Development Of Image Acquisition Software for Digital Radiograph and X-Ray CT

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Abstract
There have been done a development of software for digital radiograph acquisition and X-ray CT. Development has been made for both software to control the rotated table and image acquisition of X-ray radiated object. This paper will have limited scope only for software module that is image acquisition result. X-ray that is coming out from X-ray generator will be passed through via collimator, then to be pointed to object test where located on rotated table. X-ray radiated result of the object test will be captured by digital detector array or fluorescence screen. Because of fluorescence screen usage, digital camera will be used to get the projection result of X-ray to object test. Software select connected camera port and digital camera will start to record. In this system test, image acquisition and rotated table software will use machine block and ignition coil. It will be located on rotated table and to be arrange for 0° to 360° angles, with voltage 160kV, current 5 mA, source object to detector distance 120 cm, source to detector distance 135 cm. Image acquisition software test result shows the image is clearly seen.

Keywords: digital Radiograph, X-Ray CT, Fluorescence screen

1. Introduction
The development of digital radiography is currently very rapid, both in the field of health and industry. Digital radiography has many uses, one of which is to detect or test the damage or defect of a product that is not visible in the manufacturing industry. Tools used to detect defects are called non-destructive testing devices or Non-Destructive Examination (NDE). The most widely used NDE device for the manufacturing industry today is the NDE-based X-ray tomography device. NDE-based X-ray tomography is a device that can display the inner side of an object from different angles in 2D images. The results of the 2-dimensional images are in the form of radiographic digital files. To view images from different angles, the object must be rotated 360° by using turntable whose control is integrated with the image capture software. If the 3D image will be created, then the image of the acquisition result in the form of 2D image can be reconstructed using certain software.
The development of digital radiography and X-ray CT prototypes for manufacturing industries implemented in 2018, is a continuation of engineering activities undertaken from 2017. In the previous activities have been made detailed design of hardware (consisting of mechanical and electronic) and software modules. The shape of this system is named prototype α Radioscopy, where X-rays coming out of the X-ray generator, will be passed through the collimator and then directed to the test specimen placed on the turntable. The projected image of the x-ray exposure to the specimen is captured by a digital detector array or a fluorescence screen. Because using the fluorescence screen, then to take the results of x-ray projection of the test object used digital camera. Image data generated in the form of 2-dimensional images taken from various angles. This image capture is done by rotating the object placed on the turntable up to 360o.

2. Theory
The principle used in the NDT method is the principle of x-ray attenuation on a material. Where the intensity of x-rays will change after penetrating a material. Mathematical formulation of the changes are as follows: [1]

\[ I = I_o e^{-\mu W} \]

where:
- \( I \) Intensity after penetrating the material
- \( I_o = \) Initial intensity
- \( \mu = \) attenuation coefficient of material/absorber
- \( W = \) thickness of the material/absorber

When penetrating an uneven material surface or while penetrating the cracks/defects in the material there will be also changes in intensity. The description of this, can be seen in Figure 1.[2]

![Figure 1](image)

**Figure 1.** Changes in intensity after penetrating different material thickness

- System description
In Figure 2, we can see images of digital radiography systems and X-ray based CT. In the picture, the X-rays emitted by the X-ray generator penetrate the test object placed on the turntable (where the table is rotated at the desired angle) and then the projection of the object due to the x-ray exposure is captured by the fluorescence screen. As a result of capturing photons that come from X-rays, will cause the fluorescence screen will glow. To change the image that appears due to the glowing fluorescence screen in the form of visible light, then used a digital camera that serves to record the image in digital form. The image that have been recorded from digital camera can be viewed on monitor screen and also can be directly stored on PC.
Figure 2. Digital radiography system and X-ray CT

- **Image Requirements for CT**
  In order for 2D images can be reconstructed into 3D (tomography), the following data are needed: projection image from various angles, beam profile image and dark image.[3]

- **projection image**
  A parallel beam geometry requires a projection image between angles 0° to 180°. The final image is at an angle of 180, not used for reconstruction but is used for rotation center calculation (COR). In geometry Fan and cone beam require projection above 360° or 180° + fan or cone opening angle. In case of large openings angle is recommended to do projections up to 360. Ideally, when do projection image of various angles, the resulting image no noise. But in practice, cases like this never happen. Noise arises because of the static nature of measurement. The detector requires a sufficient level of gray level (dynamic range). If the detector used is 12 bits or less, then when will take the image at every angle, so that the resulting image has good quality, done by means of integration or calculate the average value of the image (frame integration). This approach can improve the quality of image reconstruction significantly.
  The number of projected imagery is theoretically defined as $\pi \times N / 2$, approximately 1.5 times the number of detector line pixels for 180° scan, and $\pi \times N$ for 360° scanning. The number of image projections is often lower for practical applications, but it is recommended to use a projection number that is proportional to or higher than the number of pixel detectors in a row. More image projections can improve the statistics and quality of reconstruction, but also increase scan time and reconstruction time.

