ECG signal monitoring based on Covid-19 patients: Overview

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Abstract

ECG signal monitoring is a very important step for patients. Especially for those infected by covid-19. This pandemic has shown that the use of artificial intelligence helps to control the propagation of this virus. Particularly the high spread of this virus influences the number of the infected population. As well as the fact that this virus attacks the respiratory system which influences the cardiac system. Therefore, an ECG signal monitoring is mandatory. Our work presents an overview based on various approaches developed for ECG signal monitoring. These techniques are based on non-contact monitoring approaches. These approaches will help to avoid frequent contact with patients and doctors. As well as non-contact ECG signal monitoring is based on low-cost techniques, which reduces the price compared to other sensors. After the revision, we can conclude that the most suitable solution for heart rate monitoring is based on image processing using RGB cameras. These solutions are accurate, low cost, and protect the doctors.

Keywords: ECG signal, Artificial intelligence, Covid-19, RGB camera, Heart rate

1.Introduction

The global epidemic for COVID-19 has grown around the world, impacting almost all countries and regions. The epidemic was initially recognized in Wuhan, China, on December 2019 [1-4]. The public was warned by countries around the world to take reactive care. Strategies for public care have involved hand hygiene, facial masks, avoiding physical distance, and staying out of large gatherings and meetings. Confinement and home maintenance strategies were introduced to break the curve and control disease transmission. This pandemic is known for its strong propagation, which limits the relationship between the different populations [5-7]. To control this pandemic, we can take China as an example. This country has managed to control this pandemic using artificial intelligence, which has been applied to control the people. The application of this type of system improves the tracking of the contaminated people, as well as helps to identify the people who can be infected by the virus. in this context, china has used several solutions based on image processing. we can find for example the use of thermal cameras to determine the temperature of people. As soon as the temperature is above the normal threshold, the system captures the patient's face and records it for follow-up. So we can find the use of drones which helps to dampen the envy.

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The monitoring of ECG signals in patients infected by covid-19 and the respiratory system is very important because the virus directly attacks the respiratory system, which influences the cardiac system. For this reason, these two vital parameters are very critical [8-10]. Generally, Traditional methods used to monitor these vital parameters consist of contact sensors. This contact between the patient and the doctor can make the virus pass through, making these techniques very dangerous. In this context, several works have been developed for heart rate monitoring based on a contactless approach. The adaptation of this type of technique in the case of the covid-19 pandemic will reduce the contact between the different components of the hospitals, including doctors, nurses, and other personnel. Among these techniques, we can find the PPG signal prediction and its improvement the iPPG signal. These two approaches are the best known in terms of the accuracy and reliability of results. Generally, it is based on RGB images collected by low-cost cameras [11].

In our paper, we present review of various approach for heart rate monitoring. As well as the adaptation of these techniques in the case of contaminated patients by Covid-19 virus. our study will focus on the mathematical aspect of image processing and physiology to mount the heart rate. We will also present the different types of signals that can be extracted from an image sequence and the sensors used. Also, diagnostic techniques were used to limit the propagation of this pandemic.

Our work is as follows: we start with an introduction and then define the Covid-19 virus and its different characteristics. Afterward, we have an overview of the various techniques of ECG signal and heart rate measurement. Then we have a discussion and future works and finally a conclusion.

2. Covid-19 Pandemic

COVID-19 is a pathogenic, rapidly spreading virus attack caused by SARS-CoV-2, which has resulted in a worldwide epidemic with a catastrophic impact on human health. The genomic review showed SARS-CoV-2 is related phylogenetically to SARS-like viruses of bats, and therefore the bats may serve as the main source. The secondary origin and transmission to people is not clear, but the rapid transfer from human to human has been largely confirmed. There is no currently available anti-viral medicine for use in the treatment of COVID-19 [12-15]. As soon as this virus gets into the human body, it creates many syndromes. Among these syndromes, we can find fatigue or weakness, loss of smell or taste, temperature equal or superior to 38°C, and shortness of breath or difficulty in breathing. These different syndromes vary between the different patients. But the most serious is the complication in the respiratory system, which influences people's health.
The virus can be transmitted by infected people who do not show any symptoms. It is possible that these people

- Have no symptoms yet (presymptomatic)
- Never have symptoms (asymptomatic)

This type of spread occurs in people who are in close contact or closed or crowded places.

