Modelling Human Perception of Facial Expressions by Discrete Choice Models

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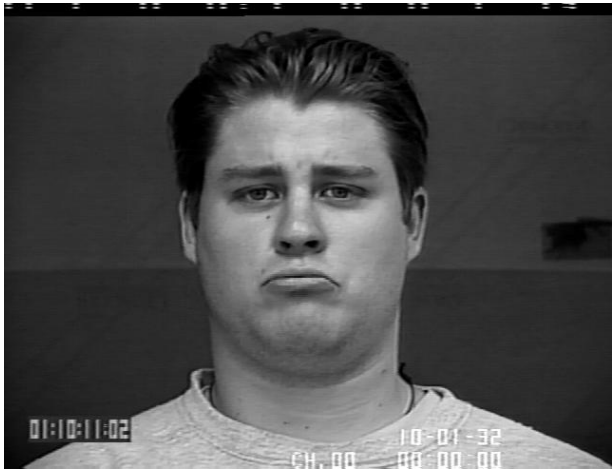
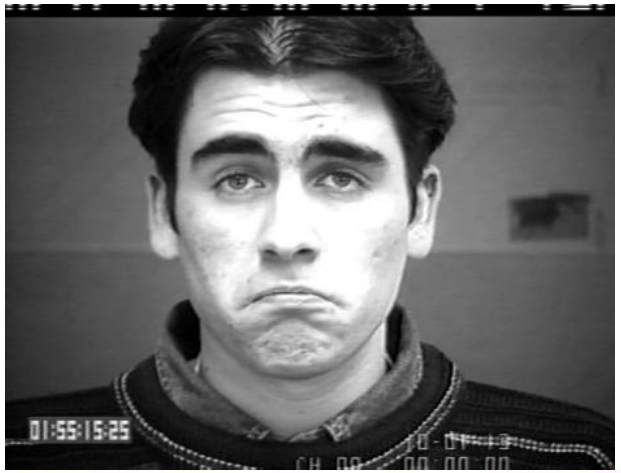
Outline

- Introduction
- Objectives
- Data
- Features extraction: Active appearance model (AAM)
- Behavioural modelling : Discrete choice model (DCM)
- Application
- Conclusions and future works

Introduction





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Introduction

Expert

Face's picture

Face expression decision

Applications:

- Driver's attention state;
- Smart meeting rooms;
- Human-Machine interfaces.

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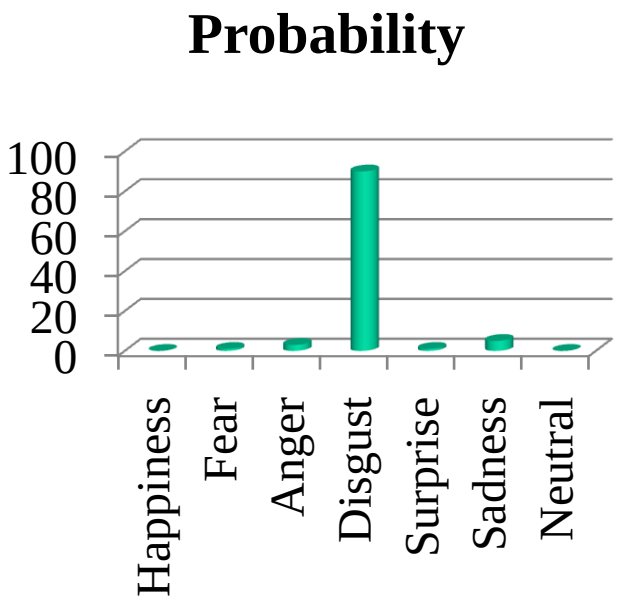
Objectives

Model the way an expert identifies the face expression on a picture.

Input

Output



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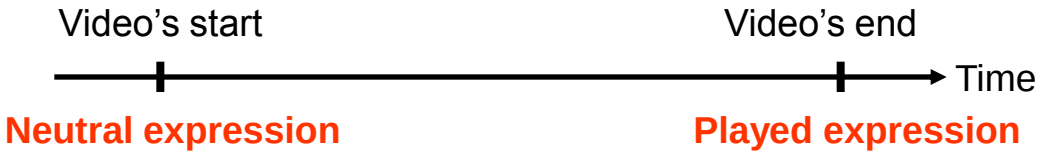
Data : Pictures

