Asteroids: New Observations, New Models
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DEEP-South: Automated Observation Scheduling, Data Reduction and Analysis Software Subsystem

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Abstract. We started 'DEep Ecliptic Patrol of the Southern sky' (DEEP-South, DS) (Moon *et al.* 2015) in late 2012, and conducted test runs with the first Korea Microlensing Telescope Network (KMTNet) (Park *et al.* 2012), a 1.6 m telescope with 18k x 18k CCD stationed at CTIO in early 2015. While the primary objective of DEEP-South is the physical characterization of small Solar System bodies, it is also expected to discover a large number of such bodies, many of them previously unknown. An automated observation scheduling, data reduction and analysis software subsystem called 'DEEP-South Scheduling and Data reduction System' (DS SDS) is thus being designed and implemented to enable observation planning, data reduction and analysis with minimal human intervention.

Keywords. minor planets, asteroids

1. Introduction

The DEEP-South Scheduling and Data reduction System (DS SDS) consists of two separate software subsystems, each having different locations and facilities: Headquarters (HQ) at Korea Astronomy and Space Science Institute (KASI), and SDS Data Reduction (DR) at Korea Institute of Science and Technology Information (KISTI). HQ runs the DS Scheduling System (DSS), DS database (DB), and Control and Monitoring (C&M) designed to monitor and manage overall SDS actions. DR hosts the Moving Object Detection Program (MODP, Bae *et al.* 2005), Asteroid Spin Analysis Package (ASAP, Kim *et al.* 2014) and Data Reduction Control & Monitor (DRCM). MODP and ASAP conduct data analysis while DRCM checks if they are working properly. The functions of SDS is three-fold: (1) DSS plans schedules for three KMTNet stations (in CTIO, Chile; SAAO, South Africa; and SSO, Australia), (2) DR performs data analysis, and (3) C&M checks whether DSS and DR function properly; if they are not, it immediately intervenes in the control processes. DSS prepares a list of targets, aids users in deciding observation priority, calculates exposure time, schedules nightly runs, and archives data using Database Management System (DBMS). MODP is designed to discover moving objects on CCD images, while ASAP performs photometry and reconstructs their lightcurves. Based on ASAP lightcurve analysis and/or MODP astrometry, DSS schedules follow-up photometry to be conducted with three KMTNet telescopes.

2. DSS: Scheduling @HQ

DSS writes an observation schedule to be sent to site operators at 15 h (local time) on every observing date. DSS uses monthly ephemerides of more than 13,000 NEOs provided

by the Minor Planet Center (MPC), to prepare a list of targets and to calculate their ephemerides for each KMTNet station. DSS tabulates a target list, calculates observational parameters such as exposure time to achieve the best signal to noise ratio (SNR), and checks various conditions such as observation window and lunar phase, giving users feedback on the results of its analysis, such as phase coverages of target asteroids.

3. DR: Data Reduction @KISTI

DR consists of DRCM and a suite of data processing software. Once DRCM receives CCD images transferred from KMTNet stations, it calls and carries out a series of data processes. Three pieces of DR software that we developed or are being implemented for DEEP-South are listed below:

BI: Basic Inspection (BI) is the first step of the DR process, and is done immediately after transfer of an image. BI checks various parameters in an image header, and performs basic analysis such as seeing measurement of an image to produce fundamental data for later stages of data reduction and analysis.

MODP: An automated software package for moving object detection, applied to three consecutive images called image triplets taken on the same field of view with the same band filter.

ASAP: An automated software package designed to derive spin period and composite lightcurve of asteroids. ASAP runs using the parameter sets obtained from MODP procedure.

4. C&M: Monitoring & Control

The ground rule for DSS/DR operation is autonomous management. All processes of the DSS/DR are being displayed and monitored at HQ. Whenever a problem is encountered while they are running, their performance status and self-diagnosis result is immediately reported to users via email and Short Message Service (SMS) for a prompt action.

5. Future works

We expect stable operation of the current version of SDS to be achieved in late 2015. At the same time, we have a plan to upgrade DS SDS in mid-2016 in order to achieve more finely-tuned observation strategies and better efficiency in automated data reduction and analysis processes.

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