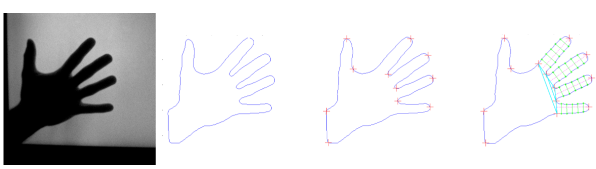
Show Your Hands: A Vision-Based Approach to User Identification for Interactive Surfaces

Dominik Schmidt and Hans Gellersen
Computing Department, Lancaster University
Lancaster, UK
{schmidtd, hwg}@comp.lancs.ac.uk

ABSTRACT
User identification opens up new interaction possibilities on interactive surfaces. Yet many current multi-touch systems only detect isolated touches and cannot identify users. This paper presents a low-cost, biometric method for user identification for vision-based interactive surfaces. To identify users, we extract characteristic contour features from a flat hand posture and use Support Vector Machines (SVM) for classification. Our evaluation shows the method's robustness together with high true and low false positive rates of 96% respectively 0.5%. We further outline possibilities to integrate this method with surface interaction techniques, taking into account that users have to perform distinctive hand postures to afford identification.

ACM Classification Keywords
H.5.2 Information interfaces and presentation (e.g., HCI):: User Interfaces—*Input devices and strategies (e.g., mouse, touchscreen)*



(a) (b) (c) (d)

Figure 1. Extraction steps: (a) raw camera image, (b) extracted contours, (c) high curvature points, (d) extracted hand features

INTRODUCTION
Multi-touch input allows users to interact in a direct and natural fashion with computers. By handling simultaneous input from multiple users, surface computing systems play an important role in facilitating co-located collaboration; hence much of the research in this area is focused on multi-user interaction. The ability to identify and keep track of users enables a new set of functionalities in this context, such as complex gestures [5], multiuser-aware interfaces [8], and access control [7, 9].

Due to their low-cost setup and easy scalability, vision-based surfaces are currently wide spread [10, 4]. Although they can track multiple points of contact, they cannot discriminate between different users. Hand geometry has been used in the context of control access systems [1]. It appears to be a promising candidate also for interactive surfaces because of its modest hardware (low resolution camera) and software (low computational cost algorithms) requirements. In addition, it does not require user instrumentation and can easily be integrated with existing systems.

RELATED WORK
User identity has been explored in the context of single- or shared-display groupware (SDG) before surface systems emerged. Stewart et al. [11] associate users to cursors respectively input devices and present a collaborative drawing application. External devices for interacting with a shared display are used in the Pebbles project [6]. On a conceptual level, Ryall et al. [8] introduced a framework of identity-differentiating widgets which gives rise to novel interaction techniques.

DiamondTouch [2] is a tabletop technology for front projected systems which supports user identification for up to four users. It uses capacitive coupling through the user who has to be in constant contact with a receiver. Dohse et al. [3] take a first step towards identifying users in a vision-based tabletop system based on where they are standing around a table. Boreki et al. [1] use a flatbed scanner to capture images of the isolated hand in the context of a control access system.

IDENTIFICATION METHOD
We equipped our vision-based surface system—a rear projected tabletop using the diffused illumination principle—with an overhead mounted camera for capturing hand silhouettes. Finger and hand tracking is initially independent. After aligning the different coordinate systems, we assign touches to a hand if they are contained in the corresponding contour. Hand geometry based identification demands gestures or postures which reveal distinctive features, such as finger widths or lengths. In line with prior work [1], we hence require the user to perform a flat hand posture, the fingers kept clearly apart, to afford identification. As the hands

are continuously tracked, users remain identified as long as their hands stay above the surface.

To afford identification, the user puts his hand flat on the surface. The hands' silhouettes are clearly set apart from the surface as it is amply illuminated with infrared light from below (Figure 1(a)). Images are captured with the overhead camera. After subtracting the background, we apply a binary thresholding filter and extract contours using the chain code contour extraction method (Figure 1(b)).

