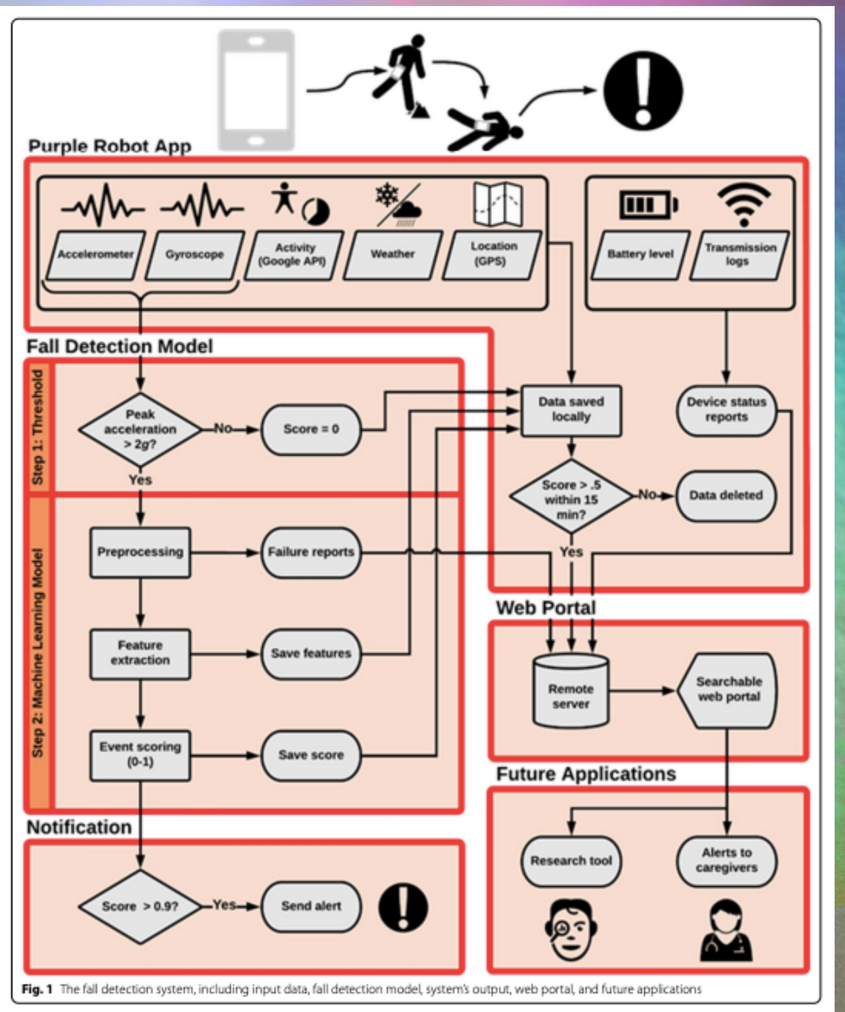


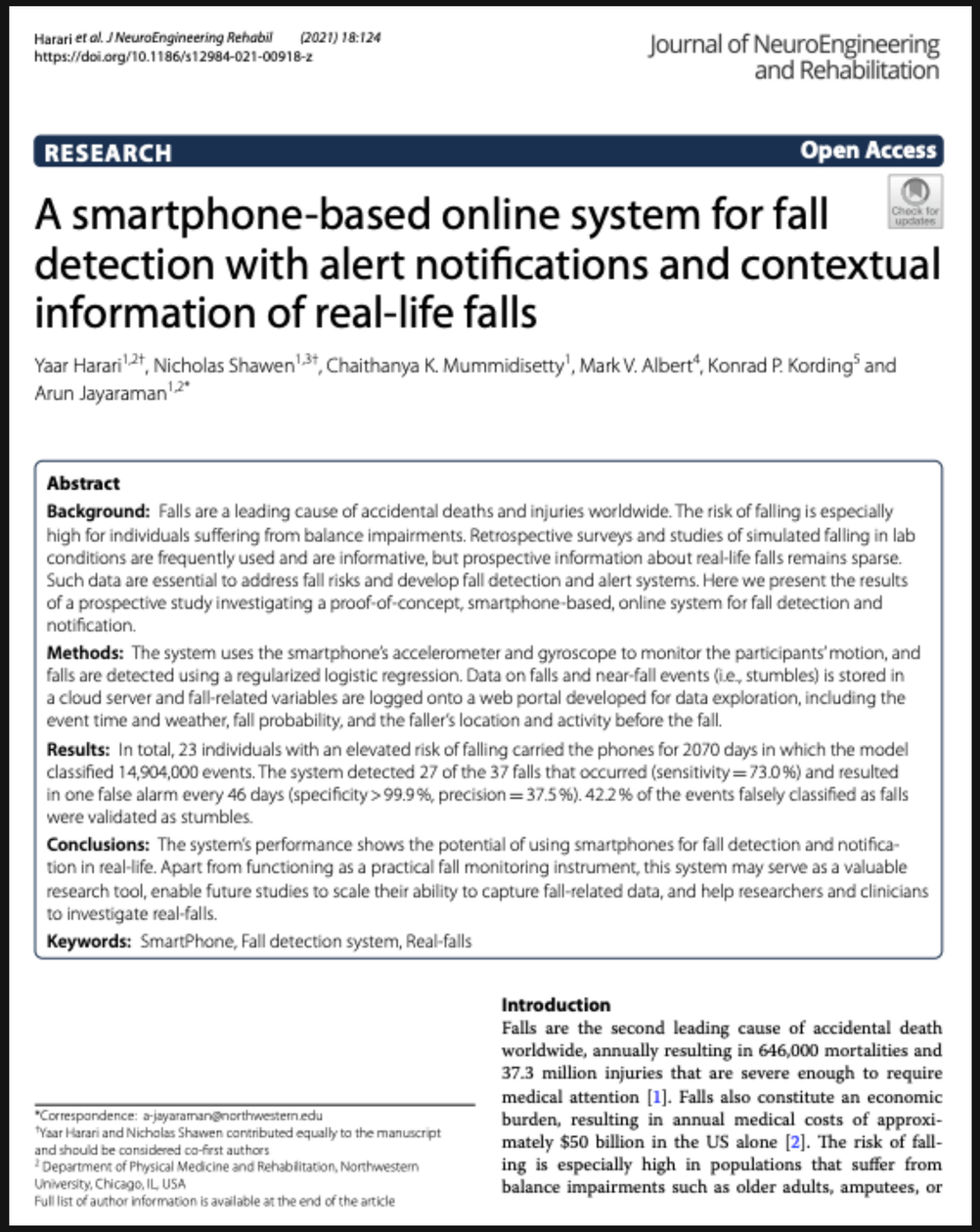
Fig. 1 The fall detection system, including input data, fall detection model, system's output, web portal, and future applications

