Project Report

On

STATISTICAL PERSPECTIVE OF HEALTHCARE DEVICES

Submitted

in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE

in

APPLIED STATISTICS AND DATA ANALYTICS

by

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CERTIFICATE

This is to certify that the dissertation entitled, **STATISTICAL PERSPECTIVE OF HEALTHCARE DEVICES** is a bonafide record of the work done by Ms. **KARTHIKA S** under my guidance as partial fulfillment of the award of the degree of **Master of Science in Applied Statistics and Data Analytics** at St.Teresa's College (Autonomous), Ernakulam affiliated to Mahatma Gandhi University,Kottayam.No part of this work has been submitted for any other degree elsewhere.

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DECLARATION

I hereby declare that the work presented in this project is based on the original work done by me under the guidance of **ANU MARY JOHN**, Assistant Professor, Department of Mathematics, St.Teresa's College(Autonomous), Ernakulam and has not been included in any other project submitted previously for the award of any degree.

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I express my sincere gratitude to ANU MARY JOHN, Assistant Professor, Department of Mathematics and Statistics, St Teresa's College, Ernakulam for the guidance and support throughout the project for the successful completion of the project.

I also thank all the teaching and non teaching faculties of the department who provided with all the necessities for the completion of the project.The atmosphere provided us an external support that helped us to complete the project amidst of all those circumstances

Above all I thank God almighty and my parents for giving me the blessings to take over the project.

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Date: **SM21AS009**

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Chapter 1

INTRODUCTION

Health is one of the major concepts that we are concerned about in post covid scenario. By the theme of WHO in 2022, 'Our Planet, Our Health', we promote for the overall well being, equity and sustainable development. From the traditional hospitalization we reached at the modern age where we carry out our healthcare mini report recorded at every seconds that helps in easy monitoring and analysis of health.

The concept of healthcare devices ranges from that used in hospitals to that we carry out daily including Fit bit, Apple Watch, Blood pressure monitor and many. These devices produces daily report of the user that include heartbeat rate, calories burned, no of steps and thereby helps in continuous monitoring of the health. We had reached at the situation were we have to carry mobile doctors so as to control and monitor our body changes by every minute.

To bring conclusion regarding the health condition and thereby pro-

ducing the report it is essential that we have to obtain the clear idea regarding the analysis of heartbeat from those graphical report, there lies the importance of statistical study of healthcare devices.

The project report gives the idea behind the idea of Fourier analysis that act as the key idea for statistical study of healthcare devices. This project takes through the idea of Fourier transform and photoplethysmography and its several applications. Chapter 1 deals with the basic idea of Fourier series, Fourier transformations,Fourier analysis. Chapter 2 discusses the idea of Fast Fourier Transformations. Chapter 3 and 4 gives the real life applications of Fourier analysis that includes Electrocardiograms and Photoplethysmography. The project ends with Chapter 8 by giving a idea to recognize the type of cancer cells using Fourier analysis.

Chapter 2

OBJECTIVE

2.1 Objective

In this project the following are the objectives that are considered

- Brief introduction about Fourier Analysis.
- Understand Fast Fourier Transformations.
- Statistical analysis of wave forms in healthcare devises.
- To apply the idea of Fourier Analysis in the Study of Electrocardiogram.
- To extent the idea of Fast Fourier Transformations in the field of Photoplethysmography.
- Extending the applications of Fourier analysis medical industry.
- Understanding the efficiency of Fourier based treatment methods as a supplement to ultrasound endoscopy in detection of pancreatic cysts.

Chapter 3

LITERATURE REVIEW

Wearable devices generates large amount of data time by time that are used to study about the behaviour of human health and hence could be able to predict the future condition of the human in near future. Signal processing and data analysis are widely used methods in biomedical research uses certain algorithm like FFT(Fast Fourier Transformation) that helps in ECG(electro-cardiogram) recording and are now used in smartwatches that uses the idea of statistical model for analysing heartbeat, therby helping to regulate and maintain body conditions

Chapter 4

FOURIER SERIES

4.1 Introduction to Fourier series

A Fourier series can be expressed as an expansion of periodic function of f(x) in terms of infinite sum of sine and cosine functions.Introduced initially by Jean-Baptiste Joseph Fourier(1768-1830) with the help of preliminary conclusions made by Leonhard Euler, Jean le Rond d'Alembert and Daniel Bernoulli, that was initial used for obtaining the solution of heat equation. It is possible to represent any function as the sum of sine and cosine function or by the linear combination , by the property that the infinite sine and cosine functions are mutually orthogonal and exclusive and hence they produce Fourier series linear representation. [12]Fourier series is a periodic way of representing trigonometric functions with periodic function $f(x)$ of period 2L in the interval (-L,L). The mathematical formula can be expressed as follows

$$f(x) = \frac{a_0}{2} + \sum_{n=1}^{\infty}(a_n cos\frac{n\pi x}{L} + b_n sin\frac{n\pi x}{L})$$

where

$$a_0 = \frac{1}{L}\int_{-L}^{L} f(x)dx$$

$a_n = \frac{1}{L}\int_{-L}^{L} f(x)cos\frac{n\pi x}{L}dx, n = 1, 2, ...$

$b_n = \frac{1}{L}\int_{-L}^{L} f(x)sin\frac{n\pi x}{L}dx, n = 1, 2, ...$

4.2 Odd and Even functions

On analysis of graph of sine and cosine function it is clear that they follow some sort of symmetry among themselves in such a way that cosine function is symmetric along y axis whereas sine function is anti symmetric. This symmetric property depend upon the exponent(n), whether it is odd or even in the power of x^n.

