IoT Based Patient Health Monitoring System to Combat COVID-19 Pandemic

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Abstract-**Despite the vaccination campaigns in most countries in the world, we see horrible numbers of contaminations and even deaths daily. According to the WHO, 181 521 067 confirmed cases including 3 937 437 deaths. As of 30 June 2021, a total of 2 915 585 482 vaccine doses have been administered. Although efforts to raise awareness of the severity of the corona virus, many people no longer respect the health protocol, which manifests through wearing a mask and respecting physical distancing. Research laboratories have spared no effort to find an effective vaccine. This will help minimize the effects of the virus and save the lives of those infected. On the other hand, COVID-19 patients admitted to hospitals ensure permanent control of their health conditions and intervene at the right time. Saving the lives of these is a necessity, and we are all cooperating to bring life back to its normal pattern before pandemic, which took a toll on countries' economies. This research focuses on the development of an intelligent system based on the IOT for remotely control the covid-19 patient from a monitoring unit. This solution will be very useful for treating patients during COVID-19 outbreak. It is a question of exchanging clinical information between medical staff thanks to new technologies and of putting the patient under permanent control. The virtualized treatment guarantees a healthy environment for personnel.**

Keywords-**Internet of Things, COVID-19, Robot, e-health, Wearable devices, Remote diagnosis.**

I. INTRODUCTION

The COVID-19 pandemic is an emerging respiratory infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS CoV-2), which is a new virus first discovered in China in December 2019, quickly emerged, and attacked millions of people around the world. The novel coronavirus was reported to the World Health Organization (W.H.O) on 31st December 2019 [1].

The daily increase in cases of COVID-19 patients around the world in the face of the limited number of detection resources available in several countries, make it difficult to identify and treat those infected. In fact, the radical solution set out by the WHO for the fight against contamination is physical distancing. Therefore, it is necessary to make use of new technologies to develop a solution for working safely in many fields. The use of advanced technologies facilitates interventions of the medical profession in frequent tasks and ensures their safety [2].

Since its appearance at the end of 2019, COVID-19 has presented a serious challenge for researchers, scientists, health professionals and administrations around the world, from its detection to its treatment. Ongoing efforts are being made by researchers to deploy possible solutions to control this pandemic in their respective areas. The most common effective methods applied by researchers is the use of new technologies; in robotics and IoT [3-10]. Not only is the medical or biomedical field involved in the study and monitoring of this epidemic, but also researchers in other fields of data science, machine learning, distributed computing, artificial intelligence, Internet of things, robots, are participating to prevent and control the disease. These present their technical views and provide their own solutions to limit the spread of the virus [11-14].

The Internet of Things (IoT) is an emerging technology for the new generation of the Internet that enables dialogue between interconnected devices. The IoT acts as an assistant in health care and plays an extremely important role in broad areas of medical services. By determining the main parameters observed, the character of the disease can be expected. The aim here is to design a system with low-cost medical monitoring for people attacked by COVID-19, the solution that protects healthcare workers from a high probability of attack by frequently examining a patient [12].

The concept of IoT has shifted the approach of communication between people to objects that talk to each other or that speak to people. A range of different communicating objects, similar or different, have today become capable of collecting, processing, saving, and disseminating information anytime and anywhere [13]. In hospital, automated system for the daily monitoring and control of the evolution of the COVID-19 patient's condition is necessary to save time for health professionals and ensure their safety. With the advent of the Internet of Things and robotics, the coupling of two technologies gives birth to the IoRT that can be perfectly exploitable in the case of communicable diseases in general and especially in the case of COVID-19 [14].

Robotics seems to have created a parallel universe in certain areas in industry and health. The application areas are added every day. This allows fast and efficient execution with minimal or no exposure to risk. Therefore, robotics plays a major role during the epidemic. Motivated by the need for a rapid interpretation of the disease and a permanent treatment of patients, this article proposes an intelligent control system for infected people admitted to hospitals. It was thought to replace the medical profession by a robot that controls the clinical parameters. The system collects values of measurable medicals parameters anytime and transmits them to the Cloud to be saved and interpreted by a doctor since the healthcare service in the hospital.

The remainder of the article is organized as follows: First, section II presents research that has served IoT and robotics in healthcare during the coronavirus pandemic. Then, the system and its methodology have been described in section III. Section V presents the main hard components used. Finally, the system operational strategy is described in section IV.

II. RELATED WORKS

This section presents the most important works based on these technologies that offer systems and solutions used during the epidemic caused by the coronavirus.

