LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

LFE Medieninformatik • Eric Rademacher

DigitSense

Grasp Recognition Using Fingerprint Sensors

Medieninformatik Oberseminar
Sommersemester 2010
Antrittsvortrag Masterarbeit
Betreuer: Raphael Wimmer
Verantwortlicher Hochschullehrer:
Prof. Dr. Heinrich Hußmann

Goal

Grasp Recognition: How is the object lying in the hand?
Using Fingerprint Sensors: Which parts of the hand touch the sensors?

NOT about: orientation of the device in 3D space
BUT about: which part of the hand touches which surface

Wimmer et al, 2009 [1]

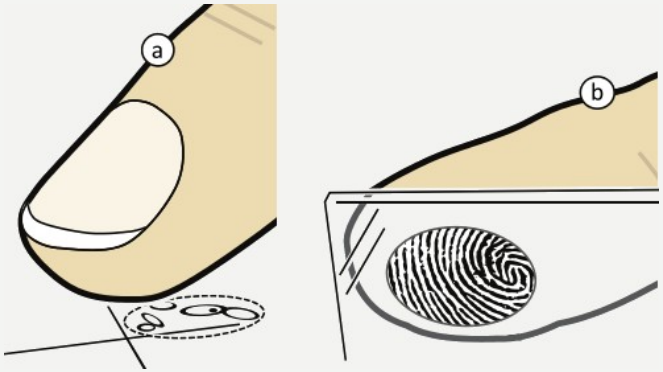
Motivation:
- Extending interaction interface to whole surface
- Using grasp as implicit or explicit interaction possibility
- Adjusting display interface to user‘s handedness
- Implicit user recognition

Related Work

Grasp Recognition: HandSense Wimmer et al, 2009 [1]
Grasp Recognition Using Capacitive Sensors
- 4 sensors => 80% correct estimates
- Very quick, no complex algorithms
- No user recognition possible

Wimmer et al, 2009 [1]

Fingerprint Sensors: Holz et al, 2010 [3]
Generalized Perceived Input Point Model
Increasing Touch Accuracy Using Fingerprints
- Calibration: storing fingerprints at different orientations
- Recognition: SURF Bay et al, 2006 [2] (Speeded Up Robust Features)



Holz et al, 2010 [3]

Challenges

Identify hand part on sensor in Real Time (Matching)
- Brute Force search (employing directional fields)
- Feature Extraction (SURF: Speeded Up Robust Features Bay et al, 2006 [2])
- Minutiae-based Matching

Derive grasp out of hand parts in Real Time
- 3D model fitting

Prototype
- Sphere input device with 5-6 sweep sensors
- Sensor model AuthenTec AES2501 [4] (9,8 mm * 0,8 mm)

User Study
- How reliably are grasps recognized among different users?


AuthenTec AES2501 [7]

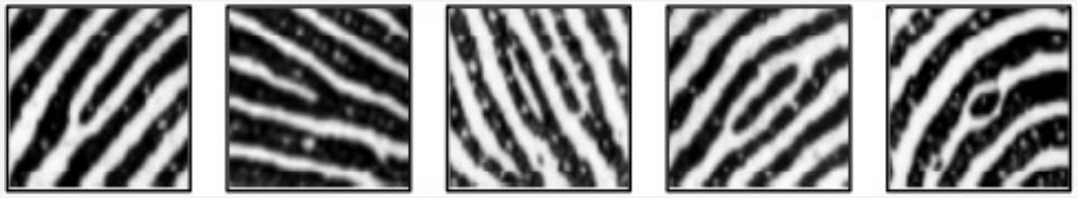
Fingerprints

Maltoni et al, 2009 [5]

- Fully developed at about 7 months of fetus development
- Structure partially geneticly, partially environmentally formed
- Do not change during a whole lifetime (except for bruises, scars...)
- Uniqueness not scientifically established fact, but empirical observation

- Structure:
  - Level 1:
    General ridge line flow
    and singularities

  - Level 2: Minutiae



  - Level 3: Ridge details and sweat pores: high-res images necessary

Matching

Approaches

Correlation-Based (Brute Force)

- Superimpose fingerprints and calculate a similarity measure
- On pixel-level extremely slow and vulnerable to image quality (skin condition, distortion...)
- For us: small slices often not unique enough

Minutiae-Based

- Most popular approach due to high reliability
- Many steps necessary for good results (image enhancement, binarization, thinning, minutiae detection, minutiae filtering) => slow
- For us: not each slice contains minutiae (on average ~1,76 minutiae/slice)

