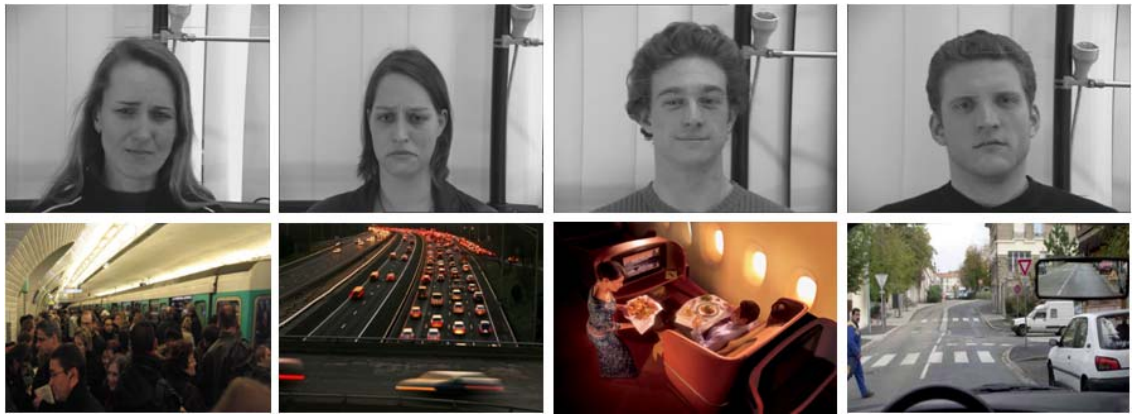
Dynamic facial expression recognition using a behavioural model



Thomas Robin **Michel Bierlaire** **Javier Cruz**

The context

- Recent interest for emotion recognition in transportation

  → Driving assistance

  - Safety
  - Mobility

  → Well-being measuring of users

  - Improve public transportation offers
  - Improve car comfort

Abou-Zeid, M., Ben-Akiva, M. and Bierlaire, M. (2008). Happiness and travel behavior modification, *Proceedings of the European Transport Conference*, Leiden, The Netherlands.

The context

- Emotion: **mental** and **physiological** state associated with a wide variety of feelings, thoughts and behavior.

- Emotions signs easy to measure with non-intrusive techniques for transportation users:

  - Behavior
  - Face expression
  - Voice intonation

The context

Driving assistance

→ Adapt car behavior to a danger

Well being measuring

→ Improve level of service

Objectives

- Model the facial expression recognition made by a person looking at a face video sequence
- Model explicitely the **dynamic process**
- **No classification**
- Estimate the model on **behavioural** data (relax ground truth assumptions)

Outline

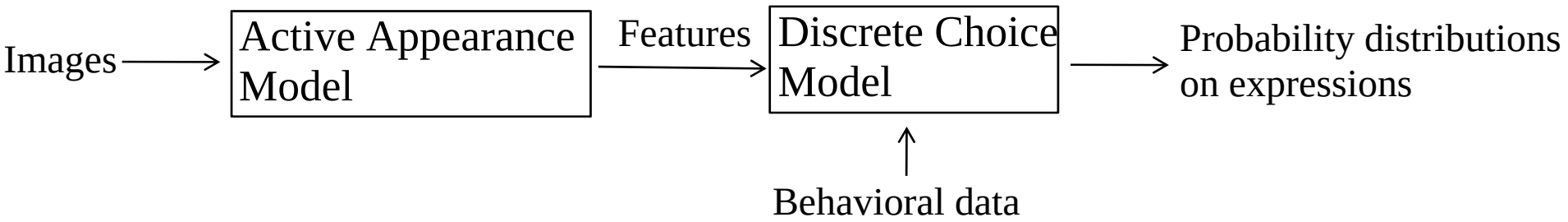
- Introduction
- Data: video
- Features extraction
- Data: behavioral data
- Model framework
- Model estimation
- Model predictions
- Conclusion and Perspectives

Introduction

- Static version of the work:

M.Sorci, M.Bierlaire, J-P.Thiran, J.Cruz, Th.Robin and G.Antonini (2008) Modeling human perception of static facial expressions, paper presented at *8th IEEE Int'l Conference on Automatic Face and Gesture Recognition*.

- Images: Cohn-Kanade database
- Behavioral data: internet survey



- **Static** → **Dynamic**

Introduction

- Dynamic framework inspired from dynamic model:

→ Hidden Markov Model

| - State transition process
| - Measurement equation

→ Choudhury, C. F. (2007) Model driving decisions with latent plans, Ph.D. Thesis, Massachusetts institute of technology.

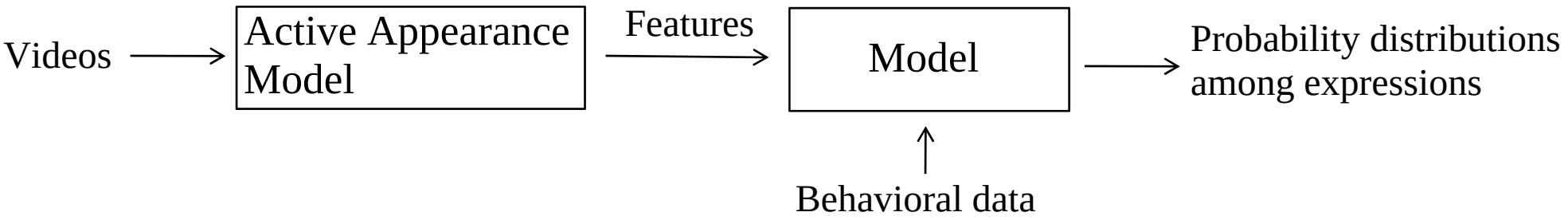
| - Behavioral models
| - Latent decisions

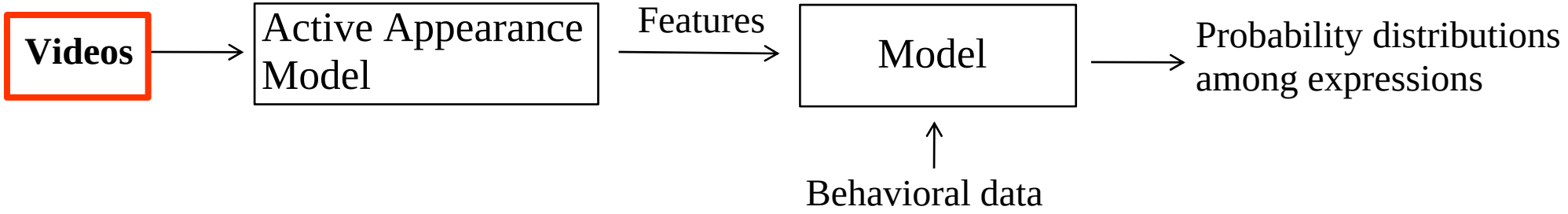
→ J.L.Walker (2001) Extended discrete choice models: Integrated framework, flexible error structures, and latent variables, Ph.D. Thesis, Massachusetts Institute of Technology.

| - Latent segmentation models

Introduction

- Model overview:




Videos
Active Appearance Model
Features
Model
Probability distributions among expressions
Behavioral data

