UNIVERSITY OF CAGLIARI

DIEE - Department of Electrical and Electronic Engineering

Project design

- Example -

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Project document

- It is a document comprises both analysis and design phase
- For the analysis part:
  - Definition of the scenario
    - Define all your assumptions
  - Analysis of the possible competitors and study of their pros and cons (OPTIONAL)
  - Analysis of functional and non-functional requirements
  - For each functional requirement:
    - Analysis and choice of available HW (development board, sensors, actuators, and so on)
    - Analysis and choice of the application protocol and communication technology (mostly WiFi)
    - Analysis of suitable user interfaces
- NOTE: some choices could be global (i.e. the same for the all requirements, such as development board, user interface)

Project document

- For the design part:
  - Architecture definition
  - Design of the algorithms (such as flowchart) – there could be as many algorithms as the FRs
  - Any approach used for sending data
  - Design of HW wirings
  - Discussion on the association real objects – Digital Twins
  - Mock-up of any user interface

Request

- This project aims to monitor falls in a home environment, regardless of which room a person is in

- When a fall is detected, an alarm message needs to be sent to close relatives

- Bluestar Seniortech
- SureSafe
- greatcall
- Buddi
- Bay Alarm Medical
- Medical Guardian
- Philips
- MobileHelp
- MyNotify
- Apple

Brand	Price (device/ montly plan/ automatic fall detection)	Landline[13]	Mobile[14]	Range[15]	Phone Connection[16]	Fall Localization[17]
BlueStar SeniorTech						
Sentry in-Home Medical Alert	$29.95 per month	Yes	No	600ft	No	No
SureSafe						
SureSafe GO 2 'Anywhere' Alarm	139$ + 25$ per month	No	Yes	Nd	Yes	No
GreatCall						
GreatCall Lively	40.99$ + 14.99$ per month	No	Yes	30ft	Yes	No
Buddi						
Buddi	wristband 99£ clip 149£ + £1.99/£4.99 per week	No	Yes	30ft	Yes	No
Bay Alarm Medical						
In home	19.95$ per month + 10$ per month (automatic fall detection)	Yes	No	800ft	No	No
On the Go	$79.99 + 24.95$ per month(support) + 10$ per month (fall detection)	No	Yes	Nd	Yes	No
Medical Guardian						
Home Guardian	$34.95 per month + $10.00/month each (fall detection)	Yes	No	600ft	No	No
Classic Guardian	$29.95 per month + $10.00 per month each (fall detection)	Yes	No	1300ft	No	No
Philips						
HomeSafe with Auto Alert	$44.95 + $50	Yes	No	Nd	No	No
MobileHelp						
MOBILEHELP CLASSIC	$19 per month + $10 per month	No	No	600ft	Yes	No
MyNotifi						
MyNotifi	$99.00	No	Yes	Nd	Yes	No
Apple						
Apple Watch	Starting from: 439 € + 4,99€	No	Yes	Nd	Yes (but only with Apple devices)	No

Scenario

- Target: elderly people who live alone
- Must operate in a domestic environment (indoor application)
  - No indoor tracking with GPS (issue!)
- Internet connection through WiFi available in the home environment
- Preliminary idea:
  - 1 device for fall detection (wearable) -> where? Arm,wrist, ankle, neck..
  - Several devices for fall location (granularity) -> exact location or room, floor?
  - 1 speaker for alarm
  - 1 button to cancel alarm within a time frame/to request help even without detection

Functional requirements

Fall detection	
Description	The system must detect possible serious falls, in order to sending an alarm to the user relatives.
Input	Physical measure evaluated for distinguishing between a fall and other activities.
Output	Trigger for the fall evaluation.

Functional requirements

Fall detection	
Fall evaluation	
Description	Evaluation of the fall severity, by evaluating if the user is able to stand up independently, or if the external assistance is needed, and the eventual manual cancelation through the button pushing.
Input	Trigger for the fall evaluation.
Output	Trigger for the localization function.

