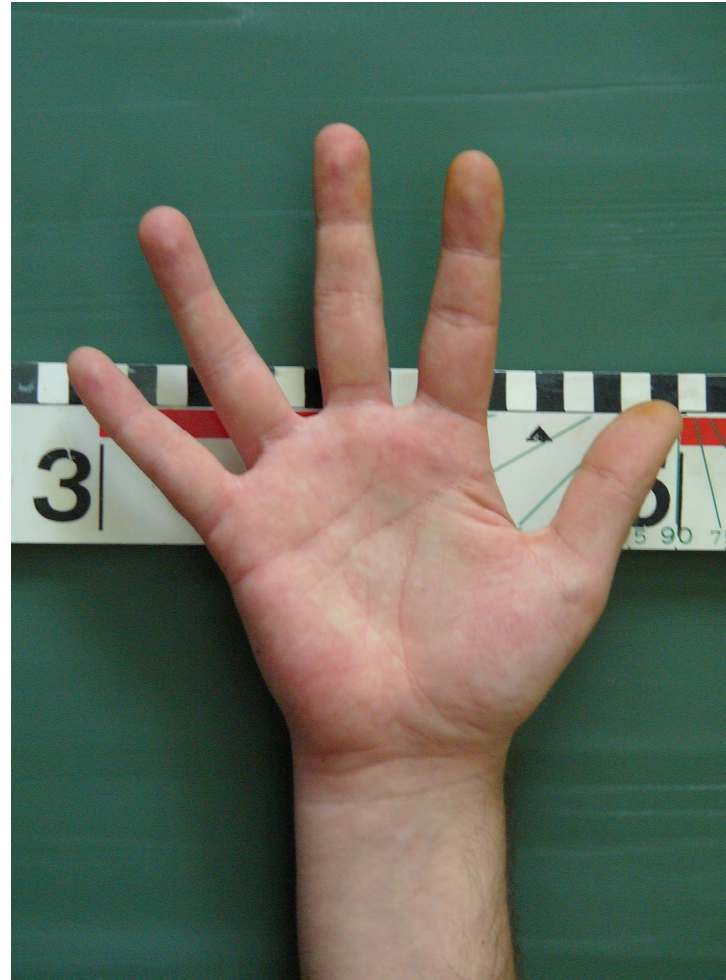# Real-Time Camera-Based 3D Hand Tracking

Daniel Mohr & Gabriel Zachmann

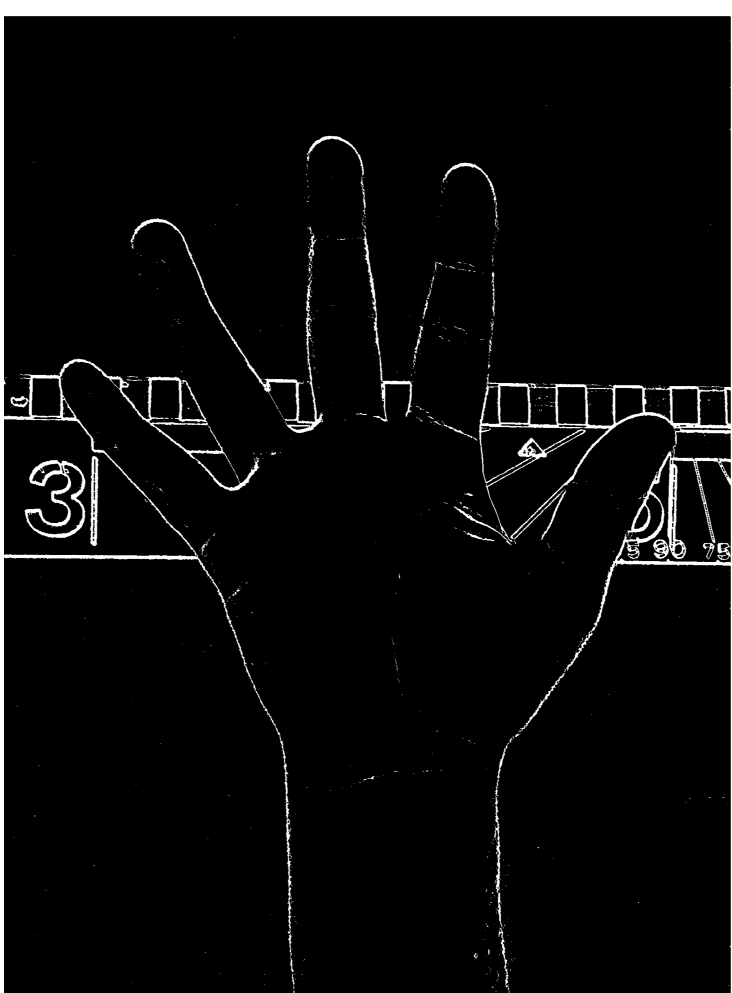**Goal:**
- Observe hand with cameras
- Determine hand position and state in real-time