In short odd and even function can be defined as follows.

- **A function is even if $f(x) = f(-x)$ for all x,then the Fourier series expansion of $f(x)$ has the cosine terms and can be then expressed as**

  $f(x) = \frac{a_0}{2} + \sum_{n=1}^{\infty}(a_n cos\frac{n\pi x}{L})$

  where $a_0 = \frac{1}{L}\int_{-L}^{L} f(x)dx$

  and $a_n = \frac{2}{L}\int_{0}^{L} f(x)cos\frac{n\pi x}{x}dx, n = 1, 2, ..$ **,**$b_n = 0$

- **A function is odd if $f(x) = -f(x)$ for all x, then the Fourier series expansion $f(x)$ has the sine terms only and then expressed as**

  $f(x) = \sum_{n=1}^{\infty}(b_n sin\frac{n\pi x}{L})$

  where $b_n = \frac{2}{L}\int_{0}^{L} f(x)sin\frac{n\pi x}{x}dx, n = 1, 2, ..$

4.3 Periodic and Aperiodic Signals

4.3.1 Periodic Signal

A signal can be considered as periodic if it repeats over a cyclic regular intervals of time, represented by the equation $f(t) = f(t + T)$ from the classical definition we have that the Fourier series are periodic in nature.

For sine waveform T=2π-0=2π sec

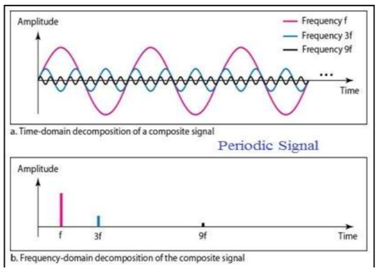


fig 4:3(a)

4.3.2 Aperiodic Signals

A signal is said to be aperiodic when it does not repeat in a regular pattern over the interval of time. Most of the series are aperiodic in nature.

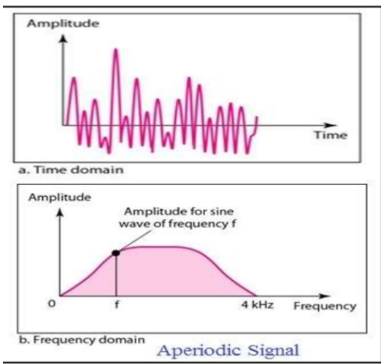


fig 4:3(b)

4.4 Types of Fourier series

There are basically two types of Fourier series they are

- **Trigonometric Fourier Series(TFS)**
- **Exponential Fourier Series(EFS)**

4.4.1 Trignometric Fourier Series (TFS)

Any function $f(t)$ **over the interval** $(t_0, t_0 + \frac{2\pi}{w_0})$**can be expressed as**

$f(t) = a_0 cos0w_0t + a_1 cos1w_0t + a_2 cos2w_0t + ... + a_n cosnw_0t + .. + b_0 sin0w_0t + b_1 sin1w_1t + ... + b_n sinnw_0t$

$= a_0 + a_1 cos1w_0t + a_2 cos2w_0t + ... + a_n cosnw_0t + .. + b_0 sin0w_0t + b_1 sin1w_1t + ... + b_n sinnw_0t$

hence $f(t) = a_0 + \sum_{n=1}^{\infty}(a_n cosnw_0t + b_n sinnw_0t) \qquad (t_0 < t < t_0 + T) \quad (1)$

where $a_0 = \frac{\int_{t_0}^{t_0+T} x(t).1.dt}{\int_{t_0}^{t_0+T} 1^2 dt} = \frac{1}{T}\int_{t_0}^{t_0+T} x(t)dt$

$$a_n = \frac{\int_{t_0}^{t_0+T} x(t).cosnw_0tdt}{\int_{t_0}^{t_0+T} cos^2nw_0tdt}$$

$$b_n = \frac{\int_{t_0}^{t_0+T} x(t).sinnw_0tdt}{\int_{t_0}^{t_0+T} sin^2nw_0tdt}$$

here $\int_{t_0}^{t_0+T} cos^2nw_0tdt = \int_{t_0}^{t_0+T} sin^2nw_0t \ dt = \frac{T}{2}$

