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Cardiac rehabilitation management system

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ABSTRACT

Here, the mechanisms involved examine and effectively control patients for cardiac rehabilitation. The solution focuses on exercise prescriptions and also supports healthy behavior's. The innovative techniques and design take into account health promotion models to provide safe, assistive exercise training sessions and personalized feedbacks. Cardiac rehabilitation exercise includes many concepts of our present needs and should observe the conditions of the patients accurately at a different level to be sent to a physical therapist (PT). The estimated/approximated value should be re-sent to patients as a prescription for cardiac rehabilitation exercise. Also, here there is a reference to the mechanism that can handle the emergencies rapidly. Here there is research carried upon monitoring system on patients for cardiac rehabilitation, health machine control protocols, heart rate control and alarming system. It can be implemented on the systems of cardiac rehabilitation. This paper defines a new standard for Quality of Service (QoS) in the modern health services sector.

Keywords: *BMI-Body Mass Index, CRMS-Cardiac Rehabilitation Management System, ECG-Electrocardiogram, HR-Heart Rate, NIBP- Non-Invasive Blood Pressure, QOL-Quality of Life, QOS-Quality of Service, RF-Radio Frequency.*

1. INTRODUCTION

Medical doctors from various fields focus on patients who had angina pectorals, myocardial infarction, and heart surgery and make an effort to prevent the heart disease to reduce mortality from offering programs like exercise treatment, diet, smoke prohibition, behavior adjustment, stress cut-out. The reasons that lead to Cardio Vascular Disease (CVD) are high levels of certain lipids (e.g. cholesterol), old age, and tobacco smoking, diabetes, and high blood pressure, lack of physical activity, obesity and excessive alcohol consumption. Today, the exercises play a significant role in the cardiac rehabilitation treatment. The specified exercises performed under the direction of medical doctors can improve the patient's functional ability, relieve the symptom of angina pectorals, increase the introspective nature of the exercises, and reduce blood pressure, cholesterol and saturated fat which are the major risk factors of the heart disease [2].

Also, as an indicator of the heart function, it must observe the heart rate, pulse frequency, blood flow amounts etc. to set an appropriate exercise for each person reflecting their heart's function to prevent any future heart injury. In many countries, they have already provided the individual rehabilitation training treatment concerning their heart conditions and practicing monitoring system from the expert medical doctor while training. The individual rehabilitation training treatment concerning the patients' condition, such as intensity, frequency, time and form of exercise after understanding the risk factors of the heart is mandatory. In order for secure rehabilitation training, monitoring and management in an emergency from the expert medical doctor during rehabilitation training are needed. Electrocardiogram (ECG) monitoring can be used to forecast possible coming heart problems, or to support a patient during Controlled Cardiac Rehabilitation (CCR) by offering relevant guidance e.g. during an exercise. Cardiac Rehabilitation thus emphasizes on the four major components, that is:

• Regular Exercise

• Adopt a Heart-Healthy Diet

• Reduce stress

• Medical Therapy

2. OVERVIEW

The healthcare industry is predominantly consumer driven. Experts in the area propose new techniques for a new sustainable approach to care that focus on the improvement of the quality of services and are also cost-effective. In these new models, two aspects are important: the use of technology and the promotion of self- management for care delivery. This cardiac Rehabilitation management system is the perfect solution that brings about changes in the future heath care systems, that uses technology to facilitate patients' engagement and empowerment. In many cases, the lack of commitment is caused by insufficient information or a wrong approach in its delivery. However, these days, even if technologies facilitate the "health information era", there are still barriers that threaten the citizens and cause the citizens' perception of the usefulness of the available. The figure 1.1 below specifies the patient-specific cardiac rehabilitation plan.

