Various Applications of Digital Signal Processing (DSP)

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ABSTRACT:-

This paper overviews mainly about the various applications of Digital Signal processing (DSP). DSP is one of the core technologies used in rapidly growing application areas such as wireless communications, audio and video processing and industrial control. The number and variety of products that include some form of digital signal processing has grown dramatically over the last few years. DSP has become a key component in many of the consumer, communication, medical and industrial products which implement the signal processing using microprocessors, field programmable gate arrays (FPGAs) etc.

Keywords:- Digital Signal Processing (DSP), image, speech, radar

1.INTRODUCTION:-

Digital Signal Processing (DSP) is an area of science and engineering which has developed rapidly over the past few decades. The techniques and applications of DSP are as old as Gauss and Newton and as new as today's digital computers and Integrated Circuits (ICs).These rapid development of Digital Signal Processing (DSP) has been a result of the significant advances in digital computer technology and IC fabrication technology. Digital Signal Processing (DSP) is the mathematical manipulation of an information signal to improve or modify it in some way. It is characterized by the representation of discrete time, discrete frequency, or other discrete domain signals by a sequence of numbers or symbols and the processing of these signals.

There are various applications of Digital Signal Processing (DSP). It requires high speed processor to implement the Fast Fourier Transform (FFT). Some of these applications are listed below:-

1. Image Processing
2. Speech Processing
3. Radar Signal Processing
4. Digital Communications
5. Spectral Analysis
6. Sonar Signal Processing
7. Telecommunication

2.IMAGE PROCESSING

An image is an array, or a matrix, of square pixels (picture elements) arranged in columns and rows. Thus, an image may be defined as a two dimensional function f(x, y), where x and y are spatial (plane) coordinates, and the amplitude of it at any pair of coordinates (x, y) is called the intensity or gray level of the image at that point. Digital Processing of images requires two dimensional DSP tools such as Discrete Fourier Transform (DFT), Fast Fourier Transform(FFT) algorithms and Z-Transform. Processing of electrical signals

extracted from images by digital techniques includes image formulation and recording, image compression, image restoration, image reconstruction and image enhancement.

In a (8-bit) gray scale image, each picture element has an assigned intensity that ranges from 0 to 255. A gray scale image is what people normally call a black and white image, but the name emphasizes that such an image includes shades of grey. A normal gray scale image has 8 bit color depth=256 gray scales. A "true color" has 24-bit color depth=~16 million colors.

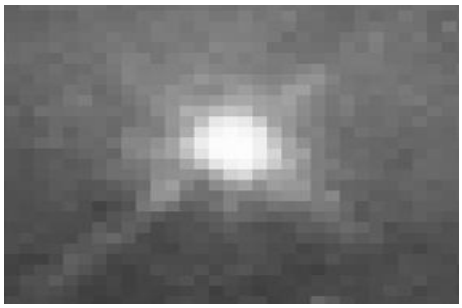


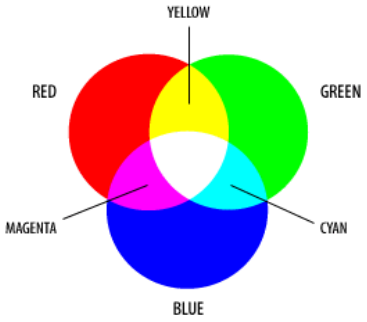
Figure above shows an image:-an array or a matrix of pixels arranged in columns and rows.

2.1COLOURS

For science communication, the two main color spaces are RGB and CMYK.

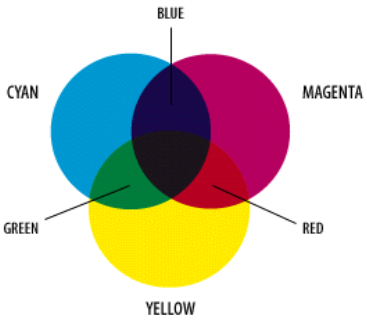
RGB

The RGB color model relates very closely to the r, g and b receptors in the retinas of human eye. RGB uses additive color mixing and is the basic color used in television, computers, web graphics, but it cannot be used for print production. The secondary colors of RGB-Cyan, magenta and yellow-are formed by mixing two of the primary colors (red, green or blue) excluding the third. The combination of all three primary colors makes white.