The Cohn-Kanade data base

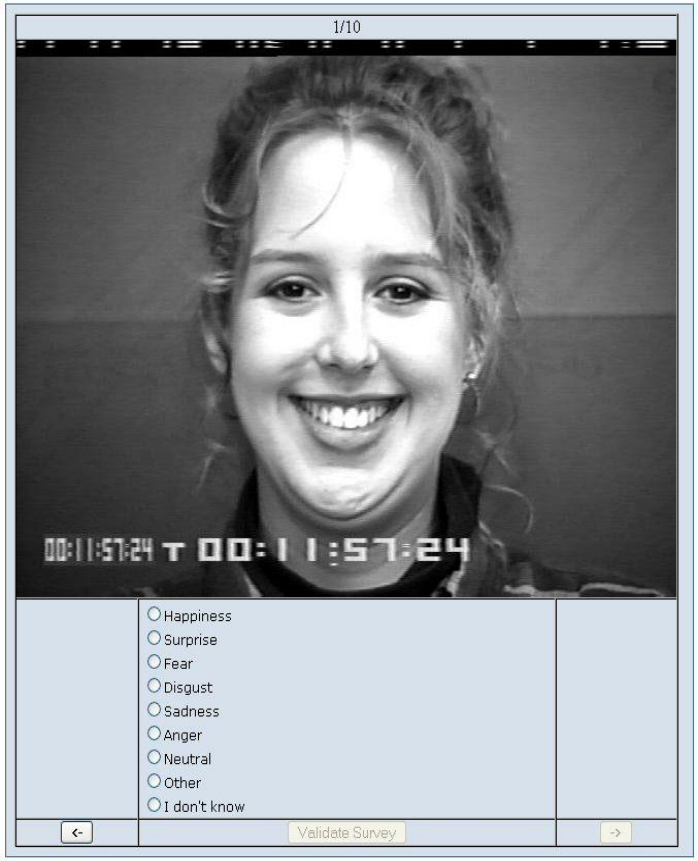
- Video sequences of actors face: actors play expressions starting from the neutral one



Pictures = frames of the videos

- 1272 pictures from 11 subjects

Data : Internet Survey



- People have to label randomly chosen pictures

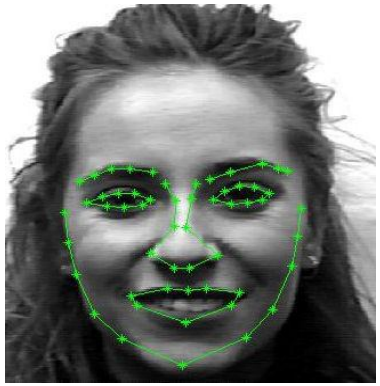
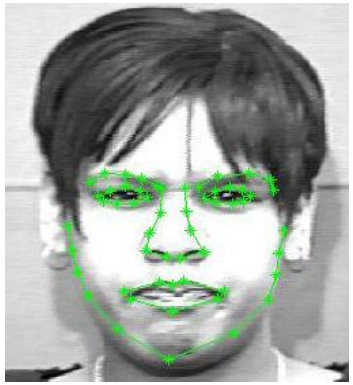
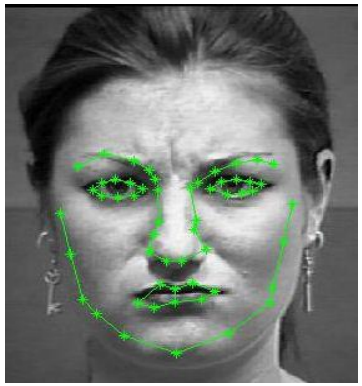
- People report their socio-economics characteristics (age, formation, job…)

- 1718 participants for more than 39000 labeled images

http://lts5www.epfl.ch/face

Active Appearance Models

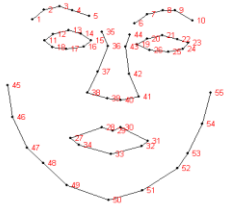
- State of the art of image analysis algorithm
- Provide numerical features of each image

Cootes, Edwards and Taylor "*Active Appearance Models*" *PAMI, 23, 681-685, June 2001*

Active Appearance Model (AAM)

AAM



Shape, $\mathbf{x} = (x_1, y_1, \ldots, x_n, y_n)^T$

Texture, **g**

Attributes

FACS

EDU

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

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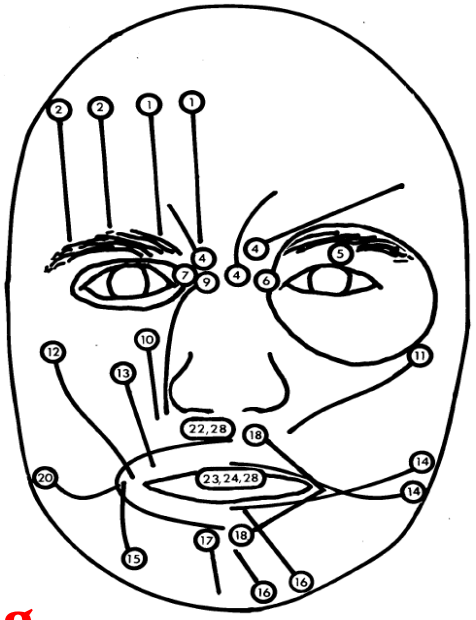
AAM Output: FACS

