Image fusion using MIM software via picture archiving and communication system

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Abstract The preliminary studies of the multimodality image registration and fusion were performed using an image fusion software and a picture archiving and communication system (PACS) to explore the methodology. Original image voluminal data were acquired with a CT scanner, MR and dual-head coincidence SPECT, respectively. The data sets from all imaging devices were queried, retrieved, transferred and accessed via DICOM PACS. The image fusion was performed at the SPECT ICON work-station, where the MIM (Medical Image Merge) fusion software was installed. The images were created by reslicing original volume on the fly. The image volumes were aligned by translation and rotation of these view ports with respect to the original volume orientation. The transparency factor and contrast were adjusted in order that both volumes can be visualized in the merged images. The image volume data of CT, MR and nuclear medicine were transferred, accessed and loaded via PACS successfully. The perfect fused images of chest CT/^{18}F-FDG and brain MR/SPECT were obtained. These results showed that image fusion technique using PACS was feasible and practical. Further experimentation and larger validation studies were needed to explore the full potential of the clinical use.

Keywords Image registration and fusion, Radionuclide imaging, Picture archiving and communication system, Computed tomography, Magnetic resonance imaging

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1 INTRODUCTION

Correlative image fusion between functional and anatomical images has been an active research field for many years. The registration of images from several modalities can provide a highly advantageous approach to identifying, correlating, and quantifying regional changes in anatomy and function. The interpretation and review of single photon emission computed tomography (SPECT) or position emission tomography (PET) images registered with magnetic resonance imaging (MRI), computed tomography (CT), digital subtraction angiography (DSA), or ultrasound (US) images frequently contribute additional and new information to the workup of subjects beyond that obtained from the individual procedures.[1]

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Recently, systematic comparison studies on the images fusion techniques were performed, which demonstrated that many algorithms and computer software were practical and feasible.[2~5] In the present study, the methodological investigation of the image fusion was performed using a picture archiving and communication system (PACS) and image fusion software.

2 MATERIALS AND METHODS

2.1 Image devices and techniques

Original image voluminal data are acquired with a Siemens Somatom Plus S CT scanner, Magneton Vision 1.5T MR and E.CAM$^+$ dual-head coincidence SPECT, respectively. The SPECT acquisition workstation is a double CPU PC and its processing workstation is Apple Macintosh G3. All datasets acquired with these image devices are volume data.

2.2 PACS

PACS is a computer application system established by our hospital, which can acquire, access, query, process and transfer medical image information. Original images are transferred and accessed using DICOM format (a networking standard supported by ACR-NEMA), and the images are not damaged. Main connection of the PACS local network is showed in Fig.1.

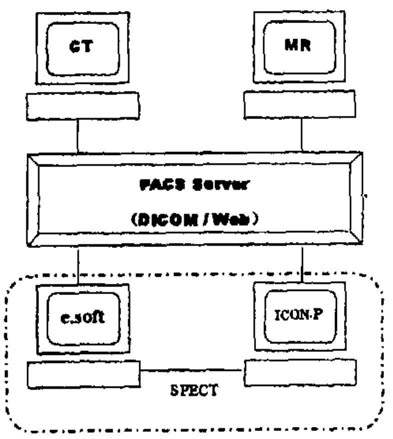

Fig.1 Connection sketch map of PACS

2.3 Main computer software

The SPECT acquisition workstation is installed with a Windows NT 4.0 operating system and e.soft 1.0 special software, chiefly performing acquisition of radionuclide image and partially processing images. The processing workstation ICON-P is installed with ICON 8.5 and MIM 1.0 (Medical Image Merge) image fusion software and so on. Both computers are installed DICOMlink software, which sustains communication and transfer between the computers and accessorial devices. There are Windows NT operating systems in the computers of CT and MR.

2.4 Image transfer

Two methods, or say routes, are used to transfer data. Method A: The CT or MR information in the PACS server is queried and selected at ICON-P workstation and then is retrieved and transferred into ICON-P. Method B: The CT or MR information of the PACS server is queried, selected, retrieved and stored at e.soft workstation and then transferred into ICON-P. All SPECT images are transferred from e.soft into ICON-P.

