

StrengthSense Dataset: IMU Daily Strength Demanding Activities

Note: This dataset is only open access to scientific research within EU countries according to the Ethics Committee and GDPR protocol. Any other proposal or scope using this dataset is not allowed other than additional application to Aalto Wearable Systems Lab [wearsys@aalto.fi].

1. Data collection

a. Hardware setup

10 MoveSense HR+ bluetooth IMUs (inertial measurement units) were used:

- Sampling frequency: 52Hz
- More information of the sensors can be found in the official website:
<https://www.movesense.com/product/movesense-sensor-hr/>
- Positions of the sensors:
 - 1 IMU on the chest
 - 1 IMU on the abdomen
 - 2 IMUs in the middle of the thighs on both sides
 - 2 IMUs in the middle of the tibia on both sides (Note: The initial z-axis of the above 6 IMUs is facing the front of the body, and the x-axis is pointing towards the ground.)
 - 2 IMUs are located on both sides of the upper arms
 - 2 IMUs are located on both sides of the forearm (The z-axes of the above four IMUs all point to the left and right sides of the body, and the x-axes all point to the ground.)

The schematic diagram of the IMU sensor is shown **Fig. 1(a)** and **Fig. 1(b)**:



Fig. 1(a) Actual picture of IMU sensor placement.

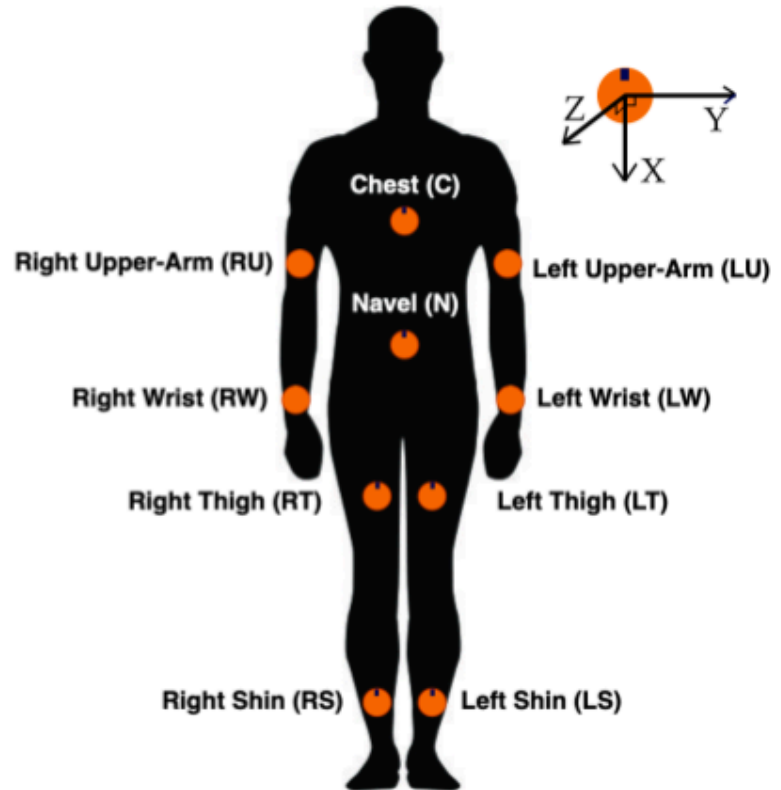


Fig. 1(b) Illustration of IMUs wearing orientation.

b. Subjects

29 subjects engaged in the data collection:

- Mainly staffs and students in Aalto University
- 12 females, 17 males
- Aged 18-50 years
- Weight 40-90 kg
- Height 150-191 cm

c. Data collection protocol

Data collection was conducted in a controlled manner, allowing only one participant at a time. As shown in **Fig. 2**, the process was supervised by two researchers: an experimental coordinator and an assistant. Their responsibilities included preparation, instruction, and data collection.

