THE COLOR OF SMILING: COMPUTATIONAL SYNAESTHESIA OF FACIAL EXPRESSIONS

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Problem

Synaesthesia is a neurological phenomenon in which stimulation of one sensory or cognitive pathway leads to automatic, involuntary experiences in a second sensory. Here we adopt it as a good metaphor of the rechannelling ability in artificial agents, in particular we consider the problem of transducing a sensed facial expression $\mathbf{V}$ into a color stimuli $\mathbf{C}$.

Solution: a probabilistic model that realizes the transduction $\mathbf{V} \mapsto \mathbf{C}$, relying upon a continuous latent affective space $\mathbf{E}$ determined by the Information Bottleneck (IB) approach [1].

Information Bottleneck

IB is an information-theoretic principle for the extraction of relevant components of an *input* random variable $\mathbf{X}$, with respect to an *output* random variable $\mathbf{Y}$.
The objective function, is to minimize

$$\mathcal{L}[Q] = I_Q(\mathbf{V};\mathbf{E}) - \beta I_Q(\mathbf{E};\mathbf{C}), \quad (1)$$

where $I_Q(\mathbf{X};\mathbf{Y})$ denotes the mutual information with respect to some probability distribution $Q(\mathbf{x},\mathbf{y})$, and β controls the tradeoff between compression and preservation of relevant information.

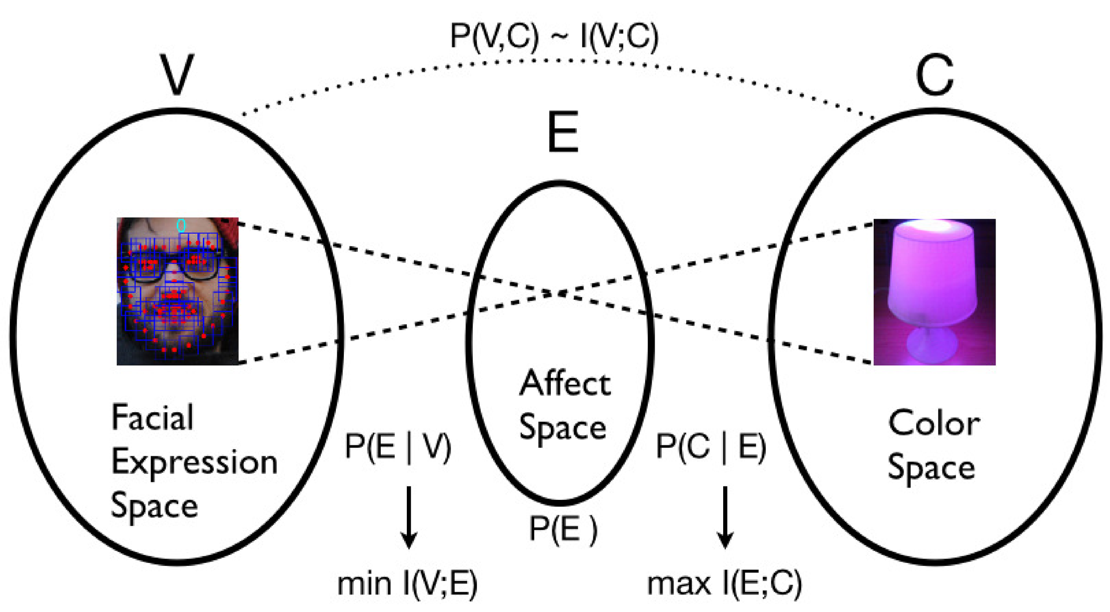

Fig.1: *The IB framework.*

Demo

Watch the Moodlamp demo video by scanning the QR code below.

References

[1] N. Tishby, F. C. Pereira, and W. Bialek. The information bottleneck method. In Proc. of the 37th Annual Allerton Conference on Communication, Control and Computing, pages 368-377, 1999.

[2] Cuculo, V., Lanzarotti, R., Boccignone, G.: Using sparse coding for landmark localization in facial expressions. In: 5th European Workshop on Visual Information Processing (EUVIP), pp. 1-6, December 2014

Acknowledgements

The research was carried out as part of the project "Interpreting emotions: a computational tool integrating facial expressions and biosignals based shape analysis and bayesian networks", which is supported by the Italian Government, managed by MIUR, financed by the Future in Research Fund.