A smartphone-based online system for fall detection with alert notifications and contextual information of real-life falls. - Harari, Y., Shawen, N., Mummidisetty, C.K. et al. (2021)

& Online fall detection system using Python by Ignacio Córdova

Ignacio Córdova Pou

ESTUDIANTE DEL MÁSTER UNIVERSITARIO EN CIENCIA DE DATOS



Harari et al. J NeuroEngineering Rehabil (2021) 18:124
https://doi.org/10.1186/s12984-021-00918-z

Journal of NeuroEngineering and Rehabilitation

RESEARCH Open Access

A smartphone-based online system for fall detection with alert notifications and contextual information of real-life falls

Yaar Harari[1,2†], Nicholas Shawen[1,3†], Chaithanya K. Mummidisetty[1], Mark V. Albert[4], Konrad P. Kording[5] and Arun Jayaraman[1,2*]

Abstract

Background: Falls are a leading cause of accidental deaths and injuries worldwide. The risk of falling is especially high for individuals suffering from balance impairments. Retrospective surveys and studies of simulated falling in lab conditions are frequently used and are informative, but prospective information about real-life falls remains sparse. Such data are essential to address fall risks and develop fall detection and alert systems. Here we present the results of a prospective study investigating a proof-of-concept, smartphone-based, online system for fall detection and notification.

Methods: The system uses the smartphone's accelerometer and gyroscope to monitor the participants' motion, and falls are detected using a regularized logistic regression. Data on falls and near-fall events (i.e., stumbles) is stored in a cloud server and fall-related variables are logged onto a web portal developed for data exploration, including the event time and weather, fall probability, and the faller's location and activity before the fall.

Results: In total, 23 individuals with an elevated risk of falling carried the phones for 2070 days in which the model classified 14,904,000 events. The system detected 27 of the 37 falls that occurred (sensitivity = 73.0 %) and resulted in one false alarm every 46 days (specificity > 99.9 %, precision = 37.5 %). 42.2 % of the events falsely classified as falls were validated as stumbles.

Conclusions: The system's performance shows the potential of using smartphones for fall detection and notification in real-life. Apart from functioning as a practical fall monitoring instrument, this system may serve as a valuable research tool, enable future studies to scale their ability to capture fall-related data, and help researchers and clinicians to investigate real-falls.

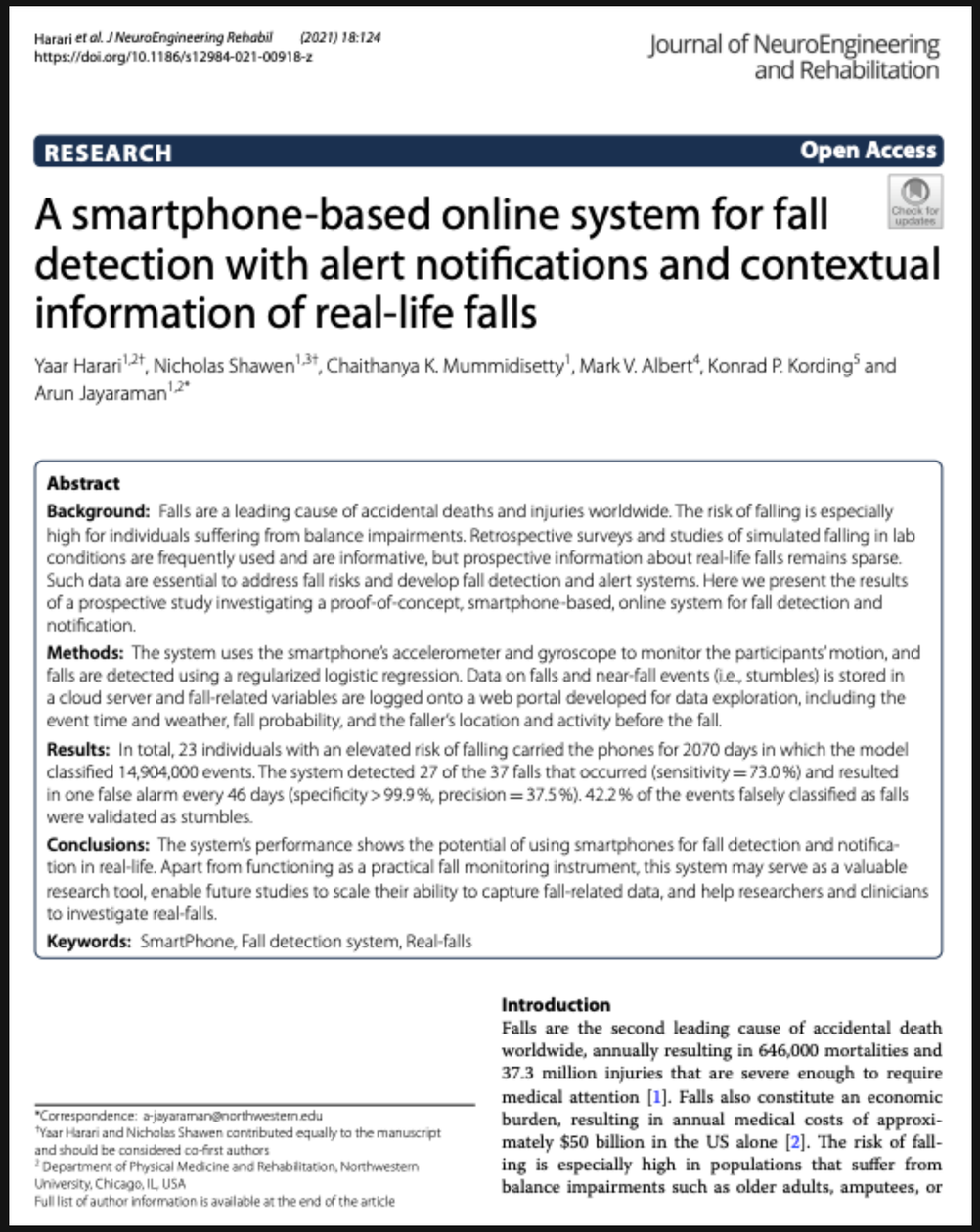
Keywords: SmartPhone, Fall detection system, Real-falls

Introduction

Falls are the second leading cause of accidental death worldwide, annually resulting in 646,000 mortalities and 37.3 million injuries that are severe enough to require medical attention [1]. Falls also constitute an economic burden, resulting in annual medical costs of approximately $50 billion in the US alone [2]. The risk of falling is especially high in populations that suffer from balance impairments such as older adults, amputees, or

*Correspondence: a-jayaraman@northwestern.edu
†Yaar Harari and Nicholas Shawen contributed equally to the manuscript and should be considered co-first authors
[2] Department of Physical Medicine and Rehabilitation, Northwestern University, Chicago, IL, USA
Full list of author information is available at the end of the article

Falls are the second leading cause of accidental death worldwide, annually resulting in 646,000 mortalities and 37.3 million injuries that are severe enough to require medical attention [1]. Falls also constitute an economic burden, resulting in annual medical costs of approximately $50 billion in the US alone [2].



