Coronary heart disease monitoring system based on wireless sensors

ABSTRACT

An intelligent cardiac auscultation is a process of monitoring the heart beat signals variations of a patient monitoring system for monitoring the patient's health condition automatically through sensors based connected networks in the Internet of Things (IoT). It detects the critical condition of a patient by processing sensors data and instantly provides push notification to doctors. There is no process of monitoring of a particular cardiac disease which can lead to loss of life due to improper checkups and not following the lifestyle proposed by the doctor. In our proposed system, coronary heart disease monitoring based on wireless sensors are used to monitor the cardiac patient for 24/7 without any human intervention using piezoelectric sensors which are used to measure artery thickness by the flow of blood vessels and extract the waveform. The waveform is classified into the normal and abnormal waveform. This abnormal waveform is sent to the mobile application where it receives the data and plots the signal curves in real-time. The mobile application acts as the display device and has the capability to upload data to a cloud platform for further analysis and an intimation is sent to the cardiologist. The authorized Cardiologist can get access to the cloud platform to get the dataset and results via any peripheral devices which are equipped with specific software and diagnose the results.

Keywords— Piezoelectric sensors, IoT, Mobile application

1. INTRODUCTION

The primary purpose of the Internet of Things in health care is to connect doctors with patients through a smart device, without restrictions. In fact, the patients might open up better, helping the doctors reach a better diagnosis faster. This leads to an empowerment of the consumer, with practically no inefficiencies, and the doctor invariably makes informed decisions through better connectivity, precision centered monitoring and information gathering.

Fig. 1: An overview of health monitoring using ECG sensing network, IOT cloud and Graphical User Interface

Figure 1 shows the architecture of the IoT based Wearable Sensors by smart Monitoring using Mobile Application. Coronary heart disease refers to a narrowing of the coronary arteries, the blood vessels that supply oxygen and blood to the heart. It is also known as coronary artery disease. It is a major cause of illness and death. Coronary heart disease (CHD) normally happens when...
cholesterol accumulates on the artery walls, creating plaques. The arteries narrow, reducing blood flow to the heart. Sometimes, a clot can obstruct the flow of blood to the heart muscle. CHD commonly causes angina pectoris (chest pain), shortness of breath, myocardial infarction, or heart attack. When plaque builds up, it narrows your coronary arteries, decreasing blood flow to your heart. Eventually, the decreased blood flow may cause chest pain (angina), shortness of breath, or other coronary artery disease signs and symptoms. A complete blockage can cause a heart attack. Because coronary artery disease often develops over decades, you might not notice a problem until you have a significant blockage or a heart attack. But there's plenty you can do to prevent and treat coronary artery disease. A healthy lifestyle can make a big impact.

1.1 Symptoms
If coronary arteries narrow, they can't supply enough oxygen-rich blood to your heart especially when it's beating hard, such as during exercise. At first, the decreased blood flow may not cause any coronary artery disease symptoms. As plaque continues to build up in your coronary arteries, however, may develop coronary artery disease signs and symptoms, including:

1.2 Chest pain (angina)
This pain referred to as angina, usually occurs on the middle or left side of the chest. Angina is generally triggered by physical or emotional stress. The pain usually goes away within minutes after stopping the stressful activity. In some people, especially women, this pain may be fleeting or sharp and felt in the neck, arm or back.

1.3 Shortness of breath
The heart can't pump enough blood to meet your body's needs.

1.4 Heart attack
A completely blocked coronary artery will cause a heart attack. The classic signs and symptoms of a heart attack include crushing pressure in your chest and pain in your shoulder or arm, sometimes with shortness of breath and sweating. Women are somewhat more likely than men are to experience less typical signs and symptoms of a heart attack, such as neck or jaw pain. Sometimes a heart attack occurs without any apparent signs or symptoms.

