Facial movement dysfunctions:
Conceptual design of a therapy-accompanying training system

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Outline

1. Facial Dysfunctions
2. Therapy at home
3. Our Aim
4. Conceptual design: A comprehensive theoretic model
5. State-of-Play
6. Future work

1. Facial Dysfunctions: Background

Diseases like **stroke**, **parkinson**, **herpes** as well as the **mechanical injury of the facial nerve** can lead to a dysfunction of facial muscle movement.

Problems for affected persons:

- Visible impairment can lead to psychological problems
- Persons are misunderstood with respect to their facial expression or speech
- Risks of eye damage because of limited eyelid closure (especially at night!)
  impaired control of facial muscles can lead to problems concerning eating, drinking etc.

People avoid social interactions, have limitations in daily life and risk for further damages

Facial Dysfunctions: Background (2)

Speech and language therapy

- Therapy ambulant or in-patient
- Patient conducts **exercises** with the muscles of his face to improve his facial expression abilities.
- He is instructed by a **speech-language therapist** (dt. Logopäde).
- Additionally: Exercises **at home without supervision**

Facial exercise training with an instructor and at home without instruction

Facial Dysfunctions: Background (3)

Example: Facial Palsy after a stroke

Cooperation with the Fachklinik Bad Liebenstein (Department: Weiterführende Neurorehabilitation, Prof. Dr. med. Gustav Pfeiffer).

Patient with facial palsy on his right side.

Exercise ***right cheek puffed***.

Exercise is conducted **correctly**:
Bulge is a passive process (reaction of higher air pressure inside the mouth)

Exercise ***left cheek puffed***.

Exercise in conducted **incorrectly**:
Lack of contraction in the right buccinators leads to the bulge of the right cheek.

2. Therapy at home: facts

According to the thesis of Anette Wolowski, incorrect execution of exercises can impede the training success or even lead to further impairment.

Correct exercise execution is important but supervision is not always possible

“Exercise performance evaluation” – “Feedback”

Existing solutions for the home environment?

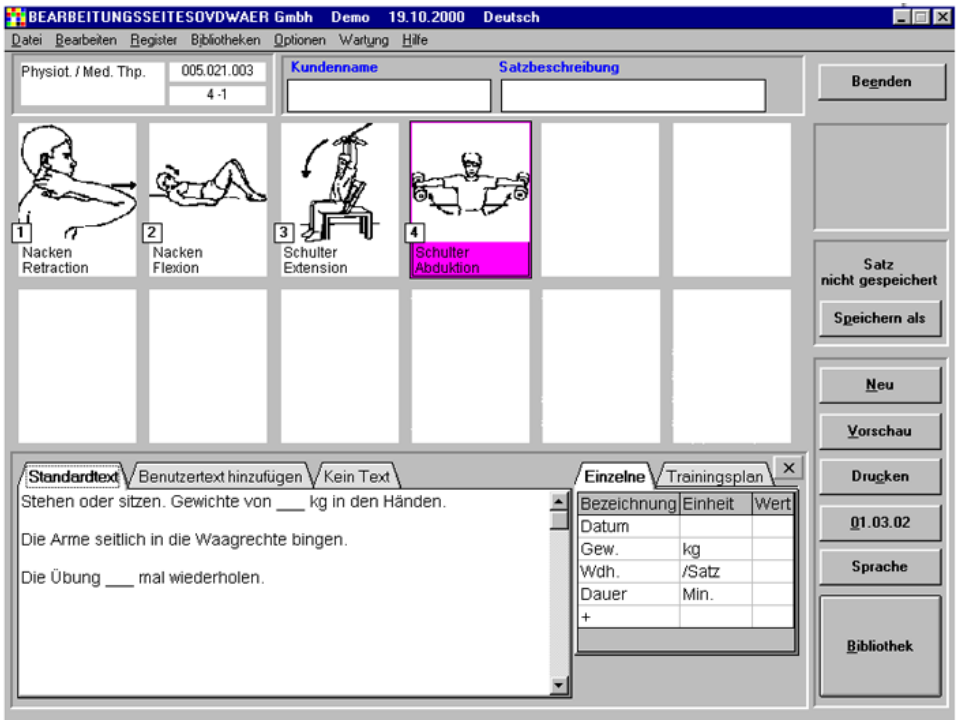
http://www.therapie-zentrum-wangen.de

Source: Wolowski, A.: *Fehlregenerationen des Nervus facialis – ein vernachlässigtes Krankheitsbild*. Thesis 2005. Universität Münster.

Therapy at home: Existing solutions (2)

Software that gives **visual instructions**: printed drawings or videos.

PhysioTools (*www.theorg.de*), ***LogoVid*** (*www.logomedien.de*)



TUTORIAL FUNCTIONALITY

Therapy at home: Existing solutions (3)

Software that enables documentation of training frequency:

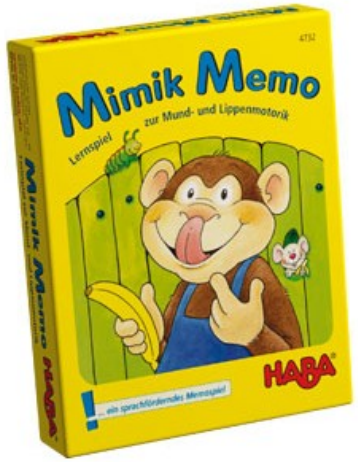
CoMuZu (*www.comuzu.de*)

DOCUMENTATION FUNCTIONALITY

Therapy at home: Existing solutions (4)

Solutions that focus on the gratification and gamification aspect.