Data: video database

- The Technical University Munich database (TUM)
  Facial Expression and Emotion Database (FEED)

➡ Students faced to a video, natural expressions recorded

138 sequences, 18 subjects

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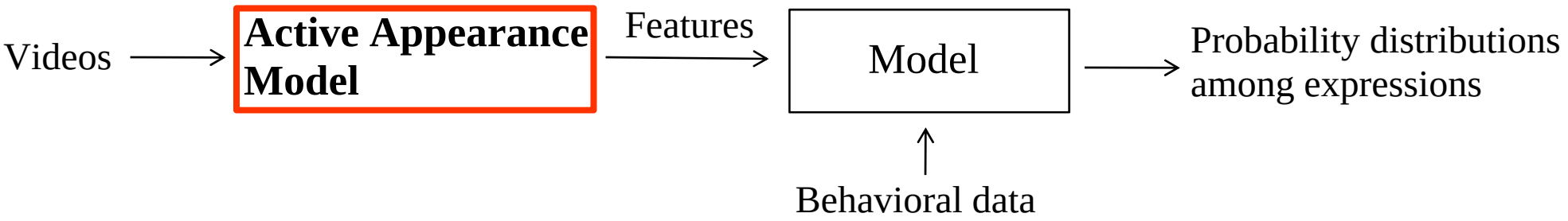
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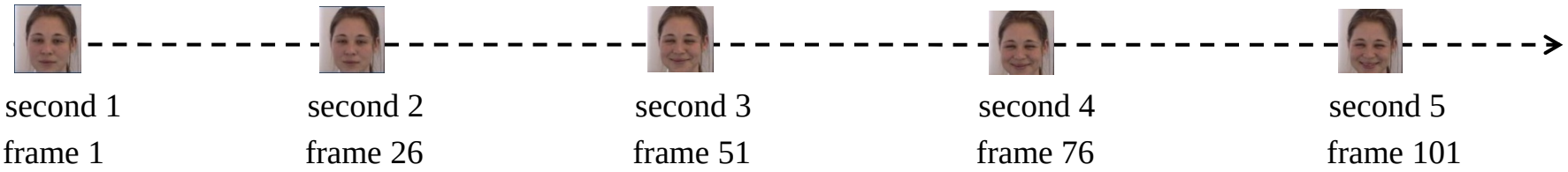
Features extraction: Active Appearance Model

- Video = succession of images, called frames

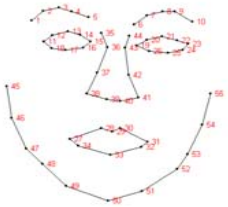
  ⇒ information extracted on each frame

- Hypothesis: individual perception evolves at regular time step (1 s)

  ⇒ - a video contains 25 frames per second
  - first frame of each second retained



Features extraction: Active Appearance Model



AAM

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

Texture

(C vectors)

FACS

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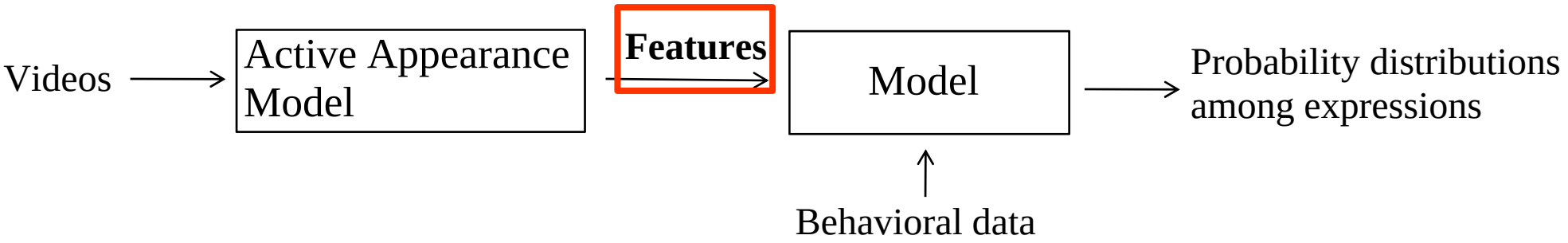
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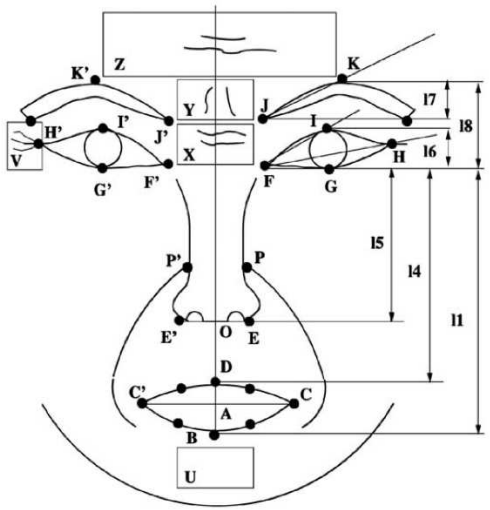
Features: Facial Action Coding System

- FACS developped by Ekman and Friesen (1978)
- Mesurement units, called “Action Units” (AUs) associated to expressions

➡ **leading standard for measuring facial expressions**

AU1  Inner Brow Raiser	AU2  Outer Brow Raiser	AU4  Brow Lowerer	AU5  Upper Lid Raiser	AU6  Cheek Raiser	AU7  Lid Tightener
AU9  Nose Wrinkler	AU10  Upper Lip Raiser	AU12  Lip Corner Puller	AU15  Lip Corner Depressor	AU16  Lower Lip Depressor	AU17  Chin Raiser
AU20  Lip Stretcher	AU23  Lip Tightener	AU24  Lip Pressor	AU25  Lips part	AU26  Jaw Drop	AU27  Mouth Stretch



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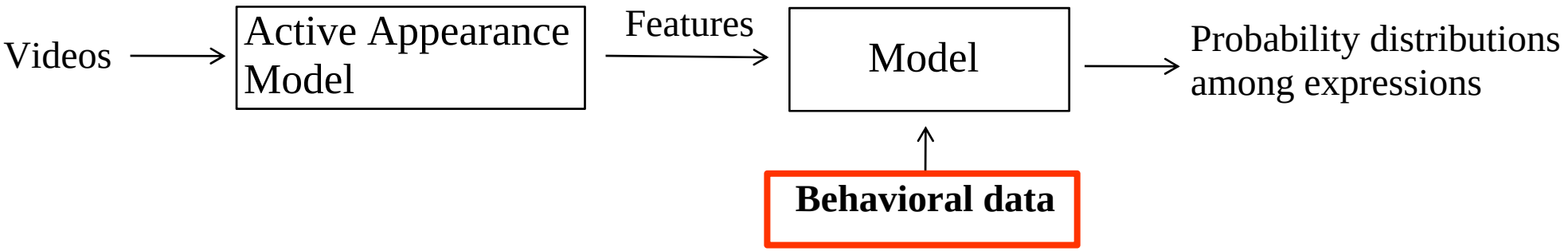
Features: C vectors

