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## CHAPTER 11

# Smart sensing systems for in-home health status and emotional well-being monitoring during COVID-19

Diana-Roxana Izdrui<sup>1</sup>, Marius Gheorghe Hagan<sup>2</sup>, Oana Geman<sup>3</sup>,  
Octavian Postolache<sup>4</sup> and Ricardo Alexandre<sup>4</sup>

<sup>1</sup>Stefan cel Mare University of Suceava, Suceava, Romania

<sup>2</sup>Gheorghe Asachi Technical University of Iasi, Iasi, Romania

<sup>3</sup>Health and Human Development Department, Stefan cel Mare University of Suceava, Suceava, Romania

<sup>4</sup>ISCTE-Instituto Universitario de Lisboa, Instituto de Telecomunicacoes, Lisbon, Portugal

### 11.1 COVID-19 virus and the evolution of the pandemic

There are a lot of things to say when we are talking about COVID-19: “What is it?” “Why did it appeared?” “How is that a lot of people are infected?” “Why is it spreading so much fear?” and the most important, “What can we do to pass through this period and what can we bring that is new into the fight with this disease?”

What we do know by now about coronaviruses (CoV) is that they are single-strand RNA viruses. There are different types of coronaviruses and can be classified into four genotypes of CoV. As shown in the following lines we can enumerate here: the Alpha-coronavirus ( $\alpha$ CoV), the Beta-coronavirus ( $\beta$ CoV), the Delta-coronavirus ( $\delta$ CoV), and the Gamma-coronavirus ( $\gamma$ CoV).  $\alpha$ CoV and  $\beta$ CoV viruses are extremely infectious for bats and rats, and the  $\delta$ CoV and  $\gamma$ CoV appear predominant in birds (Fang, Karakioulakis, & Roth, 2020; World Health Organization, 2020; Zhang, et al., 2020). Coronaviruses can also be classified as Severe Acute Respiratory Syndrome CoV (SARS-CoV) which appeared in China in 2003; Middle East Respiratory Syndrome CoV (MERS-CoV) in the Emirates in 2012; and in Severe Acute Respiratory Syndrome CoV-2 (SARS-CoV-2) or the Coronavirus (COVID-19) in China in 2019. The COVID-19 genotype involves four main protein molecules: spike (S), membrane (M), envelope (E), and nucleocapsid protein (N) (Fang, et al., 2020). SARS-CoV-2 is a packed molecule of about 60–140 nm in diameter, almost spherical or pleomorphic (Zhang, et al., 2020).

“Coronavirus disease (COVID-19) is an infectious disease caused by a newly discovered coronavirus. Most people infected with the COVID-19 virus will experience mild to moderate respiratory illness and recover without requiring special treatment. Older people and those with underlying medical problems like cardiovascular disease,

diabetes, chronic respiratory disease and cancer are more likely to develop serious illness” (World Health Organization, 2020). The COVID-19 virus affects mostly the organs’ vital functions, but especially the respiratory function.

During this pandemic, the most recommended thing was to remain at home. Hospitals were overworked, the number of infected patients was increasing, and because of it, solutions needed to be found.

## 11.2 In-home health smart sensing systems

The many discoveries that have been made in recent years in almost every field have been made thanks to technology. The healthcare services have benefited from innovations and improvements due to advances in electronic technology. The challenge for healthcare is how to develop new methods of diagnosis and treatment that allow the remote monitoring and commissioning of in-home health care devices and to improve their quality of services. The reliability, flexibility, and scalability of in-home health-care monitoring systems are considered as the main requirements that are considered in the context of the current pandemic needs.

In this context the domain of smart, wearable, and textile-based sensors are discussed, taking into account the integration of sensing functionalities on the level of in-home distributed sensor networks. The main function seems to be health monitoring, especially for elderly people, for well-being, and for sports and fitness. This domain needs materials and devices which are not high-cost, adapted for the inclusion in the “intelligent” clothes, and also very precise. The number of patents, papers, and device proposals during the last years is commensurate with the predicted growth of the domain, yet several difficulties remain.

Smart sensors have as processing cores microcontrollers that assure dedicated computation functions, specific to certain categories of sensors. The ease of use of microcontrollers in such applications consists of the software description of the functional blocks (AD conversion, digital filtering, data integration), the processes taking place in real time.

