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A BRIEF STUDY ON FOURIER TRANSFORM AND ITS APPLICATIONS

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Abstract - *Fourier transforms is one of the oldest and a well-known technique in field of mathematic and engineering mathematical work. Fourier transform method represents the variable as a summation of complex exponentials. Fourier analysis has been used in signal processing and digital image processing for the analysis of a single image as a two-dimensional wave form, and many other type of form like Quantum mechanics, Signal processing, Image Processing. This analysis also represents filters, Transformation, representation, and encoding, Data Processing, Analysis and many more fields. The use of Fourier transform in various applications has increased in recent years. This transform is one of the simplest transform among the other transformation method used in mathematics. The time consumption is lesser due to this method. It has vast use in power distribution system, mechanical system, industries and wireless networks. Mainly in power distribution system, it is the mitigation of power quality disturbance required fast, accurate and high noise immune method. This paper has large of its applications in the fields of medical science and the use of it in the cell phone. In cell phone, the Fourier transform uses the signal processing forms and the making of the mobile phone. This paper includes the definition of Fourier transformation and it properties through which the solution of the problem will be easier than expected. The Fourier transform is very important for the modern world for the easier solution of the problems. This paper review the strength of Fourier transform, in recent year demand of this method and its use in different field and their applications.*

Key Words: **Fourier transforms, signal processing, Data processing, power distribution system, cell phone**

1. INTRODUCTION

Mathematics is everywhere in the world, it is used in every field. It is in every phenomenon, every technology, every observation, every experiment and more. All we need to do is to understand the logic hidden behind it and apply the mathematics in it. Since mathematical calculations give us a way to results of every experiment, it becomes quite pertinent to analyze those calculations before reaching to a conclusion. In power system the use of power generation as well as distribution of power and their processes is very important. Some amounts of power get reduced during distribution because the fault, degradation of load switching, energized transformation and capacitor switching. The above factors arises the problems in Power Distribution system such as sag, swell, interruption, transient, harmonics, flicker and spikes [1]. The signals are improved and being processed by using the proposed transformation. PQDs are inherently non-stationary and require simultaneous time-frequency analysis. Some popular techniques are used for PQ analysis and they are: Short-time Fourier transforms, Gabor transforms, Hilbert-Huang transforms, Kalman filters, parametric methods, Wavelet transform and Stockwell transform [2]. Fourier analysis is also being termed as spectral analysis or Harmonic analysis, decomposes a time-dependent periodic phenomenon into a series of sinusoidal wave functions, each one is defined by an unique amplitude and phase values. Fourier transform convert complex curves into sum of a series of cosine waves and an additive term. Each wave is being defined by unique amplitude and a phase angle, where the amplitude value is half the height of a wave, and the phase angle defines the offset between the origin and the peak of the wave in between the range of 0 to 2π. Each term determines the number of complete cycles completed by the wave over the defined interval. Some harmonic terms are being added to produce a complete complex curve and component curve, and accounts for a percentage of the total variance in the original complex curve [3]. Fourier analysis has been used in digital image and processing of image and for analysis of a single image into a two-dimensional wave form, and more recently has been used for magnetic resonance imaging, angiographic assessment, automated lung segmentation & image quality assessment and Mobile stethoscope. Fourier transforms which is also used in frequency domain representation. Fourier analysis used as time series analysis proved its application in Quantum mechanics; Signal processing, Image Processing and filters, representation, Data Processing and Analysis and many more.

Fourier transforms are obviously very essential to conduct of Fourier spectroscopy, and that alone would justify its importance. Fourier transforms are very vital in other pursuits as well; such as electrical signal analysis,

diffraction, optical testing, optical processing, imaging, holography, and also for remote sensing. Thus, knowledge of Fourier transforms can be a springboard to many other fields. The main idea behind Fourier transforms is that a function of direct time can be expressed as a complex-valued function of reciprocal space, that is, frequency.

The Fourier Transform is a mathematical procedure which transforms a function present in the time domain to the frequency domain. Fourier Transform is a mathematical method which uses the trigonometric functions to transform a time domain into a frequency domain spectrum.

2. DEFINATION

The Fourier transform dissolve a function of time or signal into the frequencies that makes in a way similar to how a musical chord can be expressed as the pitches of its constituent notes. It is also called the frequency domain representation of the original signals.

The Fourier transform of a function 'f' is being denoted by providing a circumflex ƒ. there are many common conventions for defining the Fourier transform of an integral function. Here we will provide the following definition:

$$f(\xi) = \int_{-\infty}^{\infty} f(x) e^{-2\pi i x \xi} d\xi$$

For real number 'ξ'.

The reason for the negative sign convention in the exponent is that in electrical engineering, it is common to use to represent a signal with zero initial phase and frequency ξ_0 which may be positive or negative. The negative sign convention causes the product to be 1 (frequency zero) when causing the integral to diverge. The result is a dirac delta function at $\xi=\xi_0$ exactly what we want since this is the only frequency component of the sinusoidal signal.

