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ALERT SIMULATOR - A SYSTEM FOR SIMULATING DETECTION OF TRANSIENT EVENTS ON LSST

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Abstract. Large Synoptic Survey Telescope will be a large ground-based telescope system which will provide sky survey in unsurpassed details. One of the modules will be time-domain astronomy and detection of transient events.

In order to properly design the system, a simulation framework is required to optimize algorithms to large data volumes and frequent events. The Serbian contribution to the project is the Alert Simulator, a system which will simulate detection of transient events. Main use of AlertSim will be to test the performance of event brokers/CEP engines and their ability to detect and identify transients as well as various failures or exceptional/extreme modes of operation.

1. INTRODUCTION

Large Synoptic Survey Telescope (LSST) will be a large, ground-based, optical telescope that will obtain images over half the sky every few nights (Ivezić et al. 2008). It will contain an 8.4 m primary mirror, 3.2 Gigapixel camera and will operate in six bands (u,g,r,i,z and y). After 10-years survey period, it is expected that total amount of about 100 PB of data will be collected.

2. TRANSIENT EVENTS AND ALERTS

2.1 LSST data products

LSST data products will mostly consist of catalogs and images (Jurić et al. 2013). Since they will be used for different purposes, there will be three main categories of data products. **Level 1** products are intended to detect time-domain events. These data are the product of continuous observations (nightly) followed by analysis of difference images. Variable and moving objects are the result of L1 data products. **Level 2** products are generated as part of a Data Release. These data are the product of yearly observations, followed by analysis of direct images. Catalogs and images are the result of L2 data products. **Level 3** products will be generated by users, using LSST software and/or hardware. Various user-created data will be available that not belong to automatically generated L1 and L2 products (Jurić et al. 2013, Conolly et al. 2013).

2.2 Transient events

A transient astronomical event is the event where the image of observed object changes in time, usually in short time period. Roughly, they can be classified as variable objects, where flux changes are detected and moving objects, where position changes are detected.

Variable objects (Flux changes)	Moving objects (Position changes)
Variable stars Eclipsing binaries Transits of extrasolar planets Galaxies AGN Bursts (optical)	Planets Asteroids Comets Trans-Neptunian objects

2.3 Transient alert

A Transient Alert is a notification of the detection and characterization of a moving or variable object. Very simple procedure can be described as follows. A visit image is acquired from the telescope. A template image presents what should be seen. Visit image is compared against the template image, and if the difference exists, the alert is raised. This explanation is very simplified. Actually, each of these steps consist several other subprocedures, but the core idea is as described.

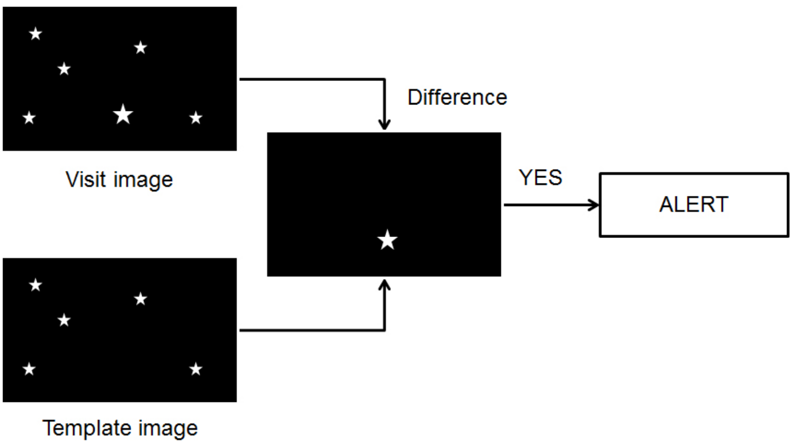

Figure 1: Basic procedure.

A transient alert is a piece of information containing characterization of the object. Each alert contains several data:

- alert ID
- timestamp
- level1 database ID
- Science data
  - position
  - flux, size, and shape
  - light curves in all bands (up to a year; stretch: all)
  - variability characterization (e.g., low-order light-curve moments, probability the object is variable)
- cut-outs centered on the object (template, difference image)

In addition, alerts will have the following properties:

- Alerts will be available world-wide within 1 min of visit acquisition. This is the result of fast image processing as well as distributing procedures.
- The rate of generating alerts is expected to be quite high, about 10 M per night or about 10 k per visit. This assumption is included in design of Alert Simulator process.
- The format should be easy to read and process by variety of systems. The most appropriate format is XML, or even better VOEvent (XML record with defined structure, used to describe events in astronomy)

3. SIMULATOR

LSST will produce several millions alerts per night. Such amount of data requires particular approach of handling it. One of such approaches is filtering, a set of algorithms for analysing incoming alerts and to reduce their number to most relevant ones. In early design stage, useful tools are simulations, to test the performance well in advance of first light. Alert Simulator will be a software package whose main purpose will be to simulate input that is expected to encounter in operation mode, and then to test the behaviour of the system. In this way, the proper respond and performance will be predicted, so appropriate design can be made.

3.1 Requirements

In order to accomplish the tasks, this software package has to meet the following requirements (Jevremović et al. 2014):

- to generate realistic streams of alerts at data rates that are expected in operational mode
- to simulate various failures or exceptional/extreme cases that might occur:

  - large numbers of fake/spurious detections
  - unusually large numbers of detections simulating observations of high-density fields
  - disruptions in the event stream, which may occur due to forced termination of difference image processing
  - corruptions of the event stream, which may occur due to hardware or software errors
  - network connectivity interruptions
- to provide facilities to ease troubleshooting. This will be achieved through logging and packet inspection (VO Event is structured information, so it can be processed easily).
- to be configurable, automated, and capable of keeping provenance information
- to follow standards and conventions. The package will be written in accordance with standards, conventions, and development processes defined in LSST documents. Some examples are that it will be written in Python programming language and the format will most probably be VOEvent.
- to be developed in coordination with group. Alert Simulator will be just one part of the large software system. There are several groups working on simulations (photon, operations, catalog, image simulations), so Alert Simulator will be developed in cooperation with them to ensure integration and interoperability with other parts of the system.

3.2 Goals and benefits

The main goal of simulator is to evaluate whether the properties of as-delivered components are sufficient. It will also evaluate how design modifications or optimizations impact the overall science performance of the system. Finally, it will verify that the algorithms used in the processing the LSST data are capable of characterizing the astrometric, photometric, and morphological properties of sources at the level of fidelity described in the SRD) (Conolly et al. 2013).

In addition, it will reduce LSST Operations cost by (Jevremović et al. 2014):

- Delivering functionality early, that is currently planned to be developed in Operations
- Reducing the need for help desk and technical support personnel by automating the validation/troubleshooting activities and increasing this aspect of staff productivity.
- Further reducing potential down-time and troubleshooting personnel costs by providing the capability for full characterization of the behaviour of connected public brokers in the full suite of exceptional/extreme operation modes that may occur in Operations, but are unlikely to occur with real data in Commissioning.

4. CONCLUSIONS

Alert Simulator will provide predictions of system behaviour and its performance in case when frequent events are expected. This will allow to design the system appropriately and optimize algorithms before the first light, so the overall cost will be reduced.

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