2.5 Image fusion

The MIM image display system enables the operator to display easily and manually overlay tomographic images including MR, SPECT, and CT. During image displaying, MIM performs "on the fly" conversion of the volume slices to isotropic dimensions. Slice separation between adjacent slices displayed on the screen can be selected from 1 to 15 mm. At each location, the displayed slice is interpolated from the original volume data. Typical image fusion procedures are as follows: (1) Loading images (CT or MR in DICOM format, SPECT in Siemens ICON format). (2) Adjusting the contrast in each image set. (3) Selecting fusion options. (4) Selecting an image slice for fusion, which has an anatomic landmark, e.g. spine that is seen well in both image volumes. (5) Adjusting the transparency factor so that both volumes can be visualized in the merged images. (6) Translating image to roughly align it in the sagittal orientation. (7) Translating the image to roughly align in the coronal orientation. (8) Repeat steps 6 and 7 applying rotation as needed. (9) Checking alignment in the axial orientation. (10) Checking alignment throughout the volume by either creating a splash view of several fusion slices using the window size function or using the slice selection function. It is often convenient to change the transparency factor to display alternately the movable and reference images while watching an anatomic structure of interest.

3 RESULTS

When original data were queried and retrieved using method A, the classes of the data series of DICOM format were not able to be identified accurately, and many files were transferred. The image confusion or computer dead machine happened in loading CT or MR data using the MIM software, so that image fusion could not been continued.

After CT or MR data were imported from the PACS server into e.soft, the computer could identify every class of image data, and browse an image using a browser software. Therefore, a practicable image series of the patient was sent to ICON-P and then run MIM to perform image fusion. The images of CT, MR and nuclear medicine were transferred, accessed and loaded successfully via this PACS route. The thoracic CT/^{18}F-FDG, Cerebral MR/^{99m}Tc-ECD images fusion was performed and perfect images were obtained (Fig.2,3).

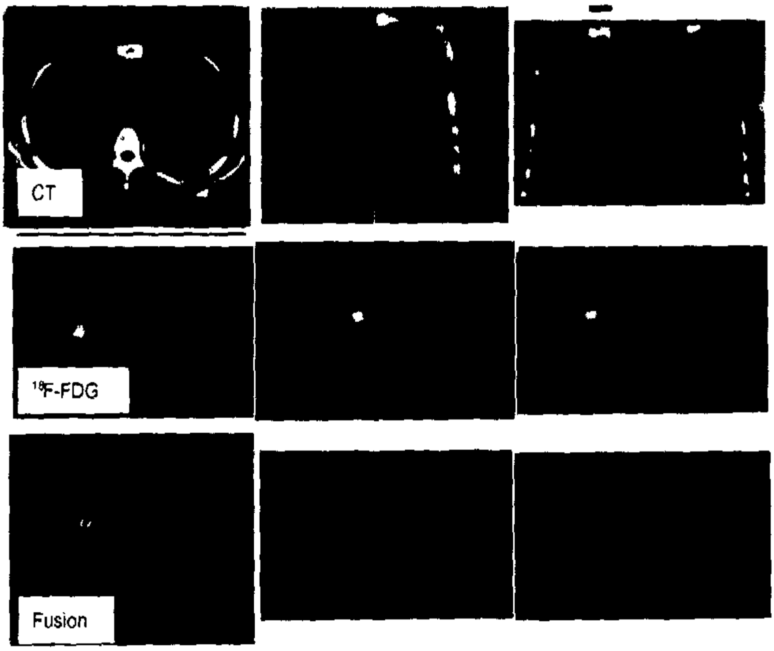

Fig.2 Thoracic CT/^{18}F-FDG image fusion
a. CT image, b. ^{18}F-FDG image, c. Image fusion

4 DISCUSSION

In recent years, image registration and fusion techniques become gradually perfect because the technology has been developed and more imaging modalities use digital image acquisition, storage, processing, and display techniques. The MIM software only requires calculation of translation and rotation for the displayed slices. It maintains the original scan volume accuracy while avoiding the time required for pre-calculation of the resized image volumes and is faster than the methods that require translation and rotation of the entire image volume. The operator controls three orthogonal slice display view ports of each volume, and aligns image volumes by translation and rotation of these view ports with respect to the original image voluminal orientation. The multimodality image fusion has been used clinically for detection and location of the focus, providing a more accurate surgery and radiotherapy treatment planning,[6] assessing prognosis and therapy,[7] direct biopsy[8] and attenuation correction for low or high energy ranges based on the CT images[2,9] etc.