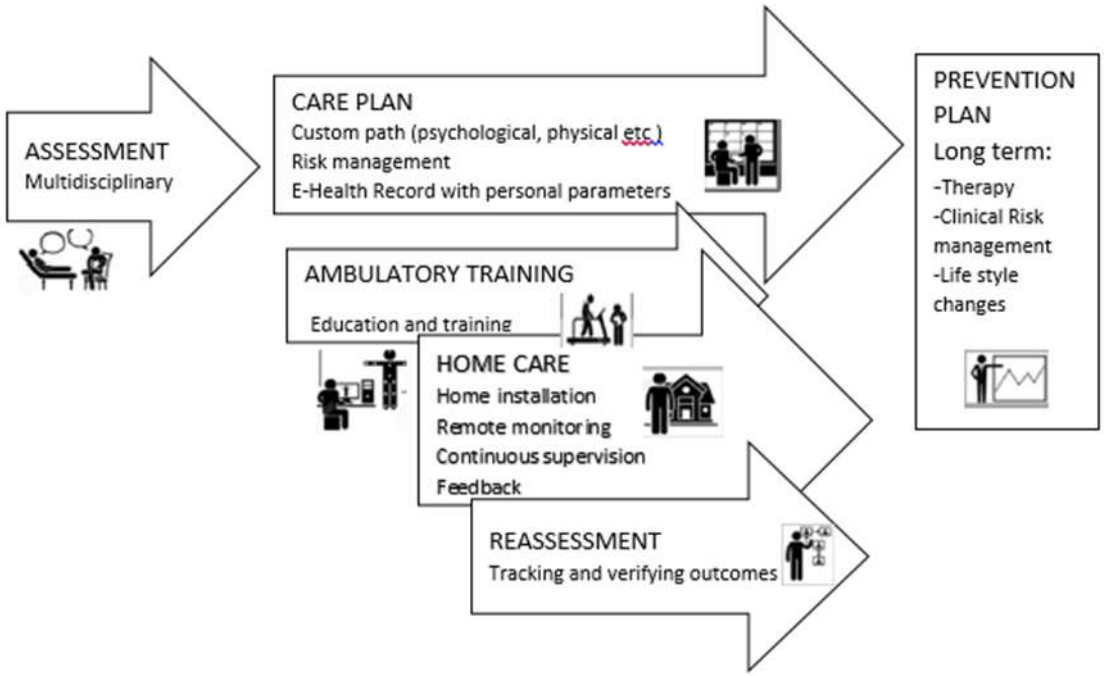

Figure 1 Patient-specific cardiac rehabilitation plan

3. SYSTEM ARCHITECTURE FOR CRMS

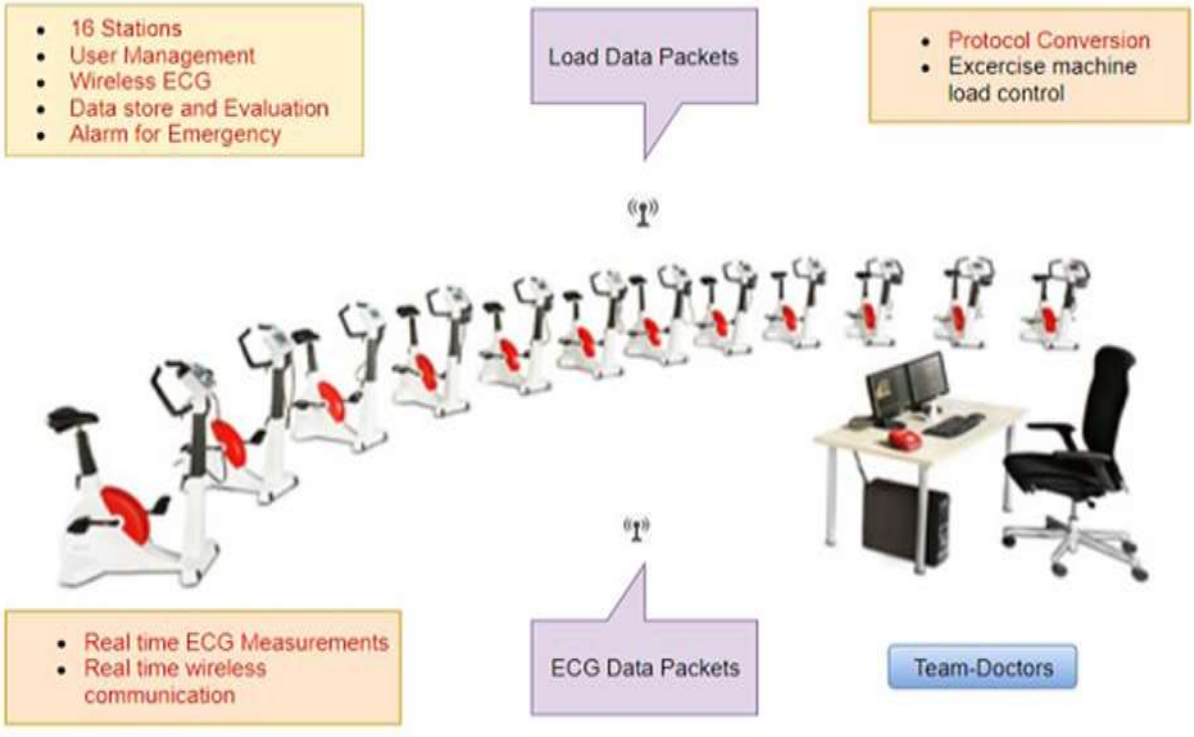

Figure 2 System Architecture for Cardiac Rehabilitation Management System

System Architecture of CRMS is shown above in figure 1.2. Some of the Features of this system are:

i. Ergometer Cycle and Treadmill

Treadmill test, as well as bicycle ergometry, are the most common methods from the category called cardiac stress tests – ECG is recorded while a patent does particular exercises. The main aim of such tests is to measure the ability of the heart to respond to certain physical stress in a controlled environment. Cardiac stress tests are mainly used to diagnose coronary heart disease, their most important advantages are – non-invasiveness, virtually unlimited availability and low cost.

ii. Allocation of 16 stations to 16 different patients simultaneously.

iii. Presence of Non-Invasive Blood Pressure Monitoring

It involves the monitoring of systolic, diastolic, mean blood pressure, as well as heart rate with 7% accuracy in one to eight patients. The NIBP (Non-Invasive Blood Pressure) consistently tracks the changes of systolic, diastolic, and mean blood pressure measured non-invasively.

iv. SPO2 or Oximetry

The Oximetry parameter provides the continuous non-invasive monitoring of oxygen saturation (%SpO2) in the blood and pulse rate (PR).

v. Wireless ECG monitoring system

The wireless ECG monitoring system significantly improves the quality of life of the cardiac patients, reflected primarily in the permanent monitoring.

vi. Presence of wireless data transfer.

vii. Maintenance of patient data bank.

viii. Involvement of various training programs.

ix. Detailed Evaluation tools.

x. This system supports Multi-Language.

Basically, ECG data delivered from the exterior should be exact/accurate and ECG systems should be wireless to reduce the patient's restriction while training. This system is developed on the basis of wireless ECG measuring system and its efficiency test has been examined.

4. METHODOLOGY