- In 1978 Ekman and Friesen developed the **Facial Action Coding System**
- Mesurement units: “Action Units” (Aus)
  - AUs are contractions 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

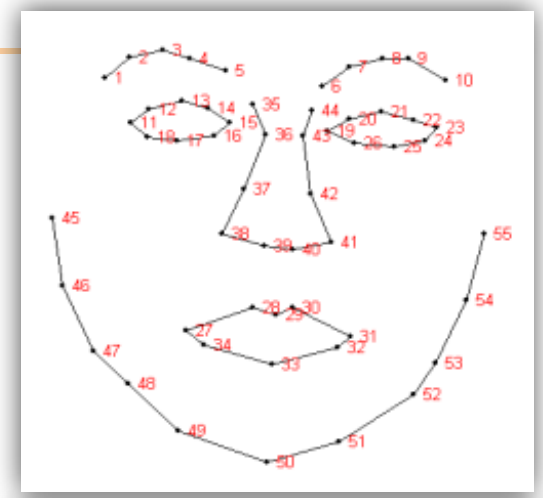


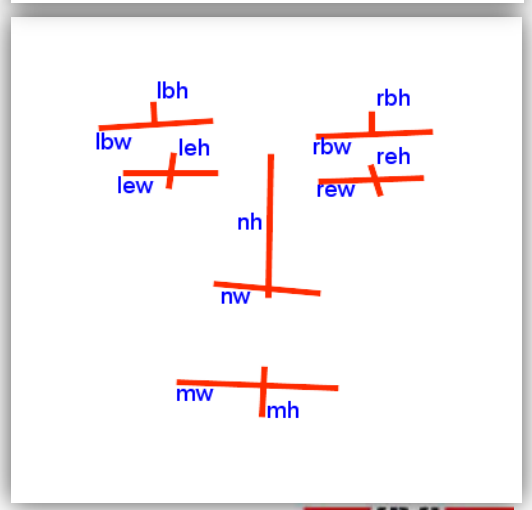
The FACS has become the leading standard for measuring facial expressions

AAM Output: EDU

- **Expression Descriptive Units** by Antonini, Sorci, Bierlaire and Thiran in « Discrete Choice Models for Static Facial Expression Recognition »

EDU1	$\frac{lew+rew}{leh+reh}$	**EDU8**	$\frac{leh+reh}{lbh+rbh}$
EDU2	$\frac{lbw}{lbh}$	**EDU9**	$\frac{lew}{nw}$
EDU3	$\frac{rbw}{rbh}$	**EDU10**	$\frac{nw}{mw}$
EDU4	$\frac{mw}{mh}$	**EDU11**	EDU2 / EDU4
EDU5	$\frac{nh}{nw}$	**EDU12**	EDU3 / EDU4
EDU6	$\frac{lew}{mw}$	**EDU13**	EDU2 / EDU10
EDU7	$\frac{leh}{mh}$	**EDU14**	EDU3 / EDU10





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AAM Output: Texture

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

Behavioural Modelling

Discrete Choice Model (DCM)

- Econometrics models with discrete response
- Capture the behaviour of individuals in choice situations, when the set of available alternatives is finite and discrete (choice set)
- Random utility models

Appropriate to model the image labeling process

Behavioural Modelling: DCM

- Multinomial Logit model
- 9 Alternatives (choice set):

1. Happiness
2. Surprise
3. Fear
4. Disgust
5. Sadness
6. Anger
7. Neutral
8. Other
9. I don’t know

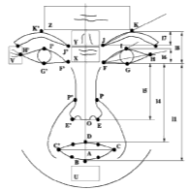
- Expression of the probability for the individual n to choose the expression j :

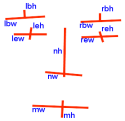
$$P_{nj} = \frac{e^{V_{ni}}}{\sum_j e^{V_{nj}}}$$

Behavioural Modelling: DCM

- Expression of the utility perceived by the individual n for the expression j :

$$V_j = ASC_j + \sum_{k=1}^{K_1} I_{kj}\beta_{kj}^{FACS} AU_k + \sum_{h=1}^{K_2} I_{hj}\beta_{hj}^{EDU} EDU_h + \sum_{l=1}^{K_3} I_{lj}\beta_{lj}^{Texture} Texture_l$$





model 1

model 2

model 3

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Behavioural Modelling: model estimation