Computational Synaesthesia

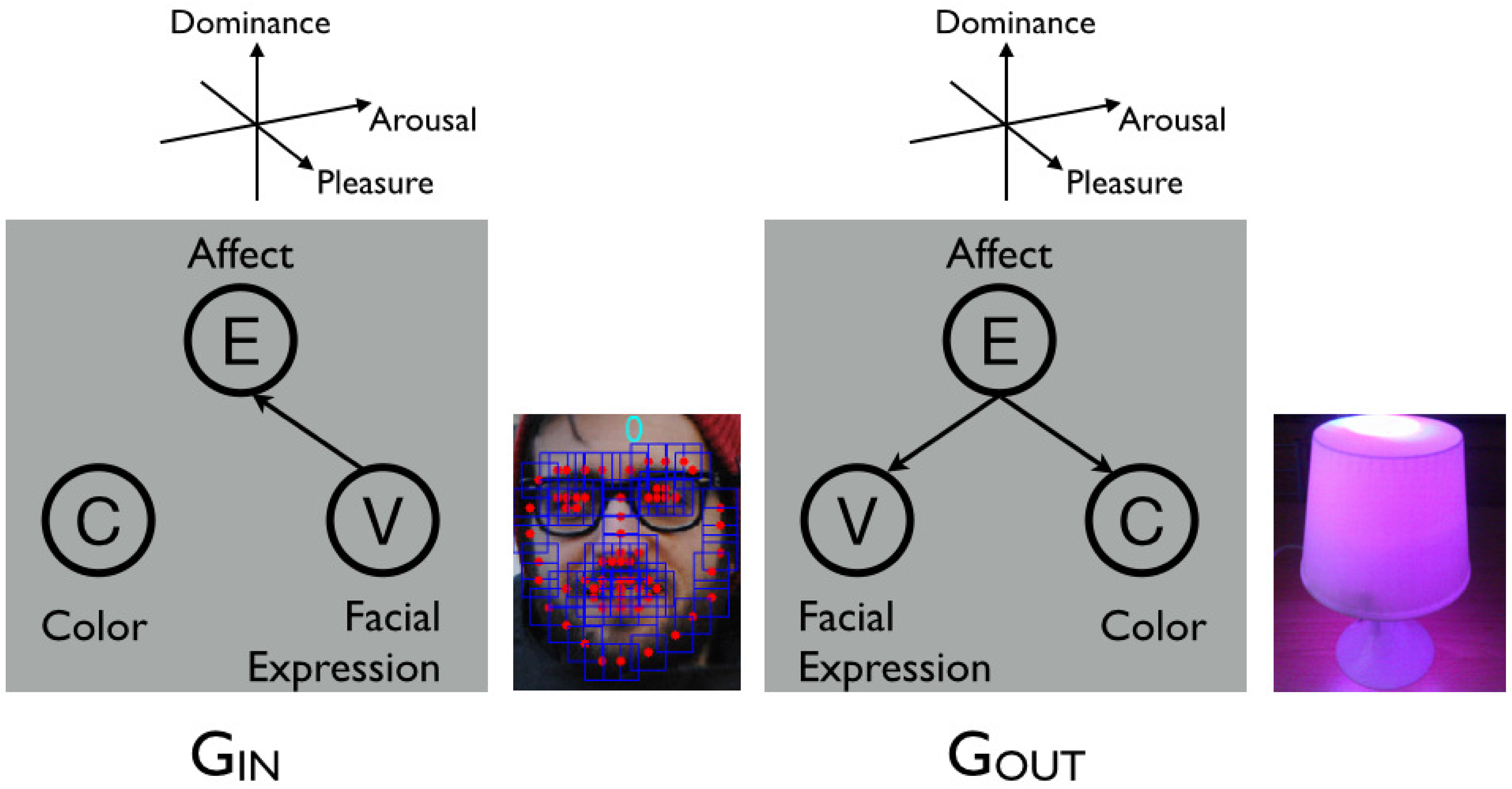

Fig.2: *A Probabilistic Graphical Model representation of IB.*

The computational framework could be seen as made of two main parts, each of which relies on the search of a "mapping" probability, respectively $P(\mathbf{E} \mid \mathbf{V})$ and $P(\mathbf{C} \mid \mathbf{E})$.

Facial Expression ↦ Mood

The left side of the PGM ($\mathcal{G}_{IN}$) encodes the compression process, consisting in three steps:

1. Facial landmark localization
   Adopting a sparse coding-based feature descriptor (HSC) [2], that maximises the probability of certain landmark configuration $\mathbf{L}$ given the responses from local detectors:

$$\mathbf{L}^* = \arg\max_L \sum_{k=1}^{m} \int_t \prod_{i=1}^{n} P(\Delta \mathbf{l}^i_{k,t}) P(\mathbf{l}^i | \mathbf{f}^i) dt, \quad (2)$$

2. Expression parameters extraction
   The extracted landmarks $\mathbf{L} = [\mathbf{l}^1 \cdots \mathbf{l}^{40}]^\mathsf{T}$ are mapped into a vector of visible expression parameters (EP) $\mathbf{V} \in \mathbb{R}^7$ by measuring the landmark displacements.

3. Regression of $\mathbf{V}$ parameters in the latent affective space $\mathbf{E}$, in terms of PAD (Pleasure, Arousal, Dominance)

Mood ↦ Color

The right graph ($\mathcal{G}_{OUT}$) is the target model representing which relations should be maintained or predicted. It consists of a generative model

$$\mathbf{c} = \mathbf{W}_C \mathbf{e} + \xi_C, \qquad \xi_C \sim \mathcal{N}(\mathbf{0}, \Sigma_{\xi_C}). \quad (3)$$

that maps the values from the continuous affective space $\mathbf{E}$ to the continuous color space $\mathbf{C}$, where $\mathbf{c} = [HSL]^\mathsf{T}$ corresponds to the HSL color space.

