

Motion Compensated Filtering

Version 2.0.1

Motion compensated filtering performs video filtering along moving object trajectories [1]. Therefore, it produces superior results when compared to standard 3D or 2D video filtering that does not take into account motion information.

The Motion Compensated Filtering module is preformed by using the `mcfilter.dll` which should reside in the working directory of DIVA3D where `DIVA3D.EXE` resides. When DIVA3D starts, a sub-menu called *Motion Compensated Filtering* appears under the DIVA3D Modules menu. The options of this sub-menu provide several different implementations for motion-compensated temporal or spatio-temporal filtering of a grayscale (single-channel) noisy video sequence. In all implementations, motion estimation is performed by a three-step search block matching method on the noisy image sequence. For all the available options, the same procedure is followed: the user first selects the input video stream (containing the video sequence to be filtered) and then specifies the input parameters for the selected filter through a filter-specific dialog box. The operations of this module are supported by the Camera IO module.

The input parameters of each filter are described below.

- **MC T Median:** It is an implementation of a motion-compensated temporal median filter. In this implementation, only the temporal filtering is performed. The frames for which no temporal information exists (when the temporal window exceeds the start and end frames of the sequence) remain unfiltered. A view of the MCT Median filter option dialog box can be seen in Figure 1. The input parameters of this dialog box are explained below:

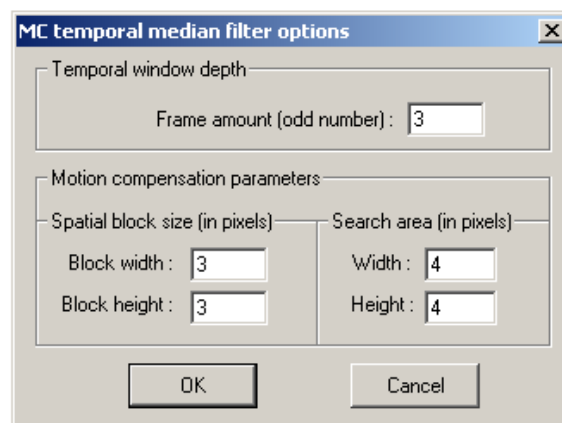


Figure 1: MC temporal median filter options dialog box.

- *Temporal Window:* The *Depth* parameter determines the 1D temporal window size. If the current frame is k , then the frames that will be used for its filtering will be: $[k - (\text{int})(\text{Depth}/2), \dots, k-1, k, k+1, \dots, k + (\text{int})(\text{Depth}/2)]$. The length of the temporal window must be an odd integer number.
- *Motion Compensation:* The *Block Width* and *Block Height* parameters represent the block size that will be used by the block matching algorithm in order to estimate the motion fields on the frames inside the temporal window. The *Search X* and *Search Y* parameters are used in defining the search region size $[(\text{Width} + 2 \cdot \text{Search}_X) \cdot (\text{Height} + 2 \cdot \text{Search}_Y)]$ used by the block matching algorithm.
- **MC SP-T Median:** It is an implementation of a motion-compensated spatio-temporal median filter. Figure 2 displays the filter option dialog box.

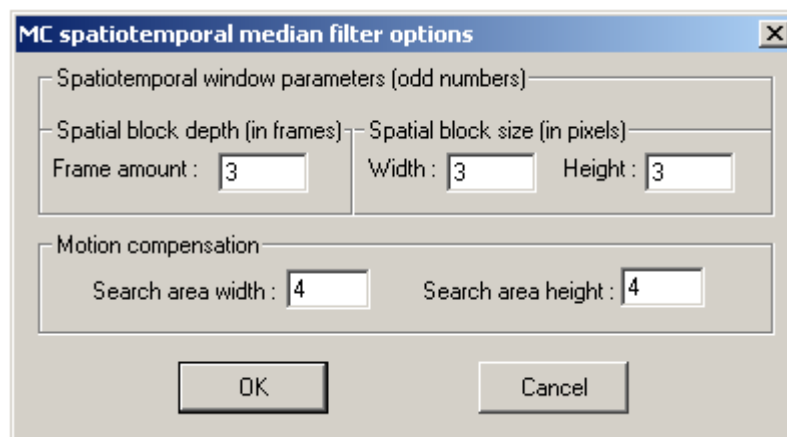


Figure 2: MC spatiotemporal median filter options dialog box.

The input parameters of this dialog box are explained below:

- *Spatio-Temporal Window:* The *Width*, *Height* and *Depth* parameters determine the spatio-temporal filter window dimensions in the x , y and t coordinates respectively. Specifically, for the temporal window size *Depth*, if the current frame is k , then the frames that will be used for its filtering will be in the range: $[k - (\text{int})(\text{Depth}/2), \dots, k-1, k, k+1, \dots, k + (\text{int})(\text{Depth}/2)]$. The spatial filter window is positioned in all other frames inside the temporal window (except frame k), according to the estimated motion trajectory. The block size used by the block matching algorithm is set to be equal to the spatial block size. Both spatial and temporal window dimensions must be odd numbers.
- *Motion Compensation:* The *Search X* and *Search Y* parameters are used in defining the search region size $[(\text{Width} + 2 \cdot \text{Search}_X) \cdot (\text{Height} + 2 \cdot \text{Search}_Y)]$ used by the block matching algorithm.

- **MC SP-T LMMSE:** It is an implementation of a motion-compensated spatio-temporal adaptive linear minimum mean square error (LMMSE) filter. Figure 3 displays the filter input parameter dialog box.

