

The Cardio Kinesiograph System



Mohammad Reza Dawoudi*

Turku University of Applied Sciences, Finland

Submission: October 30, 2017; **Published:** January 19, 2018

***Corresponding author:** Mohammad Reza Dawoudi, Turku University of Applied Sciences, Finland, Email: m.reza.dawoudi@abo.fi

Abstract

The Cardio Kinesiograph System (CKinG) is a novel computerized diagnostic system incorporating a computer model of cardiac kinesis. Cardiac Kinesis (CK) is the interpretation of heart movement or electrical activity of specialized cardiac muscle cells in response to biochemical reactions. The mechanical events occurring during the cardiac cycle consist of changes in pressure in the ventricular chamber which cause(s) blood to move in and out of the ventricle [1]. The events of the cardiac cycle start with an electrical signal and proceed through excitation-contraction coupling (which involves chemical and mechanical events) to contraction of the ventricle (pressure generation) and ejection of blood (flow) into the pulmonary and systemic circulations [2]. Thus, we can characterize the cardiac cycle by tracking changes in ventricular volume (LVV), ventricular pressure (LVP), left atrial pressure (LAP) and aortic pressure (AoP) [3]. In the other hand, because electrical events always precede mechanical events in the cardiac cycle, distortions of a part or parts of the electrical signal have been used as diagnostic indicators of both electrical and mechanical dysfunctions of the heart muscle [4]. There are numerous methods and technical systems available for diagnosis or predict heart disease. However, medical errors and undesirable results [5] in these systems are reasons for a need for conventional computer-based diagnosis of heart diseases systems. The purpose of this study is to design and develop a system that can observe and analyze Kinesiographical Cardiac based on statistical models and identifies some fundamental characteristic of heart motions.

Keywords: Cardiovascular biomechanics; Statistical analysis methods; Medical heart imaging modalities; DNA modelization in biomedical image

Introduction

Since 1950 cardiologists have studied the functions of heart moments to employ them in the diagnostics of ischemic heart disease (IHD). Indeed, changes of the movements have found their diagnostic application in this field. If blood supply to a certain area of ventricular myocardium is insufficient the contractions in this area diminish and even ceases. After systolic increase in ventricular pressure this area dilates and forces intercostal tissues out, causing a "bulge" wave on the record.

Cardiokymography was one of several noninvasive techniques able to detect coronary artery disease. It can qualitatively determine abnormal left ventricular motion, and, based on animal models, this can be directly related to abnormalities in the left coronary artery [7]. Nevertheless sensitivity of cardiokymography in detecting patients with ischaemic left ventricular wall motion abnormalities depended on the extent of left ventricular ischaemia [8]. Cardiokymography is no longer valid [9]. Today Computer Aided Diagnosis (CAD) is one of the trusted methods in the field of medicine [10]. Advances in medical imaging and image processing techniques have greatly enhanced interpretation of medical images. Computer aided diagnosis (CAD) systems based on these techniques play a vital role [11] in the early detection of cardiovascular diseases and hence reduce death rate. CAD is the most preferable method for the initial diagnosis of heart disease. The combination of Digital and Medical Image Pro-cessing, Cardiac Electrophysiology, Ventricular Pressure-Volume Technique and Phonocardiogram etc makes the CAD system more reliable and efficient. One

example of the medical applications in computer aided diagnosis is the detection system for heart disease based on Cardiovascular Magnetic Resonance (CMR). Cardiovascular magnetic resonance of the heart provides a potentially useful way to assess cardiac mechanical function. Besides CMR, positron emission tomography (PET), and cardiac CT are able to illustrate kinesis of cardiac muscles. Perfusion imaging with cardiac PET is used clinically to produce images of myocardial blood flow, aiding the diagnosis of coronary artery disease and the monitoring of condition of coronary circulation in response to treatment [12].

Clinical imaging in positron emission tomography (PET) is often performed using single-time-point estimates of tracer uptake or static imaging that provides a spatial map of regional tracer concentration [13]. However, dynamic cardiac techniques (e.g. PET, Myocardial perfusion imaging and Dynamic cardiac SPECT [14]) are used to estimate rate parameters activity of myocardial blood flow, and there are limited studies evaluating the role of Cardiovascular Magnetic Resonance and cardiac PET and cardiac CT for the assessment of cardiac kinesis. Therefore, scientific communities in computational cardiovascular science [15] have contributed to developing mathematical models and algorithms to improve efficiency of cardiac safety data management in clinical trials. In this way in 2014 proposed a new method based on a mathematical model, "Fourier Transform" which calculates an amplitude parametric image for the assessment of cardiac kinetics. This image, calculated from the Cine MR images, allows the localization and quantification