Variable x represents time which is independent in nature; the transform variable ξ represents frequency (for example if the time is measured in seconds, then the frequency is in terms of hertz). Under certain conditions, f is being determined via the inverse transform:

$$f(x) = \int_{-\infty}^{\infty} f(\xi) e^{2\pi i x \xi} \, dx$$

for any real number x.

3. PROPERTIES OF FOURIER TRANSFORM

This topic provides some properties of Fourier transforms. Particularly give attention to the transform of a convolution and its conjugates, the transforms related to its product, perhaps the significance of all Fourier transform properties.

3.1 Linearity property

This type of transform gives the sum of two functions which is equal to the sum of their individual transforms.

$$ƒ\{f(x)+g(x)\}=F(Y)+G(Y)$$

Thus, In LSI system the sum of signal in a spectrum can be provided by simply adding together their individual spectra.

3.2 Transform of a transform

If,

$$ƒ\{f(ξ)\} = F(x)$$

then,

$$ƒ\{F(x)\} = f(-ξ)$$

3.3 Transform of a convolution

The Fourier transform of a convolution is provided by the product of their individual transforms.

$$ƒ\{f(x) * g(x)\} = F(ξ)g(ξ)$$

3.4 Transform of product

The Fourier Transform of a product is completed by the convolution of their individual transforms.

$$ƒ\{f(x)g(x)\} = F(ξ)*g(ξ)$$

4. TYPES OF FOURIER TRANSFORM

There are mainly four different forms of Fourier Transform, which are classified below:-

- A periodic continuous signal, continuous and aperiodic spectrum. This is the general form of continuous time Fourier Transforms.
- Discrete aperiodic spectrum and periodic continuous signal.

- Continuous periodic spectrum and periodic discrete signal.
- Periodic discrete signal and discrete periodic spectrum.

5. APPLICATIONS OF FOURIER TRANSFORM

5.1 Fourier Transform in Medical Engineering

Fourier transforms is the oldest and most used technique in signal processing. This method represents signals in terms of summation of complex exponentials. Fourier analysis, also being termed as the spectral analysis and also Harmonic analysis, it transforms a time-dependent periodic function into a series of sinusoidal functions, which is defined by unique amplitude and their phase values. Fourier transform also convert complex curve into simple sum of a series of cosine waves and an additive term. Fourier analysis has played a key role in digital image processing for analysis of a single image as a two-dimensional wave forms, and more recently it has been used for basic magnetic resonance imaging, angiographic assessment, automated lung segmentation and image quality assessment and also Mobile stethoscope [4].

M. Guerquin has used Fourier transform for analytical simulation tool which are suited for parallel magnetic resonance imaging and allowing one to build a realistic phantoms. This paper also explains analytical simulation tools very effectively and that are suited to parallel magnetic resonance imaging and allow one to build realistic phantoms. The proposed phantoms are built of ellipses and regions with piecewise polynomial boundaries, includes contours which are spline contours, Bezier contours, and polygons. In addition, they consider the channel sensitivity into account, for which we solve two possible models. Analytical formulations provide us a very well defined data for both the spatial and k-space domains. Their main research is being closed form for determination of the Fourier transforms [5].

Tobias Benz has also frequently used Fourier based approach to the angiographic assessment of flow diverter efficacy in the treatment of cerebral aneurysms which is a type of diseases. In this article they propose a metric analysis for the angiographic assessment of flow diverter deployments in the treatment of cerebral aneurysms (type of diseases). By analyzing the frequencies of signals derived from digital subtraction angiography (DSA) series, the main aim to quantify the prevalence of frequency components which corresponds to the patient of specific heart rate. For the estimation of the power spectral density (PSD) of a time contrast curve (TCC), the period gram estimator was used, which is a PSD estimator based on the discrete Fourier transform [6].

JIE WEI have frequently used Fourier transformation for automated lung segmentation and image quality assessment for a clinical 3-d and 4-d-computed tomography. In this paper, they have smartly applied the ideas and algorithms from images and signal processing, computer vision, and machine learning to 4DCT lungs data so that the lungs can easily be reliable segmented in a fully automated manner, lungs feature can be seen or visualized and can be measured on the fly via user interactions, and data quality classifications can be also computed in a robust manner. They developed two different approaches for automatic analyze of 4D-computed tomography images and produce number of indicators for measuring the quality in batch mode, first approach use Fourier analysis technique [7].

D. Chamberlain smartly and very conveniently uses Fourier transform for Mobile stethoscope and signal processing algorithms for pulmonary screening and diagnostics. In this research a lower cost stethoscope and smart phone are used to record lung sounds. We discuss problems to encounter the initial design and demonstrate an improved design that are currently being used in the fields. We also describe an algorithm which is capable of automatic detection of wheeze sounds. The automatic wheeze detection algorithm also uses the capability of time frequency analysis. The Short Time analysis of Fourier Transform to identify the sections of wheezing in recording of lung sound files [8].