The increasing need and the high significance of remote monitoring systems for post-cardiac patients has been emphasized in numerous studies. A shift can be noticed in the CR technology, from self-monitoring, self-awareness, and self-determination towards automated monitoring, automated feedback systems and real-time data processing . The proposed solution for a cardiac rehabilitation program, including a server-side application and a web portal for educational materials, for providing statistics or health reports and for discussion messaging. This solution was capable of automatically transmitting data to the server without the user intervention and provided an automatic data synchronization of new parameters, without making any changes to the application. During the exercise sessions, patients were guided through traffic light indications. The patient's health condition was evaluated by transforming different activities like walking, swimming or cycling into MET-hours and not by continuously measuring the heart rate. A more advanced system was proposed by Kyriacou et al. (2011), where the system is supporting the recording and transmission of health parameters such as ECG, heart rate, blood pressure, oxygen saturation and others, directly from the measuring devices. Despite the advanced technological support, the data aggregation is used only for telemonitoring, and, other functionalities such as sending personalized alarms or messages according to each patient's condition or establishing the risks zones of each patient in function of his/her medical parameters and/or past training sessions, are not included.[1]

Fig.5.4 shows the class structure of our Cardiac Rehabilitation Management system. A Setting Manager includes information about clinic details, Training station configuration, ECG filters, Training Parameters and Ergometer/Treadmill communication port details.

The Cardiac Rehabilitation Management System consists of the MainForm and Viewer form. Further, the MainForm consists of Patient Management and Configuration Manager. The Patient Management comprises of User Information and Database Manager. The Viewer comprises the Display Manager and Signal Manager. The CRMS also consists of USBCom that handles the Communication Manager, USBCom Thread and Message Queue.

