Multi-Modal Human-Computer Interaction

Attila Fazekas

University of Debrecen, Hungary

IMAGE PROCESSING GROUP OF DEBRECEN
http://ipgd.inf.unideb.hu

Road Map

- Multi-modal interactions and systems (main categories, examples, benefits)
- Face detection, facial gestures recognition, etc.
- Body gesture detection
- Examples

Human-Centered View

- There are two views on multi-modal interaction:
- The first focuses on the human side: perception and control. There the word modality refers to human input and output channels.
- The second view focuses on synergistic using two or more computer input or output modalities.

The Modalities

- We can divide the modalities in seven groups
- Internal chemical (blood oxygen, etc.)
- External chemical (taste, etc.)
- Somatic senses (touch, etc.)
- Muscle sense (stretch, etc.)
- Sense of balance
- Hearing
- Vision

Definition of the Multimodality

- "Multi-modality is the capacity of the system to communicate with a user along different types of communication channels."
- Both multimedia and multi-modal systems use multiple communication channels. But a multi-modal system strives for meaning.

Two Types of Multi-modal Systems

- The goal is to use the computer as a tool.
- The computer as a dialogue partner.

History

- Bolt's Put-That-There system. In this system the user could move objects on screen by pointing and speaking.
- CUBRICON is a system that uses mouse pointing and speech.
- Oviatt presented a multi-modal system for dynamic interactive maps.

Benefits

- **Efficiency** follows from using each modality for the task that it is best suited for.
- **Redundancy** increases the likelihood that communication proceeds smoothly because there are many simultaneous references to the same issue.
- **Perceptability** increas when the tasks are facilitated in spatial context.

Benefits

- **Naturalness** follows from the free choice of modalities and may result in a human-computer communication that is close to human-human communication.
- **Accuracy** increases when another modality can indicate an object more accurately than the main modality.

Applications

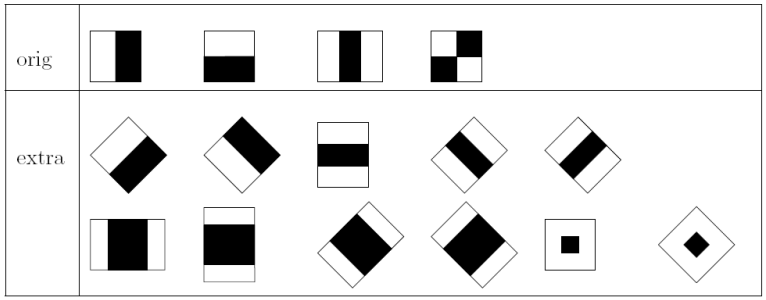
- Mobile telecommunication
- Hands-free devices to computers
- Using in a car
- Interactive information panel

Face Analysis

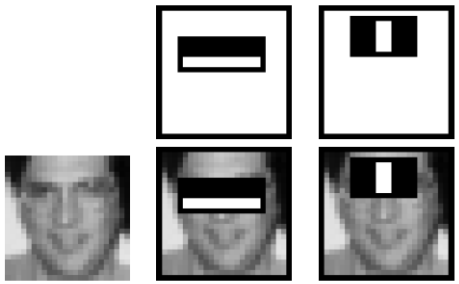
- Face carries a lot of important information in communication
- Monitoring the face is fundamental in HCI
- First step: **face detection** (**localization**)
- Using the localized face can be performed:
  - **Tracking face** and **facial features**
    - 2D face tracking, gaze estimation, head-shake detection
  - **Face classification**
    - gender, age, facial expressions, race
  - **Feature extraction**
    - skin/eye/hair color
    - mustache/beard detection

Face Detection/Tracking

- Viola and Jones detector is used
  - Face detection is reduced to image classification problem
- Given a set of feature types:



- Training:
  - positive (faces) and negative (random images) examples
  - those features are selected which fits on the positive set (finding position and their extent)
  - the selected features are collected into a cascade file
- Face detection
  - the different scale of the input image is scanned through
  - fitting the set of features:
    - if all are fitting => there is a face

