Imaging cerebrovascular pulsatility with MRI hypersampling and reinforcement learning

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Introduction: The recently found importance of vascular integrity for the health of the central nervous system calls for diagnostic methods to evaluate the impact of pulse pressure waves on the brain. Cerebrovascular compliance absorbs the impact of the pulse pressure wave on the brain, and the pressure gradient caused by arterial pulsatility is thought to be a driving force in the brain's glymphatic waste clearance system.

Objective: To demonstrate how a combination of dynamic image processing, machine learning, and inverse problem solving provides unprecedented insights into the very fast pulse waves traveling through the brain.

Methods: Pulse waveforms are extracted from dynamic MRI image sequences by the method of hypersampling by analytic phase projection.

Results: Estimates of pulse waveforms show characteristic features known from extracerebral pressure measurements, such as a systolic upstroke and dicrotic notch. In simulations, pulse waveforms can be modeled by forward and reflected pulse waves.

Conclusion: Pulse wave profiles afford a compact, visual, easily interpreted means for displaying information contained in pulse waves. Forward and reflected wave components might carry information about vascular impedance in general, and their estimation from data poses an interesting inverse problem.