The difference between an intelligent sensor and a classic one is given by the intelligence-related capabilities manifested by the functions implemented in the sensor: self-diagnosis, self-identification or self-adaptation, data fusion, and others (Hagan, 2012).

The biomedical sensors are characterized by vital importance in modern life. We live in an age of computerization for every area of life. As we all know, computers can only process data. However, the data must be collected, stored, if necessary, and transferred to a computer. These sensors are designed for data collection. It may be necessary to collect data for inpatients in the hospital setting, at home for inpatients or for outpatients. This is the equivalent of monitoring. Monitoring is a necessary activity in risky environments, such as mining, diving, mountaineering, and especially in all kinds of military and security actions. All these broad areas of application have

common requirements. The biomedical sensor should be compact and should not force the wearer to leave the comfort zone. These common requirements suggest smart textiles along with the notion of wearable (Dobrea & Dobrea, 2017).

The concept of wearable corresponds to a device that is always attached to a person, is comfortable, easy to store and use, and is as discreet as clothing. Portable systems are rather nonconstrictive devices that allow doctors to overcome the limitations of outpatient technology and provide an answer to the need to monitor people for weeks or even months. They are usually based on wireless sensors, miniature sensors hidden in patches or bandages, or on wearable items such as a ring or a shirt. Recent advances in miniature devices, as well as in the field of mobile computers, have fostered a dramatic increase in interest in wearable technology. Sensors and wearable systems have evolved to the point where they can be considered ready for clinical application. This is due not only to the extraordinary growth of research efforts in this field in recent years, but also to the large number of companies that have recently begun to invest aggressively in the development of wearable products for clinical applications. Stable trends showing an increase in the use of this technology suggest that wearable systems will soon be part of routine clinical evaluations. The interest in wearable systems stems from the need to monitor patients over extended periods. Regular clinical or hospital monitoring of physiological events, such as an electrocardiogram (ECG) or blood pressure, provides only a brief window into the patient's physiology.

Health monitoring applications are a key area in which wearable sensor systems have received much attention from both research communities and industry. These systems apply from infants to the elderly. Portable monitoring systems are dedicated not only to patients or people with different types of injuries. Providing accurate information about people's activities and behaviors (i.e., recognizing human activity) is an important function of wearable devices with a wide range of applications: coaching (e.g., fitness), performance improvements (e.g., tennis), entertainment, continuous surveillance of soldiers in the field, monitoring of people in critical environments, etc.

The extra chance of life we receive today is mostly due to medical technology. Thus there are now people who are operated on by laser or benefit from transplants with the most complex organs, including brain transplantation. Even the treatment of cancer and the fading of cancer cells seem to be a revolutionary discovery for mankind, given that in the past this was considered almost impossible to treat.

Nowadays, finding solutions that are as simple as possible to implement and develop on a large scale has become a priority, given that everything we use or wear now has a certain degree of technology integrated. The integration of electronic information in textile fibers means for us, today, smart clothing. These items of clothing are sensitive and can respond to environmental conditions, but also to other factors. The main feature of smart clothing is that they are wearable, but also easy to monitor in real time. On the other hand, the system can adapt to the conditions of the environment in which it operates and can respond, if necessary, to certain incentives in favor of the wearer.

Important in the manufacture of smart materials, and so that they can achieve a wide range of smart functions that can be found in both flexible and rigid electronic products, is the very collaboration between textile design and electronics.

From the most common signals such as body temperature, environmental or biomedical characteristics (salinity, humidity, contamination) to the capture of signals with the most complex functions such as electroencephalogram (EEG), ECG, or electromyogram (EMG), these sensors can be used in extensive fields of activity and research. And here we are not only talking about medicine and social assistance, but also about areas such as the military, sports, or the aerospace industry. Sensors with small size and high complexity, we can say that the main advantages of smart clothes are convenience, accuracy, and feasibility.

For this, many scientists have begun to develop more and more the idea of portability. This is how smart clothes began to appear, clothes that are able to adapt to different environments and that could provide information about certain medical problems. These textiles can interact with the environment in which they are developed or with the user. Electronics and textile design are an important collaboration for the manufacture of intelligent materials that are able to perform a wide range of functions that can be found in electronic products.