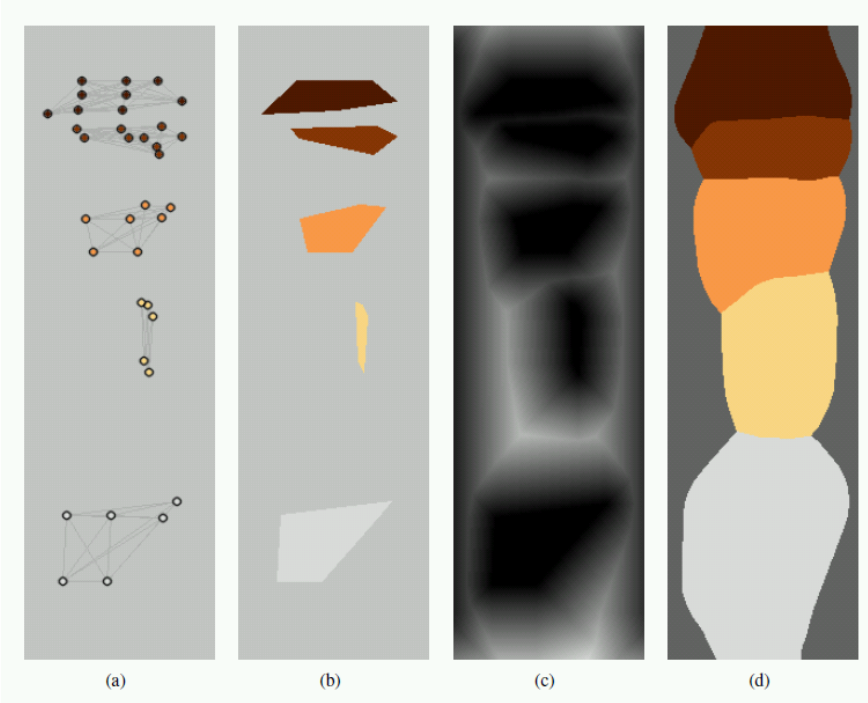


Face Classification

- Can be used for: gender, age, facial expression, race detection
- Preprocessing – for feature extraction
  - Cutting the face
  - **LBP transform**
  - Gabor transform
- Classification (using the model file)
  - **SVM**
  - AdaBoost
- Databases: Cohn-Kanade, FERET
- Currently we have the following classifiers trained (LBP+SVM)
  - Gender (male vs. female)
  - Facial expressions (happy, sad, surprised, angry)
  - Age estimation (10-29, 30-49, 50-)
  - Race (asian, hispanic, black, white)

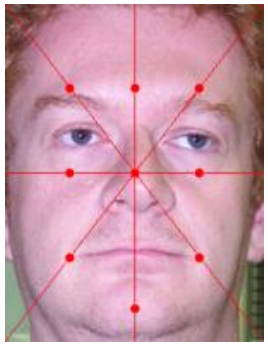
Facial Feature Color Extraction

- Determining the color of various facial features: skin, hair and eyes.
  - The full color range of the segmented face image will be reduced to color categories based on human cognition principles
  - The segmentation steps of the HI plane in case of hair colors: (a) color marker points, (b) convex hull, (c) distance transform and (d) the segmented plane:



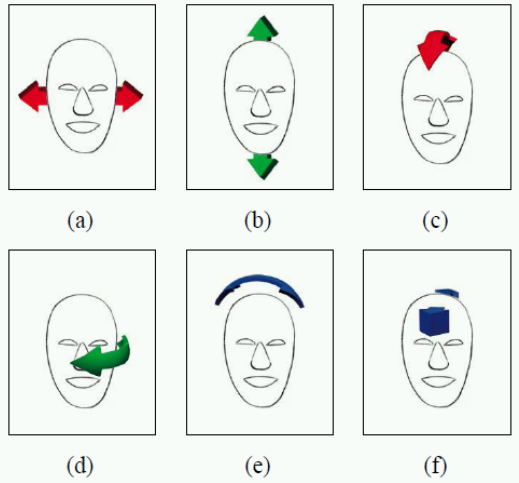
Facial Feature Color Extraction

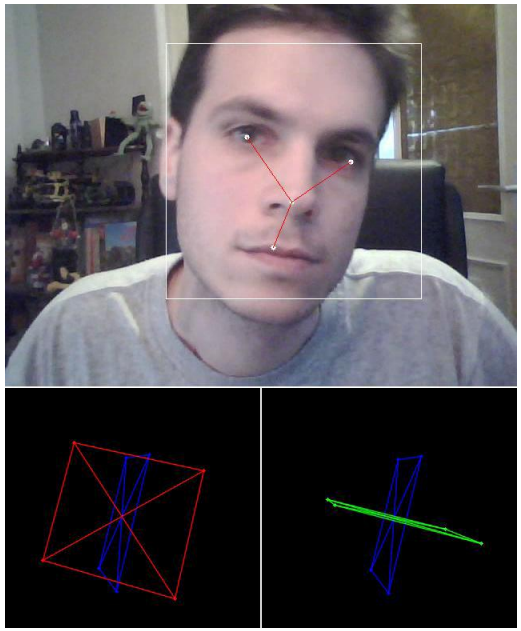
- The colors of the facial features are determined in two steps:
  - First, the skin, eyes and hair are segmented in the image using only structural information
  - Then, within the segmented regions the huge number of colors in real color images is substituted by a smaller color set, which is used to determine the color of a given feature.