Yang shen et al in their article [2] provide a comprehensive study of the robotic systems that emerged during the pandemic. They focused on the difficulties presented in almost all industries with the increasing acceptability of robotic systems and robotic developers open up many opportunities.

Pasika Ranaweera et al [3] offer a Multi-Access Edge Computing (MEC) -based edge computing approach for treating COVID-19 patients in a facility trough their paper. The solution would be beneficial for mediating a pandemic situation like COVID-19. As part of the evolution of hospital information systems, they are looking for an IT ecosystem that optimizes the network.

While M.A. Akkas et al [4] focus on the application of IoT technology in the medical and healthcare sector. The paper discusses the penetration of IoT technologies in the health sector and the future trends in its development.

The review presented by Shashi Bahl et al [5] name major benefits of Telemedicine for fighting COVID-19 pandemic that improve the quality of patient care at a remote location where healthcare is not available. They consider that technology provides a convenient solution for patients at remote locations or under lockdown. It improves healthcare quality.

Olutosin Taiwo and Absalom E. [6] proposed a smart healthcare support for remote patient monitoring during covid-19 in quarantine. It is an implementation of intelligent home medical assistance based on IoT capable of reducing unnecessary burdens on hospitals. Mainly, the new system is also able to provide essential comfort for patients since their homes.

In the same approach, Ben Hassen et al. [7] describe their solution "A home hospitalization system based on the Internet of Things, Fog computing and cloud computing "which is a smart health care service. It is going to be a promising service, which aims to alleviate the suffering of patients, especially the elderly, by avoiding moving to hospital for treatment and even long

waiting times for a role, which exposes them to the risk of contamination. The challenges of the COVID-19 pandemic facing individuals and healthcare systems are described [8] using the benefits of the latest technologies, such as the sensor network and IoT. This study presents the survey, results, and applications from the use of IoT innovation. The goals are to assemble and integrate information on the state of current and most recent uses of IoT in healthcare, especially to mitigate the COVID-19 crisis.

III. DESCRIPTION OF INTELLIGENT SYSTEM

The ordinary scenario consists of frequent control of the doctor and nurses to monitor the evolution of the patient's condition with COVID-19. This scenario caused a high risk when personnel healthcare is around contaminated patient. To ensure patient follow-up while avoiding the risk of contamination as much as possible, the robot can act as an intermediary and replace medical staff. The Robots help to become a mediator between doctor and patient and therefore to minimize person-to-person contact. The whole system operates on three subsystem platforms. These are:

- A set of data acquisition systems (DAS) installed on the COVID-19 patient side.

- A wireless local area network (W-LAN) based on a robot and a Cloud server to store and transfer data from DAS to the monitoring platform.

- An application that can be used in a healthcare service for daily monitoring of the evolution of patients' condition.

Figure 1 presents the architecture of proposed system, which is identified as an Internet of Robotic Things System for combating the coronavirus disease pandemic (COVID-19) in hospital. Several components make up the system (figure 2). To monitor the condition of the COVID-19 patient, the doctor specifies a set of medical parameters that must be always monitored. Therefore, the nurse can lace up the necessary sensors.
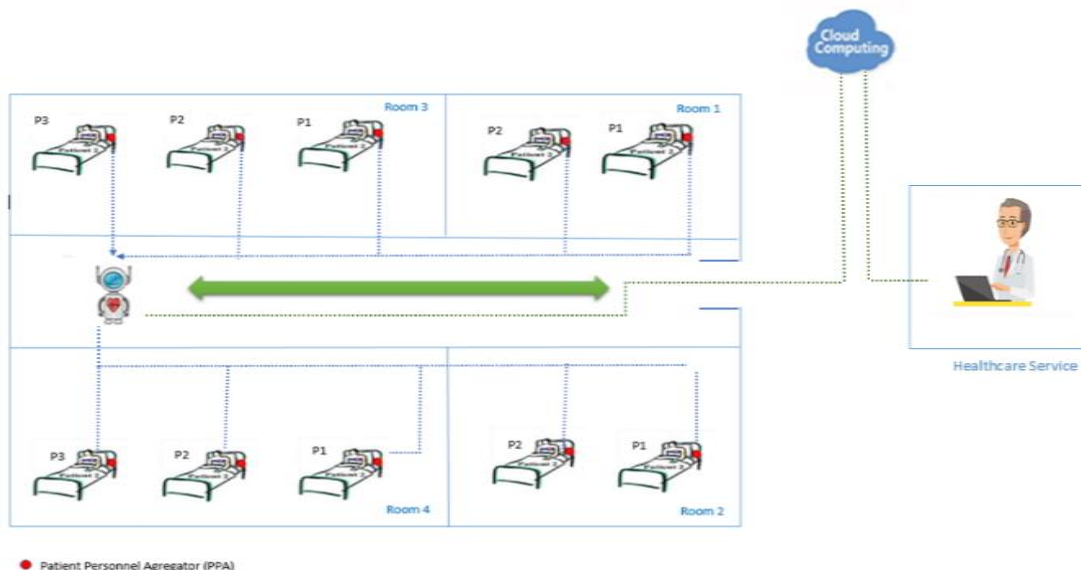

