Skysong Innovations
Advancing the Arizona State University Knowledge Enterprise

1475 N. Scottsdale Road, Suite 200
Scottsdale, AZ 85287-3538
Phone: 480 884 1996 Fax: 480 884 1984

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Inventors

Duo Lu

Dijiang Huang

Contact

Shen Yan
shen.yan@skysonginnovations.com

A 3D In-the-Air Finger-Motion-Based User Login Framework for Gesture Interface

Background

Efficient user identification and authentication are crucial components of human-computer interfaces, allowing personalized access to resources, services, and private data. Current login procedures rely on either typed passwords or biometrics, which both present disadvantages. Typing passwords often involve inconvenient physical or touchscreen keyboards, and password strength requirements can result in decreased recallability by the user. Physiologically focused biometric login processes (e.g., facial recognition) can be effective with minimal user effort but can raise privacy concerns.

As the sensing and imaging capabilities of computer systems continue to evolve, gesture-based login methods can offer a viable alternative. Specifically, a framework based on in-the-air finger handwriting greatly improves user-friendliness yet is not subject to the privacy concerns associated with storing a user's static biometric attributes. However, several technical challenges exist for developing an in-the-air motion login platform, including: (1) accurate feature extraction of handwriting that tolerates natural variations and noise, (2) efficient indexing of a large volume of user accounts, and (3) effective data-driven model training from registered handwriting samples.

Successfully addressing these issues is crucial for integration into a wide range of applications including in virtual reality (VR), gaming, and medical settings where touchless interfaces can preserve cleanliness.

Invention Description

Researchers at Arizona State University have developed a unified login framework for in-the-air finger-motion user identification and authentication. Finger motion, captured by either a wearable inertial sensor or a 3D depth camera, is sent to a server as a login request. A compact binary hash code is generated from the motion signals for efficient searching within an in-air handwriting database via a hash table. An ensemble of Support Vector Machine (SVM) classifiers is trained for each account for user authentication, allowing accommodation of minor variations in writing behavior. A deep convolutional neural network (CNN) is used to index motion signals for user identification with constant time cost. With the aid of data

augmentation methods, the CNN is trained with limited amounts of data acquired at user registration.

Potential Applications

- Virtual reality
- Gaming
- Touchless interfaces for high-cleanliness environments

Benefits and Advantages

- Robust – Accommodates minor gesture variations during login
- Effective – Prototype achieves 0.1% and 0.5% Equal Error Rate (EER) for user authentication, and 96.7% and 94.3% accuracy for user identification
- User-Friendly – Gesture-based login allows quick and easy computer access
- Privacy-Preserving – Finger-motion login data can be changed as desired, and does not involve storage of physiological biometric features

Related Publication (PDF): FMCode: A 3D In-the-Air Finger Motion Based User Login Framework for Gesture Interface

Related Publication (PDF): FMHash: Deep Hashing of In-Air-Handwriting for User Identification

News Feature: A Hand Gesture Could Be Your Next Password (Fast Company)

Homepage of Professor Dijiang Huang