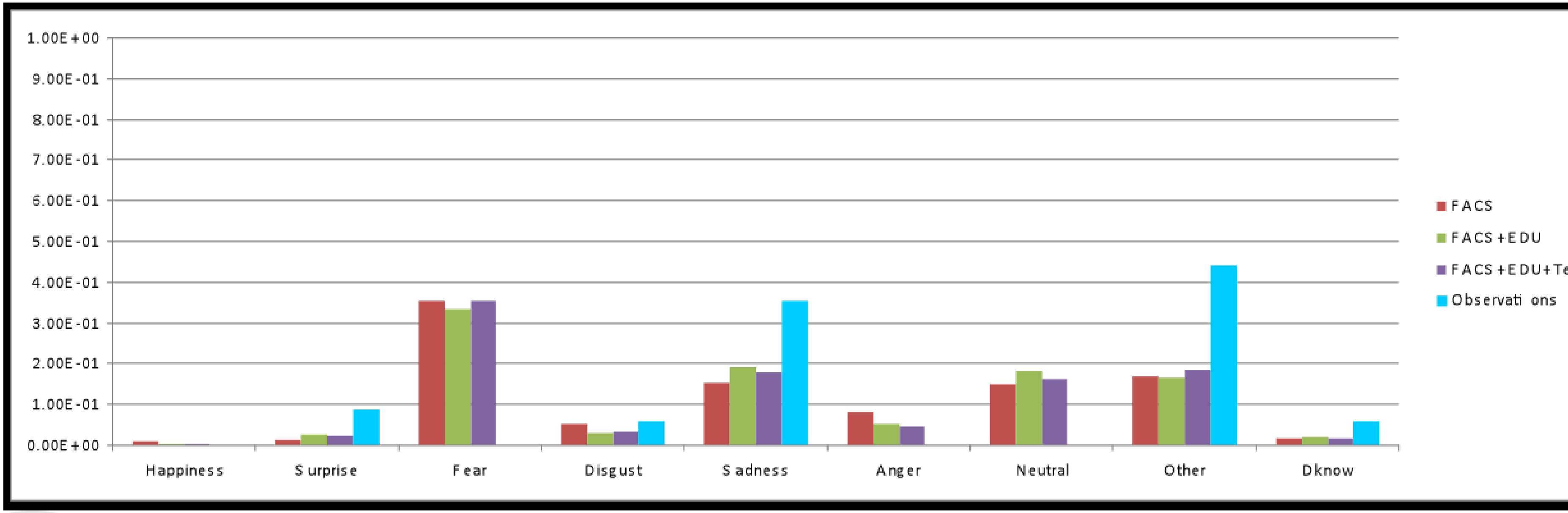
38 observations



Simulation: poor



38 observations



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Dynamic Expressions

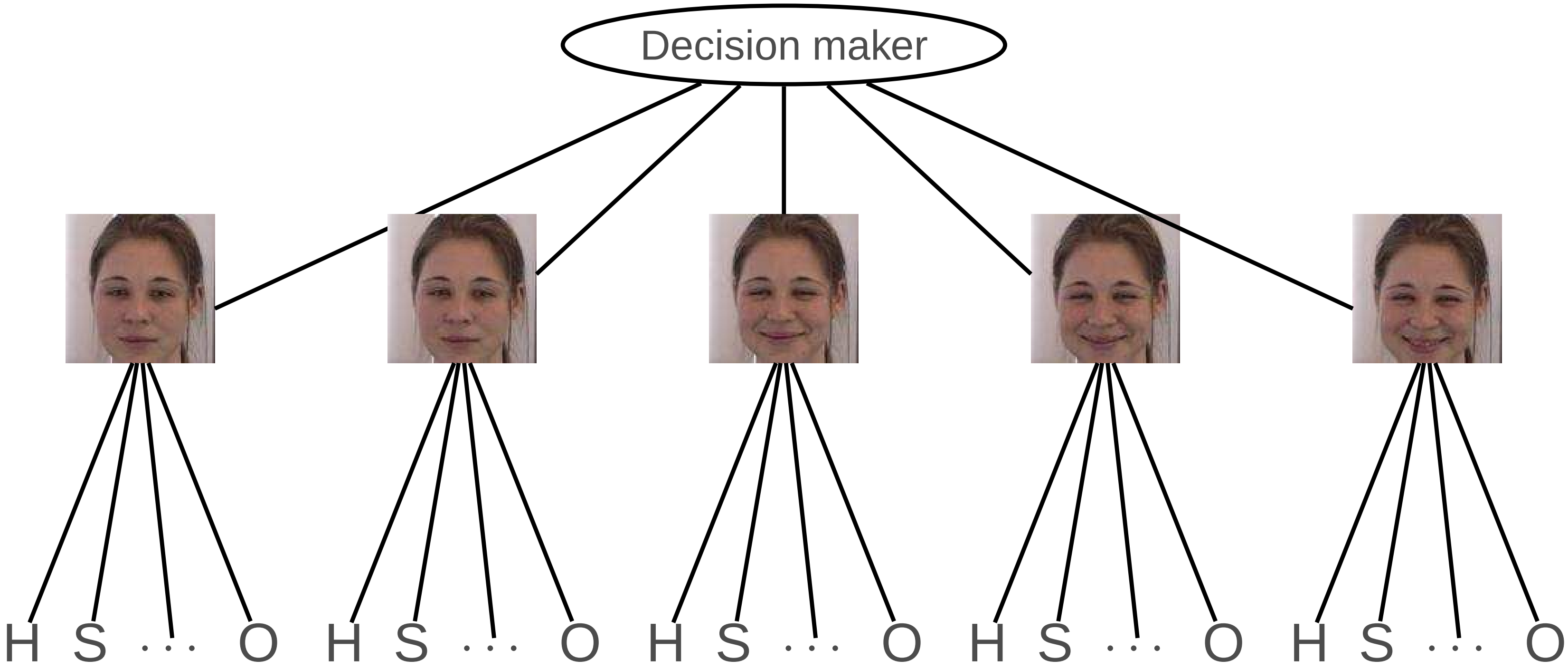
Video = sequence of images

Dynamic Expressions

Modeling assumptions :

- Time discretization (frames) : one second
- One frame will trigger the choice
- The choice of this frame is not observed
- For a given frame, we use the same model as for static expressions

Dynamic Expressions



Models and variables

- Video sequence o
- Decision maker n
- Prob. that frame t is selected: $P_n(t|o)$ (logit). Variables:
  - image attributes, e.g. size of the mouth
  - duration since beginning
