

# Tracking Your Steps on the Track

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Time series data collection of body sensor recordings during a controlled walking experiment  
Edition 1.1, May 2011

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This is the documentation for Tracking your Steps on the Track — time series data collection of body sensor recordings during a controlled walking experiment. The current documentation is Edition 1.1, last updated 8 May 2011. For the newest version available, check the version information on the page <http://users.ics.tkk.fi/jhollmen/Data/>.

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# 1 Introduction

Tracking Your Steps on the Track is a time series collection of body sensor recordings during a controlled walking experiment. Several people have contributed to the current state of the time series collection.

The project was initiated in 2006 by the SAFE team, who conceived the idea, designed and constructed the device consisting the acceleration sensors and the wireless connection to the central computer used for data logging, designed the experiments and performed them. The researchers at the Laboratory of the Computer and Information Science at the Helsinki University of Technology in Finland provided the SAFE team advice concerning measurement of data and sampling rates during the execution of the project, and also provided an initial outlook how the data analysis of such time series data could look like. These initial solutions were presented in the final project presentation by the SAFE team. After the project finished, the data set was archived and unused. In order to bring the data gathered during the experiments to the use of the large community of data mining, machine learning and time series analysis researchers, a group of researchers at Aalto University School of Science curated and cleaned the data set. You are reading the documentation of the data set and the walking experiment. We hope that this is accurate enough to provide insight to the data so that the time series collection can be used by researchers and students in their initial studies of the topic, or perhaps as by a group of students in a research project.

We ask that when you make use of this data, you make a reference to the following publication: Jeffrey Lijffijt, Panagiotis Papapetrou, and Jaakko Hollmén. **Tracking your steps on the track: Body sensor recordings of a controlled walking experiment**, In *Proceedings of the 3rd International Conference on Pervasive Technologies Related to Assistive Environments (PETRA'2010)*, Article No 58, ACM International Conference Proceedings Series, June, 2010. Available at: <http://doi.acm.org/10.1145/1839294.1839363>.

## 2 Body Sensors

This chapter describes the sensor measurements used in the project.

There are number of acceleration sensors attached to the human body. In addition, there are pressure sensors attached to the insoles of the shoes. The triaxial acceleration sensors are used to measure the movement of the human body while walking, the pressure sensors are used to measure the pressure on the bottom of the shoes while stepping down.

Each of the acceleration sensors measures acceleration in three directions. The places where acceleration sensors are placed are listed in the following: one in the upper back, one in the lower back, one on the left knee, one on the right knee, one on the left ankle, and one on the right ankle. The first dimension of the three dimension points perpendicularly to the plane defined by the circuit board, the rest of the two axis

In addition, there are four pressure sensors in each insole of the shoe, that is, four in the left shoe, and four in the right shoe. Three of the pressure sensors are located on the ball of the foot (near the toes) and one in the back part of the insole near the heel.

There are 26 sensor measurements altogether. From a time series point of view, each recorded experiment yields a multi-dimensional time series with dimension 26. The length of the time series varies from experiment to experiment, as the experiment is conducted from the beginning to end as instructed, and the completion times vary between the study subjects.

The placement of the sensors is not accurately calibrated, that is, the position of the sensors may vary based on the height of the persons and may vary from experiment to experiment. The exact directions of the three axes measuring acceleration can not be guaranteed, either. The relative direction between the three axes of individual acceleration measurements, on the other hand, can be safely assumed to be fixed and relatively accurate.

## 3 Walking Experiments

This chapter describes the protocol of the controlled walking experiments.

The SAFE team initially motivated the project by the preventive healthcare and proactive assistance of the elderly, in preventing them to fall and cause injury to themselves due to balance problems. The SAFE team wanted to find a set of experiments in which the designed and implemented devices could be deployed, and would result in a data set that could be of value to original question at hand. The real experiments were conducted on two consecutive days in March 2006.

The SAFE team invited volunteers to take part in the experiments. The volunteers agreed to the study protocol and that their data would be recorded. The true identity of the volunteers remains anonymous. We will refer to the persons as study subjects. There are 12 study subjects altogether in the curated time series collection. There were two trained physicians overlooking the experiments.

