## Examination of Segmented Averages in ICA Filtered EEG

Introduction:

To measure the effectiveness of ICA, as well as the utility of correlation as an error metric, the absolute error between relevant averaged segments of the baseline EEG and its ICA filtered approximation were compared. The averaged extracted blinks were also compared to the averaged projected blinks.

Procedure:

The different averaged segments: baseline, filtered (FastICA and Infomax), projected blink and corresponding ICA extracted blink, were generated by first segmenting the data into 200 ms intervals centered at the simulated blink peaks. We then averaged across these segments, producing one averaged segment for each case. The reader may reference NicTR2004 - 3, 7 and 8 for further details on this segmenting process.
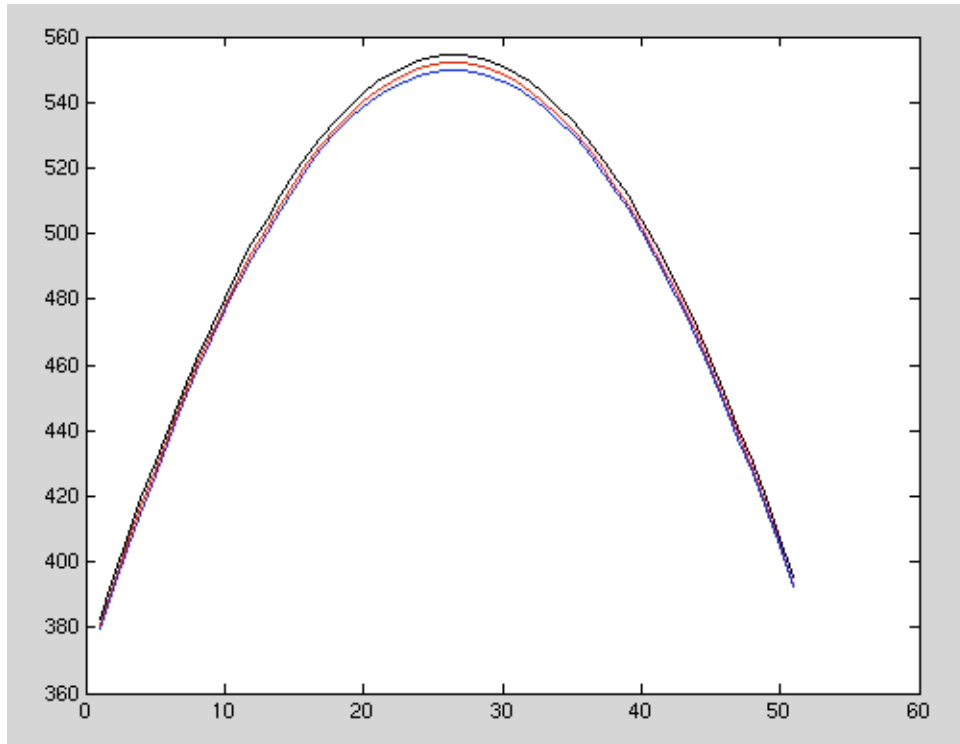
Figure 1: Projected Blink, Infomax Extracted Blink and FastICA-Run # 1 Extracted Blink
(Channel # 2 | Simulated Blink Type # 5)
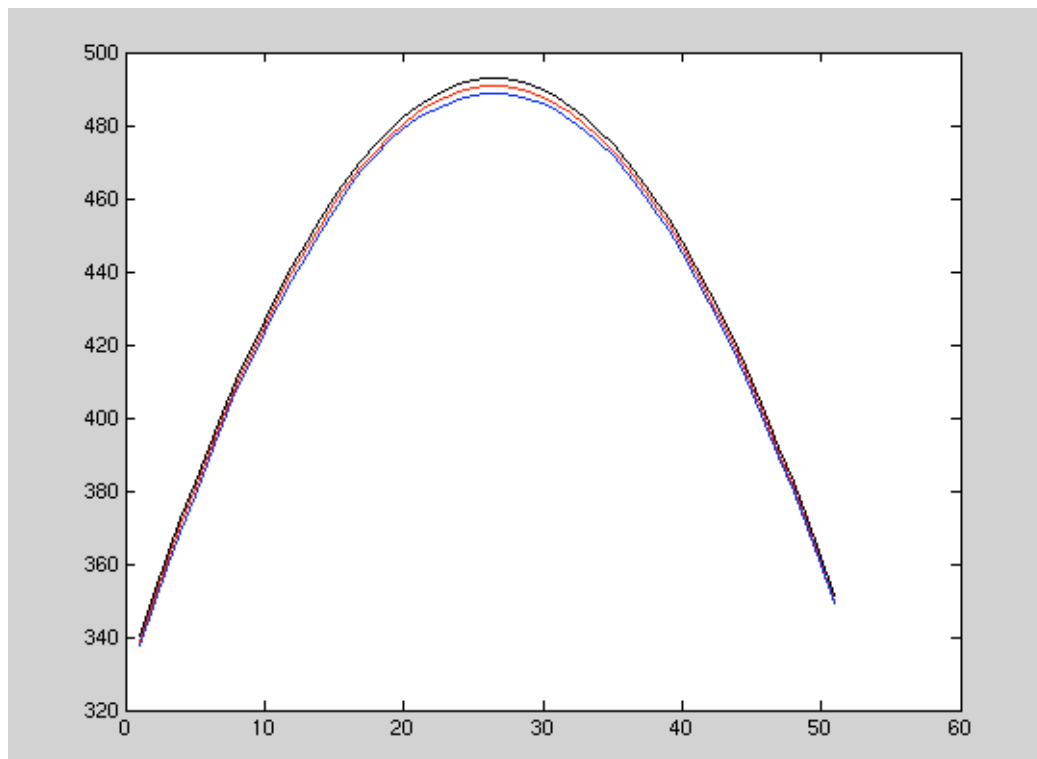
Horizontal Scale: Samples (sample # 25 = blink peak) | Vertical Scale: Microvolts
Blink-Template Tolerance: 0.95 | #IC Extracted: 1(FastICA) / 1(Infomax)

