Automatic Registration and Segmentation of pancreatic images

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INTRODUCTION:

Pancreatic cancer results in abnormal increase in size of the pancreas [1]. Due to patient breathing and its proximity to the lungs, the relative location of the pancreas changes significantly with the respiration cycle. A comparison of the progression of the cancer or treatment evaluation requires precise localization of the pancreas. Within subject registration is imperative for comparison of the pancreas for both within-session and between-session analyses. Once the motion artifacts are corrected, the pancreatic region can be segmented and analyzed for cancer progression or treatment evaluation. The current work presents a non-rigid, automatic global registration algorithm for abdomen MR image volumes and a clustering-based segmentation method for segmenting the pancreas from the registered volume.

ALGORITHMS:

Mutual Information was used as the *metric* for registration and the *optimization* was done by maximizing the normalized Mutual Information [2] between a reference pancreatic image (volume) and a distorted pancreatic image using a downhill simplex optimization algorithm [3]. The normalized Mutual Information was computed using a joint histogram of the different intensity levels in the image volume. The best initial-guess values for the simplex vertices in the optimization algorithm were estimated and used in the algorithm instead of giving random guess values. The registration algorithm comprised of two steps: the first step involved compensating for the shear in the image volume along the X and Y directions and the second step involved linear-shift, rotational-shift and linear scaling corrections respectively.

Segmentation was done by grouping voxels of similar intensities based on the *k-means* clustering algorithm [4,5]. The required cluster corresponding to the pancreas was then selected manually. Using this clustered section, a 3D binary mask was obtained and the location of the pancreas in the actual volume was highlighted by superimposing this mask over the volume. This method can only be employed in cases where the different regions have distinct and uniform intensity values.

METHODS:

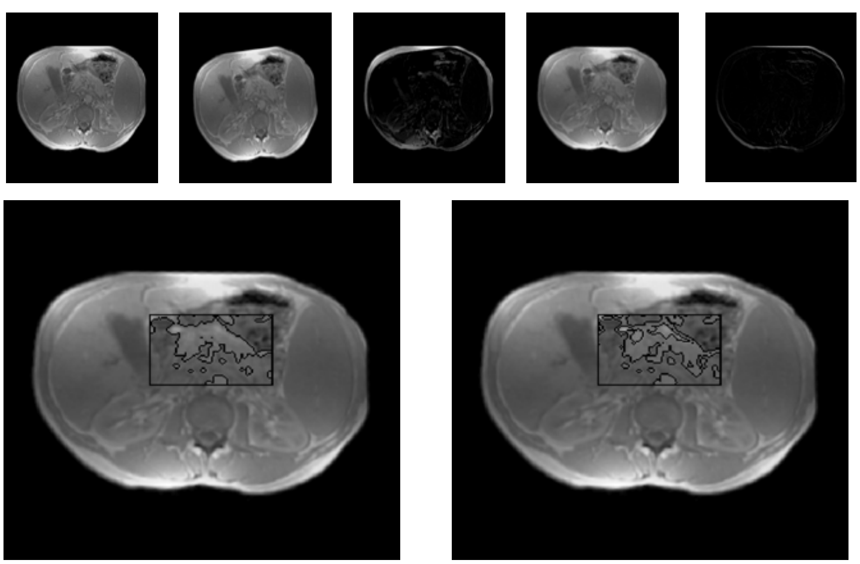
Abdomen MRI volumes with 9 slices (encompassing the entire pancreas) were acquired using a 1.5 Tesla GE scanner. A contrast agent was used prior to scanning to enhance the contrast of organs within the abdomen. Three such volumes with TR/TE equal to 1570/92, 180/4 and 180/1 ms respectively were obtained and used for the simulation. The simulation was performed to introduce distortions by linearly shifting, scaling and rotating the image volumes. The linear shift was randomly given ranging from 1 voxel unit to 20 voxel units along the X, Y and Z directions respectively. An affine scaling was given along the X and Y directions to produce the linear shape distortions varying from 80% to 120% of the actual volume. Finally, rotational shifts ranging from -10 degrees to +10 degrees (in 1 degree increments) along the Z axis were also given. Shear distortions were not simulated. However shear-correction was done in cases where there was a significant shear of slices in the volume due to patient breathing, using the first phase of the registration algorithm. The algorithms were implemented in MATLAB (Mathworks Inc., MA, USA) software.

RESULTS:

Simulation results showed that the registration algorithm was able to perform with a maximum linear-shift correction accuracy of ±0.5 voxel units, a maximum rotational-shift correction accuracy of ±0.5 degrees and the shape-distortions were corrected with a maximum error of ±3.1% of the shape of the reference image, on an average. Performance comparison for a 3D volume with a 2D slice (Figure 1) shows that the accuracy of this intensity-based registration algorithm is more for 3D volumes (where comparatively more intensity information is available). Further, on processing the noisy images by eliminating the non-uniform intensities along the various sections of the pancreas, the segmentation procedure was able to detect the pancreas in majority of the cases. The clustering was better for the aligned 3D volumes compared to 2D images. Results for a single slice (that prominently shows the pancreas) from the test volume are shown in Figure 2. The algorithm took an average time of approximately 4 minutes on a 3.5GB RAM, 3 GHz desktop computer.

DISCUSSIONS / CONCLUSION:

Thus, an automatic registration algorithm for registering pancreatic images has been developed. The pancreas segmentation procedure incorporated in the present work is simple and effective, however it is sensitive to intensity variations and therefore would not work well with noisy images. These methods together can thus be used for the effective diagnosis of pancreatic cancer. This procedure as a whole can also be used for other the study of other organs with respiratory deformity.



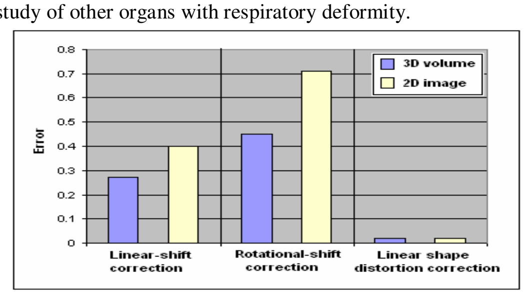


Figure 1

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Figure 2: (Clockwise from top left) Reference image, Distorted target image, Difference between reference and distorted target, Registered image, Difference between reference and registered, Pancreas segmented assuming 5 clusters, Pancreas segmented assuming 3 clusters (More number of clusters result in more localized segmentation)