- Direct output of the Principal Component Analysis (PCA) conducted in the AAM

⇒ It characterises both **face shape** and **face shadows**

⟶ C vector: 100 elements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Data: internet survey

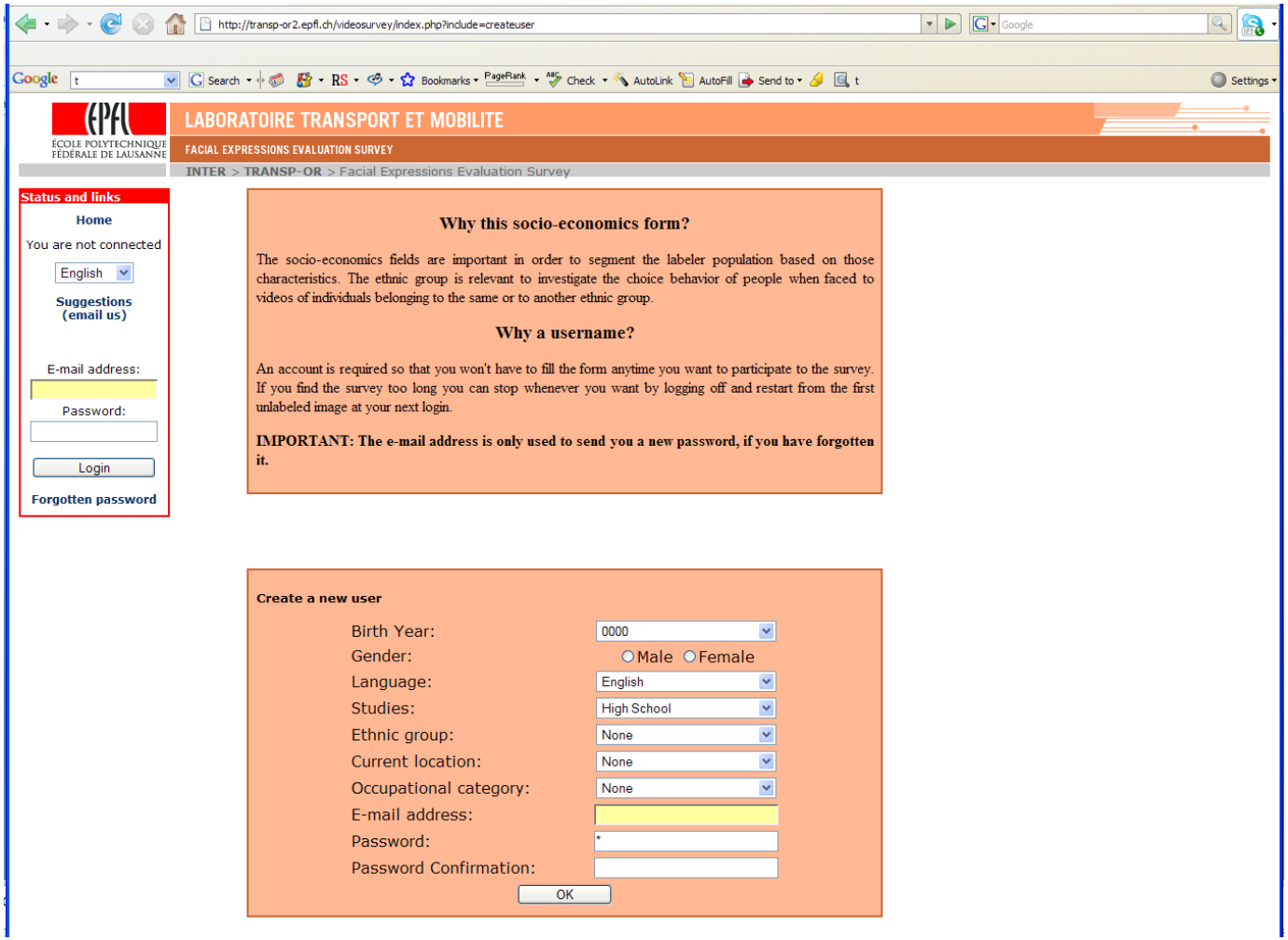
- Survey conducted at the address below(English, French, Italian, Spanish):

  http://transp-or2.epfl.ch/videosurvey/

- Respondents have to:
  - create an account
    → Socioeconomics attributes
  - label some video sequences with expressions
    → **observations**

- 1 database of video is used:
  - Facial Expression and Emotion Database (FEED)

Data: socio-economics



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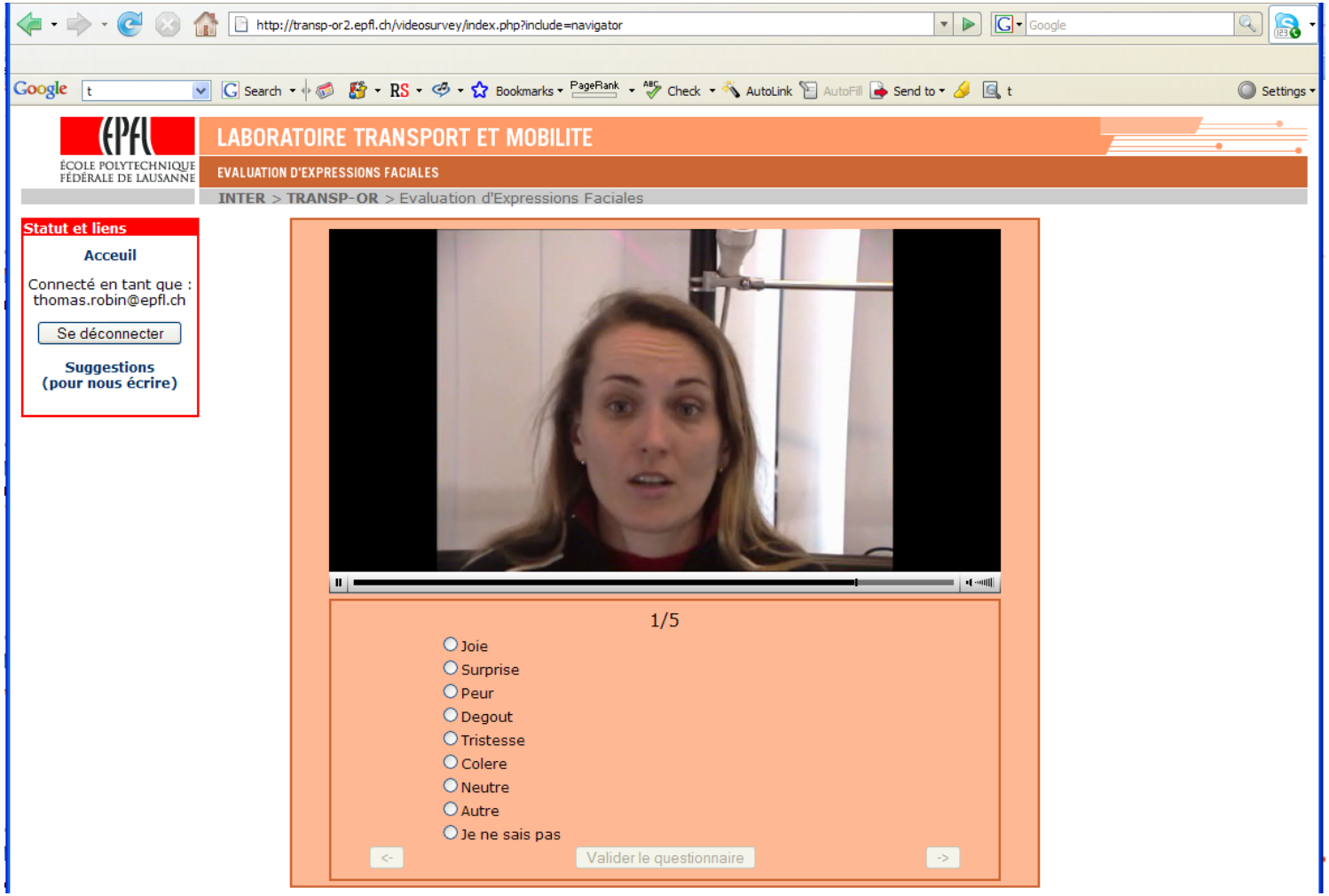
Data: labels



