Performance and Security Analysis of Gait-based User Authentication

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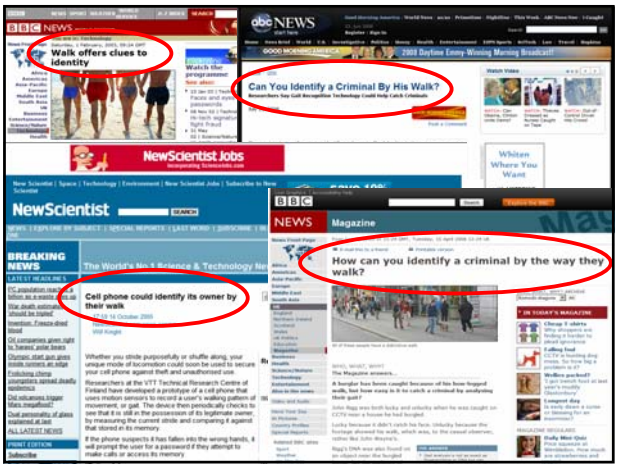
Project administrative data

- Project name:
  - Security of approaches to personnel authentication
- Duration
  - 2003-2008
- Resources
  - PhD student: Davrondzhon Gafurov
- Industry contact
  - ***Thales*** Norway AS (wearable computers)

Motivation example:

User authentication in mobile phones

- Personal data e.g. video and images can be stored
- Phones can be used in m-banking and m-commerce
- 800.000 mobile phone theft in 05/06 [UK crime survey]
- Authentication
  - Mainly based on PIN code
  - Static, i.e. user enters PIN code once
  - Obtrusive, i.e. requires explicit action



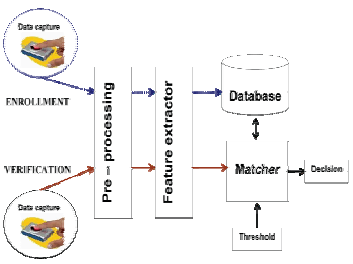
Performance and Security Analysis of Gait-based User Authentication

- Main research questions:
  - ❖1) What is the performance of recognition methods that are based on the motion of particular body parts during gait?
  - ❖2) How robust is the gait-based user authentication?
  - ❖3) What aspects do influence the uniqueness of human gait?

User authentication

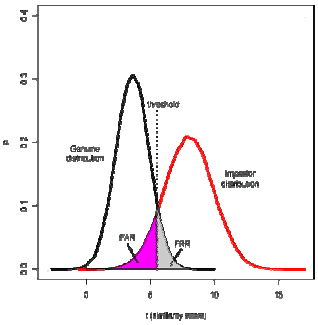
- Verifying the identity of a user based on something the user:
  - *Knows*, e.g. passwords and PIN codes.
  - *Has*, e.g. keys, cards, etc.
  - *Is (Biometrics)*,
    - Physiological: fingerprints, face, iris, etc.
    - Behavioural: walking style, typing rhythm, mouse usage, cardiac sounds, brain signals, etc.

Biometric authentication



- Attempts
  - Genuine
  - Impostor
- Main errors
  - FRR
  - FAR

Biometric system: scores & errors



- Analytical:

$$FAR = \int_{-\infty}^{t_0} P_{imp}(t)\,dt$$

$$FRR = \int_{t_0}^{+\infty} P_{gen}(t)\,dt$$

- Empirical:

$$FAR = \frac{Number-of-accepted-impostor-attempts}{Total-number-of-impostor-attempts}$$

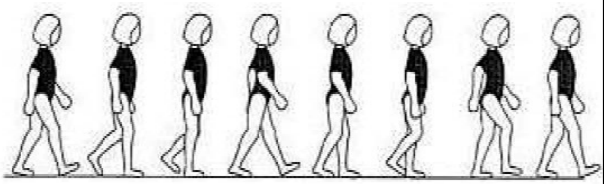
$$FRR = \frac{Number-of-rejected-genuine-attempts}{Total-number-of-genuine-attempts}$$

Gait recognition

[www.racewalk.com]

- Recognizing individuals based on their walking style
- Advantages:
  - Captured from distance
  - Unobtrusive data collection

Gait cycle

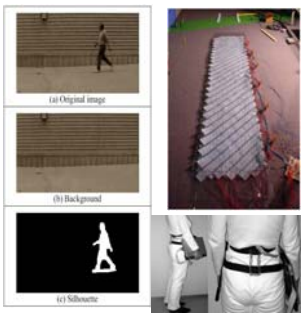


Initial Contact | Loading Response | Mid Stance | Terminal Stance | Pre Swing | Initial Swing | Mid Swing | Terminal Swing

