

What Detection Algorithms Do We Need?

Image processing during the production of a Data Release (DR) cleanly separates into two categories:

1. Differencing every science image from a template image, followed by detection and measurement of sources (Nightly Reduction Mode)
2. Simultaneous processing of stacks of science images that cover a particular region of sky (Stack Processing Mode)

The results of both modes are incorporated into the LSST Science Database to enable joint analysis of their results.

The science drivers for Nightly Reduction Mode are all related to transient and variable objects. These are mostly pointlike, eg supernovae and variable stars, but with a few interesting cases of extended objects, eg light echoes and variable strong lenses. Moving objects can also be a source of extended objects - either very extended (nearby comets) or slightly extended (an active asteroid or NEO).

The science drivers for Stack Processing Mode are far more diverse:

1. Shape measurements of faint galaxies for weak lensing
2. Accurate galaxy photometry, in particular for photo-Z's
3. Detailed galaxy morphology
4. Accurate stellar photometry, in crowded as well as uncrowded fields
5. Accurate astrometry

Our current software design envisions all of these diverse goals being achieved by a single Deep Detection package. The purpose of this note is principally to suggest that we will probably require several different algorithms for the five purposes listed above, although it is very likely that they can all make use of some common machinery (in particular PSF estimation and sky subtraction)

Here's a brief summary of some of the requirements for each application.

Shapes for Weak Lensing

1. Probably best to only measure ellipticities e_1 , e_2 rather than complex shape parameters
2. Can ignore overlapping galaxy images (?)
3. Can ignore galaxies over some size (?)
4. Time dependence unimportant

Accurate Galaxy Photometry (eg for producing fundamental plane plots)

1. Must deblend overlapping images
2. Large galaxies important
2. Need complex shape model to accurately measure isophotes
3. Time dependence probably unimportant

Detailed Galaxy Morphology

1. Must deblend overlapping images
2. Large galaxies important
2. Need complex shape model to allow queryable shape parameters ("show me all barred spirals")
3. Time dependence unimportant

Accurate stellar photometry

1. Must work in crowded as well as uncrowded fields, so have to do best possible job at deblending
2. Time dependence important - want measurements as frequently as the SNR enables, every exposure is desirable
3. Eliminating systematics from sky level, seeing, crowding is critical to meeting SRD photometric accuracy goals

Accurate stellar astrometry

1. Must work in crowded as well as uncrowded fields, so have to do best possible job at deblending
2. Time dependence important - but time separations less than 1 week or maybe 1 month probably not important
3. Accurate centroids, rather than accurate photometry, dictates different image processing than for photometry

How do the requirements overlap?

Judging only from this short matrix of requirements, it looks as if perhaps detailed galaxy morphology and galaxy photometry could be handled by the same package, with the others separate. If we provisionally accept that assessment, it's worth considering what sort of processing flow would support these different packages with a minimum of duplicated effort.

Some things that can be shared

1. Infrastructure to deliver image stacks in some optimal order. But perhaps different apps naturally have different sky patch sizes?
2. Object detection on coadded images. Deblending (segmentation) should be done here, probably taking into account information from multiple bands. Possibly use colors to help separate overlapping galaxy images.
3. PSF determination - everybody needs it, there's a lot of effort needed to get this right

Open Questions

Shall we have some representation for really large objects, such as globular clusters or large nebulae, or only for the individual objects that make them up? Should there be some upper size limit for an object?