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Mathematical Model Optimization Techniques under Unreliable Electromagnetic Field for ECG Waves

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Abstract:
The electrocardiogram (ECG) has significant scientific importance for analyzing the majority of cardiovascular diseases. On one side the technologies are growing very fast, on the other side there is a need to check and balance their effect on human health. The activity of the heart ECG voltage vector is well explained by the modeling of the ECG wave. It is one of the essential tools to do so. In the proposed work we tried to elucidate a mathematical model for the ECG wave by presumptuous the human body as a cylindrical complex dielectric and conducting medium. The human heart is considered as a harmonic bio-signal generator positioned in this medium. Nowadays, technologies are enhancing in various aspects as the graph of mobile phone users increasing rapidly day by day. Essentially, it needed to understand its side effects on the human body and especially for the health of the human heart. The electrical equivalent of the heart can be used to develop a mathematical model for the human heart as per its functioning. The ECG parameters which are affecting due to the electromagnetic wave can be analyzed using a proposed mathematical model. If mathematical expressions are available relations can be formed and understand for each part of the human heart. As mobile phone and its, some component gives electromagnetic exposure to the human body. Hence there is a need to develop a model of the human heart using mathematical analysis. Hence, this paper proposes a mathematical model for ECG and variation of parameters due to electromagnetic field- based.

Key Words: Electrocardiogram (ECG), ECG modeling, ECG generator, ECG Parameters, optimization, data compression, Mathematical Expressions, Human Heart, Mobile Phone, and Electromagnetic Wave.

Introduction

The heart of a human is the sole of the body and its needs to be monitored and check regularly. Now a day from children to elder people everyone using smartphones with all its feature. As mobile phone and its, some component gives electromagnetic exposure to the human body. Human health is most important under any technological era. On one side technologies are growing very fast so on another side there is a need to balance and check their effect on human health. Hence there is a need to develop a model of the human heart using mathematical analysis. Already many researchers have worked in this field; therefore the related research work is discussed in the second section [1].

The study focused on development as well tests for a whole-heart mathematical model, including cardiovascular effects that vary with changes in heart rate [2]. This model was developed based on the paradigm and model presented by Ottesen and Densielsen, which was used to model internal cuts. Parameters results in various studies have revealed interactions between parameters throughout the cardiovascular model as well performance (including maximum pressure and stroke volume) of all rooms [3].

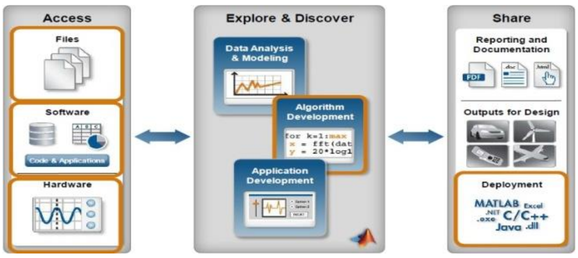
While there are many computers existing models to study the electrical or mechanical response of their rooms, the combined electro-mechanical response of the whole heart remains poorly understood [4]. We illustrate the controlling balance of entertainment cuts to unite and divide them using a single, cohesive environment. Basic metaphor Features of our model, we visualize the power of electricity and the decline of the machine throughout the human heart during its heart cycle. Comparing our imitation with the common heart metrics function, we extract the pressure-volume relationship and show that it fits well with clinical observations [5].

The proposed modeling and analysis concept is explained in detail. The mathematical expressions and model are discussed and illustrated after analysis and the conclusion of the work is discussed. The proposed modeling and analysis concept is explained in the third section. The mathematical expressions and model are discussed and illustrated in the fourth section. Then, the analysis and conclusion of the work are discussed.

