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Human Activity Recognition using microcontrollers and AI algorithms

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Aim of the reserach

- Recent studies show that up to 40% of people above the age of 65 are subjects to accidents such as falling, which carries the risk of not only bone fracture, but also circulation problems and concussion.
- With recent developments in the area of embedded systems, we can observe a growing interest in devices described as 'wearables', which can help people in many different ways including for example fall detection.
- **The main aims** of this research are:
 - to build a low-cost, low-power device which could be used as a tool for helping elderly people or people with disabilities who are dependent on others.
 - testing the effectiveness of recognizing movement patterns with the use of a microcontroller, an inertial sensor and AI algorithms.

An experimental system for the detection of a fall or lack of movement

The concept of the system:

ATmega328P



Power supply



MPU-6050
inertial sensor



Bluetooth
module



Mobile device



An experimental system for the detection of a fall or lack of movement

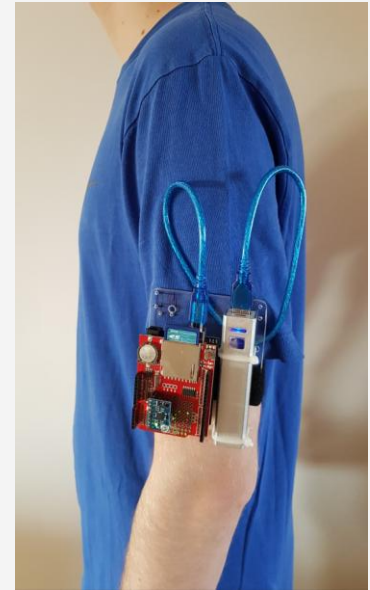
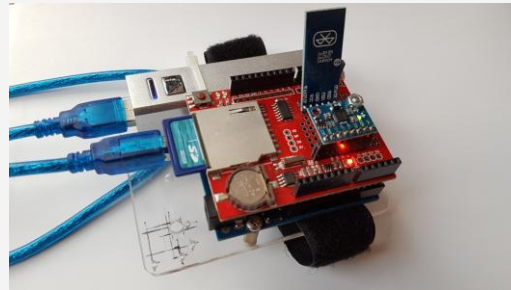
Main components:

- Arduino UNO with microcontroller ATmega 328P
- MPU 6050 module (6 DOF - accelerometer and gyroscope)
- Bluetooth HM-17 device

Application software environment:

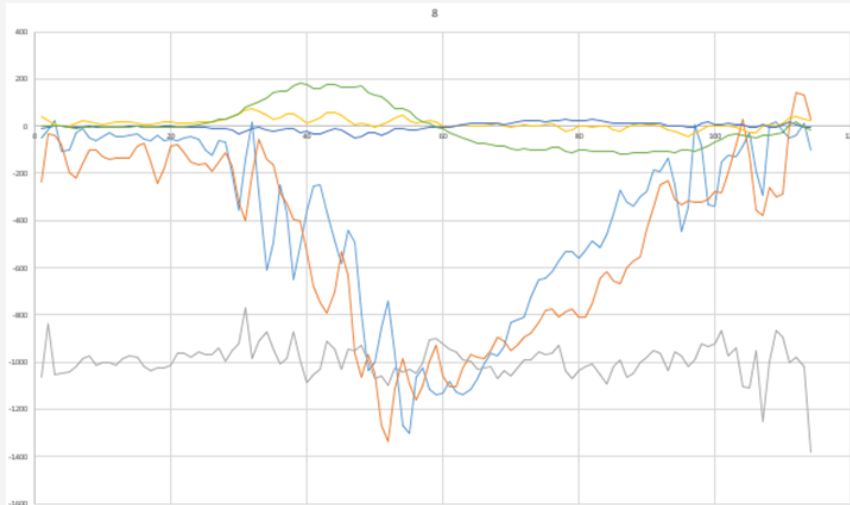
- Arduino IDE
- MIT App Inventor – for mobile app