CoMuZu (*www.comuzu.de*), ***Mimik Memo*** (*www.haba.de*)



MOTIVATIONAL FUNCTIONALITY

Therapy at home: Existing solutions (5)

Software that enables evaluation of training success:

CoMuZu (*www.comuzu.de*)

BUT

Users (target group: teenagers) have to evaluate the training success on their own.

EVALUATION FUNCTIONALITY

OBJECTIVE FEEDBACK?

3. Our Aim

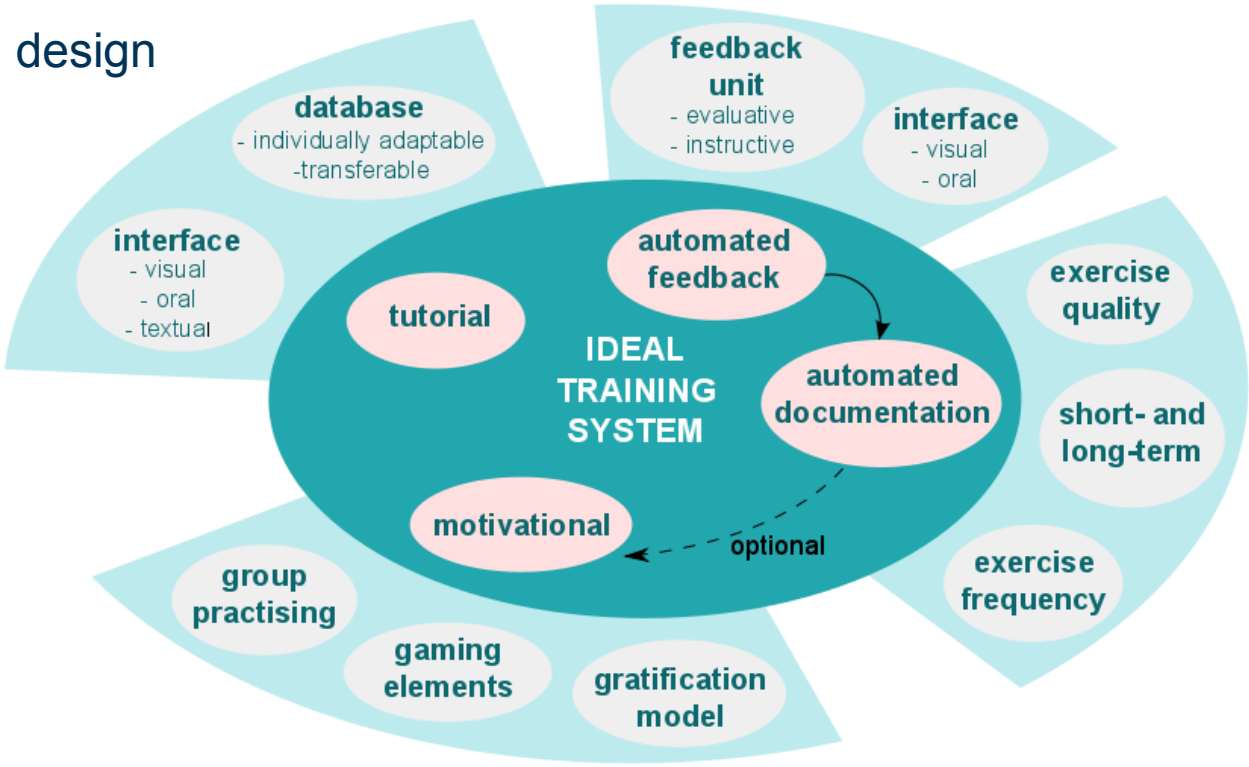
Development of an intelligent training platform