5.2 Fourier Transform in Cell Phones

Mathematics is everywhere used, almost in every phenomenon, technology, observations, and experiments etc. All we need to do is to understand the logic hidden behind the provided question, solution is being provided by mathematics. Since mathematical calculation provides us a way to the ultimate results of every experiment, it becomes quite easy to analyze those calculations before concluding. The present era of communication and technology has provided us some major catalysts in developing the modern human society. Communication involves automatic transmission of the data through wires and radio circuits through signals. In communication systems, signal processing, and electrical engineering, signals are the function that transfer the information about the behavior or attributes of certain phenomenon. Signals are basically a mean to transmit information in accordance with certain pre-arranged system. It includes audio, video,

speech, images, communication, geophysical, sonar, radar, medical and musical signals and many more.

One of the most important communication devices in modern era, the Cell Phones is dramatically changing the typical system of people interaction and communication with each other. Cell phones emits very small amount of electromagnetic signals via their radio waves through a low power transmitter provided in cell phone. While talking over the mobile phones, the transmitter present in cell phone takes the sound of voice and changes it into a continuous sine wave. Sine wave is measured in term of frequency. Transmitter transfers the sine wave to antenna. Antenna further transmits the sine wave in the same form which is electromagnetic signal to the BTS. Cell phone works by communication between service networks through cell tower. Cell towers distribute the city into small areas. As the user moves from one area to another, the signal along with the information is transfer from tower to tower.

Today mobile phones are the best communication service which not only provide the basic functions of telephone and radio but also being used as data sharing devices. Mobile phones being cheap and reliable, phones are the fastest adopted technology by human in 2 billion years of history.

How mathematics is being involved in manufacturing cell phones work and make calls?

The cell phone has being designed by using a lot of mathematics in just about every aspect of their design. Also mobile phones operate by principles of electro-magnetics, which are described mathematically.

- Person has to dial a number that it is based on a protocol which is named as Internet Protocol (IP). Protocol is nothing but a basic a set of mathematical rules.
- The phone has to use the coordinates for the location of the Satellite to receive and transmit other end.
- Then they have to convert from a wave system into a voice system that it is based in alphabetical words, and then again translated between the two system based in a numerical system called binary.
- This binary system is integrated into the satellites, transmitter and receivers by the motherboard integrated in each system, then incorporated into each system through programming and all being traversed by mathematics. By the mean of binary system it is multiple of 2's, and they goes by the 0's and 1's and it is also called machine language because those machines only work with electric impulses which are On and Off.

Role of Fourier Transform in Cell phone

Jean Baptiste Joseph Fourier, the maker of Fourier transform and the French mathematician/physicist made many astonishing discovery in 1800. According to this, every function can be represented by an infinite series of elementary trigonometric functions of sine and cosine. Let provide an example, consider decomposition of signal into its trigonometric constituents reveals the fundamental frequencies which combine to produce the instrument's distinctive timbre. Fourier analysis is very important component of much of modern applied mathematics. It converts an exceptionally powerful tool for solving a broad range of partial differential equations. Fourier analysis lives at the heart of signal processing, including audio, speech, images, videos, seismic data, radio transmissions, and many on. Many modern technological advances, including television, music CD's and DVD's, cell phones, movies, computer graphics, image processing, fingerprint analysis and storage, are, in one way, founded upon the many ramifications of Fourier theories.

The principle of the Fourier transform in this case is that any signal, such that the produces sound by a musical instrument, example- piano, violin, trumpet, and drum. Any type of sound recording which is being recorded can be expressed as the sum of a collection of sine and cosine waves with different frequencies and amplitudes. This collection of waves can be manipulated with relative ease for example, allowing a recording to be compressed. This Fourier decomposition lives at the heart of modern electronic music- a synthesizer combine pure sine and cosine tone to reproduce the diverse sounds of instruments, both naturally as well as artificial, according to Fourier general prescription. Anyone who is being marveled at the small size of an MP3 files compared with the same recording which is not being compressed form has seen the power of the Fourier transform at work. The Fourier Transform is an algorithm used in different type of functions, including signal processing and statistical applications across a broad range of applications. Our mobile phone is device performing Fourier Transformations. Every mobile device network, notebook, tablet, and phones have been built for high-speed cellular data connections, just like Fourier Transform. The Fourier Transform is a method for doing this process very efficiently [9].

6. CONCLUSIONS

The proposed Fourier transform has a wide range of help in various domains like power distribution system, wireless, signal processing, cell phone manufacturing, mechanical and industrial application. In power system, proposed method easily analyzes the faults, harmonics and disturbance. In wireless system, they identify the noise and easily calculating the losses in same way. The Fourier transform provides the world an easy and most comfortable method for solution of questions.

Fourier transformation is also frequency domain which represent time series analysis proved its application in Quantum mechanics, Signal processing, Image Processing and filters, Transformation, and encoding, Data Processing and Analysis and other fields. In this paper showed that Fourier transform can successfully applied in the field of medical engineering hence some more research yet to be explored.
The idea behind Fourier transforms is that a function of direct space can be expressed equivalently as a complex valued function of reciprocal space that is frequency sometimes called Fourier space.

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