



Keystroke Authentication

It's All in How You Type

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Overview

What is Keystroke Biometrics

How Effective is Keystroke Biometrics

Advantages of Keystroke Biometrics

Markets for Keystroke Biometrics

Future for Keystroke Biometrics



$$\frac{1}{\sqrt{(\ell+m)(\ell-m+1)}} \frac{1}{\sin^{m-1} \theta} \frac{\partial}{\partial(\cos \theta)} \sin^m \theta e^{-i\ell Y_\ell^m}$$

What is Keystroke Biometrics

Biological Measurements

- ❑ Physical aspects of a person that determine identity
- ❑ Static measurement
 - ❑ Absolute match
- ❑ Quality of measurement is only variable by the quality of the capture device
- ❑ Examples:
 - ❑ DNA
 - ❑ Iris/Retina Scan
 - ❑ Fingerprint
 - ❑ Hand Geometry / Vein Structure
 - ❑ Facial Recognition



$$Y_{\ell}^{-\ell}(\theta, \varphi), Y_{\ell}^{-\ell+1}(\theta, \varphi), \dots, Y_{\ell}^{-1}(\theta, \varphi), Y_{\ell}^0(\theta, \varphi), Y_{\ell}^1(\theta, \varphi), \dots, Y_{\ell}^{\ell-1}(\theta, \varphi), Y_{\ell}^{\ell}(\theta, \varphi)$$

What is Keystroke Biometrics

Behavioral Measurements

- ❑ Characteristic traits exhibited by a person that can determine identity
- ❑ Dynamic measurement
 - ❑ Confidence match
- ❑ Quality of measurement varies by behavioral and other external factors
- ❑ Examples:
 - ❑ Keystroke Heuristics
 - ❑ Handwriting Analysis
 - ❑ Voice Verification
 - ❑ Language Removal Identification



$$\langle L_{\pm}^k Y_{\lambda}^m, L_{\pm}^k Y_{\lambda}^m \rangle = [\lambda - (m \pm (k - 1)) (m \pm k)] \cdots [\lambda - m(m \pm 1)] \langle Y_{\lambda}^m, Y_{\lambda}^m \rangle$$

What is Keystroke Biometrics

Pattern exhibited by an individual using an input device in a consistent manner

- ❑ Input Device
 - ❑ Keyboard, Keypad, Stylus, ...

- ❑ Raw measurements available by the input device
 - ❑ Dwell time
 - ❑ Flight time
 - ❑ Absolute versus Relative timing

- ❑ Factors
 - ❑ Timing / Cadence
 - ❑ Content
 - ❑ Spatial Configuration
 - ❑ Consistency (as well as consistent inconsistencies)

- ❑ Signature Processing
 - ❑ Deduction of key factors from an arbitrary data stream
 - ❑ Robotic vision, Economic trending, Quantum physics



$$L_{\pm} Y_{\ell}^{\pm \ell} \equiv \pm e^{i\phi} \left(\frac{\partial}{\partial \theta} \pm i \frac{\cos \theta}{\sin \theta} \frac{\partial}{\partial \varphi} \right) P_{\ell}^{\pm \ell}(\theta) e^{\pm i \ell \varphi} = 0$$

What is Keystroke Biometrics

History of the World, Part I

- ❑ **1979:**
 - ❑ Technology originally developed by SRI International.
- ❑ **1984:**
 - ❑ National Bureau of Standards (NBS) study concluded that computer keystroke authentication of 98% accuracy.
- ❑ **1988:**
 - ❑ Keystroke authentication hardware device passes NIST Computer Security Act of 1987.
- ❑ **2000:**
 - ❑ Keystroke authentication passes the Financial Services Technology Consortium (FSTC) / International Biometric Group (IBG) Comparative Testing program.
- ❑ **Patents (partial list):**
 - ❑ 4621344, 5557686, 4805222, 4962530, 4998279, 5056141



$$\sum_{\ell=0}^{\infty} \sum_{m=-\ell}^{\ell} Y_{\ell}^m(\theta, \varphi) \overline{Y_{\ell}^m(\theta', \varphi')} = \frac{\delta(\theta - \theta')}{\sin \theta} \delta(\varphi - \varphi')$$

How Effective is Keystroke Biometrics

Fingerprint

- FAR= ~0%
- FRR= ~1%

Keystroke Biometrics

- FAR= ~0.01%
- FRR= ~3.0%
 - Manufacturer recommended settings
 - Variable (application-defined)

Facial Recognition

- FAR/FRR vary according to: compression, distance, illumination, media, pose, resolution, and other temporal factors.

Voice Recognition

- FAR= ~1.6%
- FRR= ~8.1%



$$H_\nu(kR)e^{i\nu(\Omega-\theta_0)} = \sum_{m=-\infty}^{\infty} J_m(kr_0)H_{\nu+m}(kr)e^{i(\nu+m)(\theta-\theta_0)}$$

How Effective is Keystroke Biometrics

What If

- ❑ *I injure my hand?*
 - ❑ How many people have you met that have had hand injuries?
 - ❑ How many people have you met that forgot their password?