Harari *et al. J NeuroEngineering Rehabil* (2021) 18:124
https://doi.org/10.1186/s12984-021-00918-z

Journal of NeuroEngineering and Rehabilitation

RESEARCH Open Access

A smartphone-based online system for fall detection with alert notifications and contextual information of real-life falls

Yaar Harari[1,2†], Nicholas Shawen[1,3†], Chaithanya K. Mummidisetty[1], Mark V. Albert[4], Konrad P. Kording[5] and Arun Jayaraman[1,2*]

Abstract

Background: Falls are a leading cause of accidental deaths and injuries worldwide. The risk of falling is especially high for individuals suffering from balance impairments. Retrospective surveys and studies of simulated falling in lab conditions are frequently used and are informative, but prospective information about real-life falls remains sparse. Such data are essential to address fall risks and develop fall detection and alert systems. Here we present the results of a prospective study investigating a proof-of-concept, smartphone-based, online system for fall detection and notification.

Methods: The system uses the smartphone's accelerometer and gyroscope to monitor the participants' motion, and falls are detected using a regularized logistic regression. Data on falls and near-fall events (i.e., stumbles) is stored in a cloud server and fall-related variables are logged onto a web portal developed for data exploration, including the event time and weather, fall probability, and the faller's location and activity before the fall.

Results: In total, 23 individuals with an elevated risk of falling carried the phones for 2070 days in which the model classified 14,904,000 events. The system detected 27 of the 37 falls that occurred (sensitivity = 73.0 %) and resulted in one false alarm every 46 days (specificity > 99.9 %, precision = 37.5 %). 42.2 % of the events falsely classified as falls were validated as stumbles.

Conclusions: The system's performance shows the potential of using smartphones for fall detection and notification in real-life. Apart from functioning as a practical fall monitoring instrument, this system may serve as a valuable research tool, enable future studies to scale their ability to capture fall-related data, and help researchers and clinicians to investigate real-falls.

Keywords: SmartPhone, Fall detection system, Real-falls

Introduction

Falls are the second leading cause of accidental death worldwide, annually resulting in 646,000 mortalities and 37.3 million injuries that are severe enough to require medical attention [1]. Falls also constitute an economic burden, resulting in annual medical costs of approximately $50 billion in the US alone [2]. The risk of falling is especially high in populations that suffer from balance impairments such as older adults, amputees, or

*Correspondence: a-jayaraman@northwestern.edu
†Yaar Harari and Nicholas Shawen contributed equally to the manuscript and should be considered co-first authors
[2] Department of Physical Medicine and Rehabilitation, Northwestern University, Chicago, IL, USA
Full list of author information is available at the end of the article

While smartphone devices have been explored in the previously published prospective studies, a major drawback is that all of them except one [35] were offline and could not send a real-time fall notifcation. Terefore, there is a need for an online system which is capable of sending a timely alert of a fall to a researcher, relevant caregiver, or emergency medical services.

