



# GAIT BASED BEHAVIORAL BIOMETRICS

This briefing reports scientific evidence of a rapid review that investigates concepts, strategies, and metrics related to using gait based behavioral biometrics to develop authentication systems.

## FINDINGS

### BEHAVIORAL BIOMETRICS

Biometric systems may be classified as Physiological or Behavioural based. Physiological characteristics are anatomic and biological properties of an individual. For instance, fingerprints, facial recognition, iris scan, voice recognition, palm veins, and DNA. Behavioural biometrics, on the other hand, refers to factors such as gait, GUI interaction, haptics, programming style, registry access, system call logs, mouse dynamics, and keystrokes. It depends on how an individual behaves [5].

### GAIT BASED BEHAVIORAL BIOMETRICS

Gait recognition involves identifying a person by analysing his/her walking pattern. It is useful in scenarios where explicit user interaction is not desired [8]. Gait recognition techniques are usually based on the silhouettes of a person. The most common approach is based on temporal alignment, focusing on both shape and dynamics of the human body, treating the sequence of images as a time series [12].

### STRATEGIES TO IMPLEMENT GAIT BASED BEHAVIORAL BIOMETRICS

- A study proposes that gait based authentication systems should comprise the following **activities**: obtaining the original images, segmentation, feature extraction, feature matching, and matching decision [6].
- A study presented a **feature fusion-based gait recognition method** where the raw skeletal data is transformed into scale and view independent feature representations, namely, joint relative distance and joint relative angle [8].
- Some strategies **incorporate complementary modalities to increase the robustness** of gait based biometrics, in particular to reduce the sensitivity due to changes in clothing and carrying conditions [8].
- Another study reported using a strategy based on **unsupervised clustering** [8].
- A research reported an approach for recognition by using the human upper body motion only. This strategy uses a **Gaussian mixture model (GMM)** generative classifier [12].
- Another research proposes a **strategy that identifies users as clients or impostors** via a Hidden Markov Model (HMM) classifier, concerning the dynamic motion and an Attributed Graph Matcher (AGM), concerning the static anthropometric information. A score level fusion of both classifiers is performed by a Support Vector Machine (SVM) algorithm implemented on a Gaussian kernel and the validity of the final score is then verified by a quality factor based on ergonomic restrictions [13].
- A study proposes a **generic framework** to develop authentication systems based on behavioral biometrics. A designer of an authentication approach is able to extend the framework easily by integrating new algorithms through predefined APIs [14].

### TYPES OF DATA COLLECTED IN GAIT BASED AUTHENTICATION SYSTEMS

In gait based biometrics, parameters such as kinematic patterns, knee ankle movements, moments, angles, hunch, and othes are used. Typical features may include arm swing, walking speed, stooping of the back, step size, head-foot distance and head-pelvis distance [4].

The approach proposed in [9] calculates **12 skeleton features** on the basis of the locations of the following joints: Head; Neck; Torso Center; Left/Right Shoulder; Left/Right Elbow; Left/Right Hand; Left/Right Hip; Left/Right Knee; Left/Right Foot.

### METRICS TO EVALUATE STRATEGIES

- **FAR**: It is the false acceptance rate. It is the ratio of the amount of attack instances incorrectly labelled as authentic to the total number of attack instances. Value of FAR must be as small as possible [5].
- **FRR**: It is the false rejection rate. It is the ratio of the amount of authentic interactions that were incorrectly classified as attacks and the total number of authentic, valid instances [5].
- **EER**: is the error rate that is achieved by tuning the detection threshold of the system such that FAR and FRR are equal. Accuracy is the fraction of samples that is accurately classified, without distinction between the two error types [7].
- **HTER**: The Half Target Error Rate (HTER) is the average between the FAR and FRR at some arbitrary threshold [5].
- **ROC**: It is the Receiver/Relative operating characteristic. It is a plot which represents a compromise between FAR and FRR. The matching algorithm of a biometrics mechanism has an established threshold which evaluates how close to the learned format an instance must be so that it qualifies as authentic. Increasing the threshold reduces the FAR but increases the FRR. Decreasing the threshold will reduce FRR but lead to higher FAR. The ROC helps to identify the optimum threshold so that both FAR and FRR are minimized [7].
- **AUROC**: The Area under the ROC Curve (AUROC) ranges from 0.5 (random guessing) to 1 (perfect classification) and aggregates the system's performance at all threshold settings [7].

### INPUT DEVICES

To capture the biometric data some input devices can be used, such as floor sensors, machine vision systems, or wearable sensors [4]. Here we focus in gait based behavioral biometric using machine vision systems only. In this context, some approaches use a set of ordinary cameras [13], special cameras [12], and Microsoft Kinect [8] [9].

### ADVANTAGES OF GAIT BASED APPROACH

- The gait of an individual can be **captured at a distance** unlike other biometrics such as fingerprint recognition [6].
- Gait based authentication can be non-invasive and **doesn't necessarily need the subject's cooperation** [6].
- It provides **persistent security**. The authentication process is not complete after the login, but there is continuous monitoring [5].
- It is **difficult to replicate the behavior**, hence making identity theft less likely [5].

### DISADVANTAGES OF GAIT BASED APPROACH

- Gait and activity-related features are typically **sensitive to changes in clothing and carrying conditions** [8]. A person during pregnancy, after an accident/disease affecting the leg, or after severe weight gain / loss can all affect the movement of an individual. Drugs and alcohol will affect the way in which a person walks [6].
- Most of the gait based behavioral biometric faces the common **challenges in capturing human motion** such as the effects of varying illumination, representation of real position/direction in a 3D space and foreground segmentation [12]. However some approaches have been proposed to reduce this problem such as in [12].
- Gait recognition approach **requires the individual to walk and complete a full gait cycle** in order to obtain the best possible match result, making it not suitable for applications where the space to gather the information is limited [12]. However some approaches have been proposed to deal of such problems, such as in [12].

### What is a Rapid Review?

*It is a method that searches for scientific studies about a specific topic, extracts relevant evidence and synthesizes the findings in order to support decision-making in real-world software development projects.*

### Who is this briefing for?

Software engineers who want to make decisions related to gait behavioral biometrics authentication systems based on scientific evidence.

### Where the findings come from?

All findings of this briefing were extracted from 14 scientific studies about gait based behavioral biometrics, identified on a rapid review.

### Where can the complete scientific studies be found?

On the link at the dark bar on the bottom of this briefing.

### What is NOT included in this briefing?

Findings that are not based on scientific evidence.

### For more evidence briefings like this, access:

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