Digital Angio

Development of CT-like Imaging Function for BRANSIST safire Angiography System VC17

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1. Introduction

Much attention is being given to CT-like imaging, a technique whereby cross-sectional images like those obtained with CT are constructed from rotational images gained from a C-arm angiography system equipped with an FPD. Here, I would like to report on our development of this function for the BRANSIST safire VC17 angiography system, which is equipped with a 17-inch direct-conversion FPD.

2. The Aim of CT-like Imaging Performed with an Angiography System

The main aim of CT-like imaging is, by allowing 3D information to be obtained during IVR treatment without moving the patient, to help increase the safety of examinations and treatments and improve therapeutic efficacy. 3D-angiography is another technique that allows 3D information to be reconstructed from rotational images obtained with a C-arm. It is mainly used, however, to visualize blood vessels illuminated with contrast medium, whereas CT-like imaging offers much greater low-contrast resolution, making it possible to visualize tumor stains. Because of this characteristic, CT-like imaging is mainly used for the following two applications:

1) The identification of feeding vessels in the execution of chemotherapy for a tumor and the determination of the appropriate amount of drugs for chemotherapy to be used from the size of the affected area.
2) Evaluation of efficacy and checking for bleeding after IVR treatment.

Patients used to be moved to the CT room during IVR treatment for the above reasons. With CT-like imaging, the risk of this movement is avoided and information can be obtained quickly. An IVR-CT system has the same functions, but both in terms of cost and operation, CT-like imaging attains superior cost-effectiveness.

Fig. 1 shows a clinical image obtained with this system using CT-like imaging during arterial portography. A defect of contrast medium in the liver tumor can be seen clearly.

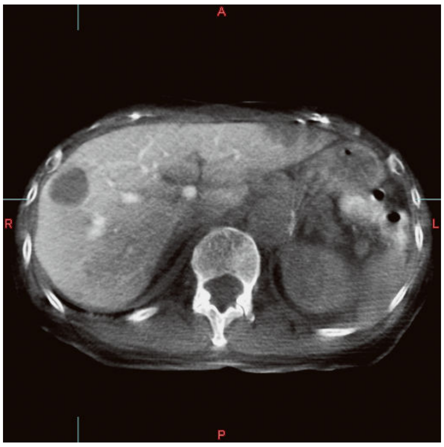

Fig. 1

3. CT vs. CT-like Imaging

CT-like imaging is by no means superior to CT. **Table 1** shows a comparison of the basic performance of the two modalities. CT-like imaging is, in fact, inferior to CT in terms of low-contrast resolution. This is because it is based on the use of an angiography system, and consequently the data bit length and the number of exposures are limited. Also, with CT, the scattered radiation that enters the sensor is reduced to around 1% by a grid, whereas with an angiography system, the basic mechanical structure makes this kind of reduction impossible, and roughly half of the X-rays that enter the FPD consist of scattered radiation component. Although this scattered radiation component can be corrected to some extent with image processing, it cannot be removed accurately, and this results in inaccuracy of the CT values of reconstructed images. At present, CT-like imaging does not produce absolute CT values, but rather visualizes the relative differences in the X-ray absorption coefficients of different objects. As the name implies, it is a technique that produces images that are comparable to, but not the same as, those produced with CT.

On the other hand, CT-like imaging is superior to CT in some aspects. One such aspect is high-contrast resolution (spatial resolution). With CT-like imaging, it is possible to create isotropic 3D images with a high level of spatial resolution. Also, the system that we developed can perform acquisition for CT-like imaging with an exposure level of no greater than one fifth to one half that of CT. This yields clinical benefits. For example, in cases where there are multiple feeding vessels, CT-like imaging is acceptable for each one.

Specification	CT-like Imaging Performed with BRANSIST safire VC17	Multislice CT
X-ray detector	17-inch FPD	Scintillator + Photodiode
Rotation mechanism	C-arm	Gantry
Rotational imaging range of imaging system	225°; continuous rotation not supported	360°; continuous rotation supported
Exposure time (1 scan)	10 or 20 s	0.5 to 1.5 s
Number of exposures (number of views)	Approx. 300 or 600	800 to 1,200 min.
Data bit length	14 bits	20 bits min.
Low-contrast resolution (16cm-dia. CATPHAN)	Approx. 10 HU/10 mm	Approx. 3 HU/3 mm
High-contrast resolution (10% MTF)	0.45 mm min. (isotropic)	0.6 mm min. (non-isotropic)
Exposure dose	Approx. 1/5 to 1/2 of CT dose	—

Table 1 Performance Comparison of CT and CT-like Imaging

4. The Principle of CT-like Imaging

Fig. 2 shows the flow of the imaging data processing performed by this system. Broadly speaking, the rotational images obtained are converted to CT-like images in three stages.

In the first stage, the pixel values of the rotational images are converted to X-ray absorption coefficients. The pixel values are first subjected to gain correction, and then after the scattered radiation component is removed by scattered radiation correction processing, beam hardening correction is applied to complete the conversion to X-ray absorption coefficients.

In the next stage, the following four types of correction are performed as part of reconstruction preprocessing:

- C-arm trajectory correction, which corrects the displacement from the ideal trajectory
- Ring artifact correction, which removes noise in the sinogram
- Truncation correction, which interpolates the sinogram for parts that protruded outside the exposure range during rotational imaging
- Pai correction, which corrects differences in the amount of acquired data that arise between the center and periphery in half-scan reconstruction due to the cone-beam effect

After the above corrections are performed, the data is converted to 3D information via reconstruction processing. The reconstruction algorithm is based on the FBP (filtered back projection) method. The basic idea behind this method is illustrated in Fig. 3. Fig. 3a shows the relationship between an object and a projected image. Given a projected image, because the projected image is a shadow of the object, it can be said that the object is within the cone described by shadow formed on the sensor and the focus (Fig. 3b). If there is another projected image obtained from a different direction, the location of the object can be narrowed down to the region where the two cones intersect (Fig. 3c). If there are multiple projected images obtained from different directions, the position of the original object in 3D space can be identified (Fig. 3d). This method of combining projected images in 3D space is called "back projection". FBP is a more precise version of back projection in which filtered projected images are used instead of projected images themselves in order to reconstruct 3D information about the original object that includes density information (X-ray absorption coefficients). This system uses a type of FBP method called the "Feldkamp" method.

