Testing and Verification of SAM

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The SAM programs have been modified for the purpose of improving speed and performance. This report contains a summary of the changes as well as the testing and verification results.

Changes to SAM

The programs *SAMsrc* and *SAMkurt* are the ones affected by these changes. Although all changes to the source code are in the files *SAMsrc.cc* and *SAMkurt.cc*, the following files have also been added to the SAM libraries.

eig33.cc
geig22.cc
KENsolve.cc
KENsolve2D.cc
Fwd2d.cc
FwdVec.cc
cholinv3.cc

All these files, as well as most of the changes in *SAMsrc.cc* and *SAMkurt.cc* were imported from the R&D code.

The change to *SAMsrc.cc* focused on replacing the CPU-intensive grid search for the optimal source orientation with the solution proposed by Sekihara. In the Sekihara method the source location, magnitude, and orientation are solved for simultaneously using a minimum-variance technique with multiple linear constraints.[1]

The change to *SAMkurt.cc* included (1) more aggressive decimation, (2) storing the data in the decimated array and declaring it as an array of floats to save memory (3) Increasing the filter order and using a band-pass filter instead of a low and high pass filters. In addition, the code segment in SAMkurt.cc where the kurtosis is calculated has been moved to a new function called *kurtosis.cc* which is placed in the SAM libraries.

For more details on these modifications, and for the coding details please see SPRs 4668 and 4632 which cover *SAMsrc* and *SAMkurt*, respectively.

Testing

[1] Sekihara et. al., IEEE Transactions on Biomedical Engineering, vol. 48, No. 7, July 2001.

The programs were tested on simulated and real datasets. The simulations included four files with a single dipole, two dipoles, three dipoles and four dipoles. The datasets included five epilepsy datasets. Comparisons were made between three versions of SAM: the orginal version (referred to as **SAMold** in this document), the modified version (**SAMnew**), and the R&D version (**SAMR&D**). These comparisons included: (1) comparing localization results from both *SAMsrc* and *SAMkurt* between the three versions, (2) comparing source strength results (or Z-deviates) for the same, and (3) comparing weight files which are generated by *SAMsrc* and used by *SAMkurt*.

Tests on single and multiple dipole simulations

Tables 1-4 show a four-way comparison for the source localization results between the actual simulated dipole position, and the three versions of *SAMsrc* described above (**SAMold**, **SAMnew**, and **SAMR&D**). Each of these simulations were generated by running the program *dsim*. Since SAM requires data containing noise, an internal-release program was used to add 20 ft/√Hz noise to each of these datasets.

The program *SvlPeak* was used to determine the position and strength of the sources in the image file (.svl) which is created by SAMsrc. As may be seen from these tables, all versions of SAM localize the dipole precisely to where it was placed in the simulation.

	Simulation	SAMold	SAMnew	SAMR&D
X (cm)	2.000	2.000	2.000	2.000
Y	-1.000	-1.000	-1.000	-1.000
Z	8.000	8.000	8.000	8.000

Table 1: single dipole simulation.

	Simulation	SAMold	SAMnew	SAMR&D
1st dipole				
X (cm)	2.000	2.000	2.000	2.000
Y	-1.000	-1.000	-1.000	-1.000
Z	8.000	8.000	8.000	8.000
2nd dipole				
X (cm)	5.000	5.000	5.000	5.000
Y	3.000	3.000	3.000	3.000
Z	7.000	7.000	7.000	7.000

Table 2: two-dipole simulation.

	Simulation	SAMold	SAMnew	SAMR&D
1st dipole				
X (cm)	2.000	2.000	2.000	2.000
Y	-1.000	-1.000	-1.000	-1.000
Z	8.000	8.000	8.000	8.000

2nd dipole				
X (cm)	5.000	5.000	5.000	5.000
Y	3.000	3.000	3.000	3.000
Z	7.000	7.000	7.000	7.000
3rd dipole				
X (cm)	-4.000	-4.000	-4.000	-4.000
Y	1.000	1.000	1.000	1.000
Z	5.000	5.000	5.000	5.000

Table 3: three-dipole simulation.

	Simulation	SAMold	SAMnew	SAMR&D
1st dipole				
X (cm)	2.000	2.000	2.000	2.000
Y	-1.000	-1.000	-1.000	-1.000
Z	8.000	8.000	8.000	8.000
2nd dipole				
X (cm)	5.000	5.000	5.000	5.000
Y	3.000	3.000	3.000	3.000
Z	7.000	7.000	7.000	7.000
3rd dipole				
X (cm)	-4.000	-4.000	-4.000	-4.000
Y	1.000	1.000	1.000	1.000
Z	5.000	5.000	5.000	5.000
4th dipole				
X (cm)	0.000	0.000	0.000	0.000
Y	-4.000	-4.000	-4.000	-4.000
Z	3.000	3.000	3.000	3.000

Table 4: four-dipole simulation.