1.5 Causes
Coronary artery disease is thought to begin with damage or injury to the inner layer of a coronary artery, sometimes as early as childhood. The damage may be caused by various factors, including:

- Smoking
- High blood pressure
- High cholesterol
- Diabetes or insulin resistance
- Sedentary lifestyle

1.6 Prevention
The same lifestyle habits that can help treat coronary artery disease can also help prevent it from developing in the first place. Leading a healthy lifestyle can help keep your arteries strong and clear of plaque. To improve your heart health, you can:

- Quit smoking
- Control conditions such as high blood pressure, high cholesterol, and diabetes
- Stay physically active
- Eat a low-fat, low-salt diet that's rich in fruits, vegetables, and whole grains
- Maintain a healthy weight
- Reduce and manage stress

Once the inner wall of an artery is damaged, fatty deposits (plaque) made of cholesterol and other cellular waste products tend to accumulate at the site of injury in a process called atherosclerosis. If the surface of the plaque breaks or ruptures, blood cells called platelets will clump at the site to try to repair the artery. This clump can block the artery, leading to a heart attack.

**Fig. 2: Accumulation of plaques in the lining of artery**

Figure 2 shows the accumulation of Plaques in the lining of an artery in the blood vessels.
2. LITERATURE SURVEY

G. Papanastasiou, M. C. Williams , M. R. Dweck; S. Mirsadraee, N. Weir; A. Fletcher , C. Lucatelli , D. Patel , E. J. R. van Beck, D. E. Newby, S. I. K. Semple (2018) [6], proposed a multimodality quantitative assessments of myocardial perfusion using dynamic contrast-enhanced magnetic resonance and 15Olabelled water positron emission tomography imaging where where a Kinetic modeling of myocardial perfusion imaging data allows the absolute quantification of myocardial blood flow (MBF) and can improve the diagnosis and clinical assessment of coronary artery disease (CAD). The performance measures obtained was between(r=0.83-0.92). The issue of this system is that the Positron emission tomography (PET) imaging can help to find comparative performance but results produced by PET cannot be accurate for Obstructive CAD detection.

Stefano Fiorentini, Lars Mølgaard Saxhaug, Tore Grünér Bjåstad, Espen Holte, Hans Torp, Jørgen Avдал (2018) [16], proposed a maximum velocity estimation in coronary arteries using 3D tracking doppler where commercial ultrasound system was locally modified to perform trans-thoracic, 3D high frame-rate imaging of the coronary arteries. Results from simulation also show that 3D tracking Doppler performance is acceptable up to 10 cm depth and 75° beam-to-flow angles. Results from simulations based on realistic coronary flow data suggest that the method can improve the accuracy of maximum velocity measurements in patients. The issue in this paper is that thickness of Blood measurement cannot be made by fat deposit in blood as the only amount of blood flow to test through ultrasound high-frequency sound waves is measured.

Yihui Cao, Qinjia Jin ,Yundai Chen, Qinye Yin ,Xianqing Qin Jianan Li ,Rui Zhu, Wei Zhao (2018) [19], proposed an automatic side branch ostium detection and main vascular segmentation in intravascular optical coherence Tomography Images where a fully automatic method for side branch ostium detection and main vascular segmentation. The evaluated performance of the presented method by comparing the manual and automatic detection and measurement results. A total of 4618 images from 22 pullback runs were used to evaluate the performance of the presented method. The validation results of side branch detection were TPR=82.8%, TNR=98.7%, PPV=86.8%, NPV=98.7%. The average ostial distance error (ODE) was 0.22mm, and the DSC of main vascular segmentation was 0.96. In conclusion, the qualitative and quantitative validation indicated that the presented. The issue of this paper is Detection and Segmentation is a time-consuming process.

Nikolas Lessmann, Bram van Ginneken , Majd Zreik ,Pim A. de Jong , Bob D. de Vos , Max A. Viergever , Ivana Išgum (2018) [13], proposed automatic calcium scoring in low-dose chest CT using deep neural networks with dilated convolutions where a method for automatic detection of coronary artery, thoracic aorta, and cardiac valve calcifications in low-dose chest CT using two consecutive convolutional neural networks. This method was trained and evaluated on a set of 1744 CT scans from the National Lung Screening Trial. Linearly weighted kappa coefficients for risk category assignment based on per subject coronary artery calcium were 0.91 and 0.90 for soft and sharp filter reconstructions, respectively. These results demonstrate that the presented method enables reliable automatic cardiovascular risk assessment in all low-dose chest CT scans acquired. The issue of this paper result is not well suited for coronary artery calcification (CAC) automatic cardiovascular risk assessment is not that accurate.