Functional requirements

Fall detection	
Fall evaluation	
Manual alarm	
Description	The system must allow the voluntary assistance requests by the user himself/herself.
Input	Manual alarm button pushing.
Output	Trigger for the localization function.

Functional requirements

Fall detection	
Fall evaluation	
Manual alarm	
User localization	
Description	In case of a detected fall or manual alarm, the user must locate the user in order to evaluate his/her position in the environment, in order to speed up the assistance.
Input	Trigger for the localization function.
Output	Information related to the user location, and trigger alarm alert.

Functional requirements

Fall detection	
Fall evaluation	
Manual alarm	
User localization	
Alarm sending	
Description	The system must send an alarm message, also containing information about the user location, through the transmission system.
Input	Information related to the user location, and trigger alarm sending.
Output	Alarm message.

Functional requirements

Fall detection	
Fall evaluation	
Manual alarm	
User localization	
Alarm sending	
Alarm deactivation	
Description	The system must allow the possibility to deactivate a false alarm before sending it to the relatives, as well as an involuntary assistance request due to an unintentional pushing of the alarm button. The system warns the user through a sound alarm, identifying the following alarm sending, while the user can deactivate that by pushing the button. After this period, the system switches to the alarm sending stage.
Input	Manual deactivation button pushing.
Output	Cancel of alarm generation, or continuation in sending the alarm.

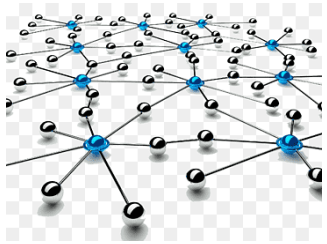
Non-functional requirements

Fall detection accuracy (detect 80% of real falls with less than 5% false alarms)
System robustness (system works with not-working subsystem, e.g. localization)
Latency (alarm to close relatives within 5 seconds)
Privacy (close relatives need access to the user information with user and password)
Fall detection device security (the device can resist 1000 falls)
Power management (device lifetime of 1 week before recharge)
Price (final device in the range 30-50$)
Scalability (backend able to support 10,000 contemporaries users)
Non-invasinveness (wearable with dimension comparable to a smartwatch or less)
Simplicity of use (how can you measure it??)

Analysis

- Analysis of available HW
  - Comparison between main board
    - Node MCU ESP8266, Arduino UNO, Raspberry Pi 3
  - Comparison between sensors for fall detection
    - Wearable, visual, ambient, smartphone-based, combination
  - Comparison between sensors for fall localization
    - GPS, ultrasonic, video-based, floor, PIR, BT
- Analysis of suitable user interfaces
  - SMS, Telegram, Email, WhatsApp, Facebook Messenger, Push Notification on Smartphone, Ad hoc App
- Choice of the most appropriate protocol
  - Client-server OR publish-subscribe