Emotion	H	S	L	P	A	D
joy	60	67	100	0.81	0.51	0.46
ecstasy	60	67	100	0.62	0.75	0.38
fear	120	100	59	-0.64	0.60	-0.43
terror	120	100	50	-0.62	0.82	-0.43
amazement	203	100	88	0.16	0.88	-0.15
sadness	240	68	100	-0.63	-0.27	-0.33
boredom	300	22	100	-0.65	-0.62	-0.33
annoyance	0	45	100	-0.58	0.40	0.01
anger	0	100	100	-0.51	0.59	0.25
interest	29	45	100	0.64	0.51	0.17
vigilance	29	100	100	0.49	0.57	0.45

Tab.1: *Proposed mapping of color values (HSL) with emotions (PAD).*

Experiment

The transcoding process has been experimented through the Mood Lamp, an affective object conceived as a sensing interface, namely a low-cost web camera / notebook communicating via USB with a modified IKEA lamp, equipped with an Arduino Uno board to control two RGB LEDs (Fig.5a). A sample of results from our preliminary experiments is presented in Fig.5b.

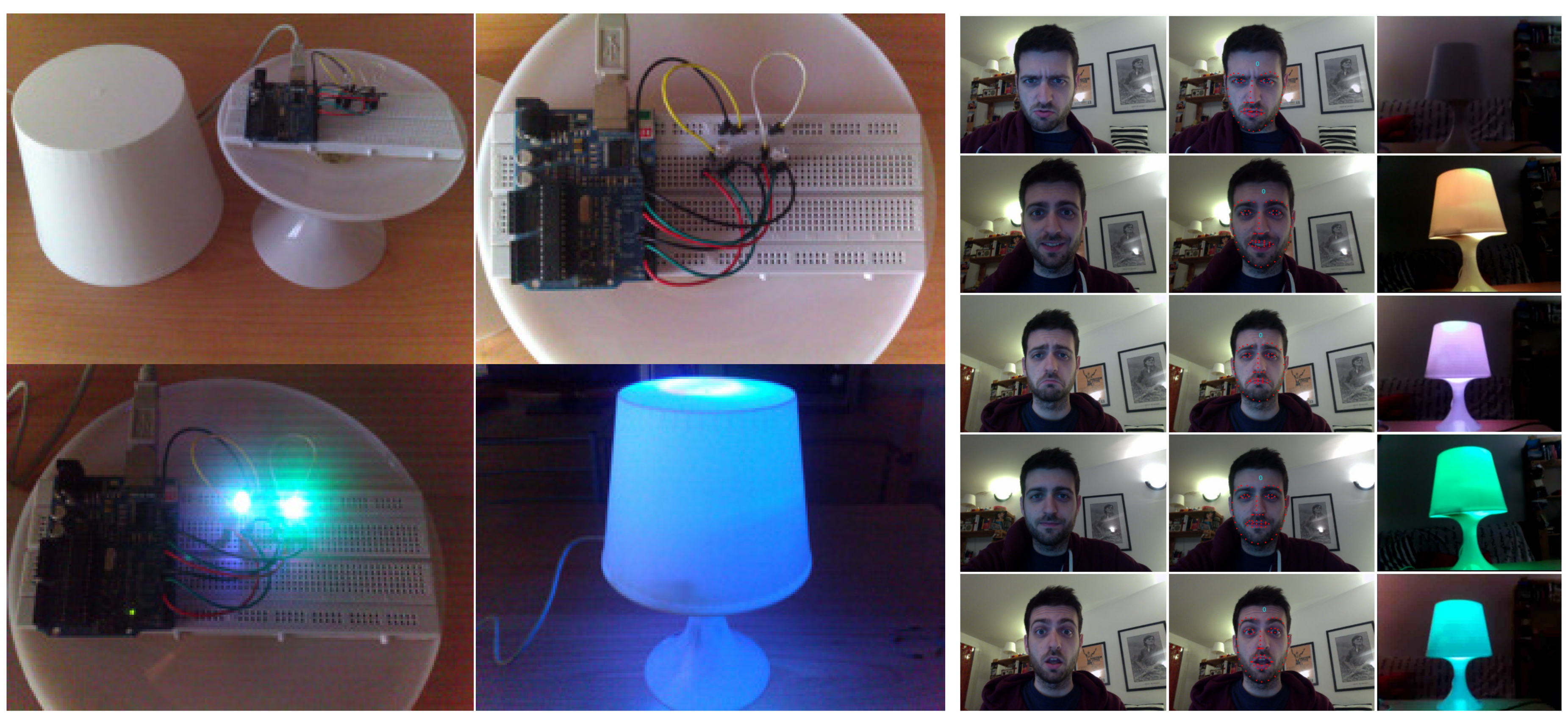

Fig.3: *a) Color control: the actual color stimulus is generated through a modified Ikea lamp, where the RGB LED is controlled by an Arduino UNO board. b) Experimental results of transcoding using the Mood Lamp.*