Imaging, Interaction, and Innovative Interfaces
@ the UCSB Four Eyes Lab

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Background: Computing has changed...

- **Function, form, and context** have all changed dramatically
- The *central data element* of computing has evolved:
  - Numbers
  - Text
  - Image
  - Audio+video
  - 3D
  - ...
  - *All data underlying communication*

- What are the implications for how we interact with computers?
The evolution of user interfaces

We’ve moved from:

Switches and punched cards [1950s]

to

Command-line interfaces [1970s]

to

Graphical user interfaces (GUI) [1980s]

to

... WHAT in the 21st century???
Some ideas...
Relevant interface technologies

- To develop powerful, adaptive, compelling interfaces that reach well beyond the GUI, researchers need to develop and integrate various relevant sensing, display, and interaction technologies, such as:

  - Vision (recognition and tracking of users)
  - Graphics, animation, visualization
  - Augmented reality
  - Haptic I/O
  - Tangible interfaces
  - Affective computing
  - User modeling
  - Speech recognition and synthesis
  - Natural language processing
  - Conversational interfaces
Vision Based Interaction (VBI)

• Visual cues are important in communication!
• Useful visual cues
  – Presence
  – Location
  – Identity (and age, sex, nationality, etc.)
  – Facial expression
  – Body language
  – Attention (gaze direction)
  – Gestures for control and communication
  – Lip movement
  – Activity

VBI – using computer vision to perceive these cues
UCSB Four Eyes Lab

4 I’s: Imaging, Interaction, and Innovative Interfaces

Directors: Matthew Turk and Tobias Höllerer
~12 PhD students and visitors, several MS and BS students

Primary research areas:
– Vision based and multimodal interfaces
– Augmented reality and immersive environments
– Wearable and mobile computing
– 3D graphics
– Interactive multimedia
– ….

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Four Eyes Lab: General motivation

• Provide better, more compelling HCI technologies in a variety of important computing environments
  – Desktop, immersive, VR
  – Mobile, AR, ubiquitous

• …and for a variety of application areas
  – Science, entertainment, information visualization, collaboration…

• Investigate fundamental issues in developing robust, real-time, working technologies for interactive systems
  – Computer vision
  – Computer graphics
  – Human-computer interaction
Some Four Eyes Lab projects
1. HandVu: Gestural interface for mobile systems

- Goal: To build highly robust CV methods that allow out-of-the-box use of hand gestures as an interface modality for VR and AR
Hand tracking
Example application
An Augmented Reality application
HandVu software

- A library for hand gesture recognition
  - A toolkit for out-of-the-box interface deployment

- Features:
  - User independent
  - Works with any camera
  - Handles cluttered background
  - Adjusts to lighting changes
  - Scalable with image quality and processing power
  - Fast: 5-150ms per 640x480 frame (on 3GHz)

- Source/binary available, built on OpenCV
2. Multiview 3D hand pose estimation

- Appearance based approach to hand pose estimation
  - Based on ISOSOM (ISOMAP + SOM) nonlinear mapping
- A MAP framework is used to fuse view information and bypass 3D hand reconstruction
The retrieval results of the MAP framework with two-view images
3. Facial expression analysis (2D → 3D)

- Facial expression representation and visualization
- Use non-linear manifolds to represent dynamic facial expressions
- Intuition:
  - The images of all facial expressions by a person makes a smooth manifold in (high-dimensional) image space, with the “neutral” face as the central reference point
Manifold visualization of expression
3D

deformation transfer

standard model

embedding

expression mapping functions

models in training videos

generalized expression manifold

synthesized expressions for editing
4. Surgeon-computer interface

Uses depth data (stereo camera) and video
5. Continuous Multimodal Biometrics

\[
P(Person\text{Present}_t|e_1,\ldots,e_t) = \begin{cases} 
\frac{p_{\text{genuine}}}{p_{\text{imposter}}} & 
\frac{p_{\text{absent}}}{p_{\text{genuine}}} 
\end{cases}
\]
6. Interactive FogScreen

- The FogScreen is a novel method for forming a high quality, physically penetrable dry fog display
- A walk-through screen
- Now with interactive applications
The convergence of research and innovation.
7. Multi-flash imaging and applications

- Goal: Use active illumination to detect depth discontinuities in images
  - Much more useful than intensity edges

- General idea:
  - Take $N$ images with $N$ differently located flashes
  - Reason about the cast shadows to determine depth discontinuities
  - Application #1: Non-photorealistic rendering
  - Application #2: Finger spelling (for sign language recognition)
Ratio images and directions of epipolar traversal

Shadow-Free Depth Edges
Application: Nonphotorealistic rendering
The convergence of research and innovation.
Application: Medical imaging

Tan, Kobler, Feris, Dietz, and Raskar (MICCAI’04)
Application: Reducing specularities
Flash Image

Our Result
Application: Finger spelling recognition

- We are using the multi-flash camera to pursue vision-based finger spelling recognition using depth discontinuities

- Part of sign language
  - Lots of occlusion!
Multi-flash stereo vision

- Combine multi-flash imaging with stereo vision
  - Not knowing depth discontinuities has always been a problem in stereo correspondence matching!
Conventional 9x9

Conventional 31x31

Our Approach 31x31

--- Conventional Stereo

Our Approach

RMS

--- Conventional Stereo

--- Our Approach

Window Size
...and more

• Several other projects in areas such as
  – Semi-automated video annotation
  – Mobile augmented reality systems
  – Human tracking for security and surveillance
  – Interfaces for 3D scene reconstruction
  – 3D immersive displays
  – ...

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Media Arts and Technology (MAT)

Media Arts and Technology is an interdisciplinary graduate program at UCSB, founded to pursue emerging opportunities for education and research at the intersection of Art, Science, and Engineering.