# Progress Check #1: Deep Learning-Based Gait Recognition Using Smartphones in the Wild

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*Abstract* – **We have studied the paper in detail and begun the implementation of the methods proposed by the authors of the original paper, for gait recognition using smartphones. We have used the 8 datasets, required to train and test the proposed architectures for the aforementioned purpose, that is made available on OneDrive by the authors. The dataset provided for training the architectures is 1022x6x1024x1 i.e. the training dataset is split into 1022 samples with 6 rows containing the inertial gait data, 1024 steps, and 1 label specifying whether the data is walking session or non-walking session. Similarly, the testing dataset consists of 332 samples with 6 rows containing the inertial gait data, 1024 steps, and 1 label specifying whether the data is walking session or non-walking session. The labeling dataset, used for training the architectures, comprises 1022 rows, for the 1022 samples, and 1024 columns, for the 1024 steps. Similarly, the labeling dataset, used for testing the architectures, comprises 332 rows, for the 332 samples, and 1024 columns, for the 1024 steps. We have successfully implemented the codes for the gait data extraction, identification, and authentication, on the given datasets and received high training and testing accuracies, as discussed in this report. We have started working on building an android application to collect inertial gait data using the accelerometer and gyroscope in smartphones.**

## I. Problem statement

The method proposed by the authors of the paper[1], to identify and authenticate a person by the way they walk, comprises three steps: gait data extraction, identification, and authentication. As a result of the extraction part of the proposed method, the inertial data collected by smartphones is partitioned into walking and non-walking sessions, gait features are then extracted from the walking data. The person identification and authentication models are constructed based on the results from the feature extraction step. Compared to other biometrics, gait is difficult to conceal and has the advantage of being unobtrusive. Inertial sensors, such as accelerometers and gyroscopes, are often used to capture gait dynamics. These inertial sensors are commonly integrated into smartphones and are widely used by the average person, which makes gait data convenient and inexpensive to collect. In this paper, we study gait recognition using smartphones in the wild. In contrast to traditional methods, which often require a person to walk along a specified road and/or at a normal walking speed, the proposed method collects inertial gait data under unconstrained conditions without knowing when, where, and how the user walks. To obtain good person identification and authentication performance, deep-learning techniques are presented to learn and model the gait biometrics based on walking data. Specifically, a hybrid deep neural network is proposed for robust gait feature representation, where features in the space and time domains are successively abstracted by a convolutional neural network and a recurrent neural network.

## II. Key Literature:

The code is mostly written in python. The Code can be found at https://github.com/qinnzou/Gait-Recognition-Using-Smartphones. The datasets needed for this project are available at: https://onedrive.live.com/?authkey=%21APJZLtdpd%5FJQ1Ck&id=8B12BDBA699C6D2B%219501&cid=8B12BDBA699C6D2B. We have been working on developing an android app for the collection of our datasets. Such an app has also been provided by the author(s) of the git repository https://github.com/umer0586/SensorServer but has a few bugs that only allow the app to work with Wi-Fi or USB which cannot be possible for everyone in all scenarios. Gait recognition has been also carried out by Johannes Preis et. al. in the paper 'Gait Recognition with Kinect'[2]; Liang Wang, Tieniu Tan, Huazhong Ning, Weiming Hu in the paper 'Silhouette analysis-based gait recognition for human identification'[3]; Rong Zhang, C. Vogler, D. Metaxas in the paper 'Human Gait Recognition'[4]. All of these papers aim to work on images to recognize humans. The authors have also referred to the following papers: The ORL active floor [sensor system][5], Gait modeling for human identification[6], and Gait recognition using wearable motion recording sensors[7]. Our selected paper works on the identification and authentication of humans based on the available sensors in everyone's smartphones. The authors have collected the inertial gait data in the wild, where the subjects are not limited to walking on specific roads or speeds. This collection of datasets is called the 'whuGAIT' dataset. All the collected data have been pre-processed by the gait-extraction algorithm. 118 subjects are involved in the data collection. Each data sample contains the 3-axis accelerometer data and the 3-axis gyroscope data. The sampling rate of all sensor data is 50Hz. According to different evaluation purposes, the authors have constructed six datasets based on the collected data. Datasets #1- #4 are used for Identification. The authors interpolate a single sample into a fixed length of 128 using linear interpolation. To enlarge the scale of the dataset, we make a one-step overlap between two neighboring samples for all subjects. In this way, a total number of 36,844 gait samples are collected. These samples are sorted by time. For each subject, the authors select the first 90% samples for training and the rest 10% for test. There are 33,104 training samples and 3,740 test samples, without overlap between the two subsets. Datasets #5 and #6 are used for authentication. They contain 74,142 authentication samples of 118 subjects, where the training set is constructed on 98 subjects and the test set is constructed on the other 20 subjects. There are 66,542 samples and 7,600 samples for training and test, respectively. Positive and negative samples each account for half of the total samples. Each authentication sample contains a pair of data samples that is from two different subjects or one same subject. The data sample consists of a 2-step acceleration and gyroscope data, which are interpolated in the way described in Dataset #1. The two data samples are horizontally aligned to create an authentication sample. Datasets #7 and #8 are used to demonstrate gait data extraction. Dataset #7 contains 577 samples of 10 subjects, with data shaped as $6 \times 1.024$. Among these samples, 519 are used for training and 58 are for tests. Both the training and test samples are from the 10 subjects. Dataset #8 contains 1,354 samples of 118 subjects, with data shaped as $6 \times 1{,}024$. Among these data, 1,022 samples from 20 subjects are used for training, and 332 samples from the other 98 subjects are used for tests. For both datasets, each sample is attached with a label file, which contains 1,024 binary values, with ‘1’ as the walking data, and ‘0’ as the non-walking data. The labels are manually annotated.