- Prob. that expression i is selected in frame t: $P_n(i|t,o)$. Static model (logit)
- Prob. that expression i is selected

$$P_n(i|o) = \sum_t P_n(i|t,o) P_n(t|o)$$

Models and variables

- Panel effect: random parameter ξ_n

$$P_n(i_1, ..., i_{O_n}|\xi_n) = \prod_{o=1}^{O_n} P_n(i_o|o, \xi_n) = \prod_{o=1}^{O_n} \sum_t P_n(i_o|t, o) P_n(t|o, \xi_n)$$

- Integrate

$$P_n(i_1, ..., i_{O_n}) = \int_\xi \prod_{o=1}^{O_n} \sum_t P_n(i_o|t, o) P_n(t|o, \xi) f(\xi) d\xi$$

- Log likelihood

$$\mathcal{L} = \sum_{n=1}^{N} \log \int_\xi \prod_{o=1}^{O_n} \sum_t P_n(i_o|t, o) P_n(t|o, \xi) f(\xi) d\xi$$

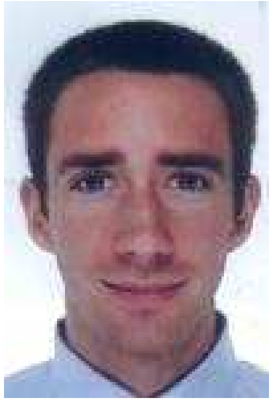
Dynamic expression

- Ongoing project
- Estimation procedure under development
- Model specification must be investigated further