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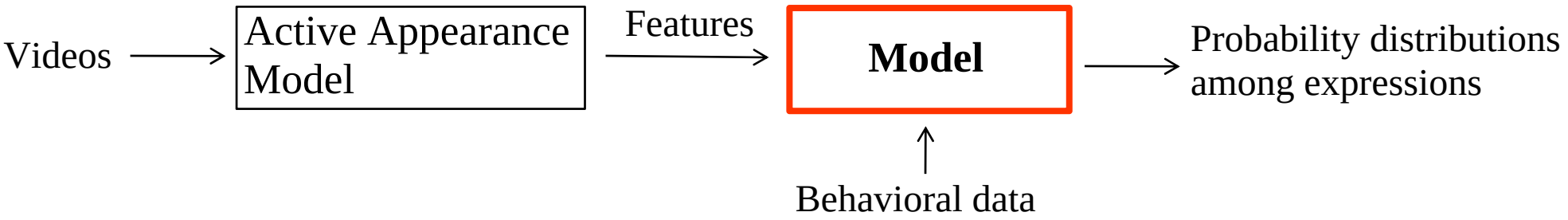
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Model: introduction

- Combination of 2 DCMs

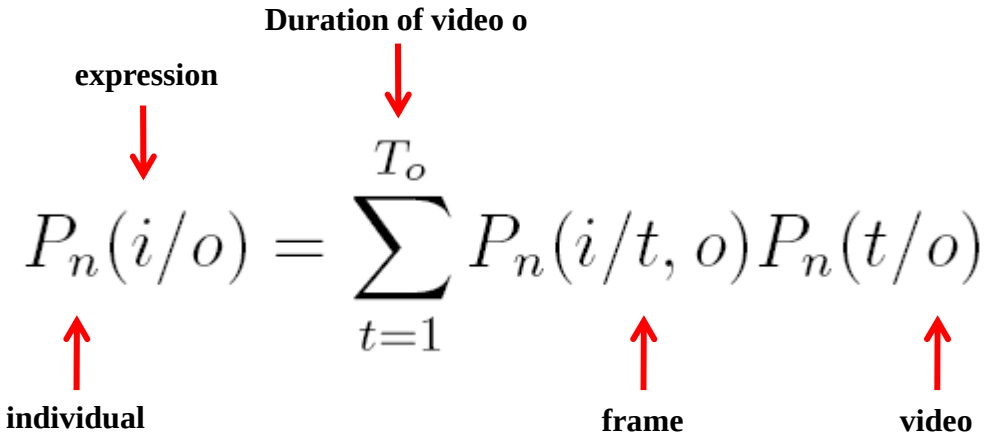
→ **Instantaneous expression perception sub-model**

- Similar to static model
- Choice set: expressions
- Attributes: facial features

→ **Video frames weighting sub-model**

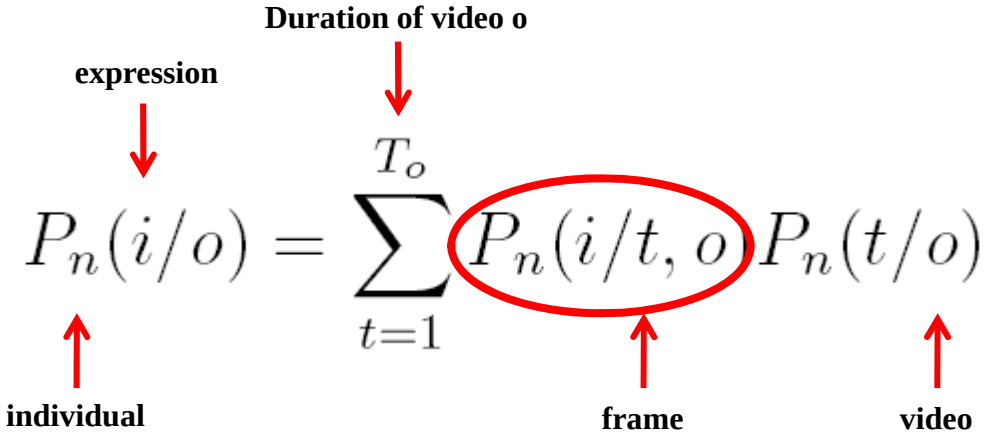
- Capture influence of each frame on final expression perception
- Choice set: frames (depend on the video)
- Attributes: dynamic features, such as facial features derivatives

Model: general framework



- $P_n(i/t,o)$: Instantaneous expression perception sub-model.
- $P_n(t/o)$: Video frames weighing sub-model.
- $P_n(t/o)$: Model.

Model: expression perception sub-model



- Choice set: 9 expressions (Happiness, Surprise, Fear, Disgust, Sadness, Anger, Neutral, Other, Don't know)
- Logit model
- Memory effect : captured in expression utilities

Model: expression perception sub-model

- Memory effect : captured in expression utilities

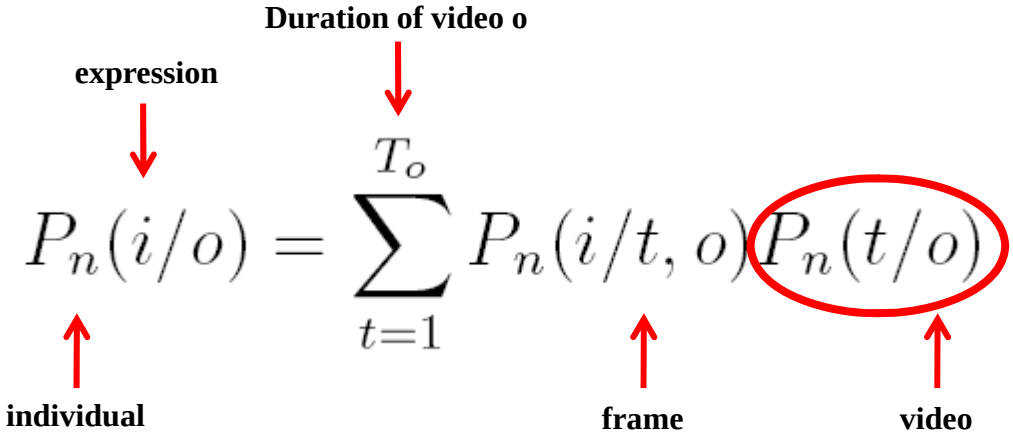
$$V_n(i/t, o) = V generic_n(i/t, o) + a_{i,n} V generic_n(i/t - 1, o)$$

