DSD project

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Content

[Abstract 3](#_Toc94116546)

[Introduction 4](#_Toc94116547)

[Fall detection system 5](#_Toc94116548)

[Background. 5](#_Toc94116549)

[How it works? 6](#_Toc94116550)

[Pulse meter 7](#_Toc94116551)

[BCG system 8](#_Toc94116552)

[Background. 8](#_Toc94116553)

[How it works? 9](#_Toc94116554)

[Business aspects 10](#_Toc94116555)

[Manual for users 11](#_Toc94116556)

[Results and Summary 12](#_Toc94116557)

# Abstract

# Introduction

Being aware and taking care of health state is a popular phenomenon in the modern society. High variety of different inventions related to the human health are producing every day. One of the such devices was produced by us. The main purpose of the device is providing the data about the user’s health. Most of old people have to leave live alone separately from their relatives. At this point, it may lead to the actual issue directly connected with their well-being. How to take care of them or how to know that everything is ok? For instance, according to THL, 44% of injuries in Finland that resulted in death were caused by falling. Falls result in various fractures around the hip and it is essential to get medical care as soon as possible for this as it can lead to massive internal bleeding. For the over-65 years old population, falling can be a serious health risk. Three million older people each year are treated in emergency rooms for fall-related injuries, and one in four older adults falls each year.

The first thing that comes to the mind in order to manage it is providing the human resource to the old person. However, it cannot be actual solution for big number of people at the elderly age. Our project tries to take into account all of such nuances and satisfy them. Also, high functionality of our product makes it unique and gives a possibility to use it for other categories of people which expands the target group. There are three main functions that our device includes: fall detection system, pulse meter and BCG system. As it was mentioned, due to this multifunctionality feature, the target audience can be variable. Since, there is no strict rule that implies the device only for people over 65, therefore people who have desire to take care of their health are also able to use it. Especially, the group of population who suffer from heart diseases are tend to purchase our gadget in order to collect the data about ballistocardiography and pulse rate which can be used in medical purposes.

# Fall detection system

## Background.

It is important for the mental health and well-being of people to maintain autonomy and private time. This is also the motivation behind distance care scenarios for elderly people. Elderly patients are given the opportunity to continue to live on their own, while possible accidents or critical situations are monitored by sensors installed in the environment or worn by the subject, which may comprise specific body-internal conditions, such as strokes, heart issues, or diabetes related complications, as well as body-external events, such as falls. Indeed, among elderly people living on their own, falling, for instance, as a result of tripping, loss of balance, slipping or loss of consciousness, is a major health risk that can lead to severe injury. Each year, one third people above 65 years fall, which might result in severe injuries [1]. In particular, it has been suggested that the event of a fall may be fatal for half of the elderly people who are unable to get up for an hour or more even without direct injuries [2]. In this context, fall detection systems which alert caregivers, or other persons of trust provide the necessary protection in case of accidents or critical situations. An extensive amount of recent work has been conducted on fall detection systems based on a range of different approaches (wearable, environmental, etc.). Environmental technologies include computer vision, passive infra-red sensors, and wireless technologies. Among these, computer vision based approaches have proven to be highly accurate, however, they suffer in occlusion cases [3] and their perceived privacy intrusion may prevent an installation in private domains [4]. Other environmental sensing approaches comprise microphones, pressure, or vibration sensors, however, they are prone error since other sources of pressure or sound may cause false alarms [5]. Recently, especially the detection through RF-based approaches, such as radar, or channel state information (CSI, e.g. wireless sensor networks, WiFi) have become popular. CSI-based approaches are based on time domain, or time-frequency domain, similar to radar based fall detection. High recognition accuracies of 78% [6], 81% [7] and 93% [8] have been demonstrated in the literature. Among wearable technologies, a range of fall sensors have been proposed such as ECG, accelerometers, RFID, gyroscopes, pressure sensors and smart phones. While wearing sensors can be very effective, in particular in outdoor environments, it may not always be complied with by older people. In particular, for body-worn solutions, no protection is provided during periods in which the person decides to not wear the system, such as, for instance, during the night or in a (slippery) bathroom while having a shower. Among those elderly people that live on their own, about half of the falls occur outside their own premises [9], which suggests the need for a reliable wearable fall detection scheme, which covers not only the own home, but also arbitrary other environments. For a comprehensive survey on fall detection systems using various technologies, we refer to [10,11,12].

