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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 disablities 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

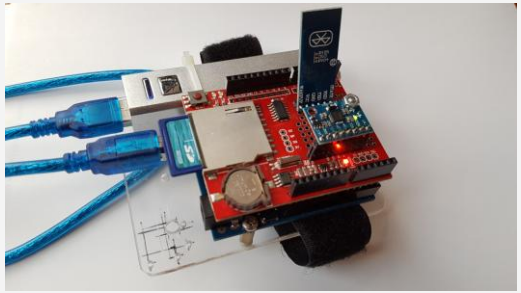
An experimental system for the detection of a fall or lack of movement

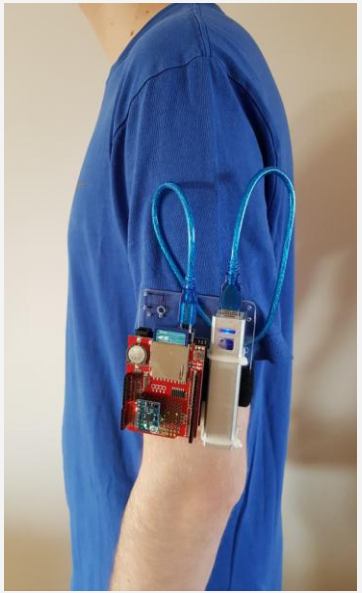
Main components:

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

Application software environment:

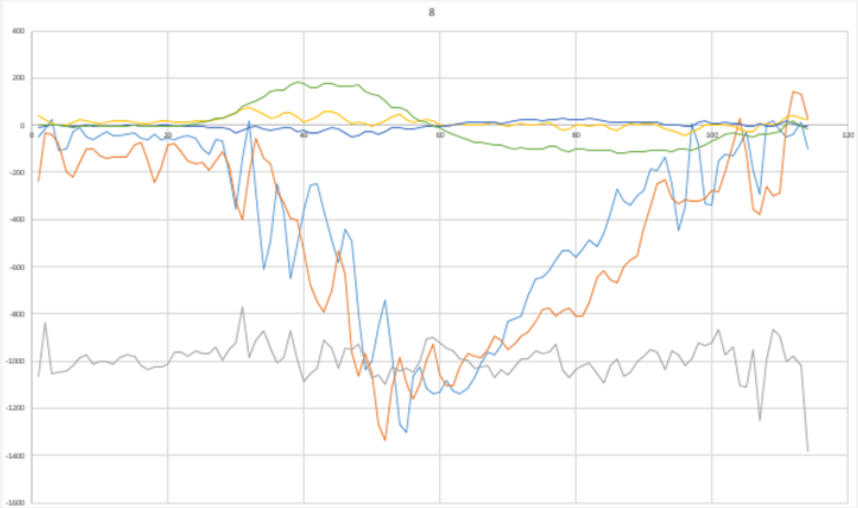
- Arduino IDE
- MIT App Inventor – for mobile app



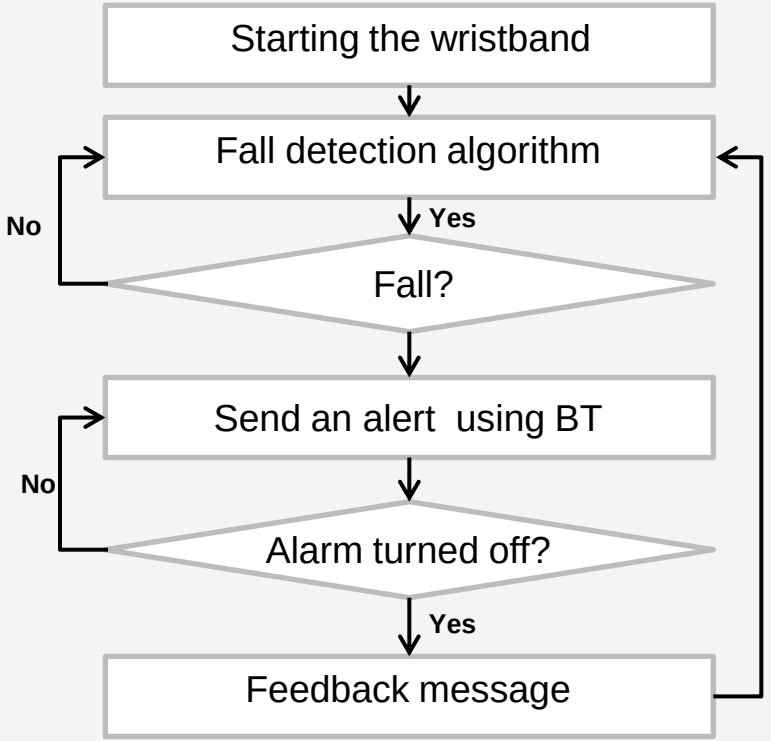


An experimental system for the detection of a fall or lack of movement

How does the device work?



