Support Vector Regression based Denoising for MRI Image

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Target Audience

Researchers and clinical practitioners who are interested in developing new algorithms for MRI image denoising and MRI image processing.

Purpose

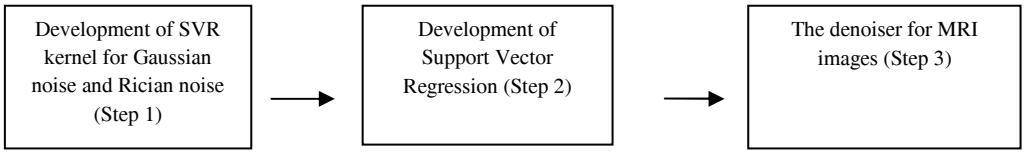
A generic problem of MRI images is the low SNR, and filtering is the widely used technique to suppress MRI image noise. Images filters based on machine learning algorithms, such as Support Vector Machine (SVR), have been shown to have superior performance because the signal can be preserved better. In this abstract, we apply Support Vector Regression based denoiser (SVR denoiser) for MRI image processing. Generally speaking, SVR denoiser takes advantages of existing information of image noise, while filtering does not.

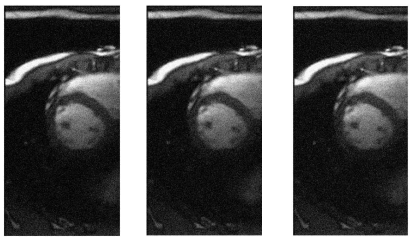
Methods

We develop SVR denoiser for MRI images, and SVR denoiser for MRI images has the generic format:

$$\min_{w,b} \varphi(w) = \frac{\|w\|^2}{2} + C \cdot \sum_{i=1}^{n} \varepsilon_i.$$

The framework of SVR denoiser is shown in the following figure:

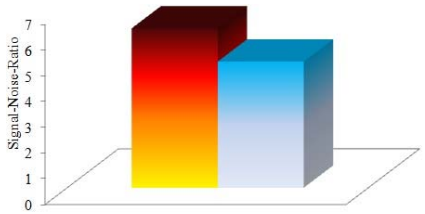




(a) (b) (c)

Figure 1 The image quality of SVR denoiser for MRI image with Gaussian noise and Rician noise: (a) the original image with Gaussian noise and Rician noise, (b) the denoised image by SVR denoiser, and (c) the denoised image by filter

The algorithm development has four steps: Step 1. develop SVR kernel for Gaussian noise and Rician noise; Step 2. develop the algorithm of Support Vector Regression; Step 3. develop the SVR denoiser with the kernels for Gaussian noise and Rician noise; Step 4. evaluate SVR denoiser for MRI images by measuring the image quality and calculating Signal-Noise-Ratio. We apply SVR denoiser to Cardiac images, and compare the image quality and Signal-Noise-Ratio against the conventional method Gaussian filter.



(**Figure 2** The calculated Signal-Noise-Ratio of the denoised MRI images against the original image by: (a) SVR denoiser, and (b) Gaussian filter denoiser

Results

Figue 1 shows the image quality of SVR denoiser for Cardiac image, where Figure 1 (a) is the orignial MRI image with Gaussian noise and Rician noise. Figure 1 (b) is the SVR denoised MRI image, Figure 1 (c) is Gaussian filter denoised MRI image. From Figure 1 we can see, both SVR denoiser and Gaussian filter denoiser improve the quality of the orignal MRI image in Figure 1(a). From Figure 1 we can also see, the image quality from SVR denoiser is significantly better than the conventional Gaussian filter denoiser.

Figure 2 shows the calculated Signal-Noise-Ratio from SVR denoiser against that from the conventional method of Gaussian filter denoiser. From Figure 2 we can see, the Signal-Noise-Ratio from SVR denoiser is significantly higher than the Signal-Noise-Ratio from the conventional Gaussian filter denoiser. The original image for Figure 2 is Figure 1.

Discussion

In this study, we have demonstrated that SVR is an ideal algorithm for MRI image denoising: significant image quality improvement over SVR denoiser, and signicant Signal-Noise-Ratio improvement over SVR denoiser. We successfully applied SVR denoiser to MRI image with Gaussian noise and Rician noise, but the performance of SVR denoiser can be further improved by methods such as designing better kernels. In future research, we will develop more sophisticated Support Vector Machine for MRI image denoiser with better using existing information of image noise. Currently, we are working on C++ implemenation of SVR denoiser.

Conclusions

We applied SVR denoiser to MRI image with Gaussian noise and Rician noise. Experimental results show that, SVR denoiser significantly improves the quality of MRI image with Gaussian noise and Rician noise, and SVR denoiser significantly increases the Signal-Noise Ratio of MRI image with Gaussian noise and Rician noise.

References

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