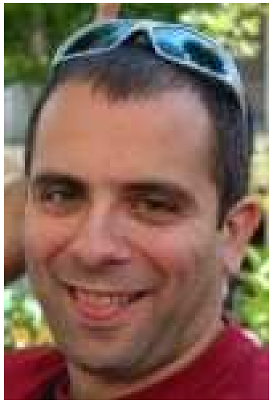
Summary

- Main idea: consider the identification of an expression as a choice
- Explanatory variables: features of the face
- Static case:
    - combine three types of variables
    - obtain meaningful model with significant parameters
- Dynamic case:
    - extend the static model
    - assume that one frame is representative

The faces of the team

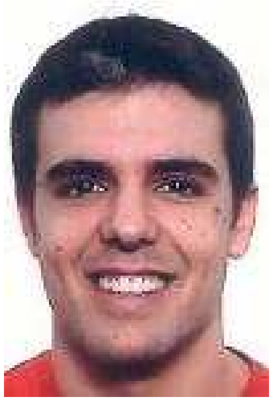


Thomas Robin



Matteo Sorci

Jean-Philippe Thiran



Javier Cruz

Gianluca Antonini

Michel Bierlaire

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Exploiting mobility data from Nokia smartphones

Michel Bierlaire, Jeffrey Newman
Transport and Mobility Laboratory
Ecole Polytechnique Fédérale de Lausanne

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Nokia @ EPFL

- Nokia Research Centers research.nokia.com/locations
  - Bangalore, India
  - Beijing, China
  - Cambridge, UK
  - Cambridge, Ma
  - Helsinki, Finland
  - Hollywood, Ca
  - Lausanne, Switzerland (since June 2008)
  - Nairobi, Kenya
  - Palo Alto, Ca
  - Tampere, Finland

Research project

- Objective:
  - Investigate the potential of Nokia smartphones for mobility data collection
- Project Manager: Jeffrey Newman
- Research assistant: Jingmin Chen
- Steps:
  - Design and prepare the data collection campaign
  - Organize the data collection
  - Estimate behavioral models

Proposed data collection campaign

- Approximately 100 participants
- They receive a Nokia N95 phone, with data collection software preloaded
- They fill travel & activity surveys

Proposed data collection campaign

- They utilize their own personal SIM card, and are reimbursed for data-transmission charges incurred
- Data collected, and survey contents, will be coordinated between TRANSP-OR and other EPFL labs, to suit a range of current and future research needs

Nokia N95 Phone Features

- GSM (regular wireless phone network) info
- GPS tracking, network-based Assisted GPS available
- Accelerometer
- 802.11b/g WiFi
- Bluetooth
- Camera
- Calendar
- Phone / Instant Message logs

Ethical issue

- The project is currently submitted to an ethic committee
- Highly personal information is being collected
- Participants must be aware of:
  - What data is actually collected
  - What we are doing with the data
- They have the right to
  - Access the data about them
  - Drop from the survey and have the data erased

Potential data uses

- GPS and accelerometer: current position, speed and acceleration → mode and route
- When GPS signal is unavailable, position can be guessed with GSM, WiFi, historical data
- Phone book, phone log: social network
- Calendar: activities
- Audio and video samples: contextual measurements