In our days, the world has known an immense propagation of the virus. We have 203479773 cases of covid-19 in the world, with 4306398 dead. Figure 1 shows the global cases between 13/07/2021 and 9/08/2021[16].

These cases are separated into several countries. But the most contaminated countries are America, India, Brazil, Russia, France, the United Kingdom, Turkey, Argentina, Colombia, and Spain.

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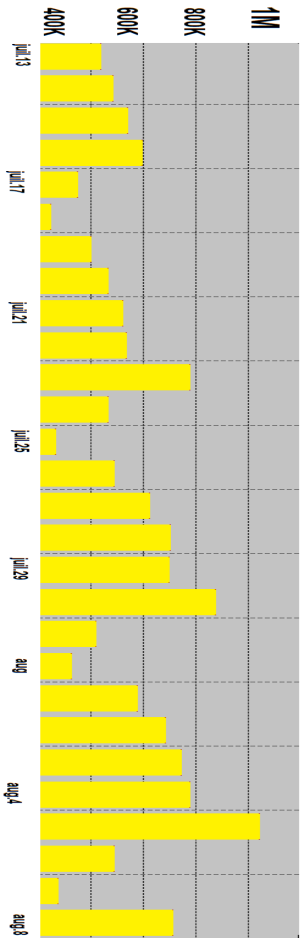

Figure 1 : Daily Covid-19 case in the word

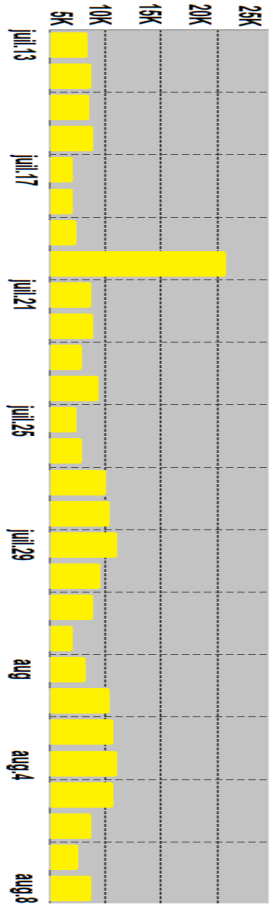

Figure 2: Daily Covid-19 deaths in the word

Generally, many vaccine candidates will be evaluated before being considered secure and successful. However, for example, of all the vaccines that are tested in laboratory and animal studies, approximately seven out of 100 will be classified as sufficiently effective to progress to human testing. Of the vaccines that proceed to clinical trials, only about one in every five will be considered successful. With several different vaccines in development, the probability of identifying one or more safe and effective vaccines for priority target populations is improved.

Generally we have three methods of manufacturing vaccines:

1. Use of a verus or a whole bacterium
2. Part that triggers the human system
3. Only the genetic material.

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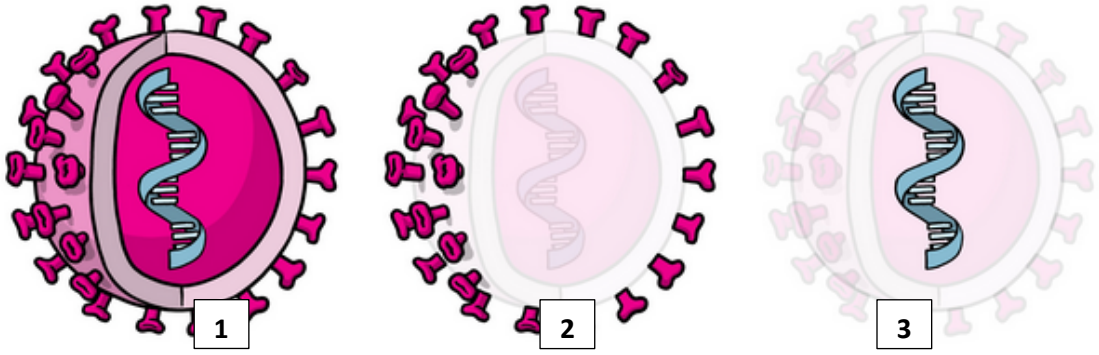

Figure 3 : Different types of vaccines[12]

Figure 4 shows the number of people vaccinated in the world based on the different types of Covid-19 that exist [16]..