Arduino IDE

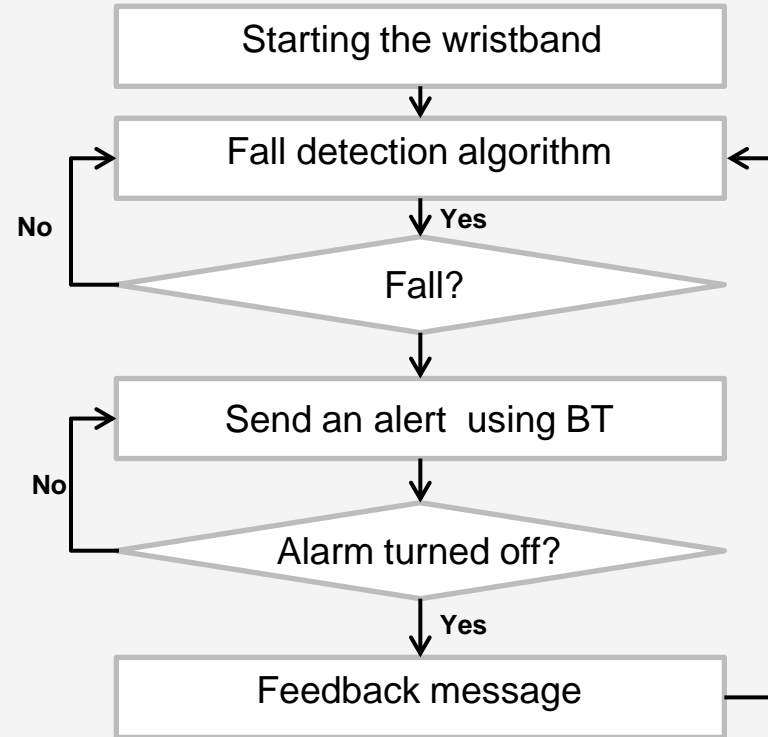


An experimental system for the detection of a fall or lack of movement

How does the device work?



Data from IMU

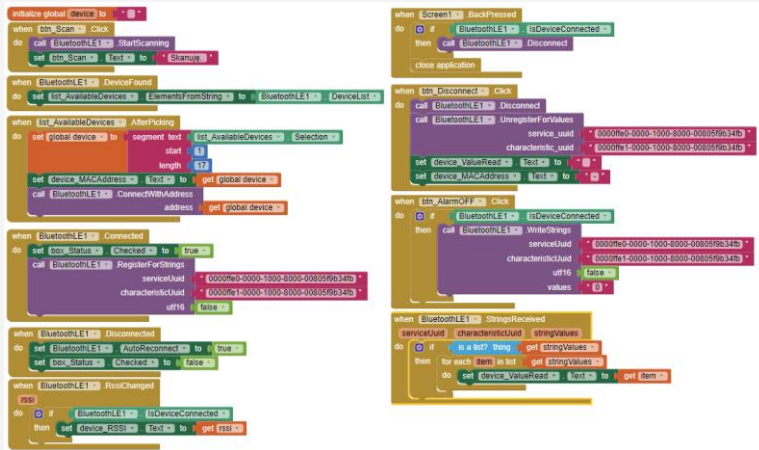


An experimental system for the detection of a fall or lack of movement

Smartphone app:

- designed in open-source visual environment MIT App Inventor

- application interface (in Polish)



```
initialize global device to [BluetoothLE1]
when btn_Scan clicked
do call BluetoothLE1 StartScanning
set btn_Scan text to Skanuj

when BluetoothLE1 DeviceFound
do set list_AvailableDevices ElementsFromList to BluetoothLE1 DeviceList

when list_AvailableDevices AfterPicking
do set global device to segment list list_AvailableDevices Selection
set device_MACAddress length 17
call BluetoothLE1 ConnectWithAddress address get global device

when BluetoothLE1 Connected
do set btn_Status checked to true
call BluetoothLE1 RegisterForStrings serviceUuid 00001800-0000-1000-8000-0000561416 characteristicUuid 00001800-0000-1000-8000-0000561416 uuid false

when BluetoothLE1 Disconnected
do call BluetoothLE1 AutoReconnect to true
set btn_Status checked to false

when BluetoothLE1 RSSIChanged
do if BluetoothLE1 DeviceConnected
then set device_RSSI text to get RSSI

when Screen1 BackPressed
do if BluetoothLE1 DeviceConnected
then call BluetoothLE1 Disconnect
close application

when btn_Disconnect clicked
do call BluetoothLE1 Disconnect
call BluetoothLE1 UnregisterForStrings serviceUuid 00001800-0000-1000-8000-0000561416 characteristicUuid 00001800-0000-1000-8000-0000561416 uuid false
set device_ValueRead text to
set device_MACAddress text to

when btn_AlarmOFF clicked
do if BluetoothLE1 DeviceConnected
then call BluetoothLE1 WriteString characteristicUuid 00001800-0000-1000-8000-0000561416 uuid false values alarm

when BluetoothLE1 StringReceived
do if is a list? thing get stringValues
then for each item in list get stringValues
do set device_ValueRead text to get item
```