Smart clothing has increasingly attracted the attention of researchers mostly because of their ability to interact with the environment in which they are and ability to respond to certain stimuli. They tried to introduce as many sensors as possible in the tissues in order to monitor more and more physiological parameters and to widen the research area in this field. “Smart textiles” have a high degree of intelligence and can be classified into three groups as follows: passive intelligent textiles that use only sensors to sense the development environment and the user; active intelligent textiles incorporating actuation functions and detection devices, but which may react to environmental stimuli, and very intelligent textiles which are able to perceive, react, and adapt their properties to environmental conditions.

In passive intelligent textiles, sensors are a signal detection system. In recent years, textiles have become an increasingly popular platform for integrating the multitude of sensors that give them active or passive functionality. At the same time, bionic hands or gloves were created to detect the position of the hand and recognize the language of gestures, pants that monitor the movement of the lower limbs, or various clothes and accessories that help record the ECG, EMG, respiratory activity (respiratory rate), or EEG.

Healthcare, military, aerospace, and sports are just some of the areas in which smart textiles have been very involved lately. In order to ensure a better human life, but also to increase the life rate, these fields have developed a lot, reaching to combine very well both design and electronics.

The article “Concepts and developments of a wearable system—an IoT approach” (Dobrea & Dobrea, 2017) presents an intelligent clothing system designed as an IoT

device. This device connects to a cloud Internet service to exchange data. The smartphone or personal computer acts as a middleware for the interaction between the application and the Internet (cloud) and smart clothing.

The intelligent clothing system has a series of capacitive sensors that monitor the position and movements of the head, such as analysis of the tremor of the head of people with neurological disorders, augmented reality system (synthetic images are mapped from the global coordinate system to the helmet coordinate system)—with a lot of applications in the military, biomedical and entertainment industries, navigable menu without hands, etc.

The working principle of capacitive detection solutions is based on the interaction between the electric field lines generated by the capacitive sensor and the objects in its vicinity.

The advantages of this system presented in this article are low power, high noise, high sensitivity immunity, small size, high versatility, and more. It is an IoT device that can be integrated into the final product very easily.

Another interesting article that tells us about this field is “Wearable sensors for athletes (suh2015)” (Suh, 2015). He concluded that the biggest advantage of real-time nonstop wearable health monitoring systems is only possible if we insert the sensor into clothing or accessories. The technical analysis of the physiological signals captured by the sensors is performed by small electronics outside the clothes. These electronic products can deliver the health data of a designated person or institution—hospitals or training staff—remotely via wireless communication.

Textile sensors are created by incorporating conductive materials into textile structures. Silver has been used most often in textile sensors, although other conductive materials are available, such as gold, copper, and stainless steel. Conductive materials are combined with nonconductive components, which are polymers. In the following examples we find some applications of in-home health that are already on the market.

LifeShirt (from VivoMetrics Inc., Ventura, United States) (Grossman, 2004) is one of the initial models of wearing health monitoring systems, introduced to the market in the early 2000s. The system includes clothing, a portable device, and computer-based analysis software. Clothing, in the form of a waistcoat or chest strap, continuously monitors ECG, breathing, activity, and posture. The ECG signal is traditionally detected by the ECG pipes inserted through slots on the waistcoat. Respiratory data are measured with RIP. A sinusoidal thread is woven into high-length Lycra knitted fabrics, and worn around the chest and abdomen. A two-axis accelerometer is built into the center in front of the vest and records the wearer’s posture and activity level. Those sensors are connected to the portable device, which records, encrypts, and uploads data to the Vivologic database for analysis. Optional sensors for electroencephalography (EEG), skin temperature, blood oxygen saturation, and blood pressure can be connected to additional ports in the system for multifunctionality.

The system has been used in leading research institutes, medical schools, and hospitals for clinical or research applications. In particular, it has been actively applied to monitor various types of sleep apnea.