supporting

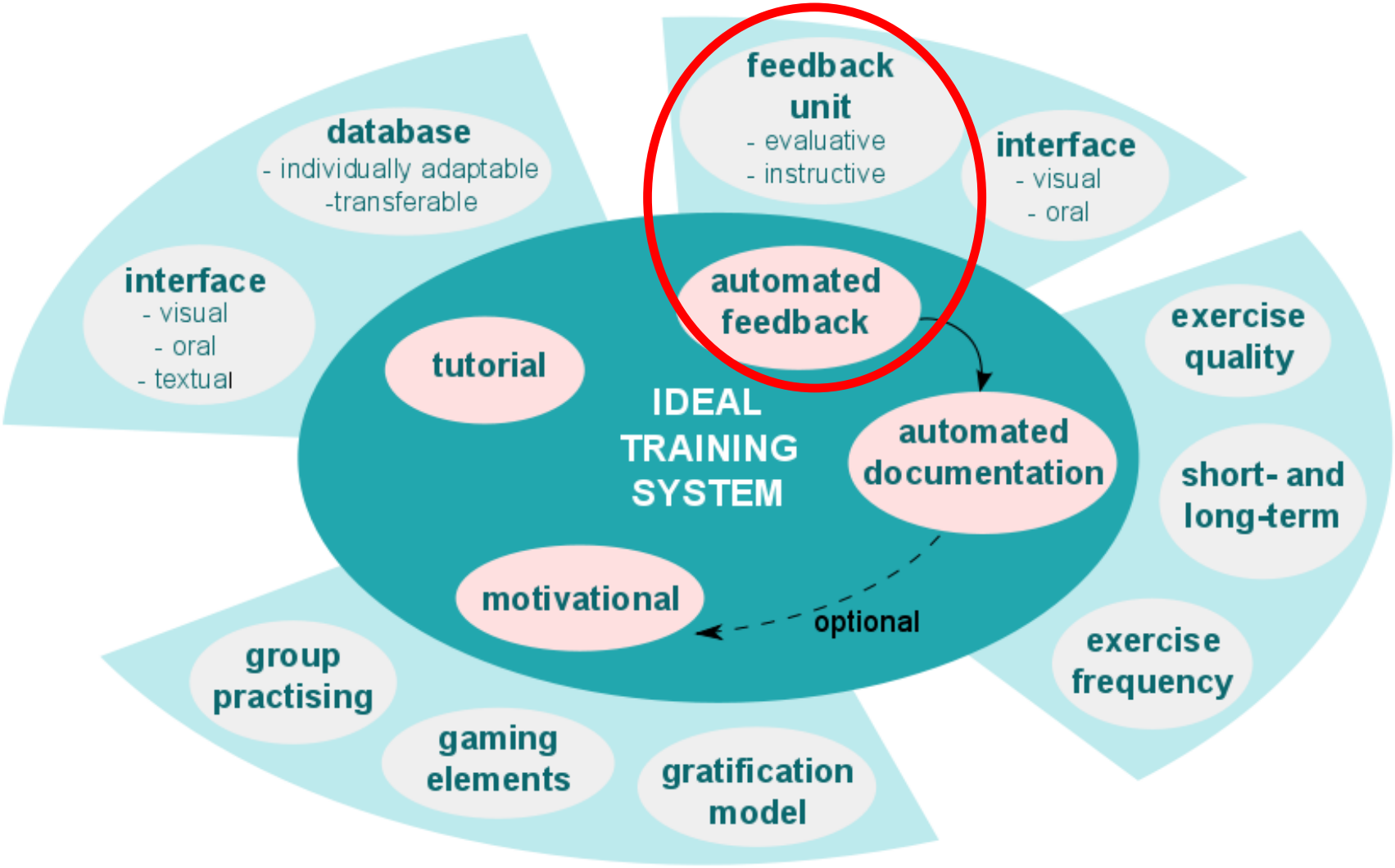
therapy and aftercare for persons with facial muscle dysfunctions.

4. Conceptual Design: Comprehensive Theoretic Model

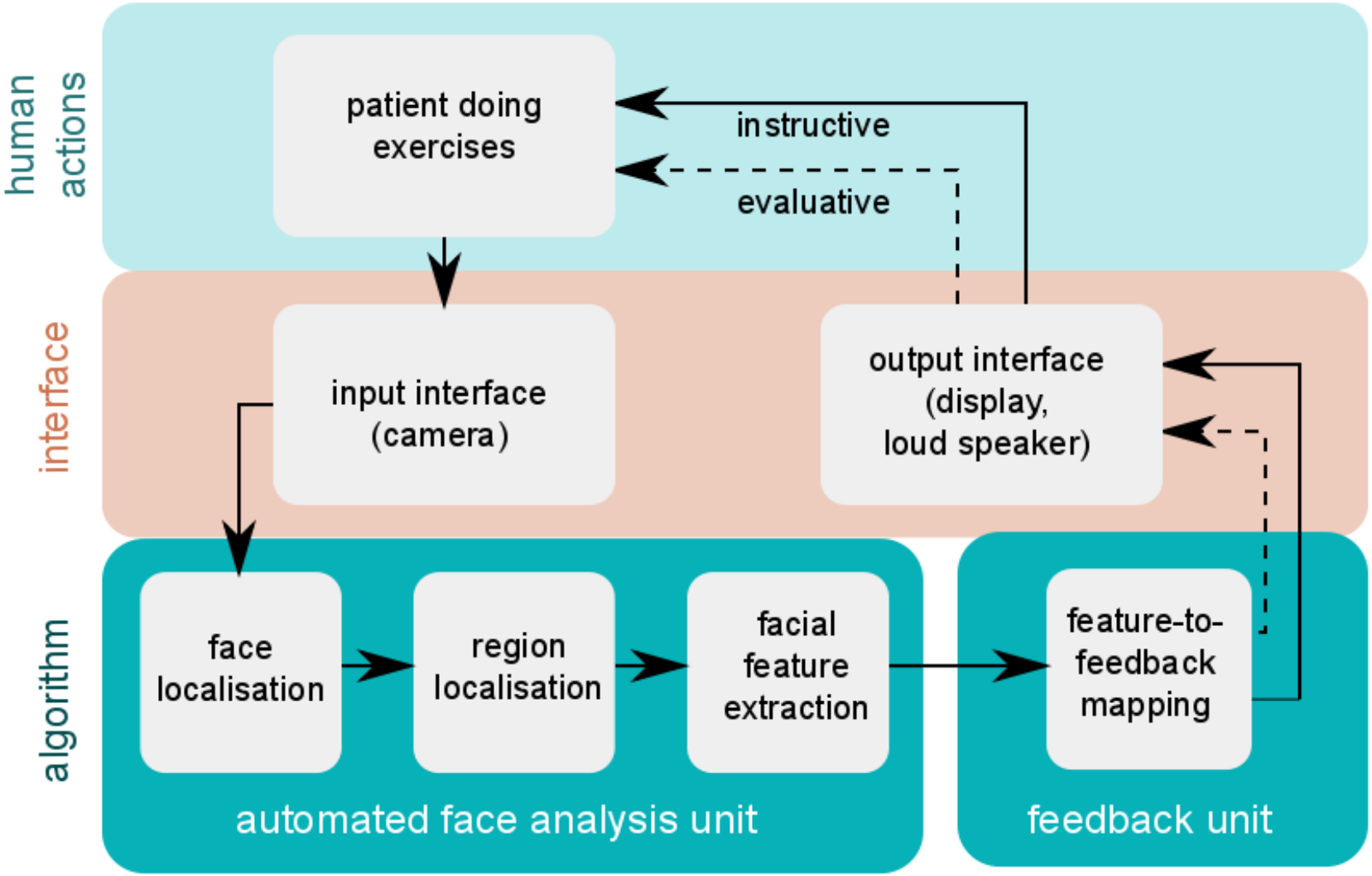
- suited for various systems of cognitive and physical stimulation
- more extensive than necessary for a single real-world application
- modular
- target user adapted design