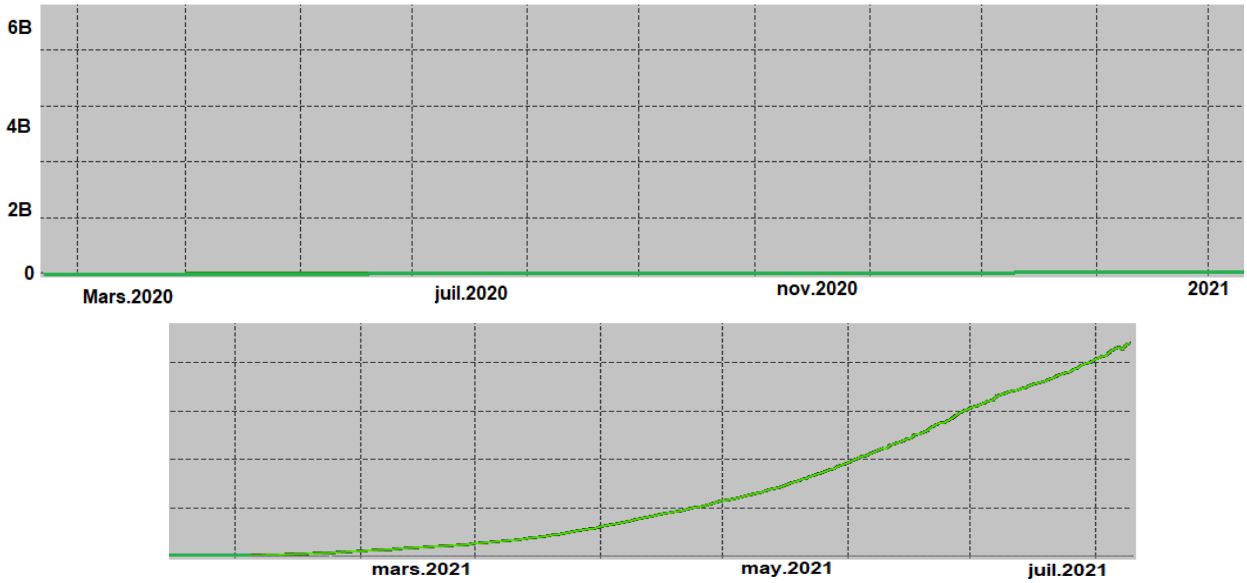

Figure 4: Total vaccine doses [16]

3. ECG and HR monitoring

Heart rate and ECG signal monitoring is a very critical step in all Covid-19 patients. Generally, we find various approaches developed, but the most suitable for the monitoring of Covid-19 contaminated patients as an application is the non-contact approach.

3.1 ECG signal and heart morphology

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The cardiac mechanism requests an autonomous electrical stimulation to create the necessary contraction and expansion to push the blood to the various body parts. This means that an electrical signal is delivered to generate the pressure to push the blood around the body's circulation system [17]. A popular approach to diagnosing heart problems is to examine the electrical signals that the heart emits. ECG activity is received by the electrodes and sent to the heart and blood vessels. ECG activity is passed from the electrodes to the ECG machine through cables, and the machine shows it in waveform form. The electrical flow both contracts and expands the cardiac muscle. Figure 5 shows the anatomy of the cardiac system [18-20].

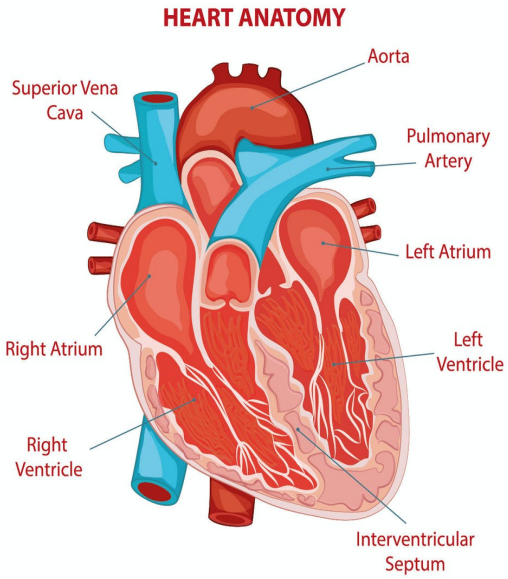

Figure 5: Heart anatomy [21]

A cardiac signal or electrocardiogram is a signal that contains several waves. These waves have a role in describing the heart's state in each stage. generally, we find the P wave representing the electrical activity of the different superior chambers. Its origin comes from the signal delivered by the sinus node in order to ensure the contraction of the atria. We also have three very important waves in a cardiac signal that represent the QRS complex. This complex reflects the electrical activity of the ventricles. It is composed of the Q wave that always descends, the R wave that helps to calculate the heart rate in an ECG signal, and finally, we have the S wave. These components have a specific shape if one of these waves is presented with a different shape that reflects that the heart is functioning male Figure 6 shows the different waves of cardiac activity [17].