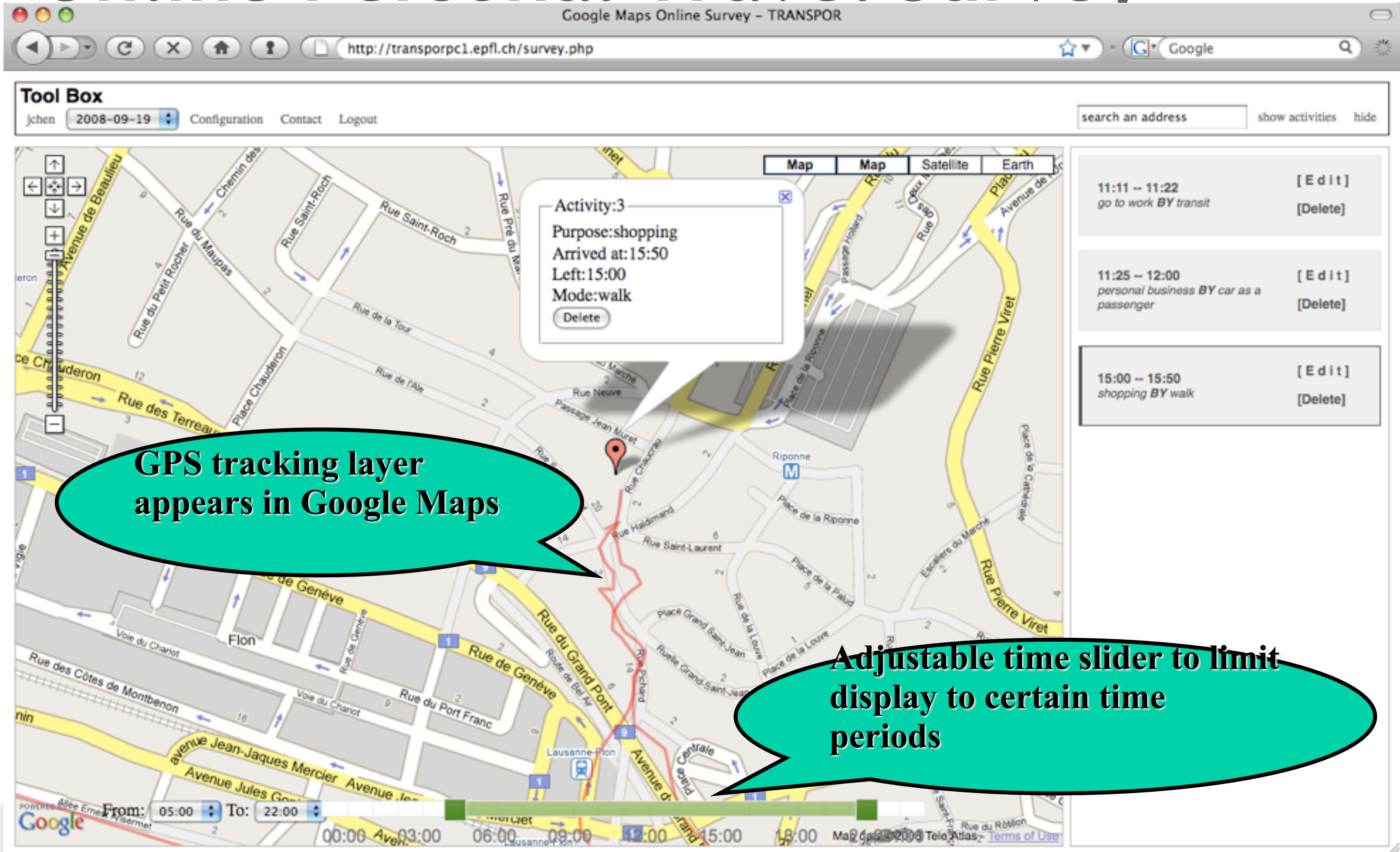
Potential data uses

- Phone interface design and usage
- Signal processing
- Indoor positioning
- Etc.