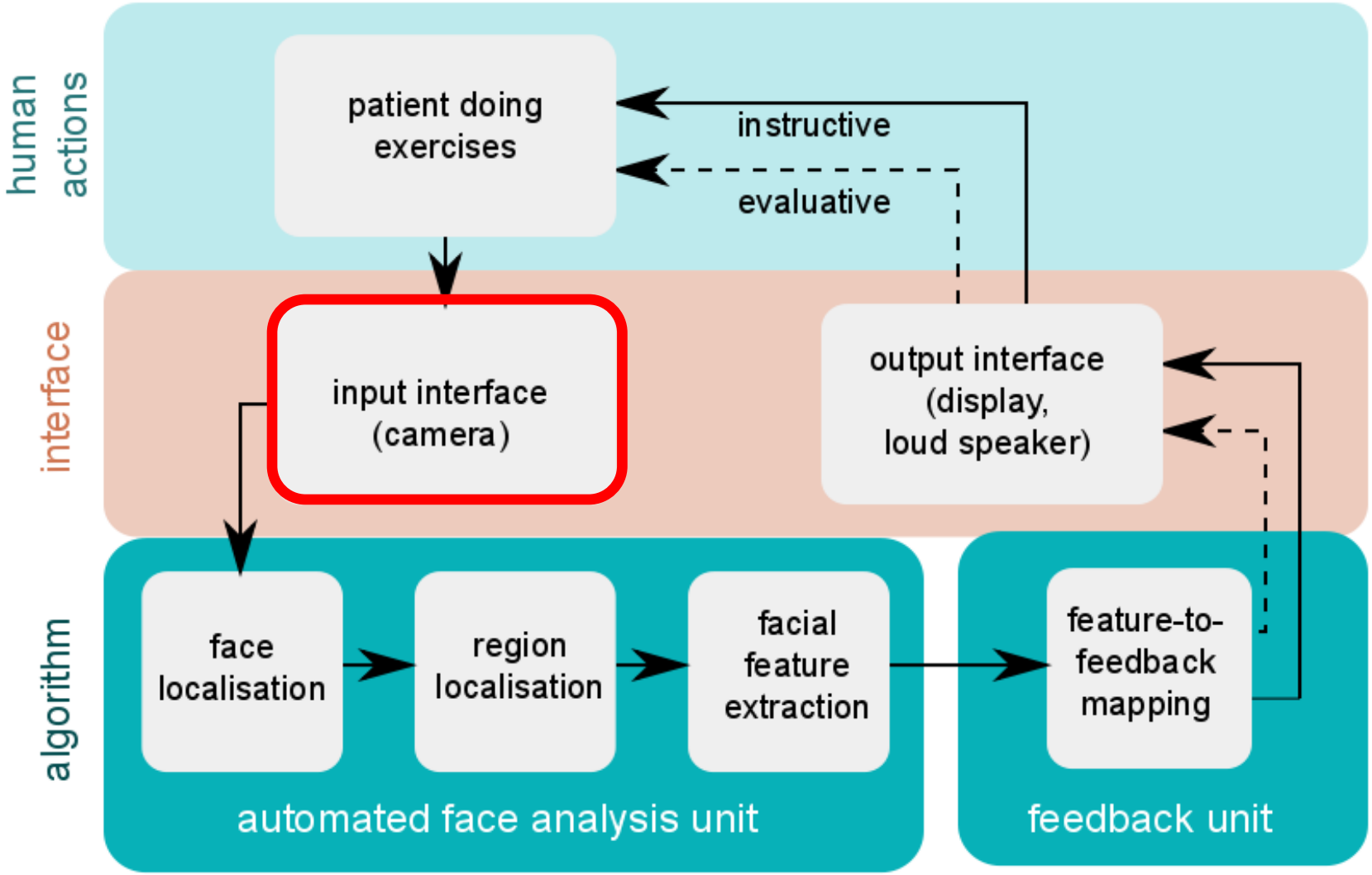
Conceptual Design: Comprehensive Theoretic Model (2)



5. State-of-Play: Overview of Workflow



State-of-Play: Overview of Workflow (2)