$a_n = \frac{2}{T}\int_{t_0}^{t_0+T} x(t)cosnw_0t \ dt$ **and** $b_n = \frac{2}{T}\int_{t_0}^{t_0+T} x(t)sinnw_0t \ dt$

4.4.2 Exponential Fourier Series(EFS)

Exponential Fourier series representation of the signal $f(t)$ **over the interval** $(t_o, t_0 + T)$ **is given by**

$f(t) = \sum_{n=-\infty}^{\infty}(F_n e^{jnw_0t}) \qquad t_0 < t < t_0 + T. \quad (2)$

where $e^{jnw_0t}(n = 0, \pm1, \pm2, ..)$ **are set of complex exponential functions**

which is orthogonal over the given integral ,with time peiod T=$\frac{2\pi}{w_0}$ and

$F_n = \frac{\int_{t_0}^{t_0+T} f(t)(e^{-jnw_0t})dt}{\int_{t_0}^{t_0+T} e^{-jnw_0t}(e^{-jnw_0t})dt} = \frac{1}{T}\int_{t_0}^{t_0+T} f(t)e^{-jnw_0t}dt$**.**

4.5 Relationship between Trigonometric and Exponential Fourier Series

Consider the equation represented by (1) and (2), if

$f(t) = F_0 + F_1e^{jw_0t} + F_2e^{j2w_0t} + ... + F_ne^{jnw_0t} + ...F_{-1}e^{-jw_0t} + F_{-2}e^{-j2w_0t}... \quad .+$

$F_{-n}e^{-jnw_0t} + ..$

comparing the coefficients we have the relationship that

$a_0 = F_0$ **,** $a_n = F_n + F_{-n}$ **and** $b_n = j(F_n - F_{-n})$

Chapter 5

FOURIER ANALYSIS

5.1 Time and Frequency Domain Analysis

Consider an illustration of time domain and frequency domain representation of electrical signals are depicted respectively as

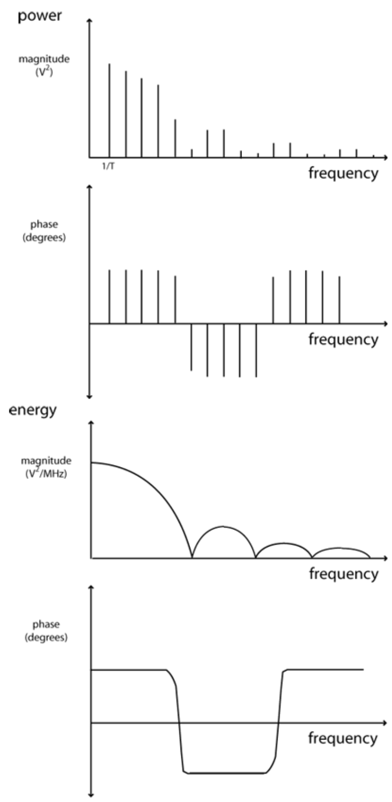


fig 5:1(a)

A graph that has a frequency and an amplitude can be expressed either

in the form of time domain and frequency domain. Considering the general signal graph that contain peak and trough, the signal is periodic then it could be easy for plotting the frequency from the graph with respect to the time. But if the graph is aperiodic this may not be the case as the signal in the temporal domain may undergo fluctuations with respect to the function of time. For example considering a general cosine function

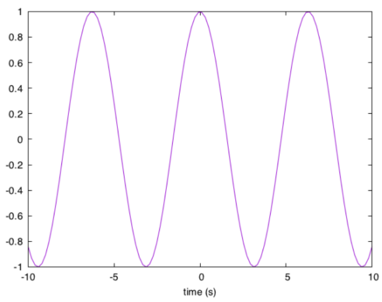


fig 5:1(b)

Here the frequency ranges from -1 to 1 and repeats the value periodically with corresponding time period t such the the frequency f can be calculated by $f = \frac{1}{t}$, measured in Hertz.

To make interpretations faster, accurate and easier we transform those time domain graph into frequency domain graph as in the form of an energy spectrum. The continuous time series is changed to discrete form when transformed to frequency domain.

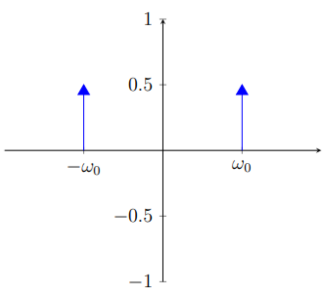


fig 5:1(c)

This change was made by representing the time domain to frequency domain with the help of the equation

$x(w) = \frac{1}{2}\delta(w - w_0) + \frac{1}{2}\delta(w + w_0)$

w_0**=cosine's natural frequency and**

$\delta(t) = \{+\infty \ if \ \ t = 0, \quad 0 \quad if \ t \neq 0\}$

subject to the condition $\int_{-\infty}^{+\infty} \delta(t)dt = 1$ **where** w **turns to angular frequency as depicted in the graph.**

Frequency domain indicates how signal energy can be distributed in a range of frequency. Both the domain has its own importance such that the for analysing signal's periodic properties we use frequency domain, while to identify impulse function and the outliers in the graph we could use time domain analysis. This process of transforming signals from one domain to the other domain is called as Fourier Analysis.