of abnormalities related to difference in contraction and their extent [16]. In 2015 Zakyntinaki [17] has also presented effective mathematical model of heart rate kinetics in response to movement. She made conclusion that the new model is able not only to provide important information regarding an individual's cardiovascular condition but to also simulate and predict heart rate kinetics for any given exercise intensities. The existing models of cardiac kinetics focus mainly on amplitude images or are limited to simulation of biological transformation. The present study provides a novel mathematical model of cardiac kinesis based on visual presentation of numerical data (obtained through the cardiac kinesis) in the form of graph, with a particular focus on Human Cardio Kinesiograph Analysis. The purpose of this study was to de-sign, develop and evaluate a novel method for Kinesiograph of Cardiac for the clinical assessment of cardiac and vascular function.

Methods and Materials

The system includes the following steps:

Data collection: In order to obtain an accurate data, the Cardiovascular Magnetic Resonance imaging (CMR), Cardiovascular Ultrasound or Cardiac Computed Tomography are produced better performances for detection of cardiac mobility. However, CMR is provided the most comprehensive anatomic picture for patient selection [18]. The system therefore is obtained relevant information from the CMR.

Video quality assessment: Different medical imaging methods may introduce common artifacts include image distortion, signal pileup (bright regions), and image dropout (area without signal) [19], therefore the quality assessment is an important factor at the operational level. The assessment of quality of video depends upon the type of distortion [20]. Numerous video quality assessment methods and metrics have been proposed over the past years with varying computational complexity and accuracy [21]. We utilize different forms of quality assessment methods, however the merit of these methods is often judged by assessing the quality of a set of results through lengthy user studies [22].

Motion estimation and inertial measurements: Motion estimation is the process of determining the movement of blocks between adjacent video frames (MathWorks). Efficient and accurate motion estimation is an essential component in the domains of image sequence analysis [23] and medical video processing. The estimation of motion is also important from the viewpoint of matching metric technique, which is computed the context similarity between two images. There exist several methods for motion estimation image, and video processing (e.g. pixel-based motion estimation, block-based motion estimation, optical flow method). In this study in order to increase the computational accuracy and improve efficiency in solving problem, DNA Modeling (Dawoudi, 2017) method in biomedical image matching has been proposed. The method is based on the linear mapping and the one-to-one correspondences between

point features extracted from the frames and on calculating similarities in pixel values. This correspondence is determined by comparing two strings constructed from pixel values of the frames. The method uses a table called the Quarter Code table, which is the set of characters and numbers. In this table every number between 0 and 255 is translated into a unique string of four letter alphabet. Letters A,C,G,T are chosen, since they are the same as used in DNA sequences. In this way it possible to utilize tools originally programmed to DNA sequences analysis. When all pixel values of the frames (images) are converted to virtual DNA sequences, one can show the differences between two virtual DNA sequences.

Visual representation of numerical data in the form of graphs: The E-value gives a measure of the similarity of sequences. From this function we can obtain the correlation coefficient which will give us a single value of similarity. The rate of similarity between sequences (frames) is plotted as a graph and it's appearing in the Monitor.

Experiment Results

We demonstrate the system by performing experiment 2D cardiac CMR video (Source: HBSNS library). The practical framework consists of four steps:

A. Step 1: Extract frames from cardiac mri video

The information is obtained by extracting frames from CMR imaging video. There are different tools in order to extract frames from cardiac MRI Video (e.g. Free Video to JPG Converter, VLC or Virtual Dud) (Figure 1).

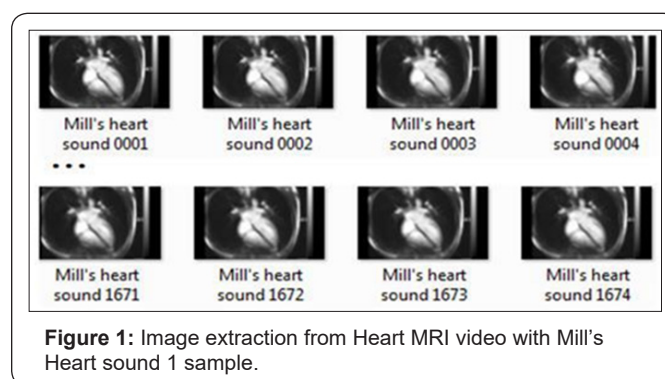


Figure 1: Image extraction from Heart MRI video with Mill's Heart sound 1 sample.