- Estimation by maximum of Likelihood (in practice use of the loglikelihood)

$$L = \sum_{n=1}^{N} \left(\sum_{j=1}^{9} y_n log(P_{nj}) \right)$$

- Estimation made using the free Biogeme package (biogeme.epfl.ch)

- Model 1: “FACS” (Primary AU + Secondary AU + Transient Features)
  - 93 parameters , **LL = - 57121**
- Model 2: “FACS + EDU”
  - 120 parameters , **LL = - 55027**
- Model 3: “FACS + EDU + TEXTURE COEFFICIENTS”
  - 145 parameters , **LL = - 54657**

Behavioural Modelling: model parameters

ASC

Texture

Name	Value
ASC_A	-2.81
ASC_D	0.307
ASC_DK	-2.29
ASC_F	-1.91
ASC_H	23.5
ASC_N	0
ASC_O	-4.94
ASC_SA	-15.7
ASC_SU	1.12
BETA_T1_O	-10.4
BETA_T1_SA	5.63
BETA_T2_A	14.3
BETA_T2_D	9.34
BETA_T2_F	15.5
BETA_T2_H	22.8
BETA_T2_O	-5.66
BETA_T2_SA	12.5
BETA_T2_SU	15.2
BETA_T3_A	42.2
BETA_T3_H	38.4
BETA_T3_O	-8.5
BETA_T3_SU	7.77
BETA_T4_A	-24.6
BETA_T4_D	32.3
BETA_T4_F	55.3
BETA_T4_H	32.6
BETA_T4_O	22.9
BETA_T4_SA	26.7
BETA_T4_SU	27
BETA_T5_A	-13.3
BETA_T5_D	-15.2
BETA_T5_F	-29.6
BETA_T5_H	-67.3

EDU

b_EDU_10_O	15.5
b_EDU_10_SA	15.5
b_EDU_10_SU	-3.63
b_EDU_5_D_F	-1.94
b_EDU_5_H	2.69
b_EDU_5_SA	-1.3
b_EDU_6_D	-20
b_EDU_6_H	-16.3
b_EDU_6_O	-25.9
b_EDU_6_SA	-26.1
b_EDU_7_A_F	2.42
b_EDU_7_D	1.51
b_EDU_7_H	2.82
b_EDU_7_O	2.18
b_EDU_7_SA	2.23
b_EDU_8_A_F	-1.95
b_EDU_8_D	-4.02
b_EDU_8_H	-6.72
b_EDU_8_O	0.76
b_EDU_8_SA	8.5
b_EDU_8_SU	-5.76
b_EDU_9_D	12.5
b_EDU_9_F	-2.46
b_EDU_9_H	-5.22
b_EDU_9_O	11.8
b_EDU_9_SA	15.3
b_RAP_brow_A_SU	-5.34
b_RAP_brow_D	-9.29
b_RAP_brow_F	-11.1
b_RAP_brow_SA	13
b_RAP_eye_A	-3.84
b_RAP_eye_F	9.81
b_RAP_eye_H	-18.6