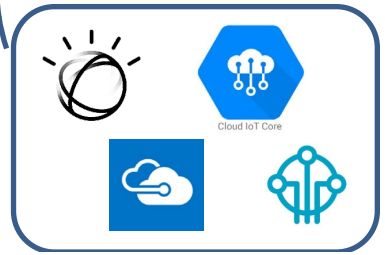
IoT solutions



Sensor Networks

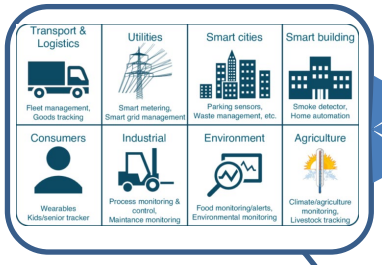
IoT Devices

HTTP, MQTT, CoAP, AMQP, XMPP



IoT Platform

IoT application protocols

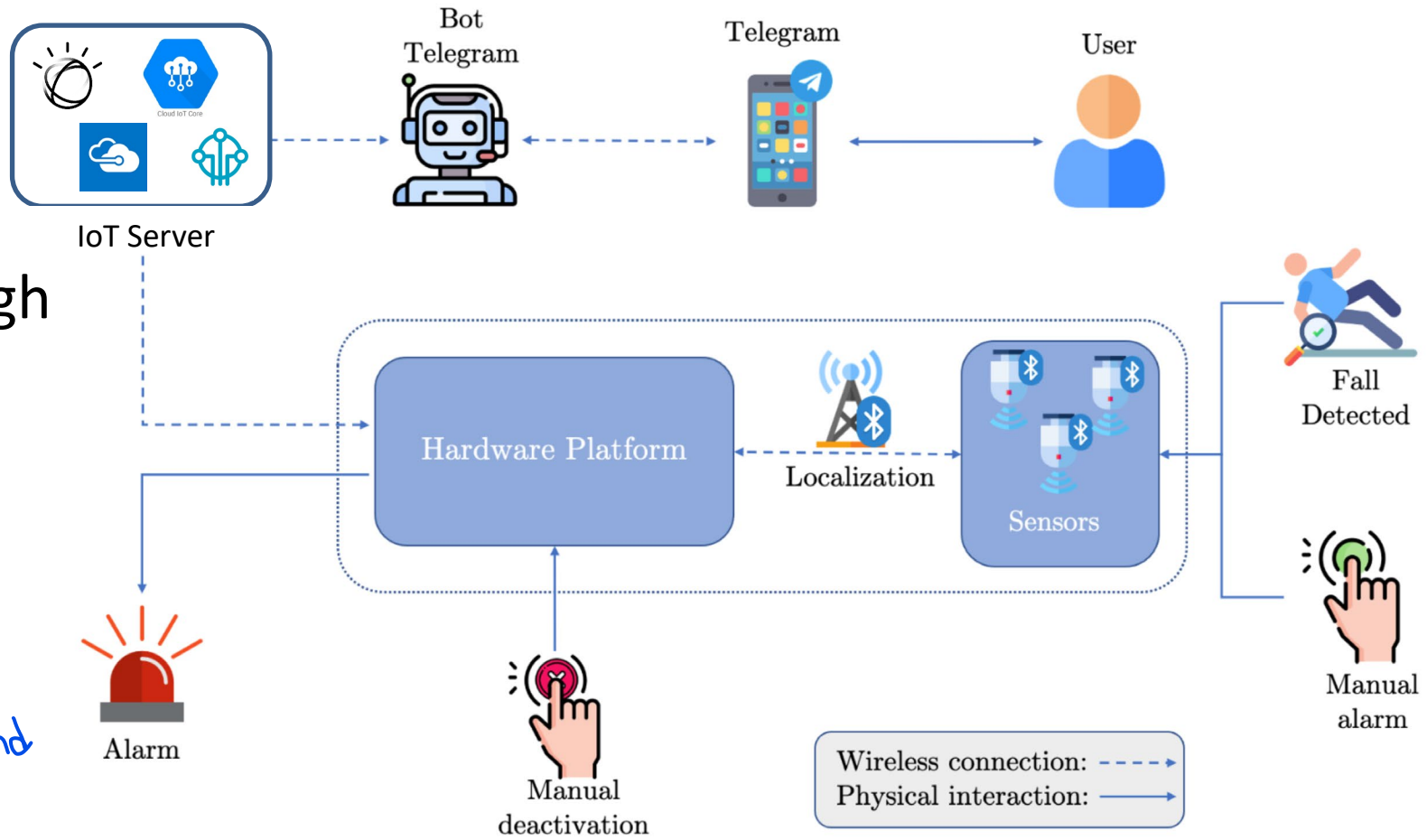


IoT applications

INTERNET

Architecture definition

- Fall detection:
  - Automatic (through wearable)
  - Manual (through button)
- Where to implement the algorithms for fall detection? Backhand



Algorithms and flowchart

- Fall detected based on the threshold value of:

