Imaging the Black Hole

——The VLBI Imaging Challenge

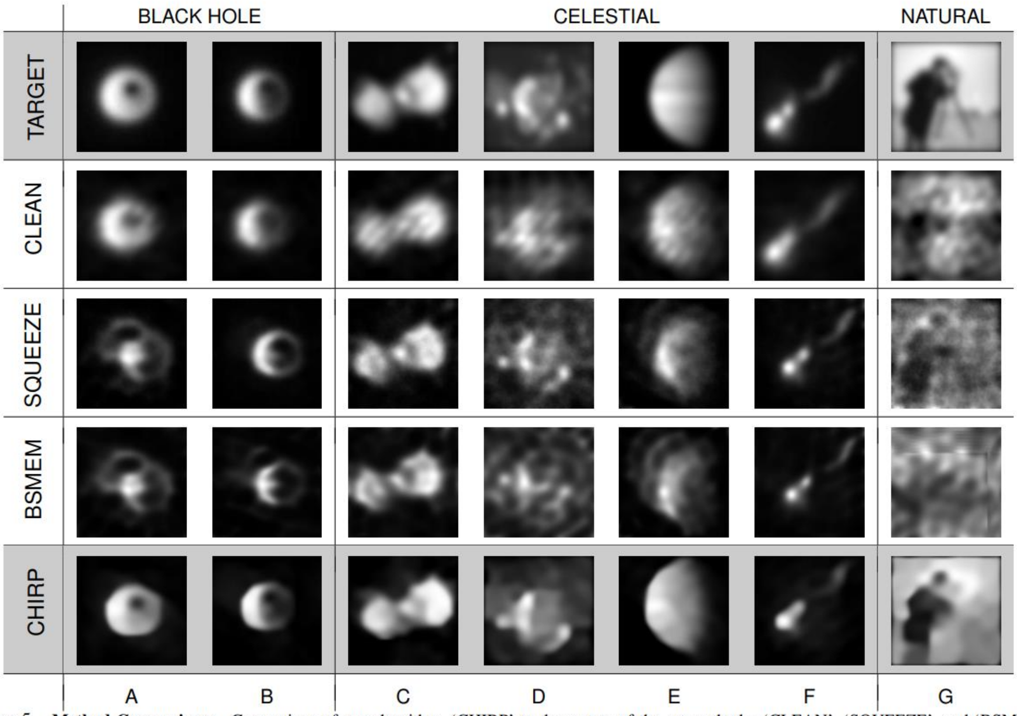

Figure 5. **Method Comparison:** Comparison of our algorithm, 'CHIRP' to three state-of-the-art methods: 'CLEAN', 'SQUEEZE', and 'BSMEM'. We show the normalized reconstruction of a variety of black hole (a-b), celestial (c-f), and natural (g) source images with a total flux density (sum of pixel intensities) of 1 jansky and a 183.82 μ-arcsecond FOV. Since absolute position is lost when using the bispectrum, shifts in the reconstructed source location are expected. The 'TARGET' image shows the ground truth emission filtered to the maximum resolution intrinsic to this telescope array.

1 Introduction

Imaging distant celestial sources with high resolving power requires telescopes with prohibitively large diameters due to the inverse relationship between angular resolution and telescope diameter. However, by simultaneously collecting data from an array of telescopes located around the Earth, it is possible to emulate samples from a single telescope with a diameter equal to the maximum distance between telescopes in the array. Using multiple telescopes in this manner is referred to as very long baseline interferometry (VLBI).

Reconstructing an image using VLBI measurements is an ill-posed problem, and as such each there are an infinite number of possible images that explain the data. The challenge is to find an explanation that respects these prior assumptions while still satisfying the observed data. The goal of this website to aid in the process of developing these algorithms as well as evaluate their performance.

The ongoing international effort to create an Event Horizon Telescope capable of imaging the environment around a black holes event horizon calls for the use of VLBI reconstruction algorithms. The angular resolution necessary for these measurements requires overcoming many challenges, all of which make image reconstruction more difficult. For instance, at the mm/sub-mm wavelengths being observed, rapidly varying inhomogeneities in the atmosphere introduce additional measurement errors. Robust algorithms that are able to reconstruct images in this fine angular resolution regime are essential for scientific progress.

2 Related Work

The official VLBI website [2] provides all kinds of interfaces you will need, including date generation and algorithm testing. You can find more about of VLBI imaging from [3] and [4].

3 VLBI Imaging Challenge

This challenge is meant to help understand the performance of different imaging algorithms on future Event Horizon Telescope (EHT) data. The results of the challenge will help us better understand the biases of each imaging algorithm, and aid in developing better methods. The Challenge website is at [1]. You can download data from the website and also submit your result to the leader board.

References

[1] The vlbi imaging challenge. http://vlbiimaging.csail.mit.edu/imagingchallenge

[2] The vlbi reconstruction dataset. http://vlbiimaging.csail.mit.edu/

[3] Katherine L. Bouman, Michael D. Johnson, Daniel Zoran, Vincent L. Fish, Sheperd S. Doeleman, and William T. Freeman. Computational imaging for vlbi image reconstruction. In The IEEE Conference on Computer Vision and Pattern Recognition (CVPR), June 2016.

[4] Anthony Richard Thompson, James M Moran, and George Warner Swenson. Interferometry and synthesis in radio astronomy. 2001.