There were two separate tasks that differ in difficulty. The first task was to walk backwards on a straight line, back facing the walking direction. The second task was to walk on a curved path forming a figure eight. All experiments were repeated twice. The study subjects performed the experiment, then drank a controlled portion of alcohol and performed the following experiment. Before the start of an experiment, the alcohol level was measured and recorded.

The body sensor measurements were logged on the central computer for later use.

## 4 Data Format

This chapter describes the time series collection and the format of the data.

The Tracking Your Steps on the Track time series collection of 293 time series. They have been measured of 12 study subjects wearing body sensors consisting of 26 different sensor measurements. The lengths of the 293 time series vary, the distribution of time series lengths is presented in the accompanying paper. The sampling frequency of the data is 25 Hz. The average length of a time series of 12 seconds has also been reported in (Lijffijt et al., 2010).

The data set has mainly two parts: the collection of time series, and the data documenting the details of the study protocol. We will refer to the two data sets as time series data and protocol data.

Time series are presented as matrices with a row of data representing samples at one time point. Time proceeds in the array, first row is the first time point, second row at the second point in time etc.

The collection of time series consists of following three-dimensional time series of triaxial acceleration measurements:

- UpperBack
- LowerBack
- LeftKnee
- RightKnee
- LeftAnkle
- RightAnkle

The collection also has the following four-dimensional time series consisting of pressure sensor measurements in the bottom of each shoe:

- LeftSole
- RightSole

Following data concerning the protocol in the controlled walking experiment are available:

- Duration
- Timestamp
- person
- round
- test

The variable Duration stores the duration of each experiment. The timestamp has the textual information on the duration of the experiment. Variable person encodes the identity of the study subject, or person. Round is a variable indicating the number of the experiment. The variable test encodes whether the test is a backwards walking (t) or a repeat of backwards walking test (t2), figure-8 walking (8k), or a repeat of a figure-8 walking experiment (8k2, 8k3).

The data is distributed as a Matlab workspace file. The contents of the workspace file is seen in the following.

```
>> load steps-data.mat
>> whos
```

Name	Size	Bytes	Class	Attributes
Duration	1x293	59708	cell	
LeftAnkle	1x293	309692	cell	
LeftKnee	1x293	310976	cell	
LeftSole	1x293	401984	cell	
LowerBack	1x293	310271	cell	

RightAnkle	1x293	310484	cell
RightKnee	1x293	310412	cell
RightSole	1x293	403040	cell
Timestamp	1x293	59772	cell
UpperBack	1x293	310367	cell
person	1x293	2344	double
round	1x293	2344	double
test	1x293	33996	cell

It must be noted that no attempt to remove noise or erroneous data originating from damaged sensors, for instance, has been made.



## 5 Acknowledgments

The SAFE team consists of the following members (in alphabetical order): Esa Ahlgren, Paula Alanko, Justus Dahlén, Kirsi Hakio, Jarno Jaakkola, Juha Jokinen, Jyrki Juhala, Luis Perez Meliá, Tatu Piispanen, and Ari Viitala. The SAFE team was led by Justus Dahlén.

The SAFE team conceived the idea, designed and implemented the body sensors consisting of acceleration sensors and the pressure sensors. SAFE team also designed the experiments and executed them. The SAFE team consulted Jaakko Hollmén and Amaury Lendasse for advice on measuring and sampling time series data and design of experiments during the project execution. The time series curation to the current format was performed by Jeffrey Lijffijt, Panagiotis Papapetrou, and Jaakko Hollmén in 2010. They have also described the data briefly in a conference publication (Lijffijt et al. 2010).

In this document, we will refer to all of the above mentioned people as SAFE team and contributors.

## 6 References

Jefrey Lijffijt, Panagiotis Papapetrou, and Jaakko Hollmén. **Tracking your steps on the track: Body sensor recordings of a controlled walking experiment**, In *Proceedings of the 3rd International Conference on Pervasive Technologies Related to Assistive Environments (PETRA'2010)*, Article No 58, ACM International Conference Proceedings Series, June, 2010. Samos, Greece. Available at: <http://doi.acm.org/10.1145/1839294.1839363>.

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