Challenges:
- Measurement noise
- Mutual occlusions
- High dimensionality (27 deg. of freedom, 6 *global* pos. & orient. 21 *local* joint angles)
- Fast hand motions
- Large working volume

Our Model-Based Approach

Task 1: Edge Detection
Challenge:
- Cluttered background
- Illumination / shadows

Solution:
- Convolution (Sobel, Laplace)
- Canny edge detector
- Morphological filter (reduces artifacts)

Task 2: Skin detection
Challenge:
- Uncontrolled illumination
- Different skin types
- Ambiguity (same color for skin and non-skin pixel)

Solution:
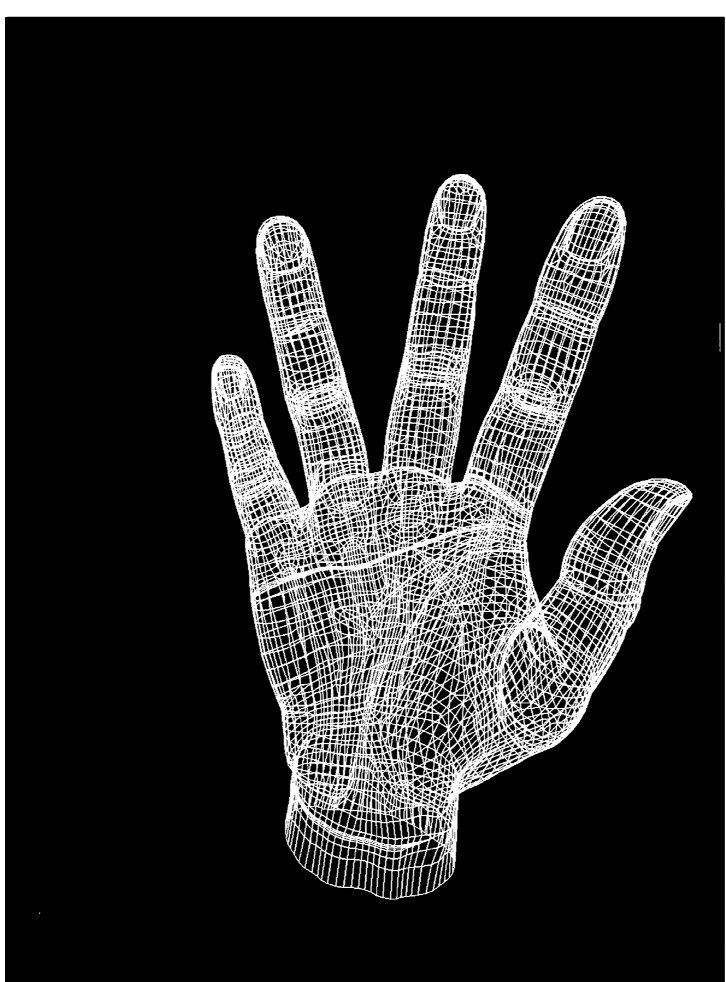- Histogramming / machine learning
- Morphological filter

Task 3: Find silhouette
Challenge:
- False positives and false negatives from edge and skin detection