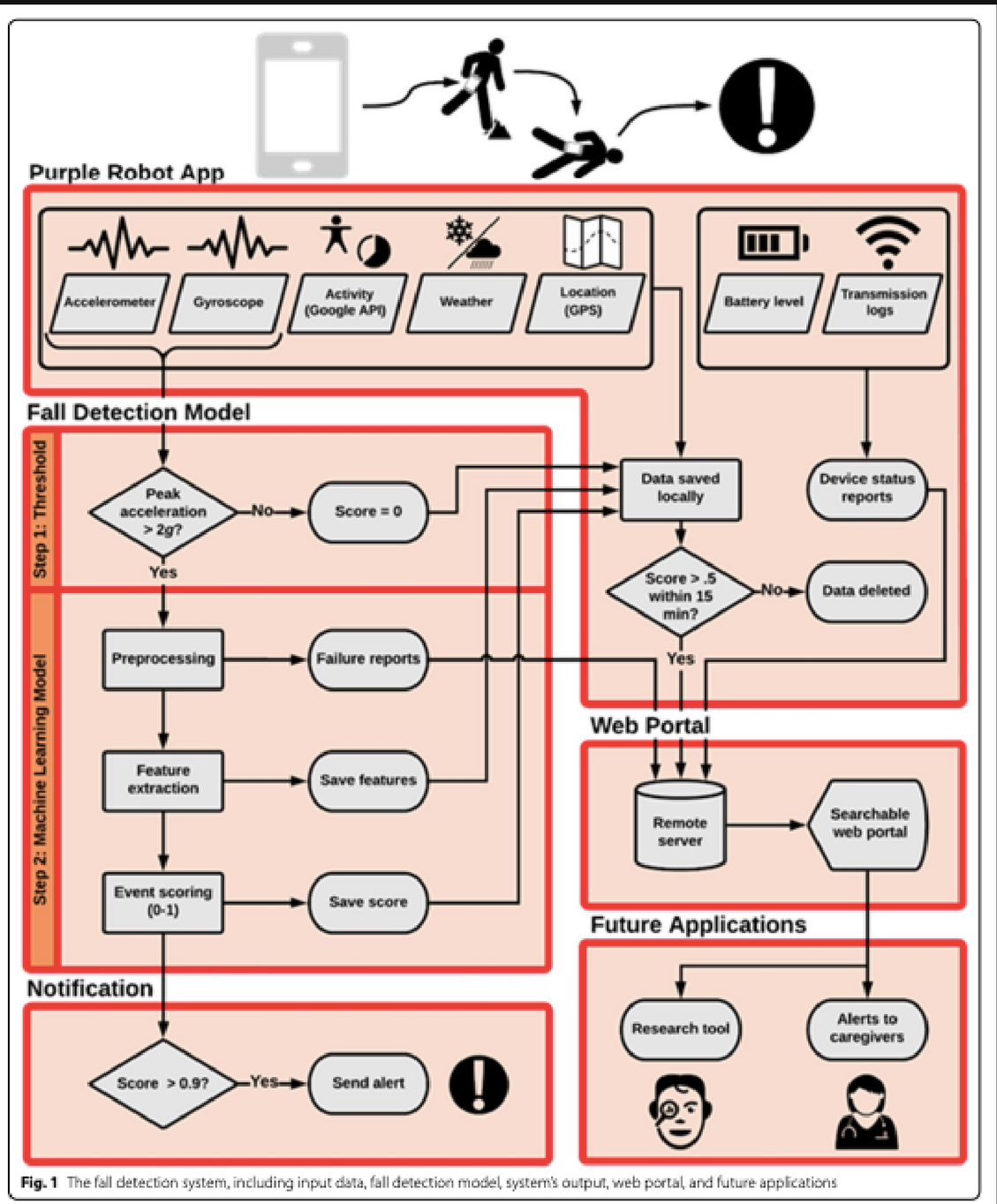
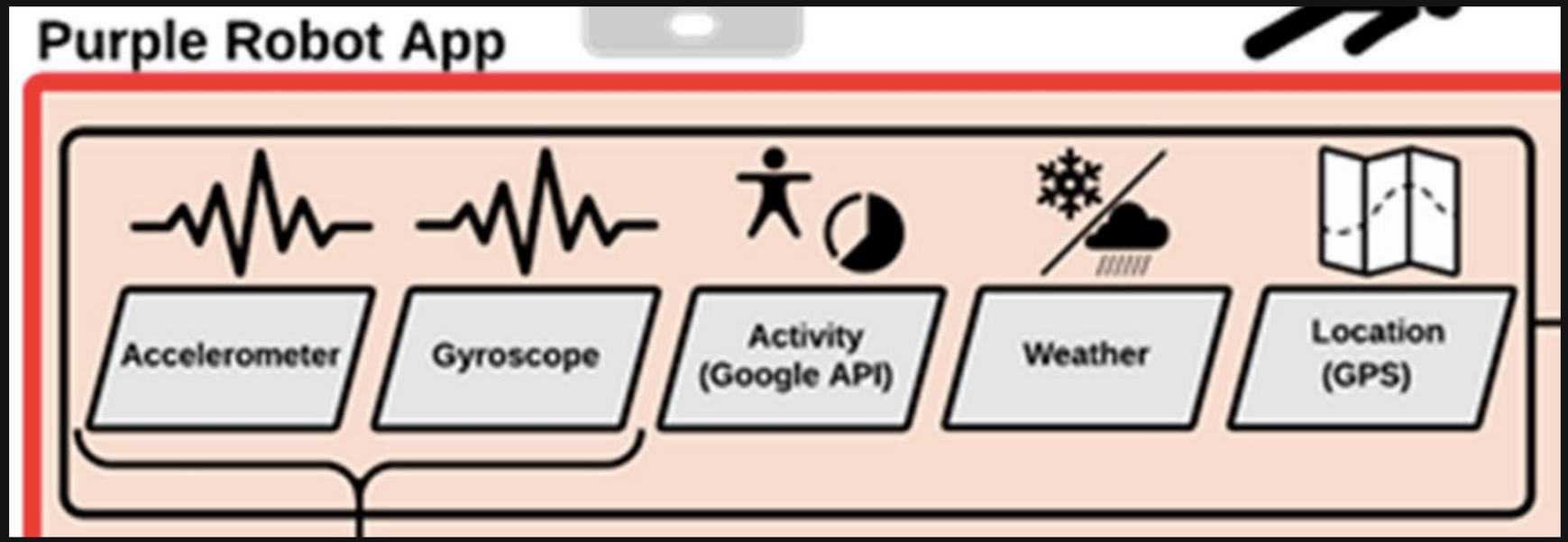
