Posture, position & biometrics: guidelines for self-service technology

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POSTURE, POSITION & BIOMETRICS: GUIDELINES FOR SELF-SERVICE TECHNOLOGY

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Biometric technology provides an opportunity to improve identification security across a range of different transactions. This user-centred investigation examined the effect of position on the usability and accessibility of biometric devices. Using an approach based upon ISO 9241-11 Standard for Usability, the performance of fingerprint and palm vein technology was assessed for a self service context. Postures were also recorded and scored using the RULA posture assessment tool. The devices was tested at three heights, 1000mm, 1100mm and 1200mm and three angles 0°, 15° and 45°. Device position was found to significantly affect participants' satisfaction ratings and the postures they adopted. The palm vein device out-performed the fingerprint device. This investigation shows how the physical placement of biometric devices can affect the systems' performance, and has implications for its use in the self service environment.

Introduction

Biometric authentication systems are beginning to find application in customer-facing, commercial environments. Traditional authentication methods include token-based authentication, such as keys or cards and knowledge-based authentication such as passwords or personal identification numbers (PINs) (Jain, Hong & Pankanti, 2000). Knowledge and token based methods do not provide a high level of security as tokens can be borrowed, lost or stolen, while passwords and PINs can be shared with others, written down and forgotten. Biometric identification is an alternative approach to user authentication which is not thought to suffer from the same limitations as knowledge or token based authentication. Various physical and behavioural characteristics can be used in biometric systems such as fingerprints, irises, and signature or keystroke behaviour. Biometric characteristics cannot be borrowed, forgotten or easily stolen. Biometrics are often described as the future of user authentication and are seen as guaranteeing the presence of the legitimate user in a way that other approaches cannot.

Implementations of biometrics are more likely to be successful and accepted by users, if the technology is usable. Maguire (2001) highlights the benefits of having usable products as; increased productivity, reduction in errors, reduced learning and training times, improved user acceptance and a competitive advantage. All of these attributes would be beneficial to an implementation of biometric authentication technology.

Although the use of biometrics could improve security there are numerous issues that need to be considered before the technology can be implemented on a large scale. Previous research has shown that the physical placement of biometric devices has an effect on performance. Stanton, Theofanos, Orandi, Micheals, & Zhang (2007) found that the height of a four-digit, 'slap' fingerprint sensor affected usability. They found significant differences in transaction time, image quality and user preference as the height of the system was varied. Though height was assessed in this experiment, the effect of the angle of the sensor was not measured. Currently, there is no information about how the angle of biometric sensors affects the performance or usability of the technology.

If biometrics is to be widely used in self service technology such as self-checkout systems or automatic teller machines (ATMs) usability and accessibility become key issues. The self service environment is particularly demanding for technology as 'walk up and use' systems must accommodate a wide range of users with little or no training, supervision or external guidance. In these applications, usability and accessibility are critical; design features that have a small impact on usability may have a substantial impact on the success of the system as a whole.

Assessment Approach

The aim of this research was to investigate the effect of position on the performance of biometric sensors and determine the optimum placement location for such technology. This evaluation was designed to expand on the research carried out by Stanton et al (2007) and investigate the effect of device angle on usability. In this experiment a fingerprint sensor and a palm vein sensor were tested as examples of biometric technology based on characteristics of the finger and hand respectively. Measures of usability were based on the ISO 9241 Standard for Usability, which defines usability as "The extent to which a product can be used by specific users to achieve specified goals with effectiveness, efficiency and satisfaction in a specific context of use." In this evaluation these terms were defined as follows:

Effectiveness – measured through image quality scores
Efficiency – measured using participants verification times
Satisfaction – measured through a subjective comfort rating given by participants

The postures adopted by participants when using the technology, were assessed using the rapid upper limb assessment (RULA) method (McAtamney and Corlett, 1993). RULA is a postural assessment tool with a focus on the positions of the trunk and upper limbs, developed to distinguish between acceptable and unacceptable postures.