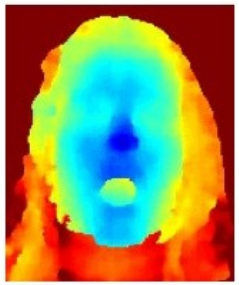
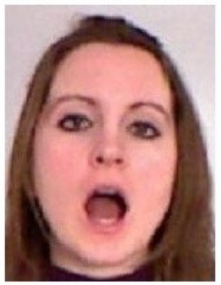
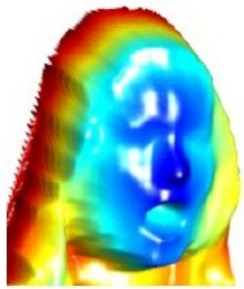


5.1 Input interface

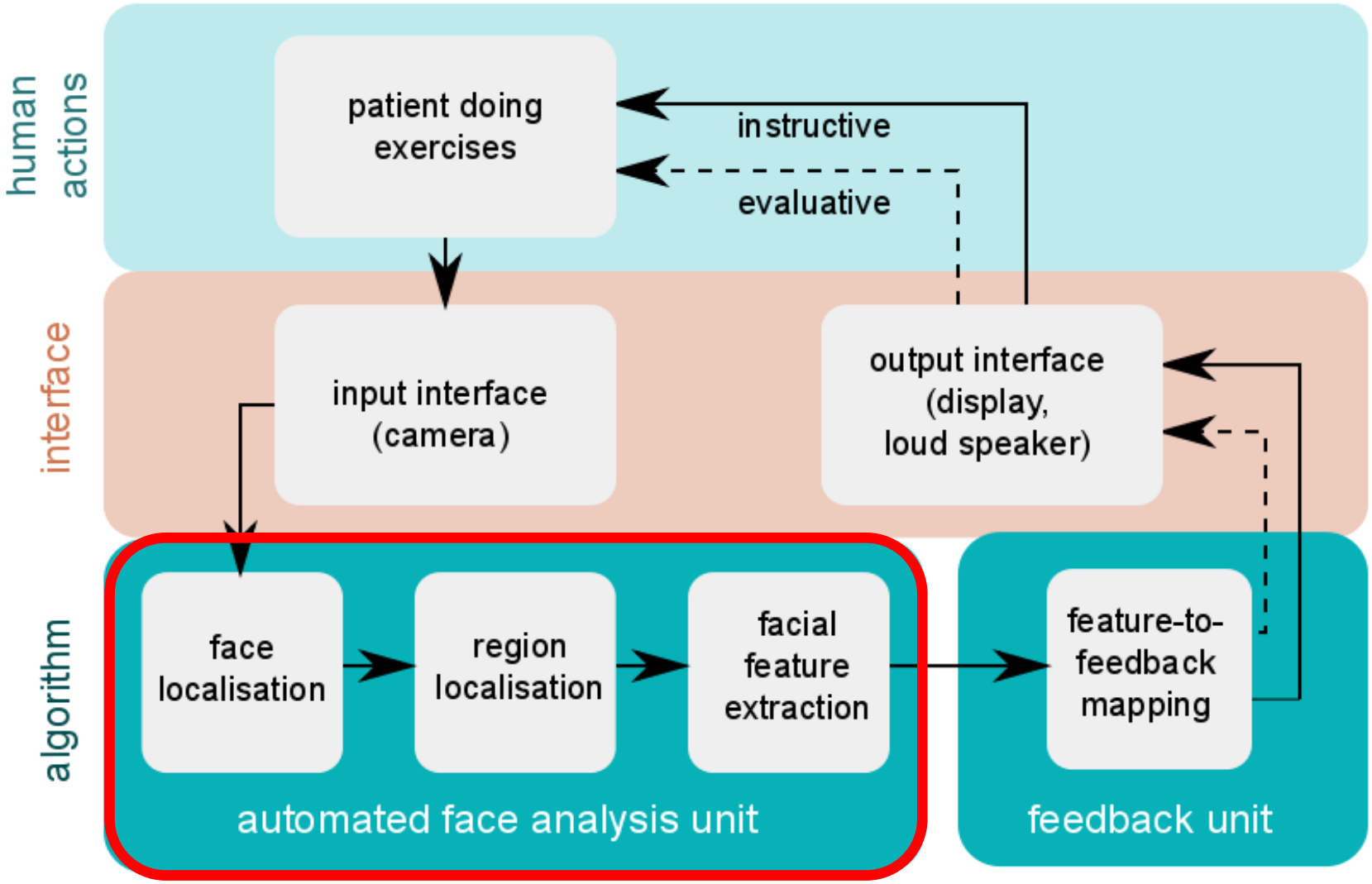
Which camera is suited?

- price
- availability
- various data types
  - RGB image
  - depth information
  - acoustic data (microphone)