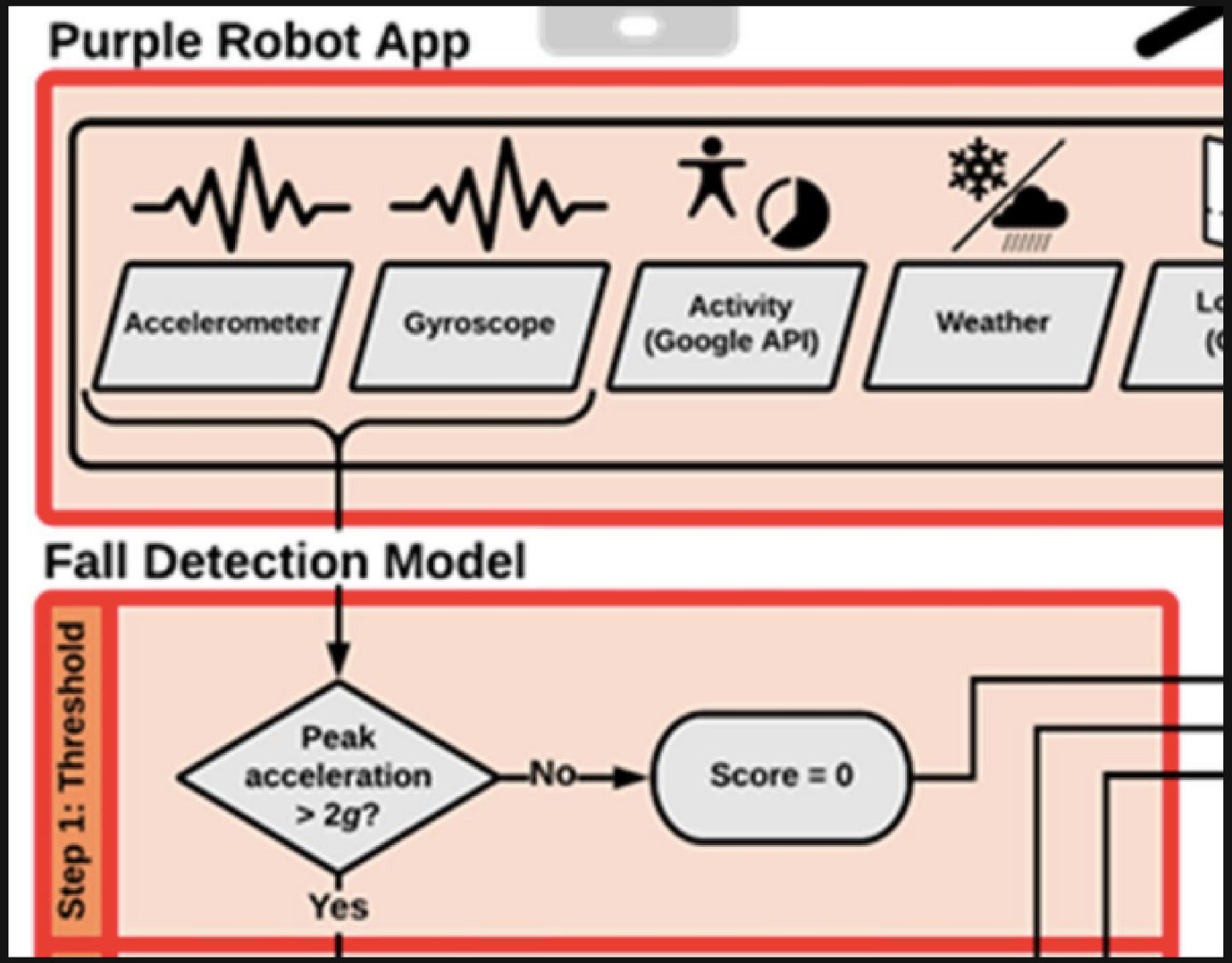
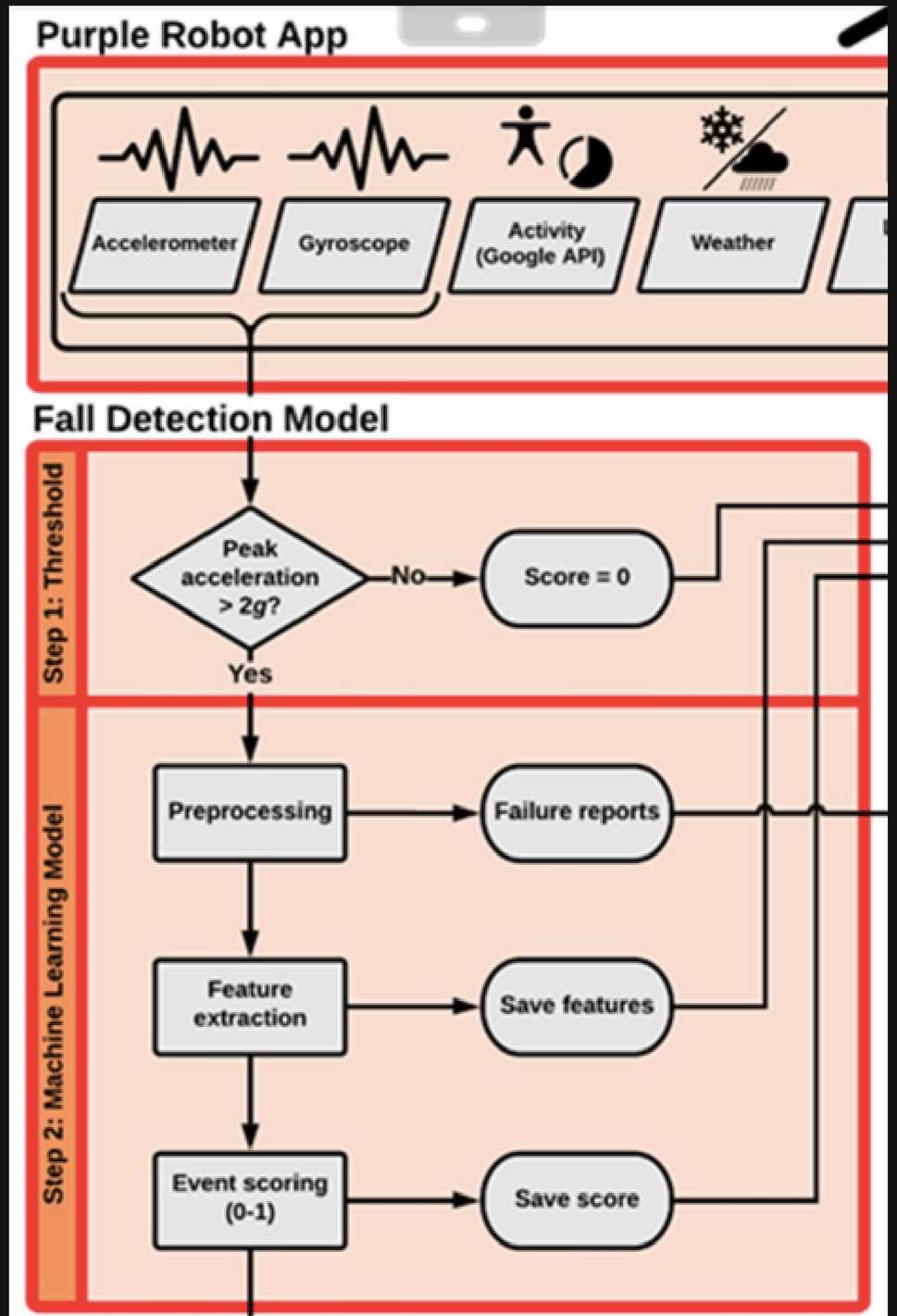


