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Data Article

Data about fall events and ordinary daily activities from a sensorized smart floor

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ABSTRACT

A smart floor with 16 embedded pressure sensors was used to record 420 simulated fall events performed by 60 volunteers. Each participant performed seven fall events selected from the guidelines defined in a previous study. Raw data were grouped and well organized in CSV format.
The data was collected for the development of a non-intrusive fall detection solution based on the smart floor. Indeed, the collected data can be used to further improve the current solution by proposing new fall detection techniques for the correct identification of accidental fall events on the smart floor.
The gathered fall simulation data is associated with participants' demographic characteristics, useful for future expansions of the smart floor solution beyond the fall detection problem.

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Specifications Table

Subject	Computer Science Applications
Specific subject area	Fall detection, the act of differentiating ordinary daily activities from the accidental fall event.
Type of data	Table
How data were acquired	Data were acquired using the smart floor, a floor surface with embedded Force Sensing Resistors (FSR). The smart floor has 16 FSR sensors linked to an ArduinoMega microcontroller. Fall data is recorded using a Java program on a personal computer linked to the ArduinoMega. The Java program and the Arduino sketch are provided as supplementary material. Additional data was acquired using the questionnaire provided as supplementary material under the file name *questionnaireExample.pdf*.
Data format	Raw
Parameters for data collection	The data gathering was organized as an open event, where anyone could volunteer to contribute. We have not established any constraint on the age or physical traits of participants. Each participant performed 7 different fall events.
Description of data collection	The data were collected at a data gathering event organized in a gym. Each participant was asked to simulate 7 different fall events. The data was recorded using the smart floor [4]. A proprietary program that collects data from sensors and manages the data gathering process was used in the experiment. The program is added as part of the dataset, but it is also accessible on Gitlab: https://gitlab.com/Dormage/smart-floor-fall-detection. The version tag *031194d73413a7bbdb68825236bd96f457735b30* was used in data gathering process. A total of 420 fall events were recorded.
Data source location	Koper - Slovenia
Data accessibility	Repository name: Zenodo Data identification number: https://doi.org/10.5281/zenodo.4605619 Direct URL to data: https://zenodo.org/record/4605619 Instructions for accessing these data: unzip the archive, all data is distributed in folders for easy access. There are two main folders: dataset and program. Data is distributed in csv format, each line represents one experiment (one person simulating the falls).

Value of the Data

- The data is useful for the development of fall detection systems and new methods to recognize accidental fall events among ordinary daily activities. The data can also be used for the development of new techniques for multivariate time-series analyses.
- Accidental fall events are a significant threat to the health and independence of older adults [1]. Approximately 30% of people aged 65 fall each year, and the odds increase for those aged over 70 years [2]. Hence, the development of fall detection systems is crucial to identify a fall event and provide immediate help.
- The provided participant's demographic data acquired through the questionnaire can be used to explore future expansions of the smart floor solution beyond the fall detection problem. A similar solution [3] was developed to identify a person's unique walking gait over a smart mat monitoring system.
- The gathered fall simulation data can be used to investigate fall patterns, and how a person reacts during a fall event.

1. Data Description

We provide the data in two formats. The raw data as result of the data acquisition process is stored in the folder **raw_data**, and the CSV formatted data, which is a user-friendly representation of the raw data. However, an accurate description of the data set is provided only for CSV formatted data. The CSV formatted data is contained in the folder **csv_data**.