5.2 Fourier Transform

Fourier transform can be added as an extension to the mathematical model made under complex Fourier series that helps to transform a series from one domain to other domain mainly from time domain to frequency domain and vice versa under the limit tending to ∞**. Fourier transform can be divided into two they are**

- **Forward Fourier Transform**
- **Inverse Fourier Transform**

Both can be represented by the set of equations as below

$F(K) = \int_{-\infty}^{\infty} f(x)e^{-2\pi ikx}dx$

$f(x) = \int_{-\infty}^{\infty} F(K)e^{2\pi ikx}dk$

The first equation represents Fourier Transform of $f(x)$ and the second formula is called Inverse Fourier Transform of$F(K)$.$F(K)$ represents complex amplitude presents in f(x)(aperiodic function). In other words $F(K)$ is the frequency domain and $f(x)$ is the time domain of the signal wave.

5.2.1 Discrete Fourier Transform

A Continuous Time Fourier Transform(CTFT) and Discrete Time Fourier Transform can be represented respectively by the formula as

$x(w) \approx \int_{-\infty}^{\infty} x(t)e^{-iwt}dt$

$x(w) \approx \sum_{-\infty}^{\infty} x[n]e^{-iwn}$

where $x(t)$is a continuous signal of the integral and i represents the complex number, w is the angular frequency measured in radians per second, $x[n]$is a discrete aperiodic function, n an integer.

If $x(w)$ complex function of Fourier Transform represents the periodic function defined by

$x(w) = x(w + 2k\pi)$

where k is any integer ,then DTFT can transform a aperiodic function in time domain to aperiodic function in frequency domain. Discrete Fourier Transform (DFT) is used when the signal is periodic and discrete given by the formula

$x_k \approx \sum_{n=0}^{p-1} x[n]e^{-iw_0kp}$,

where p and k are integers of period ,

x_k**- Fourier series coefficients,**

w_0 **-angular frequency**

DFT has the following properties

- **transform periodic time domain to periodic frequency domain.**
- **uses complex exponential in its analysis by changing x_k to x_{k+Np}.**
- **used i signal processing and used for studying Fast Fourier Transformations.**
- **if $h(t)$ has Fourier transform $H(f)$ then Fourier transform of $H(t)$ is $H(-f)$.**

5.3 Fast Fourier Transform

Fast Fourier Transform is an algorithm that considered either discrete Fourier transform or its inverse i.e(DFT or IDFT). While computing DFT matrix through ordinary calculation we use the formula $O(N^2)$ it takes a long procedure since the value could be more complex depending upon how large the value of N becomes. Through FFT the equation reduces to $O(NlogN)$ where N is the data size and hence makes the computation faster. There are different types of algorithm includes Cooley-Tukey algorithm, Bruun's FFT algorithm, Rader's FFT algorithm etc. To illustrate an FFT algorithm consider that we have a data of size N=4096.Through normal method we calculate N^2 complex multiplications and $N(N-1)$ complex additions of which that determines $O(N)$. This hectic calculations can be easily done through FFT algorithm that compute the same output with $\frac{N}{2}log_2(N)$ complex multiplications and $Nlog_2(N)$ complex additions with less than times as that of the normal calculation.

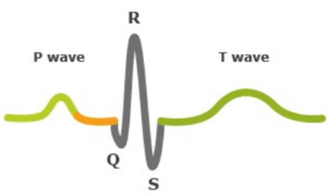
5.3.1 Cooley-Tukey Algorithm

This algorithm is a type of FFT algorithm that breaks DFT into various smaller size of$N$**. Consider a DFT of size** $N = N_1 N_2$ **into smaller DFT's of size** N_1 **and** N_2 **along** $O(N)$ **multiplications by complex roots of unity (twiddle factors). Popularized by Cooley and Tukey in 1965, this algorithm divide the transform into two pieces of size** $\frac{N}{2}$ **at each step and limited to size of power 2 and this method is called radix-2 or mixed-radix cases.**

Chapter 6

REAL LIFE APPLICATIONS OF FOURIER ANALYSIS: ELECTROCARDIOGRAM

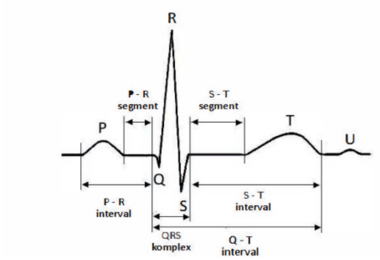
Electrocardiogram(ECG) machine is a device that simply determine the heart beat rate with the help of impulses produced by the body occur as part of connection between nerve and muscle. When electrodes are pasted on our body , that is at skin at chest they record all these impulses controlled in by the heart and are read by machines (ECG) that monitors and records those observations.
Normally a heartbeat contain types of waves say P(excitation spreads across two atria), Q, R, S (they records the impulse when blood reaches ventricles of the heart)called as QRS complex, T wave represents the end of reading when finally the ventricles relax.The normal QRS complex are shown by an example.