Estimated parameter

- Utility specification:

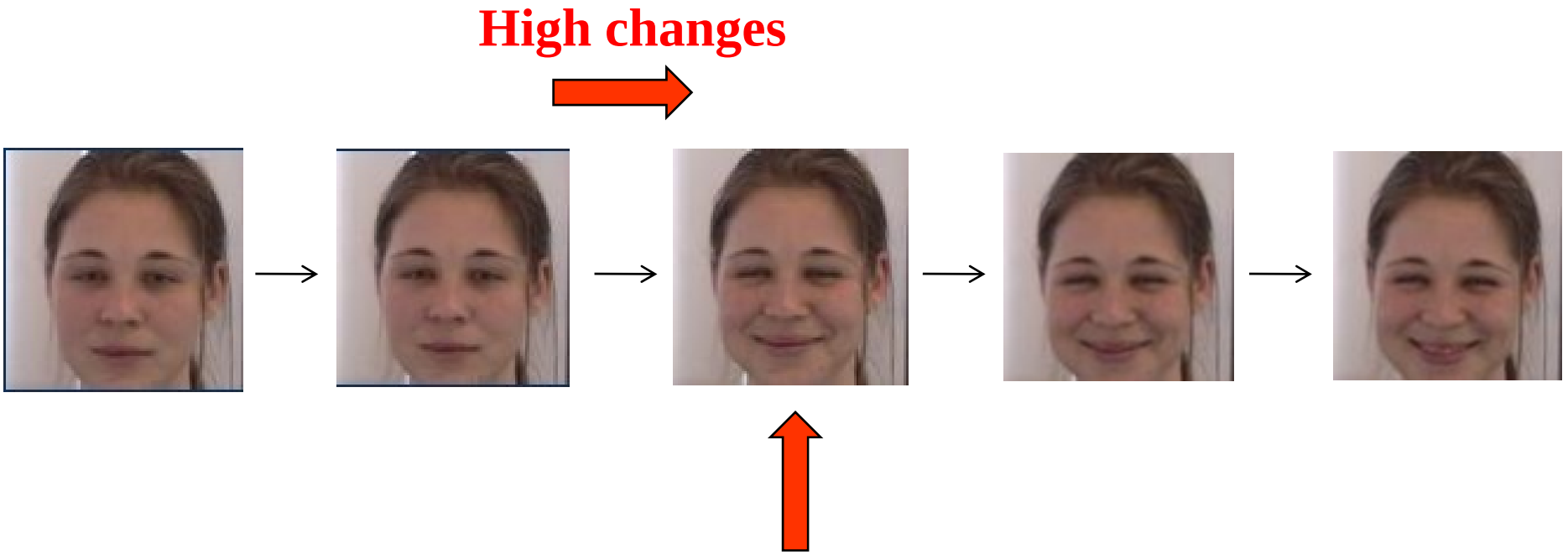
  - Alternative Specific Constants (**ASC**)
  - Measures corresponding to **AU**s (FACS)
  - Elements of **C vectors** (outputs of AAM)

Model: frames weighting sub-model



- Choice set: Frames of the videos (it depends on *o*)
- Logit model
- Utility specification: Derivatives of facial features

Model: frames weighting sub-model



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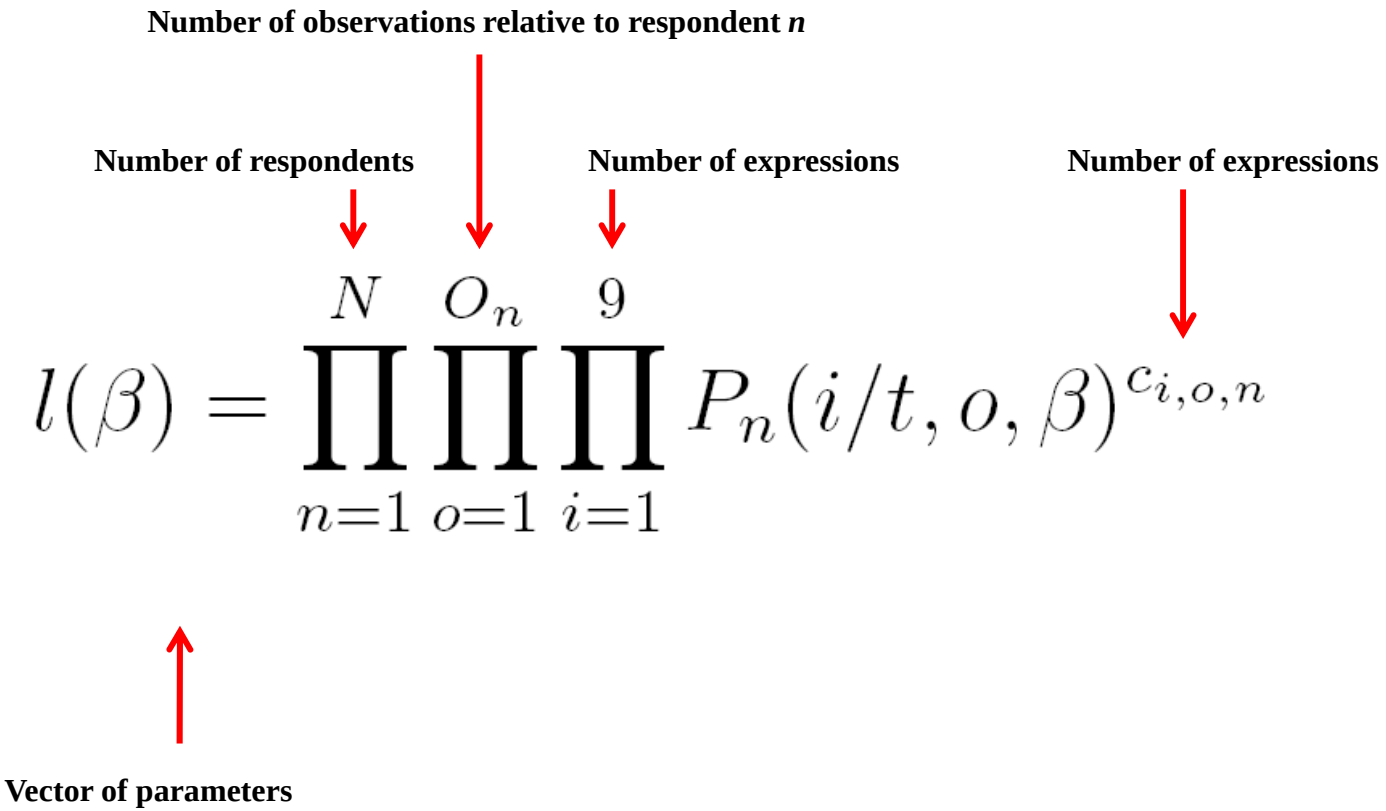
Model: likelihood function