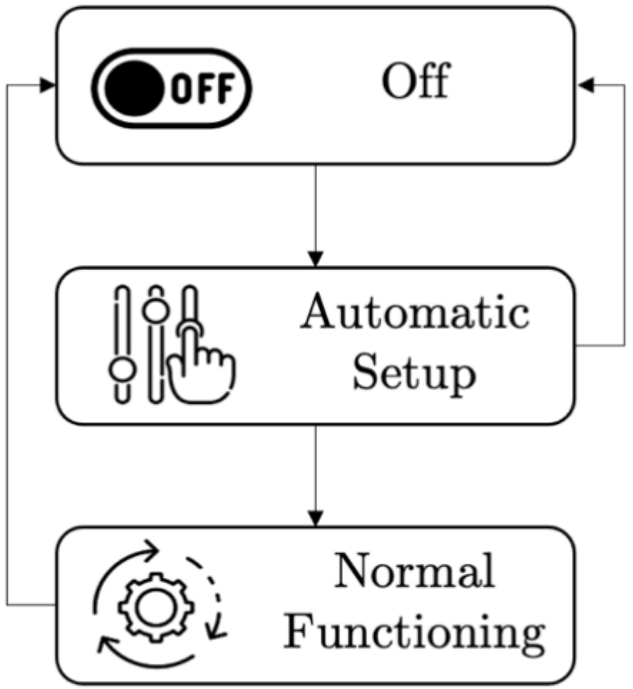
$$a_h + a$$

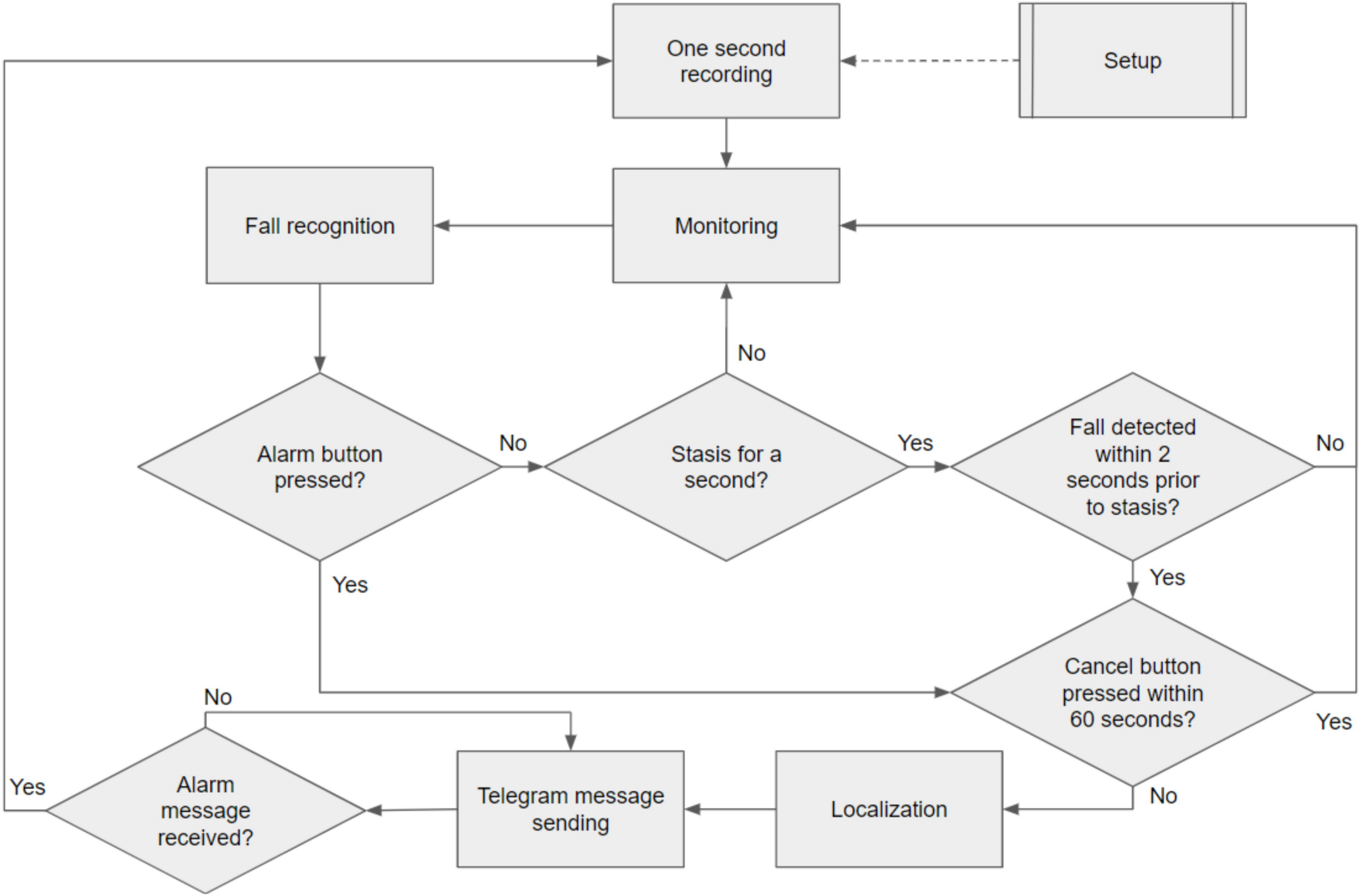
$$a_h = \sqrt{a_x^2 + a_z^2}$$

Sum vector magnitude on the horizontal plane.