6(a)

6.1 Analysis of waves in electrocardiogram

For an electrocardiogram there are different types of waves ,that can be represented as



6:1(a)

6.1.1 P wave

The signal starts with the P wave that that records the impulse the atrial at the sino atrial node. The P wave records values starting at level 0 and ends at the starting of P-R segment.The amplitude of the P wave is normally 0.3mV with duration 100ms.

6.1.2 P-R interval

For a healthy individual the value of P-R segment lie between 120-200ms that records the value ranging from the intial point of P wave till the initial point of Q wave. That is it records the impulses from the atrial depolarization till the ventricular depolarization. The normal

value of P-R interval lies between 120-200ms.

6.1.3 QRS complex

QRS complex consists of three waves, Q, R and S.The QRS complex starts at the end of P-R segment that has a small deflection downwards call as the Q wave and then there is a deflection upwards represented by R followed by a deflection downwards denoted by S that ends up with small upward deflection. The normal length of QRS complex ranges from 80 to 120ms representing a healthy heart.Here both Q and S waves are negative .

6.1.4 S-T interval

S-T interval marks from the end to QRS complex till T wave, where T represents ventricular systole.

6.2 Fourier series in ECG signals

ECG signals follows aperiodic property. To study with that of the Fourier series and to apply the idea of Fast Fourier Transform(FFT) in ECG we have to convert those aperiodic functions into periodic functions and hence apply Fourier transformations. To study about the Fourier series in ECG we divided into 11 components as shown below

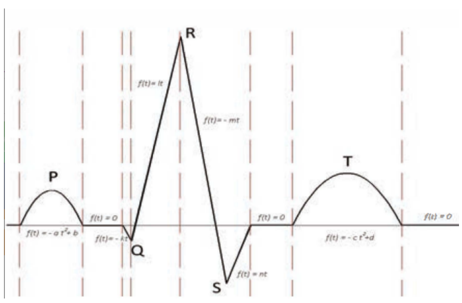


fig 6:2(a)

6.3 Models for each interval

The model for various areal under decomposition depends upon the function of t

6.3.1 QRS Complex

The QRS complex are the main part of an ECG signal. Consider the basic function $ft) = t$ from the representation it is clear that the graph contain both upward and downward deflection hence the function of t could be changed as $f(t) = t$and $(t) = -t$ respectively for rising and falling.

Consider the upward case where the function it's represented by $f(t) = t$.Then its corresponding Fourier series representation could be

$a_0 = \frac{1}{\pi}\int_c^{c+2\pi} tdt$=**0**

$a_k = \frac{1}{\pi}\int_c^{c+2\pi} tcos(kt)dt$=**0**

$b_k = \frac{1}{\pi}\int_c^{c+2\pi} tsin(kt)dx$=$(-1)^{k+1}\ \frac{2}{k}$

$f(t) = 2\sum_{k=1}^{\infty} \frac{(-1)^{k+1}}{k} sin(kt)$

Hence the resultant graph could be

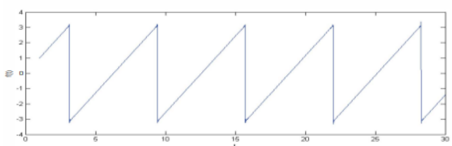


fig 6:3:1(a)

Models of P and T waves

P and T are said to be parabolic function that satisfies the equation $f(t) = -t^2$. hence from the equation we have

$a_0 = \frac{1}{\pi}\int_c^{c+2\pi} -t^2 dt$

$a_k = \frac{1}{\pi}\int_c^{c+2\pi} -t^2 cos(kt)dt$

$b_k = \frac{1}{\pi}\int_c^{c+2\pi} tsin(tx)dx = 0$

$f(t) = 4\sum_{k=1}^{\infty} \frac{(-1)}{k^2} cos(kt)$

The resultant decomposition could be

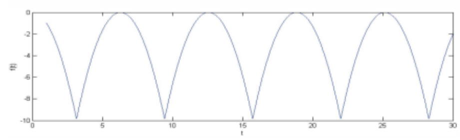


fig 6:3:1(b)

6.3.2 R-R Interval

Since the graph repeats we obtain several QRS complex.The distance between two R in the successive QRS complex is called as the R-R interval. It is necessary to calculate two R-R interval is that it helps us to monitor the heart rates and check whether they are regular or not.

6.3.3 Illustration with a sample ECG

The following sample marks the heartbeat of a random individual with the scale on x-axis=Time(ms(millisecond)) y axis=Amplitude(mV)

The data was secondary and contains 150002 rows .The following represent the first 10 values.