In the Smartex wearable system (Sweeney, Kearney, Ward, Coyle, & Diamond, 2013), ECG electrodes were created by knitting conductive wires into conventional fabric knitting. Conductive wires included two stainless steel wires twisted around a nonconducting nuclear wire. With a two-layer knitted structure, the electrodes could be isolated from the external environment. To improve the signal quality, a membrane hydrogel covered the rough surface of the electrode and a higher percentage of elastomer was incorporated into the base. The respiratory sensors were made of piezoresistive threads, which were knitted in Lycra fabric covered with carbon rubber. It was a triaxial accelerometer incorporated in structured knit for monitoring the posture and movement of the wearer.

Another example of smart sensing system is described in the paper “Gait Segmentation Method Using a Plantar Pressure/Measurement System with Custom-Made/Capacitive Sensors” (Aqueveque, Germany, Osorio, & Pastene, 2020). They say that in recent years there has been a huge interest in low-cost design of portable devices for measuring and tracking human movement in a comfortable way for the patient, with high measurement capacity in different environments (without restrictions). These wearable devices must perform rapid and easy analysis of human movement based on objective and repeatable measurements. Portable devices can also benefit from cases where the disease requires continuous monitoring during daily living conditions, and longer periods of time to perform the analysis.

In recent decades, the interest in wearable devices has been growing significantly, which has led to the development of simple and robust devices capable of recording objective data indexes from human gait analyzes. Smart shoe applications are wearable devices that are able to measure the plantar pressure inside the shoe, making it possible to obtain accurate measurements. These systems allow the measurement of dynamic pressure while the carrier is moving, recording data, performing real-time analysis, and communicating information using wireless communication through protocols such as Bluetooth or WiFi standards. So far, the devices available with these features have been very expensive (priced at over \$ 10,000). In addition, commercially available devices are not sufficiently miniaturized, with electronics somewhere in the shoe that affect normal gait patterns and compromise data quality.

So, they propose a new system incorporated in shoes composed of an insole instrumented shoe with customized capacitive pressure sensors, capable of performing automated human gait segmentation and analysis. The sensors are placed on the most anatomically representative places of the foot. The proposed system incorporates all the electronic components in the sole, making the system comfortable and easy to use. These tools allow high-precision analysis and help diagnose diseases such as Parkinson's, cerebral

palsy, multiple sclerosis, and stroke. This is another good example of a system which can be successfully used as an in-home healthcare system and can increase the efficiency of the medical care system during a pandemic such as COVID-19.

Another application which suitable for the in-home health smart sensing system is an application whose main aim is to diagnose Parkinson's disease. Nowadays, receiving biomedical information from the skin and transmitting it through the same mechanism have become areas of interest, and facilitating access to this type of device is becoming increasingly vital. The article presents the importance of capturing the biomedical information from skin using interdigital sensors embedded in the fabric and the transmission of this information to a smart device; an application which will facilitate a number of other applications, both in the medical field (monitoring babies, people with high risk of heart disease) and in other areas, but which is extremely suitable for in-home health monitoring during pandemics.

The application was developed especially for people with the risk of diseases whose main condition is head tremor (Parkinson disease). Tremors are muscle movement which occur involuntarily in certain areas of the body. Commonly, the tremor affects the upper limbs and head, but this is not a rule. To detect head tremors, in this application a network of capacitive interdigital and optical sensors was embedded in the collar of a coat which monitors the movements of the wearer's head.

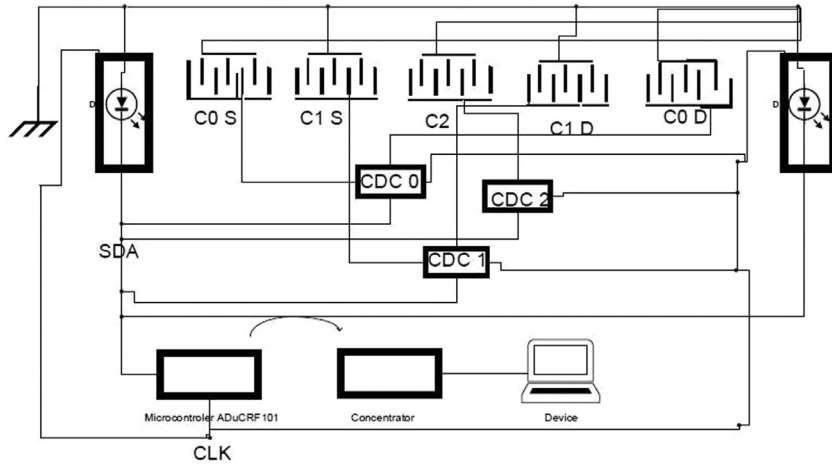
The principle of the interdigital sensor (Fig. 11.1) follows the rule of using two capacitors with parallel plates as armatures, where the electrodes open to ensure access on one side of the exposed material. The sensor behaves like a capacitor whose capacitive reactance becomes a system function. Because the electrodes of an interdigital sensor are coplanar, the measured capacity will give a high signal-to-noise ratio. To obtain a strong signal, the interdigital sensor electrode pattern can be repeated several times.