B. Step 2: Adjacent frames comparisons

The difference between two adjacent frames is used to estimate motion direction and magnitude. This process has been implemented within a tool called Image Diff. The Perforce image diff tool enables researchers to compare two adjacent frames. The following represents pixels difference value (Percent Changed; Pixels) and color difference value (Percent Change; Color) between adjacent Frames (Table 1).

C. Step 3: Presenting data in graphic form

In the final step the percentage of change (pixels and color) from one value to another, between frames are plotted as a graph (Figure 2 & 3).

Table 1: Pixels and Colour difference values.

Frames	Percent Change(Pixels)	Percent Change (Colour)	Threshold
18 19	8.13 (Start point)	1.08 (Start point)	49
19 20 ...	2.09		49
113 114....	1.31		49

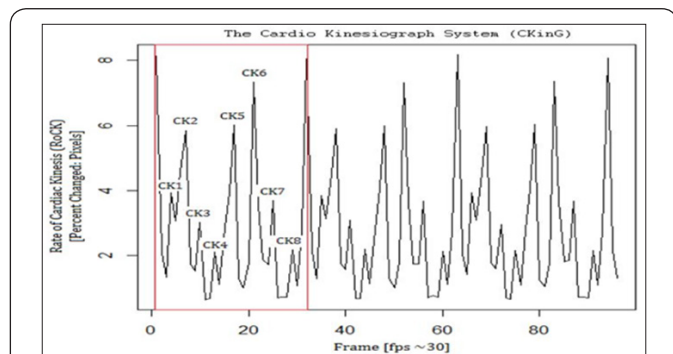


Figure 2 : Measured cardiac kinesigraphic signal showing three cardiac cycles. There are eight CK (cardiac kinesis) events (CK1, CK2, CK3, CK4, CK5, CK6, CK7 and CK8) for each cycle. There are labeled for the first cycle.

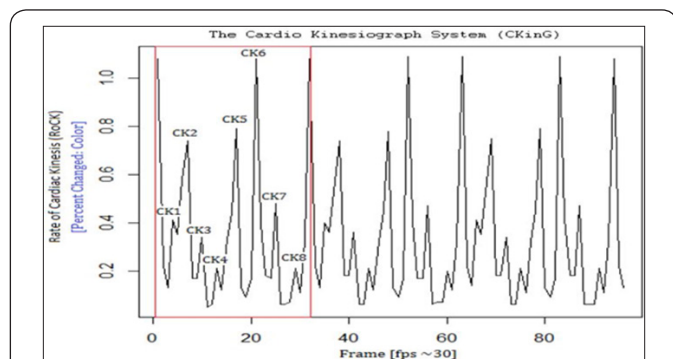


Figure 3 : Measured cardiac kinesigraphic signal showing three cardiac cycles. There are eight CK (cardiac kinesis) events (CK1, CK2, CK3, CK4, CK5, CK6, CK7 and CK8) for each cycle. There are labeled for the first cycle.

Results

The results show that the proposed design approach works efficiently in the Cardio Kinesis System for clinical applications of cardiovascular assessment.

Conclusion

In conclusion, the proposed Cardio Kinesiograph System (CKinG) may become a robust and efficient tool for the clinical assessment of Cardiac and Vascular function. CKinG-based Computer-Aided Diagnosis (CAD) holds the promise of improving the diagnosis accuracy and reducing the cost.

Discussion

The developed system can be used as a prototype in the clinical sectors for the evaluation of cardiovascular diseases. However, a novel method for real time MRI of cardiac kinesis

and simultaneously Kinesiographical Cardiac Analysis Based on Statistical Methods are proposed. The proposed methods may become efficient Medical Diagnostic Support tools (DSTs) for Heart Diseases.

Related Work

The publications below are based on Morbid Motion Monitor related topics:

- A. Dawoudi Mohammad Reza (2017) Morbid Motion Monitor. Current Trends in Biomedical Engineering & Biosciences. ISSN: 2572-1151.
- B. Dawoudi MR (in press) (2017). Nursing and Technology foresight in Futures of a Complex World. European Journal of Futures Research.