[Vankoski and Dias, 1999]

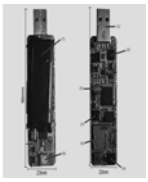
Taxonomy of gait recognition methods

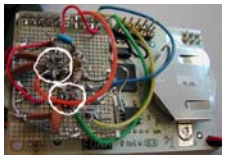
- Machine Vision
  - Using video camera
- Floor Sensor
  - Using sensors on the floor
- **Wearable Sensor**
  - Using sensors on the body



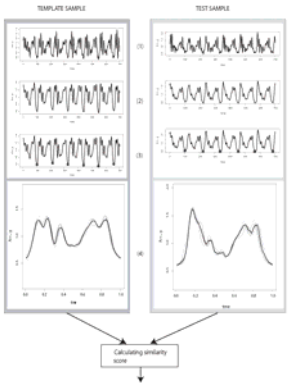
Motion Recording Sensors

- Developed at Gjøvik University College
- "Small" and portable
- Accelerometer:
  - 16/100 samples/sec.
- Memory: 64+ MB
- Communication:
  - USB, Bluetooth





Recognition method



Data collected from sensor

After filtering

Cycle detection

Construction of average cycle

Comparing gate cycles: Some distance metrics

- Absolute $$s(A,B)=\sum_{i=1}^{100}|a_i-b_i|$$
- Euclidean $$s(A,B)=\sqrt{\sum_{i=1}^{100}(a_i-b_i)^2}$$
- Weighted Euclidean $$s(A,B)=\sqrt{\sum_{i=1}^{100}(w_i-1)*(a_i-b_i)^2}$$

Gait authentication - Research results

- Performance when varying
  - sensor placement/back pack
  - shoe types
- Robustness with respect to 'gait' attacks
- Nature of gait uniqueness
  - Temporal
  - Directional

Summary of results

- Body motion as a weak biometrics
  - Hip 13% (100),
  - Trousers pocket 7% (50),
  - Arm 10% (30),
  - Ankle 5% (30)
- Security (on hip)
  - Robust against minimal-effort mimicking
  - Can be vulnerably to the attackers who know their closest person or gender of the person in the database.
- Uniqueness (on foot)
  - Heavy footwear tends to diminish foot discriminativeness
  - Sideway motion has most discriminative compared to up-down or forward-backward motions
  - Gait cycle parts vary in their uniqueness contributions

Spinoffs

- Collection and analysis of human motion data – MR analyzer
- Fall og aktivitetsmonitorering.ppt

List of papers

1. Davrondzhon Gafurov, "**A Survey of Biometric Gait Recognition: Approaches, Security and Challenges**",In Proceedings of Annual Norwegian Computer Science Conference, Tapir, pp. 119-130, 2007.
2. Davrondzhon Gafurov, Kirsi Helkala and Torkjel Søndrol, "**Gait Recognition Using Acceleration from MEMS**", In Proceedings of IEEE International Conference on Availability, Reliability and Security (ARES), pp. 432-437, 2006.
3. Davrondzhon Gafurov, Einar Snekkenes and Patrick Bours, "**Gait Authentication and Identification Using Wearable Accelerometer Sensor**", In Proceedings of IEEE Workshop on Automatic Identification Advanced Technologies (AutoID), pp. 220-225, 2007.
4. Davrondzhon Gafurov and Einar Snekkenes, "**Arm Swing as a Weak Biometric for Unobtrusive User Authentication**", In Proceedings of International Conference on Intelligent Information Hiding and Multimedia Signal Processing, Special Session on "Biometrics - From Sensors to Standardization", IEEE Press, 2008.
5. Davrondzhon Gafurov, Einar Snekkenes and Tor Erik Buvarp, "**Robustness of Biometric Gait Authentication Against Impersonation Attack**", In Proceedings of International Workshop on Information Security, Springer LNCS 4277, pp. 479-488, 2006.
6. Davrondzhon Gafurov, Einar Snekkenes and Patrick Bours, "**Spoof Attacks on Gait Authentication System**", IEEE Transactions on Information Forensics and Security, Special Issue on Human Detection and Recognition, 2(3), pp. 491-502, 2007
7. Davrondzhon Gafurov, "**Security Analysis of Impostor Attempts with Respect to Gender in Gait Biometrics**", In Proceedings of IEEE International Conference on Biometrics: Theory, Applications and Systems (BTAS), 2007.
8. Davrondzhon Gafurov and Einar Snekkenes, "**Towards Understanding the Uniqueness of Gait Biometric**", to be submitted.

Questions?