Model estimation: general results

- Likelihood maximization
- Behavioral data: labels on the FEED videos (natural videos)
- Simultaneous sub-models estimation
- Estimation program based on the BIOGEME software
- General model fit:

Nb of observations:	294
Nb of parameters:	44
Null log-likelihood:	−645.98
Final log-likelihood:	−358.82
$\bar{\rho}^2$:	0.38

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Model estimation: parameters values

Expression perception sub-model

	Id	Parameter name	Value	Std-error	t-test 0
ASCs	1	*ASC_A*	−7.83	5.31	−1.47
	2	*ASC_D*	6.90	4.10	1.68
	3	*ASC_DK*	−0.54	0.39	−1.40
	4	*ASC_F*	−31.90	8.89	−3.59
	5	*ASC_H*	24.23	5.31	4.56
	6	*ASC_O*	5.31	3.14	1.69
	7	*ASC_SA*	8.70	6.85	1.27
	8	*ASC_SU*	−13.33	2.97	−4.48
AUs	9	*b_broweye_l2_SA*	570.49	134.49	4.24
	10	*b_broweye_l3_SU*	70.73	19.54	3.62
	11	*b_broweye_r2_A_D_F_SA_SU*	−99.24	26.90	−3.69
	12	*b_eye_angle_below_l_F*	6.24	2.46	2.54
	13	*b_eye_angle_l_F_SA*	17.33	5.01	3.46
	14	*b_eye_angle_r_F_SA*	−10.17	3.08	−3.30
	15	*b_eye_brow_angle_l_SA*	−16.58	3.95	−4.20
	16	*b_eye_mouth_dist_l2_D*	−49.54	24.91	−1.99
	17	*b_eye_mouth_dist_l_H_O_SA*	−97.20	36.70	−2.65
	18	*b_eye_nose_dist_l_A*	248.02	36.42	6.81
	19	*b_eye_nose_dist_l_D_F_O_SA*	101.16	22.25	4.55
	20	*b_eye_nose_dist_r_D_F_O_SA_A*	−131.09	19.88	−6.59
	21	*b_leye_h_F*	660.84	145.33	4.55
	22	*b_leye_h_SU*	340.57	62.41	5.46
	23	*b_mouth_h_A_D_H_SA_F_SU*	79.71	25.32	3.15
	24	*b_mouth_nose_dist2_A_SA*	−283.30	56.02	−5.06
	25	*b_mouth_nose_dist_H*	−324.71	52.45	−6.19
	26	*b_mouth_w_A_D_F_H_O*	36.40	15.42	2.36
C vector	27	*b_C_1_SU*	90.35	20.63	4.38
	28	*b_C_1_F*	153.47	28.59	5.37
	29	*b_C_1_D*	115.28	19.57	5.89
	30	*b_C_1_A*	170.99	27.17	6.29
	31	*b_C_2_H*	23.23	10.47	2.22
	32	*b_C_2_SU*	33.94	13.28	2.56
Memory effect	33	A_H	−0.70	0.13	−5.25
	34	A_D	−0.15	0.10	−1.49
	35	A_SA	−0.49	0.11	−4.28
	36	A_A	−0.15	0.09	−1.58

Frames weighting sub-model

	Id	Parameter name	Value	Std-error	t-test 0
C vector deriv	1	*b_FRAME_C_1_deriv*	−45.46	25.41	−1.79
	2	*b_FRAME_C_2_deriv*	−224.99	72.18	−3.12
	3	*b_FRAME_C_3_deriv*	240.01	79.08	3.04
	4	b_FRAME_C_5_deriv	−73.34	27.28	−2.69
AUs deriv	5	b_FRAME_eye_h_deriv	−805.69	226.21	−3.56
	6	b_FRAME_eye_brow_angle_deriv	43.97	14.33	3.07
	7	b_FRAME_mouth_h_deriv	1309.91	399.85	3.28
	8	b_FRAME_mouth_w_deriv	−184.44	56.81	−3.25

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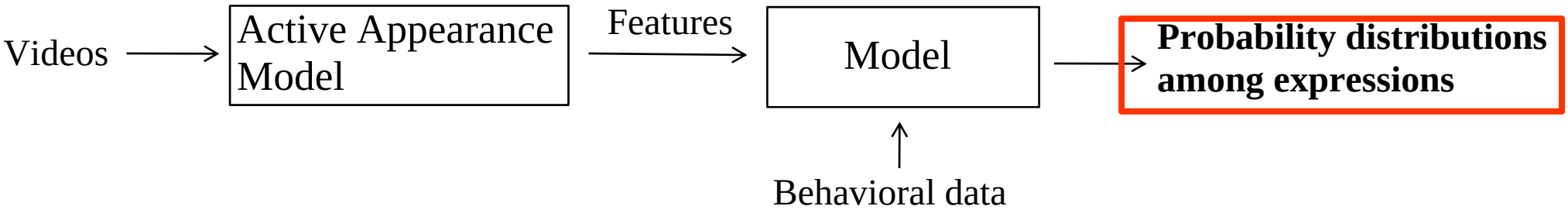
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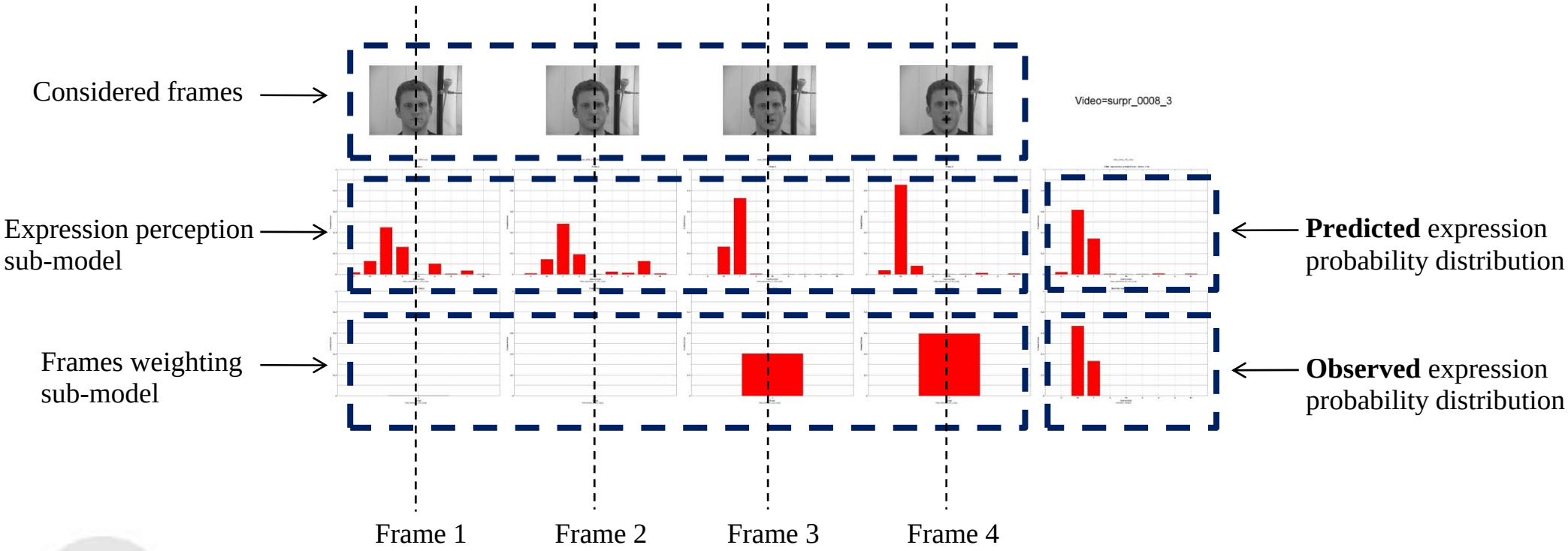
Model predictions: introduction