CMYK

The 4-color CMYK model is used in printing production. This model uses the subtractive color model. CMYK stands for Cyan(C) , magenta(M) ,yellow(Y) and black(K).



2.2FUNDAMENTAL STEPS IN DSP

Image Acquisition is the first process. This step could be as simple as being an image that is already in digital form. This step usually involves preprocessing, such as scaling. Image enhancement is among the simplest yet appealing areas of DSP. The purpose of enhancement is to give out the details that is obscured or to highlight certain features of interest in the image, like, we increase the contrast of an image so that "it looks better". This is a very subjective area of image processing.

Image restoration is an area which deals with the appearance of the image. Unlike

enhancement, this is an objective area of signal processing. The next step, Color Image Processing, is very much gaining importance owing to the significant increase in the use of digital images over the internet. Wavelets form the base for representing image in various degrees of resolution. Compression, as the name suggests, deals with techniques used for reducing the storage required to save an image, or the bandwidth required to transmit it.

Morphological processing deals with the tools for extracting image components that are useful in the representation and description of shape of the image. Segmentation involves partitioning an image into its constituent parts or objects. In general, more accurate the segmentation, the more likely recognition is to succeed. Representation and description almost always follow the output of a segmentation stage, which is usually raw pixel data, constituting either the boundary of a region or all the points in the region itself.

Boundary representation is appropriate when the focus is on external shape characteristics, such as corners and infections etc. Regional representation is appropriate when the focus is on internal properties, such as texture or skeletal shape. In some applications, these representations complement each other. Choosing an appropriate representation is only part of the solution for transforming raw data into a form suitable for subsequent computer processing.

Description, also known as Feature Selection, deals with extracting attributes that result in some information of interest regarding the image or are basic to distinguish one class of objects from other. Recognition refers to the phenomenon of assigning a label or title to an image based on its description.

3.SPEECH PROCESSING

Speech is a natural way of human to human communication. Speech is a one dimensional signal. There are several ways of characterizing speech, one of which according to information theory is to represent the speech in terms of its message or information content. Another way is to represent speech in terms of signal carrying the message or information, such a signal is called an acoustic waveform. The information that is communicated through speech is discrete in nature which means it can be represented by concatenation of elements from a finite set of symbols.

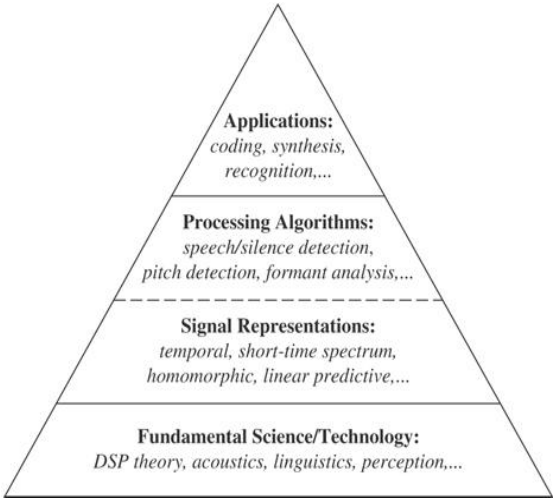
The purpose of speech processing is to understand speech as a mode of communication, represent it for transmission and reproduction, to analyze it for automatic recognition and extraction of information and lastly, to discover some physiological characteristics of the speaker.

3.1FUNDAMENTAL STEPS IN SPEECH PROCESSING STACK

At the top of speech processing stack is the signal applications which including speech coding, synthesis, recognition, verification, enhancement and language translation. Speech Coding is the process of transforming the speech signal into a representation for efficient transmission

and storage of speed.Synthesis of Speechis the process of generating a speech signal using computational means for effective human-machine interaction. Speech Recognition is the process of extracting usable linguisticinformationfrom a speech signal in support of human-machine communication by voice which means translation of spoken words into text. Speech Verification is used for access to premises or information. Speech Enhancement is used in noisy environment. Language translation is conversion of one language into another to facilitate natural language dialogues between people speaking different languages, as in case of tourists and business people.