Yuanwei Li, Chin Pang Ho, Matthieu Toulemonde , Navtej Chahal , Roxy Senior , Meng-Xing Tang (2018) [20], proposed fully automatic myocardial segmentation of contrast echocardiography sequence using random forests guided by shape model where in this paper, a demonstration is made of how to overcome the above limitations of classic RF by presenting a fully automatic segmentation pipeline for myocardial segmentation in full-cycle 2D MCE data. The performance measure achieved in RF training takes 7.1 minutes for 1 tree. Given a test image, RF segmentation takes about 25.5s using 20 trees but tree prediction can be parallelized so that it takes 1.3s per tree. our sequence dataset Datset2 is small and only based on 6 subjects. Increasing the training data on this set can allow us to train better models than the one derived from Dataset1 which comprises only ES and ED frames.

Ling Zhang, Andreas Wahle ,Zhi Chen John J. Lopez , Tomas Kovarnik ,Milan Sonka (2018) [9], proposed predicting locations of high-risk plaques in coronary arteries in Patients receiving statin therapy where a machine-learning approach demonstrated that location-specific prediction of future plaque phenotypes related to MACE is feasible, thus improving risk stratification in patients with established coronary artery disease. Performance measures obtained using local vascular characteristics in a spatial context (42.6%) and systemic/demographic information (20.4%). The SVM-based feature selection and imbalanced data learning approaches predict high-risk plaque locations better than the previously clinical predictors and underline the importance of local factors on the development of high-risk plaques. The issue of this paper is the limited resolution of VH-IVUS does not allow direct measurement of thin fibrous caps (<65μm), and recent study questions the accuracy of the histological correlation of VH-IVUS characterization.

Juan Wang, Huanjun Ding, Fatemeh Azamian Bidgoli, Brian Zhou, Carlos Iribarren, Sabee Molloi, Pierre Baldi (2017) [7], proposed detecting cardiovascular disease from mammograms with deep learning where Coronary artery disease is a major cause of death in women. The FROC analysis shows that the deep learning approach achieves a level of detection similar to the human experts. The calcium mass quantification analysis shows that the inferred calcium mass is close to the ground truth, with a linear regression between them yielding coefficients. The performance measure of determination was 96.24%. The issue of this paper is FROC analysis shows that the deep learning approach achieves a level of detection similar to the human experts but not accurate.

Antonis I. Sakellarios, Lorenz Räber , Christos V. Bourantas , Themis P. Exarchos , Lambros S. Athanasiou , Gualtiero Pelosi , Konstantinos C. Koskinas , Oberdan Parodi , Katerina K. Naka , Lampros K. Michalis , Patrick W. Serruys , Hector M. Garcia-Garcia,Stephan Windecker, Dimitrios I. Fotiadis (2017) [3], proposed prediction of atherosclerotic plaque development in an in vivo coronary arterial segment based on a multi-level modeling Approach where a multilevel modeling approach, which can be used for prediction of plaque growth. The approach is based on modeling of blood flow, LDL transport as well as macrophages migration and foam cells formation. The performance achieved is show that ESS and LDL concentration have a good correlation.
with the changes in plaque area \( R^2=0.365 \) (P=0.029, adjusted \( R^2=0.307 \)) and \( R^2=0.368 \) (P=0.015, adjusted \( R^2=0.342 \)), respectively whereas the introduction of the variables of oxidized LDL, macrophages and foam cells as independent predictors improves the accuracy in predicting regions potential for atherosclerotic plaque development \( R^2=0.847 \) (P=0.009, adjusted \( R^2=0.738 \)). The issue in this paper is advanced computational models need to be used to increase the accuracy to predict regions which are prone to plaque development.

