Event Horizon Telescope Optimal Real-Time Scheduling Algorithm

Scope of Work (SoW) Document

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Background

On April 10, the Event Horizon Telescope (EHT) Collaboration released the first image of a black hole. Through development of cutting edge instrumentation deployed at sites around the world, the EHT created a virtual telescope with the highest angular resolution currently possible from the surface of the Earth. How high? It is equivalent to being able to read a newspaper in Los Angeles while sitting in Boston. When the EHT trained all its dishes on M87, the supermassive black hole at the heart of the VirgoA galaxy (55 million light years away), they simultaneously recorded radio waves from near the black hole on banks of hard disk drives. These drives were brought to a central processing facility where the recordings were perfectly aligned in time to account for the different radio wave arrival times around the Earth, and images of the black hole were formed.

To operate in this way, the EHT requires reasonably good weather across most of the array at the same time. Currently there are eleven radio dishes in the array: South Pole, the APEX and ALMA facilities in Chile, the LMT in Mexico, the JCMT and SMA facilities on Mauna Kea in Hawaii, the SMT and Kitt Peak observatories in Arizona, the GLT in Green- land, the Pico Veleta telescope in Spain, and the NOEMA observatory in France.

Observing conditions can be excellent in some locations, but if there are not enough telescopes that can participate due to poor weather elsewhere, observations cannot proceed as they wouldn't produce high enough quality data.

Problem Statement

This project is aimed at developing an automated decision support system to help the EHT determine which nights should be triggered for global observations. The EHT observations typically take place during a 10- 12 day window with 5-6 days to be triggered when conditions are optimal. The decision on whether a night should be triggered will be a function not only of the atmosphere's conditions at the sites, but also how many days have been triggered so far, location within the observing window, sizes of the telescopes, and angles shooting at the scientific object .

Resources

The available data are pulled from Global Forecasting System (GFS), on a 6-hour schedule. We started to pull data from Oct 03, 2019. There were some missing data here and there due to the data pulling mechanism.

Additionally, we obtained from Shep a sample scheduling file and some historical records on the nights that were triggered.

Deliverables

In the end, we hope to deliver our model in a Python package with a nicely-built graphical user interface (GUI). We will also compose a documentation that guides the users to use the package.

The input is the weather forecast, date window, number of days to trigger. The output would be our strategies, which includes whether to trigger today, the suggested path in the following days, and might also include confidence level, second optimal path as well as visualizations.

Timeline

Date	Tentative Schedule
10/18/2019	- Midterm Presentation - Short Report to EHT - EDA - Baseline Model / Evaluation - Experiment with different reward functions
10/25/2019	- Second meeting with EHT - Get to understand files even more - Brainstorm different uncertainty measurement - Experiment with different reward functions
11/1/2019	- Experiment with different uncertainty measurement
11/8/2019	- Third meeting with EHT - Experiment with different uncertainty measurement - Find more optimization ways
11/15/2019	- Milestone 3 Presentation - Short report to EHT - Find ways to incorporate visualization into the output
11/22/2019	- Build visualization around the output - Build GUI
12/6/2019	- Finalize the advanced model - Get ready to ship the package
12/9/2019	- IACS showcase
12/11/2019	- Final presentation

12/12/2019	- Final deliverables (slides, blog, self- and peer-evaluations)