Comments and Corrections

Corrections to "Comparison of the Ptychographic Inversion Engine to Principal Components Generalized Projections"

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In the aforementioned paper [1], there is an error in how the Ptychographic Inversion Engine (PIE) and the extended Ptychographic Inversion Engine (ePIE) was implemented. The PIE and ePIE algorithm should update the next guess by random application of the spectral data [2], [3]. In [1], the next guess was updated using sequential application of the spectral data. No effect in the performance of the PIE algorithm, where the gate is known, was observed, and none of the conclusions regarding its performance were changed. However, random vs. sequential application of the spectral data did improve the performance of the ePIE algorithm as applied to inversion of second harmonic generation (SHG) frequency-resolved optical gating (FROG) data. This improvement was most prevalent in the compound pulse test set. Overall, performance of the ePIE SHG algorithm is very close to the performance of the principal components generalized projections (PCGP) SHG algorithm when a full FROG data set is used. Performance of the ePIE SHG algorithm still drops when spectral data is omitted.

This paper will be organized as follows. The first section will discuss changes in performance observed when the corrected ePIE SHG algorithm used. The next section will add some details to the benchmark test sets, and the last section will correct typographical errors in [1].

I. Changes to ePIE Performance

Noiseless performance test sets were re-run with the correct ePIE algorithm. Both the ePIE SHG and the PCGP SHG algorithms were tested using exactly the same pulses and exactly the same initial guess. Correction of the ePIE had no effect on the first test set (random pulse), and a very significant improvement on the performance of the third test set, the compound pulse test set. The second test set, random chirp, was also slightly improved. With α randomly varied uniformly between 0.05 and 0.1, the ePIE SHG algorithm had the following success rate: 1) 69.8% $\pm$ 1.4%; 2) 69.7% $\pm$ 1.3%; 3) 64.5% $\pm$ 1.4%; overall 68.0% $\pm$ 2.3%. The PCGP had the following success rate: 1) 71.9% $\pm$ 1.0%; 2) 90.2% $\pm$ 0.9%; 3) 58.9% $\pm$ 1.9%; overall 73.6% $\pm$ 2.3%. Because of the change in the algorithm, tuning the α parameter was also re-examined. With α randomly varied uniformly between 0.1 and 0.5 [3], the ePIE SHG algorithm had the following success rate: 1) 74.8% $\pm$ 1.2%; 2) 62.5% $\pm$ 1.5%; 3) 55.1% $\pm$ 1.5%; overall 64.1% $\pm$ 2.4%. The random pulse test set improved, but performance dropped in test sets 2 and 3, the random chirp and compound pulse test sets, respectively.

The performance of the ePIE algorithm did not change significantly for dropped data when $\alpha \in [0.05, 0.1]$. Thus Table 3 does not change. The performance did slightly improve for dropped data when $\alpha \in [0.1, 0.5]$. For every other spectrum, the convergence increased to 38% from 32.3%; for every 4th, the convergence increased to 28% from 22%. For the random spectra (10%, 25%, 33%, 50%) convergence increased to 3.2% (from 2%), 20.5% (from 16%), 27.8% (from 23.3%), 43.1% (from 30.3%), respectively.

Based on improvements of the ePIE performance on noiseless benchmark data, we expect the noise performance of the ePIE to improve as well.

Conclusions in [1] stated the ePIE SHG algorithm is not as robust as the SHG Principal Components Generalized Projections (PCGP); however, using the corrected form of the ePIE, where random application of the spectral data is used, performance is very close to the SHG PCGP algorithm. Shown in Figure 1a is the replacement for Figure 5b in [1]. Correcting the ePIE algorithm dramatically improved the noise convergence for the compound pulse. The structure of the Percent Converged vs. Retrieved Pulse Intensity Error for the first two test sets are very similar, but the plot for test set 3 (compound pulse), is quite different, showing a structure similar to the other plots. Indeed, an optimized ePIE SHG algorithm overall performs nearly as well as the PCGP algorithm.