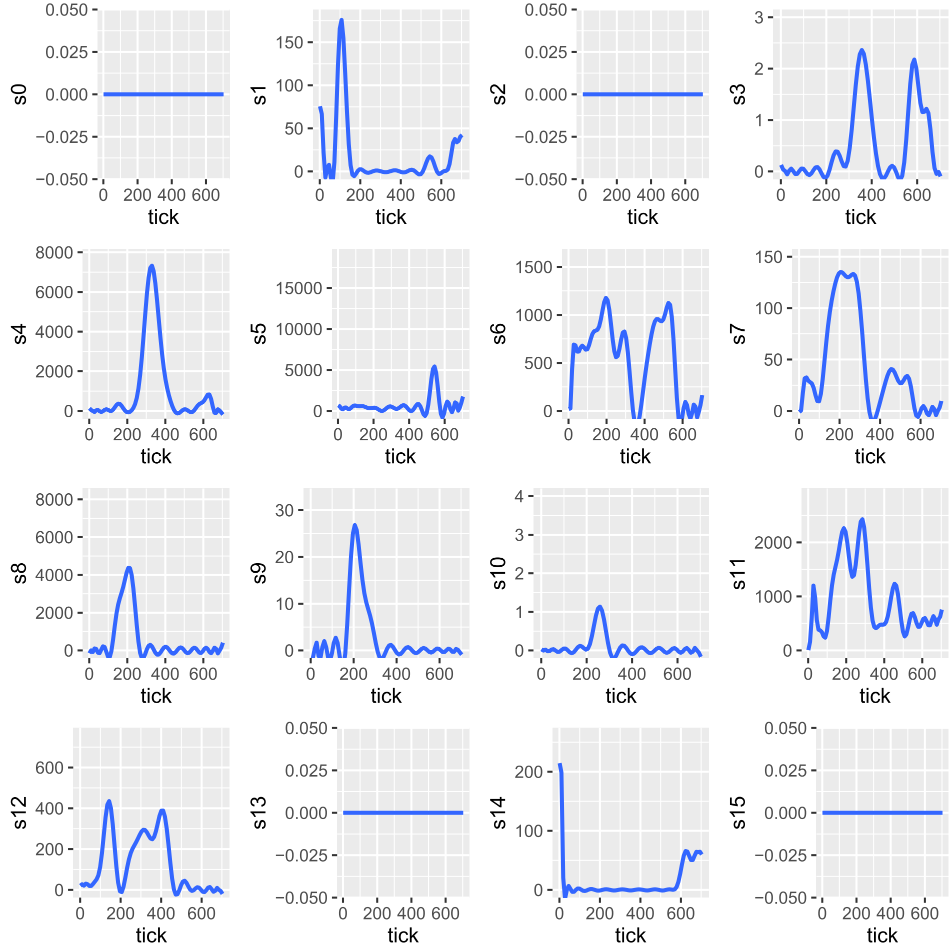


Fig. 1. Visualisation of recorded sensor telemetry during a fall event.

1.1. raw_data

The folder **raw_data** contains raw data obtained as result of the data acquisition process described in Section c. The raw data consists of numerous files. Each file contains the recording of an activity and is associated with a PERSON_ID. The PERSON_ID links the recorded activity with other activities performed under the same PERSON_ID, and with data acquired from the questionnaire.

Pressure sensors are arranged on the smart floor as shown in Fig. 5. An activity recording contains the value of the 16 pressure sensors recorded in a time interval (Fig. 1). Each column represents measurements of a pressure sensor. The first column takes values of the sensor *s*0, the second column takes values of the sensor *s*1, and so on. The rightmost column takes values of the sensor *s*15. Sensor values are increasing proportionally to the force applied on the sensor. Measured values range from 0 to 65535 at the maximum applied force, which is a decimal representation of the 16-bit binary interval provided by the controller in the process of converting the analogue signal from the FRS. The measurements of all 16 pressure sensors is performed at

Table 1
Example of data recorded from 16 pressure sensors contained in the **raw_data** folder.