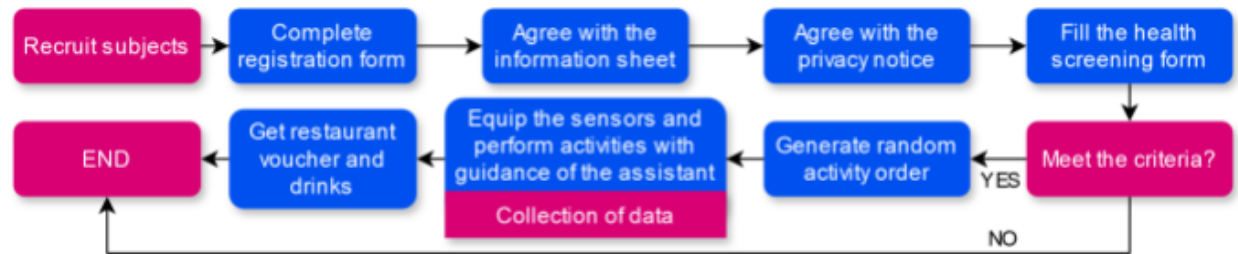


Fig. 2 The pipeline of data collection protocol

Based on the health screening form, participants identified as able-bodied were fitted with the Movesense device under the assistant's guidance and were provided with instructions on the activities to be performed. (Note: The research study only processes personal data that is necessary for the purpose and execution of the study. The research data is processed during the analysis phase of the research in a manner that the subjects are not directly identifiable to the researchers. The subject's direct identifiers, such as name, have been replaced, for example, with a random identifier. In case the research participant reveals directly identifiable information during the questionnaire or experiment, based on which the identity of the research participant may be deduced, such as the contact information, such information is deleted in the initial phase. Identity of the individual research participant will not be disclosed in a scientific publication or other research results to be published. During the execution and analysis phase of research, research data containing personal data will not be transferred to non-EU / EEA countries or international organizations. However, if non-EU/EEA countries or international organizations request a data transfer, the school's lawyer will be consulted to ensure that the transfer complies with the General Data Protection Regulation requirements. Each case of data transfer request will be analyzed individually.) Meanwhile, the experimental coordinator ensured that all equipment was functioning properly and prepared a randomized sequence of activities.

Before recording the first activity, participants were asked to perform a jump. This motion generated distinct spikes in the sensor data, which were later used to synchronize all devices. Each activity was performed three times (trials). However, in cases where issues arose—such as sensor disconnection from the experimental laptop or loosening of the sensor straps—additional trials were conducted to ensure accurate data collection.

To maintain data integrity, data collection was paused between trials to prevent the recording of any irrelevant movements.

2. Data format

a. Folder format and filename format

The dataset is structured into **29 folders**, each corresponding to a unique subject and labeled **subjectN**, where **N** represents the subject's identification number.

Within each **subjectN** folder, there are two subfolders: **laptop1** and **laptop2**.

- The **laptop1** folder contains an **IMU9** subfolder, which in turn includes another **IMU9** folder that stores IMU data collected from the subject's **upper body**. Specifically, this data includes IMU readings from sensors placed on the **chest, left upper arm, right upper arm, left lower arm, and right lower arm**.
- The **laptop2** folder contains IMU data from the **lower body**, with sensors positioned on the **waist, left thigh, right thigh, left shin, and right shin**.

All IMU data files in the **IMU9** folder are stored in **.CSV format**, following a predefined organizational structure detailed below.

Each **.csv** file represents a single trial of a specific activity performed by the same subject, facilitating both annotation and file management.

The filenames correspond to the ground truth labels of each trial and follow a systematic naming convention in the format:

s*_a*(@)_t*_xx.CSV, where:

- **s** represents the subject
- **a** indicates the activity
- **t** refers to the trial
- ***** is a numeric placeholder
- **@** specifies subcategories for the same activity
- **xx** denotes the data source

The **xx** field can take values such as **u** for upper-body **IMU9** sensors and **l** for lower-body sensors. The **@** symbol is used only in **activity 1 (walking)** to differentiate between walking on flat ground (**w**), walking on an incline (**wi**), and walking on a decline (**wd**).

For example, the file **s11 a3 t2 l.csv** represents the **lower-body IMU9 data** from the **second trial** of **activity 3** performed by **subject 11**.

b. Data columns

Synchronized and labelled raw data from 5 IMUs (The data collected from the upper and lower body are stored separately in files with similar names except for the data source.) Each data-files contains 46 columns per row, the columns contain the following data:

- 1 timestamp(1/52s per row and initialized to 0 in each file)
- 2-46 [BodyLocation] IMU9 [SensorType] (X/Y/Z)
 - BodyLocation: 2-3 letter body segment abbreviation:
 - * Chest: CHS

- * Upper arms: LU (left), RU (right)
- * Forearms: LF (left), RF (right)
- * Waist: WAS
- * Thighs: LT (left), RT (right)
- * Shins: LC (left), RC (right)
- SensorType with units:
 - * Accelerometer: Acc (m/s²)
 - * Gyroscope: Gyro (rad/s)
 - * Magnetometer: Magn (T)
- X/Y/Z: Cartesian axes in sensor-local coordinates

c. Activity IDs

- 1a - Walk in a circular path around the center of the venue.
- 1b - Walk from the base of a straight slope to its peak.
- 1c - Walk from the peak of a straight slope to its base.
- 2 - Rise from a seated position on a sofa or chair.
- 3 - Walk in a circular path around the center of the venue while holding a portable shopping cart in one hand.
- 4 - Begin in a standing position, vacuum the center of the field five to six times, and then return to a standing position.
- 5 - Starting from a standing position, squat down and then transition to a lying position on a mat on the ground.
- 6 - Transition from a standing position to sitting on a sofa.
- 7 - Begin in a standing position, sit on the sofa, and then transition to a lying position.
- 8 - Greet the camera using one or both hands.
- 9 - Opening a bottle of water, pouring water into a glass, and drinking
- 10a - Climbing up the stairs
- 10b - Climbing down the stairs
- 11 - Begin in a standing position, transition to a lying position, and perform three to five push-ups.
- 12 - Begin by lying flat on your back and perform sit-ups.

- 13 - Starting from a standing position, do 3 to 5 squats.

Note: in the real data file, the 1a is marked as 1(w), the 1b and 1c is marked as 1(wid), the 10a and 10b is marked as 10.

Because we did not mark uphill and downhill slopes or stairs separately during the data collection period.