Kalina Orphanou, Athena Stassopoulou, Elpida Keravnou (2016) [8], proposed Dynamic Bayesian networks (DBNs) are temporal probabilistic graphical models that model temporal events and their causal and temporal dependencies. Temporal abstraction (TA) is a knowledge-based process which abstracts raw temporal data into higher level interval-based concepts. An extended DBN model which integrates TA methods with DBNs applied for prognosis of the risk for coronary heart disease (CHD). The Performance measure obtained was 72%. The issue in this paper is to assess the robustness of the model against the chosen cut-off values for deriving the temporal abstractions.

Xinglong Liu, Fei Hou, Hong Qin, Aimin Hao (2016) [18], proposed robust optimization-based coronary artery labeling from X-Ray angiograms a novel coronary artery labeling system from X-ray angiograms. The uniqueness of-oft this system is its simultaneous handling on labeling as well as various applications for physiological parameter extraction. At the labeling stage, formulate the labeling problem using an energy optimization approach solved by belief propagation without the need for explicit feature extraction, registration, and tracking. The Performance measure obtained is 150 seconds for Coronary Artery Labeling. The issue of this paper is shortcomings due to the low quality of images. Due to dynamic movements of the heart, the imaging quality is very poor, unavoidably causing severe artifacts if the contrast agent is not injected steadily, and unfortunately, this scenario is extremely challenging for all cardiovascular processing methods.

Abolfazl Khedmati, Alineza Nikravanshalmani, Afshin Salajegheh (2016) [1], proposed a semi-automatic detection of coronary artery stenosis in 3D CTA for detection of coronary artery stenosis, from 3D computed tomography angiography (CTA), is applicable for inspecting heart diseases. A semi-automatic method is used where the stages include 3D CTA pre-processing, vessel enhancement, coronary artery segmentation, centerline extraction, arteries cross-section diameter estimation, and stenosis detection. The authors consider two types of performance evaluations results for stenosis detecting, more than 50%, on 18 real data. In the first type, a sensitivity of 88.89% and a positive predictive value (PPV) of 88.89% are obtained, and in the second type, a sensitivity of 44.2%, and a PPV of 34.27% is achieved. The issue in this paper is to use more features on centreline longitude like tissues features and to combine them with geometric features, i.e. diameter, or area of vessel cross-section to detect stenosis.

Nabiul Islam, Sudip Misra (2016) [12], proposed “Catch the Pendulum” the problem of asymmetric data delivery in electromagnetic nanonetworks where the network of novel nano-material based nanodevices, known as nanoscale communication networks. The problem of asymmetric data delivery in such nano network-based systems and propose a simple distance-aware power allocation algorithm, named catch-the-pendulum, which optimizes the energy consumption of nanoDESs for communicating data from the underlying nanonetworks to radio frequency (RF) based macro-scale communication networks. The algorithm exploits the periodic change in mean distance between a nanoDES, inserted inside the affected coronary artery, and the NM, fitted in the intercostal space of the rib cage of a patient suffering from a CHD. The performance measure obtained is only 50%. The issue of this paper is that heart wall deforming factors, including segmental and area strain, translational and tettering, and specific deformations need to be focused which is not concentrated in this paper.

Weijian Cong, Jian Yang, Danni Ai, Yang Chen, Yue Liu, Yongtian Wang (2016) [17], proposed quantitative analysis of deformable model-based 3-D reconstruction of coronary artery from multiple angiograms where a novel mean composited external force back-projective composition model is proposed and integrated into the deformable model framework for the 3-D reconstruction of coronary arteries from multiple angiograms. The experimental results of performance measure demonstrate the effectiveness and robustness of the proposed model, which can achieve a mean space error of 0.570mm and a mean re-projection error of 0.351mm. The issue in this paper is that the deformable curve may evolve to its closet boundaries instead of the true topology structures of the vascular centerlines when large curvature variances are present for the vessel segments.

Samuel E. Schmidt, Claus Holst-Hansen, John Hansen, Egon Toft, Johannes J. Struijk (2015) [14], proposed acoustic features for the identification of coronary artery disease in which the current study identified new features, describing changes in the low-frequency part of the signal, for the diagnosis of CAD patients. Known features from the higher frequencies performed poorly in the recordings from the electronic stethoscope, which is probably due to noise from various sources, such as motion artifact which is a specific problem for the handheld electronic stethoscope. The diagnostic performance of the current CAD score is close to the widely used ECG exercise tests, but if the noise problems would be solved the features from high and low-frequency bands might supplement each other well and thereby improve the performance of the stethoscope based CAD-score. The performance measure obtained is the area under the receiving operating characteristic for the CAD score was 0.73 (95% CI: 0.69-0.78). The issue of this paper is further improvements in potential in heart sounds for the diagnosis of CAD are necessary to gain clinical relevance.