FACS

b_RAP_eye_O	-8.79
b_RAP_eye_SA	-15
b_RAP_eye_SU	2.16
b_RAP_mouth_A	-11.2
b_RAP_mouth_F	9.16
b_RAP_mouth_H	7.4
b_RAP_mouth_O	4.23
b_RAP_mouth_SA	-5.16
b_RAP_mouth_SU	8.19
b_brow_dist_A	-19.9
b_brow_dist_F	-15.7
b_brow_dist_SA	-50.7
b_broweye_l2_A	-16.9
b_broweye_l2_O	36.6
b_broweye_l2_SA	-16.1
b_broweye_l2_SU	35.1
b_broweye_l3_A	-21.5
b_broweye_r2_A	-90.9
b_broweye_r2_D	-52.6
b_broweye_r2_SA	-98.7
b_browwr_D	11.6
b_browwr_O	4.38
b_eye_angle_below_r_F	2.3
b_eye_angle_l_A	1.32
b_eye_angle_l_F	4.85
b_eye_angle_l_SA	2.09
b_eye_angle_r_A	1.74
b_eye_angle_r_F	-3.25
b_eye_angle_r_SA	-1.46
b_eye_brow_angle_l_F	3.77
b_eye_brow_angle_l_O	-4.18
b_eye_brow_angle_r_F	-2.02
b_eye_brow_angle_r_O	-0.728
b_eye_brow_angle_r_SA	8.65
b_eye_brow_angle_r_SU	-2.92
b_eye_mouth_dist_l2_D	-16.3
b_eye_mouth_dist_l_F	55.9
b_eye_mouth_dist_l_H	-57.7
b_eye_mouth_dist_l_SA	24.5
b_eye_mouth_dist_r2_D	34.8
b_eye_mouth_dist_r2_O	-4.88
b_eye_mouth_dist_r_F	-38.8
b_eye_mouth_dist_r_H	-66.7
b_eye_mouth_dist_r_SA	27.5
b_eye_nose_dist_l_A	83.1
b_eye_nose_dist_l_D	89.2
b_eye_nose_dist_l_F	39.2
b_eye_nose_dist_l_O	77.4
b_eye_nose_dist_l_SA	93.8
b_eye_nose_dist_r_A	-44.5
b_eye_nose_dist_r_D	-129
b_eye_nose_dist_r_F	-63.7
b_eye_nose_dist_r_O	-74.5
b_eye_nose_dist_r_SA	-106
b_fore_F	0.683
b_fore_O	0.126
b_fore_SU	0.525
b_leye_h_F	-123
b_leye_h_H	130
b_leye_h_SU	-30.5
b_mouth_h_A	96.2
b_mouth_h_D	23.9
b_mouth_h_SA	59.3
b_mouth_nose_dist2_A	5.13
b_mouth_nose_dist2_SA	-20.2
b_mouth_nose_dist_D	-14
b_mouth_nose_dist_H	50.1
b_mouth_w_F	23.5
b_mouth_w_H	36.8
b_mouth_w_SA	-40
b_naslab_D	0.565
b_naswr_D	16.6
b_naswr_O	5.62
b_reye_h_H	183
b_reye_h_SU	45

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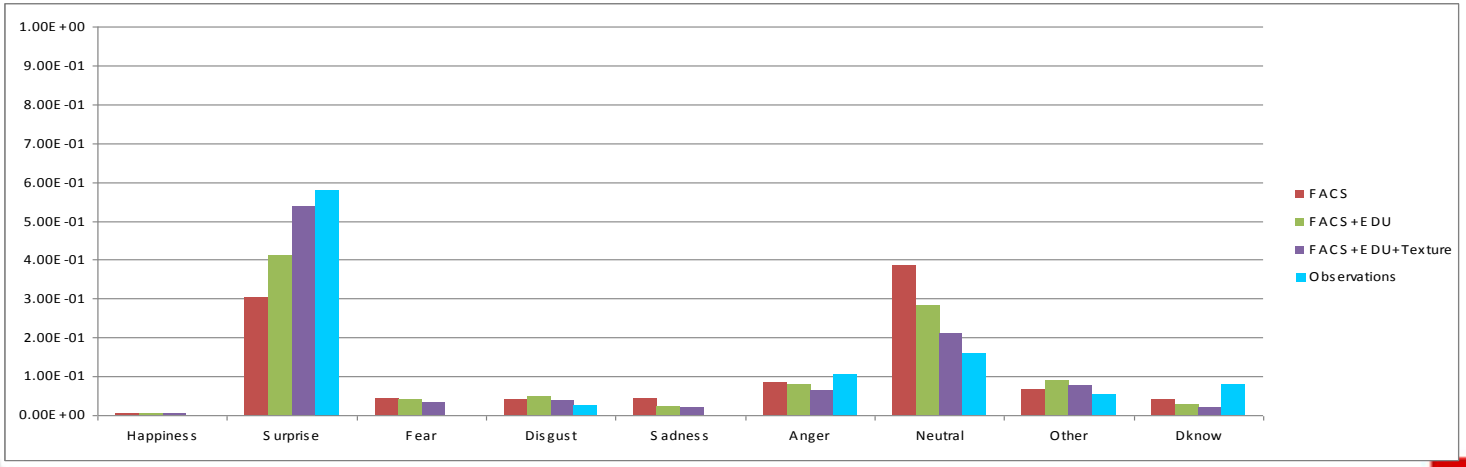
Behavioural Modelling: model parameters

