

## Visualization And Analysis Of 3D Scientific Data

Pranoti Nage<sup>1</sup>, Priyanka Sharma<sup>2</sup>, Vaishali Salvi<sup>3</sup>, Jyothi Arun<sup>4</sup>, Pragyamani Sharma<sup>5</sup>

<sup>1</sup>(Department of Information Technology, University of Mumbai, India)

<sup>2</sup>(Department of Information Technology, University of Mumbai, India)

<sup>3</sup>(Department of Information Technology, University of Mumbai, India)

<sup>4</sup>(Department of Information Technology, University of Mumbai, India)

<sup>5</sup>(Department of Information Technology, University of Mumbai, India)

**Abstract:** on-destructive testing (NDT) is used in the industry to check for the properties of the material, internal flaws, etc. without cutting open the samples. Digital Radiography (DR), an NDT, is a form of x-ray imaging, where digital x-ray sensors are used. Advantages of DR include time efficiency, ability to digitally enhance and transfer images. In the proposed system, solid industrial objects like computer chip, reactor parts, etc. are considered. The proposed software converts these radiographs into tomographic images (virtual slices) as done in Computed Tomography (CT). CT is another powerful Non-Destructive Evaluation technique for producing 2D and 3D cross-sectional images of an object from the x-ray images. CT is widely used in the medical and in the industrial sectors. As the slices of the object can be viewed using the software, internal flaws, defects and the overall product can be observed. 3-D models of sample objects are reconstructed from the set of x-ray frames.

**Keywords:** Non-Destructive Testing; Digital Radiography (DR); Computed Tomography (CT); 3D analysis

### I. Introduction

Non-Destructive means without destroying or breaking. Non Destructive methods and techniques are being widely used today in various different fields, almost all of them. There are several types of non-destructing activities being used which include NDT (Non Destructive Testing), NDE (Non Destructive Evaluation/ Non Destructive Examination) and NDI (Non Destructive Inspection). NDT is a wide group of analysis techniques used in science and industry to evaluate the properties of a material, component or system without causing damage. By this technique, internal complex parts can be precisely measured without destructive testing. Inspection and analysis costs are reduced. These methods can be performed on metals, plastics, ceramics, composites, cermets and coatings in order to detect cracks, internal voids, surface cavities, delamination, incomplete defective welds and any type of flaw that could lead to premature failure.

Non-destructive Evaluation (NDE) is an interdisciplinary field of study which is concerned with the development of analysis techniques and measurement technologies for the quantitative characterization of materials, tissues and structures by non-destructive means. Non-destructive Inspection (NDI) is the examination of an object or material with technology that does not affect its future usefulness. NDI can be used without destroying or damaging a product or material. Because it allows inspection without interfering with a product's final use, NDI provides an excellent balance between quality control and cost-effectiveness. The term "NDI" includes many methods that can detect internal or external imperfections, determine structure, composition, or material properties and measure geometric characteristics.

Popular Non- Destructive Testing methods include vibration analysis, Infrared thermography, acoustic emission analysis, Digital Radiography (DR), X-ray Computed Tomography (CT), Ground Penetrating Radar (GPR), eddy current imaging, Magneto inductive cable testing and Optical Imaging. This paper focuses on DR and CT, two powerful Non-Destructive Testing methods.

### Computed Tomography

Industrial CT has its main application in specific examinations in flaw detection, analysis of failure and dimensional measurement of not accessible geometric features, inspection of assemblies or statistical investigations of material properties as density distribution [1].

Today the most important application of CT has become scanning for 3D-digitizing purposes. Includes point cloud generation for first article inspection procedures, reverse Engineering on a Motorcycle engine cylinder, reverse Engineering of a cylinder head, etc. Computed tomography is excellent for generating 3D data of complex cast parts. Aluminium as the mostly used material in engine production can easily be penetrated up to 300 mm diameter in the range of 0.2 mm. Now the process of CT may be discussed. X-ray slice data is