SAMkurt was also tested on these datasets and showed complete consistency between the three versions..... (Stan)

Tests on epilepsy data

Five epilepsy datasets were used to test the three versions of SAM. The five strongest dipoles from each dataset are shown in tables 5-9. Since **SAMnew** and **SAMR&D** use the SAM algorithms for dipole localization (the Sekihara solution) the results should match exactly, and as may be seen from tables 5-9 they do. However, these two versions of SAM use algorithms different from **SAMold**, and although they should essentially give the same localization results, the agreement will be limited by the resolution (or step size). In the computation at hand, a step size of 0.5 cm was chosen, and the criteria for an agreement between **SAMold** and either **SAMnew** or **SAMR&D** is that the localization results do not differ by more than 0.5 cm. To verify that this is indeed a resolution effect,

the computation for one of the datasets was repeated using a step size of 0.2 cm. In this case a comparison of the results showed that sources whose locations differed by 0.5 cm in the previous analysis did not differ by more than 0.2 cm.

As can be seen from tables 5-9 the difference in source strength between **SAMold** and **SAMnew** is small for all cases and is attributed to the differences between the two algorithms. These two versions, however, differ from **SAMR&D** in source strength values. The reason is that **SAMR&D** computes the source strength differently, and that part was not imported from the **SAMR&D** since the purpose of this project is to substantially decrease the CPU time and keep the results largely unchanged.

	SAMold	SAMnew	SAMR&D
1st dipole (Z-deviate)	4.44	4.44	N/A
X (cm)	5.000	5.000	5.000
Y	-4.000	-4.000	-4.000
Z	6.000	6.000	6.000
2nd dipole	4.22	4.22	N/A
X (cm)	2.000	2.000	2.000
Y	-4.500	-4.500	-4.500
Z	5.500	5.500	5.500
3rd dipole	4.22	4.22	N/A
X (cm)	2.000	2.000	2.000
Y	1.500	1.500	1.500
Z	10.000	10.000	10.000

Table 5: Epilepsy dataset (C0767_EPI_01_E01.ds).

	SAMold	SAMnew	SAMR&D
1st dipole (Z-deviate)	4.21	4.34	N/A
X (cm)	4.500	5.000	5.000
Y	-4.500	-4.000	-4.000
Z	6.000	5.500	5.500
2nd dipole	4.16	4.22	N/A
X (cm)	2.000	2.000	2.000
Y	-4.500	-4.500	-4.500
Z	5.500	5.500	5.500
3rd dipole	4.07	4.07	N/A
X (cm)	0.500	0.500	0.500
Y	-5.000	-5.000	-5.000
Z	7.500	7.500	7.500

Table 6: Epilepsy dataset (C0767_EPI_01_E02.ds).

	SAMold	SAMnew	SAMR&D
1st dipole (Z-deviate)	4.11	4.23	N/A
X (cm)	5.000	5.500	5.500
Y	-4.500	-4.000	-4.000
Z	5.500	5.500	5.500
2nd dipole	4.07	4.09	N/A
X (cm)	-1.000	-1.000	-1.000
Y	-4.500	-4.500	-4.500
Z	7.000	7.000	7.000
3rd dipole	3.94	3.95	N/A
X (cm)	0.500	0.500	0.500
Y	-5.000	-5.000	-5.000
Z	7.500	7.500	7.500

Table 7: Epilepsy dataset (C0767_EPI_01_E03.ds).

	SAMold	SAMnew	SAMR&D
1st dipole (Z-deviate)	5.25	5.32	N/A
X (cm)	2.500	2.500	2.500
Y	-4.000	-4.000	-4.000
Z	7.500	7.500	7.500
2nd dipole	4.70	4.70	N/A
X (cm)	1.500	1.500	1.500
Y	2.000	2.000	2.000
Z	10.500	10.500	10.500
3rd dipole	4.68	4.68	N/A
X (cm)	-0.500	-0.500	-0.500
Y	-4.000	-4.000	-4.000
Z	8.500	8.500	8.500

Table 8: Epilepsy dataset (C0767_EPI_02_E01.ds).

	SAMold	SAMnew	SAMR&D
1st dipole (Z-deviate)	4.58	4.58	N/A
X (cm)	-0.500	-0.500	-0.500
Y	4.500	4.500	4.500
Z	7.500	7.500	7.500
2nd dipole	4.37	4.38	N/A
X (cm)	-1.000	-1.000	-1.000
Y	-3.500	3.500	-3.500
Z	8.000	8.000	8.000
3rd dipole	4.34	4.38	N/A
X (cm)	-0.500	-0.500	-0.500
Y	1.500	1.500	1.500

Z	9.500	9.500	9.500

Table 9: Epilepsy dataset (C0767_EPI_02_E02.ds).

The weights from these three versions of SAM were also compared. These weights are critical since they are used by *SAMkurt* to localize peaks in the spectral time series, particularly in epilepsy studies. Table 10 shows the results.... (Nuri)

Comparisons of the output from these three versions from *SAMkurt* showed complete consistency between the three versions. Table... (Stan)

Tests on SEF data