HIGH RESOLUTION COMPUTERIZED TOMOGRAPHY SYSTEM USING AN IMAGING PLATE

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Abstract:

A new type of computerized tomography (CT) system for industrial applications taking full advantages of an imaging plate (IP) is presented. An imaging plate features high sensitivity, wide dynamic range and excellent linearity. Its distinct advantage over a conventional detector arrangement is a higher resolution in the order of several tens microns, which is mainly determined by a spot size of a stimulating laser light for read out of signals. The experimental CT system reported in this paper utilizes Iridium-192 radio-isotope (RI) as a gamma-ray source. A combination of translation and rotation mechanism with a thin aperture slit in a radiation shield enables a recording of full projection data in a single imaging plate. A new algorithm for reconstruction is developed, which allows a fast continuous scanning without interruption. The system is very inexpensive and hence will expand areas of industrial applications of CT.

Introduction:

A computerized tomography (CT) system has been used as an effective diagnostic tool in the clinical medicine1). This advanced non-invasive medical–imaging technique has also been offering a means of non-destructive inspection in various industrial fields2), where the imaging methods have to meet severer requirements for the image quality and operating conditions in contrast to the situations in the medical field. In this digital imaging system, the resolution, which is one of the most essential factors to affect the image quality, is dependent on the spatial size of radiation detector installed in the system. The detector arrangement of conventional CT is usually composed of gas-counters or solid state detectors, and the half-width of its PSF is actually in the order of 1 mm.

In this paper, a new type of high-resolution CT system using an imaging plate with optically stimulated luminescence is presented. In an imaging plate, a latent image of X-ray or gamma-ray radiation exposure is formed and then luminescence stimulated by a scanning laser beam, the intensity of which is proportional to the radiation dose, is read out. Its distinct advantage over a conventional detector arrangement for a CT is a higher resolution in the order of several tens microns, which is mainly determined by a spot size of a stimulating laser light for read out. In addition to those, an imaging plate features high sensitivity, wide dynamic range and excellent linearity for the radiation dose. With those effective characteristics in imaging technique, a unique CT system is available for various industrial applications for non-destructive testing.

Experimental Methods:

Utilizing an imaging plate instead of conventional detector array to observe projection data, an experimental CT system has been developed. A schematic of the whole system is illustrated in Fig.1. As a radiation source, Iridium-192 isotope (7.8 Ci) is used. This RI source is contained in a platinum shield case and it is pulled out to the assigned position through a guide tube by remote control.

A standard imaging plate (ST-VI, Fuji Film Co. Ltd., Japan)3) encapsulated in an IP film cassette is installed on the cassette holder just behind lead shielding. A combination of object rotation and imaging plate translation mechanism with a thin aperture slit (0.5~1mm) in a radiation shield enables a recording of full fan-beam geometry projection data around the object in a single imaging plate. An IP film cassette with an imaging plate (354mmX430mm) makes vertical motion precisely synchronized with the rotation of an object on the turntable. In connection with the projection data collection method, a new algorithm for reconstruction is developed. The algorithm allows a fast continuous scanning avoiding the stepwise motion of the imaging plate.

Results:

In order to examine the spatial and density resolutions of the CT system, a test phantom as shown in Fig.2, which is composed of acrylic pipes, a lumber beam and a wooden trunk, is prepared. This phantom is placed on a turntable for the object rotation and the projection data (fan-beam) for 360 degree rotation around the object are collected. The whole projection data are continuously stored on an imaging plate.

Figure 3 shows a sinogram for the object obtained in the fan-beam geometry expressed in 1,670x2,010 pixels. After the fan-parallel inversion and a logarithmic transform to obtain the projection data expressed in the magnitude of attenuation coefficient, the image is reconstructed by applying a modified filtered back-projection algorithm3) to the parallel-beam geometry projection data. The thus obtained reconstructed image is shown in Fig.4. It clearly illustrates the fine inner structures in the phantom, such as annual rings in the wooden trunk, where the variation in attenuation coefficient is merely in the range of 10~15%. The resolution less than 0.5 mm is attained in this reconstructed image.

Discussion and Conclusion:

The high-resolution CT system using an imaging plate would appear to offer various advantages over conventional approach. Since the new system enables to collect the projection data represented in almost arbitrarily selected sampling length down to the laser beam spot size for read out, it can provide the magnified reconstructed images merely by changing the sampling length for the same projection data. In connection with this projection data collection method, a limited region reconstruction algorithm5) is effectively applied to obtain a magnified reconstructed image for a specified region-of-interest.

Another particular feature of an imaging plate is its flexibility to fit with a curved surface. If such a flexible IP is fabricated in a tape form, then, by successively winding the irradiated parts on the tape, a detector arrangement is available to collect the projection data for a rotating radiation source. By combining this data collection method with a rotating mechanism of a radiation source, it is possible to develop a high-resolution CT for a spatially fixed immovable object.

References:

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Fig.1

Schematic of experimental arrangement for high-resolution CT.

