A Functional Mapping Workstation of Human Brain Images

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Abstract

A platform is developed for fast and effective functional mapping of human brain, which can allow semi-automatically the whole processes of an image segmentation, a fusion of MR and PET images, and 3-D rendering of volumetric data, including DICOM-based image transfers from PACS archiver within a short period of time.

Introduction

Clinicians gather relevant information from the various tests their patients undergo. In many instances, more than one imaging technique is used in clinical diagnosis, therapy planning, or evaluation of therapy. Generally clinicians mentally determine the spatial relationship of the various images, thereby solving a complex three-dimensional puzzle. Different imaging modalities usually provide complementary information. SPECT(single photon emission computed tomography), PET(positron emission tomography), and MRS(magnetic resonance spectroscopy) provide functional information but delineate anatomy poorly, whereas MRI(magnetic resonance imaging), ultrasound, and X-ray imaging, including CT(computed tomography), depict aspects of anatomy, but provide little functional information. Integration of the information acquired with different techniques is difficult, owing both to the complementary nature of the contents of the images and to differences in resolution, positioning and orientation of the scanned volumes. Computer-assisted image matching has proven to be a valuable tool to combine information obtained from different imaging modalities. It produces the transformation that relates the coordinate systems of the images. In the case of matching two tomographic images, either image can then be resliced into spatial coordinates of the other image, which enables a comparison of corresponding slices. Furthermore, one can combine information of multiple modalities by visualizing the results in a hybrid display. These fused images may either portray slices taken from the three-dimensional data sets, or volumetric structures. And the matched PET and MR image may aid in determining stereotactic biopsy site and planning surgical resection.

Methods

Any registration method will produce a set of equations that transforms the coordinates of each point in one image into the coordinates of the corresponding point in the other image. A universal reference system based on a Cartesian coordinate reference system keyed to a common anatomic landmark, the anterior commissure(AC), is used to provide a framework for a system containing any kind of experimental data for which a spatial relationship to this Co-ordinate system can be determined. This coordinate system is advantageous because of the anatomic consistency of the key landmarks, the AC and PC, and their ease of identification with current *in vivo* imaging techniques, particularly MR. The surface matching method is a method of image correlation in three dimensions based on computer matching of surfaces but which does not suffer from the limitations needed anatomical landmarks. This registration algorithm based to our approach and developed by Pelizzari[1] and coworkers, is a 3D parametric correspondence method to register tomographic brain images. A surface model("head") extracted from on image is related to a set of points("hat") extracted from contours in another image by transformation. The "hat" is fitted on the "head" by a search strategy that minimizes the mean-squared distance between that "hat" points and the "head" surface. To speed up the algorithm and to prevent it from

finding local minima some user interaction is allowed to select a good starting point and to interrupt the search to modify transformation parameters. Sufficient surface should be scanned to prevent the problem from being worser. Surface of an anatomical structure visible in all scans of interest is used to define a PET-MR coordinate reference. Surface fitting begins with a series of points(Pw) from the already reformatted MR data space in the parallel to AC-PC line, a first attempt, or rough, registration(R0) and a surface model(S). The transform is computed using the same svd algorithm for correlated pairs, but the use of svd is not essential. However, the points in the PET data space are determined here not by visual identification, but by transforming each point in Pw, using registration transform Rn, into the PET data space, then selecting the point on the surface of the model which is closet to the transformed point. Sufficient shape information guarantees that the algorithm eventually converges to a solution where the transformation Rn maps the points Pw to a set which minimizes the average distance of the transformed points from the surface model. These mentioned method is developed in SUN Ultra-2 system.

For scanning data, a MR image is scanned in the SPGR pulse sequence on a GE Signa Advantage for a volumetric data with 1.5mm slice gap and 124 transaxial slices. A [^{18}F]FDG PET image is scanned on a GE Advance with 4.5mm slice gap and 35 transaxial slices. The preliminary results are as follows; Figure 1. A [^{18}F]FDG PET image, showing a hypermetabolic tumor, is superimposed on the corresponding 3-D reconstructed surface of the MR image in the top right and the tumor area is visualized interactively in cut planes, while the corresponding MR, PET, and the fused slice are shown on the 1st, 2nd and 3rd column.
In the Fig.2, figure 1 shows the SPGR-MR axial brain slice parallel to AC/PC line and the FDG-PET of the same patient is shown at the figure 2. The brain atlas of the figure 3 is the axial AC/PC plate of Talairach's brain atlas[4]. The FDG-PET resliced to match the MR slice of the figure 1 is shown at the figure 4. In figure 5, the resliced FDG-PET of figure 4 is co-registered to the figure 1's MR. All of MR, the resliced PET and the brain atlas are superimpositioned by linear transformation method at the figure 6. The figure 6 might help the localization and quantization of lesions as well as the brain structures with unique colors such as the blue color of the cortex.

