**EarGate: Gait -based User Identification with In-ear Microphones**

**Rahavee Prabakaran**

The research paper investigates the feasibility of earable-based gait identification. Gait-based identification from the sounds induced by walking and propagated through the musculoskeletal system in the body is specifically addressed. The system proposed in this paper is called EarGate which leverages an in-ear facing microphone which exploits the earable’s occlusion effect to reliably detect the user’s gait from inside the ear canal, without impairing the general usage of earphones. Further the paper also investigates how gait identification model could live both as a stand-alone or cloud-coupled earable system. First the paper starts with a brief introduction to rationale driving the work carried out in the paper and also provides evidence of the feasibility of our approach. In this rationale, the paper leverages on occlusion effect, then the advantages of using occlusion effect and an inward-facing microphone are discussed. Later the Human Gait Primer is studied to understand the feasibility to identify people with the acoustic signals measured with the in-ear microphone. The paper further goes on to describe the overview of EarGate, its functionalities and a description of the proposed gait-based identification pipeline. Several features that could represent the characteristics of user gait from each cycle such as Mel-Frequency Cepstral Coefficients, Chroma of Short-Time Fourier Transform, Mel Spectrogram, Root-Mean-Squared Energy and Onsets are studied. Then the fact that EarGate requires an enrollment phase has led it to study Identification Methodology. The paper has its own EarGate prototype to have full control on the data. The hardware prototype consists of a cheap and easily available in-ear facing microphone placed in commercially available pair of earbuds. The data collection involves obtaining clearance for carrying out the studies from Ethics Board of institution where 31 subjects were recruited. Each participant performed 8 different walking sessions, accounting for a total of 52,046 steps. Then the various metrics to assess the performance of the system is discussed. The various metrics include False Acceptance Rate, False Rejecting Rate, and Balanced Accuracy. To evaluate the system, 4 training-testing protocols are studied namely One-Class SVM, Imbalanced Binary SVM, Balanced Binary SVM and Balanced Binary SVM with part of subject’s data. Then the impact of Data Imbalance is studied and intuitively Bi-SVM is expected to perform better than OC-SVM because like clustering problem and the model has to learn the correlation of the data without information on outliers. Then the paper addresses the effect of walking conditions, such as footwear or ground material on gait identification performance. Then the impact of music playback is also studied. To do so, a spectrum analysis of All-time Top 100 songs launched by Billboard is studied. Impact of Human speech is also studied and the results are satisfactory for both tiles and carpet, which denotes how human speech has little impact on EarGate. The paper then talks about sensor multiplexing, Transfer Learning, Impact of training size and contribution of specific features. The various system consideration includes On-device identification, Distant identification, Distant identification (features offloading). The paper concludes by saying EarGate will not affect the general functionality of earbuds and is robust to high-frequency noises like music playback and human speech.

**Three strong points:**

1.Experimental results under various conditions is studied in the paper

2. Performance comparison of FAR, FRR and BAC of different footwear and ground material is presented clearly using bar graphs.

3.The EarGate Prototype is clearly understood through the image.

**Three weak points:**

1.The paper did not describe on what basis a prototype is proposed to have full control of the data.

2. The paper did not compare EarGate to other systems to make the readers understand the advantages of EarGate.

3. The various components of the hardware protype is not described in detail.