Non-rigid Registration of Histological and MRI Sections for Prostate Cancer Mapping

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Background: Registration of medical images is an active area of research with important clinical applications. Alignment of images from the same modality is a critical component of many routine clinical tasks including monitoring of therapy progress and dynamic contrast enhanced (DCE) MRI. Multimodal image registration methods are also under active development for a variety of visualization and diagnostic applications such as image guided surgery and multimodal image fusion for cancer diagnosis and treatment planning. For example, training of computer-assisted detection (CAD) systems require extent spatial of cancer to be mapped from another modality with ground truth [1,2], such as histology. While automated registration techniques are currently used to align multimodal images, vast qualitative differences between modalities as well as artifacts often hinder the use of previous registration methods for such multimodal imagery. We present a new non-rigid registration method termed COFEMI-TPS for robust alignment of multimodal images, and demonstrate the method for alignment of 26 prostate MRI-histology slice pairs by identifying spatial extent of cancer on MRI by directly mapping histological cancer ground truth to the resulting co-registered MRI. It was observed that the cancer labels on MRI found using our registration method are qualitatively accurate and comparable to expert-determined labels.

Methods: The rigid registration technique, known as COFEMI [3], uses the notion of combined mutual information to incorporate high order statistical information from MRI for robust multimodal registration. Following rigid registration using COFEMI, thin plate splines (TPS) [4] are used to define a non-rigid warping of histology to MRI based on manually placed control points. To demonstrate our non-rigid COFEMI-TPS technique, corresponding MRI and whole mount digitized histology were obtained for two radical prostatectomy specimens comprising a total of 26 pairs of images in which cancer is present. Cancer extent on histology is first obtained via hematoxylin and eosin (H&E) staining. MRI and histology are then aligned using COFEMI-TPS and maps of cancer presence are established on each of the 26 MRI images by direct mapping from registered histology.

Results: A histology section and the corresponding MRI slice are show in Figure 1(a),(f) and 1(b),(g). The dark region indicated by the arrow in Figure 1(a),(b) which represents cancer is directly mapped to MRI following alignment of Figure 1(a),(f) to 1(b),(g) by the registration method. The mapping is shown in Figure 1(d),(i). Note that significant non-linear deformations are visible in the original histology, necessitating non-rigid transformation to correctly align the image pair. Overlay of MRI and aligned histology is shown in Figure 1(e),(j).

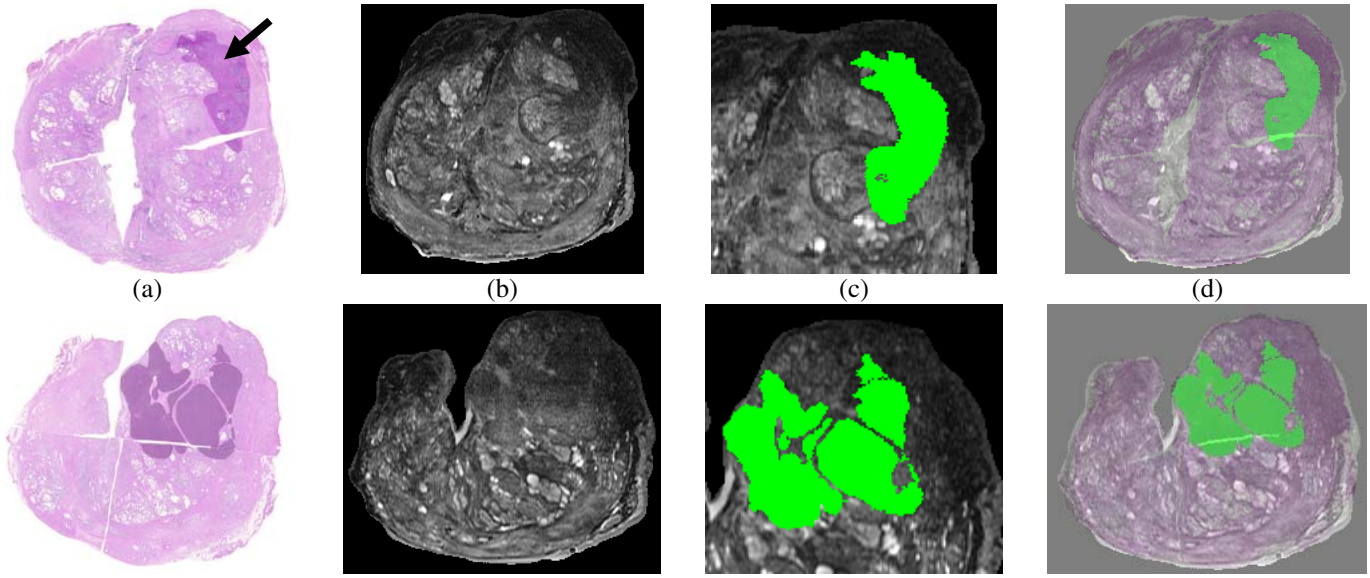

Figure 1: Histological cancer ground truth indicated by the arrow in (a) H&E stained histology is mapped to (b) MRI. (c) Cancer mappings by non-rigid COFEMI alignment method. (d) Overlay of MRI and histology. (f)-(j) Similar registration of another MRI-histology slice pair.

Conclusion: We demonstrate our new non-rigid registration method COFEMI-TPS for the task of aligning prostate histological sections with *ex vivo* MRI. While other techniques have struggled to align images from vastly different modalities such as MRI and histology, COFEMI-TPS is able to robustly align multimodal images. When utilized in CAD applications, our registration technique will provide improved classifier training instances and hence better tissue classification accuracy.

References:

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