Conclusion

Superimposition of brain PET image onto 3D brain surface of MR image may be useful for precise localization of metabolically active tumor regions and for clarifying the spatial relationship between eloquent cerebral cortex and tumor, in the stereotactic surgery of the brain tumors. Our 3-D registration tool may be useful for planning stereotactic neurosurgery.

References

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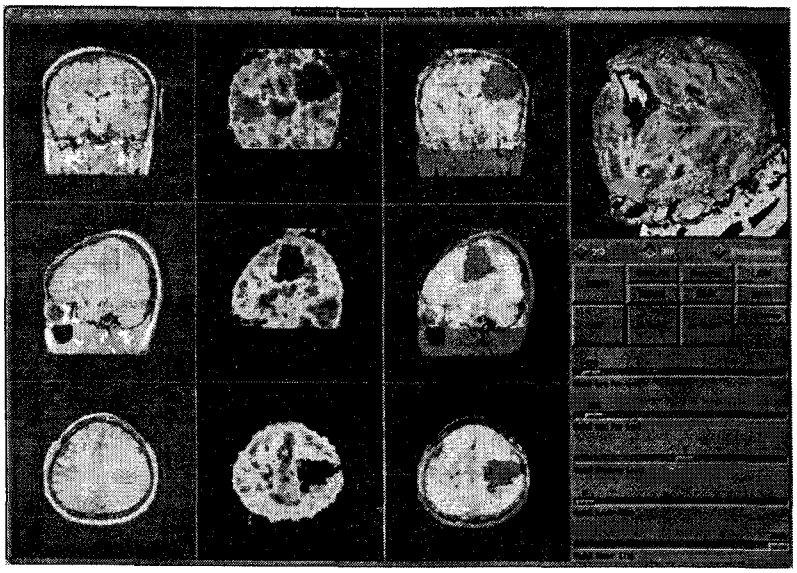

Figure 1. A [18F]FDG PET image, showing a hypermetabolic tumor, is superimposed on the corresponding 3-D reconstructed surface of the MR image in the top right and the tumor area is visualized interactively in cut planes, while the corresponding MR, PET, and the fused slice are shown on the 1st, 2nd and 3rd column.

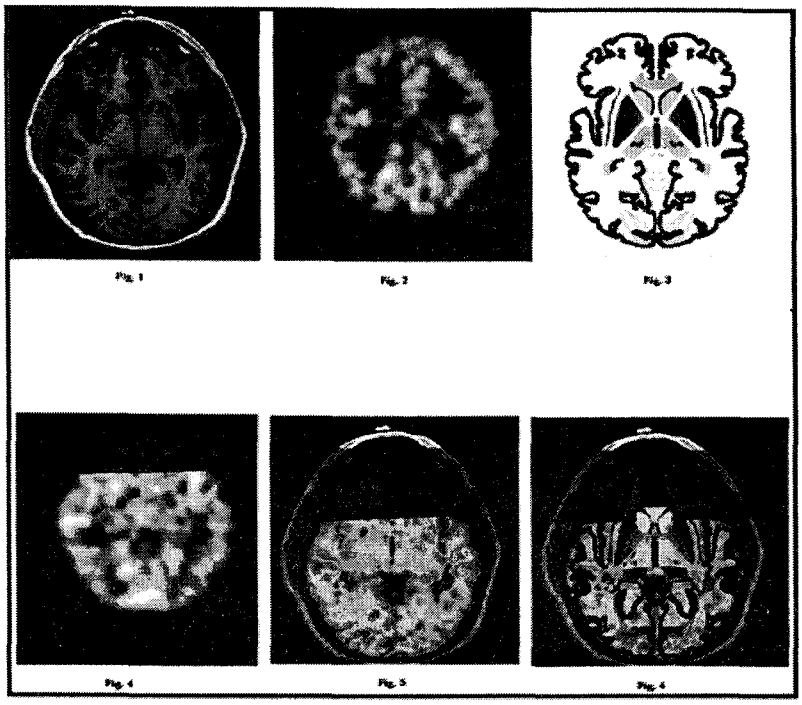

Figure 2. Coregistered PET and MR images with the corresponding Talairach Brain Atlas.