Simple and efficient image processing techniques to improve the registration between the MR and light microscopy images

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INTRODUCTION

Light microscopy images of stained tissue sections have high spatial resolution and can be co-registered to MR images of the same sample in order to make cross-modal comparisons. However, there are artifacts, such as tearing, deformation, or disappearance of tissue fragments, in the stained sections. Those artifacts make the registration between MRI and micrographs more difficult. In this study, two image post-processing techniques are introduced, both of which can provide better initialization for nonrigid registration [1].

METHODS

MR images of fixed, ex vivo, non-human primate brain specimens were acquired on a 9.4T Varian scanner. The brains were subsequently frozen and sectioned. A digital camera, mounted above the microtome, was used to acquire photographs ('block face' images) of the tissue block at regular intervals in the sectioning process. Tissue sections were stained for myelin and mounted on slides for microscopy. Case 1: For several sections, one or more lobes of the brain were displaced from their original relative locations during the process of staining and mounting (Fig. 1a). To correct these problems, the iterative closest point (ICP) algorithm [2] was applied to the micrograph prior to registration with MR. The ICP algorithm calculates the transformation and distance between two point sets extracted from two surfaces iteratively. Once the distance is detected to converge to a user-selected threshold, the algorithm is terminated. In this study, we apply the ICP to multiple components. First of all, the components in the source image and the corresponding components in the target image are selected by the user. The ICP algorithm is then applied to each individual component to generate the corresponding rigid body transformation. The multiple transformations are applied to the different components to deform the source image.

Case 2: For the light images which were torn during the staining process (Fig.2a), first of all, the contour of the torn region is selected by the user. The center line of this region is computed and the distance between each pixel on the contour and the centerline is calculated. All pixels whose columns lie in the torn region are translated towards the center line, according to the calculated distances.

RESULTS

Figure 1 shows an example of case 1. Fig.1a displays one light microscopy image (target) of a monkey brain. Three components in the light image were displaced from their proper locations during the staining process, making the registration more difficult. Without applying the ICP algorithm to the three components in the light image, the blockface (Fig.1c) and MR (Fig.1e) images were deformed incorrectly when they were aligned to the original light image. Hence, the ICP algorithm, applied to multiple components, provides a better initialization for the nonrigid registration algorithm, leading to a more accurate result (Fig.1d & 1f).

Figure 2 shows an example of case 2. The light slices were torn during the staining process (Fig.2a). After translating the related pixels, the holes in the images were closed (Fig.2b). Fig.2c-2f show the registration results after the blockface and MR images were aligned to the light image with and without holes, respectively. Obviously, the registration result is more accurate and less distorted using the image processing technique.

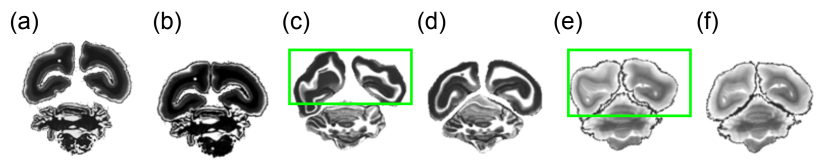

Fig. 1: (a) The original light image, (b) the corrected light image using the ICP algorithm, (c)&(d) the deformed blockface images, and (e)&(f) MR images registered to (a)&(b), respectively. The green region shows the large distortions when the ICP correction was not applied to the light image.

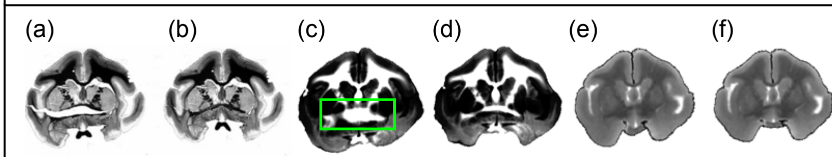

Fig. 2: (a) The original light image, (b) the light image without the hole, (c)&(d) the deformed blockface images and (e)&(f) MR images registered to (a)&(b), respectively. Note the green region in (c) was torn by the nonrigid registration algorithm in order to match the hole in (a), causing a distortion.

CONCLUSIONS

Two simple and efficient image processing techniques are introduced to improve the registration among MR, blockface, and light images. Further efforts will include investigating other image processing approaches and evaluating whether the corrections have an influence on the reconstruction of 3D blockface and light microscopy volumes.

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