Fig 1. Architecture of the proposed system

The parts for a medical monitoring system can be seen as different parts, which are collecting information, transporting, saving, and evaluating it:

- **Data acquisition:** This step is directly linked to the patient. Each sensor can detect one or several

physiological characteristics from the human body or its environment.

- **Data transport:** The medium used by medical wireless sensor networks is radio waves. The radio standards that have been used for applications based on sensor networks are The IEEE 802.15.1 for Bluetooth standard, the IEEE 802.15.4 for Zigbee standard, the IEEE standard 802.15.6 for WBAN network and the IEEE 802.11x for WiFi standard.
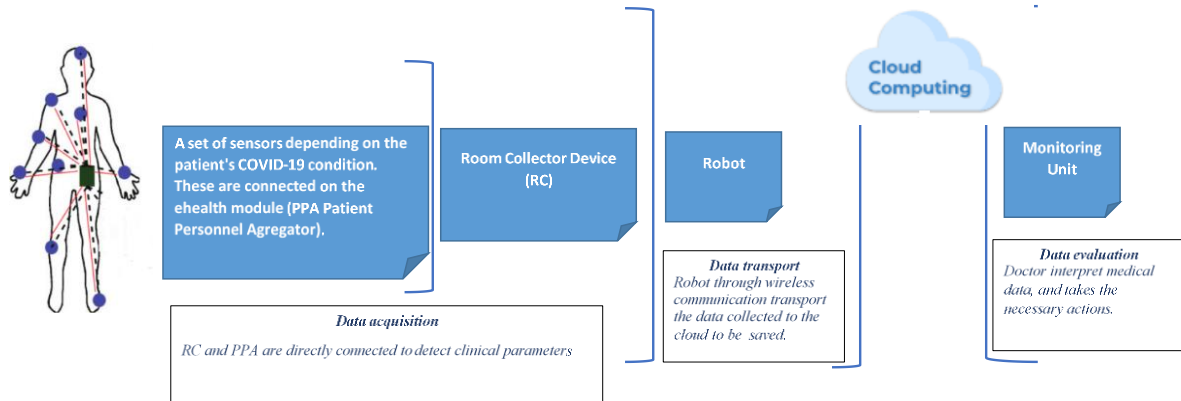
- **Data backup:** The data is saved in servers. Each data server including database in which each patient has a digital record, it is necessary that this file be updated periodically for each measurement.

- **Data evaluation:** In this phase, the collected medical data are interpreted, and the necessary actions are taken.

Fig 2. Secure Remote-Control System for COVID-19 Patients

IV. MAIN HARD COMPONENTS OF THE SYSTEM

It is possible to use ten different sensors of course depending on the patient's condition [9]: pulse, oxygen in the blood (SPO2), air circulation (breathing), body temperature, electrocardiogram (ECG), glucometer, galvanic response of skin (GSR- position (accelerometer) and muscle sensor / electromyography (EMG). The obtained values are used to monitor a patient's condition in real time or to obtain sensitive data for further analysis for medical diagnosis.

The biometric information collected can be sent wirelessly using any of the connectivity options available: GPRS, Bluetooth, 802.15.4 and ZigBee, depending on the application.

Fig 3. E-health Shield Complete Kit

This module (figure 3) will be connected directly to the Arduino board for reading the data detected from sensors.

- **Arduino Card:** It is a programmable electronic card (equipped with a processor and memory) on which we can connect temperature, humidity, vibration or light sensors, a camera, buttons, electrical contacts. Depending on the area of application of the system designed. There are also connectors for connecting LEDs, motors, displays; a screen. This card thus makes it possible to create electronic systems intelligent and to animate mechanical devices. We install the packages on the Arduino board in order to acquire data from the various sensors.

- **Raspberry card:** A single card can connect to a monitor and a keyboard / mouse assembly and with Wi-Fi and Bluetooth interfaces. It starts from a micro-SD card and works under an O.S. Linux or Windows.