1	ms	heartrate
2	0	504
3	2	504
4	4	504
5	6	504
6	8	506
7	10	508
8	12	507
9	14	508
10	16	508

fig 5:3:3(a)

The heartbeat detection was found as follows

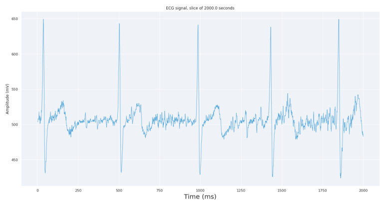


fig 5:3:3(b)

The peak for detecting R-R interval was found and cross correlation was done from the samples from 0 to 2000 and a constant value(here 600) was kept in order to obtain the corresponding peak. The output was as follows

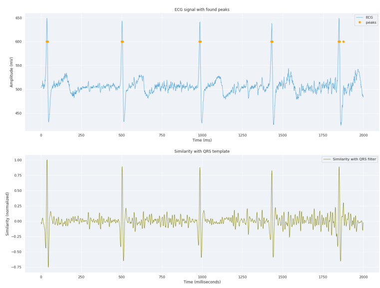


fig 5:3:3(c)

Chapter 7

REAL LIFE APPLICATIONS OF FOURIER ANALYSIS 2: PHOTOPLETHYSMOGRAM

We live in an electronic world where we could be able to monitor our health at every second at our fingertips. PPG or so called Photoplethisgraphy is a low cost optical instrument that measures the variations in blood circulation from the surface of the skin. The word consists of two components 'photo' meaning light and 'plethysmo' meaning volume and ;graphy' meaning recording. The most recent example of PPG are so called smart watches that track the heartbeat rate and helps in body monitoring. The PPG in such devices measures the report by using the lighting detector that measures by how the blood in the skin reflects back the light. The idea of Photoplethysmography started at 1930's extended to clinical pulse oximetry and now reached at optical heart rate monitor. The PPG wave forms are found in the

form of a graph where the plethysmograph calculate the heartbeat of the individual.

The limitation with the ECG machine is that it needs certain time for initialization i.e in order to obtain the heart rate through ECG there should be certain electrode that has to be placed at the various parts of the body so as to obtain the correct heartbeat. This limitation can be reduced with the help of PPG at the smart devices that monitor HRV(Heart Rate Variability), thereby helping to analyse the heartbeat more easily. These devices are easily portable,can be placed at the easily accessible positions like earlobe, fingertips that give clear PPG signals.

7.1 Representation of a general PPG waveform

The general representation is given by

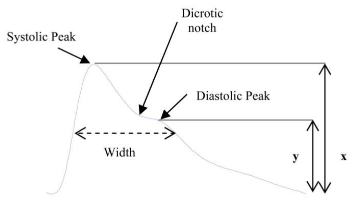


fig 6:1(a)

The photoplethysmogram can be divided into two stages anacrotics and catacrotic phase. The first phase is concerned with the systole and contains a systolic peak where the second phase is concerned with the diastole with a dicrotic notch(pressure at the central arteries).

The diagnosis of PPG occurs in three stages they are

- **Prepossessing of signal**
- **Feature extraction from the pre-processed data**
- **Classification and Diagnosis**

7.2 Respiration and PPG

With increase in the number of cardiovascular deceases it is necessary that we should make use of newly developed PPG devices like nasal canula or a chest band that records the rate of signal considering the following factors flexibility of pulse wave amplitude in blood vessels, pulse envelope etc that measure the heart rate using the oxygen saturation in the blood. Hence using the idea of PPG in heartbeat detection helps us to get accurate results about heartbeat detection

7.3 PPG and Fast Fourier Transform

Combining the idea of Fast Fourier Transform and PPG we could be able to obtain the peak and heartbeat rate of a patients that are anesthetic. When an algorithm like FFT can be implemented we obtain the heartbeat rate rate more easily with accuracy. This techinique uses the advantages that the those are able to capture signals from the frequency components.

7.3.1 Detection of heartbeat using FFT

From the basic definition heart rate detection we have the formula

$Heartrate = frequency * 60$ (1)

The N-point DFT can be given by the formula

$x_n = \frac{1}{N}\sum_{k=0}^{N-1} X_k.e^{i2\pi kn/N}$ **n element of Z**

where x_n is discrete -time signal with period N From the frequency domain obtained from the graph of FFT algorithm and by using the definition of heartbeat we can obtain the heartbeat spectrum easily through FFT. The below is an illustration of a PPG signal that are filtered.

