MR Quantification: An automated self-normalization technique to reduce variability in functional maps.

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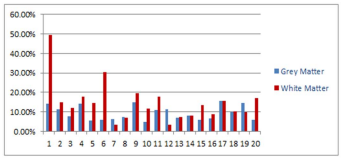
Target Audience: Physicists and radiologists interested in MR Quantification and. reducing variability in functional maps generated by perfusion studies.

Purpose: MRI though considered being an advanced technique for clinical diagnosis has not yet been accepted clinically as a quantification tool. Reliable and reproducible results have always been a challenge for MRI. For perfusion analysis, commercial vendors report relative functional maps due to various factors that prevent quantification. The criticality in reporting quantitative values is of at most need in perfusion based analysis. Stroke for example, decision for selection of candidates that require tPA(Tissue plasminogen activator) is an task for clinicians using relative values, Quantification can help reduce the risk involved in this decision making process and help identify candidates more accurately. Manual intervention always brings subjectivity into picture, automated approach for normalizing the functional maps can help in reducing user induced variability leading towards more reproducible results.

Methods:
Assess Variability (Internal): Two post processing techniques are supported for perfusion analysis in GE's commercially available products Functool and ReadyView namely BrainStat GVF and BrainStat AIF. We subjected the relative Cerebral Blood Volume (rCBV) functional map to region of interest (roi) analysis and report variability calculated as the ratio of standard deviation and average of the roi, and reports it as a percentage. To do this analysis we choose 20 data sets from field with variable inputs for scan parameter. These sample data sets selected show some representative values input at scan time and we choose two kinds one that follow ACR recommendations and others which don't. Results of the roi analysis are shown below. Fig 1: represents inter subject variability for 20 cases reported by BrainStat GVF and Fig 2 for BrainStat AIF.

Fig 1 

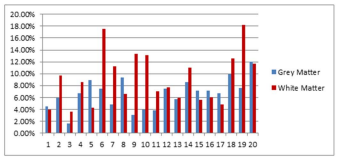


Fig 2

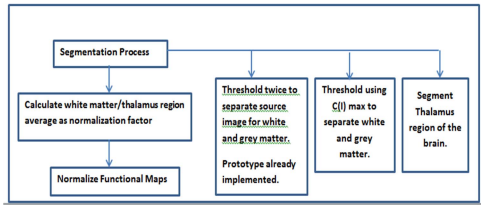
Fig 1: Inter subject variability for BrainStat GVF (Max reported - 48%) and Fig 2Inter subject variability for BrainStat AIF (Max reported - 20%).

Previous Publication: Radiology magazine reported results of a study conducted by a group of external scientists who designed a digital phantom for evaluating perfusion studies [1]. They report that all commercial vendors were far behind research tools indicating that commercial tools had compromised quality over performance.

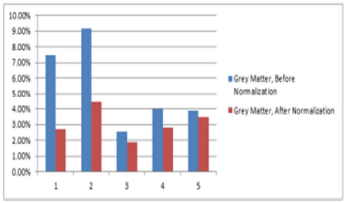
Proposed automated self-normalization approach:

A post processing technique is proposed to normalize functional maps is represented below. We use this method and generate normalized rCBV functional maps and run the roi analysis for 5 representative cases.

1. Segmentation: Segment large regions of tissue , in this approach we separate white and grey matter (We obtain this by thresholding the source image twice first to separate background and foreground and then in the second pass we separate white and grey matter)
2. Generate the white matter average of the functional map (rCBV).
3. Normalize rCBV maps with the average computed.



Results: We choose 5 data sets from the field that represent variability in input parametersat scan time and run the five data sets through the roi analysis on the normalized rCBV function map and the variability is compared with the non-normalized map. Initial results show reduction in variability by almost 50%. Both inter and intra subject variability is reduced. Reduction in variability is seen irrespective of variable inputs for parameters during scan time.

Fig 3 

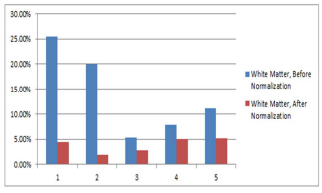


Fig 4

Fig 3: Inter subject variability before and after normalization for grey matter, Fig 4: Inter subject variability before and after normalization for white matter

Conclusion: An automated attempt to self-normalize functional maps yields reduction in variability of almost 50% in the rCBV maps. The technique demonstrated on the rCBV maps can be easily extended to other functional maps generated for perfusion analysis. The technique is effective irrespective of the variability in input parameters during scan time.

References:

[1]. **Accuracy and Reliability Assessment of CT and MR Perfusion Analysis Software Using a Digital Phantom1**
K Kudo etal ***Radiology:*** Volume 267, Pg 201.