LSST DESC Notes

Problems and Solutions for LSST Shape Measurement

The Lighthouse People and The LSST Dark Energy Science Collaboration[0]

LSST weak lensing science has unprecedented requirements for the modelling of the LSST point spread function and the accurate measurement of galaxy shapes in the face of blending. In this document, we describe the results of a workshop on these issues held at Point Montara in February 2017. We discuss available solutions for the PSF modelling and shape measurement, lessons learned from their use in the Dark Energy Survey, remaining open issues, and progress and plans towards fixing those. In addition, we lay out a strategy for handling multi-epoch image data in an API useful with present weak lensing image analysis codes and a framework for validating PSF and shape measurement through image simulations.

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Introduction

We skip the introduction for now, but keep an introduction to this LaTeX class for reference.

This is a paper and note template for the LSST DESC (Ivezic et al. 2008; LSST Science Collaboration 2009; LSST Dark Energy Science Collaboration 2012). You can delete all this tutorial text whenever you like.

You can easily switch between various LaTeX styles for internal notes and peer reviewed journals. Documents can be compiled using the provided `Makefile`. The

Table 1. Example table.

Column 1	Column 2	Column 3	Column 4
	deg	kpc	deg
Obj1	(0,0)	10	0.1
...	...	...	...
ObjN	(0,0)	10	0.1

command `make` with no arguments compiles `main.tex` using the `lsstdescnote.cls` style. If you want to upgrade your Note into a journal article, just choose a journal name, between `make apj` (ApJ preprint format), `make apjl` (which uses the `emulateapj` style), `make prd`, `make prl`, and `make mnras`.

There are a number of useful LaTeX commands predefined in `macros.tex`. Notice that the section labels are prefixed with `sec:` to allow the use of the `\secref` command to reference a section (i.e., Section 1). Figures can be referenced with the `\figref` command, which assumes that the figure label is prefixed with `fig:`. In Figure 1 we show an example figure. You'll notice that the actual figure file is found in the `figures` directory. However, because we have specified this directory in our `\graphicspath` we do not need to explicitly specify the path to the image.

The `macros.tex` package also contains some conventional scientific units like Å, GeV, $M_\odot$, etc. and some editorial tools for highlighting **issues**, **text to be checked**, *comments*, and new additions.

Similar to the figure before, here we have included a table of data from `tables/table.tex`. Notice that again we are able to reference Table 1 with the `\tabref` command using the `tab:` prefix. Also notice that we haven't needed to specify the full path to the table because in the `Makefile` we include `./tables` directory in the `$TEXINPUTS` environment variable.

Equations appear as follows, and can be referred to as, for example, Equation 1 – just as for tables, we use the `\eqnref` command using the `eqn:` prefix.

$$\langle f(k) \rangle = \frac{\sum_{t=0}^{N} f(t,k)}{N} \tag{1}$$

Figure 1 shows an example figure, referred to with the `\figref` command and the `fig:` prefix.

Figure 1. An example figure: the LSST DESC logo, copied from `.logos/desc-logo.png` into `figures/example.png`.

If you are planning on committing your paper to GitHub, it's a good idea to write your tex as one sentence per line. This allows for an easier `diff` of changes. It also makes sense to think of latex as *code*, and sentences as logical statements, occupying one line each. Each line must "compile" in the mind of the reader.

MEDS: Multi-epoch data structures

write why we need this: unified API for PSF modelling / shape measurement / photometry codes to access single frame image, weight, astrometry and PSF information

High-order instrumental astrometric distortions in MEDS

Gary, Troxel, Mike, Erin: describe how this is implemented

The MEDS python class would allow for flexibly swapping out the WCS in the input file FITS header by something more elaborate if we have the base class provide access functions for the `cutout_row/col` variables (in addition to the Jacobian) **(Erin)**. A derived class could then implement these differently, e.g. by evaluating Gary's WCS **(Gary)**. Both this and the way shape measurement codes find the

matching PSFEx model files could be implemented by an external simple table that maps exposure and CCD IDs to auxiliary filenames.

A MEDS API for LSST

Jim, Erin, Joe, Josh, Daniel: describe how this is implemented; it seems like an API that generates an object's MEDS information on the fly could be feasible

PIFF: PSFs in the Full FOV

write an introduction of why we need this: astrometric distortions -¿ WCS, coherent patterns over full FOV, Zernickes, better interpolation schemes

Gaussian Process Interpolation

Josh, Gary, Mike, Niall, Pierre-Francois, Ami: describe

Shape measurement

quick intro of lessons learned from DES Y1

BFD on real data

Gary, Daniel, Joe, Katie, Ami: describe

The two components missing for this are

- a variant of `simpleImage` (see `momentcalc.py` in the BFD repository) that can take multiple postage stamps of the same galaxies with their respective WCS registrations (in the form of the position of a centroid estimated in WCS and transformed to the postage stamp pixel system) and Jacobians, PSF models, and an estimate of the overall centroid in WCS **(Katie)**
- a function that can get these inputs to the new variant of `simpleImage` from a MEDS file (using the python `meds` or a derived class) **(Daniel)**

An image simulation pipeline for PSF and shape measurement validation

Joe, Mike, Erin, Troxel, Gary, Daniel, Niall, Ami, Katie: describe

Acknowledgments

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This is the text imported from `acknowledgments.tex`, and will be replaced by some standard LSST DESC boilerplate at some point.

References

Ivezic, Z., Tyson, J. A., et al. 2008, ArXiv e-prints, arXiv:0805.2366

LSST Dark Energy Science Collaboration. 2012, ArXiv e-prints, arXiv:1211.0310

LSST Science Collaboration. 2009, ArXiv e-prints, arXiv:0912.0201