- **Beam profile image**
  Beam profile image is often called the open beam image, flat field image or bright image. This image is used to improve the beam profile, scintillator, taper or imperfections of the detector. To get beam image, do image acquisition without using sample. Since each projection is corrected with the same open beam image, any error in the beam profile image then the image will be normalized.

- **Dark image**
  Dark image or commonly called offset image is needed to correct various imperfections of the detector such as dark current, readout noise, and ADC offset. Generally the projection image, open image and dark image results, are acquired at the same integration time. It is recommended to do dark image acquisition with a large number of frames.
Determination of the principle of image taking
To perform image reconstruction (tomography), projection image data from various angles is required. To get a projection image, there are some principles of image taking such as: parallel beam geometry, fan beam and cone beam. This determination is very important because it is related to the method of reconstruction (tomography) that will be done. In figure 3, is the position of the source of radiation, the turntable (test object) and the detector / monitor screen.

The optical axis is a line through a source perpendicular to the surface of the detector. This line intersects the detector at a certain point. The line of detectors corresponding to this point (measured from above) defines the vertical center, the horizontal center column.

3. Methodology
The development of image retrieval software is done by software engineering method, that is:
1. The engineering of image acquisition and turntable controller software.
2. Testing image acquisition and turntable software.

4. Results and Discussion
Design of software system
The software module of image acquisition and control of the turntable is developed using LabVIEW professional programming language Development System 2011 which comes with options of image acquisition and vision. LabVIEW 2011 is very flexible and has adequate functionality in data acquisition, communication with video grabbing devices, control and image processing. The main menu display scheme and software support for this radiographic and CT X-ray digital device look like Figure 4 below:

Picture box is the main display screen, to display the image, when the process of image data retrieval, storage and displaying the image. The camera information and settings menu consists of selecting the type of camera to be used, setting the number of frames to be used, the level of the gray, gain, and filter values used. For setting the turntable starts from 0 to 360 degrees, with the shift setting according to what we want to be half degree or 1 degree.
Information:
1. Picture box  2. Camera information menu  3. Camera settings menu
4. Image acquisition menu  5. Control menu of the rotary table  6. Image storage menu

Figure 4. Schematic display image acquisition and table counter controller software

Flowchart for software system for image acquisition and turntable controller as shown in Figure 5.

Figure 5. Flow chart of image acquisition and turntable controller software
• **Software System Testing**

Figure 6 is the main view of image acquisition and turntable controller software after being operated to capture the image of the specimen in the form of ignition coil. In the early stages of the operation, the software will be initialized the camera, then the software reads the connected camera port. After selecting the camera port, the camera starts recording.

![Figure 6. The main view of the image acquisition and control software of the turntable](image)

Image acquisition and turntable control software has several features:

a) Display images directly in the main window along with the distribution of the image's gray values.

b) Image acquisition process can be done manually or automatically.

c) Features for turntable controller capable of performing image acquisition with various angle projection.

d) Features for camera settings.

e) Features for frame framework, which serves to reduce image noise.

f) The median filter feature used to smooth the contour of the image and suppression of damaged pixels.

g) Exposure time and gain feature used to brighten an image so as to produce a good contrast image.

h) The image acquisition process can be saved manually or automatically with 8 bit, 12 bit and 16 bit TIFF format.

• **Image of Software System Testing Results**

To obtain an image which can will be reconstructed, then tested by radiating the specimens rotated from 0 s / d 3600. Following are the results from the tests on the acquisition of images, use the engine block (a) and use the ignition coil (b), in Table 1.

| Table 1. Image of Software System Testing Results, (a). Engine Block, (b). Ignition Coil |
|---|
| a. | Machine Block, Voltage= 160 KV, Current = 5mA, SOD=120 cm, SDD=135.6 cm |

![Angle 0°](image) ![Angle 45°](image)
5. Conclusion
The result of digital radiograph image and X-ray CT design is modular basis software, consist of image acquisition main display and controlled rotated table, camera parameters and image storage.
In this system test, image acquisition and rotated table software will use machine block and ignition coil. It will be located on rotated table and to be arrange for 0° to 360° angles, with voltage 160kV, current 5 mA, source object to detector distance 120 cm, source to detector distance 135 cm. Image acquisition software test result shows the image is clearly seen.

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