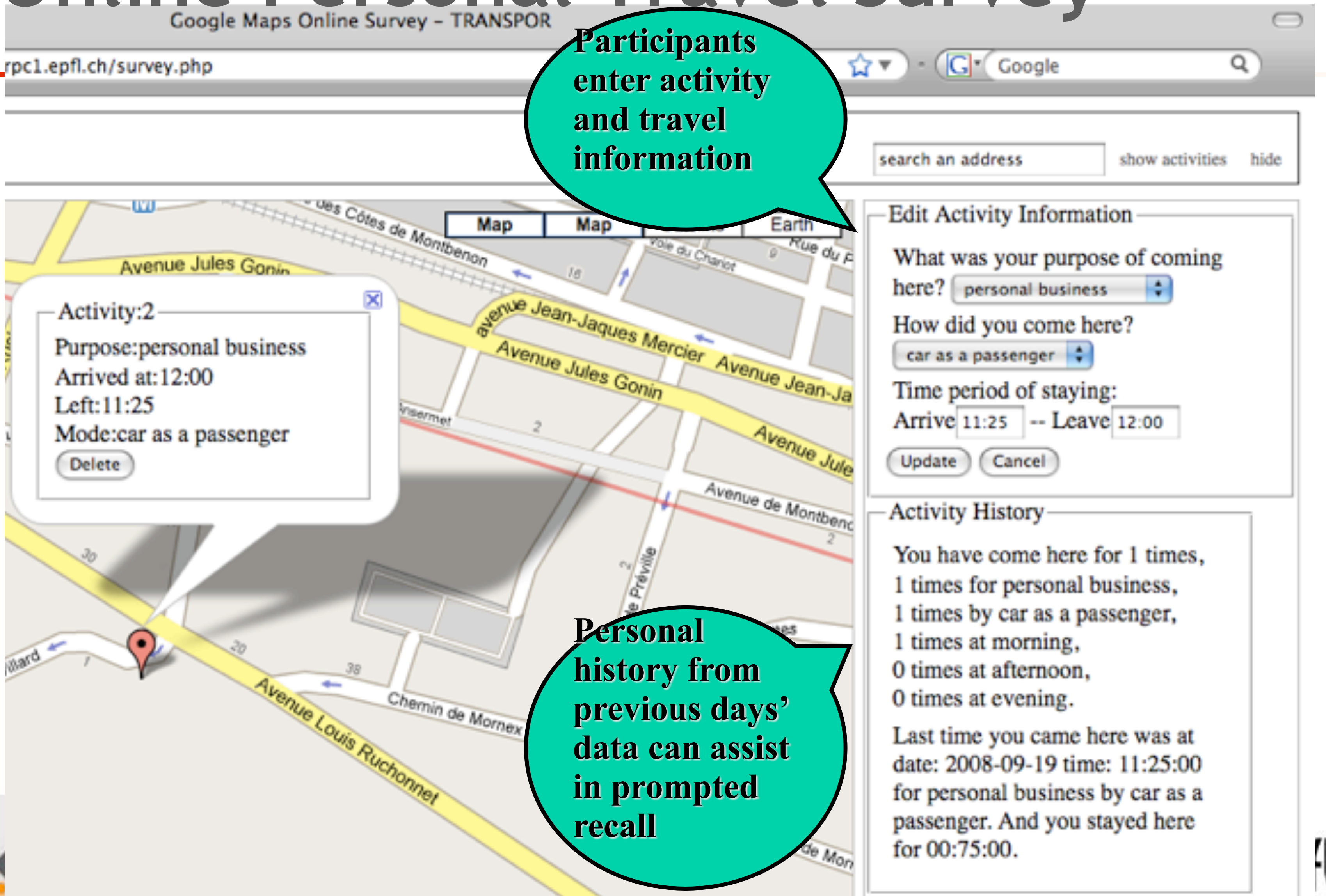
Progress to date

- A small number (6) of phones have been received by the TRANSP-OR lab for evaluation
- An online travel review and survey tool is in development
  - Designed to be (hopefully) intuitive, simple, and fast for participants
- Custom phone software for data collection is in development

Online Personal Travel Survey



Online Personal Travel Survey



Battery Problems

- Standard Nokia phone batteries:
  - BL-5F (N95) provides 950 mAh
  - BL-6F (N95 8GB) provides 1200 mAh
- Autonomy: 6 hours
  - with GPS tracking enabled continuously
  - Obviously unacceptably short
- But:
  - the phone has other position-identifying tools (GSM, Wifi, etc.)
  - Not necessary to collect GPS info continuously

GPS Switching

- Software development:
  - algorithm for switching the GPS receiver on and off at appropriate times
- Objectives:
  - minimize the loss of relevant positional data (when the subject is moving)
  - only drop unnecessary data (when the subject is stationary)

GPS Switching

- Issue:
  - The GPS unit when switched on will take some time to acquire a fix (a few seconds to a few minutes).
- Possible solution:
  - The use of the Nokia Assisted-GPS feature reduces this time
  - but it requires an active internet connection (GPRS or 3G), with concomitant battery usage