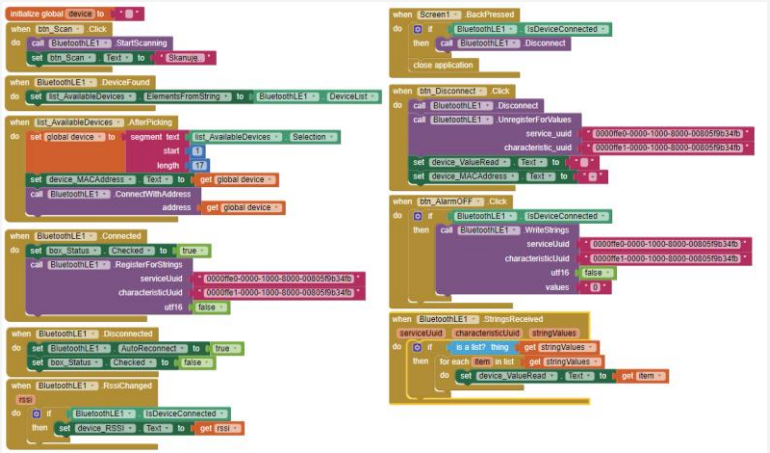
Data from IMU



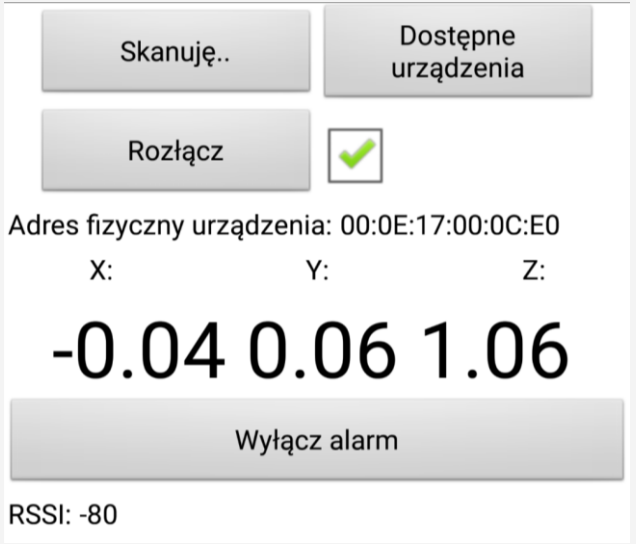
An experimental system for the detection of a fall or lack of movement

Smartphone app:

- designed in open-source visual environment MIT App Inventor



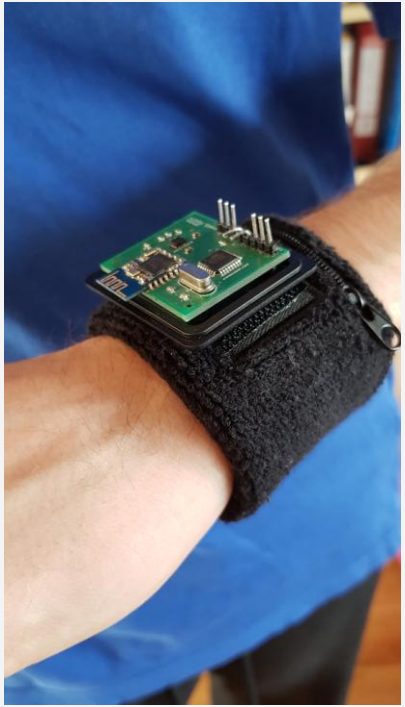
- application interface (in Polish)



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

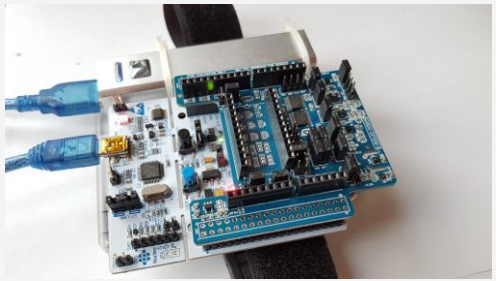


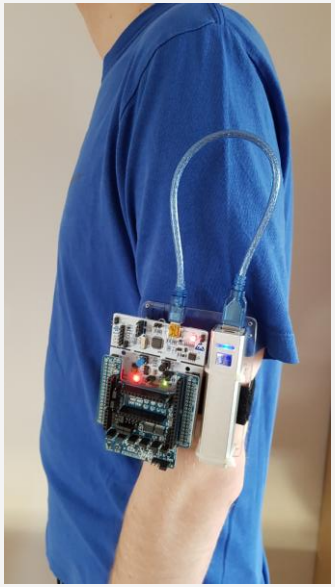
Advanced analysis of movement patterns using e-AI

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



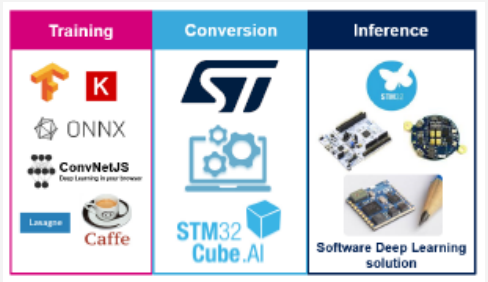


The Nucleo **STM32L476** module with Multi-sensor board containing, among others, **LSM6DSO** iNEMO 6DoF inertial measurement unit (IMU), with advanced Digital Function, Finite State Machine was used for the experimental tests.

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.