Sethuraman Sankaran, Leo Grady, Charles A. Taylor (2015) [15], proposed fast computation of hemodynamic sensitivity to lumen segmentation uncertainty where Patient-specific blood flow modeling combining imaging data (such as CT scans) and computational fluid dynamics can aid in the assessment of the functional significance of coronary artery disease. A good performance measure is obtained using the machine learning algorithm, with a correlation coefficient of 0.91 and means an absolute error of < 0.01, compared to sensitivities calculated using the stochastic collocation method. The issues of this system are the uncertainty in flow and pressure at bifurcations is not calculated using CFD for the ground truth, hence they are not captured using the perturbation model used in this work.
there are abnormal variations are being measured. The small number of observations is the other
issues that this study tries to address.

Anirban Mukhopadhyay, Zhen Qian, Suchendra M. Bhandarkar, Tianming Liu, Szilard Voros, Sarah Rinheart (2015) [2], proposed a morphological analysis of the Left Ventricular endocardial Surface Using a Bag-of-Features Descriptor where works that studies the relationship between coronary artery stenosis and the morphological alterations in the LV endocardial surface using high-resolution MDCT data and demonstrates its potential predictive value for the diagnosis of the incidence and severity of CAD. The overall performance measure used is 90.62%. The Issue of this paper is coronary arterial stenoses lead to myocardial ischemic events, there is an underlying gradual and complex myocardial process that precedes the clinical manifestation of myocardial infarction.

Didem Yamak, Prasad Panse, William Pavliceck, Thomas Boltz, Metin Akay (2014) [5], proposed non-calcified coronary atherosclerotic plaque characterization by dual-energy computed tomography where the overlap between CT attenuations measured in lipid and fibrous plaques shows that the mean density might not be an appropriate measure to characterize plaque composition. The Performance measure obtained in cross-validation was used to assess the prediction accuracy of the models on phantom data were found to be 7.36%, 5.74%, 5.70% and 5.23% for ANN, SVM, RF, and majority voting approach respectively. The Issues of this paper is that there were no histopathological findings of the patient plaques. The findings were within comparable ranges with the previously published data on density measurements. The small number of observations is the other limitation of this study.

Marcin Marzencki, Behrad Kajbafzadeh, Farzad Khosrow-khavar, Kouhyar Tavakolian, Bozena Kaminska, Carlo Menon (2014) [10], proposed diastolic timed vibrator noninvasive pre-hospitalization treatment of acute coronary ischemia. A novel method intended for pre-hospitalization treatment of patients with acute coronary ischemia that can be safely applied by a minimally trained individual prior to or during patient transportation to hospital. The Performance measure obtained is 70%. The issue of this paper is that the major challenge in implementing the device consists in reliable synchronization of the generated vibrations with the heart cycle of the subject.

Dalin Tang, Chun Yang, Jie Zheng, Gador Canton, Richard G. Bach, Thomas S. Hatsukami, Liang Wang, Deshan Yang, Kristen L. Billiar, Chun Yuan (2013) [4], proposed image-based modeling and precision medicine patient-specific carotid and coronary plaque assessment and predictions where atherosclerotic plaques may rupture without warning and cause acute cardiovascular events such as heart attack and stroke. The performance measure obtained is 80.1%. The issues of this paper are transforming into clinical applications could be even more challenging.

3. CONCLUSION
Thus Coronary Heart Disease Monitoring based on Wireless Sensors will be much benefit in the society where people who are affected with this type of cardiac diseases are monitored regularly through an application where the abnormal variations are being intimated to the caregiver/Patient as well as the Cardiologist where necessary action is taken. The paper mainly focuses on prevention/hearing of critical conditions, in turn, it can be a Life-saving process.

4. REFERENCES