The mixture of objective and subjective measurements used in this study helps to provide a more comprehensive assessment of device usability.

Test Positions

Positions of the devices were selected using numerous design guidelines including: *Access to ATMs: UK Design Guidelines*, the Canadian B651.1-01 *Barrier-Free Design for Automatic Banking Machines*, and the *Australian Bankers' Association Industry Standards*. A pilot test was conducted to refine the selection of heights and angles to be used in the main study. A range of angles (-15° to 75° in the sagittal plane) and heights (950mm-1250mm) were tested in the pilot study. The heights and angles that were used in the main evaluation were selected from the range that performed best during the pilot test.

Method

A within subject design was used with each of the 37 participants using both the fingerprint and palm vein devices. Participants ranged in age from 18-65 years old and ranged in height from 1490-1980mm. 13 participants were female and 24 male. All participants were experienced ATM users and participated voluntarily this evaluation.

Participants enrolled using their right index finger and right palm. Enrolment involved participants presenting their palm or finger three times, so that a template could be created by the software. The technology was then tested at three heights (1000mm, 1100mm and 1200mm) and three angles (0°, 15° and 45°). As seen in figure 1, the devices were mounted on camera tripods allowing height and angle to be varied. Participants verified twice at each of the 9 height/angle combinations, using each of the biometric systems. Both the order of technology use and order of positions were counter balanced across participants. Once the participants had used the sensor in each position they were asked to rate how comfortable they found the experience using a 7 point Likert scale. At the conclusion of the experiment, participants' demographic information was recorded. Postures were scored using the RULA tool from video footage taken during the evaluation.

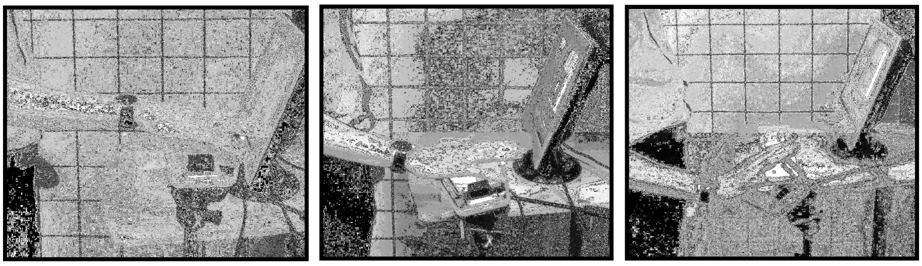

Figure 1. A participant using the palm vein device at three different angles

Results

The relevant parametric and non-parametric statistical test were used to analysis the data and significant results were significant to the .05 level or greater. All participants were able to enrol with the palm vein device. One participant could not enrol with the fingerprint device and two participants had difficulty enrolling. The position of the sensors was found to have a statically significant effect on their usability during verification. Table 1 below summarizes the significant effects of device position on the measures taken. These results suggest that the positions used in this experiment had a greater effect on the subjective measures of satisfaction and posture than on the objective performance measures

Table 1. Summary of the effect of position on performance

	Efficiency (Time)	Effectiveness (Image Quality)	Satisfaction (Comfort Rating)	Posture Score
Fingerprint	No	No	Yes	Yes
Palm Vein	Yes	N/A*	Yes	Yes

* The software did not allow for an image quality score to be recorded.

Comparison of Sensor Positions

In the interest of space not all significant effects are presented here. Overall, both the height and the angle had an effect on device usability. The results suggested that lower heights together with steeper angles should be avoided when positioning a fingerprint sensor. The 45°, 1000mm position for the fingerprint sensor caused participants to adopt the worst arm postures and participants gave this position the lowest comfort rating. The palm vein system also performed poorly in this position with 45°, 1000mm position rated significantly less comfortable than all of the other positions. Steeper angles at the 1200mm height were found to be more effective and than horizontal positioning.

Stature was found to have a significant effect on the postures adopted for both technologies, with shorter participants adopting significantly worse posture for higher positions and taller participants adopting significantly worse postures for the lower height positions. Other participant characteristics did not significantly affect interaction with the devices.

