<u>Complex FastICA Demo (3 Components)</u>

Objective:

To evaluate the performance of Complex FastICA in separating sources derived from binomial, exponential, and Gaussian distributions, transformed into complex-valued signals with random phase shifts.

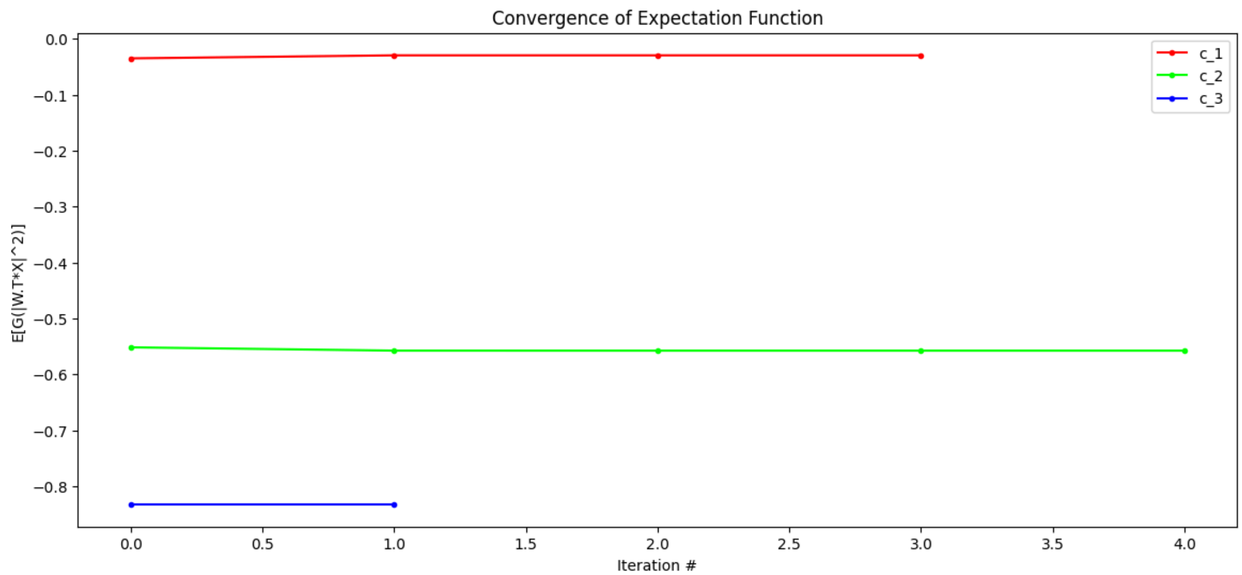
Experiment:

1. 50000 samples of three sources (binomial, exponential, gaussian) were taken.
2. All the three sources were converted to complex by adding random phase shifts.
3. A random valued complex mixing matrix was generated.
4. Complex FastICA (model='deflation', max_iteration=40) was then used to separate the mixed signals.
5. Performance evaluation was conducted using:
    a. SSE (Sum of Squared Errors) — to measure structural deviation between true and recovered sources.
    b. SIR (Signal-to-Interference Ratio) – to evaluate the leakage between recovered signals.
6. Visual assessments were performed through:
    a. Amplitude comparison plots.
    b. Phase comparison plots.
    c. Convergence of the expectation function.

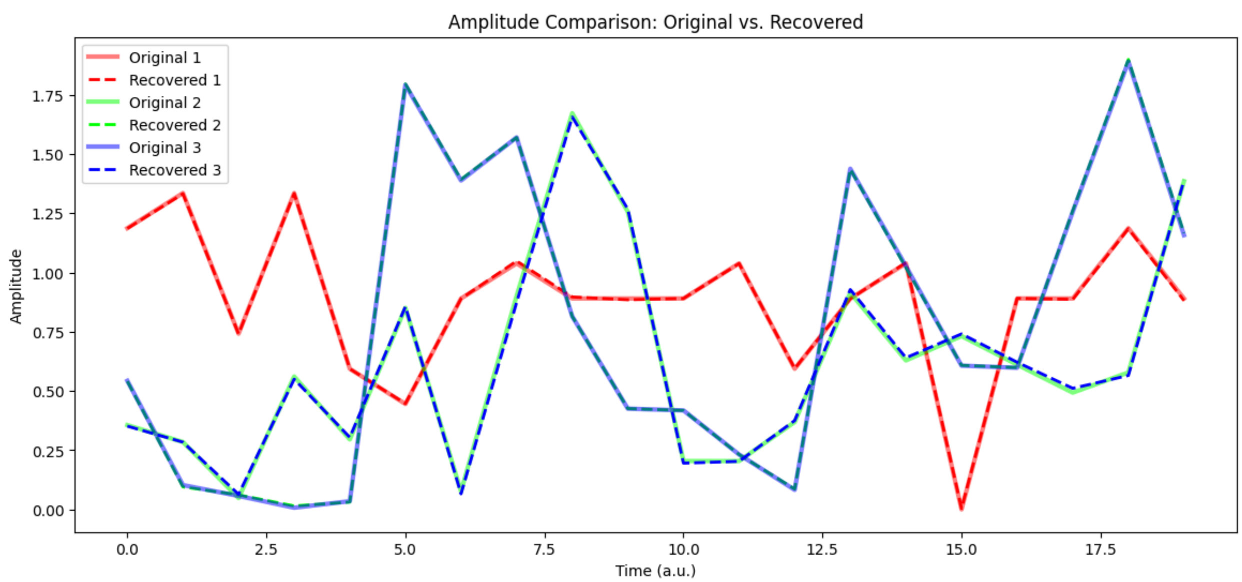
Results:

