# The Virtual Face Mirror Project: Revealing Dynamic Self-Perception in Humans

MAX-PLANCK-GESELLSCHAFT
BACS
6th EU Cognition Framework, Integrated Project, FP6-IST-027140

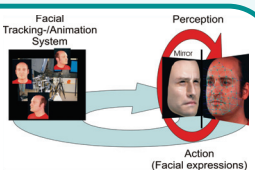



C. Curio[1] M. Kleiner[1] M. Breidt[1] H.H. Bülthoff[1,2]

perceptual graphics
Deutsche Forschungs Gemeinschaft

[1]Max Planck Institute for Biological Cybernetics, Department of Human Perception, Cognition and Action, Tübingen, Germany
[2]Department of Brain and Cognitive Engineering, Korea University, Seoul, Korea

## Introduction




The study of dynamic facial expression perception in closed-loop contexts yields important insights into the perceptual and neural mechanisms that govern the interaction between people. However, for such studies the creation of convincing and controllable feedback of facial movements in real time is a technological challenge.

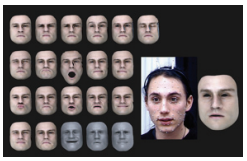
## Overall Project Goal

In this project we present a novel tool for the study of closed loop perception and self recognition of humans and present first experimental data.

## Previous Work

Development and validation of facial animation models

- How to achieve intuitive control?
- What is a perceptually efficient expression decomposition? Curio et al (2006)



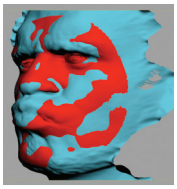
3D Facial Action Unit Models (after Ekman & Friesen 1978)

## Model Reconstruction

Processing and parameterization of 4D scan data and video

Walder, Breidt, Bülthoff, Schölkopf, Curio (2009)

- Tracking 4D surfaces with machine learning and computer vision
- Analysis by synthesis through model-based data fitting
- Spatio-temporal animation model: 4D morphable model
- Dynamic face-space for the manipulation of temporal aspects and appearance in 3D.



Model (red) fitted to 3D scan data (blue)

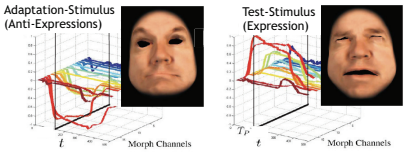
Deforming template mesh tracking of dynamic 3D scans and video

## The Neural Basis of Dynamic Facial Expression Recognition (Open Loop)

Psychophysical facial expression adaptation study

High-level after-effects in dynamic facial expression recognition

(Curio et al 2008, Curio et al 2010)




## References

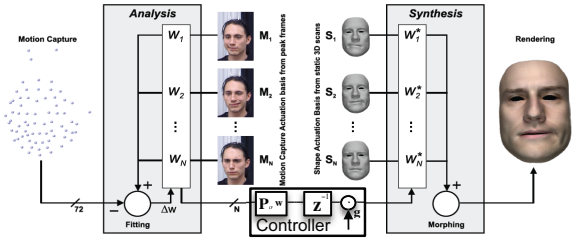
Curio, C., H.H. Bülthoff, M.A. Giese (Etds): Dynamic Faces: Insights from Experiments and Computation, MIT Press Books 2010
Walder, C., M. Breidt, B. Schölkopf, H.H. Bülthoff and C. Curio: Markerless 3D Face Tracking. Proceedings of Pattern Recognition, 31st DAGM Symposium 2009
Curio, C., M. A. Giese, M. Breidt, M. Kleiner and H. H. Bülthoff: Probing Dynamic Human Facial Action Recognition From The Other Side Of The Mean. Proceedings of Applied Perception and Graphics Visualization 2008
Curio, C., M. A. Giese, M. Breidt, M. Kleiner and H. H. Bülthoff: Exploring Human Dynamic Facial Expression Recognition with Animation. CogSys 2008
Kleiner, M., D. Brainard and D. Pelli: What's new in Psychtoolbox-3? Perception 36. ECVP 2007
Curio, C., M. Breidt, M. Kleiner, Q. C. Vuong, M. A. Giese and H. H. Bülthoff: Semantic 3D motion retargeting for facial animation. Applied Perception in Graphics and Visualization 2006

## Action-Perception Loop

Real-time facial animation properties

- Sparse 3D reconstruction of facial movements by video based tracking of color markers
- Decomposition of facial expressions by fitting a morphable model comprised of 3D Action Unit (AU) keyshapes
- Rendering and feedback of (manipulated) facial expressions with a corresponding dense computer graphics model
- Closed-loop, realtime performance: 50 Hz update rate, 50 msecs average feedback latency
- Flexible and simple implementation of experimental protocols in Matlab thanks to interface with open-source Psychophysics Toolbox-3 Kleiner et al (2006)

### Animation System Schematics




Visual feedback controller for facial movement perturbation

- Real-time detection of dynamic events
- AU channel remapping (permutation σ)
- AU channel delays ($z^{-1}$)
- AU gains (g), identity switching etc.
- Real time form-vs-motion dissociation (GPU)
- Replay of original and manipulated sequences

## Perturbation of Action Unit Signals

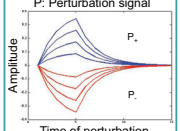
Psychophysical study (pilot data)

Task: Open- vs. closed-loop perturbation detection

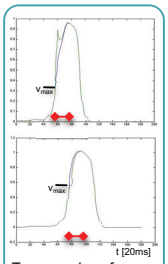
'Mouth Opening' Action Unit

As feedback signal, we added a perturbation to the performed AU trajectories (S)

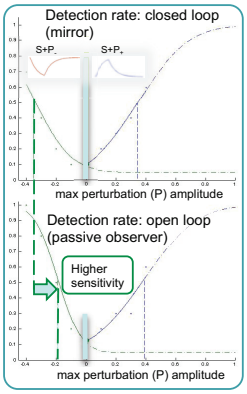
P: Perturbation signal




Time of perturbation [dT samples = 20ms]




Two samples of perturbed visual feedback and original AU feedback trajectory (S)




Results:

- The perception of self-generated facial movements in the mirror seems to differ from observing the expressions passively
- The perception seems to be modulated by the facial motor system and suggests the importance of studying self-perception with multimodal cues (proprioceptive/visual)

## Potential Impact

- Clinical intervention: Bio-feedback, facial palsies
- Psychiatry: Novel indicators for schizophrenia

Technology for new FET-Open project TANGO (2010): "Emotional interaction grounded in realistic context"