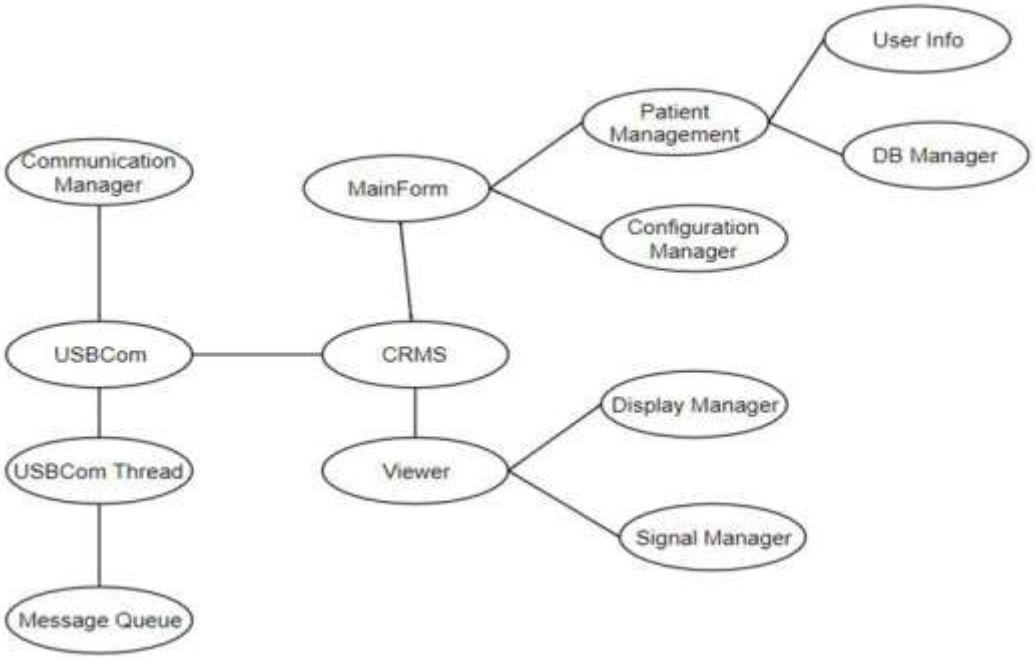

Figure 5.4 Class Diagram for CRMS

Figure 5.5 below describes the Cardiac Rehabilitation Management System in brief:

i. Setting Manager

Setting Manager Module manages the system layout information, patients' personal information, exercise information, and system information.

New User Group: It receives inputs of new patients' information and exercise management information from the PT.

Loaded User Group: It controls the system by reading the setting information of prior patient group which was saved in XML.

ii. Communication

To get the ECG raw data in the PT's system, we used PICI6c745 micro-controller for USB communication and the nRF2401 chips for wireless communication.

Communication's purposes are as below.

- Device ID isolation.
- Insert ECG data to system architecture
- Data transfer for health machine load control

For device's ID (8 bit) with data, we abstract data packet from the USB communication and insert the data inside the corresponding individual data management structure. In the PC RF receiver scans the arrived data packet. We used the communication method, Virtual End Point, which is inside the protocols of USB. It detects whether the USB reception buffer is full or not using system thread. RF packet payloads are 6 bytes. And to avoid a collision in the same frequency zone, we use the handshaking scheme and frequency hopping.

iii. ECG Signal Processing

We developed digital filters to detect the heart rate from raw data while the patients are in cardiac rehabilitation training. We used the Moving Window Integral and Differential Filter for signal processing. From R-Peak detecting algorithm, the data between R-Peak is counted and Heart Rate is obtained.

iv. Display Management & Heart Rate Control Management

Patient management module is implemented so as to collect the patient information and it contains options of either monitoring all the patients' present condition. While monitoring, the system monitoring the heart rate, if the heart rate has out of safe range, the system produces the alarm. If the PT exits the system while monitoring, the present setting information will be saved by default and it will be able to use in the next management time.