- Parameters of the SURPRISE's utility
  - Beta_mouth_opening_SU = + **8.19**
  - Beta_eye_opening_SU = + **2.16**

mouth_opening ↗
eye_opening ↗
→ $V_{Surprise}$ ↗ → $P_{Surprise}$ ↗

Application

38 observations



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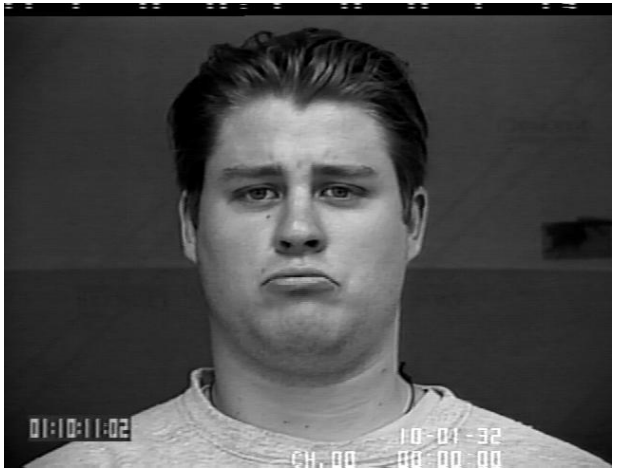
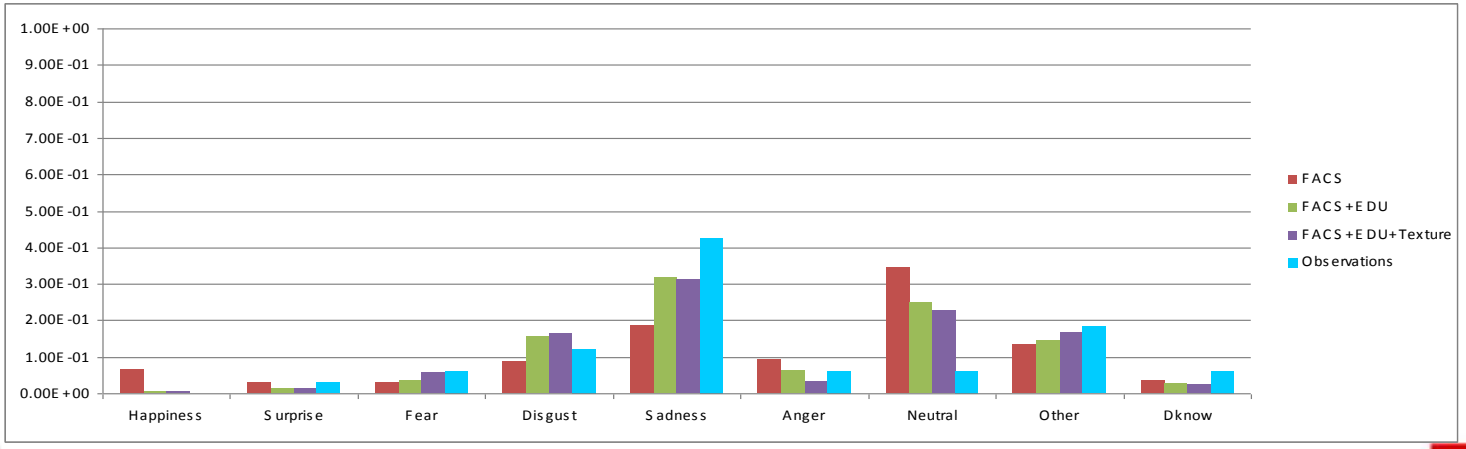
Application

33 observations





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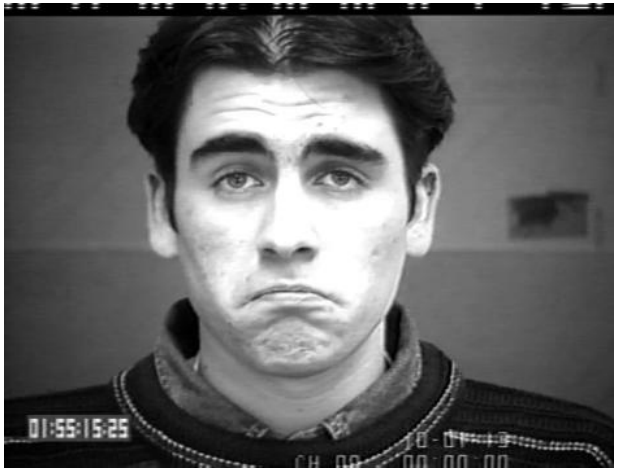
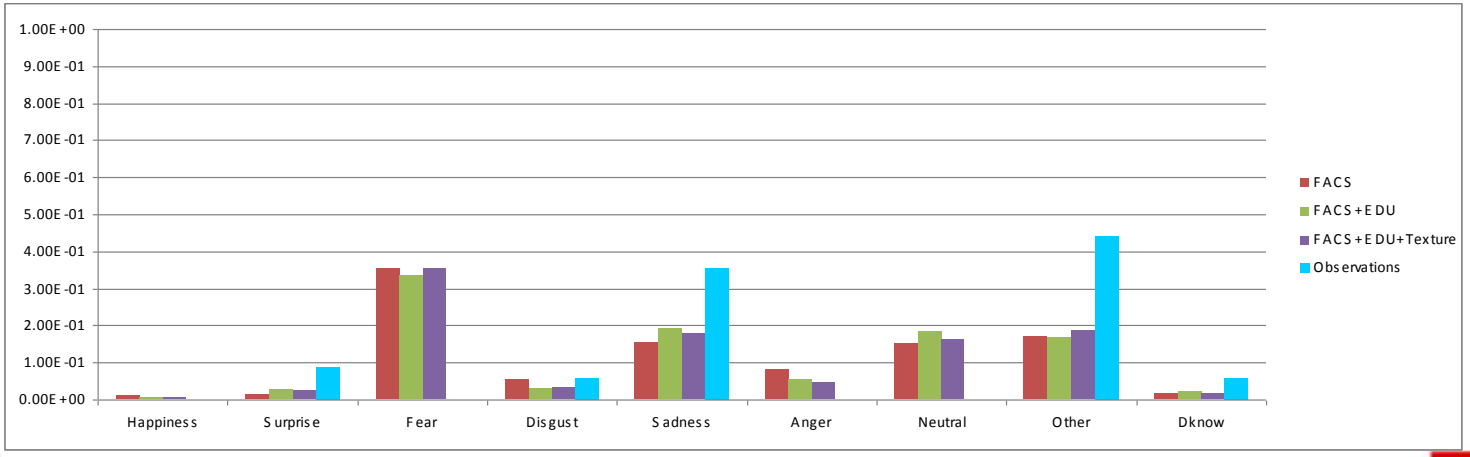
Application

