Memory-Augmented Model-Driven Network for Pan-sharpening

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Contributions

Our main contributions are summarized in the following three aspects:

☛ By extending the iterative algorithm into a multistage solution that combines the benefits of both model-based and data-driven deep learning techniques, we present a novel interpretable memory-augmented model-driven network (MMNet) for Pan-sharpening. The interpretation of the deep model is enhanced by such a design.

☛ To address the significant information loss problem in the signal flow, we suggest a new memory mechanism which is orthogonal to signal flow and develop a non-local cross-modality module. Such a design enhances the deep model's capacity for representation.

☛ Extensive experiments over three satellite datasets demonstrate that our proposed network outperforms other state-of-the-art algorithms both quali tatively and quantitatively.

Proposed approach

Model formulation:

The degradation process by using the maximum a posterior principle can be reformulated as:

$$\max_{\mathbf{H}} \frac{1}{2}\|\mathbf{L}-\mathbf{DKH}\|_2^2+\eta\Omega_l(\mathbf{H}|\mathbf{P})+\lambda\Omega_{NL}(\mathbf{H}|\mathbf{P})$$

We solve the optimization problem using half-quadratic splitting (HQS) algorithm:

$$\min_{\mathbf{H},\mathbf{U},\mathbf{V}} \tfrac{1}{2}\|\mathbf{L}-\mathbf{DKH}\|_2^2+\tfrac{\eta_1}{2}\|\mathbf{U}-\mathbf{H}\|_2^2+\eta\Omega_l(\mathbf{U}\mid\mathbf{P})+\tfrac{\lambda_1}{2}\|\mathbf{V}-\mathbf{H}\|_2^2+\lambda\Omega_{NL}(\mathbf{V}\mid\mathbf{P})$$

Updating U, V, and H alternately:

Updating U

$$\mathbf{U}^{(k)}=\arg\min_{\mathbf{U}}\frac{\eta_1}{2}\left\|\mathbf{U}-\mathbf{H}^{(k)}\right\|_2^2+\eta_2\Omega_l(\mathbf{U}\mid\mathbf{P})$$

$$\mathbf{U}^{(k)}=\operatorname{prox}_{\Omega_l(.)}\left(\mathbf{U}^{(k-1)}-\delta_1\nabla f_1\left(\mathbf{U}^{(k-1)}\right)\right)$$

$$\nabla f_1\left(\mathbf{U}^{(k-1)}\right)=\mathbf{U}^{(k-1)}-\mathbf{H}^{(k)}$$

Updating V

$$\mathbf{V}^{(k)}=\arg\min_{\mathbf{V}}\frac{\lambda_1}{2}\left\|\mathbf{V}-\mathbf{H}^{(k)}\right\|_2^2+\lambda\Omega_{NL}(\mathbf{V}\mid\mathbf{P})$$

$$\mathbf{V}^{(k)}=\operatorname{prox}_{\Omega_{NL}(.)}\left(\mathbf{V}^{(k-1)}-\delta_2\nabla f_2\left(\mathbf{V}^{(k-1)}\right)\right)$$

$$\nabla f_2\left(\mathbf{V}^{(k-1)}\right)=\mathbf{V}^{(k-1)}-\mathbf{H}^{(k)}$$

Updating H

$$\mathbf{H}^{(k+1)}=\arg\min_{\mathbf{H}}\frac{1}{2}\|\mathbf{L}-\mathbf{DKH}\|_2^2+\frac{\eta_1}{2}\left\|\mathbf{U}^{(k)}-\mathbf{H}\right\|_2^2+\frac{\lambda_1}{2}\left\|\mathbf{V}^{(k)}-\mathbf{H}\right\|_2^2$$

$$\mathbf{H}^{(k+1)}=\mathbf{H}^{(k)}-\delta_3\nabla f_3\left(\mathbf{H}^{(k)}\right)$$

$$\nabla f_3\left(\mathbf{H}^{(k)}\right)=(\mathbf{DK})^T\left(\mathbf{DKH}^{(k)}-\mathbf{L}\right)+\eta_1\left(\mathbf{H}^{(k)}-\mathbf{U}^{(k)}\right)+\lambda_1\left(\mathbf{H}^{(k)}-\mathbf{V}^{(k)}\right),$$