Framework for optimal pulse sequence design for balanced steady state free precession in magnetic resonance fingerprinting (MRF)

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Magnetic resonance fingerprinting is an emerging technique that allows for a non-invasive quantification of multiple tissue properties by using a set of acquisition pulses. To accurately classify the tissue properties, the measured signal evolutions arising from nuclear magnetisation should be as separable from one another as possible. As the signal evolutions are a function of both tissue properties as well as pulse excitation parameters, the magnetisation signals generated are varied by physically changing the pulse excitation parameters in a Magnetic Resonance Imaging machine. In MRF, the pulse sequence parameters are traditionally chosen at random, leading to the risk that some of the magnetisation signals may not be separable. Therefore, in this study, a simulation framework to optimise the level of separability of magnetisation signals from different tissues using a balanced steady state free precession [BSSFP] sequence is demonstrated. A Bloch equations simulator for a BSSFP sequence was built to simulate the magnetisation of tissues. The input variables of a BSSFP sequence are flip angle, time to repeat the pulse and number of images. An optimising mechanism was built by combining a genetic algorithm and a distance correlation function which indicates the level of separability of the magnetisation signals. The combined system was run a number of iterations until convergence was achieved. Given the parallel nature of the Bloch equations and the distance correlation function, to improve the speed of execution, the system was coded to utilise a Graphical Processing Unit [GPU]. It was observed that, not only was the system able to increase the separability of magnetisation signals as the generations of the genetic algorithm progressed, but that the number of images required could also be maintained as low as thirty.

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