## III. Computational Platform and Installation:

The platform we’ve chosen to demonstrate the gait recognition system is an Amazon EC2 p3.8xlarge Linux virtual machine. It consists of 32 vCPUs, 4 NVIDIA Tesla V100 GPUs, 64 GB of RAM, and 244 GB of storage space. The steps to launch an EC2 instance are as follows:

A. Open the Amazon EC2 console at [https://console.aws.amazon.com/ec2/](https://console.aws.amazon.com/ec2/).
B. From the console dashboard, choose Launch Instance.
C. On the Choose an Instance Type page, you can select the hardware configuration of your instance. Select the p3.8xlarge instance type.
D. On the Choose an Instance Type page, choose Review and Launch to let the wizard complete the other configuration settings for you.
E. On the Review Instance Launch page, under Security Groups, you'll see that the wizard created and selected a security group for you.
F. On the Review Instance Launch page, choose Launch.
G. When prompted for a key pair, select Choose an existing key pair, then select the key pair that you created when getting set up.
H. Don't select Proceed without a key pair. If you launch your instance without a key pair, then you can't connect to it.
I. When you are ready, select the acknowledgment check box, and then choose Launch Instances.

Since the code is written in Python, we have installed Anaconda and Jupyter Notebook to run the code and conduct our research. This can be installed via the terminal. The steps to install Anaconda are:

A. Using your browser, download the Anaconda installer for Linux.
B. Verify data integrity with SHA-256: Open a terminal and run the following: sha256sum/path/filename
C. Enter the following to install Anaconda for Python 3.7: bash ~/Downloads/Anaconda3-2020.02-Linux-x86_64.sh
D. The installer prompts “In order to continue the installation process, please review the license agreement.” Click Enter to view license terms.
E. Scroll to the bottom of the license terms and enter “Yes” to agree.
F. The installer prompts you to click Enter to accept the default install location, CTRL-C to cancel the installation, or specify an alternate installation directory. If you accept the default install location, the installer displays “PREFIX=/home/<user>/anaconda3” and continues the installation. It may take a few minutes to complete.
G. The installer prompts “Do you wish the installer to initialize Anaconda3 by running conda init?” We recommend “yes”.
H. The installer finishes and displays “Thank you for installing Anaconda 3!”

Jupyter Notebook is included in the Anaconda package; we do not need to install it separately.

## IV. Progress up until now:

We managed to create an Android App using MIT App Inventor that collects live accelerometer and gyroscope data and saves data logs in the external/internal storage of the smartphone. Currently, we are facing issues with the storage of the log files. We are working on another app as a backup plan called SensorServer. This app can stream phone's sensors (motion, environmental, and position) to Websocket clients in real-time. A WebSocket client could be a web browser or any application running on a PC or a mobile device that uses WebSocket Client API. Also, we ran the code on the datasets provided by the authors. Video Link.

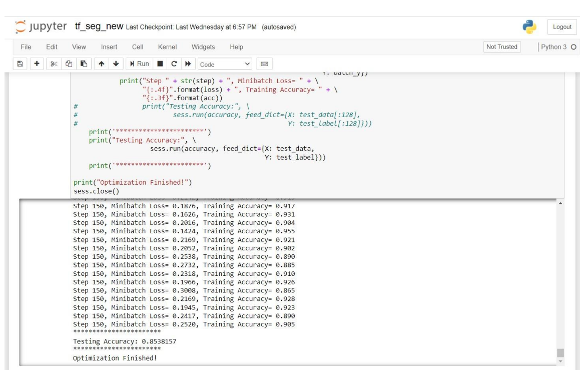

**Figure 1: Data Extraction**

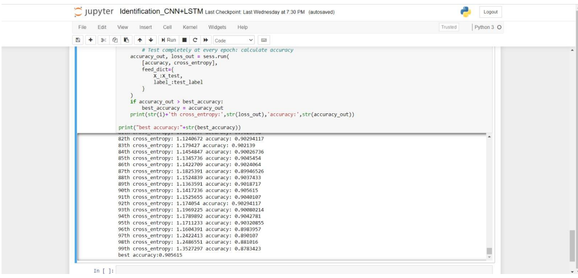

**Figure 2: Identification**

## V. Activities towards the end product

We have planned the following activities and milestones:

A. Complete app development for data collection
B. Distribute app amongst peers and collect their gait data with their consent
C. Run the code with the new dataset
D. From the code for authentication, obtain performance metrics and evaluate the accuracy of the network
E. Compare the results with the results provided by the author

Individual Responsibilities:

A. Aniruddha Anand Damle (1222585013): Create and distribute the android app. Work on the authentication network.
B. Prakriti Biswas (1222851266): Work on Identification network and design performance metrics
C. Aditya Shrikant Kaduskar (1222545896): Work on Segmentation (Data Extraction) and evaluate the end results with the designed performance metrics

## VI. Bibliography:


[1] Q. Zou, Y. Wang, Q. Wang, Y. Zhao, and Q. Li, "Deep Learning-Based Gait Recognition Using Smartphones in the Wild," Nov. 2018, doi: 10.48550/arXiv.1811.00338. [Online]. Available: http://dx.doi.org/10.48550/arXiv.1811.00338. [Accessed: Mar. 19, 2022]

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[7] GafurovDavrondzhon and SnekkenesEinar, "Gait recognition using wearable motion recording sensors," *EURASIP J. Adv. Signal Process.*, Jan. 2009, doi: 10.1155/2009/415817. [Online]. Available: https://dl.acm.org/doi/abs/10.1155/2009/415817. [Accessed: Mar. 19, 2022]