generated using an X-ray source that rotates around the object; X-ray sensors are positioned on the opposite side of the circle from the X-ray source. The earliest sensors were scintillation detectors, with photomultiplier tubes excited by (typically) iodide crystals. Cesium iodide was replaced during the 1980s by ion chambers containing high-pressure Xenon gas. These systems were in turn replaced by scintillation systems based on photodiodes instead of photomultipliers and modern scintillation materials (for example earth garnet or rare earth oxide ceramics) with more desirable characteristics. Initial machines would rotate the X-ray source and detectors around a stationary object [2]. Following a complete rotation, the object would be moved along its axis, and the next rotation started. Newer machines permitted continuous rotation with the object to be imaged slowly and smoothly slid through the X-ray ring. These are called helical or spiral CT machines. A subsequent development of helical CT was multi-slice (or multi-detector) CT; instead of a single row of detectors, multiple rows of detectors are used effectively capturing multiple cross- sections simultaneously. Systems with a very large number of detector rows, such that the z-axis coverage is comparable to the xy-axis coverage are often termed cone beam CT, due to the shape of the X-ray beam (strictly, the beam is pyramidal in shape, rather than conical). In conventional CT machines, an X-ray tube and detector are physically rotated behind a circular shroud [2]. An alternative, short lived design, known as electron beam tomography (EBT), used electromagnetic deflection of an electron beam within a very large conical X-ray tube and a stationary array of detectors to achieve very high temporal resolution, for imaging of rapidly moving structures. There are several advantages that CT has over traditional 2D radiography. CT completely eliminates the superimposition of images of structures outside the area of interest. Second, because of the inherent high-contrast resolution of CT. Internal complex parts can be precisely measured without destructive testing, thereby reducing inspection and analysis costs. CT is regarded as a moderate- to high-radiation technique. Also, development cost is reduced using CAD model and product quality is improved. The improved resolution of CT has permitted the development of new investigations, which may have advantages, compared to conventional radiography. Drawbacks of CT is that it is exorbitantly expensive. It delivers high dose of radiation. CT scan should never be done on a pregnant female or on diabetic patients because it damages human tissues. It damage body cells, including DNA molecules, which can lead to cancer. Younger the age, more the risk of getting affected. Applications of CT is that it is an analysis and inspection technique. It is used in assembly, part comparisons, void, crack and defect detection and geometric dimensioning and tolerance analysis. Although most common in medicine, CT is also used in other fields, such as non-destructive materials testing. Another example is archaeological uses such as imaging the contents of sarcophagi.

## **II. Existing System**

3D CT reconstruction models were directly compared to CAD models (Julien Noel, North Star Imaging Inc., Dec 2008) [4] and other CT models in order to display differences or similarities in measurements, densities, etc. Their objective was to measure the part, inspect for internal integrity and dimensionally compare the actual manufactured casting to the originally designed CAD model. For reconstruction, they converted 2D X-ray images into 3D voxels volume model. The 3D CT reconstruction was made of several million or billion voxels, could also be transformed to a surface model. The resolution of the 3D model depends on the number of voxels generated from CT reconstruction. A threshold value of radio density is chosen by the operator, and then set using edge detection image processing algorithms. From this, a 3D model can be constructed and displayed on-screen. The problem here is that the reconstruction assumes that the X-ray attenuation within each voxel is homogenous; this may not be the case at sharp edges. Reverse engineering is yet another technology that is used for digitalizing and reconstruction of products.

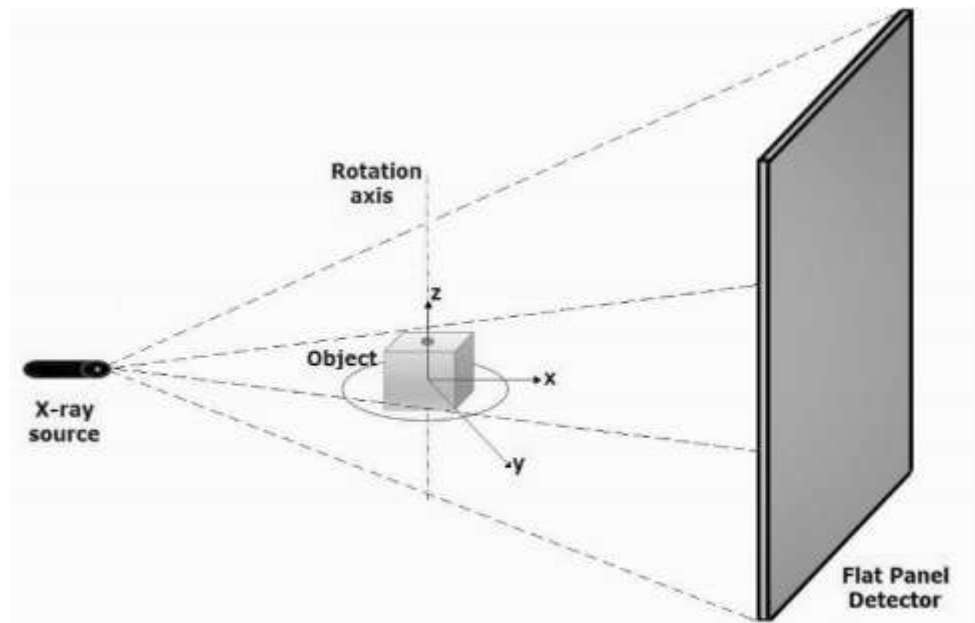
Alexander Flisch et al [5] used an x-ray source, detector system, object positioning system and a computer system. Initially Computer Aided Designs (CAD) for a sample object were made. These were then compared with the original object and scaled accordingly. Finally a 3D model of the object was created which can be worked upon. This involves the process of data acquisition, determining the threshold after segmentation, reducing amount of data, point cloud generation and reverse engineering. Object used here was motorcycle engine.