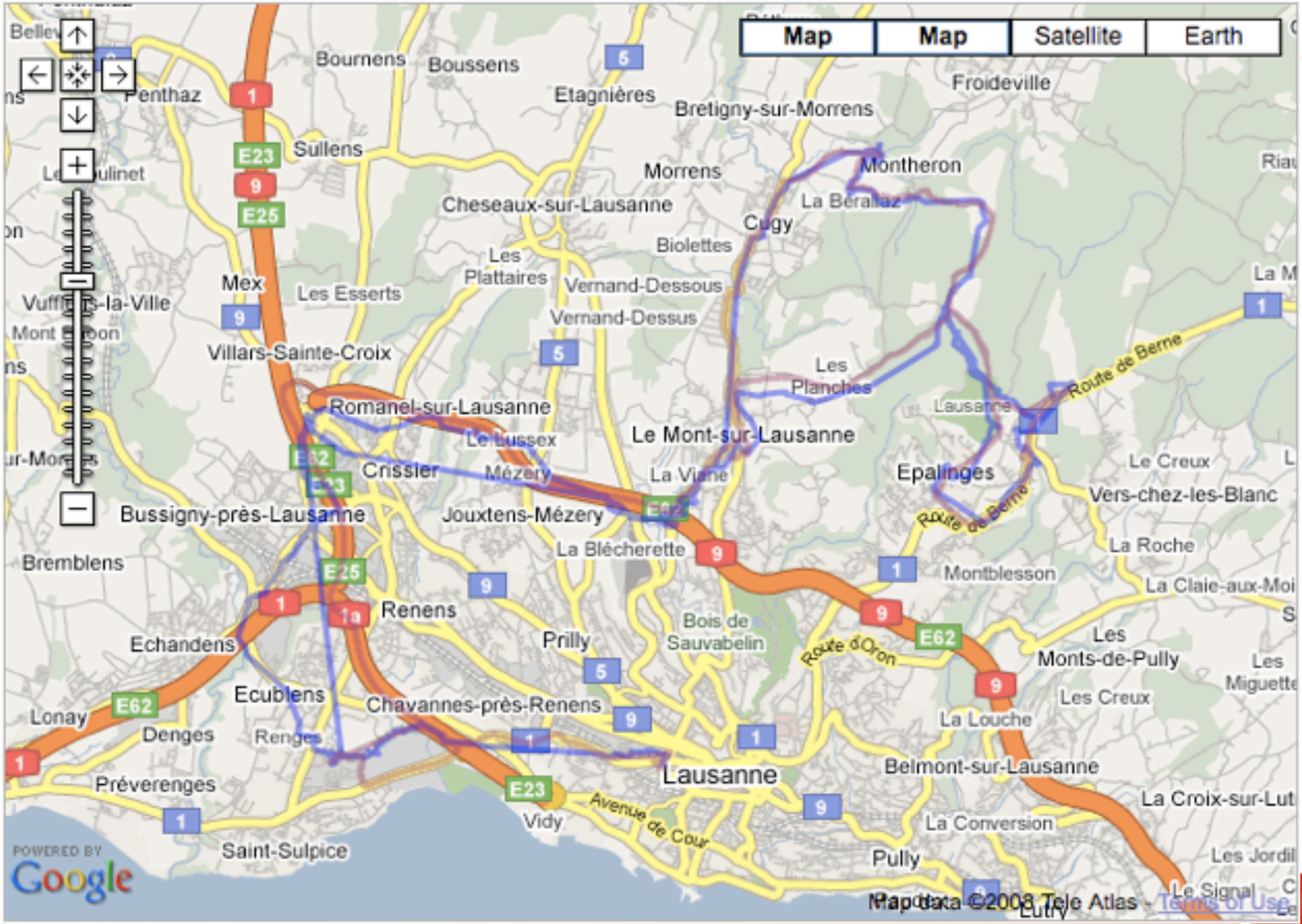
GPS Switching

- Experiment:
  - We are collecting GPS data simultaneously from the Nokia phone and a second, dedicated GPS receiver
- This will allow comparison of switched and continuous tracks, to evaluate different switching algorithms

GPS Switching

- As a side effect, we discovered that the GPS accuracy for Nokia phones is pretty low...

