# Real-Time Tracking and Visualization of Regional Lung Motion with Dual Gradient Echo Acquisition

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**Introduction:** Fast gradient echo sequences with very short TR/TE are often used to track regional lung motion and deformation [1-2]. However, the visualization of lung tissue is in general difficult due to the much higher signal intensity of the surrounding tissues, such as fat and muscle in the chest wall. In our current work, a dual gradient echo approach was introduced to address this issue by acquiring two images, one with ultra short TE (0.67 ms) and one with a longer TE (2.4 ms). Since T2* in the lung is much shorter than those of the surrounding tissues, the difference of the two images can effectively suppress the signal from outside of the lung, resulting in a much improved visualization and tracking of lung parenchyma.

**Methods:** The dual gradient echo sequence used for this study is shown in Fig 1A, in which two images were acquired with TE = 0.67 and 2.4 ms. Imaging parameters were: FOV = 420, TR =3.4 ms. Rectangular FOV was used to achieve a time resolution of 250 ms. All studies were performed on a 3-T Siemens TIM Trio scanner using body array coils for reception.

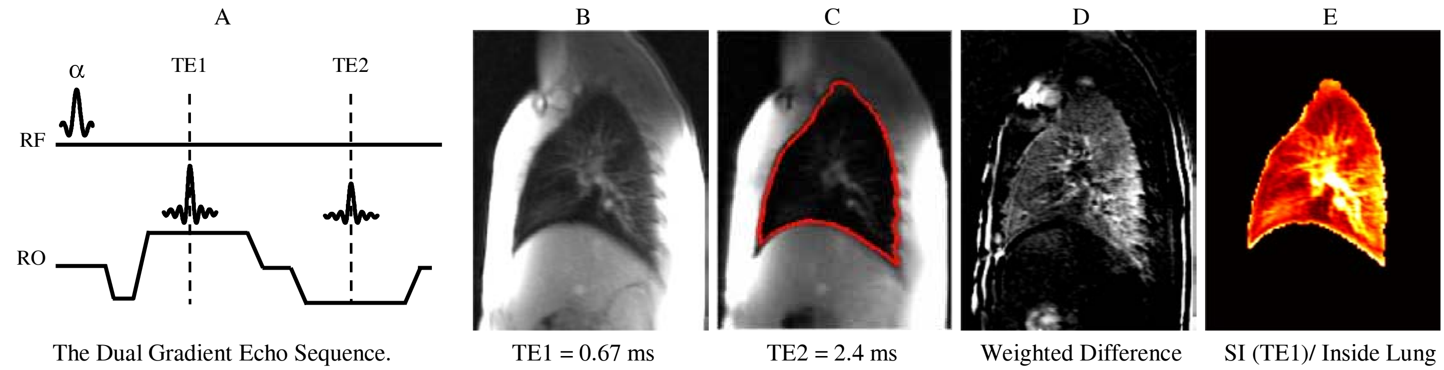


**Figure 1.** (A) Schematic diagram of the dual gradient echo sequence. (B)-(C) Images acquired at TE = 0.67 and 2.4 ms, respectively. (C) Weighted difference of the two images. (D) Color display of the signal intensity inside the lung after masking out the signal from outside of the lung.

**Results:** Figure 1B and 1C show example images obtained at TE1 = 0.67 ms and TE2 = 2.4 ms, illustrating the clear difference of signal intensity within the lung. By performing a subtraction of these two images (taking into consideration the slight signal decay of the surrounding tissues), one can obtain an image with near perfect suppression of the signal intensity outside of the lung (Fig. 1D). Alternatively, since the signal intensity within the lung is very low at TE2 = 2.4 ms, one can easily identify the boundary of the lung and create a binary mask (Fig. 1B). This mask can be applied to the image acquired at TE1 = 0.67 ms to completely remove the signal from outside of the lung (Fig 1E). When such an approach was used to acquire 100 pairs of images, it was straightforward to calculate the lung volume at all respiratory phases using such binary masks and to track the motion of the lung during normal and forced respiratory maneuvers (Fig. 2 and 3). A displacement map of regional lung motion can also be obtained using automated motion tracking software (2) (Fig. 4).

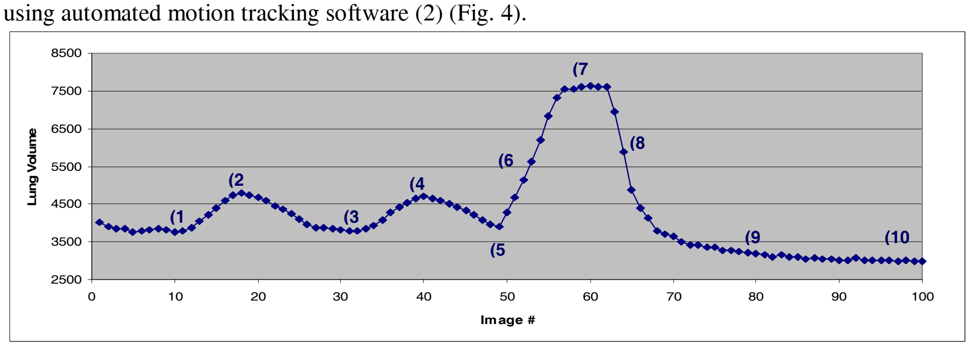


**Figure 2** Calculated lung volume from MR images for different respiratory phases.

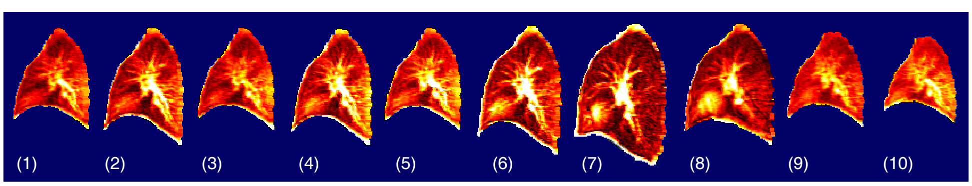


**Figure 3.** Sample images obtained at 10 selected respiratory phases.

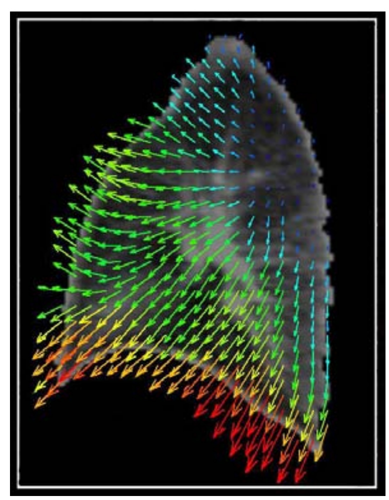

**Figure 4.** A sample displacement map of the lung during expansion.

**Conclusions:** We have implemented a fast dual gradient echo sequence for real-time tracking of regional lung motion, improving our ability to visualize the detailed local expansion of the lung during respiratory maneuvers. Since the two echoes are obtained at almost exactly the same time, they are completely registered, allowing for improved segmentation and suppression of signal contribution from outside of the lung. One drawback of the approach is the reduced time resolution from 150 ms per frame to 250 ms per frame.

**References:**

1. Voorhees, A., et al. MRI "Spirometry" for Regional Pulmonary Function Analysis. 12th ISMRM Annual Meeting, 2005, p.43.
2. Voorhees, A., et al. Real-time MR imaging and tracking of regional lung motion during forced breathing maneuvers. 13th ISMRM, 2006, p.1291.