Disadvantages of this system is that computations give a better result if they are based on real physical model rather than data being gathered from theoretical CAD models. Further, there are technologies like micro computed tomography and nano-computed tomography. These are like the traditional CT with some improvements to investigate the structure of their samples with high spatial resolution [6]. These are used to make tomographic scans of a variety of objects going from biological and geological samples. High quality detectors are used. Disadvantages are that these are exorbitantly costly and resolution of order of 10-9 m may not be always be needed. Also the technology is not widely accepted and popular. Since it is at its initial stage, system is roughly designed.

### III. Proposed System

The proposed system focuses on the development of a software for visualization and analysis of three-dimensional (3-D) scientific data. Software development includes a Graphical User Interface (GUI) tool for easy and interactive visualization and analysis of CT data of different industrial objects like computer chip, reactor parts, etc. This Software is expected to provide two different types of visualization-

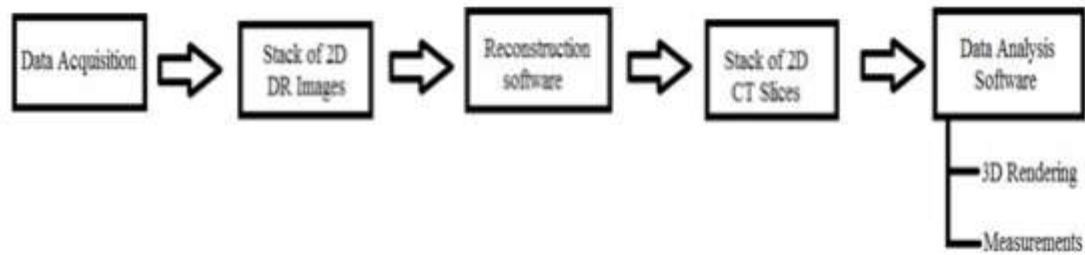
- One is to navigate the image stack in three different orientations with or without interpolation.
- The other is to render it as a volume in order to help users to understand the 3-D structure inside objects.



**Figure 1 Data acquisition process**

The entire process, shown in fig.2 has been divided into five broad categories. First is data acquisition, shown in fig.1. This is where two dimensional digital radiographs are acquired. Depending on the resolution required, the number of radiographs needed is decided. For instance, 360 radiographs may be acquired (one for every degree) for each industrial part that needs to be reconstructed and analysed. The next step in this process is stacking of 2D Images. The data acquired, namely the digital radiographs, will be stacked together in this step. Next is the reconstruction software. In this stage, the stacked DRs are converted to various computed tomographs. CTs obtained are basically the cross-sectional slices of the sample part. These CTs are sensitive to noise and will be worked upon during later stages. After this comes stacking of 2D CT Slices. Similar to the second step, stacking is performed. Only that here stacking of the two dimensional CT slices obtained in step 3 takes place. And finally the Data Analysis Software. Using the data analysis software, the reconstructed industrial part can be rotated in three dimensional space. The three dimension phantom is generated using linear interpolation. Noise removal is performed in this step with the help of filters. Also, 3D rendering generates the slices of the inner areas of the part. Using this 3D model, measurements of the object can be taken for analysis like ratio of individual elements of the object; for research purposes, etc.

In the third step for developing Reconstruction Software, Analytic algorithm is used. This method is based on exact mathematical solutions to the image equations and hence is faster. One such method to implement these solutions it is once again necessary to limit the spatial resolution of the image.



**Figure 2 Block diagram of the entire system**

Analytical reconstruction method is divided into two types as: 1. Two-Dimensional Fourier Reconstruction Method. 2. Filtered Back Projection Method. Among these two techniques Reconstruction Software will be developed using Filtered Back Projection Method as it gives better performance and its performance is not affected due to any other filtering technique. And also it is being proved that this technique is mostly used for X-ray image processing.

#### IV. Conclusion

Software can be built based on this proposition to carry out Non-destructive testing of industrial samples. The proposed system can be used for visualizing and analyzing these samples in three dimensional spaces with the principal benefit of obtaining the complete model of both external as well as internal surfaces without destroying it. The software can also measure the length and depth of the flaws. On building an extremely user-friendly front end, this proposition can be better than existing systems due to its ease of usage. Any individual with slightest of technical knowledge may also benefit from such systems. Minute flaws and defects can be detected, which may be corrected on the original sample. This technique for testing the quality of the final product can be used in various sectors apart from the industrial sector. These, to name a few, include Research, Forensic engineering, Mechanical engineering, Electrical engineering, Civil engineering and Medicine.

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