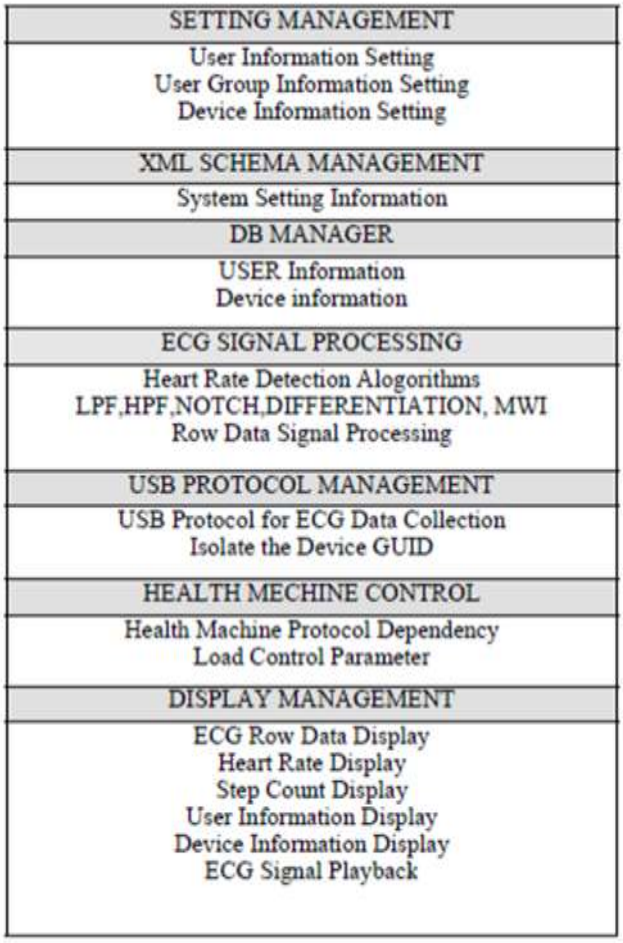

Figure 5.5 System Overview of CRMS

5. RESULTS

Outcome of this CRMS is:

i. Improved exercise Tolerance

Cardiac rehabilitation exercise training for patients with coronary heart disease or congestive heart failure (CHF) leads to significantly improvement in exercise capacity in men and women, no matter what their age is.

ii. Control of the symptoms

In patients with coronary heart disease, angina improves effectively during the cardiac rehabilitation exercise program.

iii. Effect on body weight:

Exercise training as a sole intervention has an adverse effect on controlling excess weight. Optimal management of obesity requires multifactorial rehabilitation, including nutritional education and counselling, behavioural modification, and exercise training.

iv. Effect on blood pressure:

Rehabilitation exercise training as a sole intervention has least effect; however, multifactorial intervention has been shown to have beneficial impact.

v. Improved psychosocial well-being:

Cardiac rehabilitation exercise and educational services improves measures of psychological and social functioning.

vi. Reduction of stress:

In cardiac rehabilitation programs, significant rise in emotional-stress measurements occurs. This reduction of stress is constant with improvement in psychosocial outcomes.

vii. Enhanced social adjustment and functioning:

Cardiac rehabilitation exercise training influences social adjustment and functioning.

6. CONCLUSION

The monitoring system should be designed flexibly to observe several patients simultaneously and also, should have concrete function to show heart rate signal in real time. Also, the system monitoring the heart rate, if the heart rate has out of safe range, the system generates the alarm. If we apply the system in cardiac rehabilitation exercise field, this system can be more effective managing solution to the exercise manager and to the patients. It will analyze each patient's cardiac condition and rapidly cope with unexpected accidents. By using the proposed cardiac rehabilitation system, the patient is provided with an improved QoL (Quality of Life) and QoC (Quality of Care). The proposed system has proven reliable, Secure and cost-effective. Furthermore, the system architecture and components do not limit it to the CVD medical sector. The specified architecture is used for multiple other domains such as diabetes, obesity or wellness in general. The proposed work indicates that data mining approach can be suitable to support doctors in the prescription of cardiac rehabilitation program and could represent a perfect idea for the development of decisional support system in the cardiac rehabilitation field. The goal is to expand the rehabilitation program within the region to include all acute care sites. Targeting mainly patients residing in remote areas in sparsely populated communities with minimal health care services. Thus, this rehabilitation program has the capacity to be adapted for other disease programming such as diabetes education, stoke programming and pulmonary rehabilitation.

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