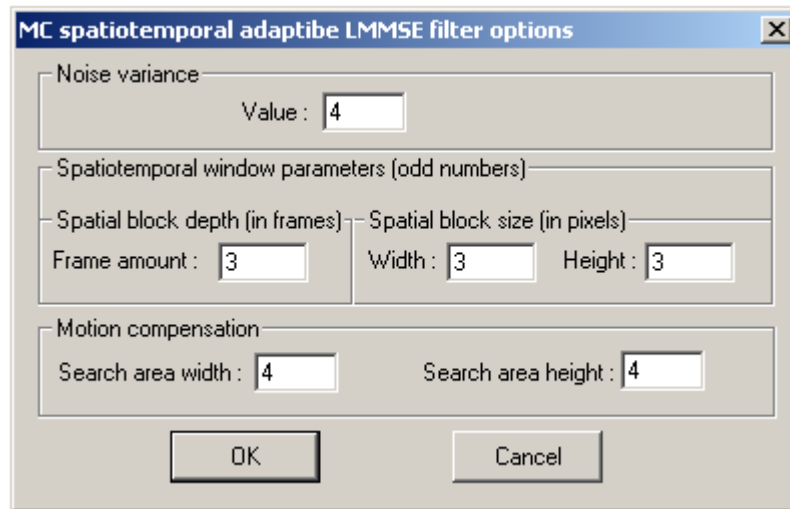


Figure 3: MC spatiotemporal adaptive LMMSE filter options dialog box.

The input parameters of this dialog box is explained below:

- *Spatio-Temporal Window:* The *Width*, *Height* and *Depth* parameters determine the spatio-temporal filter window dimensions in the x, y and t coordinates respectively. Specifically, for the temporal window size *Depth*, if the current frame is *k*, then the frames that will be used for its filtering will be in the range: $[k - (\text{int})(\text{Depth}/2), \dots, k-1, k, k+1, \dots, k + (\text{int})(\text{Depth}/2)]$. The spatial filter window is positioned in all other frames inside the temporal window (except frame *k*), according to the estimated motion trajectory. The block size used by the block matching algorithm is set to be equal to the spatial block size. Both spatial and temporal window dimensions must be odd numbers.

- *Motion Compensation:* The *Search X* and *Search Y* parameters are used in defining the search region size $[(\text{Width} + 2 \cdot \text{Search}_X) \cdot (\text{Height} + 2 \cdot \text{Search}_Y)]$ used by the block matching algorithm.

- **MC SP-T AWA:** It implements the motion-compensated spatio-temporal adaptive weighted averaging filter.

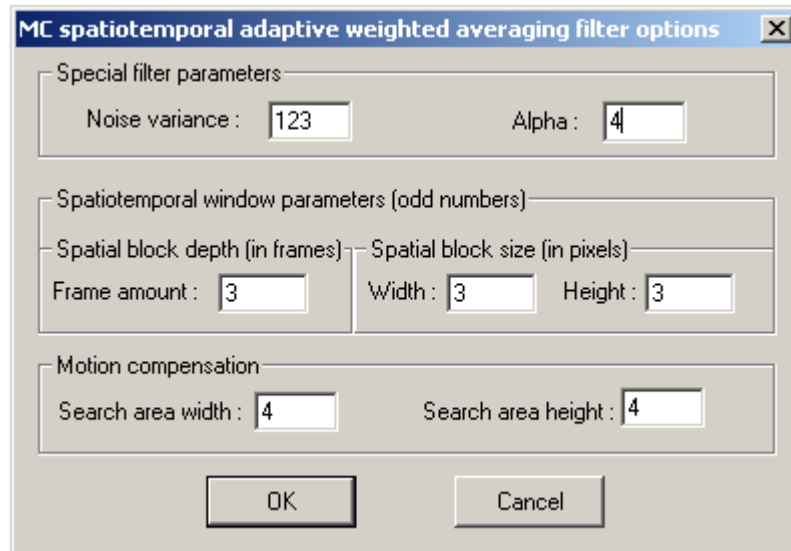


Figure 4: MC spatiotemporal adaptive weighted averaging filter options dialog box.

The input parameters of this dialog box is explained below:

- *Noise Variance:* The variance of the noise that has corrupted the input video sequence, being either known or estimated beforehand.
- *Alpha Parameter:* It represents a filter parameter affecting the filter window weights and taking positive values ($\alpha > 0$). If α is set equal to 0, all filter window weights become equal, thus leading to a moving average filter. It is usually set equal to 1.
- *Spatio-Temporal Window:* The *Width*, *Height* and *Depth* parameters determine the spatio-temporal filter window dimensions in the x, y and t coordinates respectively. Specifically, for the temporal window size *Depth*, if the current frame is k , then the frames that will be used for its filtering will be in the range : $[k - (\text{int})(\text{Depth}/2), \dots, k-1, k, k+1, \dots, k + (\text{int})(\text{Depth}/2)]$. The spatial filter window is positioned in all other frames inside the temporal window (except frame k), according to the estimated motion trajectory. The block size used by the block matching algorithm is set to the spatial block size. Both spatial and temporal window dimensions must be odd numbers.
- *Motion Compensation:* The *Search X* and *Search Y* parameters are used in defining the search region size $[(\text{Width} + 2 \cdot \text{Search}_X) \cdot (\text{Height} + 2 \cdot \text{Search}_Y)]$ used by the block matching algorithm.

Bibliography

- [1] A. Murat Tekalp, 'Digital Video Processing', Prentice Hall, 1995