## How it works?

The main purpose of the device as it was mentioned above is a giving the signal to the responsible person. Gadget is able to determine when the fall occurred. It considers several cases with executing different triggers which make calculations to check the values with thresholds. In the case fall was detected, device waits for several seconds, in order to user can cancel the signal sending. This step was implemented by taking into account that user can activate signal accidently by touching or dropping it down. Cancelling the signal happens by pressing the Push Button which is located in the center of front side. Finally, responsible person will receive a message on Telegram about signal cancelling by user. Otherwise, if button is not pressed, special signal generated by buzzer will be playing. After couple of seconds, system will send a message like “Fall detected” to the responsible person who takes care of the user via Telegram. Meanwhile, the signal does not stop its playing until the moment button is pressed manually. This idea was implemented as notification for other people around that some urgent help is required for the user. Ideally, person who hears this sound should be aware that the user has health issues. Device system is directly connected with Telegram application. Special TelegramBot was created, identified by its id and assigned to the gadget in purpose person who takes a care can get updated about the state of user. In other words, it operates like a bridge between the user and responsible person. The most important aspect that should be mentioned is Internet connection. Gadget always has to be connected to the internet shared by the user in order to send the signal. Internet credentials (name of API and password) are implemented in system in advance by the user or responsible person. This process will not represent any challenges, since no need in specific knowledge in programming. Everything is clearly explained in manual and should take only couple of seconds to write the necessary credentials.

Main components of system: ESP-32, MPU-9250, buzzer and push button. ESP operates in the role of “brain” in the system. It reads all values collected by accelerometer and does essential calculations. Also, fall detection part of device uses accelerometer MPU-9250 which contains accelerometer and gyroscope that provides opportunity to measure the acceleration and angle change of device. Roles of buzzer and button are simple and briefly explained above.

System uses I2C protocol. A serial asymmetric bus is used in electrical devices to communicate between integrated circuits. Low-speed peripheral components are connected to CPUs and microcontrollers through two bidirectional communication lines (SDA and SCL) (for example, on motherboards, in embedded systems, in mobile phones) [13].

# Pulse meter

# BCG system

## Background.

Nowadays, many of methods to get cardio signals are known and commonly used in order to take necessary data related to human’s heart rate. Most popular among them are Electrocardiogram (ECG or EKG) and Ballistocardiogram (BCG). As it was previously mentioned, the device created by us includes the function of BCG which allows to analyze heart state of a human. Since device is especially designed for elderly people, controlling and tracking their heart rate is essential factor in case of taking a care. Dozens of diseases directly related to the heart diseases are widespread among the elderly people at the age of 65 and older compared to the younger age categories. Accident heart attacks or strokes can have hazardous consequences such as being disable, lowering quality of life or can lead to much worse scenarios [14].

Method was created and developed by American scientist dr. Isaac Starr. Ballistocardiography is a method for studying the contractility of the heart muscles, recording mechanical displacements of the human body, identifying their consequences when blood is ejected from the heart into the aorta, pulmonary artery and blood flow through the vascular bed. It can be explained by accelerations of blood which happens when human in state of relaxation or contraction [15]. These cases occur with an apparatus (ballistocardiograph) in the form of a curve - a ballistocardiogram, which decreases with heart disease. The method gives a general idea of ​​the state of the cardiovascular system, especially the contractility of the heart, the elasticity of the main vessels. Generally, BCG measures heart’s and blood’s mass during the movement like in cardiac cycle and at the circulation moment. It leads to theory that Ballistocardiography is able to provide the whole complete picture of human circulation system [16].

## How it works?

# Business aspects

# Manual for users

# Results and Summary