The ePIE SHG algorithm performed better for the lower values of α in the random chirp and the compound pulse test sets when a full FROG data set was used. In general, we noticed that the ePIE tends to perform slightly better on incomplete data sets when larger values of α are used. It is also interesting to note that the structure of the corrected ePIE SHG algorithm noise performance plot (a) is very similar to the cascaded X-FROG algorithm, which becomes mathematically similar to the ePIE near convergence. Tuning of the α parameter appears desirable in real world applications.

It is instructive to observe that no difference in the performance of the ePIE SHG algorithm is seen between applying spectral constraints sequentially versus applying them randomly if only test sets 1 and 2 were used. Thus, we conclude that benchmarks, provided they test a wide range of types of pulses, can be helpful for algorithm development, comparisons (relative), and, of course, debugging of algorithms. Absolute algorithm testing using this benchmark is difficult because different programming languages use different definitions for random number generators, and performance also depends on the initial guess.

The author would like to thank Drs. Daniel Adams and Nils Geib for their helpful discussions.

II. Benchmark Test Sets

1. In [4], the test sets were called Random Noise, Random Phase and Multiple Pulse.
2. In [1], test set 1 used the Matlab rand() function which provides a uniform distribution of random numbers from 0 to 1.
3. Test sets 2 and 3 use the Matlab randn() function which produces a normal distribution of random numbers with a mean of 0 and a standard deviation of 1.

Manuscript received June 12, 2019. Date of current version July 15, 2019.
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Digital Object Identifier 10.1109/JSTQE.2019.2925721

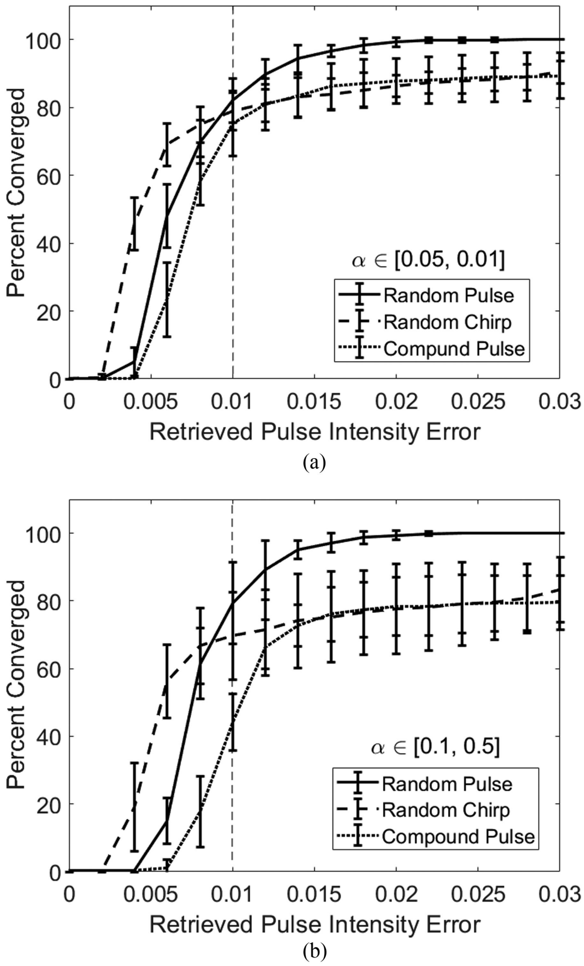

Fig. 1. Plots showing the updated noise performance of the corrected ePIE SHG algorithm. Part (a) shows the results when α is varied randomly between 0.05 and 0.1. Part (b) shows the results when α is varied randomly between 0.1 and 0.5. These tests utilize a full FROG trace data set.

4. In test set 2, the temporal chirp was added first.
5. In test set 3, the number of pulses was randomly varied between 2 and 5 uniformly.

III. Typographical Errors

For clarification, in [1, Fig. 2], $|\Psi_j(\mathbf{r})|$ should be replaced by$|\mathcal{F}(\Psi_j(\mathbf{r}))|$, where $\mathcal{F}$ is the Fourier transform. $\Psi_j(\mathbf{r})$ is in the time (spatial) domain and the constraint is applied in the frequency domain. The square-root of the spectral intensity (magnitude) is the frequency domain constraint.

In Tables I and II, all instances of "a $=$ " should be replaced by "$\alpha =$."

References

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