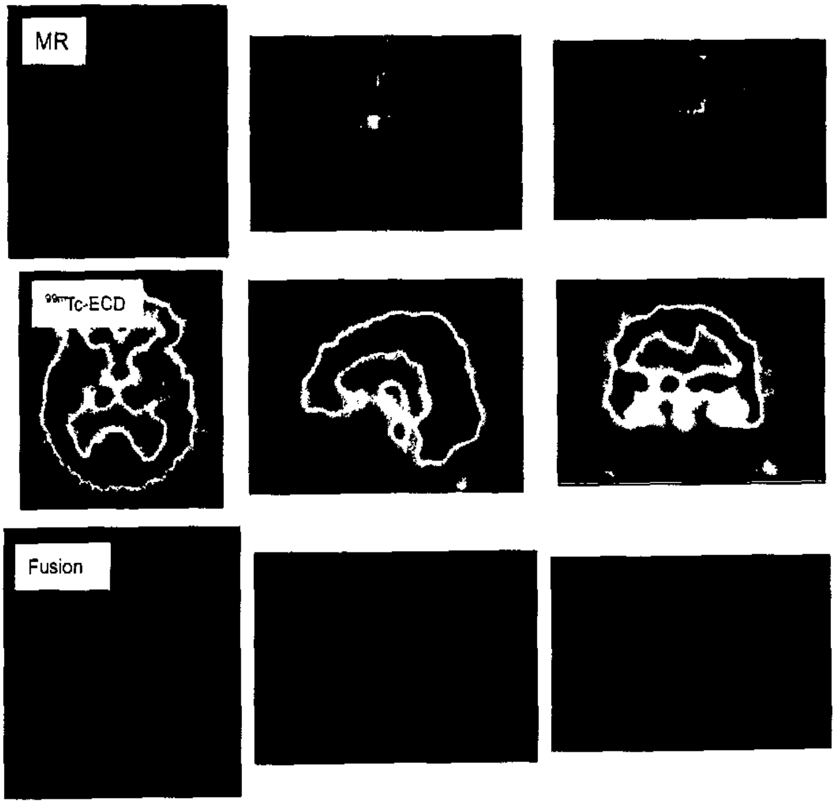

Fig.3 Brain MR/SPECT image fusion
a. MR image, b. ^{99m}Tc-ECD image, c. Image fusion

The MIM import allows to select various image formats to load and display, such as DICOM, Siemens nuclear medicine ICON format, native Siemens CT and MR format, ECAT 6 and ECAT 7 PET format and so on. This software both on Mac and Windows

NT operation systems can accept DICOM images from multiple modalities and then store these images in DICOM format. The images reside on the native computer or on the network. Our MIM of Mac version is installed on Macintosh computer, which carries out the transfer of image data using DICOM PACS. Native Siemens CT, MR or PET images can also be processed with MIM and can either be sent via file transfer protocol or copy to a networked NT computer system with a shared disk.

In the course of this study, the image confusion or computer dead machine happens in loading CT or MR data when using method A. The operation platforms of CT, MR and e.soft are Windows NT, but that of ICON-P is Mac. PACS communication between ICON-P and CT (or MR) is matched incompletely. This may be the cause of image confusion. It is important to identify the corresponding position and orientation accurately for image fusion. We select an image slice for fusion using the MIM software, which has an anatomic landmark. The anatomic structure of ^{18}F-FDG image sometimes is not clear. Whether the external markers should be used needs a further investigation. Furthermore, the integration of a low resolution CT scanner with a dual-head camera now makes it possible to perform attenuation correction and image fusion of anatomy and function into one image to improve the anatomic localization of abnormalities detected with coincidence imaging.[10] However, the hybrid SPECT/CT device must be used. In a word, further experimentation and larger validation studies are needed to explore the full potential of the clinical use.

References

1 Weber D A, Ivanovic M. Semin Nucl Med, 1994, **24**:311

2 Dey D, Slomka PJ, Hahn LJ *et al.* J Nucl Med, 1999, **40**:448

3 Koole M, D'Asseler Y, Van Laere K *et al.* Nucl Med Commun, 1999, **20**:659

4 Mongioj V, Brusa A, Loi G *et al.* Int J Radiat Oncol Biol Phys, 1999, **43**:227

5 Barnden L, Kwiatek R, Lau Y *et al.* Eur J Nucl Med, 2000, **27**:147

6 Giraud P, Grahek D, Montravers F *et al.* Int J Radiat Oncol Biol Phys 2001, **49**:1249

7 Magnani P, Carretta A, Rizzo G *et al.* J Cardiovasc Surg, 1999, **40**:741

8 Wong T Z, Connolly L P, Treves S T. Clin Nucl Med, 1999, **24**:859

9 Kinahan P E, Townsend D W. Beyer T *et al.* Med Phys, 1998, **25**:2046

10 Patton J A. Semin Nucl Med, 2000, **30**:239