Literature Survey

The human body terms are also required visual data such as container width, thickness, etc., required to calculate circuit parameters such as resistance, inductance, and capacitance, found in the well-known medical literature. The advanced

model helps to understand the human anatomic cardiovascular system and related syndromes. The model is about it vessel pressure and blood flow at certain times [6]. The scientific portrayal and displaying of the human cardiovascular framework assumes these days a critical job in the understanding of the beginning and create mint of the cardiovascular issue by giving computer-based reproduction of dynamic procedures in this framework [7]. This paper expects to give a review on lumped parameter models that have been created by numerous scientists everywhere throughout the world, to mimic the bloodstream in foundational supply routes. Looking over different references we survey various ways to deal with blood vessel trees demonstrating and examine on the uses of such models [8].
This work introduced a new mathematical model of the human heart as a hydro- electromechanical system (HEMS) [9]. This is an imitation the human heart is based on three vital functions: fluid, electrical and mechanical restrictions. This electrical model/circuit and tested by MATLAB for the comparison with the results obtained in similar to normal ECG waveforms for these generated results to be useful in clinical trials. The result is a simple electrical circulation that contains large electrical parameters converted from hydraulic models and physical therapies [10, 24-25]. Improved The MATLAB-based mathematical model will help first understand the function of the artificial heart and ECG signals performed. Complete production model a variety of such symptoms are referred to in the future in this regard paper. This study focuses on modeling a person's heart as a three-dimensional hydro-electro- mechanical system lesson [11-14, 23].
In this study, an extended model uses geometric



the size of the heart chambers is designed to describe the function of the heart. The new cardiac model was tested by comparing healthy and open cardiomyopathy (DCM) status for adults and children [15-16]. They developed a cardiovascular system model comparing hemodynamic variables with clinics diagnostic indicators within the body range of healthy and DCM proven conditions the emergence of this new model to assess clinical cases in adults and children [17, 20-22].

Mathematical Model:

In preparation of the mathematical modeling for the proposed work some challenges are;

1) Getting from mathematical concepts to a software model, 2) Validation and optimization of the mathematical model against requirements, 3) Acquiring field data from files, field instruments, and test rigs, 4) Characterizing systems using field data, 5) Representing real-world datasets as optimized lookup tables, 6) Utilizing the power of multiple processing cores to speed up calculations, and 7) Deploying models across a whole organization.
In mathematical modeling, we use mathematical language to describe a system or process to define. Various type of modeling approaches is there to describe.

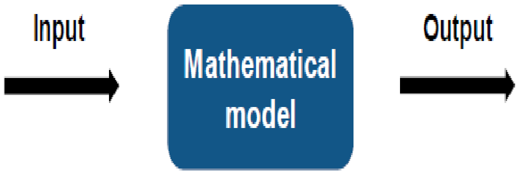
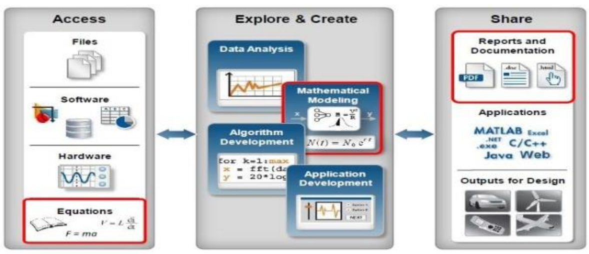


Figure 01: Different Modeling Approaches

The Principles Modeling has some advantages as fast and accurate and it has disadvantages as it requires plant and data acquisition. On the other hand, Data-Driven Modeling has insight into the behavior and physical parameters but it is time-consuming and requires expertise in handling.
Modeling with Governing Equations (or) First Principles Modeling:



Data-Driven Modeling workflow

Workflow – Non-Parametric Fitting

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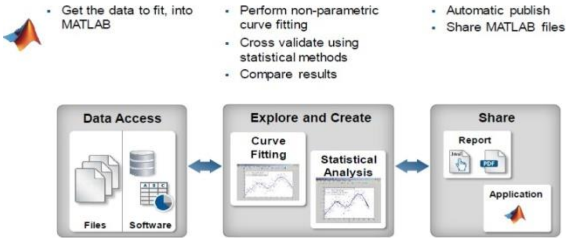

Figure 02: Mathematical Modelling using Matlab

Proposed work:

The Equations governing the whole circulatory system could be written down as in the following with the boundary conditions taking into account [18, 19];

QA(t)=QA1(t)+QM(t), (1)

QM(t)= QB(t)+QC(t), (2)

QM1(t)=QD1(t)+ QDO(t)+QX(t), (4)

QC(t)= QC1(t)+QCO(t)+ QM2(t), (5)

