



TinyBioGait—Embedded intelligence and homologous time approximation warping for gait biometric authentication from IMU signals

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ABSTRACT

The gait of a subject follows a specific pattern, but variations exist that are unique to a subject but contrasting to other subjects. This can be utilized for biometric authentication to prevent impersonation during gait studies. However, due to the dynamic nature of gait, like changes in gait speed while walking, gait biometric authentications are challenging. In the state-of-the-art, although attempts have been made to use deep learning and other signal processing methods for biometric authentication, which obtained reliable results, these are either highly resource-consuming, require several sensors or need an expensive framework, making it challenging to implement this in many scenarios. Therefore, a knowledge gap exists to build a reliable, inexpensive and resource-efficient gait biometric authentication system. The paper proposes a method for using only one embedded IMU sensor with a microcontroller for tracking the motion of a subject, resource-efficient on-device elimination of the gait speed differences by proposing a homologous time approximation warping algorithm and building a resource-efficient TinyML model for reliable biometric authentication. Based on an experiment consisting of 20 human subjects with consent, the microcontroller's on-device accuracy score for decision-making by TinyML was found to be 0.9276. The resource efficiency of the model based on memory profiling has been further discussed. Also, the prediction performance of the microcontroller with the proposed optimization was found to be only 8% slower compared to a personal computer, given that several thousands of processes run parallel on a personal computer. The work needs to be further tested for a larger sample space, and data privacy needs to be addressed.

1. Introduction

Gait is the study of walking pattern. Researchers have used gait throughout the literature to study various diseases like Parkinson's, hemiplegia, arthritis, etc. The gait of a normal human can be classified into two phases: one is stance, and the other is swing (Adhikary & Ghosh, 2022a). The stance phase can be further subdivided into initial contact, loading response, mid-stance, terminal stance and pre-swing. The swing phase can be subdivided into initial swing, mid-swing and terminal swing. Gait also has other components, including lateral sway, head and shoulder movement, jerk during foot landing, and more (Hasan et al., 2022). Every normal human follows this pattern. However, these components show variation from person to person. These variations are unique to those subjects but contrast with other subjects. This property can be utilized for biometric authentication (De Marsico

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