- Check model validity
- Prediction display example:

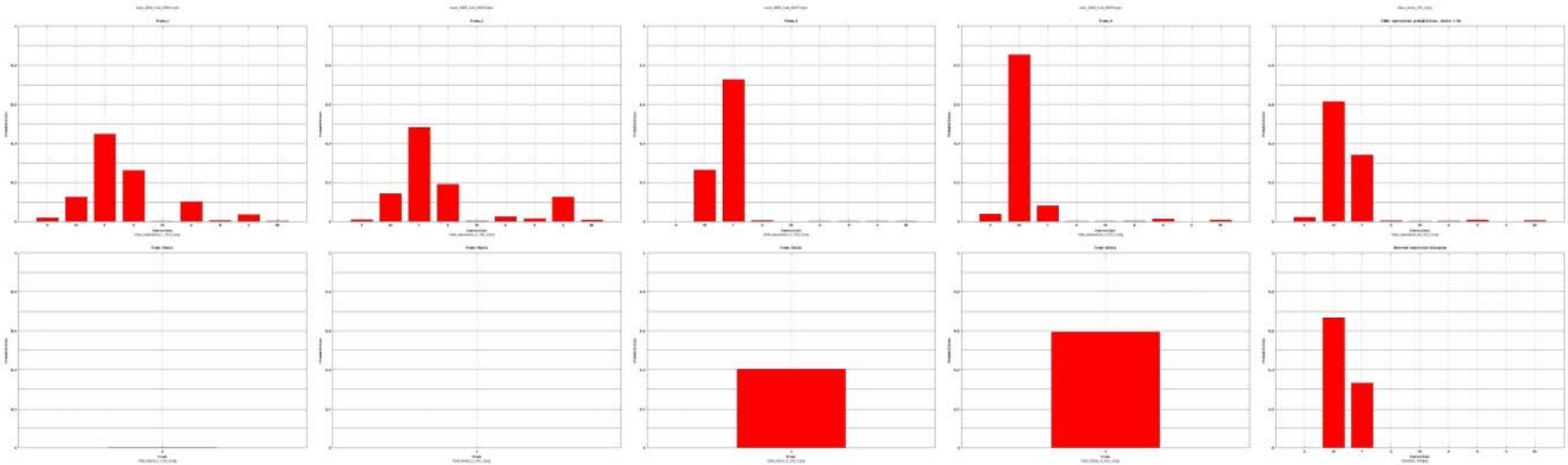


Model predictions: example 1

- Expressions order: **H, SU, F, D, SA, A, N, O, DK**




Video=surpr_0008_3

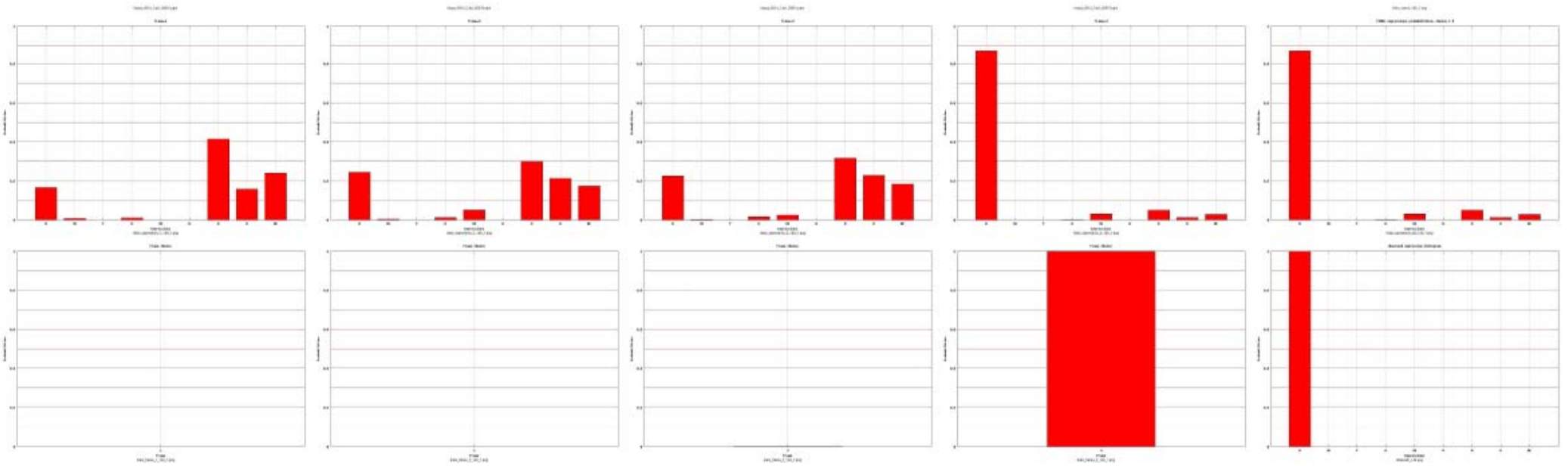


Model predictions: example 2

- Expressions order: **H, SU, F, D, SA, A, N, O, DK**




Video=happy_0014_2



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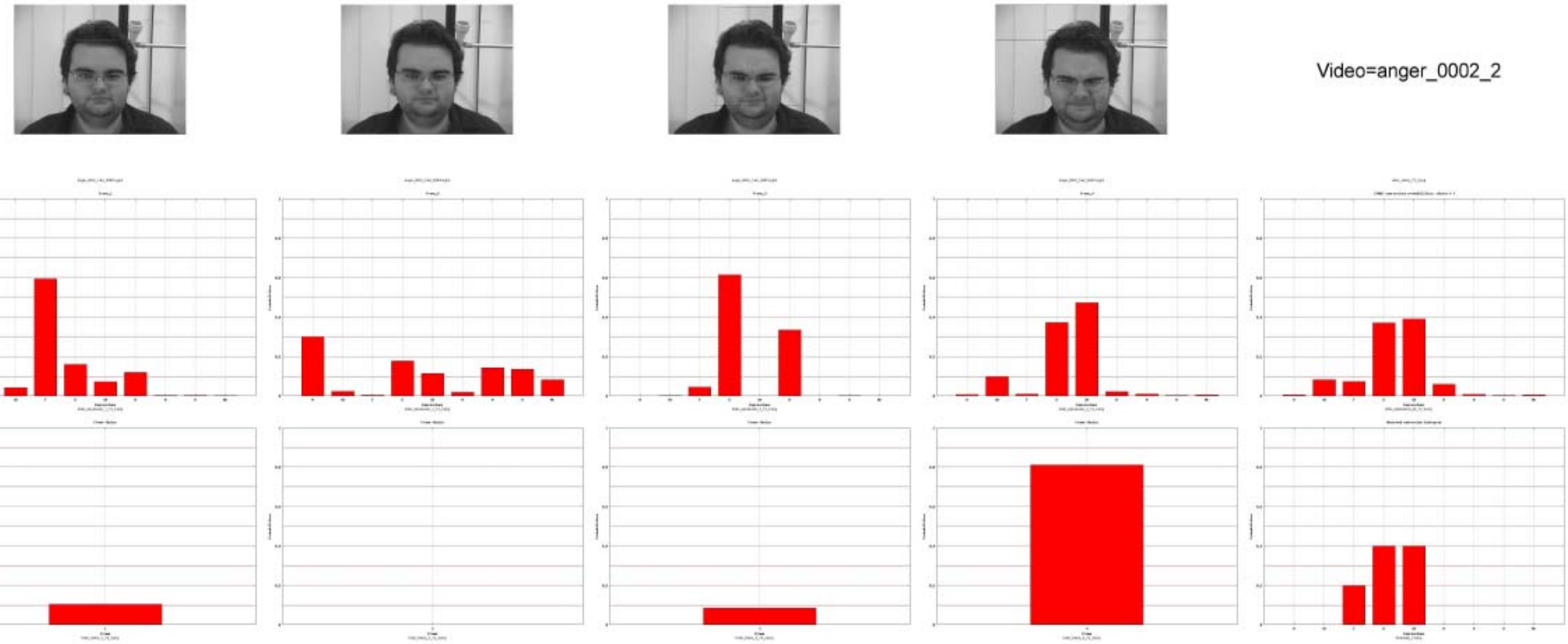
Model predictions: example 3

- Expressions order: **H, SU, F, D, SA, A, N, O, DK**



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Model pre-validation

- Comparison with simplier model: ASC model

  ➡ Only ASCs in expression perception sub-model

Proposed model

Nb of observations:	294
Nb of parameters:	44
Null log-likelihood:	−645.98
Final log-likelihood:	−358.82
$\bar{\rho}^2$:	0.38

ASC model

Nb of observations:	294
Nb of parameters:	8
