High Dynamic Range Processing Improves Global Contrast

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Introduction
High Dynamic Range (HDR) imaging principles and tools have been applied to MR in the past as a way to improve automatic windowing and leveling and as a means of artificially increasing the dynamic range of Analog to Digital Converters[1,2]. This abstract extends these principles by using professional software designed for blending photographs with differing local contrasts to improve the global contrast of a single image. The result of applying these tools to a collection of differing relaxation weighted images produces an image with increased global contrast and effective information within a single image by retaining the best features of each weighted image.

Methods
A rat ankle was imaged on a 7T Varian scanner using a standard spin echo sequence. The parameters TR and TE were adjusted to yield T_1, T_2 and proton-density weighting. The analysis was performed in Matlab with the exception of HDR image generation. Photomatix, a popular HDR photography package was used and is freely available online. Images were imported back into Matlab for a quantitative analysis of the HDR processing improvement. Local intensity regions of interest were defined by the anatomy. Four ROIs were drawn around a section of muscle, bone, cartilage and ligament. The FWHM of the local intensity distribution was used as a metric of local contrast. The FWHM of each ROI was averaged to make a quantitative estimate of global contrast.

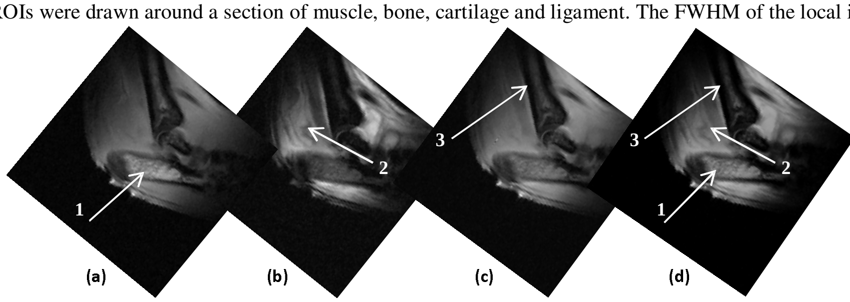

Figure 1. Rat ankle imaged using T_1 (a), T_2 (b), density (c) weighting and using the HDR method (d). Arrows indicate the two largest local contrast regions in the image set for three different rois.

Results
Qualitative results are shown in figure 1. Bone and hard tissue contrast were best captured by T_1 and density weighted images while soft muscle and ligament tissue contrast were best differentiated in the T_2 weighted images. The HDR image retains the best hard and soft tissue contrasts seen in the respective weighted images. Quantitatively, the results support these findings. Table 1 and figure 2 demonstrate that the HDR method, while not being the best in any of the local ROIs, was always better than 2 of the other modalities and on average was the highest. Each voxel in the HDR image is locally weighted for the best contrast and is a linear sum of each of the modalities, suggesting that no new information can be gained locally although on a global scale there is more information per HDR image than in any of the other modalities.

ROI	T1-weighted	T2-weighted	Rho-weighted	HDR Method
Bone	30	12	21	28
Muscle	17	54	22	32
Ligament	44	74	59	68
Cartilage	39	22	23	36
Combined	**70**	**66**	**56**	**72**

Table 1. FWHM of the histogram dynamic range (1-256). Large values indicate increased local contrast.

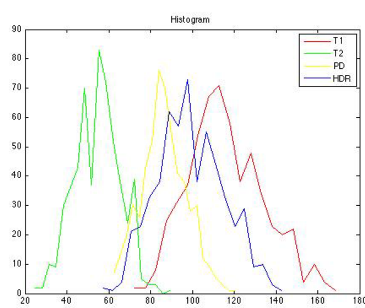

Figure 2. Hist.of pixel distribution in bone.

Discussion
Local contrast information from differing relaxation modalities can be preserved and combined into a single image using the HDR method resulting in increased over all global contrast and information per image. Increasing the amount of information per image is potentially useful in cutting down errors made in the clinical analysis of radiological images. In addition, autosegmentation and autodetection/classification algorithm performance may benefit from the improved global contrast. Future work in this area may include operations in frequency space and potentially designing specific pulse sequences to take advantage of HDR imaging capabilities.

References
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