**Imtrandetect:** a new tool/methodology for detecting transients from large image-data streams down to low S/N

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**Goals / Overview**

- One of the problems facing current and future synoptic sky surveys is how to detect transient candidates to low S/N levels **optimally, reliably, and quickly** from large data streams. This will increase our chances of discovering rare and new events, either through archival analyses or real-time follow-up of interesting events.
- By mining deeper, we need to be prepared for a higher rate of false-positives, e.g., instrumental glitches and contamination from a “fog” of uninteresting astrophysical transients. Hence we need to work harder at finding our diamonds. Consequently, we place more emphasis on reliability.
- A popular method for detecting transients is image differencing (with prior PSF-matching) against a deeper reference image. This is powerful, but can we do better? We have explored a few image-combination metrics [below].
- An optimal transient-detection method (in the max-likelihood sense) has been designed and implemented in a software tool (imtrandetect) for automated execution during a synoptic sky survey.
- The method is optimized for optical/IR data, where the underlying photon-noise is usually well into the Gaussian limit. The focus here is to detect transient candidates, not classify them, although the latter can assist the former. The software is a work in progress and will be released to the public.

**The Software: features and processing flow**

- Overall, the tool emphasizes masking of instrumental artifacts through use of img masks and dynamic masking of “static” bright sources and their artifacts.
- There is minimal impact from PSF variations (temporal and spatially).
- It has the ability to combine images from multiple filters to maximize S/N.
- Can handle data with irregularly spaced observation times and large gaps.
- Can handle images with non-uniform overlap (varying depth) across epochs.
- Tunable to detect transients to different S/N thresholds and timescales.
- Optional use of light-curve templates to assist in isolating specific candidates.
- Optional constraints to maximize reliability: e.g., must have at least n consecutive events above some S/N separated by <Δt, and must appear PSF-like.
- Generates light-curves, image cutouts, and other metadata.

**Enhancing the S/N of suspect transients from “sub-significant” single epoch events**

- We have extended the single image-epoch differencing method by combining multiple, consecutive epochs where a transient may be “active”.
- Images are combined (collapsed) in moving block windows of length NW along a growing time-series using a chi-square (χ²) and skew (S) metric.
- Reason for windowing: reduce dilution from long-run baseline noise.
- We performed simulations to test the sensitivity of these metrics for a moving window of 15 images containing varying numbers of intermittent transients with different S/N where noise is purely Gaussian and uncorrelated vs time.
- We find the skew metric is most sensitive at detecting slight asymmetries in a time-collapsed pixel distribution. Q: does a more sensitive metric exist?

**Some results from testing on real data**

- We are in the process of testing on data from the Catalina Real-Time Transient Survey (CRTS) and the WISE mission. WISE is not a synoptic survey, but irregularly spaced epochs of non-uniform depth are available.
- For CRTS, we pushed down to a single epoch S/N ~ 3, found a spurious transient rate of ~8% and lots of faint asteroids [see below].
- For WISE, we performed a blind search for variables in the LMC at 3.4µm.

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**Inputs:**

N overlapping images

**Optional:** interplate images onto common sky pixel grid; e.g., if data not synoptics (images have different pointing)

**Outputs:**

Compute global, robust baseline metrics per pixel; stack median m0 and sigma, using quantile differences (optional trimming too)

Repeat for all windows along image sequence

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**Figure:**

1. Two examples of metrics (χ² and S) to detect transients from single image epochs with S/N = 1, 2, 3...10
2. Examples of real data results from CRTS and WISE surveys.