# Efficient motion compensation for fetal MRI 

B. Kainz ${ }^{\text {a }}$ and D. Rueckert ${ }^{\text {a }}$<br>${ }^{a}$ Department of Computing<br>Imperial College London<br>SW7 2AZ London, UK<br>b.kainz@imperial.ac.uk

The recent advent of T2-weighted single shot fast spin echo (ssFSE) sequences has enabled magnetic resonance imaging (MRI) to play an essential role in fetal diagnosis, in particular where ultrasound fails to provide sufficient information to diagnose specific prenatal conditions. MRI is considered to be safe after the first trimester for 1.5 T and 3 T without the use of contrast agents. Sedation is not used during a scan and fetuses move freely while the mother breathes normally. Individual ssFSE slices can be acquired fast enough to freeze motion in time, however, motion between slices are likely to corrupt 3D scans by reducing image quality, hiding pathology and causing an overlap between different anatomical regions. Oversampling a target volume with multiple orthogonal stacks of 2D slices allows to apply slice-to-volume registration techniques (SVR) and super-resolution methods. In this talk we will review a simple but very effective and parallelisable SVR model similar to $x_{i}=W_{i} y+n_{i}$ for $1 \leq i \leq N$, where $x_{i}$ denotes a low resolution (LR) image stack of total $N$ stacks, and $y$ being a high resolution target image. $W_{i}=D B T_{i}$ combines motion compensation, sub-sampling and degradation effects, where $D$ is a sub-sampling matrix, $B$ is a blurring matrix, and $T_{i}$ is a transformation matrix of observation $i . n_{i}$ adds noise. The motion compensation problem can be divided into two main parts: (1) motion correction (estimating $W_{i}$ ) and (2) super-resolution (estimating $y$ ). Intensity-based image registration is used for estimating $W_{i}$, MRI point-spread function-informed super-resolution for obtaining a uniformly spaced motion-free high-resolution image. Expectation-maximization supports the iterative optimisation of (1) and (2) with an outlier rejection and noise mitigation model. This is joint work with King's College London: M. Murgasova, M. Rutherford, and J. V. Hajnal.