Solution:
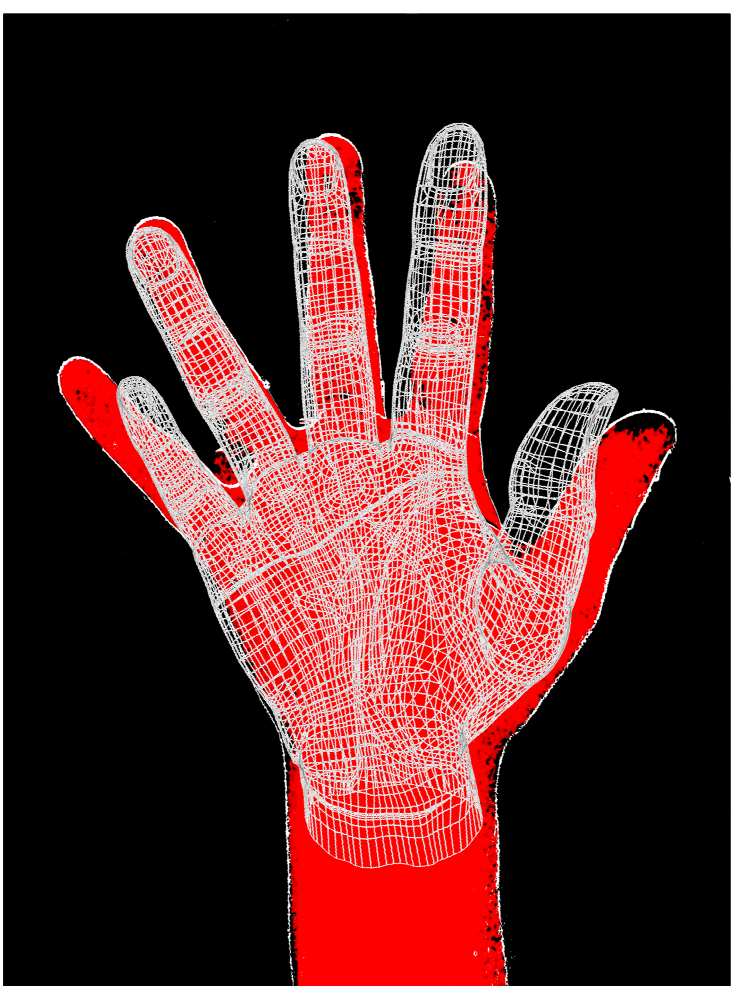- Combine edge & skin detection (e.g. active edges)

Task 4: Generate hand model
Challenge:
- Complexity of hand model
- Different people, different hands

Solution:
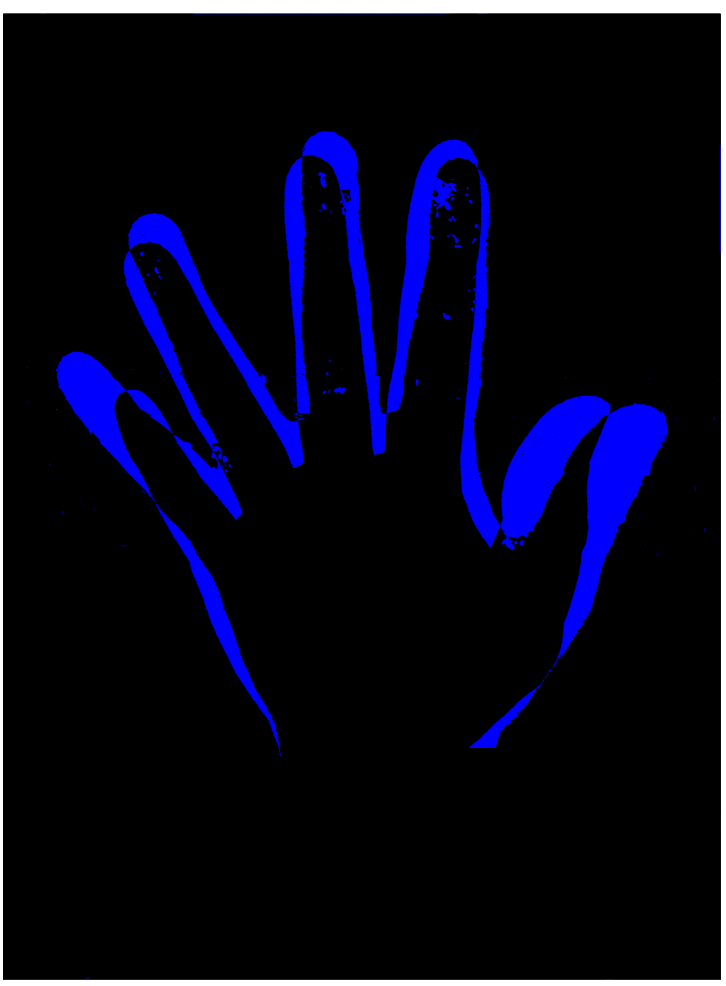- Use simplified hand model (cylinders / triangle-mesh)
- Adapt model at runtime

Task 5: Determine new hand state / position
Challenge:
- High-dim. search space
- Hand moves in 3D, contour lives in 2D

Solution:
- Project hand model
- Define penalty function
- Minimize function

Task 6: Improve performance and reliability of task 5
Challenge:
- Goals mutually contradicting

Solution:
- Reduce problem dimension (PCA, LLE, Isomap)
- Predict hand state using knowledge of previous states
- Importance Sampling, Particle Filter