0	170	0	0	0	0	87	0	345	0	329	0	11	0	0	0
0	174	0	0	0	0	87	0	346	0	319	0	11	0	0	0
0	175	0	0	0	0	87	0	346	0	320	0	9	0	0	0
0	171	0	0	0	0	85	0	349	0	319	0	10	0	0	0
0	167	0	0	0	0	83	0	346	0	327	0	10	0	0	0
0	144	0	0	0	0	15	0	141	0	14965	0	0	0	72	0
0	141	0	0	0	0	19	0	111	0	22146	0	0	0	260	0
0	79	0	0	0	0	5400	0	57	0	17287	0	0	0	325	0
0	0	0	0	0	0	43451	0	15	0	12579	0	0	0	382	0
0	27	0	0	0	0	51240	0	82	0	9981	0	4	0	424	0
0	45	0	0	0	0	25581	0	110	0	7984	0	0	0	452	0
0	21	0	0	0	0	10736	0	115	0	7254	0	0	0	450	0
0	17	0	0	0	0	3879	0	125	0	6922	0	0	0	395	0
0	26	0	0	0	0	1606	0	115	0	6415	0	0	0	421	0
0	30	0	0	0	0	940	0	78	0	5701	0	0	0	414	0
0	27	0	0	0	0	538	0	74	0	5619	0	4	0	408	0
0	24	0	0	0	0	361	0	90	0	5619	0	6	0	423	0
0	25	0	0	0	0	256	0	92	0	5305	0	2	0	433	0
0	4	0	0	0	0	203	0	92	0	4945	0	0	0	428	0
0	7	0	0	0	0	191	0	69	0	4875	0	0	0	420	0

Table 2
Name and description of attributes in the *positiveSet.csv* file.

Attribute	Description
FALL_ID	uniquely identifies the fall in the data file *positiveSet.csv*
PERSON_ID	uniquely identifies the volunteer who has simulated the fall
FALL_CATEGORY	identifies the fall execution
TICK	elapsed time of the recording, each tick counts 10 milliseconds
s0...s15	takes the value of sensors on the smart floor ranging from 0 to 65535

the same time. Measurements are collected every 10 milliseconds. An example of raw data from 16 pressure sensors is provided in Table 1.

1.2. csv_data

The folder **csv_data** contains CSV formatted data from the **raw_data** folder. The raw data was not filtered or altered. We just added headers and categorization attributes to enhance the dataset's reusability. Each volunteer has a unique id (PERSON_ID) associated with it's data. The PERSON_ID attribute links a volunteer across the data in the following files:

- *positiveSet.csv*– data about simulated fall events
- *negativeSet.csv*– data about ordinary daily activities
- *testSet.csv*– data about ordinary daily activities that might cause false positives
- *surveyData.csv*– data about participants obtained using a questionnaire

The content of the folder **csv_data** is detailed in the sections below.

1.3. csv_data/positiveSet.csv

The file contains CSV formatted data from the raw data in the folder *raw_data/positive*. The file stores 420 simulated fall events recorded in a time interval (Table 4). In Table 2 we give the description of each attribute.

Table 3
Description of different fall executions identified by the FALL_CATEGORY attribute. Ending position of the described fall events is depicted in Fig. 6.

FALL_CATEGORY	Description of the fall execution	Duration (s)
1	forward fall on the knees	5
2	forward fall with forward arm protection	5
3	forward fall ending laying flat	5
4	forward fall on the knees with rotation, ending in the lateral position	5
5	lateral fall ending laying flat	5
6	lateral fall ending laying flat with recovery	10
7	forward fall ending laying flat with recovery	10

Table 4
Example of data contained in positiveSet.csv. The first row details attribute names. The data is similarly structured also for negativeSet.csv and testSet.csv.