Phone GPS Accuracy is Low



Purple line recorded by dedicated GPS
Blue line recorded by phone

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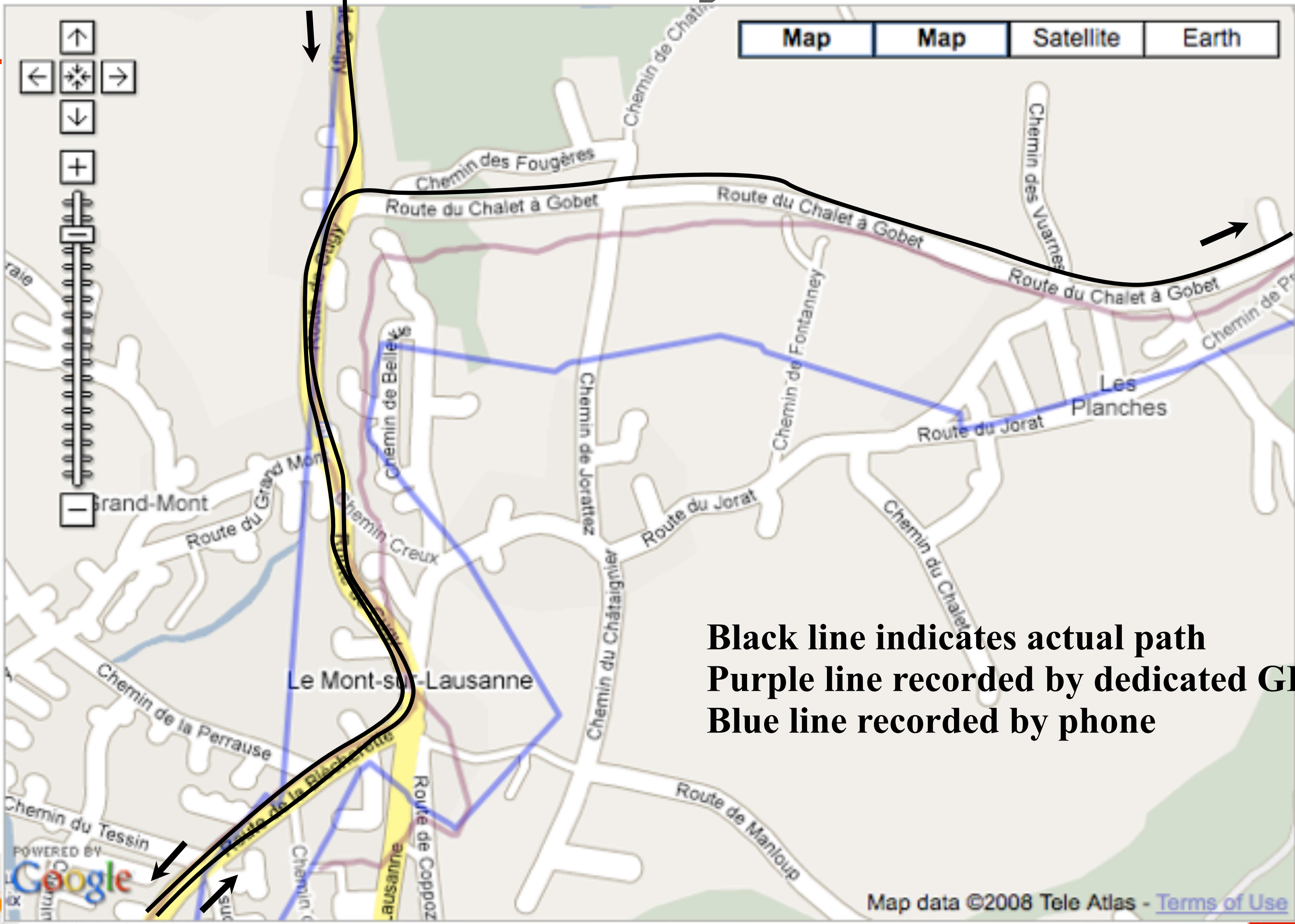
Phone GPS Accuracy is Low



Black line indicates actual path
Purple line recorded by dedicated GPS
Blue line recorded by phone

GPS Accuracy

- Low accuracy
  - not great for users
  - but provides opportunity for mathematical research: how can we account for the poor quality of GPS service?
- Traditional map matching of low quality GPS tracks could introduce large biases, creating inaccurate routes for trips
- Proposed solution: use of measurement equations

Future Plans

- Integration of phone software and web survey system
  - the phone automatically uploads each day's data over wireless connection
- Spring 2009: pilot data collection campaign
  - about30 participants
  - test the system for functionality and bugs
- Summer 2009 (?):
  - Rolling out to 100 (or more) participants for a full scale data collection effort