To create the experimental model, there was used a conductive electrical tape with the strip made of thin copper, thus being extremely flexible and which can take almost any shape. The tape can carry electricity just like a wire and also has an electrically conductive adhesive on the back, but it cannot carry significant electrical current (Fig. 11.2) (Izdru, Hagan, Geman, and Postolache, 2020).



**Figure 11.1** Interdigital sensor model. Izdru, D.-R., Hagan, M.G., Geman, O., Postolache, O.A. (2020). *Intelligent clothing using interdigital sensors network, SOFA (in press)*.





**Figure 11.2** Sensors network block diagram (CO S/D, left/right capacitive sensor; CDC, converter capacitive digital; D1, D2, optical sensors).

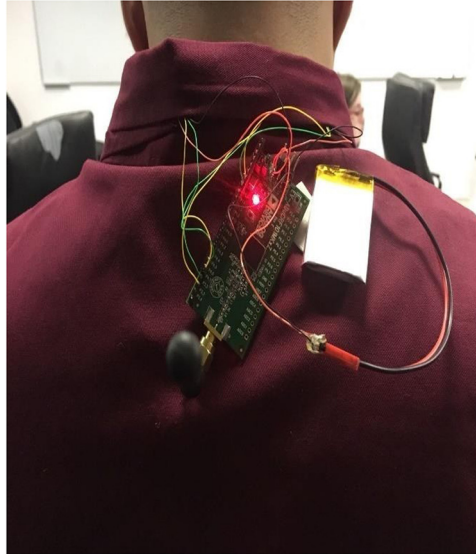


**Figure 11.3** Insertion of the interdigital capacitive sensors network into the coat.

After calibrating the sensors, they were prepared for insertion into the collar of the garment, where the data acquisition tests were repeated, this time the garment being worn by different people (Figs. 11.3 and 11.4).

As the COVID-19 pandemic has restricted the mobility of the human beings, all the above applications are suitable as portable and remotely controlled systems for the in-home health status.

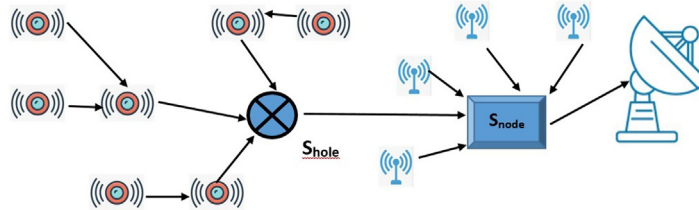
The Wireless Body Area Networks (WBAN) for Healthcare applications was reported (Taha, Mashhadany, Mokhtar, Bin Zan, & Arsad, 2020; Guay, Gorgutsa, LaRochelle, & Messaddeq, 2017; Hagan & Teodorescu, 2013; Postolache, et al., 2020; Ripp, Peccorale, & Charney, 2020; Teodorescu, 2013; Vornicu, 2006) and special attention might be considered for WBAN security. After the introduction of the sensing network, the biggest challenge of all for the Healthcare Wireless Body Area



**Figure 11.4** Sensors network inserted into the collar ready for tests. Izdrui, D.-R., Hagan, M.G., Geman, O., Postolache, O.A. (2020). *Intelligent clothing using interdigital sensors network, SOFA (in press)*.