(a) Unrestricted multi-touch interaction (b) Activation of annotation mode (c) Only the owner can make annotations

Figure 2. Integration of hand geometry based user identification into interaction design

To localize hand extremities—i.e. finger tips and valleys—in a rotation and translation invariant way, we analyze the contour's curvature profile, as described by Boreki et al. [1]. However, in contrast to their system, we have to take into account that the whole surface is captured rather than an isolated area. Therefore, we do not only encounter multiple hands, but also have to deal with a variety of different shapes since parts of the arms might be visible, depending on how far users have to lean over the surface to reach a point. Consequently, these non-hand parts have to be ignored. We remove them by searching for a pattern of alternations in contour direction which is characteristic to the five spread fingers. In the same way, unsuitable hand postures and objects other than hands can be excluded from further processing.

The lines connecting finger tips and center points between two adjacent finger valleys are extracted as the fingers' main axis and divided into six equally sized partitions (Figure 1(d)). For each finger, we select the length of the main axis, widths at five equidistant points, and the mean width as features. In addition, we include the palm width as well as three distances between different finger valley points. Using these features, we evaluated the identification performance with Support Vector Machines (SVM), a supervised classification method, on a basis of 544 hand images stemming from 17 different subjects. Results show that the system can robustly identify different users, achieving true positive rates of 96% while mainting false positive rates of 0.5%.

We adopted a scenario described by Morris et al. [5] to illustrate a possible application of our method. Here, unrestricted multi-touch interaction is possible throughout the application, i.e. users can move, scale, and rotate arbitrary photos (Figure 2(a)). However, authorization is required for sensitive actions, such as annotating photos. By using the flat hand posture as command to switch into a photo's annotation mode (Figure 2(b)), user identification is rendered implicit. In a different scenario, distinctive hand postures can be used to authenticate for interactions with sub-regions of the surface, similar to a mobile phone based concept described by Schöning et al. [9].

DISCUSSION & FUTURE WORK

We presented a robust, low-cost, biometric method for user identification for vision-based surfaces. While this approach simply requires an additional camera and no user instrumentation, it relies on distinctive hand postures to afford identification. We also showed an initial exploration of possible integrations with interaction techniques.

In future work, we are planning to test different hand postures and gestures for feature extraction to facilitate integration with interaction designs. Moreover, we are planning to evaluate the suitability of the outlined interaction techniques and further explore this design space.

REFERENCES

1. Boreki, G. and Zimmer, A. Hand geometry: a new approach for feature extraction. In *Automatic Identification Advanced Technologies '05.* (2005), 149–154.
2. Dietz, P. and Leigh, D. DiamondTouch: a multi-user touch technology. In *UIST '01* (2001), 219–226.
3. Dohse, K. C., Dohse, T., Still, J. D., and Parkhurst, D. J. Enhancing multi-user interaction with multi-touch tabletop displays using hand tracking. In *Advances in Computer-Human Interaction '08* (2008), 297–302.
4. Microsoft Corp. Surface. 04 Aug. 2009. `http://www.microsoft.com/surface`.
5. Morris, M. R., Huang, A., Paepcke, A., and Winograd, T. Cooperative gestures: multi-user gestural interactions for co-located groupware. In *CHI '06* (2006), 1201–1210.
6. Myers, B., Stiel, H., and Gargiulo, R. Collaboration using multiple pdas connected to a pc. In *CSCW '98* (1998), 285–294.
7. Ringel, M., Ryall, K., Shen, C., Forlines, C., and Vernier, F. Release, relocate, reorient, resize: Fluid techniques for document sharing on multi-user interactive tables. In *CHI '04 Extended Abstracts* (2004), 1441–1444.
8. Ryall, K., Esenther, A., Everitt, K., Forlines, C., Morris, M. R., Shen, C., Shipman, S., and Vernier, F. iDwidgets: parameterizing widgets by user identity. In *INTERACT '05* (2005), 1124–1128.
9. Schöning, J., Rohs, M., and Krüger, A. Using mobile phones to spontaneously authenticate and interact with multi-touch surfaces. In *PPD'08* (2008).
10. SMARTTech. Dvit: Digital vision touch technology, 2003.
11. Stewart, J., Bederson, B., and Druin, A. Single display groupware: a model for co-present collaboration. In *CHI '99* (1999), 286–293.