Fig. 1 The fall detection system, including input data, fall detection model, system's output, web portal, and future applications


Purple Robot App
Accelerometer
Gyroscope
Activity
(Google API)
Weather
Location
(GPS)



STEP 1: SCREENING ACCELERATION THRESHOLD



STEP 1:
SCREENING ACCELERATION THRESHOLD

+

STEP 2:
MACHINE LEARNING CLASSIFIER

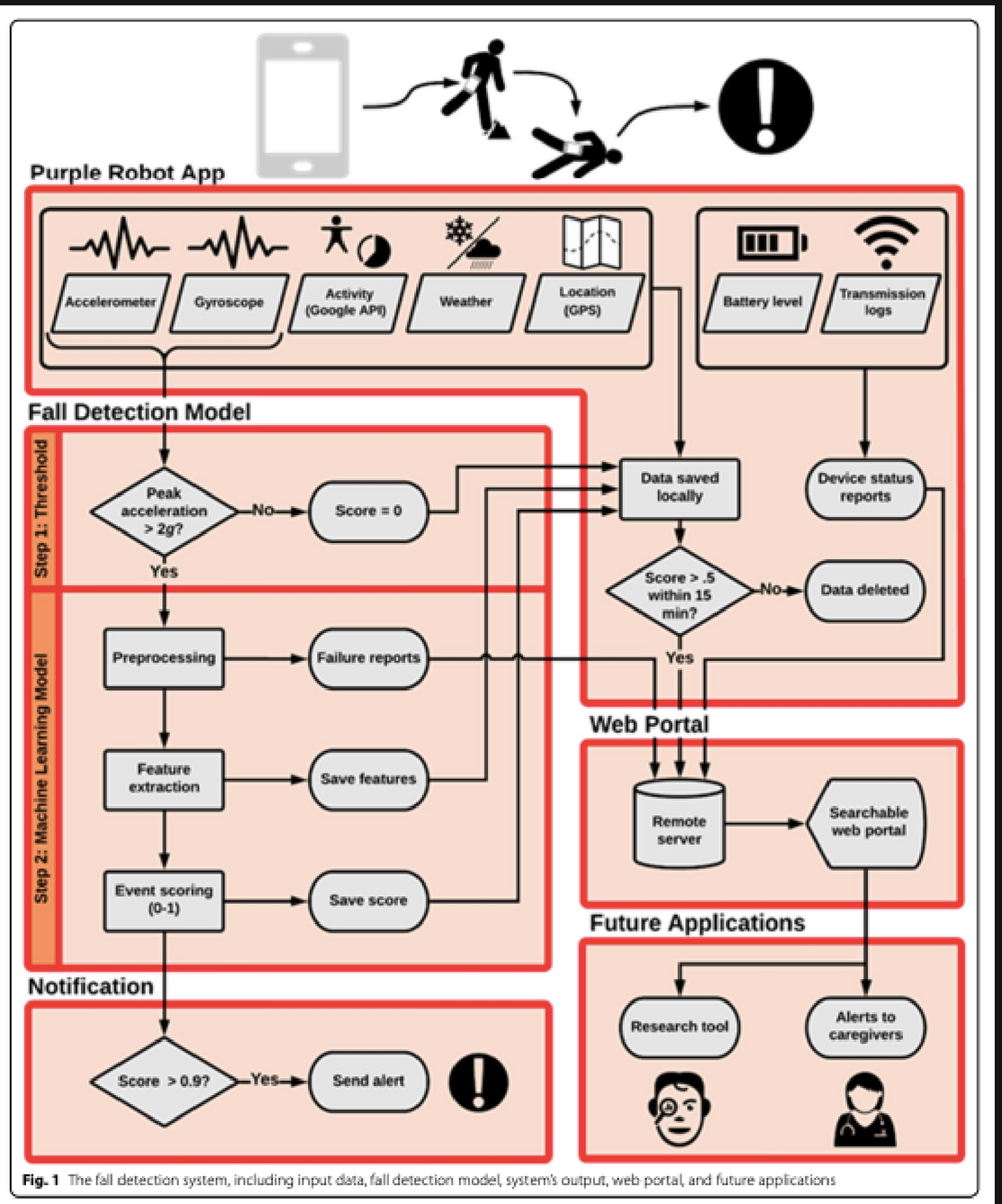


Fig. 1 The fall detection system, including input data, fall detection model, system's output, web portal, and future applications

STEP 1:
SCREENING ACCELERATION THRESHOLD

+

STEP 2:
MACHINE LEARNING CLASSIFIER

Online fall detection system using Python by Ignacio Córdova

1. Read accelerometer data.
2. Choose appropiate metric.
3. Set threshold for state detection.
4. Program a response/alert if a fall is detected

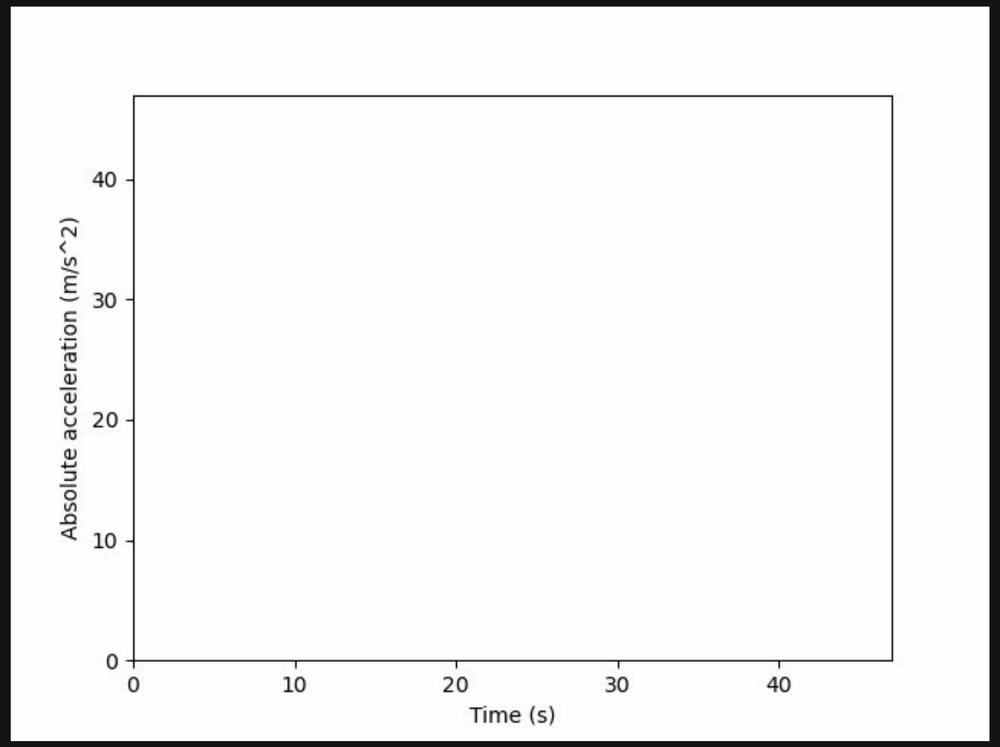
1. Read accelerometer data.


```
file1 = open('Raw Data Video.csv', 'r')
Lines = file1.readlines()
```

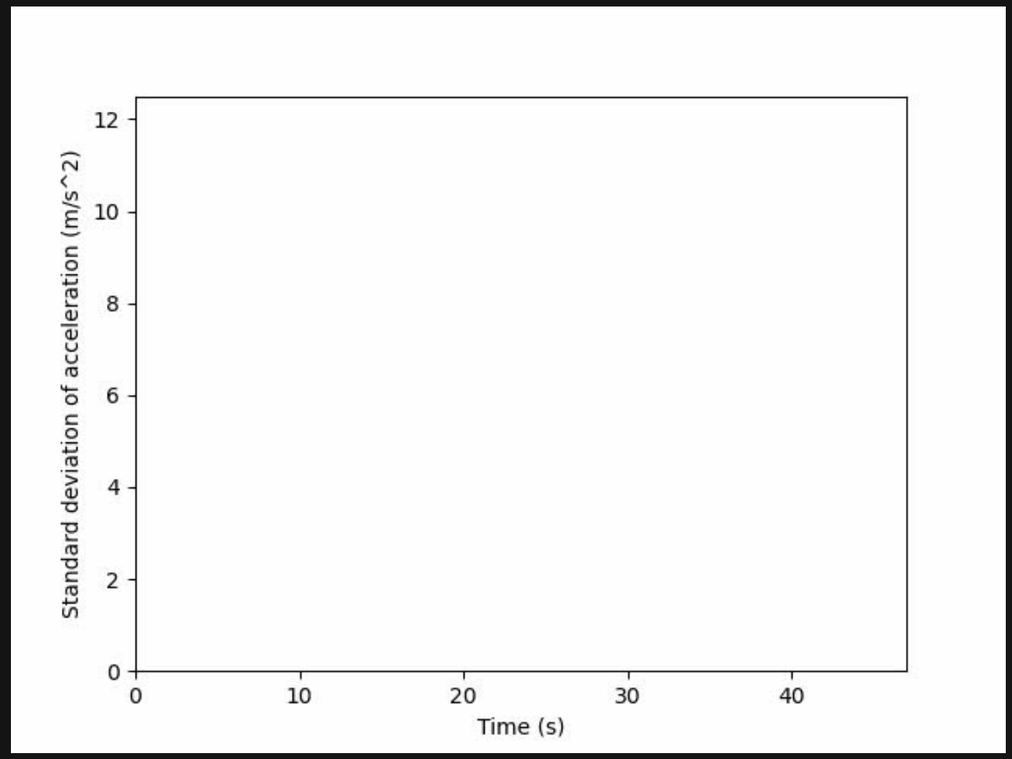
```
for line in Lines:
    # rest to simulate real-time data
    time.sleep(0.0039)
```