fallID	personID	fall_cat.	tick	s0	s1	s2	s3	s4	s5	s6	s7	s8	s9	s10	s11	s12	s13	s14	s15
1	1	1	0	0	137	0	0	0	0	92	0	409	0	367	0	23	0	0	0
1	1	1	1	0	139	0	0	0	0	93	0	408	0	367	0	23	0	0	0
1	1	1	2	0	140	0	0	0	0	94	0	409	0	363	0	23	0	0	0
1	1	1	3	0	142	0	0	0	0	93	0	411	0	350	0	23	0	0	0
1	1	1	4	0	142	0	0	0	0	93	0	411	0	340	0	24	0	0	0
1	1	1	5	0	140	0	0	0	0	94	0	411	0	332	0	23	0	0	0
1	1	1	6	0	138	0	0	0	0	94	0	411	0	328	0	23	0	0	0
1	1	1	7	0	139	0	0	0	0	92	0	411	0	329	0	24	0	0	0
1	1	1	8	0	137	0	0	0	0	92	0	411	0	327	0	24	0	0	0
1	1	1	9	0	140	0	0	0	0	92	0	413	0	331	0	24	0	0	0
1	1	1	10	0	139	0	0	0	0	93	0	413	0	332	0	24	0	0	0
1	1	1	11	0	140	0	0	0	0	94	0	413	0	331	0	24	0	0	0
1	1	1	12	0	140	0	0	0	0	96	0	414	0	332	0	24	0	0	0
1	1	1	13	0	141	0	0	0	0	96	0	413	0	335	0	24	0	0	0
1	1	1	14	0	141	0	0	0	0	96	0	413	0	339	0	24	0	0	0
1	1	1	15	0	142	0	0	0	0	96	0	413	0	339	0	24	0	0	0
1	1	1	16	0	144	0	0	0	0	95	0	413	0	342	0	24	0	0	0
1	1	1	17	0	143	0	0	0	0	95	0	413	0	344	0	23	0	0	0
1	1	1	18	0	143	0	0	0	0	96	0	413	0	347	0	24	0	0	0
1	1	1	19	0	144	0	0	0	0	96	0	414	0	351	0	24	0	0	0
1	1	1	20	0	142	0	0	0	0	96	0	414	0	351	0	24	0	0	0
1	1	1	21	0	142	0	0	0	0	96	0	414	0	357	0	24	0	0	0
1	1	1	22	0	142	0	0	0	0	96	0	414	0	359	0	24	0	0	0
1	1	1	23	0	143	0	0	0	0	95	0	416	0	360	0	24	0	0	0
1	1	1	24	0	144	0	0	0	0	95	0	414	0	357	0	23	0	0	0
1	1	1	25	0	144	0	0	0	0	95	0	414	0	360	0	24	0	0	0
1	1	1	26	0	143	0	0	0	0	95	0	413	0	360	0	24	0	0	0
1	1	1	27	0	143	0	0	0	0	96	0	414	0	361	0	24	0	0	0
1	1	1	28	0	143	0	0	0	0	95	0	411	0	350	0	24	0	0	0

Each volunteer simulated 7 different fall events. Each fall was performed following a different fall execution. The attribute FALL_CATEGORY is used to identify the fall execution. In Table 3, we describe the fall execution for each value of the attribute FALL_CATEGORY. The length of the recording time interval is expressed in seconds in the column duration.

1.4. csv_data/negativeSet.csv

The file contains CSV formatted data from the raw data in the folder *raw_data/negative*. The file stores 30 ordinary daily activities recorded in a time interval. In Table 5, we give the description of each attribute.

Table 5
Name and description of attributes in the *negativeSet.csv* file.

Attribute	Description
NEG_ID	uniquely identifies the ordinary daily activity in the data file *negativeSet.csv*
PERSON_ID	uniquely identifies the volunteer who has simulated the ordinary daily activity
NEG_CATEGORY	identifies the type of ordinary daily activity
TICK	elapsed time of the recording, each tick counts 10 milliseconds
s0...s15	takes the value of sensors on the smart floor ranging from 0 to 65535

Table 6
Description of different ordinary daily activities identified by the NEG_CATEGORY attribute.

NEG_CATEGORY	Description of the ordinary daily activity	Duration
1	random walking and random stop	8 minutes
2	empty floor	10 seconds
3	one step forward then waiting 5 seconds in position, repeat	1 minute
4	random walking	10 seconds

Table 7
Name and description of attributes in the *testSet.csv* file.

Attribute	Description
TEST_ID	uniquely identifies the ordinary daily activity in the data file *testSet.csv*
PERSON_ID	uniquely identifies the volunteer who has simulated the ordinary daily activity
TEST_CATEGORY	identifies the type of ordinary daily activity
TICK	elapsed time of the recording, each tick counts 10 milliseconds
s0...s15	takes the value of sensors on the smart floor ranging from 0 to 65535

Table 8
Description of different ordinary daily activities identified by the TEST_CATEGORY attribute.