Head-pose Tracking, Gaze Estimation

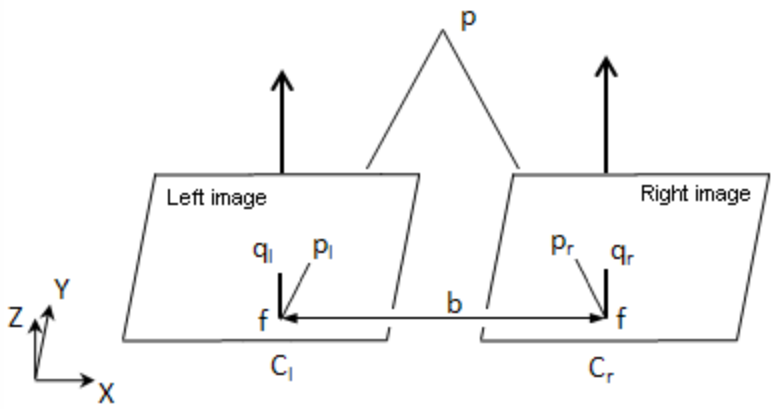
- Head pose estimation
  - Detecting the location of the facial features using individual feature detectors (Viola and Jones detectors):
    - eyes, mouth, nose tip
  - Based on the position of the facial features, the POSIT algorithm is used to estimate the three rotation and the translation vector of the head pose
- Further work:
  - Pupil tracking
  - Combining head pose with the position of the pupil for gaze estimation.





Body Gestures on Stereo Image

- Goal: estimate depth based on an image pair
- Parallel stereo configuration



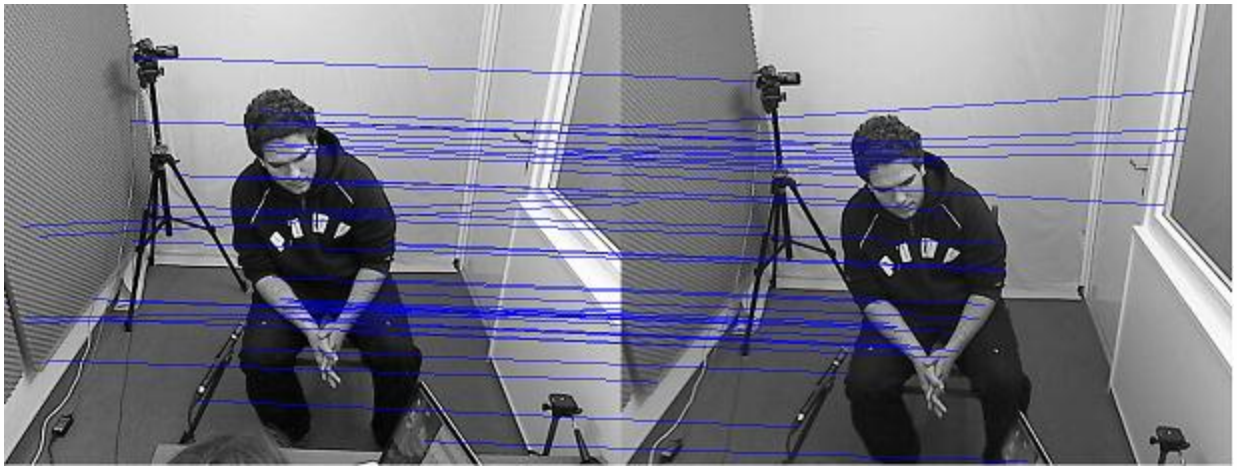
C_l, C_r - cams
f – **focal** length
b – baseline
λ - ratio:pixels/metre
$p_l(x_l, y_l)$
$p_r(x_r, y_r)$

- Disparity: $d = x_l - x_r$
- Depth estimation: $D \approx \frac{\lambda b f}{d}$

Computing Disparity

- Feature based approach
  - detect feature points (corners) on the both images
  - compute correlation between feature points on the different image
  - define stereo pairs
  - extend values (region growing, interpolation)

Computing Disparity

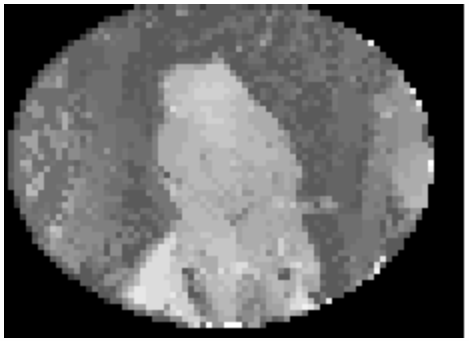


Problems:

- Too few matching pairs are there on the torso.
- Wrong matching on the similar areas.

Computing Disparity

- Decrease compute time:
  - Compute disparity on the inportant part (ellipse shape)
  - Computate disparity in the each intersection of 4. row and 4. column within ellipse, and extend disparity.
  - time: ~35ms



Computing Disparity

- Window based approach
  - Compute correlation between all the points pair of images at the same line.
  - Common correlation measure is Sum of Squared Difference

$$SSD(u,v) = \sum_{x,y \in W(u,v)} \left[L(x,y) - R(x-d,y) \right]^2$$

- SSD is sensitiv to lighting condition
- Our measure:

$$S(u,v) = \sum_{x,y \in W(u,v)} \left| (L(x,y) - L(u,v)) - (R(x-d,y) - R(u-d,v)) \right|$$

Computing Disparity

- Quality is depends on the size of window.
- Test:
  - Image size: 320x240
  - disparity range: 15-45
  - Window size: 11x11
  - time: ~900ms

Chess Player Turk-2

Thank you for your attention!