34 observations





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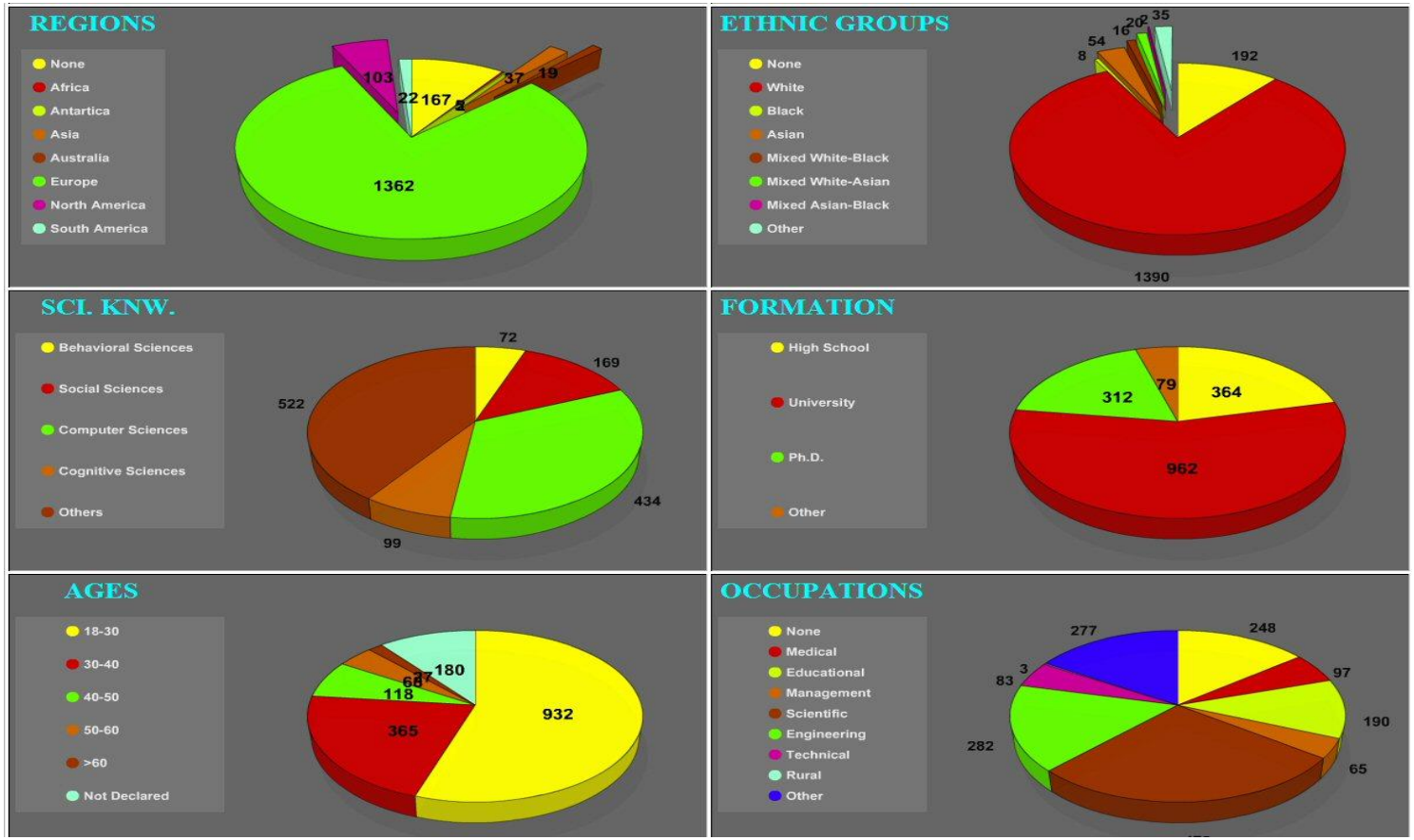
Conclusions and Future works