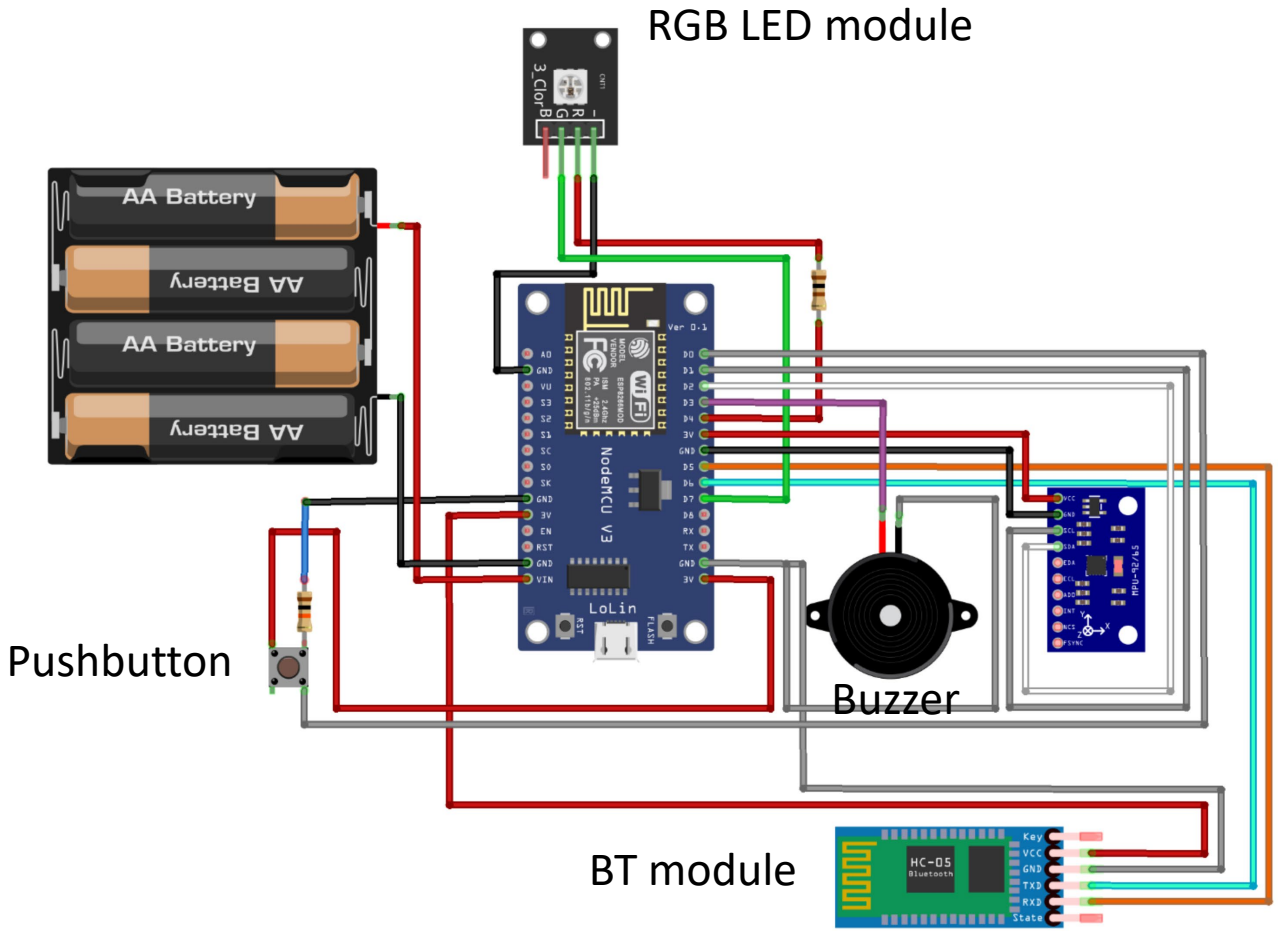
$$a = \sqrt{a_x^2 + a_y^2 + a_z^2}$$

Sum vector magnitude.

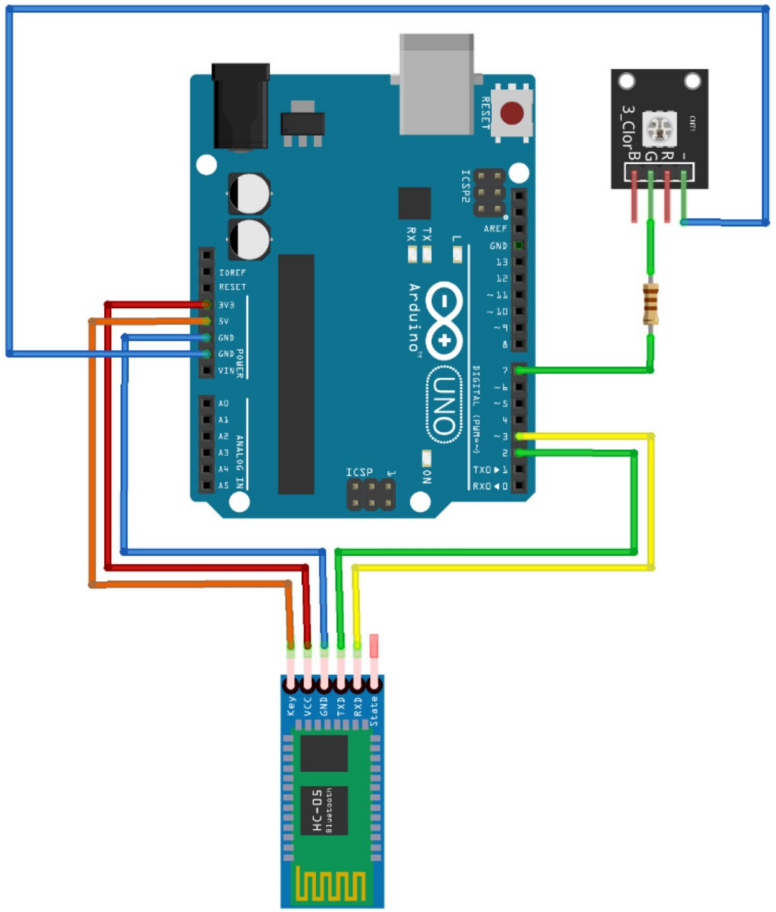



One second recording
Setup
Fall recognition
Monitoring
No
Alarm button pressed?
No
Stasis for a second?
Yes
Fall detected within 2 seconds prior to stasis?
No
Yes
Yes
Cancel button pressed within 60 seconds?
Yes
No
No
Alarm message received?
Yes
Telegram message sending
Localization

Design of HW wirings



Wearable device.



Location device.

Telegram Bot

Which information and/or interactions are useful for the users?

- when the wearable device is turned on.
- if the fall occurred and if it was detected by the installed sensors;
- if the fall occurred and if it was signaled by manually pressing the alert button;
- at what time did the fall occur;
- the estimation of the room where the fall occurred;