2. Choose appropiate metric

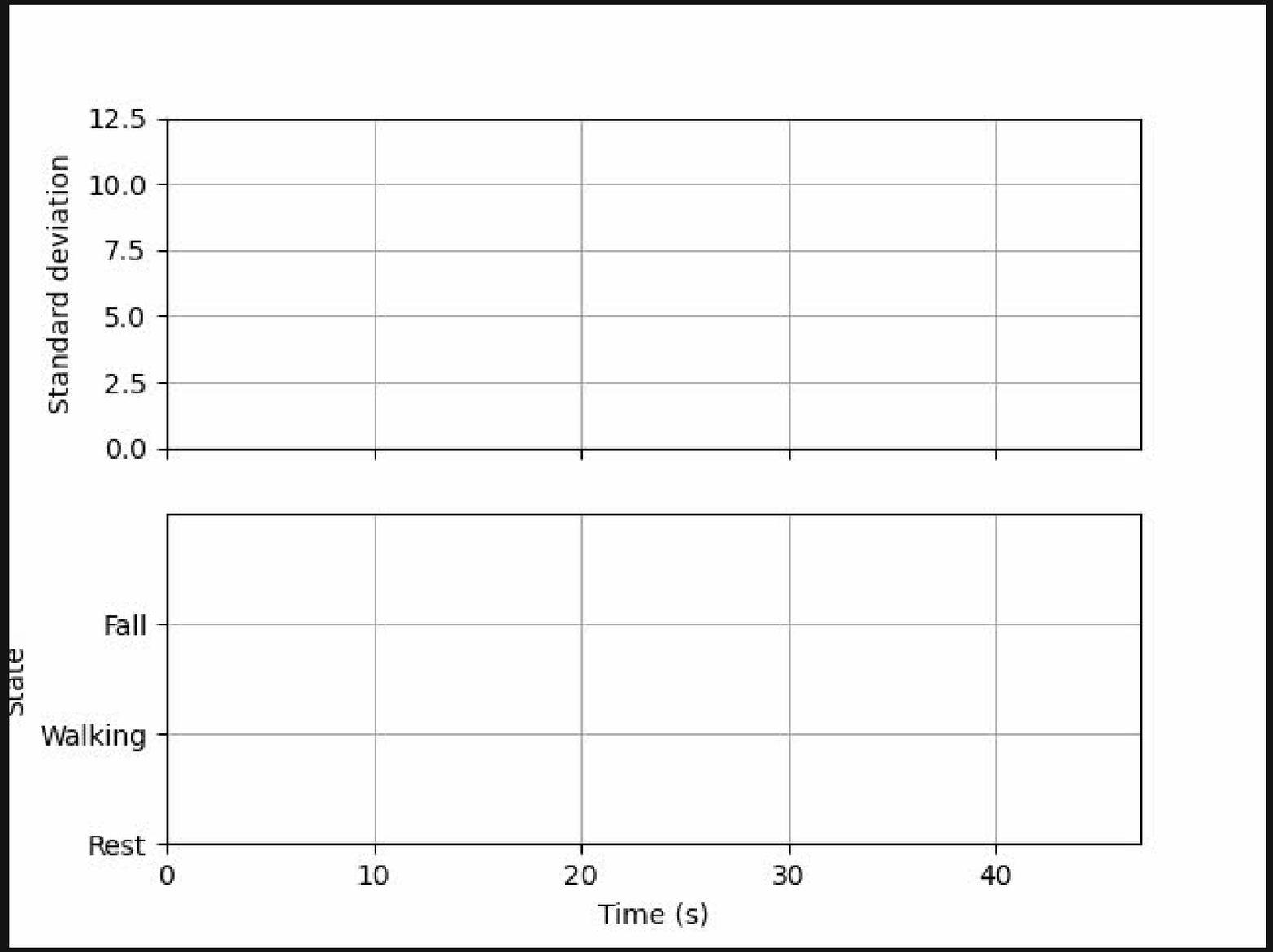
Absolute Acceleration



Standard Deviation

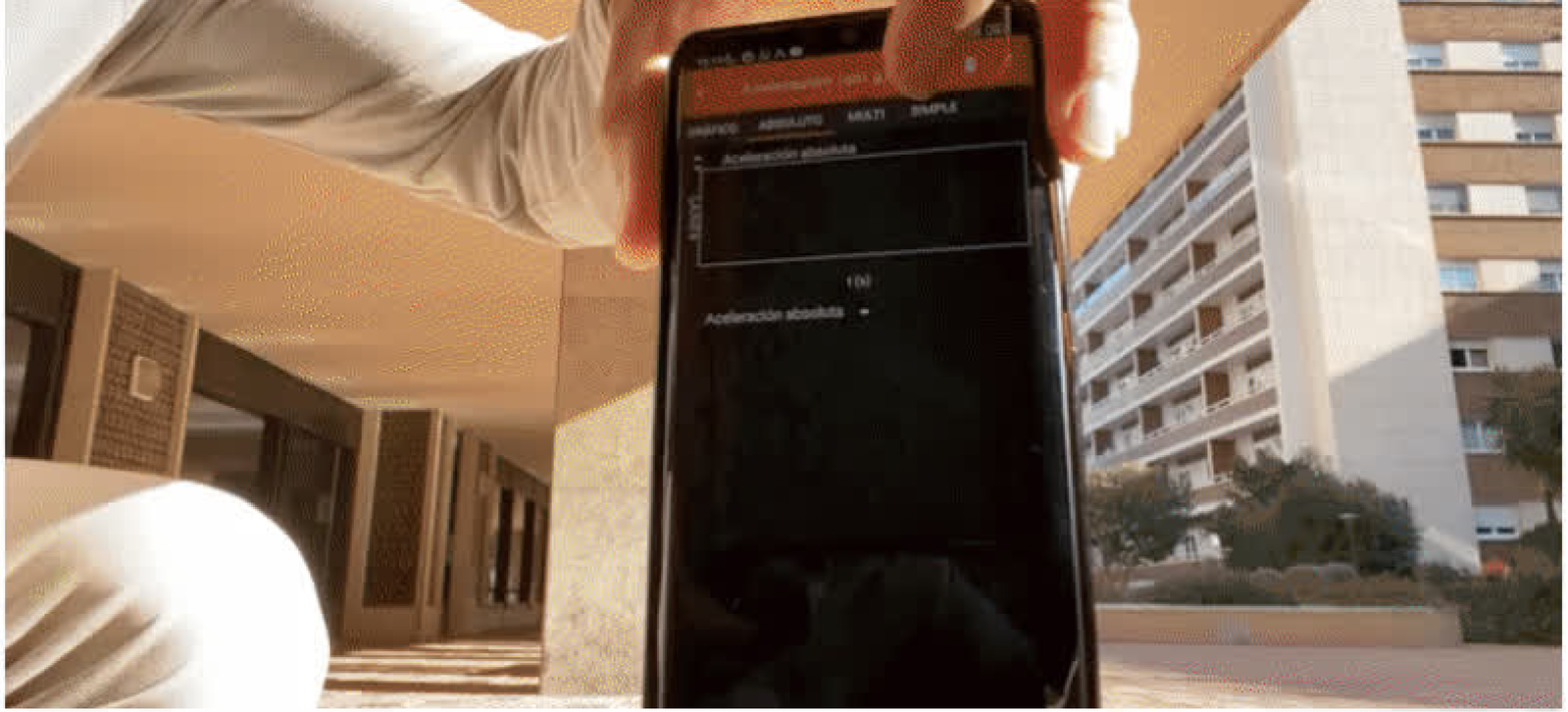


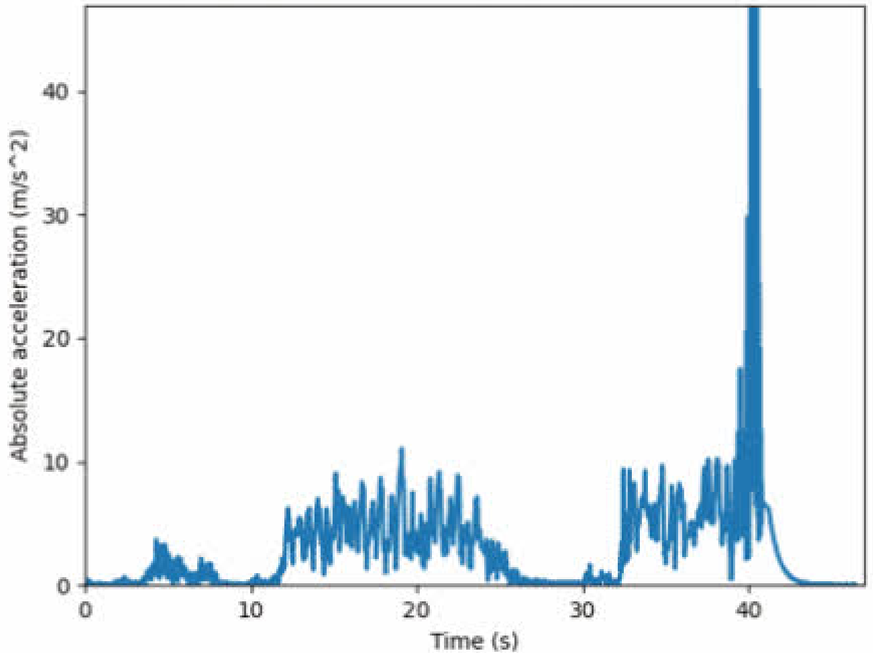
3. Set threshold for state detection

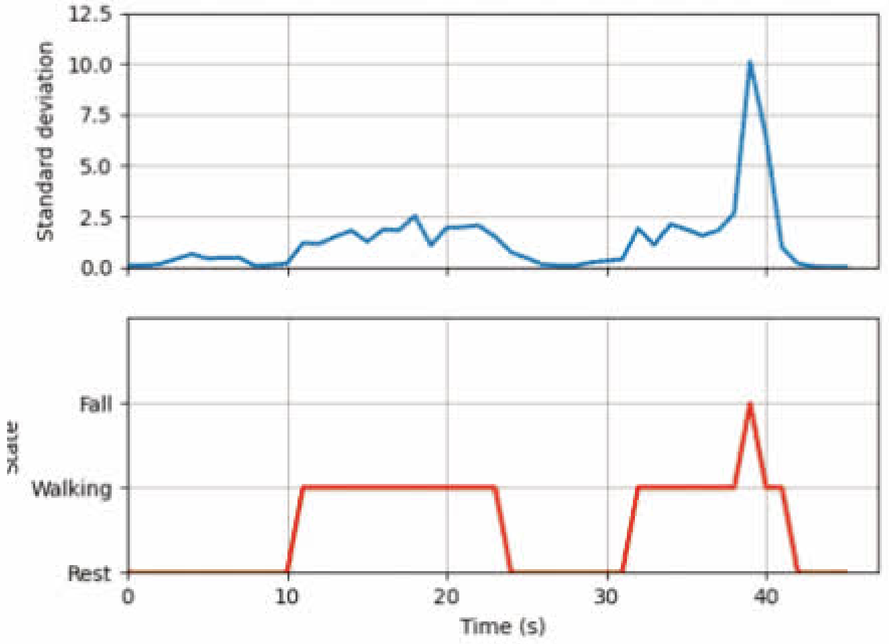


4. Program a response/alert if a fall is detected

```
elif std > 5 and (state == 1 or state == 0):
    state = 2

    print('')
    print('Fall detected at time: ', np.round(time_values[-1],2))
    print('Standard deviation: ', np.round(std,2))
    print('')

    # ask user if the person has fallen through a printed message
    ans = input('Do you need asistance? (y/n): ')
    if ans == 'n':
        print('Thank God!')
        print('')

    else:
        print('Calling 911...')
        print('')
```


Aceleración absoluta
t (s)
Aceleración absoluta


Absolute acceleration (m/s^2)
0
10
20
30
40
0
10
20
30
40
Time (s)


Standard deviation
12.5
10.0
7.5
5.0
2.5
0.0
State
Fall
Walking
Rest
0
10
20
30
40
Time (s)