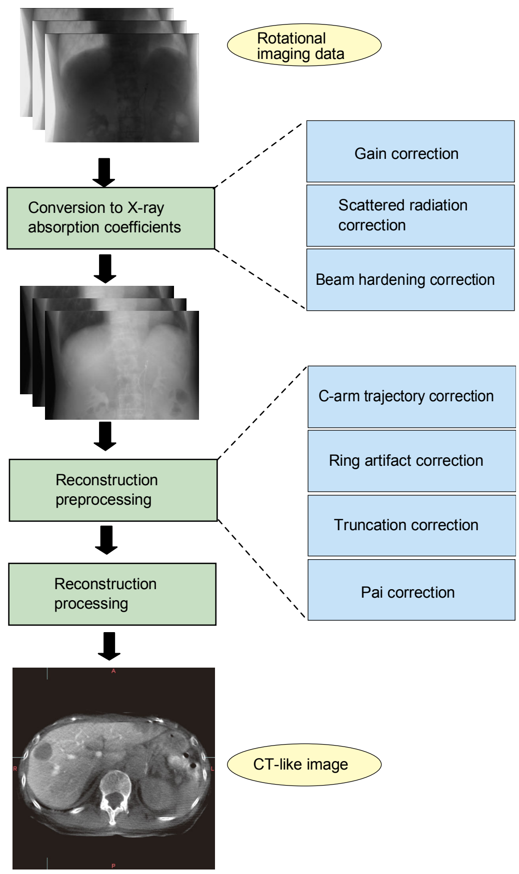

Fig. 2 Flow of Data Processing

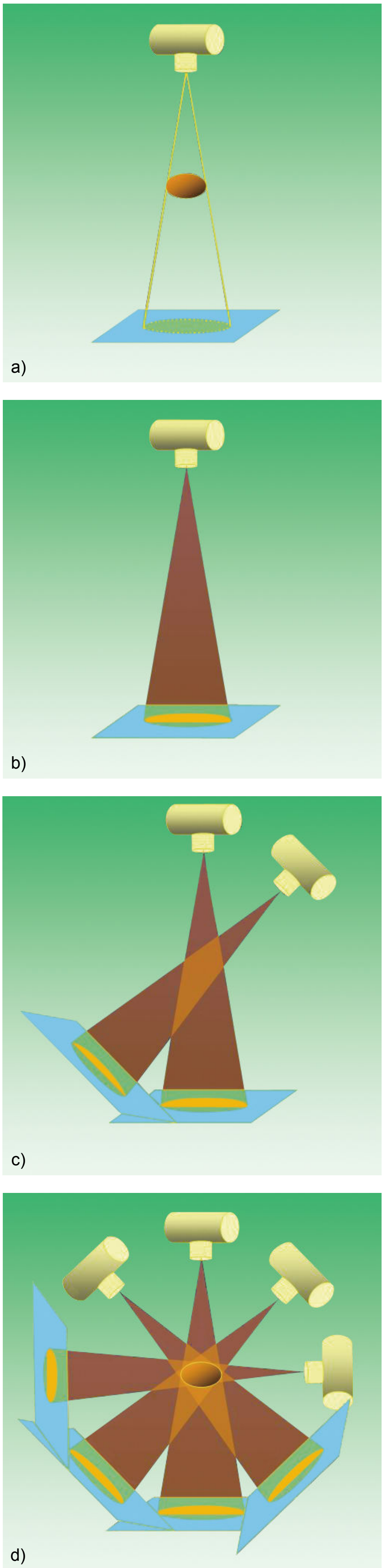

Fig. 3

5. System Configuration

The BRANSIST safire VC17 angiography system is shown in **Fig. 4**. We developed a CT-like imaging function (including a 3D-angiography function) as an option for this system (**Fig. 5**). The image processing workstation is connected to the imaging system via high-speed LAN, and after rotational images are acquired, reconstructed images can be displayed in as little as 90 sec. A CT viewer is used for image observation, and in addition to the 2D display of axial images, MPR, CPR (curved MPR), MIP, volume rendering (VR), and virtual endoscopy (VE) are supported. Various types of masking, the creation of cine images, and distance measurement are also available.

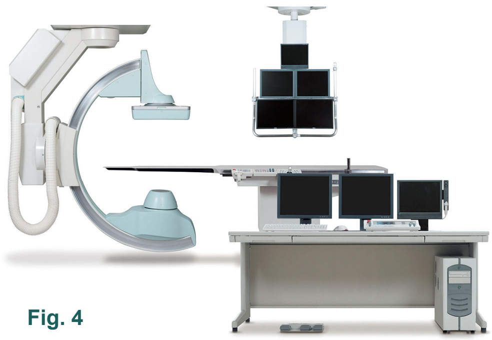
Fig. 4


Fig. 5

6. Summary

CT-like imaging performed by an angiography system is a new technology. It offers low exposure and high spatial resolution, and is expected to be used in an increasingly wide range of applications. In the future, we plan to try to improve the basic system performance by, for example, reducing the processing time, improving the low-contrast resolution, and increasing the accuracy of CT values. Finally, I would like to thank the University of Occupational and Environmental Health for providing clinical images used in this article.