Kinect

5.2 Automated Face Analysis Unit



5.2 Automated Face Analysis Unit

Task

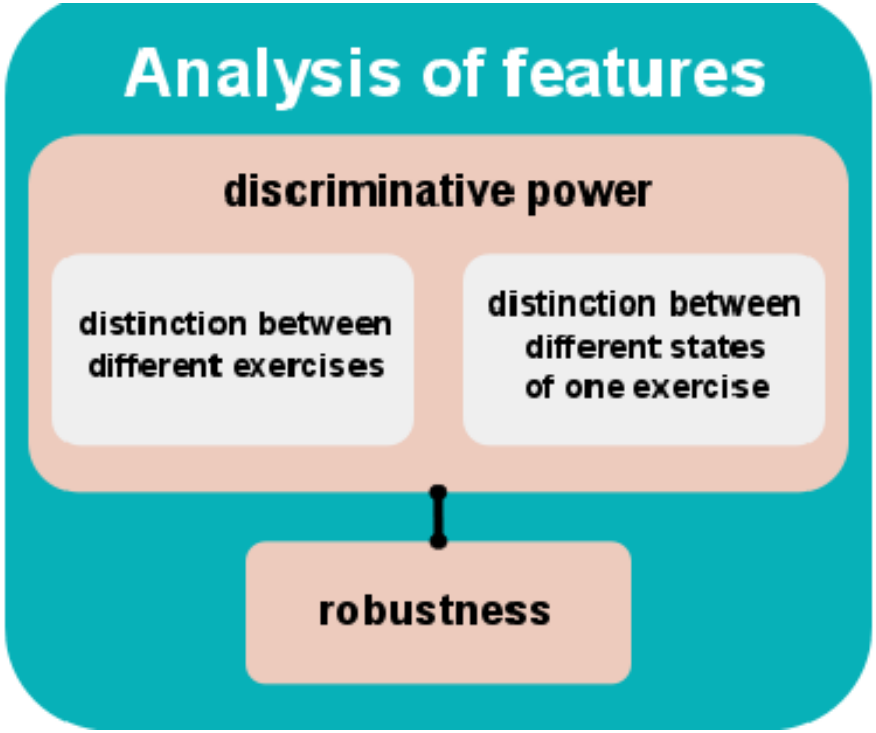
Analysis of the appearance of the face in order to derive information about the training performance

- **Extraction** of descriptive features from facial regions
- **Derivation** of feedback from these feature values

feature-to-feedback mapping

instead of

face-appearance-to-feedback mapping



5.3 Features: Which are suited?

Exercises that have been selected in cooperation with speech therapists

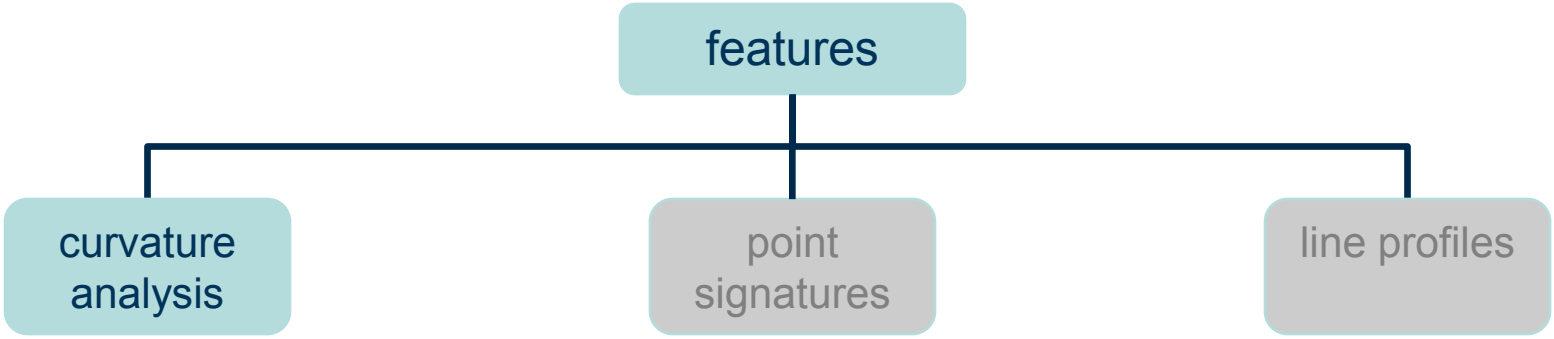
Exercises: **strong and manifold impact on the facial surface**.

- concave and convex regions (*kiss* vs. *both cheeks puffed*)
- wrinkles (*I-shape*)
- different types of bulges (*cheek boxing* vs. *cheek puffed*)

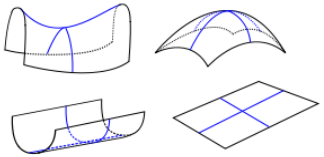
Depth features to capture the characteristics of the face surface

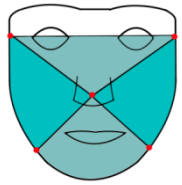
- curvature analysis
- point signatures
- line profiles

Features: Different types

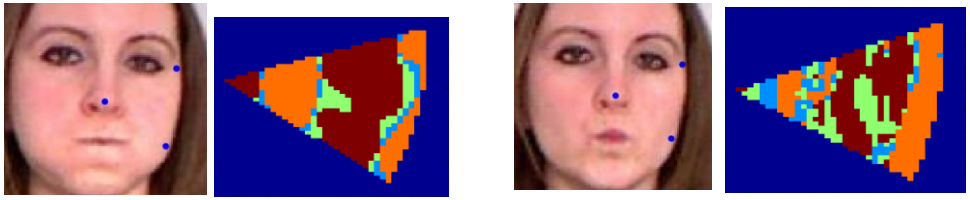


- **Curvature type** (*elliptic convex*, *hyperbolic concave* etc.) is detected for each pixel
- Face represented by 8.000 to 13.000 pixels → high dimensional feature vector → summarization with histograms
- To maintain spatial information: face is divided into four separate regions for feature extraction





