To develop Prototype for Experimental Computed Tomography

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Abstract— The development of measurement geometry for Experimental computed tomography scanner is used for cross-sectional imaging of an object from transmission data collected by illuminating the object from many different directions. The aim of this research is the development a first generation Experimental CT scanner to institute laboratory for learning which perform highly efficient to understand the actual CT working. It also plays vital role to get the knowledge of data acquisition & image reconstruction techniques.

Index Terms— Minimum Computed Tomography, Experimental CT, CT detection system, CT sources, Image Reconstruction

1 INTRODUCTION

Experimental Computed Tomography is a non-invasive medical imaging technique.CT uses X-rays to generate cross-sectional, two-dimensional images of the body. Fundamentally, tomography deals with the reconstruction of an object from its projections. The technique of tomography consists of parallel rays of the source series passes through an object and then measuring the attenuation of these rays by placing a series of detectors on the receiving side of the object. These measurements are called projections. Experimental CT consists of source- detector assembly, Mechanical assembly and its control, Data acquisition and Image reconstruction.

CT is a method for acquiring and reconstructing an image of a thin cross section of an object. It is based on measurements of X-ray attenuation through the section using many different projections. This is achieved by rotating both X-ray tube and detectors around the patient. Fundamentally a CT scanner makes many measurements of attenuation through the plane of a finite thickness cross section of the body. The system uses these data to reconstruct a digital image of the cross section in which each pixel in the image represents a measurement of the mean attenuation of a box-like element (voxel) extending through the thickness of the section. An attenuation measurement quantifies the fraction of radiation removed in passing through a given amount of a specific material of thickness Δx, as shown in. Attenuation is expressed as

$$It = Ioe^{-\mu\Delta x}$$

where, It and Io are the X-ray intensities measured with and without the material in the x-ray beam path,respectively, and μ is the linear attenuation coeffient of the specific material.

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2 SYSTEM CONFIGURATION

The block diagram of Experimental CT system in figure 1.1 shows the closed-loop with real time control system. The Power Supply is required to operate Arduino UNO, motor driver, Source and Detector assembly and Zigbee Module. In gantry assembly, source and detector array is fixed in opposite position so that when motor will rotate then gantry assembly also rotates. In this Steeper Motor is operated by motor driver IC which controls the motor used with a microcontroller. Motor driver input pins take the signal from the Microcontroller in the form of pulses and gives output to the motor. A Rubber wheels is attached to the motor shaft and fixed at the center of the gantry. Microcontroller will control stepper motor rotations from 0° to 360°. Microcontroller is used as the controller to control steeper motor at various step angles by using programming.

