# Motion Artifacts & Practical Solutions: Adaptive Motion Correction Methods

Julian Maclaren, Ph.D., julian.maclaren@stanford.edu
*Stanford University, Department of Radiology, Stanford, CA*

## Highlights/Take-home messages

- Adaptive motion correction (also known as prospective motion correction) is a means of maintaining data quality by continuously updating the imaging volume to follow the moving object of interest.
- Neuroimaging can benefit greatly from adaptive correction, as head motion is predominantly rigid body and can be accurately compensated for using adaptive methods.
- Obtaining tracking data of sufficient quality and temporal resolution is a major challenge in adaptive motion correction.

## Objectives and target audience

This presentation is aimed at scientists and clinicians interested in using motion correction or performing further research into motion correction techniques. The aim is to give a balanced view of the advantages, limitations and challenges of adaptive correction methods when applied to neuroimaging.

## Summary of presentation

*Introduction and theory:* Head motion remains a major problem in neuroimaging applications. Adaptive correction attempts to solve this problem by updating the imaging volume to follow the position of the head. This maintains the consistency of k-space data and prevents image artifacts.

*Method description and typical results:* Numerous methods have been employed to obtain tracking data for prospective correction. They can be grouped into three distinct categories: optical, field detection or navigator methods [1]. Once tracking data has been obtained, it must be transferred in real time to the MR imaging system and transformed into the coordinate system of the scanner. Finally the gradient and RF fields are updated based on the transformed tracking data. Recent results have been demonstrated at field strengths from 1.5 T to 7 T and for a range of imaging applications, including fMRI [2], DWI [3] and DTI [4], and spectroscopy [5], to name only a few examples.

*Advantages:* Adaptive correction methods have an inherent advantage over retrospective correction methods in that a uniform k-space sample density is maintained, the imaged object cannot leave the field of view, and spin history effects are avoided. Other advantages include compatibility with most imaging sequences and use of the standard reconstruction chain.

*Challenges:* The quality (precision, accuracy, latency) of tracking data is critical for successful adaptive correction. If an external tracking system is used, then MR compatibility and marker fixation are also major issues. Finally, uncorrected effects, such as B0 inhomogeneities and gradient non-linearities, can lead to residual artifacts after adaptive motion correction.

*Conclusions:* Adaptive motion correction methods show great promise in neuroimaging applications, due to their ability to maintain data quality during head motion.

*References:*

1. Maclaren, J., et al., *Prospective motion correction in brain imaging: A review.* Magnetic Resonance in Medicine: early view online, doi: 10.1002/mrm.24314.
2. Ooi, M.B., et al., *Echo-planar imaging with prospective slice-by-slice motion correction using active markers.* Magnetic Resonance in Medicine, 2011. **66**(1): p. 73-81.
3. Herbst, M., et al., *Prospective motion correction with continuous gradient updates in diffusion weighted imaging.* Magnetic Resonance in Medicine, 2012. **67**(2): p. 326-338.
4. Aksoy, M., et al., *Real-time optical motion correction for diffusion tensor imaging.* Magnetic Resonance in Medicine, 2011. **66**(2): p. 366-378.
5. Lange, T., et al., *Spectroscopic imaging with prospective motion correction and retrospective phase correction.* Magnetic Resonance in Medicine, 2012. **67**(6): p. 1506-1514.