Network was the black-hole and sink-hole attack. The data packages which were transmitted from the deployed sensor nodes were attracted by the sink-hole or black-hole node. In this way, they were attracted to the shortest path. The most difficult task to identify for the researchers was the fact that it must be very precise (Dhanaraj, Lalitha, Geman, & Izdrui, 2021). As we know, small variations in medicine may create severe illness in practice. This led to a hybrid detection framework for the attack, only by applying Proportional Coinciding Score (PCS) and also an MK-means, which is a well-known machine learning technique to rise the attack detection accuracy and to decrease the computational difficulties. All of this gives solutions for cardiac or respiratory issues (Postolache, 2018).

First of all, they reduced the gathered training data features. This was done through data preprocessing in PCS. Further, the training of the data was preceded. This means that the preprocessed features are sent to MK-Means algorithm and the classification is promoted. The Intrusion Detection System gave some attack detection measures, i.e., the number of the data packages trans-received which are identified by the MK-means algorithm. The type of attack is represented by the resultant digit (i.e., sink-hole or black-hole attack). The data transmission halts the network whenever the sink-hole or black-hole attack is apprehended. The MK-means framework yields a high detection accuracy with much lower packet loss rate and communication overhead, in addition to reduced end-to-end delay in the network, and thus improves the accuracy of biomedical data.



**Figure 11.5** Sink-hole attack. Dhanaraj, R., Lalitha, K., Geman, O., Izdrui, D.-R. (2020). *Black-hole and sink-hole attack detection on biomedical data in wireless body area networks*. CMC Journal (in press).

Based on the existing route, the sink-hole node attempts to invite the stream of traffic through a specific area. The other nodes within the network use this malicious node path and interchange their data. The sink-hole attack easily creates a way for other kinds of attacks like gray-hole, black-hole, or others mostly because the communication dependency for affected nodes is through this malicious node. Fig. 11.5 shows the model of sink-hole attack.

### 11.3 Telerehabilitation as a remotely solution during COVID-19 pandemic

The pandemic of COVID-19 limited the mobility of the population, and also the interaction between the people. All the public departments have been affected. In this period of time, many people avoided any outdoor activities, but also the activity of the doctors and hospitals has been restricted. They had to treat and monitor patients with the new Coronavirus and also the other patients.

Rehabilitation describes a range of responses to disability, from interventions to improving body function to more comprehensive measures designed to promote inclusion for all of us, including the elderly population. With regard to people affected by motor impairments, to recover the motor capabilities the physical therapy methods are best applied. The elderly people are the most affected population group by motor disabilities, from performing simple daily tasks such as picking up an object, eating alone, or even dressing. Such consequences may restrict personal activities and avoid the full participation of the elderly in the community, which generally affects the well-being of this group of population. But this is just an example. During the first phase of the COVID-19 virus pandemic, a large number of people have been locked into their homes. No medical service has been available for the ones in need, and no movement for the others. The limited space for physical activities (only in-home) and the lack of specific equipment's made many people become sedentary. The sedentary life affects people physically and mentally, along with a low level of life quality and the possibilities to develop certain diseases. For example, a study from China shows that during the initial phase of the COVID-19 outbreak, nearly 60% of Chinese adults had inadequate physical activity (95% CI 56.6%–58.3%), which was more than twice the global

prevalence (27.5%, 25.0%–32.2%). Their mean screen time was more than 4 hours per day while staying at home ( $261.3 \pm 189.8$  min per day), and the longest screen time was found in young adults ( $305.6 \pm 217.5$  min per day) (Ripp, et al., 2020).

Coming back to the ones with disabilities who are in need of constant therapy, the pandemic period has been a cessation period. Even for this aspect of the pandemic, researchers have found solutions.

The health community has shown recently an increasing interest in therapeutic approaches, mostly based on VR and AR therapeutic serious games. These games are designed and implemented to preserve the fun or entertainment for the gamer and at the same time they assure the improvement of physical and/or motor skills for people during the training session (Taha, et al., 2020; Dhanaraj, et al., 2020; Ferreira, Oliveira, & Postolache, 2017; Martin, Frango, Postolache, & Yang, 2018; Nave, Yang, Viegas, & Postolache, 2018; Postolache, 2018; Postolache, Cary, Girão, & Duarte, 2015; Postolache et al., 2020; Postolache, Viegas, Freire, Pereira, & Girão, 2017). An example of already existing solutions on the market can be Physio. This is a virtual reality rehabilitation platform for physical therapy that aims to provide a captivating experience for patients of any age (Serious Game Market, 2020) (Taha, et al., 2020; Dhanaraj, et al., 2020; Postolache, 2018; Postolache, et al., 2017; Postolache, et al., 2020).