An experimental system for the detection of a fall or lack of movement

SMD realization

in the form of low-power wristband:

- miniaturized system equipped with a Bluetooth module
- remote communication with a smartphone via dedicated app
- designed to notify the person caring for the user in the event of a fall

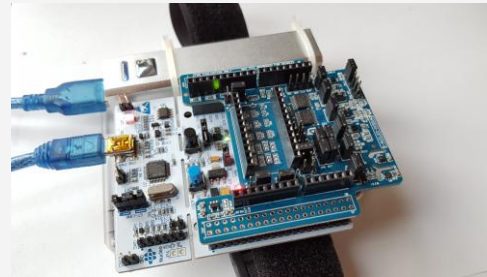


Advanced analysis of movement patterns using e-AI

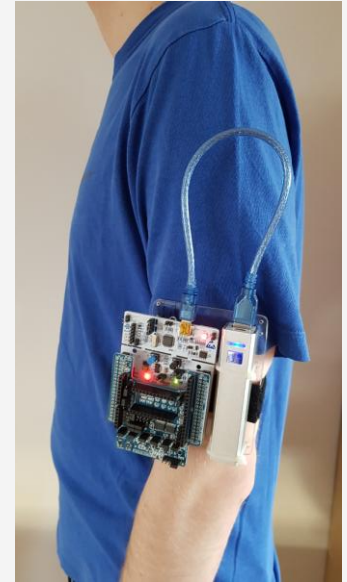
It should be noted that simple microcontrollers can detect simple events. Currently selected microcontrollers of the STM32 family allow for the implementation of algorithms for detecting complex movements.

The following experiments were investigated:

- jumping jacks
- squats
- push-ups
- twisting the torso
- turning the hips



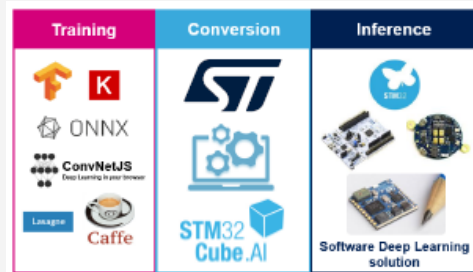
The Nucleo **STM32L476** module with Multi-sensor board containing, among others, **LSM6DSO** iNEMO 6DoF inertial measurement unit (IMU), with advanced Digital Function, Finite State Machine was used for the experimental tests.



Advanced analysis of movement patterns using e-AI

Experiments are also carried out with the modern **SensorTile.box2** module (designed by ST), which is based on the STM32L4R9 microcontroller and includes the LSM6DSOX, which is an inertial module with additional Machine Learning Core compared to the LSM6DSO.

The LSM6DSOX can be configured to run up to 8 decision trees, that are stored in the device.





Summary

- As part of the experimental research, low-cost, low-power wristband was built based on the ATmega328P microcontroller, BT module and MPU6050 inertial sensor. The used BT module (HM-17) allows you to work with distances from the receiver (smartphone) of up to 100m. The designed system allows you to detect lack of movement or fall.
- The project based on the ATmega 328P will be developed using more modern microcontrollers of the STM32 family, which allow the use of artificial neural networks. Modern electronic components such as LSM6DSOX as well as advanced programming environments and AI libraries support the solution research process.
- In the case of HAR devices based on the IMU, calibration and the correct selection of the place of installation of the device are still an important issue.