im3shape and Blending in Year One of the Dark Energy Survey

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Aims of deblending for WL

- Ultimately we want an unbiased estimate of ensemble shear.
- That could equally be achieved by:
  1. Identifying and discarding blend candidates
  2. Devising a shear measurement that calibrates out the impact of blending
  3. Explicitly deblending and iterative fitting (e.g. Multi-Object Fitting)
DES Y1: Background

In Numbers:

- 137 M galaxies across 1800 sq degrees of the southern sky
- *griz* photometry down to $r_{\text{lim}} \sim 23.2$ mag
- Two shape catalogues:
  - *metacal* ($\sim 35$ M galaxies, $n_{\text{eff}} = 5.88 / \text{arcmin}$) and
  - *im3shape* ($\sim 22$ M galaxies $n_{\text{eff}} = 3.16 / \text{arcmin}$)
DES Y1: Background
DES Y1: Background
DES Y1: Pipeline References

DES Y1: Shear Pipeline

DECam

90 sec g-band Exposures
90 sec r-band Exposures
90 sec i-band Exposures
90 sec z-band Exposures

Swarp

Detection Coadd
g-band Coadd
r-band Coadd
i-band Coadd
z-band Coadd

SExtractor

Source Catalogue
Segmentation Map

MEDS Maker

MEDS Files
überseg
Shape Code
Shape Catalogue
Object Detection

- Composite $r+i+z$ coadds built for object detection
- SExtractor run on detection images
  → detection position catalogue
- SExtractor run on single-band coadds
  → source fluxes, sizes, deblending flags
Weight maps

- Per-pixel variance maps are obtained from SExtractor run on single-band single-epoch images
- Incorporated into shape measurement as a weight to each pixel
Object Segmentation

- Object segmentation performed using SExtractor
- Each pixel is associated with a single object (no flux splitting)
- Cutouts from segmentation maps used as baseline for masking images eventually passed to the shape code
MEDS Creation

- Inputs: single-epoch images, detection catalogues, weight maps, segmentation maps
- Postage stamp size is estimated using SExtractor source parameters
- Outputs: stack of pixel cutouts per object, per band
Überseg

- Additional step prior to shape measurement, which augments the object-level masks
Überseg

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Überseg

• Additional step prior to shape measurement, which augments the object-level masks
  ➢ For each detection, does the postage stamp contain pixels associated with two or more detections?
  ➢ A pixel is zero-weighted if it (a) is a member of a contiguous cluster associated with another detection or (b) the nearest pixel associated with a non-central detection is closer than the nearest associated with the central detection
Überseg

• Tested in DES SV using simulations, shown to reduce bias due to detected blends...

• but does not account for undetected blends
**im3shape**: Basic Philosophy

- Real data contains blends of many different flux ratios
- Some are detected, inevitably some escape detection
- Neighbours, then, almost certainly will influence galaxy shape estimates
- None of this is a problem *if* one can effectively simulate and calibrate out neighbour bias
**im3shape: Base Level Blend Rejection**

- Cut on basic blending-sensitive metrics to reject most severe cases:
  - SExtractor deems galaxy to be blended (FLAGS=1,2)
  - Model centroid is > 1 arcsec from the postage stamp centre
  - Poor model fit (large $\chi^2$/pixel)
**im3shape**: Calibration Simulations

- Suite of $r$-band image simulations, roughly the size of the DES Y1 footprint
- HST COSMOS input, to $r\sim25.2$ mag
- Object positions are matched one-to-one to detection catalogue to mimic galaxy clustering
- “Detectable” galaxies supplemented with sub-detection threshold objects
**im3shape**: Calibration Simulations

- Aim to rerun as much of the image processing pipeline on the simulated data as possible
- Rerunning: object detection, segmentation, shape measurement
- Not Rerunning: PSF Estimation, coaddition, background subtraction
**im3shape**: Quantifying Neighbour Bias

- Use simulations to test the impact of blending on Y1 im3shape
- Neighbour-induced multiplicative bias $m \sim -0.06$, strong function of galaxy density
- Sub detection threshold objects contribute $m \sim -0.01$
**im3shape**: Quantifying Neighbour Bias

- Test the net impact of blending by comparing fiducial simulations with neighbour subtracted version.
- All other details identical, but neighbour light subtracted when the postage stamp is extracted.
**im3shape**: Quantifying Neighbour Bias

- Propagate difference in calibration with neighbour-subtracted simulation to $\xi_{+/-}(\Theta)$
- Test cosmological impact due to shift

$\rightarrow \sim 2\sigma$ shift in $S_8$ at DES Y1 uncertainties
Thoughts for the Future

- Is HST COSMOS sufficiently deep for DES Y3/Y5? For future datasets?
- Is the clustering of sub-threshold galaxies important?
- As datasets go deeper, undetected blends with different redshifts but correlated shear will become more common - difficult to realistically simulate
Thank You