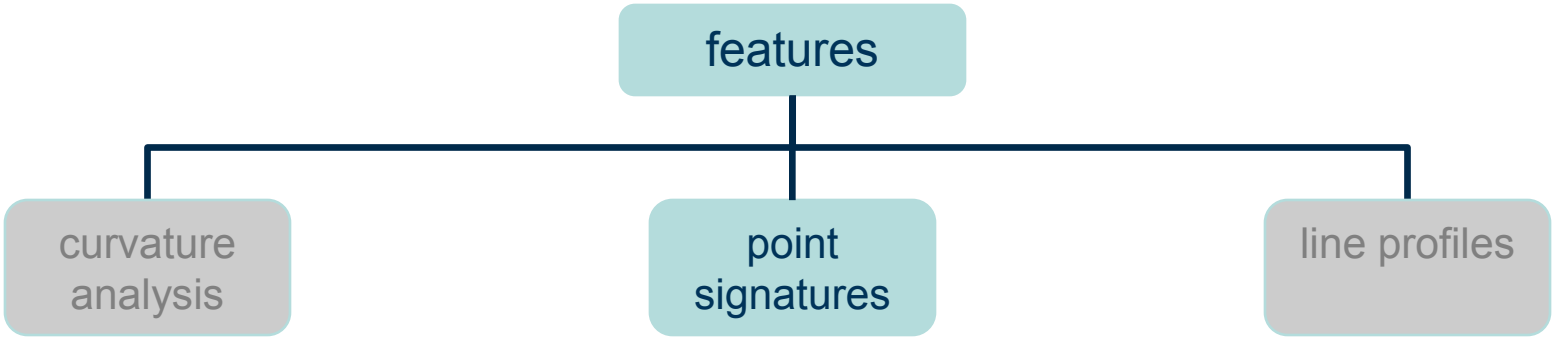
- Example:



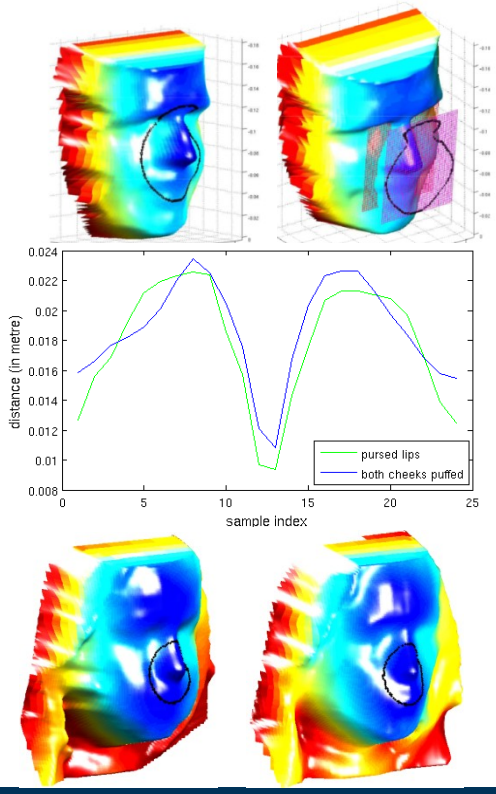
Person performing the exercise *pursed lips* and *both cheeks puffed*.
Curvature types represented by colours:

- brown: *elliptic convex*
- orange: *elliptic concave*
- green: *hyperbolic convex*
- blue: *hyperbolic concave*

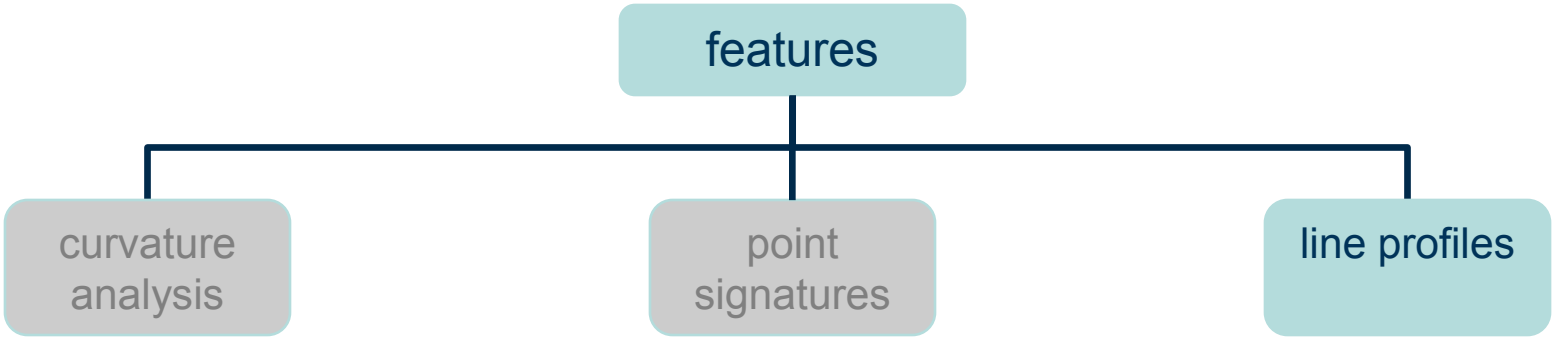
Features: Different types



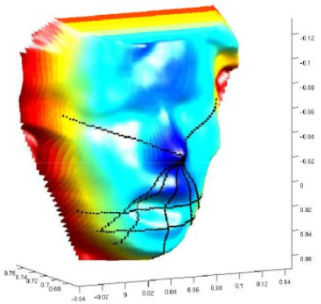
- **Radial intersection curve**: slope of the curve contains characteristic information about the area around a point
- All points on the curve have **constant distance** to the nose tip
- Several intersection curves with different radii
- Fitting of a plane to the intersection points → projecting the plane to the nose tip → distance between curve and and plane is sampled (24 samples) → feature vector → DCT for dimension reduction