TEST_CATEGORY	Description of the ordinary daily activity	Duration
1	a chair is positioned on the smart floor, and the volunteer will sit on the chair	5 seconds
2	a volunteer is sitting on a chair positioned on the smart floor, the volunteer will stand up from the chair	5 seconds
3	a volunteer will bend down and catch something on the smart floor	5 seconds
4	a volunteer will jump on the smart floor	5 seconds

The file consists of 4 different types of ordinary daily activities. Each activity type is identified by the attribute NEG_CATEGORY.

In Table 6, we describe the ordinary daily activity type for each value of the attribute NEG_CATEGORY. The length of the recording time interval is expressed in the column duration.

1.5. *csv_data/testSet.csv*

The file contains CSV formatted data from the raw data in the folder *raw_data/test*. The file stores 12 ordinary daily activities recorded in a time interval. In Table 7, we give the description of each attribute.

The file consists of 4 different types of ordinary daily activities. Each activity type is identified by the attribute TEST_CATEGORY. In Table 8, we describe the ordinary daily activity type for each

Table 9
Basic summary of the participants (surveyData.csv).

variable	min	max	mean	median	sd	n	q25	q75
age	12	51	28.63	27	8.07	60	22	33.25
weight	40	120	72.73	72	16.22	60	60	83.5
height	150	197	174.98	176	11.69	60	165.75	183.25
sportActive	1	5	3.1	3	1.1	60	2	4
worried	1	3	1.58	1	0.72	60	1	2
fallEvents	0	4	1.25	1	1.45	60	0	2

Table 10
Example of data contained in (surveyData.csv). The first row details attribute names.

person_ID	sex	age	weight	height	sportActive	worried	fallEvents
1	M	21	95	190	3	1	1
2	M	24	80	188	5	1	0
3	M	23	85	190	4	1	2
4	F	15	50	156	5	1	0
5	F	33	74	160	4	3	1
6	M	22	83	192	3	3	0
7	F	12	40	150	5	1	4
8	M	26	90	182	4	1	4
9	F	20	101	168	2	2	1
10	M	28	93	180	2	1	1

value of the attribute TEST_CATEGORY. The length of the recording time interval is expressed in the column duration.

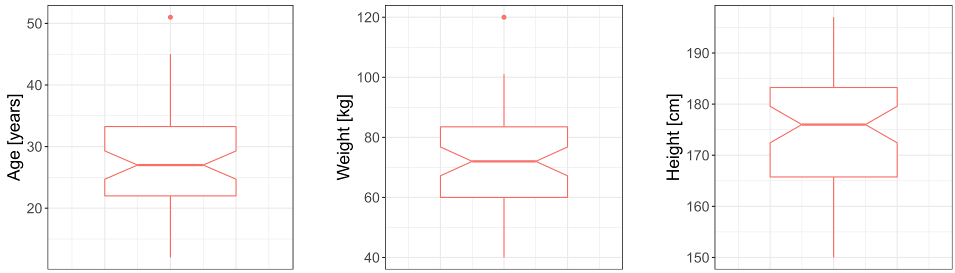
1.6. csv_data/surveyData.csv

The file contains CSV formatted data obtained using a questionnaire. An example copy of the questionnaire is provided under the filename *questionnaireExample.pdf*. Every volunteer fulfilled the questionnaire before the data acquisition. Data from the questionnaire is linked through the attribute PERSON_ID with the data in the following files: *positiveSet.csv*, *negativeSet.csv* and *testSet.csv*.

The file *surveyData.csv* contains the following basic demographic data: sex (m/f), age (years), weight (kg) and height (cm) (Table 10). The attribute PERSON_ID uniquely identifies the volunteer. The attribute SPORTACTIVE represents the self evaluation of sport activity, ranging from (1-not active) (5-very active). The attribute WORRIED represents anxieties linked with the data acquisition process, ranging from (1-not at all) to (5-very worried). The attribute FALLEVENTS represents the number of fall events experienced by the volunteer during this year ranging from (0 - zero fall events) to (4 - four or more). A summary of the dataset is provided in Table 9 and Fig. 2.