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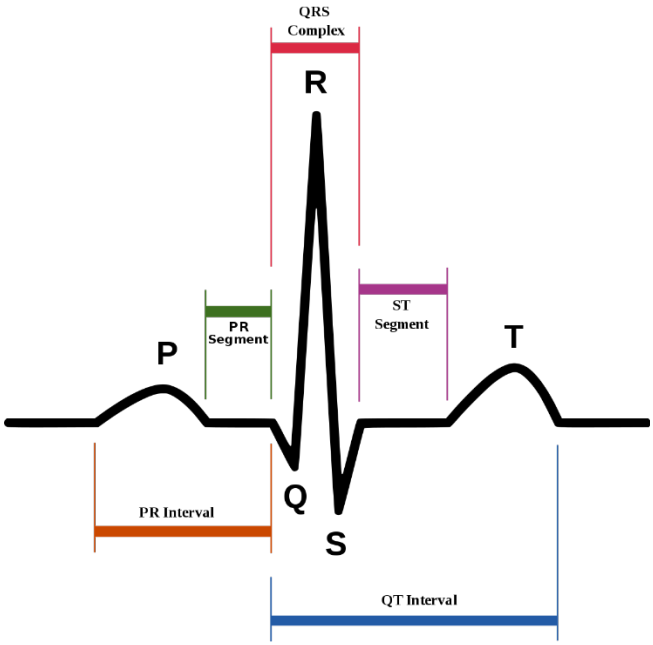

Figure 6: Different ECG signal waves

3.1 Heart rate monitoring using RGB cameras

The monitoring of the cardiac system is very important to guarantee the patients' stability. The use of traditional sensor-based techniques will serve to spread the Covid-19 virus between the patients and the different components of the hospitals. For this reason, the non-contact methods help to avoid this kind of spread. in this context L. A.M.Aarts et al. 2013 proposed an approach for PPG signal extraction to monitor heart rate. The authors were based on 19 video recordings in two NICUs in the Netherlands. The results showed that the photoplethysmography signal was well extracted for the measurement, except when the light is low. The methodology used in this study was based on the neonatal intensive care unit (NICU) in the infant unit of care in CHOC in the United States and Maximal Medical Center (MMC), the Netherlands [22]. Figure 7 shows the proposed system with A the developed system, B and C show the interest detection region.

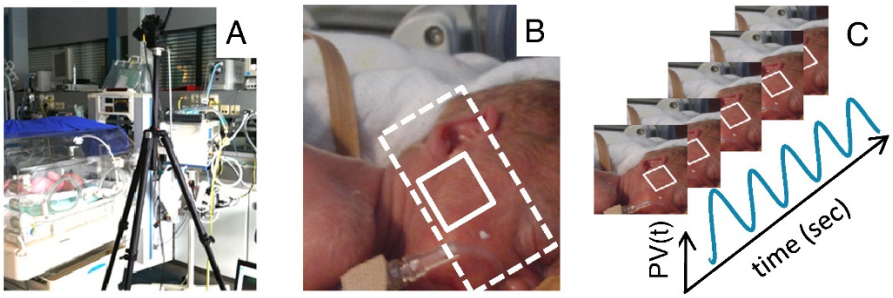

Figure 6: Proposed system in [22]

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Another work by H. Ghanadian et al. 2018 which proposed an approach for heart rate detection. The algorithm used is based on independent component analysis (ICA) to extract the source signal from RGB images. They tried to improve the accuracy of the technique that exists in the literature by minimizing the effect of the light that influences the accuracy of the results. The detection of the face was based on a learning technique in order to select the region of interest. The evaluation of the proposed algorithm showed that the error of measurement is about 1.12 bpm [23].

