D1 Can Gait Recognition Using Coupled Non-Linear Oscillators Overcome Intra-Individual Variability?

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After attending this presentation, attendees will understand how to formulate and implement gait recognition schemes using Central Pattern Generator (CPG) -based coupled non-linear oscillators for overcoming the problems of false rejection due to intra-individual variability.

This presentation will impact the forensic science community by providing a novel gait recognition scheme using a coupled non-linear oscillator model. This study will also initiate discussion regarding which gait-relevant parameters can potentially be used to solve the problem of intra-individual variability.

Gait recognition is a recently developed and still evolving technique by which individuals can be recognized based upon their gait. Two different approaches are used: (1) silhouette-based; and, (2) model-based.[1-5] The first, using silhouette information, is being tested for forensic identification purposes in Japan.[1] The second uses body-model information, such as joint coordinates or angles, and is not yet in general use. Because conventional model-based methods mainly compare similarity of joint dynamics, gait recognition is adversely affected by intra-individual variability arising from environmental or mental changes.[3,4] False rejections (i.e., incorrectly identifying the same person as "different") therefore sometimes occur due to these alterations. It is a difficult but necessary and urgent task to overcome these problems to allow expanded application of this technology. To simulate and reconstruct foot joint dynamics, previous studies have successfully demonstrated the usefulness of non-linear oscillator models, which are one of the representations of the CPG framework.[6] Gait recognition schemes incorporating those models may offer the solution to false rejections arising from intra-individual variability.

This study compares different methods using a coupled non-linear oscillator model.[6] This study involves lower extremity joint trajectories (two hips, knees, and ankles) in a model which includes three Degrees Of Freedom (DOF) for one hip, one DOF for one knee, and two DOF for one ankle. Evaluations were performed using 3D joint trajectories to focus the possibility and usefulness of the suggested method. To fit these parameters to a non-linear oscillator model, a Levenberg-Marquardt algorithm was used that evaluates errors as sum of squares of joint coordinate differences. This study examined and compared four ways of selecting features described below: (1) using all fitted parameters; (2) using some fitted parameters; (3) using simulated joint trajectories; and, (4) using dynamic properties featured as a phase-response curve, which consists of the relationships between phase changes and perturbation timings when a perturbation is added.

The 3D joint trajectories of 20 subjects were measured by Microsoft® Kinect® v2 sensors. The data was obtained from four walks obtained during each of a two-day experiment. The error rate of conventional methods used to analyze the data from two days of experiments was greater than the error rate obtained from the date of a one-day experiment. This confirmed that intra-individual variability can cause false rejections. The results of these studies and suggested methods will be presented and error rates obtained from each of the four methods of selecting key joint relevant features will be examined. The results will provide information regarding which joint parameters can or cannot be used to solve the problem of intra-individual variability.

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