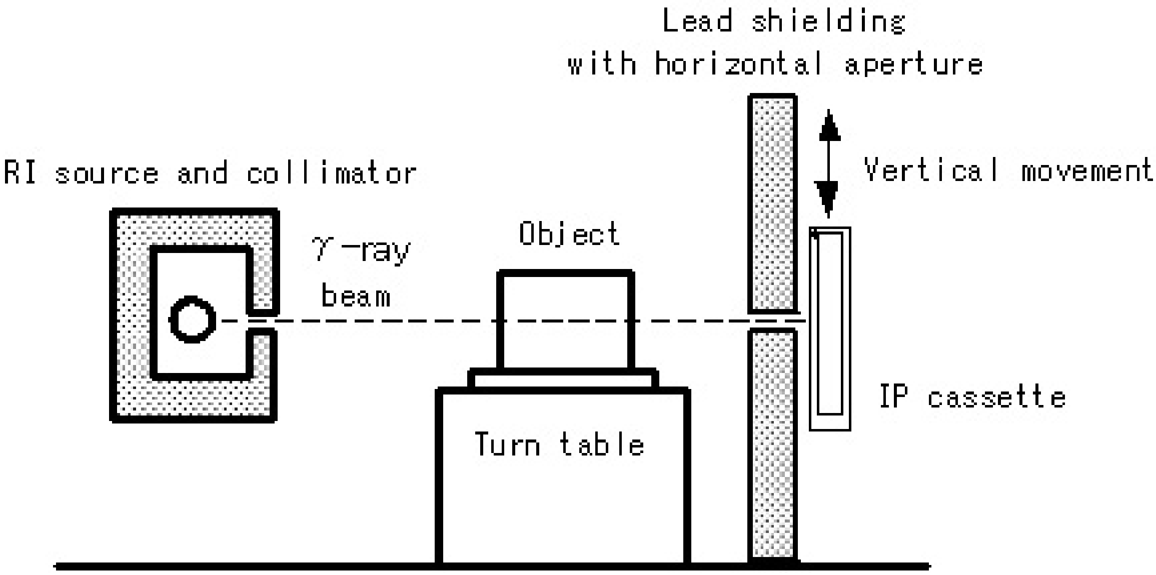

Fig.2

Cross-section of test phantom: (clockwise from top) a lumber beam, a wooden trunk, and two acrylic pipes filled with water, encased in an acrylic pipe (outer diameter: 100 mm).

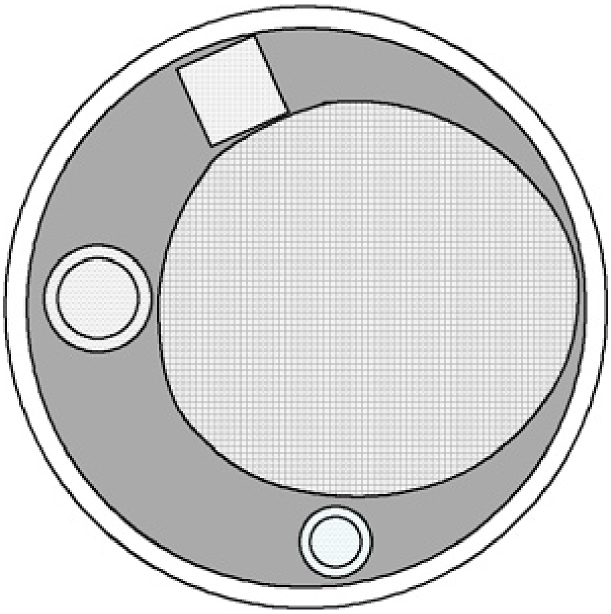

Fig.3

Sinogram for the object shown in Fig.2.

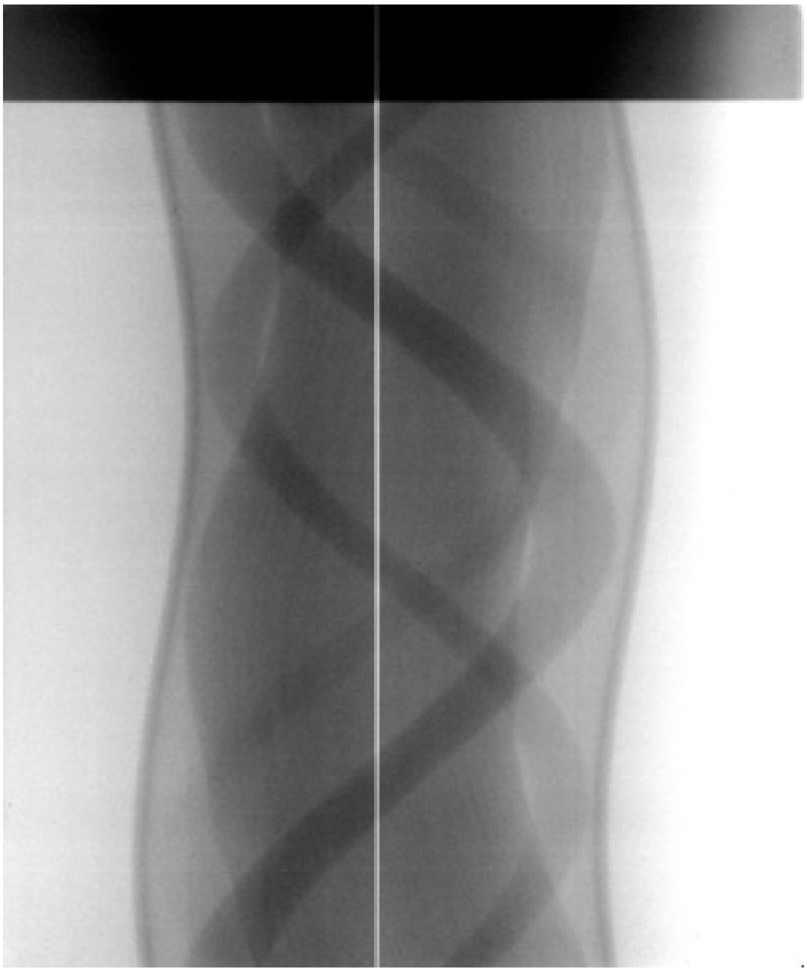

Fig.4

Reconstructed image using the projection data shown in Fig.3.