As Figure 1 shows, the Infomax (average) extracted blink was closer to the (average) actual projected blink.

Figure 2: Projected Blink, Infomax Extracted Blink and FastICA-Run # 1 Extracted Blink
(Channel # 6 | Simulated Blink Type # 5)

Horizontal Scale: Samples (sample # 25 = blink peak) | Vertical Scale: Microvolts
Blink-Template Tolerance: 0.95 | #IC Extracted: 1(FastICA) / 1(Infomax)

As Figure 2 shows, the Infomax (average) extracted blink was again closer to the (average) actual projected blink.

In both cases, Infomax was more successful than FastICA in removing the blinks from the data. However, as can be seen in the vertical separation between the curves on the figures, neither completely removed the blink activity.

This vertical separation is best illustrated by using an absolute error, which simply computes the vertical separation between the curves, point by point. Correlation, on the other hand, informs you if the curves have similar trends, and does not necessarily capture this error.

Note:
Relative error, which divides the absolute error at each point by the magnitude of the corresponding actual data value, is another useful metric, and tells you what percent the absolute error is of the actual data value at that point.

Figure 3: Table of Absolute Error Values (Max, Mean, Median and Standard Deviation)
Between (Averaged) Actual and (Averaged) Extracted Blinks for Channels 2 - 6
of Dataset 5 and Their Corresponding Correlations

| Tolerance: 0.95 | | | | | | | | | |
| Fast ICA (TanH) | | | | | InfoMax | | | | |
MaxError	MeanError	MedError	StdError	Correlation	MaxError	MeanError	MedError	StdError	Correlation
1.8838	1.5825	1.5789	0.1886	1.0000	1.6560	1.4910	1.5415	0.1475	1.0000
4.0925	3.3228	3.2796	0.4593	1.0000	1.9295	1.7281	1.7698	0.1536	1.0000
0.9707	0.8155	0.8137	0.0971	1.0000	1.0042	0.9037	0.9336	0.0902	1.0000
3.2363	2.5917	2.5317	0.3827	1.0000	1.3744	1.2282	1.2519	0.1051	1.0000
1.6399	1.3746	1.3742	0.1652	1.0000	1.5450	1.3909	1.4385	0.1379	1.0000
4.9341	4.0343	4.0025	0.5397	1.0000	2.6845	2.4084	2.4816	0.2207	1.0000

The maximums of the absolute errors, computed over the 50 sample points that comprise
the averaged blinks, are 4.09 for channel 2 and 4.93 for channel 6 (FastICA) and 1.93 and
2.68, respectively, for Infomax. These values reflect the separation between the curves in
Figures 1 and 2. The correlation in all four cases, however, is 1.0000, which does not
capture this error.