Metric	**Value**
SSE	0.0002
SIR	-20.1140

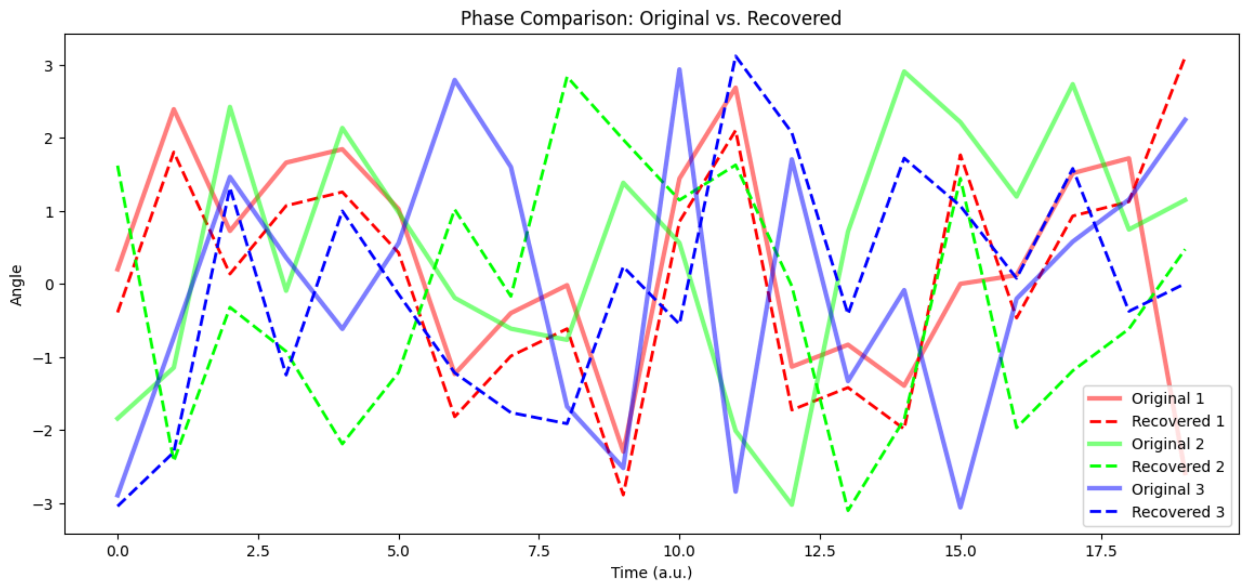
Convergence of Expectation Function:



Amplitude Comparison:



Phase Comparison:



Discussion:

1. The SSE (Sum of Squared Errors) value was observed to be low, indicating a little to no deviation between the estimated and true source structures. A lower SSE implies a more accurate demixing process.
2. The SIR (Signal-to-Interference Ratio) was reasonably high, showing that each recovered signal had minimal interference from the others, which demonstrates good separation capability.
3. The Expectation Function remains nearly constant and the algorithm converges in just 4 iterations. This indicates fast convergence and that the sources were easy to separate.
4. The Amplitude Comparison plot shows that the recovered signals closely follow the original sources in amplitude implying that ICA was successful in separating the original signals.
5. The phase plots show noticeable mismatch between original and recovered signals. This highlights a key limitation of using standard (real-valued) FastICA or a simplified version of complex ICA, while the magnitude information can be captured effectively, phase alignment is more challenging, especially in complex signals.
6. The order of two recovered signals was swapped as can be seen in the Amplitude plot. This is expected behavior in ICA because the algorithm has no knowledge of true order, and permutation of output components is allowed.

Conclusion:

The results demonstrate that the algorithm is highly effective in recovering the original source components in terms of amplitude and statistical structure. The low SSE and high SIR values affirm the success of the separation process, while the rapid convergence of the expectation function indicates the efficiency of the algorithm.

However, the observed mismatch in phase and permutation of component order reflect inherent limitations of ICA-based methods. Specifically, ICA does not guarantee preservation of signal order or phase, which is especially relevant in complex signal scenarios.