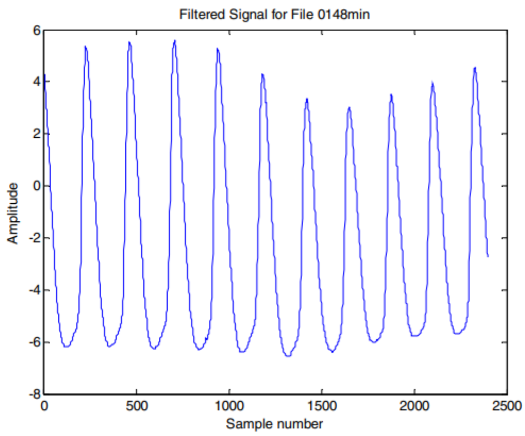


fig 7:3:1(a)

The above used sample used peaks had threshhold value(say 0,since negative peaks were not allowed) and the average peak was 1. The corresponding FFT spectrum of PPG signal could be

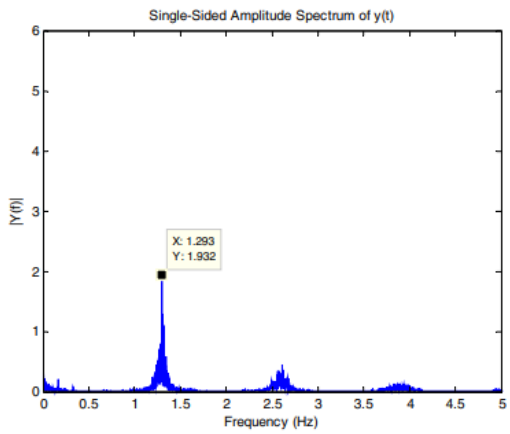


fig 7:3:1(b)

The average frequency of the PPG signal was ranging from 1.2-1.5 Hz.

7.4 Applications of PPG waveform

The application of Fourier transform are widely used in the sectors of measurement principles, clinical applications, noise definitions and pre-processing technique

Chapter 8

Extended study of Fourier Analysis

8.1 Pancreatic cysts

Pancreas is an organ in human body that helps the body in digestion process. The pancreas produces certain enzymes that helps to breakdown the food into various constituents like fats,glucose,sugar and starch and helps in endocrine and exocrine functions. A cysts can be considered as the sac like structures that are found as bulges made under the skin may contain membrane,fluid,air, or semi fluid substances.The cysts can be considered as benign or malignant base upon the fluid constituents. The treatment that are flowed for testing the type of cysts in pancrease are as follows

- Computerized tomography(CT) scan
- Magnetic Resonance Imaging(MRI) scan
- Endoscopic ultrasound

- **Magnetic resonance cholangiopancreatography(MRCP)**

Since pancreas is an internal organ the cysts can be identified only by taking the sample from the internal body. For example while considering the treatment of endoscopic ultrasound has thin needle that they insert through the gastro intestinal track and the thin needle helps to get the sample of the fluid for further testing. Even though there exist modern innovations such insertions through those track of human body may affect the patients through microbial infection, difficulty in eating and many other uncomfortable conditions.Hence through the project I would like to extend the idea of Fourier transform and Fourier analysis so that by connecting the relationship between Fourier analysis and viscosity of the fluid we can use this technique to identify the type of cysts in pancreas.

8.2 Detection on pancreatic cysts

Cysts are cells like structures.The type of cysts can be identified on the basis of the composition of its components. The main difference between benign and malignant cysts are benign cysts are less viscous than malignant cysts.Viscosity of fluid can be defined as the resistance produced by the fluid occur due to shear or stress. From the biological discovery it was found that by using Oswald viscosimeter with respect to distilled water(relative viscosity=1.0)it was found that the mucinous cysts was had viscosity greater than the normal serum(say here distilled water)of reference range(1.4-1.8)where the non mucinous cysts had a viscosity less than the normal serum. [1]

8.3 Fourier Transform Infrared Spectroscopy

The propagation of signals through fluids can be affected by viscosity of the fluids. [10]The value of viscosity and its corresponding equations in trend line is obtained using the FTIR spectra.

Illustration

[10]4 Samples of lubrication oil was tested for viscosity using Perkin Elmer FT-IR Spectrum(2000). The superimposed resultant spectrum was give as follows

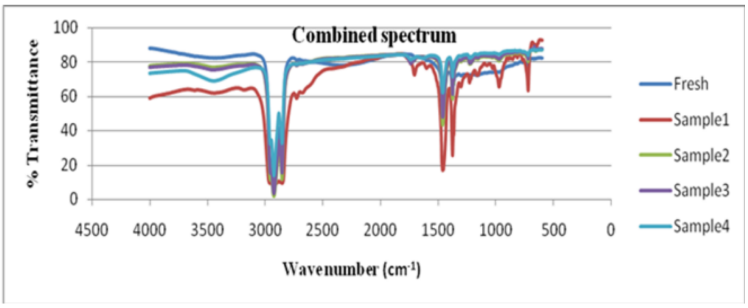


fig 8:3(a)

From the sample we obtain the correlation coefficient of viscosity.