Null log-likelihood:	−645.98
Final log-likelihood:	−572.437
$\bar{\rho}^2$:	0.10

- Aggregated prediction results on estimation data : Outliers percentage

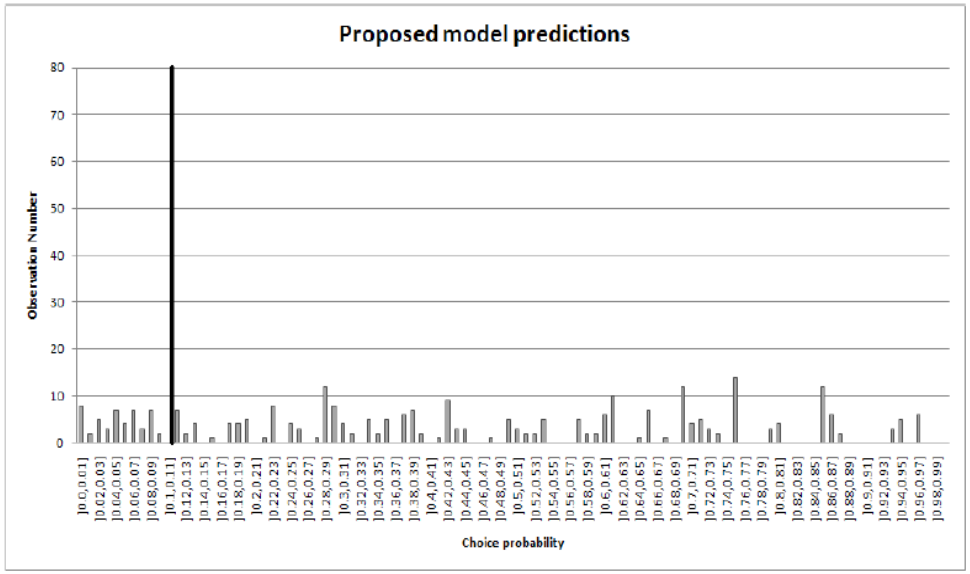
  ➡ Outlier: observation with choice probability less than $\frac{1}{9}$

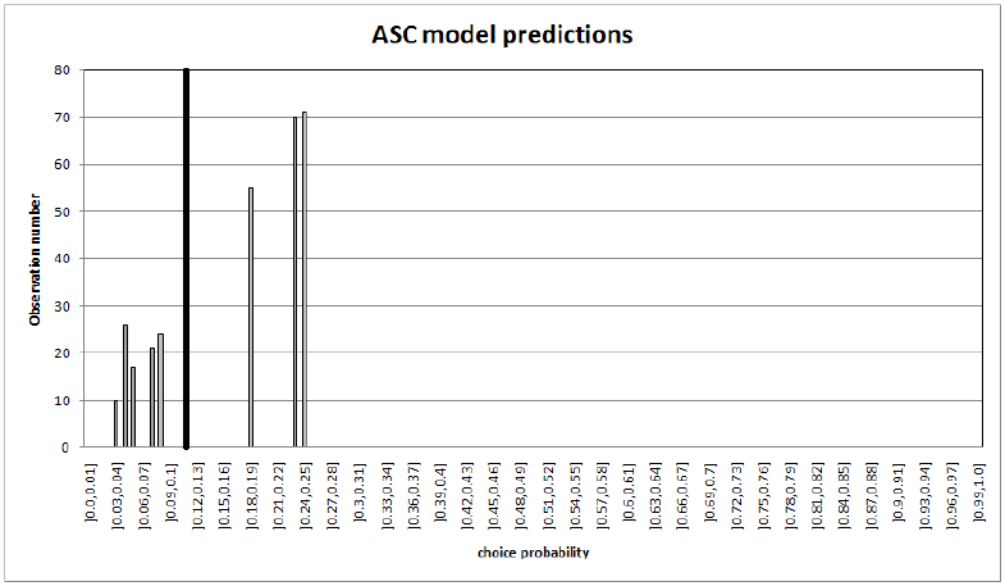
Model pre-validation: outliers

- Outlier: observation with choice probability less than $\frac{1}{9}$

Proposed model	ASC model
16.33%	33.33%

- Choice probabilities histogram





Conclusions and Perspectives

- Conclusion:
  - database of face video annotations
  - new model framework
  - model estimated using behavioral data
  - pre-validated model
- Perspectives:
  - implement the panel data effect
  - estimate the model on more data (both videos and labels)
  - use of another video database for validation

Thanks for your attention

http://transp-or2.epfl.ch/videosurvey/