The second topmost is speech processing algorithm which includes pitch detection, speech/silence detection etc. Pitch detection algorithm is an algorithm assigned to estimate the pitch or fundamental frequency of a quasi-periodic or virtually periodic signal.Speech/Silence detection, also called voice activity detection (VAD), is a technique in which the presence or absence of a human activity is detected. Formants are defined by Gunnar Fant as "the spectral peaks of the sound spectrum". The Acoustical Society of America defines it as the range of frequencies in which there is an absolute or relative maximum in the sound spectrum.



Next is signal representation that temporal, short-time spectrum, linear predictive etc. Speech is not a stationary signal which means that its properties changes with time. Therefore, a single representation on the all the samples of a speech utterance has no meaning. However, we define a time-dependent Fourier Transform of the speech that change with time as our speech properties with time. Linear prediction coding (LPC) methods are most widely used in speech coding, speech recognition and verification, speech synthesis and speech storage. LPC methods provides efficient estimate of speech parameters. The basic idea behind linear prediction is that the current speech sample can be closely approximated as the linear combination of past samples.

The last in this stack is the fundamentals of speech which comprises acoustics, linguistics, phonetics and speech perception. Linguistics is the study of languages which broadly includes language form, language meaning and language in context. Phonetics refers to study of the sounds of human speech or in the case of sign languages, the equivalent aspects of sign. Acoustics is the branch of science that deals with the study of

mechanical waves including vibration, sound, etc. Speech Perception is the phenomenon by which the sounds of the languages are heard, interpreted and understood.It is closely related to phonetics and linguistics. The three are co-related.

4.RADAR SIGNAL PROCESSING

Radar is an acronym for Radio Detection and Ranging. Radar is a device required to determine the location of an object. Depending upon the type of radar used, it can also be used to calculate the range, altitude, direction or speed of objects. The basic principle of radar is to gather information about distant objects or targets by sending electromagnetic (EM) wave at them and analyzing the echoes.

Radar system comprises trigger source, modulator, output tube, video amplifier, if amplifier, indicator and duplexer. A duplexer is a must to use a single antenna both for transmission and reception of signals. It operates in transmit mode during the transmission of the signals and then in the receiver mode to receive the signals. The transmitter should produce enough power to obtain the desired radar range. The transmitted power depends on the fourth power of the radar range. The purpose of heterodyne receiver is to separate the wanted echo signal from the combination of noise, clutter and interference. After separating, we amplify the desired before further processing. The main aim of any receiver is to maximize the SNR of the received echo signal.

Various signal processing techniques can be performed on raw receiver signals. Some common radar signal processing techniques include correlation, Doppler filtering, image rejection, detection processing and tracking. Digital Signal Processing is used in almost all modern radars to implement these signal processing techniques. These processors are very complex chips, making use of very complex algorithms. These data processors convert data produced by the signal processor into a form that is readily interpretable by radar operators. They implement Human machine interface (HMI) designs that are used to process inputs received from the operator.

5.ADVANTAGES OF DSP

The Digital Signal Processing (DSP) enjoys the following advantages over the Analog Signal Processing (ASP):-

1. DSP operations can be changed by changing the program in digital programmable system. This means that these are flexible systems.
2. There is better control of accuracy in digital systems as compared to analog systems.
3. Digital systems are less sensitive to tolerance of component values.
4. Digital circuits can be cascaded without any loading problems.
5. Digital systems are independent of temperature, ageing and other external parameters.
6. Cost of processing per signal in DSP is reduced by time-sharing of given processor among a number of signals.
7. Digital circuits can be reproduced easily in large quantities at comparatively lower cost.
8. Digital signals can be easily stored on magnetic media such as magnetic tape without loss of quality of reproduction of signal.

9. Digital signals use less bandwidth. This is just another way to say you can cram more information into the same space
10. Digital messages can be encrypted so that only the intended receiver can decode it.

6.CONCLUSION

This paper overviews about some of so many applications of Digital Signal Processing (DSP). DSP has been experienced continuous and significant expansion in the last few decades and will be an area of research as well as interest for yet so many years owing to its wide applications and potential. The usefulness of this technology is apparent in many different disciplines covering medicine through remote sensing. Today, DSPs bring power and speed to diverse applications, including automotive, consumer, biometrics, aerospace, defense, test and measurement, industrial control and more.

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