2. Experimental Design, Materials and Methods

Data were acquired using the smart floor displayed in Fig. 3, and described in [4]. The smart floor has 16 embedded Force Sensing Resistor (FSR) sensors linked to analog inputs of an ArduinoMega microcontroller. The ArduinoMega runs the *code/readData.ino* program, which triggers sensor reading every 10 milliseconds. Sensor data is sent to a personal computer linked to the ArduinoMega via serial communication. The java based client records the sensor data provided in *code/dataCollection*. The whole data collection set-up is shown in Fig. 4.



(a) (b) (c)

Fig. 2. The collected demographic data represented in boxplots.

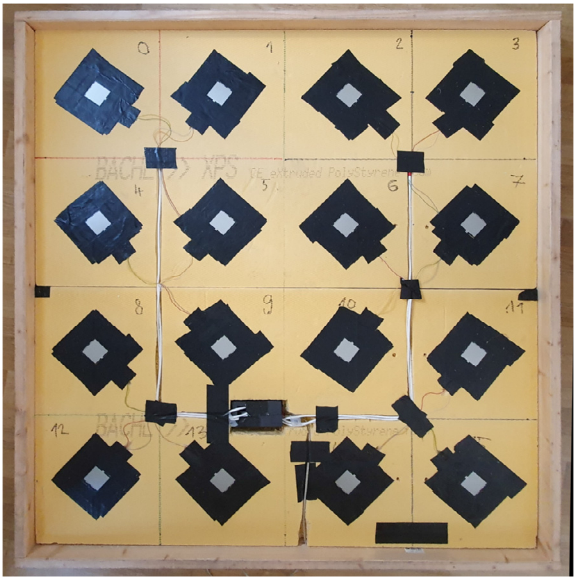


Fig. 3. The smart floor without the laminate layer. In the picture are displayed the 16 FSR pressure sensors, and the enclosure of the ArduinoMega.

The data gathering process was conducted in a properly equipped gym as depicted in Fig. 4. Each participant was informed orally and in written form about the aims of the experiment and possible risk hazards. Adequate protections for elbows and knees were offered to participants. Before the fall simulation, each participant fulfilled the questionnaire *questionnaireExample.pdf*.

Each participant was asked to simulate 7 different fall events on the smart floor surface. The fall events were selected from the article [5], which tackles the problem of fall simulation. Selected fall events are described in Table 3. All simulated fall events were recorded following the next procedure:

(note: we refer to the person that conducts the data collection as the data collector)

1. The participant stand on the right side of the smart floor as shown in Fig. 5, and waits for the signal. The participant must not step on the smart floor.
2. The data collector starts recording with the laptop and signals the participant.
3. The participant simulate the fall, and holds the ending position. The position must be maintained as if a real debilitating fall occurred.

Fig. 4. Data collection set-up: The smart floor is the white square surface surrounded by landing mats. It differs from Fig. 3, because covered with the laminate layer. Notice the laptop linked to the smart floor for data acquisition.

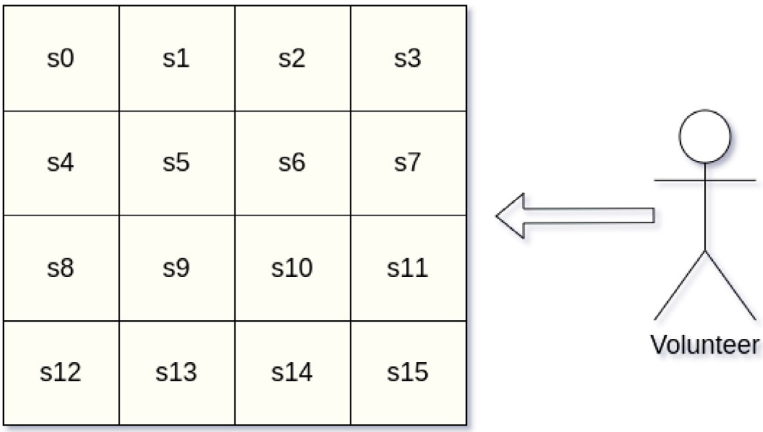
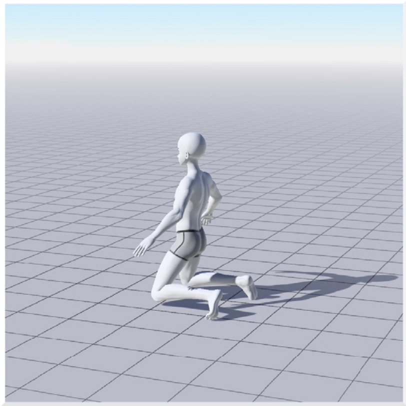