Figure 4: Baseline EEG, Infomax Filtered EEG and FastICA-Run # 1 Filtered EEG
(Channel # 2 | Simulated Blink Type # 5)
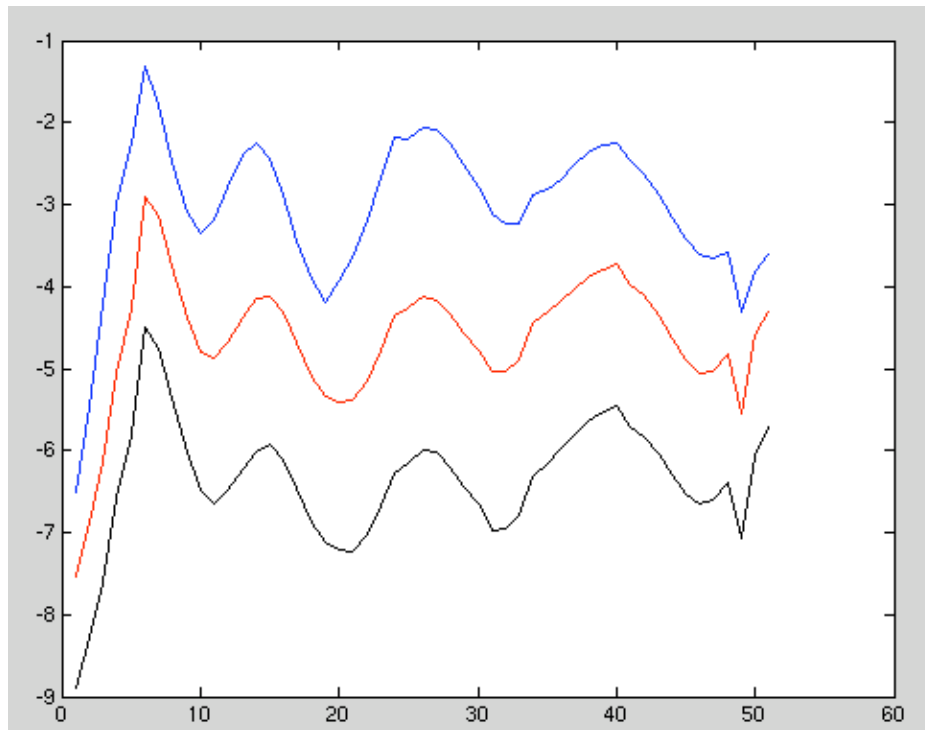
Horizontal Scale: Samples (sample # 25 = blink peak) | Vertical Scale: Microvolts
Blink-Template Tolerance: 0.95 | #IC Extracted: 1(FastICA) / 1(Infomax)

As Figure 4 shows, the Infomax (average) filtered EEG was closer to the (average) actual baseline EEG.