- Conclusions
  - Complex face-based model
  - Good prediction performance
- Future works
  - Appropriate test to compare histograms
  - Validation
  - Segmentation
  - Comparison with others methods
  - Other models structure
  - Dynamic version

Thank you for your attention

Data : Internet Survey



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Behavioural Modelling: Segmentation

- Aim : Capture behaviour's heteroginity in the population
- Method :
  - Take a socio-economic attribute and divide the data set along the class:

    ex : Gender : Male / Female

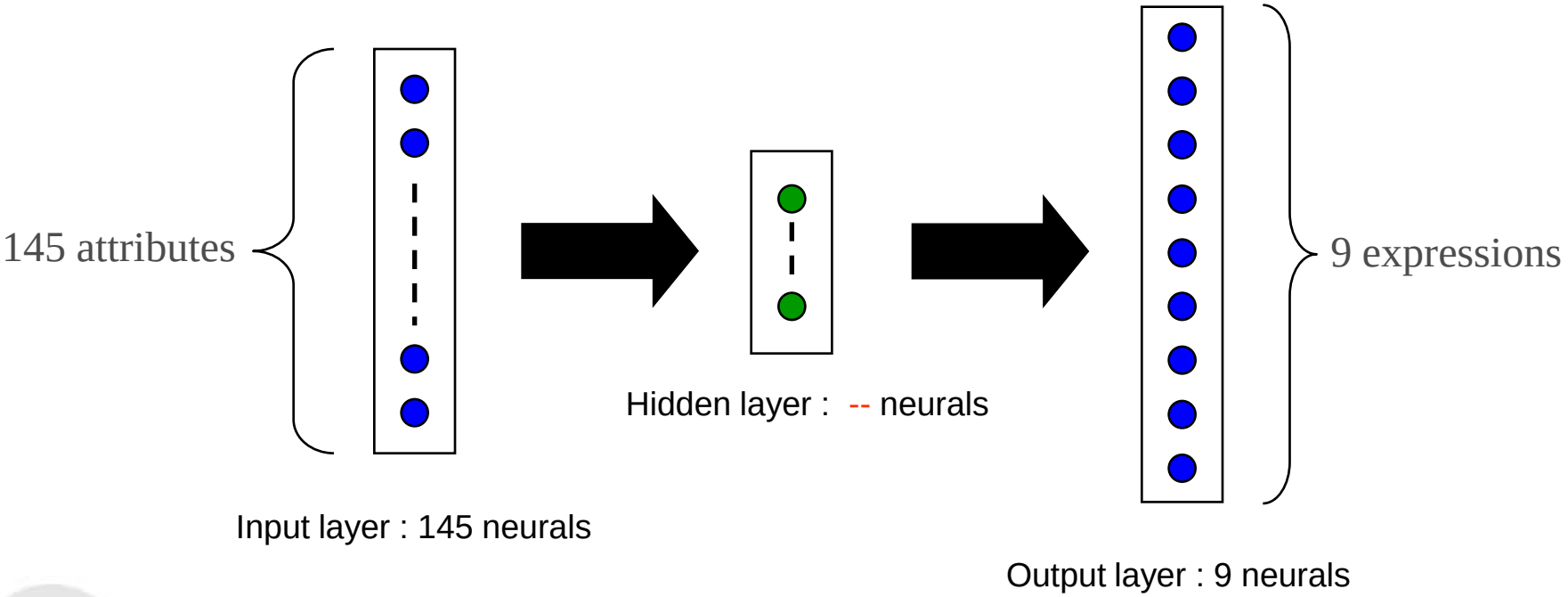
  - Estimate the developped model on the seperated data set
  - Test the differences:

    ex : parameters values, log-likelihood

Comparison with other methods

Famous machine learning method : **Neural Networks (NN)**

- Architecture of the network :



Model Overview