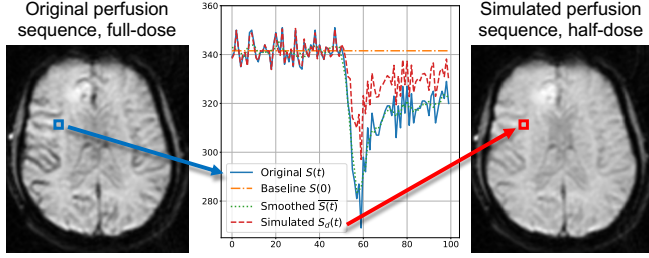


# A LIGHTWEIGHT METHOD TO SIMULATE LOW-DOSE DSC-PERFUSION SEQUENCES

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**Fig. 1.** Low-dose DSC-perfusion simulation method.

DSC-perfusion allows to quantify the blood supply of an organ. A dose of gadolinium-based contrast agent (GBCA) is injected intravenously and repeated T2\* imaging produces a temporal sequence of images. We present a method to simulate low-dose DSC sequences from reference acquisitions, show how it can be derived following simple assumptions, and validate it with preclinical rat data. This method could be used to benchmark the robustness of DSC-perfusion software.

## 1. METHOD: DEGRADE REFERENCE SEQUENCES

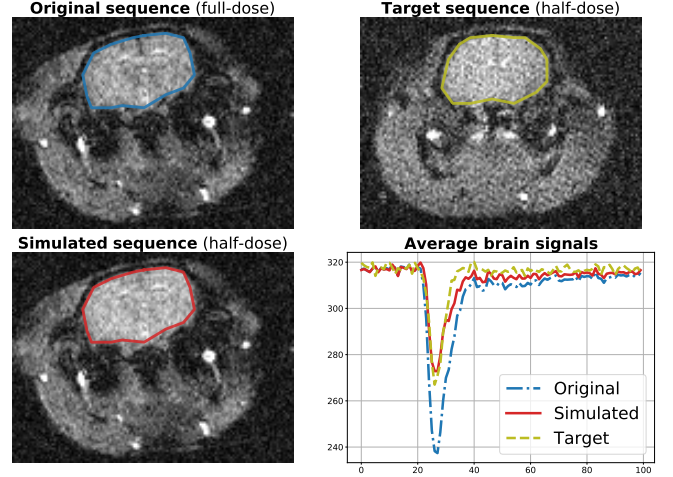
According to DSC-perfusion theory [1], the voxel signal  $S(t)$  of a perfusion sequence is proportional to the concentration  $C(t)$  of GBCA. In practice, only a discrete and noisy version of the true signal can be observed:  $S(t) = S(0) + \kappa \cdot C(t) + \epsilon(t)$  where  $\epsilon(t) \stackrel{\text{iid}}{\sim} \mathcal{N}(0, \sigma_\epsilon^2)$  and  $t \in t_0, \dots, t_T$ .

Assuming that the temporal dynamics of  $C(t)$  are slow with respect to the temporal sampling interval  $\Delta t = t_{j+1} - t_j$ , we can write  $\overline{C(t)} \approx C(t)$  where the operator  $\overline{(\cdot)}$  denotes a local average. Note that this hypothesis is reasonable since it actually corresponds to a desired behavior when selecting the sampling interval  $\Delta t$ . Since the noise distribution is assumed independent of time, we can finally write  $\epsilon(t) \approx S(t) - \overline{S(t)}$ .

Introducing the artificial dose reduction factor  $0\% \leq d \leq 100\%$ , we argue with [1] that the signal  $S_d$  that would have been observed instead of the reference signal  $S$  if the injected GBCA dose had been reduced by a factor  $d$  finally writes:

$$S_d(t) = S(0) + \kappa \cdot C(t) \times d + \epsilon(t) \approx S(t) - (1-d) \cdot [\overline{S(t)} - S(0)].$$

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**Fig. 2.** DSC-perfusion sequences either acquired from a rat or simulated, and corresponding average brain signals.

## 2. EXPERIMENT: VALIDATE WITH RAT DATA

We validate the method using rat data\*. The animal was injected in a first session with a standard 0.1 mmol/kg dose of GBCA, and the following day with a reduced 0.05 mmol/kg dose. The full-dose perfusion sequence was artificially degraded into a simulated half-dose sequence (i.e.  $d=0.5$ ). The average brain signals are then extracted and visually compared to each other. We verify on Figure 2 the good agreement between the simulated and target half-dose signals.

## 3. CONCLUSION

We derived a lightweight procedure that simulates low-dose DSC-perfusion sequences by degrading reference acquisitions, and verified its practical validity using preclinical data.

## 4. REFERENCES

- [1] Jahng et al., “Perfusion MRI: a comprehensive update on principles and techniques,” *Korean J. of Radiology*, 2014.

\*Data acquired in line with the principles of the Declaration of Helsinki.