References

1. Daniel B (2002) Mechanical properties of the heart and its interaction with the vascular system. *Cardiac Physiology*, pp. 1-23.
2. Arthur BR, Vikki H, Antonio V, Alfred NA (2011) *Biomedical engineering principles*. CRC Press Taylor & Francis Group, Abingdon, UK.
3. Sameh G, Adel M, Ali Al (2013) Innovative artificial neural networks based decision support system for heart diseases diagnosis. *JILSA* 5(3): 176-183.
4. Khaiutin VM, Lukoshkova EV, Sheroziia GG (2004) Computer cardiokymography. On its way to long-term non invasive monitoring of cardiac performance in daily life. *Russ Fiziol Zh Im I M Sechenova* 90(5): 609-624.
5. (1987) Diagnostic and therapeutic technology assessment. *Cardiokymography*. *JAMA* 257(21): 2973-2974.
6. Scherhag AW, Pflieger S, Ceconi C, Voelker W, Gehring J, et al. (1997) Evaluation of signal-averaged cardiokymography for the detection of ischaemic left ventricular dysfunction. *Int J Cardiol* 59(3): 305-312.
7. Clifford G (1988) *Medical technology assessment directory: a pilot reference to organizations, assessments, and information resources*. National Academy Press. Washington (DC), USA.
8. Muhammed PYA, Kumar SS (2014) Recent methods for the detection of tumor using computer aided diagnosis- A review. *IEEE Xplore*.
9. Megha PA, Ram Mohana RG (2011) Aided diagnosis of liver cancer on computed tomography images. *Computer Networks and Intelligent Computing* 157: 246-251.
10. Mary G, Albert JS, Chi L, Richard EC (2014) Direct EM reconstruction of kinetic parameters from list mode cardiac PET. *Nuclear Science Symposium and Medical Imaging Conference (NSS/MIC)*, IEEE.
11. Muzi M, O'Sullivan F, Mankoff DA, Doot RK, Pierce LA, et al. (2012) Quantitative assessment of dynamic PET imaging data in cancer imaging. *Magn Reson Imaging* 30(9): 1203-1215.
12. Ross SG, Gullberg GT, Huesman RH (1997) The effect of heart motion on kinetic parameter estimates for dynamic cardiac SPECT. *IEEE Transactions on Nuclear Science*. 44(3): 1409-1416.
13. Bueno OA, Britton O, Muszkiewicz A, Rodriguez B (2015) *Cardiac Modeling*. Reference Module in Bio-medical Sciences *Encyclopedia of Cell Biology* 4: 86-94.
14. Narjes BA, Nawres K, Tarek K (2014) Parametric images for the assessment of cardiac kinetics by magnetic resonance imaging (MRI). *IEEE, Sfax, Tunisia*.
15. Zakyntinaki MS (2015) Modelling heart rate kinetics. *PLoS ONE* 10(4): e0118263.

16. Bulent S (2007) Proceedings ENTERFACE 2007: Summer Workshop on Multimodal Interfaces. Bogazici University, Istanbul, Turkey.
17. Nelson CA, Luciana M (2008) Handbook of Developmental Cognitive Neuroscience. Massachusetts Institute of Technology Press Cambridge, USA.
18. Nidhi, Aggarwal N (2014) A review on video quality assessment. Engineering and Computational Sciences (RAECS), 2014 Recent Advances in Engineering and Computational Sciences (RAECS), Chandigarh, India.
19. Vijay S, Martin R, Lina JK (2011) Objective video quality assessment methods: A classification, review, and performance comparison. IEEE Transactions on Broadcasting 57(2): 165-182.
20. Tunc OA, Martin C, Karol M, Hans PS, et al. (2010) Video quality assessment for computer graphics applications. Max-Planck-Institut In-formatik.
21. Beatrice PP, Marco C, Frederic D (2016) Motion estimation techniques. TELECOM Paris Tech, pp. 1-76.
22. Metkar S, Talbar S (2013) Motion estimation techniques for digital video coding. XII, illus 32: 64.
23. ミルさん心音からの動画化 2013.3.26 / Heart MRI video with Mill's heart sound 1. Kousakunin HBSNS.



This work is licensed under Creative Commons Attribution 4.0 License
DOI: [10.19080/CTBEB.2018.11.555803](https://doi.org/10.19080/CTBEB.2018.11.555803)

**Your next submission with Juniper Publishers
will reach you the below assets**

- Quality Editorial service
- Swift Peer Review
- Reprints availability
- E-prints Service
- Manuscript Podcast for convenient understanding
- Global attainment for your research
- Manuscript accessibility in different formats
(Pdf, E-pub, Full Text, Audio)
- Unceasing customer service

Track the below URL for one-step submission
<https://juniperpublishers.com/online-submission.php>