Dynamic co-registration in pulmonary imaging using SPAMM tagging

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Introduction

The application of MRI for pulmonary imaging has come late in comparison to other regions of the body. This is due to the low proton density in the lung parenchyma and susceptibility induced static field inhomogeneities in the chest. Due to the introduction of hyperpolarized noble gases, MRI of the lungs has attracted increasing interest. Current methods of evaluating lung diseases are based on qualitative evaluation of visual appearance. Quantitative methods are required for diseases where changes are subtle and for serial studies. However, quantitation of lung function by dynamic imaging is complicated by the motion of the lungs during the respiratory cycle.

Method

A dynamic co-registration method using SPAMM tagging (1, 2) was implemented. In this technique, spin-labeled parallel tagging planes are created prior to the play-out of a MR imaging sequence. The intersections of these planes with the image plane give dark bands in the image. These grids are then imaged over time to track the underlying tissue motion. The positions of the grid intersections at each time point of the respiratory cycle are used as landmarks. These landmarks are identified on the reference image and on every image of the time series. Finally an affine transformation to map these images to the original is calculated. SPAMM tagged proton images of the lungs were acquired during inspiration (3) and matched to the first image of the time series using this approach.

Results

Figure 1 shows the deformation of a human lung during inspiration without dynamic co-registration. The time delay between consecutive images was 100 ms and so the time delay between the first and the last image was 400 ms. Considerable displacement of the diaphragm can be seen by reference to the white dashed line indicating the initial position of the right diaphragm. The effect of the co-registration algorithm can be seen in Fig. 2 which shows the same data set as in Fig. 1 but after dynamic co-registration. The horizontal line again indicates the initial position of the right diaphragm. The motion of the diaphragm and the deformation of the lung are clearly reduced.

Conclusion

The results show that SPAMM tagging and affine transformation can be successfully applied for dynamic co-registration in pulmonary imaging. This technique is applicable to both dynamic proton and hyperpolarized gas imaging. If a MR scan using hyperpolarized gas is performed after the acquisition of the proton image the calculated transformations can be applied to the gas images at equivalent phases of the respiratory cycle. The method is not restricted to lung imaging but could be applied also to other regions of the human body, e.g. to the heart. A remaining problem, especially for long time series, is the decay in the SPAMM tag which makes registration of the grid intersections in the last images of the time series inexact. Therefore, the accuracy of the technique could be enhanced by improving the visibility of the SPAMM grid over a longer time.

References

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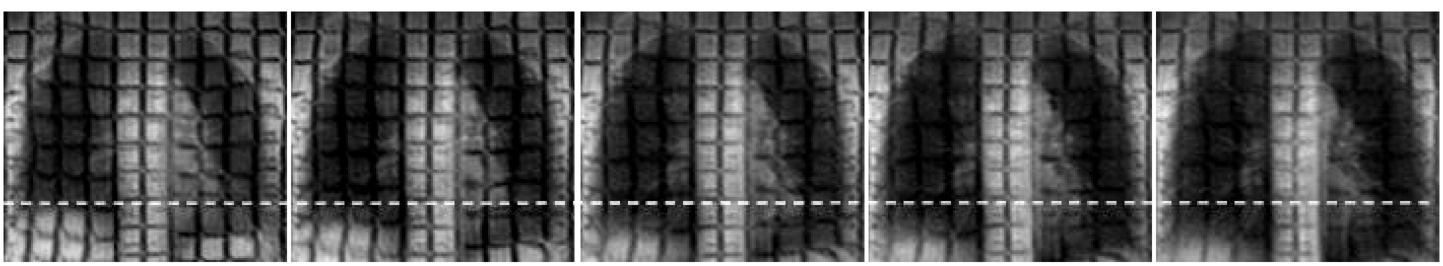

Fig. 1: Coronal proton images of a human lung during inspiration without any co-registration.

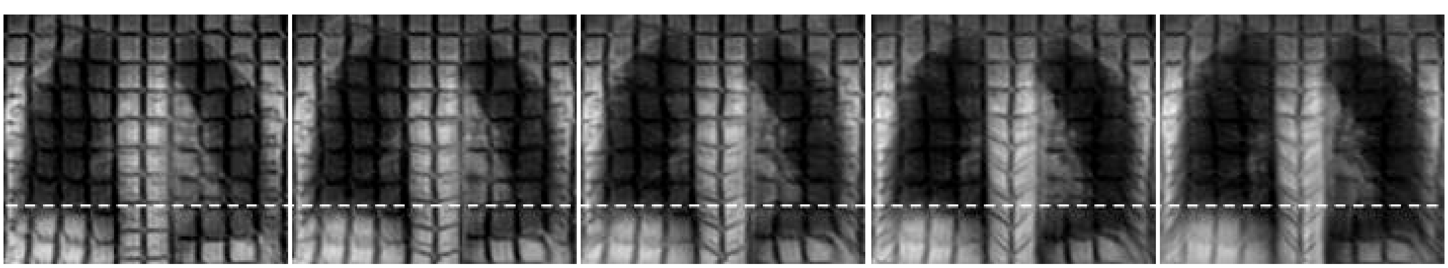

Fig. 2: Coronal proton images of a human lung during inspiration after application of the presented dynamic co-registration.