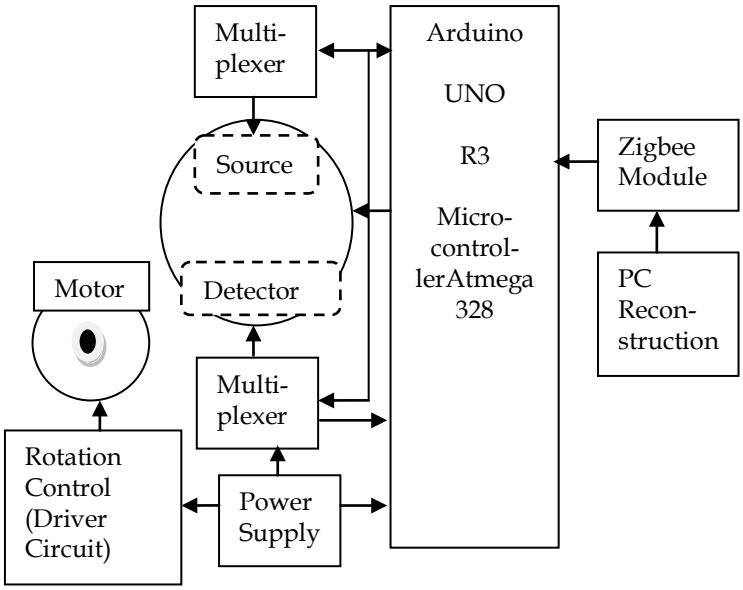

Fig. 1 Block diagram of Experimental CT System

Certain delay is also adjusted in microcontroller to stop the motor at every particular angle. In source and detector assembly, source and detector are controlled by a multiplxer with the help of 4 common select lines. Microcontroller helps the select lines of multiplexer to control the source and detector array to select particular LED and phototransitor for detection of light intensity. Output of the individual detector in an array is given to the microcontroller to convert it to a digital value. Digital value from microcontroller is acquired through wireless communication (ie. Zigbee) and then it is given to computer for Image reconstruction.

2.1 Mechanical Assembly of Gantry

It consists of gantry, its rotation mechanism, and a patient table. The mechanism used here is translating rotate mechanism. The gantry is made up of acyralic sheet and step size for its movement is set at 30 degree. The diameter of gantry is 20cm. This diameter is suited by taking source and detector into consideration. The maximum distance at which when detector is placed in front of source, gives optimum output, is the distance taken as diameter for the gantry. During the rotation movement of gantry in steps it generates 12 different projections in one complete rotation of gantry. The movement control of gantry is done with the help of stepper motor which is controlled using microcontroller. The phantom table is made up of wood on top of which glass is attached. Phantom table provides forward and backward motion of the object. Forward and backward movement of table is obtained by pulley mechanism. Glass is used because it is transparent in nature which allows light to pass through it.

2.2 Source and Detector Assembly

Source used is light. X-rays are hazardous to health, costly and cannot be preferred for educational purpose. Detector used is phototransistor. An array of fifteen source and fifteen detectors is used. The array of source and detector are decided according to the dimensions of phantom being kept for observation such that the array covers its entire area, and projections are obtained. Each source is activated by switching over each LED and light is detected by its corresponding detector. This method is used to obtain translation motion across the object to produce projection profile. The illumination of these sources is done by using multiplexer with delay of 20 milliseconds using microcontroller

2.3 Data Acquisition and Image Reconstruction

Wireless technique is used for data acquisition in order to process the data in the formation and reconstruction of image. The wireless technique used is Zigbee technology.

Arduino uno has inbuilt ADC which is 8 channel of 12 bit (ADC). An electronic integrated circuit which transforms a signal from analog (continuous) to digital (discrete) form. Analog signals are directly measurable quantities.Digital signals only have two states. For digital computer, we refer to binary states, 0 and 1. Microprocessors can only perform complex processing on digitized signals. When signals are in digital form they are less susceptible to the deleterious effects of additive noise. Thus ADC provides a link between the analog world of transducers and the digital world of signal processing and data handling. ADC is used virtually everywhere where an analog signal has to be processed, stored, or transported in digital form.

In data acquisition system, output from the Microcontroller (ADC) is send to the Zigbee Module for wireless communication. Wireless communication is beneficial to transmit data from the gantry. Zigbee Mmodule is placed inside the gantry so as to receive and transmit the signals from the detector. PC is connected to the external Zigbee Transreceiver device in order to acquire serial data form detector. The Data that is received at COM port of Zigbee Module is processed using Matlab Program.Matlab Program helps in processing the data in order to recontruct the image. GUI helps to display the image at every 30* angle; hence we have 12 recontructed image.

Image reconstruction techniques form the basis for common imaging modalities such as Computed Tomography, Magnetic Resonance Imaging, Positron Emission Tomography, and Single Positron Emission Tomography and also they are useful in medicine, biology, earth science, archaeology, materials science, and nondestructive testing.

3 RESULT

The image reconstruction was first developed by taking projections from sample image. The digital sample image which is used for developing image reconstruction algorithm is a sample digital image which is an inbuilt image in MATLAB software. The projections are taken from this image by rotating the image at various angles and then taking sum of each column forming one dimensional array. These values are the projections of image which is taken as the subject image. Here, the subject image is denoted as sample image on which the image reconstruction algorithm is developed.
The results shown below a show that as the light falls on the denser part of the phantom, we get a higher reading while there is the area without phantom or rarer medium gives a lower reading.