Comparison of Device Performance

Interaction with the palm vein device took significantly less time than interaction with the fingerprint sensor. The postures that the participants adopted whilst using the fingerprint device were significantly better than those adopted when using the palm vein device however. Participants preferred the palm vein device to the fingerprint device, giving reasons based on its ease of use, comfort and the design of the housing.

Discussion

The height of participants affected the measures taken suggesting that the height of the user population also needs to be considered when implementing biometrics. Participant heights in this evaluation covered the 2nd to 99th percentiles of European adult stature (values from People Size application) so the people who took part in this evaluation are fairly representative of the wider population.

The position of biometric technology affected the usability of these systems. The height of the sensors affected usability as did the angle that the technology was presented to the user. These differences were seen only in the subjective comfort ratings and the posture analysis however. Measures of effectiveness and efficiency were not significantly affected by device position. This suggests that the subjective or 'user centric' measures of this evaluation were more sensitive than the objective measures taken. Future studies of biometric technology should focus on subjective measures of usability rather than solely use measures generated by the technology itself. Using a greater range of subjective measure in future could help to provide better understanding of the usability issues of biometric technology.

Participants preferred the palm vein device over the fingerprint device. One possible explanation of this difference is that the palm vein system seemed to be less demanding, as the fingerprint system required careful finger placement. Another reason for the difference could be due to fingerprint device requiring blind placement of the finger, as the finger covers the sensor when it is placed onto the device and there is little indication of correct or incorrect placement.

The interface that guides the user through the process of enrolment and verification is also crucially important, as this will potentially have a large effect on the ease with which the device can be used. The device packaging, the casing around the sensor, will also have an impact on comfort and user interaction with the technology. Participants' comments in the experiment reflected this. A well designed device housing is likely to lead to better placement and better image quality.

Conclusion

This study found that the position of the biometric technology significantly affects the comfort rating and the postures adopted by the users. The positions that were most usable tended to the middle height tested and the horizontal angle. The palm vein device out performed the fingerprint sensor in this evaluation, although changes could be made to the fingerprint device to improve performance. The results extend on previous research described in the introduction to this paper. Specifically, the results presented here show the importance of considering the angle of biometric technology in addition to the height at which the sensor is positioned.

Biometric authentication does provide an opportunity to improve security in self service contexts though there are numerous issues that need to be considered before an implementation of biometric technology would be successful. This investigation addressed the problem of placement locations for biometric sensors, though other issues need to be investigated to better understand the usability and accessibility of biometrics. For instance an evaluation carried out with elderly users by Riley, McCracken & Buckner (2007) found that the vein based technology performed better than a fingerprint device. Participants who use wheelchairs should also be included in future evaluations to ensure that the most usable locations for biometric technology are also accessible. Wider contextual issues are important when it comes to biometrics and privacy issues and user acceptance also merit investigation.

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References

BSI/ISO 9241-11 (1998) Ergonomic Requirements for Office Work with Visual Display Terminals (VDTs) – Part 11: Guidance on Usability. British Standards Institute.

Jain, A., Hong, L. & Pankanti, S. (2000). Biometric Identification. *Communications of the ACM*, 43, 91-98.

Maguire, M. (2001). Methods to support human-centred design. *International Journal of Human-Computer Studies,* 55, 587-634.

McAtamney, L. and Corlett, E.N. (1993) RULA: a survey method for the investigation of work-related upper limb disorders. *Applied Ergonomics,* 24, 91-99.

Riley, C., McCracken, H. & Buckner, K. (2007) Fingers, Veins and the Grey Pound: Accessibility of Biometric Technology. Proceedings of the 25th Anniversary conference of the European Association of Cognitive Ergonomics (ECCE) 2007, London.

Stanton, B., Theofanos, M., Orandi, S., Micheals, R., & Zhang, N.-F. (2007). *Effects of Scanner Height on Fingerprint Capture* Paper presented at the Human Factors and Ergonomics Society 51st Annual Meeting, 2007, 592-596.