- ❑ *I enrolled on one keyboard and want to login on another?*
 - ❑ Tactile versus membrane
 - ❑ Full-size versus compact
 - ❑ Key-character layout

- ❑ *My connection is hijacked and someone replays my keystrokes?*
 - ❑ Fraud detection methods vary by manufacturer

- ❑ *I have a bad day?*



$$0 \leq \int_0^\pi \int_0^{2\pi} |L_{\pm} Y_{\lambda}^m(\theta, \varphi)|^2 \sin \theta d\theta d\varphi$$

Advantages of Keystroke Biometrics

Technology Advantages

- ❑ Performance:
 - ❑ Inherently narrows the identification pool to achieve lower FAR/FRR
- ❑ Portability:
 - ❑ Users are not limited to individual or specific workstations
- ❑ Flexibility:
 - ❑ Dynamically managed threshold for acceptance
- ❑ Security:
 - ❑ Constant biometric refinement of templates over time
- ❑ User Acceptance:
 - ❑ Non-invasive capture
 - ❑ Support for invisible (background) enrollment
 - ❑ Works better with pass phrases familiar to the user
 - ❑ translation: passwords *can* be easy to remember
- ❑ Paradigm:
 - ❑ Only solution that provides for limited liability risk mitigation.
 - ❑ Capabilities based policies, not simply role based



$$[\nabla^2 + \ell(\ell + 1)]Y_\ell^m(\theta, \varphi) = 0$$

Advantages of Keystroke Biometrics

Implementation Advantages

- ❑ Deployment / Maintenance:
 - ❑ No physical hardware to install or maintain
 - ❑ No manpower needed on client-side deployment for installations or upgrades

- ❑ Coverage:
 - ❑ Support for remote access and telecommuting
 - ❑ Software-only components allow integration into any software solution

- ❑ Policy Management:
 - ❑ Secondary authorization does not change current policies
 - ❑ Application and/or user managed levels of security

- ❑ Audit Control:
 - ❑ Promote proper use of existing licensing
 - ❑ Logging of biometric access creates better forensic evidence

- ❑ Exit / Override Strategies
 - ❑ No additional resources needed to override or temporarily disable biometric.
 - ❑ No invasive exit strategy Just turn off server-side secondary authentication process.



$$\|L_+ Y_\ell^\ell\|^2 = [\ell(\ell + 1) - \ell(\ell + 1)] \|Y_\ell^\ell\|^2$$

Markets for Keystroke Biometrics

Network / Intranet Security:

- ❑ Single Sign-on Solutions
- ❑ RADIUS
- ❑ Corporate Application Access
- ❑ xFS Volume Protection
- ❑ Document Control Management
- ❑ Corporate Internet Access



$$\frac{\partial^2}{\partial \theta^2} + \frac{\cos \theta}{\sin \theta} \frac{\partial}{\partial \theta} + \frac{1}{\sin^2 \theta} \frac{\partial^2}{\partial \varphi^2} \stackrel{?}{=} e^{i\varphi} \left(\frac{\partial}{\partial \theta} + \frac{i}{\sin \theta} \frac{\partial}{\partial \varphi} \right) e^{-i\varphi} \left(\frac{\partial}{\partial \theta} - \frac{i}{\sin \theta} \frac{\partial}{\partial \varphi} \right)$$

Markets for Keystroke Biometrics

Asset Identification:

- Online Training / Testing
- Document Signing
- Software Licensing and Registration



Personal Information Security:

- Primary Authorization for individual document encryption
- Secondary Authorization mechanism for online purchases
- Secure Laptop Access

$$\nabla^2 \psi = \frac{1}{r^2} \frac{\partial}{\partial r} r^2 \frac{\partial \psi}{\partial r} + \frac{1}{r^2} \left[\frac{1}{\sin \theta} \frac{\partial}{\sin \theta} \sin \theta \frac{\partial}{\partial \theta} + \frac{1}{\sin^2 \theta} \frac{\partial^2}{\partial \varphi^2} \right] \psi.$$

Future for Keystroke Biometrics

Consumer Market:

- PDA / Tablet / Stylus Input
- RIM
- ATM
- Cell phones
- Home Security Access Pads



$$\int_R \int [\psi(\bar{x}) (-) \delta^2(\bar{x} - \bar{x}_0) + G(\bar{x}; \bar{x}_0) f(\bar{x})] d^2 x = \oint_{\partial R} (\psi \bar{\nabla} G - G \bar{\nabla} \psi) \cdot \bar{n} ds .$$

Questions and Comments

Commonly Asked Questions:

- ❑ Can keystroke biometrics determine if an employee is incapacitated due to inebriation or drug abuse?
- ❑ How does keystroke biometrics protect against “Cyrano de Bergerac” breaches?



$$\sum_m \int_0^\infty k dk \int_0^{2\pi} d\alpha J_m(kr) i^m \frac{e^{im(\theta-\alpha)}}{2\pi} \sum_{m'} J_{m'}(kr_0) \frac{e^{-im'(\theta_0-\alpha)}}{2\pi} (-i)^{m'}$$

Q.E.D.

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$$\sum_{m=-\infty}^{\infty} \frac{1}{2\pi} \int_0^{\infty} k dk J_m(kr) J_m(kr_0) e^{im(\theta-\theta_0)} .$$