Reconstructed image

1. Wooden rectangle block

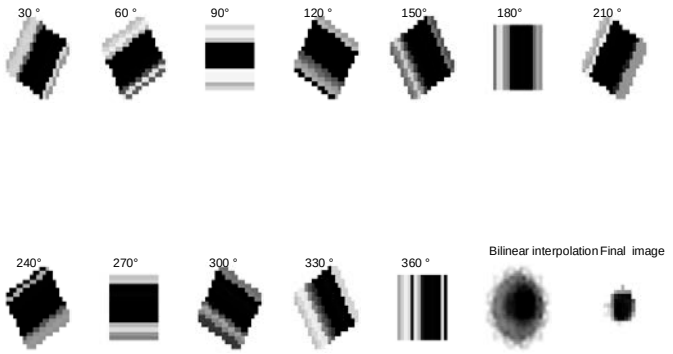

Fig. 2 Image Reconstruction for Rectangle block

4 Conclusion

Experimental CT can serve as a demo model of CT in colleges and research centers for studying the basic principle of CT. Light source and detector are used which are safer than harmful X-ray exsposure. Also mechanical, electronic and software areas of CT can be studied in detail using this model. Multiple scans can be obtained using experimental CT to obtain tomographic images. RF module, RS232-serial communication protocol, Rotary encoder and Microcontroller have been implementated for student benefits in institutes were Computated tomography is taught. Thus it is concluded that the developed design can be considered as a demo model of first generation of Experimental CT.

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References

[1]G. Hounsfield, "A method of an apparatus for examination of a body by radiation such as X-ray or Gamma radiation," U.S. Patent 1283915, 1972.

[2] J. Bushberg, "Computed Tomography," in The Essential Physics of Medical Imaging, 3rd ed. Philadelphia, USA, LW, 2012, ch10, pp.312-370.

[3] C.H. Mesquita et al.], "Development of the Mechanical System on a Third-Generation Industrial Computed Tomography Scanner, in IEEE Nuclear Science Symposium Conference Record, BZ, 2011, pp19-23.

[4] Air Bearing Application and Design Guide, New Way Air Bearings.,50 McDonald Blvd. Aston, PA19014USA, 2006

[5] E. Mylott, "Developing and assessing curriculum on the physics of medical instruments,",Eur. J.Phys vol.32, 5 July2011.

[6] L. Berland, "Computed Tomography," in Practical CT Technology and Techniques, 1st ed, New York: Raven Press, 1987, pp.271

[7] T. curry, J. Dowdey, R. murry, "Computed Tomography," in Christensen's Physics of diagnostic radiology,4th edition, Philadelphia, USA, LW, 1990, ch19, pp.289-322

[8] D. Platten (2005, October).Basic Principles of CT scanning (1sted.)[Online]. Available: http://www.impactscan.org.

[9] M. straten, H. Venema, "Reproducibility of multi-slice spiral computed tomography scans: An experimental study,"Med.phys.vol.31.Oct2004.

[10] A.Jain.(2012).*Insight - How Geared DC Motor works*( ). [Online].Available:http://www .engineersgarage.com

[11] PIC16F877A *Data Sheet*, Microchip Technology., Arizona., USA, 2003,pp.1-232.

[12] V. Subramanian, M. Kaye,"H-Bridge Motor Control" M.S.dissertation, Dept. Elect. Eng., Penn Univ., Philadelphia, US, 2012

[13] *L293D Data Sheet Quadruple Half-H Drivers,*Texas Instruments., Dallas.,TX,2004,pp1-12

[14] C. Bowman, "Postion sensing and automation solution in Rotary Encoders,"TR Electronic.,USA 2009.

[15] *Motorola European Master Selection guide MOC 7811*, Motorola Semiconductor Products., Phoenix., AZ, 1986, pp.1

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