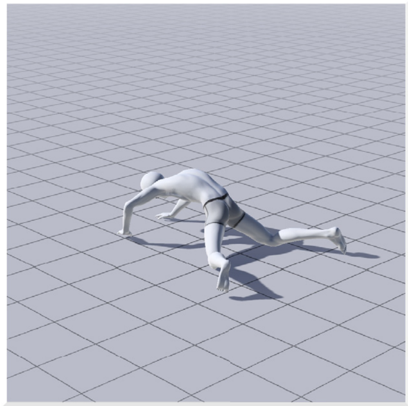
Fig. 5. Participant starting position before each fall event in relation to sensor placement on the smart floor. Sensors on the smart floor are described with the notation from s0 to s15, the same notation is used across all the provided data in CSV files.

4. After the recording interval is expired, the data collector notifies the participant, to release the ending position and leave the smart floor.

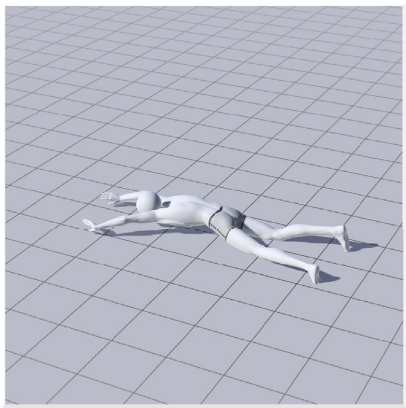
Other ordinary daily activities were recorded similarly but without any precondition on the starting position of the participant.



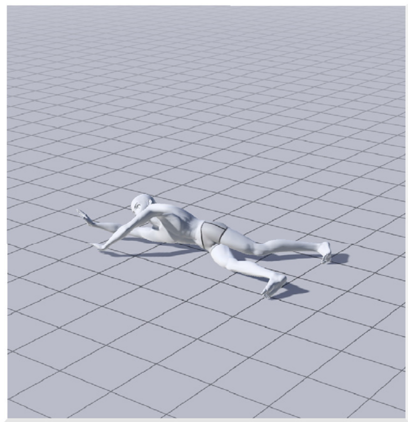
(a) forward fall on the knees



(b) forward fall with arm protection



(c) forward fall ending laying flat, lateral fall ending laying flat, lateral fall ending laying flat with recovery, forward fall ending laying flat with recovery



(d) forward fall on the knees with rotation, ending in the lateral position

Fig. 6. All possible ending position of seven simulated fall events described in Table 3.

Ethics Statement

The data gathering process involved the use of human subjects (we were observing actual human falls). Each participant was informed orally and in written form about the aims of the experiment and possible risk hazards. Participants were voluntary, and they could withdraw from the data gathering at any point. Informed consent was obtained from all the participants and in the case of minor participants from their legal guardians. The enclosed copy of the informed consent shows the exact formulation. The authors state that the study does not include anything that the Medical Ethics Committee of Slovenia would cover.

CRediT Author Statement

Aleksandar Tošić: Conceptualization, Software, Investigation, Writing - review & editing, Visualization; **Niki Hrovatin:** Software, Investigation, Writing - review & editing, Validation, Data

Curation; **Jernej Vičič:** Conceptualization, Investigation, Writing - review & editing, Supervision, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships which have, or could be perceived to have, influenced the work reported in this article.

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