Research notes on Telescope Scheduling

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“A Framework for Telescope Schedulers: With Applications to the Large Synoptic Survey Telescope”

LSST

The Large Synoptic Survey Telescope (LSST) is a large, ground-based optical survey that will image half of the sky every few nights from Cerro Pachon in Northern Chile. LSST comprises an 8.4 m primary mirror and a 3.2 gigapixel camera. With a 9.6 deg^2 field of view, it will visit each part of its 18,000 deg^2 primary survey area about 1000 times over the course of 10 yr. Each visit will likely comprise a 15 s pair of exposures with a single-visit depth of about 24.5 mag (AB) (in the six bands u, g, r, i, z, and y). The revolutionary role of this telescope calls for no less than optimal operation.

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There are four primary science drivers for the LSST project: the characterization of dark energy through the multiple cosmological probes (e.g., gravitational weak lensing, luminosity distances from Type Ia supernovae, and baryon acoustic oscillations), mapping the 3D distribution of stars within our Galaxy, a census of solar system objects within the solar system, and a detailed study of the transient and variable universe. Each of these objectives has a different set of constraints and requirements on how the observations are made (e.g., the cadence of the observations, the number of filters as a function of time, the acceptable air-mass range for an observation).

Problem Defination and Constraints

Earlier algorithmic approaches to the scheduling of groundbased telescopes are heavily based on observation proposals. Proposals are handcrafted sequences of scripted astronomical observations. They are generally tested only for feasibility (e.g., that a set of fields were visible, or lie within a specified air-mass range, or within a window in time), but not necessarily for optimality.

More recently, the development of more expensive groundbased instruments with complex missions made it impossible to rely solely on handcrafted proposals. The need for more efficient use of the instrument’s time led to the development of decision-making algorithms to optimize their science output. The scheduling at the single-visit level is referred to as optimal scheduling and it is stated that the optimal scheduling requires reevaluating the future sequence of observations once it is interrupted, but the necessary extra computation is neither affordable nor fast enough. However, in this paper we show that the scheduling in the single-visit level, optimal scheduling, can be quickly recovered after an interruption, if a memoryless framework is used. Thus, the optimality does not necessarily need to be sacrificed because of the limited computational resources.

To run a ground-based telescope with multiple science objectives, such as LSST, the scheduler has to offer *controllability*, *adjustability*, and *recoverability*

References

[1] Elahesadat Naghib et al. “A Framework for Telescope Schedulers: With Applications to the Large Synoptic Survey Telescope”. In: *The Astronomical Journal* 157.4 (2019), p. 151.