X.Yu et al 2021 proposed a technique for measuring heart rate based on photoplethysmography imaging. the study was based on the collection of videos of 10 geriatric patients and 10 other elderlies. the video collection tool is based on an RGB camera which gives images with different band, red, green, and blue. as well as near infrared images. subsequently they used image processing techniques to extract regions of interest. the evaluation of the proposed approach was to show that the error of detection of the heart rate is approximately 1.03 bpm and 0.8 for the correlation. for the evaluation use the RGB camera, the results show an error of 0.48 bpm. Figure 7 shows the proposed system [24].

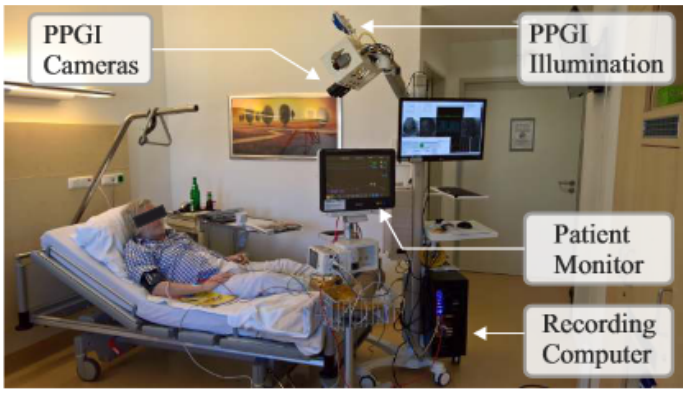

Figure 7: Proposed system in [24]

Similarly, Y.Zhang et al. 2021 proposed a new framework for heart rate detection and measurement. Based on the collection of images via RGB cameras. The proposed technique was based on ensemble empirical mode decomposition (EEMD) in order to detect IMF, which contains an energy spectrum between the frequency 0.7 and 3 Hz. The proposed approach is divided into five steps. The first one is based on the detection and used face. Then they used the different modes of conversion of RGB images to apply the bandpass filter. Then they used EEMD to select the desired IMF. And finally, the rPPG signal analysis in order to extract the frequency. Figure 8 shows the proposed algorithm [25].

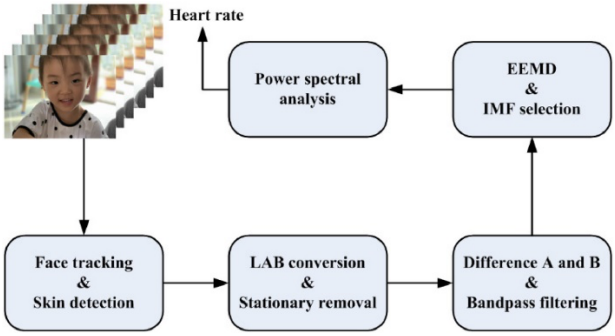

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Figure 8 : Algorithm proposed in [25]

4. Discussion and future work

The use of non-contact surveillance techniques has shown that these approaches can be an alternative solution to contact-based sensors. In the Covid-19 pandemic, we can conclude that these techniques can protect patients from contamination. Based on medical rooms equipped with RGB or multispectral cameras that will monitor patients contaminated by Covid-19.

Also, the work developed in this way has shown that most of the proposed approaches are based on real-time measurement with high accuracy. This makes these techniques robust, reliable, and accurate. These techniques can monitor many patients simultaneously, which allows the use of a single camera in a single room containing a variety of patients.

Thus, the advantages of these technologies are huge, but we have some disadvantages. Among the disadvantages of these systems, we have the light problem that influences the accuracy of the results. In this case, the extraction of color changes in the skin will be influenced by this light change. Also, we have the problem of patient movement. All these problems do not influence the use of these techniques in real scenarios.

Our future work aims to implement these approaches in embedded systems that process the algorithms respecting the temporal constraint. The use of such systems will help us to build low-cost heart rate monitoring systems. Aso, these systems are characterized by low power consomption.

5. Conclusions

In this paper, we present an overview on the different techniques of contactless heart rate monitoring. As well as the usefulness of these techniques to monitor different patients infected with the covid-19 virus. The reason for using these contactless approach is the measurement accuracy as well as the reliability of the systems used. Likewise a very important parameter is summed up in the reduction of the propagation of this virus in the hospital environment by avoiding the contact often between the patients and the doctors. So we can conclude that these heart rate measurement techniques may present an alternative to using traditional sensors as electrodes in ECG signal extraction.

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