QM2(t)=QE1(t)+QEO(t)+QY(t), (6)

QF(t)= QX(t)+ QY(t), (7)

QF(t)= QF0(t)+ QF1(t) (8)

P1(t)+P2(t)+P4(t)+ P6(t)=PIN(t) (9)

Writing down the second group of compartmental equations and differentiating both sides of the equations;

P1 (t) + P3 (t) + P5 (t) + P6 (t) = PIN (t) (10)

$$R_A.\ Q_A(t)+L_A.\frac{dQ_A(t)}{dt}+\frac{1}{C_A}.\int Q_A(t).dt+R_{IN}.Q_M(t)+R_C.Q_C(t)+L_C.\frac{dQ_C(t)}{dt}+\frac{1}{C_C}.\int Q_{C1}(t).dt+(R_{IN2}+R_E).\ Q_{M2}(t)+L_E.\frac{dQ_{M2}(t)}{dt}+\frac{1}{C_E}.\int Q_{E1}(t).dt+R_F.Q_F(t)+L_F.\frac{dQ_F(t)}{dt}=P_{IN}(t) \quad (11)$$

Taking the differentiation of both sides of the above equation

$$R_A.\frac{dQ_A(t)}{dt}+L_A.\frac{d^2Q_A(t)}{dt^2}+\frac{1}{C_A}.\ Q_{A1}(t)+R_{IN}.\frac{dQ_M(t)}{dt}+R_C.\frac{dQ_C(t)}{dt}+L_C.\frac{d^2Q_C(t)}{dt^2}+\frac{1}{C_C}.\ Q_{C1}(t)+(R_{IN2}+R_E).\frac{dQ_{M2}(t)}{dt}+L_E.\frac{d^2Q_{M2}(t)}{dt^2}+\frac{1}{C_E}.\ Q_{E1}(t)++R_F.\frac{dQ_F(t)}{dt}+L_F.\frac{d^2Q_F(t)}{dt^2}=\frac{dP_{IN}(t)}{dt} \quad (12)$$

Applying Laplace transform to both sides of the equations with the initial conditions, finally derived equations are as follows:

$$Q_{M2}(S).[S^2.L_E+S.(R_{IN2}+R_E)]+\frac{1}{C_C}Q_{C1}(S)+\frac{1}{C_E}Q_{E1}(S)+Q_F(S).[S^2.(L_F)+S.(R_F)]=[S.P_{IN}(S)] \quad (13)$$

Results & Discussions:

Table 01: Annotations of the model parameters

Parameters	Annotationsofthemodel parameters	Units
Q	Flow	ml/s
P	Pressure	mmHg
U	Voltage	Volt
C	Capacity	F
L	Inductance	H
R	Resistance	Ω
PIN	Aorticpressure	mmHg
RA	Thefluidvariableresistanceoftheaorticvalve	Ω
RIN	Thefluidvariableresistanceofthepulmonaryvalve	Ω
RB	Thefluidvariableresistanceoftheright-atriumvalve	Ω
RIN1	Thefluidvariableresistanceofthemitralvalve	Ω
RD	Thefluidvariableresistanceoftheright-ventricle valve	Ω
RC	Thefluidvariableresistanceoftheleft-atriumvalve	Ω
RIN2	Thefluidvariableresistanceofthetricuspidvalve	Ω
RE	Thefluidvariableresistanceoftheleft-ventriclevalve	Ω
RF	ThefluidvariableresistanceofventricleandAtrium interaction	Ω

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LA	Aorticinductance	H
LB	Right-atriuminductance	H
LD	Right-ventricleinductance	H
LC	Left-atriuminductance	H
LE	Left-ventricleinductance	H
LF	Ventricleandatriuminteractioninductance	H
CA	Aorticvariablecapacitance	F
CB	Right-atriumvariablecapacitance	F
CBL	Right-atrium systemiccapacitance	F
CD	Right-ventriclevariablecapacitance	F
CDL	Right-ventriclesystemiccapacitance	F
CC	Left-atriumvariablecapacitance	F
CCL	Left-atriumsystemiccapacitance	F
CE	Left-ventriclevariablecapacitance	F
CEL	Left-ventriclesystemiccapacitance	F
CF	Ventricleandatriuminteractionvariablecapacitance	F
CFL	Ventricleandatriuminteractionsystemiccapacitance	F