Features: Different types

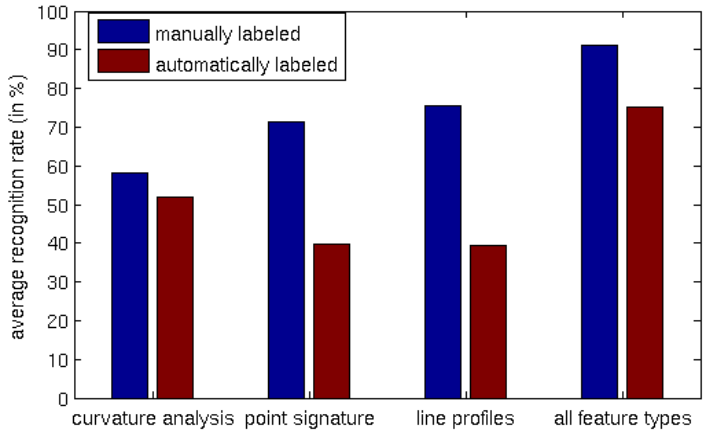


- Based on point signatures: **path along the face surface** (connecting landmarks instead of running radial around one point)
- 9 paths: each consists of *N* equidistant 3D points
- Invariance of the information to rotation and translation: Distance between neighbouring points is extracted → feature vector
- Again DCT on the feature vector for dimension reduction and to get a constant length for the feature vector.



5.4 Feature Evaluation: Exercise Recognition

- ***discriminative power***
  → features are extracted from manually labeled regions: 91,18%
- ***robustness***
  → regions automatically located (AAMs, curvature-based nose tip detection): 75,14 %



Feature types were evaluated:

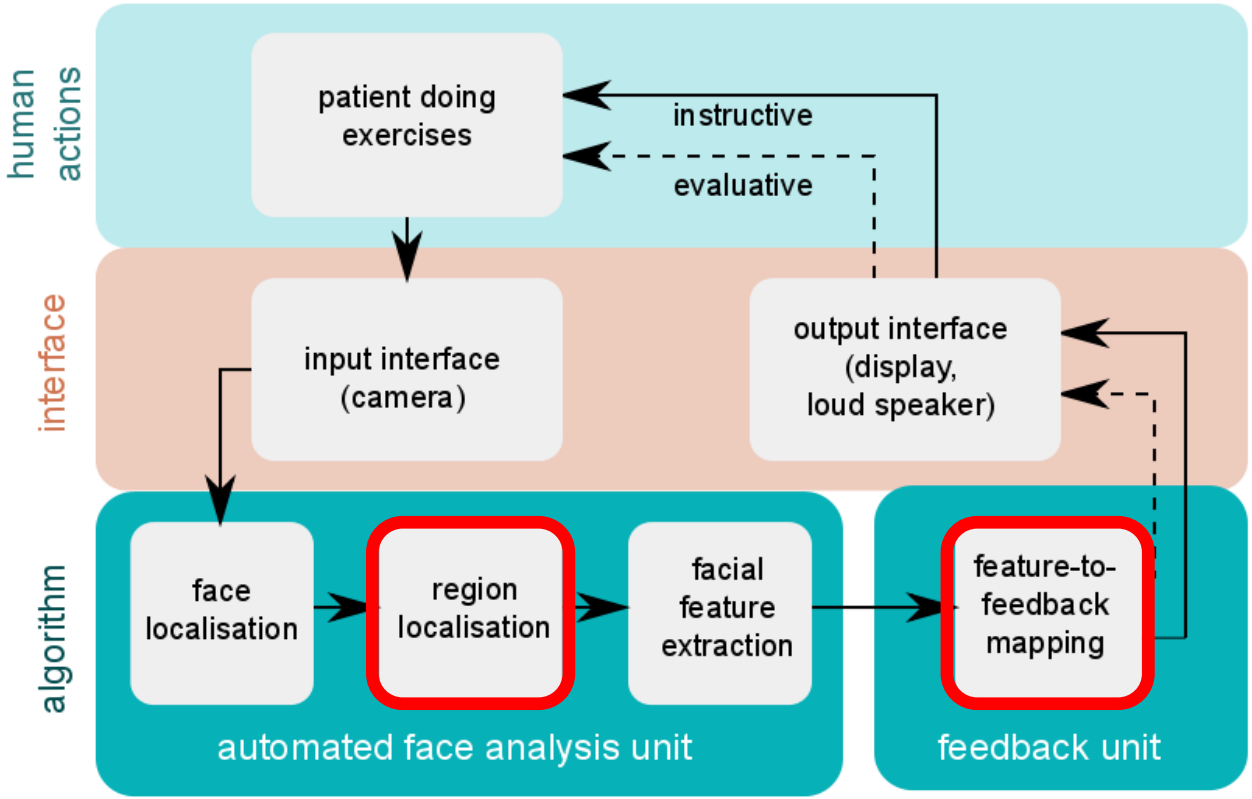
- individually
- in combination

Facts:

- 9 therapeutic exercises performed by 11 persons
- around 7 images → 696 images
- linear SVM
- linear discriminant analysis for dimension reduction
- leave-one-out cross validation + person in test image is excluded from training data

6. Future work

- Exercise evaluation
  - Instructive
  - Evaluative
- Landmark localization



Thank you for your attention!

….Questions?