The card then integrated monitoring capabilities and obtain data from instruments placed on the patient room side. It plays the role of collecting the clinical parameters of patients and ensures permanent control.

- **Cloud Computing:** Cloud and communication technologies are the keys to establishing a connection between the cybernetic world, a backup server accessible via the Internet, and the physical world represented by the IoT network [10]. In the proposed system, the robot transmits the patient data to be saved on a cloud server. A doctor responsible for diagnosing a patient's condition will collect this data.

The e-health v2.0 module is assembled with the various sensors necessary for monitoring a COVID + case. This forms a subsystem, which collects the data and sends it to the coin collector represented by the Arduino board. Data from the physical world will be captured and transferred wirelessly to the base station using the robot. The doctor specifies the main sensors that can be attached to the patient depending on his condition and the history he may have.

Robot / monitoring platform communication is provided via the Cloud. In fact, the robot communicates local information to the remote server for permanent storage.

The raspberry Pi board is attached to a wireless module in order to ensure wireless communication with the Arduino. It will be responsible for transferring the collected data to the remote server via a high-speed WiFi connection.

V. SYSTEM OPERATIONAL STRATEGIE

This section describes the scenario generated by the proposed system to reduce the contact between doctor and the COVID-19 patient. As we have observed, doctors are at high risk of being infected when they are around patients.

We thought through the intelligent system to entrust the robot with an additional task of monitoring patients' vital parameters. The robot associated with IoT technology moves around patients (figure 4). The medical staff can monitor patients remotely and intervenes at the exact time following alerts triggered from a monitoring platform. Thus, a healthy environment is guaranteed for health personnel.
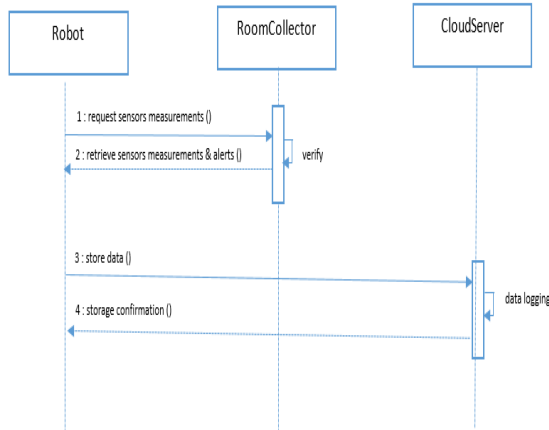

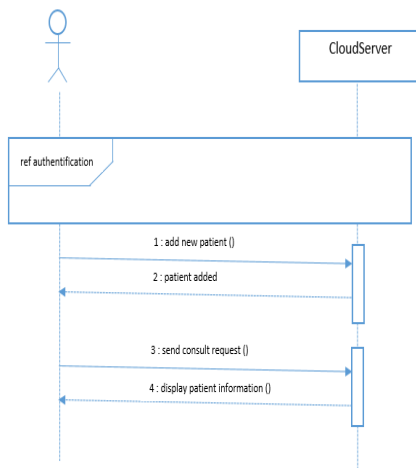Fig 4. Sequence diagram of data collection by the robot

Fig 5. Sequence diagram of registration and distance monitoring of patient COVID-19

The diagram mentioned below (figure 5), describes the scenario for registering a new patient and monitoring the condition of COVID-19 patients. The doctor can control the evolution of the patient's condition through a monitoring platform. The system generates alerts in urgent cases. As observed the doctor or nurse remotely monitors the patient's condition continuously. In reality, the medical staff is not always close to a covid-19 patient, but they intervene in periods fixed by each hospital, which is a factor of several conditions such as the number of patients, the COVID service staff and above all the availability of means of protection.

VI. CONCLUSION

In this article, we use one of the main protective factors, which is physical distancing. So, we propose an intelligent system for monitoring health of COVID-19 patients' health. It is an IoT framework that is presented to monitor the state of health of hospitalized patients whose situation requires general monitoring. The system integrates a portable IoT node with a remote monitoring application, through which it is possible to collect clinical parameters, such as temperature and oxygen saturation, and other parameters that vary depending on the condition. of the patient. The local subsystem formed by the IoT system component, and the robot connects to the Internet network to send data to the cloud server. The data will be sent for permanent storage which will be used both for real-time monitoring and for statistics which will require the hospital later. We sought a solution at lower cost, less energy intensive, and above all beneficial to ensure health care in good condition whether for the patient or for the medical staff.

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