Virtual Reality and Augmented Reality technologies can provide new experiences to the users during physical rehabilitation training sessions and new methods of tele-rehabilitation to help doctors increase the engagement for improved physical outcomes. These relatively new technologies can be a good starting point for developing new services that can be defined as “Physical Therapy at Home” or “Remote Physical Therapy.” The VR and AR serious games developed can assist and complement the regular training in clinics, where mechanical equipment is commonly used (Postolache et al. (2020).

An advantage of these telerehabilitation methods is the possibility of programming the AR or VR serious game scenario according to the type and the difficulty of the rehabilitation tasks associated with the therapeutic plans. These tasks can be imposed by the physiotherapists in complementary mode with classical physical rehabilitation methods over a period of several weeks or months, and the outcome of the participant can be evaluated by taking into account the full digitalization of the VR or AR rehab services.

The wearable interface (Taha, et al., 2020) is materialized by hardware and software components of a VR physical therapy framework that supports highly interactive therapeutic games in VR scenarios. A particular case that can be mentioned is the use of smart gloves that assure upper limb physical rehabilitation assessment. The navigation in a VR scenario is possible taking into account the use of 3D IMU mounted in headband. The IMU information can be also used to evaluate the posture of the user during the therapeutic game sessions. This system provides evaluation metrics of the patient’s rehabilitation that can be used to extract the physical rehabilitation outcomes.

The above presented framework is characterized by a set of four blocks that include hardware and software components (Alexandre & Postolache, 2018; Brezulianu, et al., 2019; Chiuchisan, Balan, Geman, Chiuchisan, & Gordin, 2017; Chiuchisan, Geman, & Postolache, 2018; Chiuchisan, Geman, Chiuchisan, Iuresi, & Graur, 2014; Ferreira et al., 2017; Geman & Zamfir, 2012; Geman, Chiuchisan, & Todorean, 2017; Geman et al., 2014; Geman, Hagan, & Chiuchisan, 2016; Geman, Postolache, & Chiuchisan, 2020; Geman, Postolache, Chiuchisan, Prelepceanu, & Jude Hemanth, 2019; Geman, Turcu, & Graur, 2013; Hagan & Geman, 2016; Lourenço, Postolache, & Postolache, 2018; Martim et al., 2018; Monge & Postolache, 2018; Nave et al., 2018; Postolache et al., 2015, 2016; Postolache, Lourenço, Pereira, & Girao, 2017). The framework assures the patient access to a set of therapeutic serious games characterized by natural interaction using the developed wearable devices and VR scenarios.

## 11.4 Conclusions

Every day, we are witnesses of a neverending revolution in technology, from increasingly smart phones to a series of devices that make our lives easier. The next step in the development of technology is toward smart applications which monitor the health of the patients and allow faster and more efficient detection of various diseases that may occur or maybe just helps in the well-being status of the patient. And all of this while they are staying home, which is not so uncommon these days. At the same time, they will have to allow the transmission of this data to a device, thus sending alerts to notify doctors or qualified personnel about their condition.

The global COVID-19 pandemic is severely affecting life, with a notable increase in the number of infections in individuals around the world. More and more nations, governments, and researchers are trying to adapt to this global emergency. As hospital systems run far over capacity, facing possible shortages of critical care medical resources and personal protective equipment, the psychological stressors necessitate a strong well-being support model for staff. This chapter explores ways of combating it using wearable solutions that can be used for in-home health status monitoring and physical rehabilitation. Many researchers have adapted their work and projected it toward finding suitable solutions in order to reduce human interaction and the spread of the COVID-19 virus among population via medical care. Applications which can collect data and transmit it remotely through smart networks of medical biosensors to track COVID-19 or any other disease, to improve the quality of care and to prevent the spread of viruses have become an interesting area of research nowadays.

There is a desire for the development and knowledge as well as the need for increasingly simple and easily accessible methods to discover and treat certain diseases

of the human body, especially if it can be done into the home comfort. These factors are fueling the rise of the world of technology every day.

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