Sl. No.	Wave No.	Inference	Correlation coefficient with viscosity
1	725	Sulphonic acid group	0.879
2	1379	S=O	0.904
3	1469	N=O and CH_2 bending	0.842
4	1620	Amides and nitro compounds	0.764
5	1750	Oxidation products, carbonyl region	0.984
6	2856	OH and CH_3 stretching	0.57
7	3500	Water	0.903

fig 8:3(b)

From the table it is clear that the oxidation products, carbonyl components had the largest correlation coefficient with viscosity (0.984)with

wave number 1750 cm^{-1} Through the experiment it was found that the equation of viscosity with respect to 1750^{-1} was

$y = 0.154x^2 - 27.48x + 1298$ **where x is percentage transmittance corresponding to wave number 1750cm^{-1},where viscosity is measured in c.St. Hence new development in FT-IR spectroscopy can be invented that can be applied to the pancreatic cysts so that it can use its spectrum definition for calculation the viscosity of the fluid in the cysts and to check whether the cysts is fluid or malignant with using surgical instruments to take the sample.This method could be effective as it could produce instant results, requires less amount of samples and are affordable and less surgical complications.**

8.4 Comparison of FT-IR spectroscopy with the existing treament

8.4.1 Illustration

[14]The given was an experiment conducted and published by the journal of medical research with the objective to investigate the clinical efficiency of laparoscopic gastrointestinal emergency surgery and post operative complications.the experiment overall undergoes the comparison between laparoscopic surgery and laparotomy for the treatment of emergency patients.

The experiment was conducted with 604 patients in the year between 2013-2018. The patients were aged from 17-79 years and their distribution of patients under several conditions were given as follows

Features	Observation group	Control group	Total
Number	304 (50.3%)	300 (49.7%)	604
Age, years (range)	40.1 ± 10.5 (17–79)		
	36.1 ± 10.2	39.2 ± 11.5	
Gender			
Male	166 (50.9%)	160 (49.1%)	326
Female	136 (49.3%)	140 (50.7%)	276
Diseases			
Peptic ulcer perforation	136 (56.7%)	104 (43.3%)	240
Acute appendicitis	87 (64.0%)	49 (36.0%)	136
Colorectal rupture	65 (50.8%)	63 (49.2%)	128
Oncological reasons	16 (45.7%)	19 (54.3%)	35
Non-oncological	49 (52.7%)	44 (47.3%)	93
Intestinal obstruction	64 (64.0%)	36 (36.0%)	100
Oncological reasons	20 (64.5%)	11 (35.5%)	31
Non-oncological	44, 63.7	25, 36.3	69
Treatment	Laparoscopic surgery	Traditional laparotomy	

fig 8.4.1(a)

From the table we obtain the patient profile with the following distribution as follows;

- **Male(326)**
- **female(276)**
- **Peptic ulcer perforation(240)**
- **Acute appendicitis(136)**
- **Colorectal rupture(128)**
- **Intestinal obstruction(100)**

The observation group undergone laparoscopic surgery and the traditional laparotomy undergone by the control group.

8.4.2 Conclusion

Consider the conclusions from the following table

Group	Case (n)	Operation time (minutes)	Intraoperative blood loss (mL)	Post-operation pain score	Length of hospital stay (days)	Time to free activity (h)
Control	300	70.34 ± 12.83	61.38 ± 9.97	5.13 ± 0.43	7.05 ± 0.13	22 ± 3.02
Observation	304	59.12 ± 10.31	41.21 ± 10.45	1.25 ± 0.25	5.13 ± 0.24	13 ± 2.96
t value		14.9	15.9	20.7	10.2	21.3
P		0.00030 <0.001	0.00015 <0.001	0.00002 <0.001	0.00071 <0.001	0.00098 <0.001

Table 4. Comparative postoperative complications during 3 months of follow-up.

Group	Case (n)	Wound infection	Abdominal infection	Septicemia	Vomiting	Nausea	Incidence
Control	300	8	12	4	12	12	48 (16%)
Observation	304	2	0	0	4	6	12 (3.9%)
χ^2							12.26
P value							0.00075 <0.001

fig 8.4.2(a)

The statistical analysis was done using SPSS 19.0 software, presented in mean±SD. Chi square test was used for enumeration with student t-test for comparison between groups . The value of p¡0.05 was considered to be significant.

From the table it was clear that the p value was less than 0.05 hence we conclude that the patients with treatment of laparoscopic surgery had improved outcomes when we compare the operation time, intraoperative blood loss,Post -operation pain score, length of hospital stay,and time needed for free activity(h)

Comparing the postoperative complications during 3 months the observation group was shorter than control group. Hence in general we can conclude that laparoscopic surgery is more reliable and acceptable than traditional used laparotomy surgery in many aspects.

If the medical field could once implement the method for detecting pancreatic cysts through the application of fourier transform to detect were the cysts is benign or malignant then the efficiency between this method and traditional used method of taking sample can be made and compared in the similar way of comparison as above.

Chapter 9

CONCLUSION

The objectives of the project mentioned initially had been achieved. The code for obtaining the ECG was created and illustrations mentioned are designed with respect to relevancy of the idea discussed. The project overall discusses about the idea of Fourier analysis and its future perspective.An attempt is made to show how Fourier analysis could be connected with healthcare devices and its statistical contribution for such development.

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