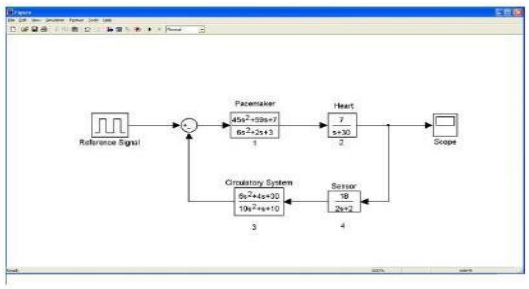
Table 02: Simulation Parameters

Parameters	Simulation-1	Simulation-2	Simulation-3
P-wave	0.07sec	NoP-Wave	Immeasurable
QT-interval	0.375sec	0.39sec	Immeasurable
PR-interval	0.20sec	NoPR-Interval	Immeasurable
QRS-complex	0.139sec	0.15sec	Immeasurable
T-wave	0.175sec	0.20sec	Immeasurable

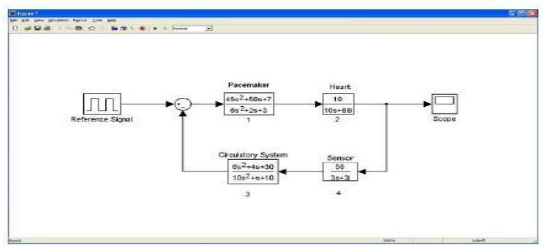
Table 02: Out Put values

TheRealCardiovascularPerformanceUnderRestingConditions			
Parameters	Values	Units	Results
PIN	0	mmHg	105
PCS	0	mmHg	120
PCD	0	mmHg	70
Initial valuesfortheSimulation			
QA1	0	ml/s	24,5
QA2	0	ml/s	22,41
QA3	0	ml/s	15,75
QACS1	0	ml/s	28
QACS2	0	ml/s	25,61
QACS3	0	ml/s	18
QACD1	0	ml/s	16,3
QACD2	0	ml/s	14,94
QACD3	0	ml/s	10,5

$$\frac{Q_A(s)}{P_{IN}(s)} = \frac{s}{s^2.L_A + s.(R_A + R_{IN})} = \frac{7}{s+30}$$

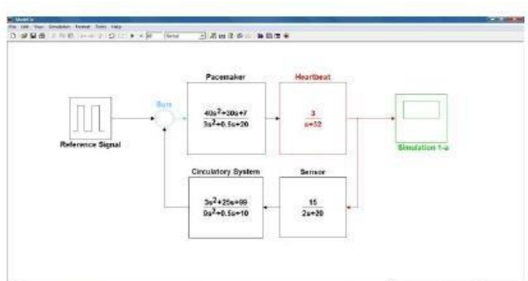


$$\frac{Q_A(s)}{P_{IN}(s)} = \frac{s}{s^2.L_A + s.(R_A + R_{IN})} = \frac{19}{10s+89}$$



U(mV)-t(sec)

$$\frac{Q_A(s)}{P_{IN}(s)} = \frac{s}{s^2.L_A + s.(R_A + R_{IN})} = \frac{3}{s+32}$$



Conclusion

Technologies are enhancing in variousaspects and the graph of mobile phone users increasing rapidly. There is a need to balance the effects of electromagnetic waves on human health. The electrical equivalent of the heart can be used to develop a mathematical model for the human heart as per its functioning. The ECG parameters which are affecting due to the electromagnetic wave can be analyzed using the proposed mathematical model. The mathematical expressions are available relation can be formed and understand for each part of the human heart. The heart of the human is the sole of the body and its needs to be monitored and check regularly. As mobile phone and its, some component gives electromagnetic exposure to the human body. Hence, a model is proposed by using the mathematical analysis for ECG and variation of parameters due to electromagnetic field-based. The proposed modeling and analysis concept is explained in detail. The mathematical expressions and model are discussed and illustrated after analysis and the conclusion of the work is discussed. The results show the proposed model working well as compare to the existing model.

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