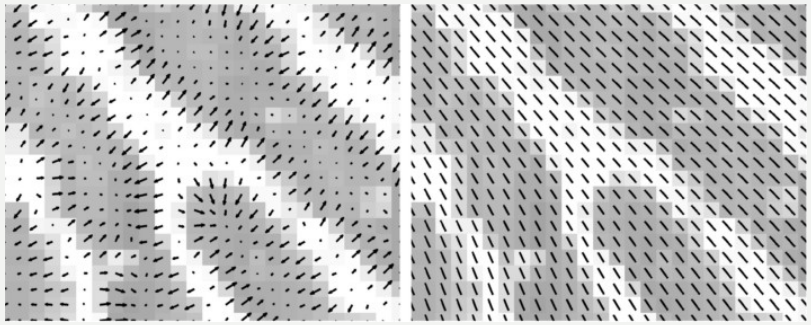
Feature-Based

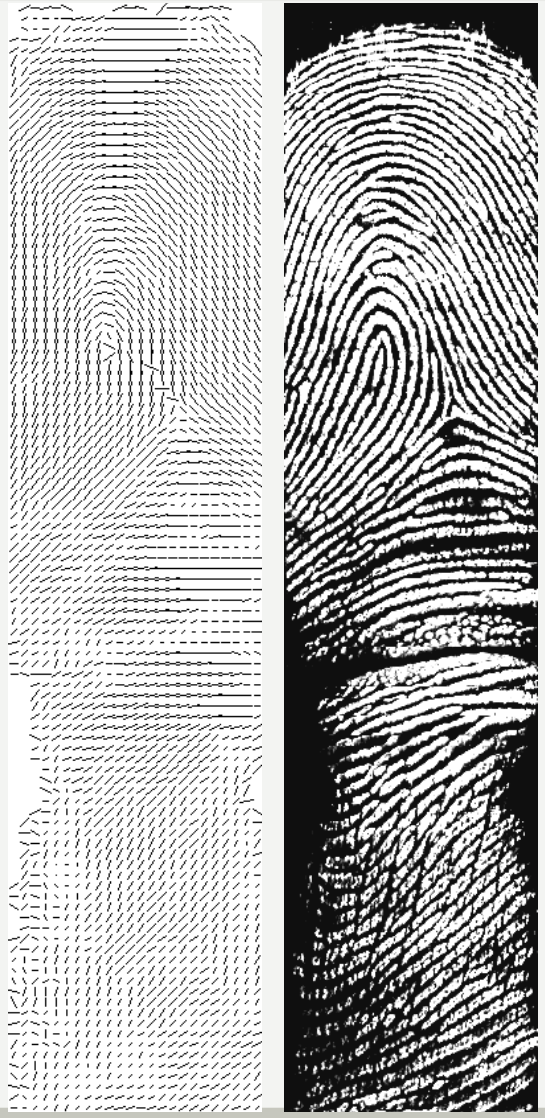
- Generic computer vision approach
- Promising, but no useful results yet with SURF

Directional Field

Bazen et al, 2002 [6]