Figure 5: Baseline EEG, Infomax Filtered EEG and FastICA-Run #1 Filtered EEG
(Channel # 6 | Simulated Blink Type # 5)
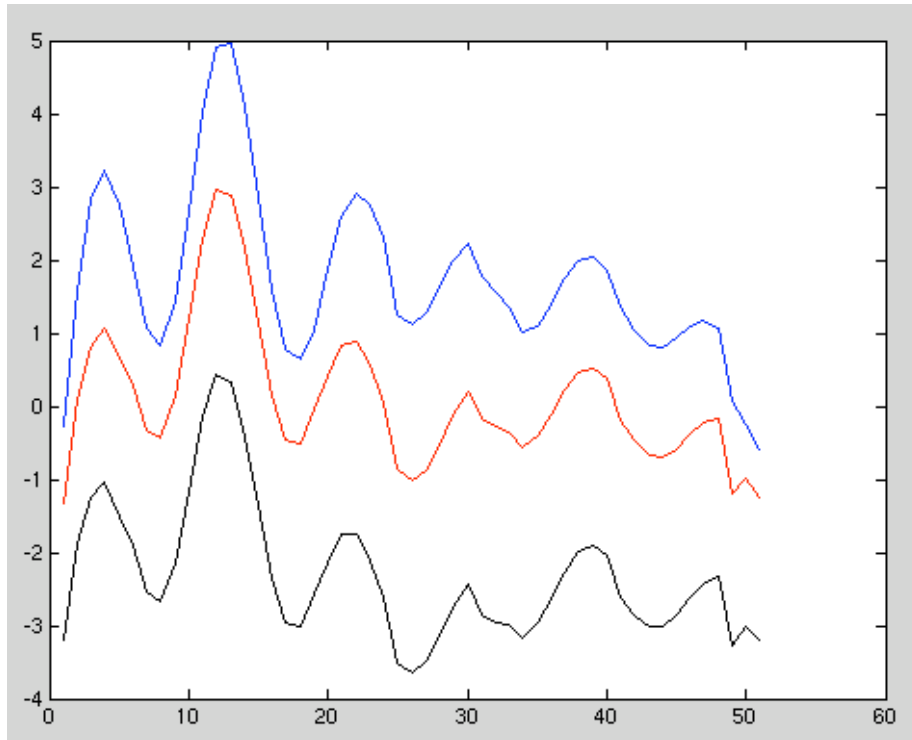
Horizontal Scale: Samples (sample # 25 = blink peak) | Vertical Scale: Microvolts
Blink-Template Tolerance: 0.95 | #IC Extracted: 1(FastICA) / 1(Infomax)

As Figure 5 shows, the Infomax (average) filtered EEG was again closer to the (average) actual baseline EEG.

Figure 6: Table of Absolute Error Values (Max, Mean, Median and Standard Deviation) Between (Averaged) Actual and (Averaged) Filtered EEG for Channels 2 - 6 of Dataset 5 and Their Corresponding Correlations

Tolerance: 0.95									
Fast ICA (TanH)					InfoMax				
MaxError	MeanError	MedError	StdError	Correlation	MaxError	MeanError	MedError	StdError	Correlation
1.8838	1.5825	1.5789	0.1886	0.8850	1.6560	1.4910	1.5415	0.1475	0.9315
4.0925	3.3228	3.2796	0.4593	0.8610	1.9295	1.7281	1.7698	0.1536	0.9812
0.9707	0.8155	0.8137	0.0971	0.9716	1.0042	0.9037	0.9336	0.0902	0.9759
3.2363	2.5917	2.5317	0.3827	0.7842	1.3744	1.2282	1.2519	0.1051	0.9811
1.6399	1.3746	1.3742	0.1652	0.9279	1.5450	1.3909	1.4385	0.1379	0.9504
4.9341	4.0343	4.0025	0.5397	0.8921	2.6845	2.4084	2.4816	0.2207	0.9731

The maximums of the absolute errors, computed over the 50 sample points that comprise the averaged EEG segments, are 4.09 for channel 2 and 4.93 for channel 6 (FastICA) and 1.93 and 2.68, respectively, for Infomax. These values reflect the separation between the curves in Figures 4 and 5. The correlations in these four cases are greater for Infomax than FastICA, and thus accurately reflect the fact that the Infomax filtered EEG more closely matched the baseline. However, the absolute error is a better indication of the vertical separation between the curves exhibited in the figures.

Conclusion:

A correlation of 1.0000 (to four decimal places) does not mean that the data sets being correlated are identical, and so should not, in and of itself, be used as the error metric to determine success or failure of an ICA filtering process. Absolute error, or relative error, which essentially quantifies the vertical separation that you see between the curves, and what a researcher sees in NetStation following the same segmentation and averaging process, may be a more useful measure, or should complement the correlation statistics.