Average of gradients on pixel level





Merged as blocks of 8 x 8 values
192 x 16 pixels => 24 x 2 orientations

Disadvantage: details like minutiae get lost

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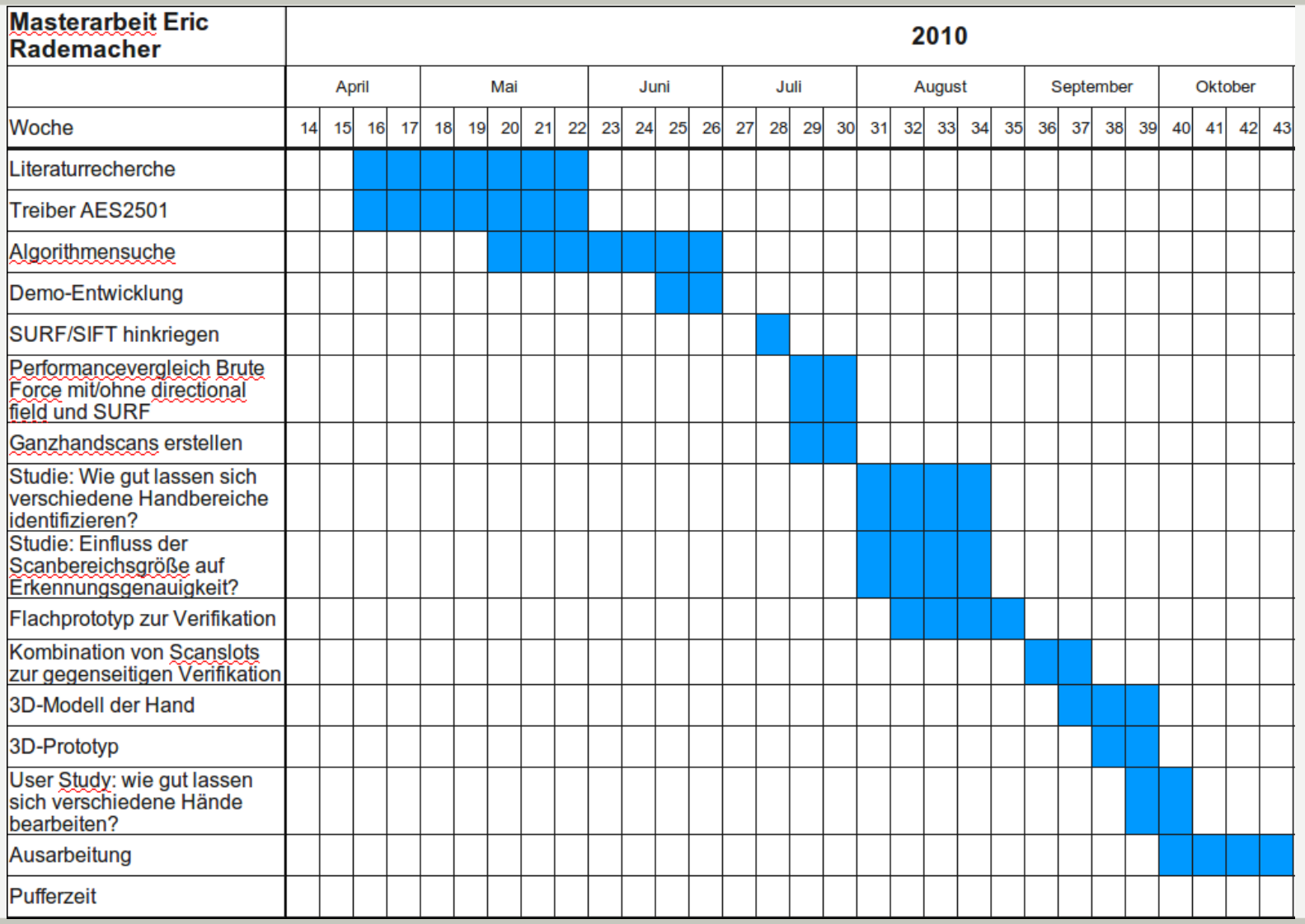
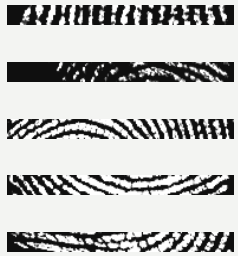
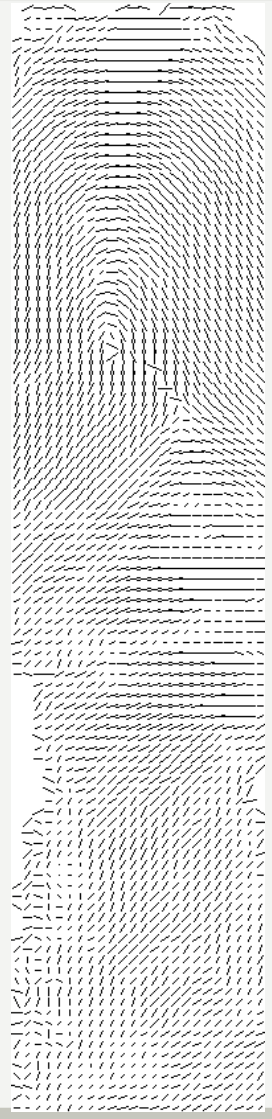
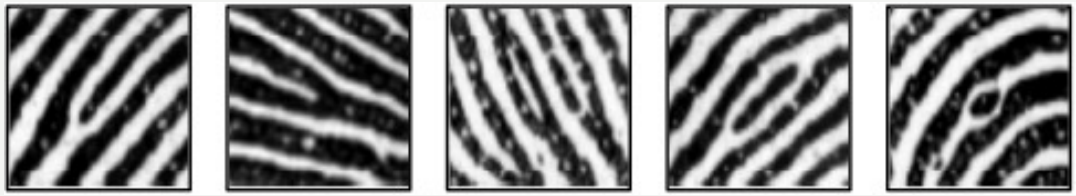






Fragen?



Resources

[1] R. Wimmer, S. Boring (2009). HandSense - Discriminating Different Ways of Grasping and Holding a Tangible User Interface. Proceedings of the 3rd International Conference on Tangible and Embedded Interaction - TEI '09.
[2] H. Bay, T. Tuytelaars, L. Gool (2006). SURF: Speeded Up Robust Features. ECCV 2006
[3] C. Holz, P. Baudisch (2010). The generalized perceived input point model and how to double touch accuracy by extracting fingerprints. Proceedings of CHI'10, pp. 581–590
[4] http://www.authentec.com/products-pcsandperipherals-aes2501b-spec.cfm
[5] D. Maltoni, D. Maio, A.K. Jain, S. Prabhakar (2009). Handbook of Fingerprint Recognition. ISBN: 978-1-84882-253-5
[6] A. Bazen, S. Gerez (2002). Systematic Methods for the Computation of the Directional Fields and Singular Points of Fingerprints. Analysis 2002, Volume 24, Issue 7
[7] http://www.griaulebiometrics.com/page/fingerprint_sdk/supported_readers