Quantifying effects of blending using simulated galaxy pairs

Sowmya Kamath
BTF Telecon: 05/21/18
Obligatory Warning

- Work in progress, any input deeply appreciated
- Simple simulations of two-galaxy blends
- Effects not studied yet:
  - Larger number of overlapping objects
  - Complex morphology
- Goal: Study impact of blending for different types of blends
All overlapping objects are blends but some overlaps are more blended than others.

- Blending is complicated
- Depending on the extent of overlap, the effects can be different
- Blending can affect
  - Detection errors (objects not detected or incorrect initial centroid location)
  - Separation of flux at pixel level
  - Measurement
  - Exclusion bias; shear dependent selection effects
Simulations

- 2800 blends
- Two galaxies simulated per image, with GalSim (WLDeblending package)
- Parametric (Sersic bulge + disk with same centers, different SEDs, flux ratio)
- Randomly selected galaxies from CatSim catalog
- 300-second LSST exposure in i band (cf. ~5% of full depth)
- Kolmogorov PSF; (i band FWHM = 0.67arcsec)
- Overlapping galaxy pairs with reasonable probability that at least one will be detected:
  - Distance between centers of galaxies: 0.6 - 2.0 arcsec (uniformly distributed)
  - i mag < 25.3 for galaxy 1
  - i mag < 27.0 for galaxy 2
Simulations

Two types of simulated images per blend:

- **Blending on**: One image of the two-galaxy blend.

- **Blending off**: Two images of the individual isolated galaxies.
1. \(x_0, y_0\)
2. Flux
3. \(e_1, e_2\)

**Blending off**
1. \( x_0, y_0 \)
2. Flux
3. \( e_1, e_2 \)

Measurement

Stack

Scarlet

Blending on
1. \( x_0, y_0 \)
2. Flux
3. \( e_1, e_2 \)

Blending on
Stack Settings

SourceDetectionConfig()
- tempLocalBackground.binSize = 32  # local background binning
- minPixels = 1  # minimum size of a source.
- thresholdValue = 5  # detection threshold for the footprint

Selection
- ['deblend_nChild'] == 0
- ['base_SdssCentroid_flag'] == False
- ['ext_shapeHSM_HsmShapeRegauss_flag'] == False
scarlet.ExtendedSource()

constraint = (
    sc.SimpleConstraint()  # sed sum to unity, all elements of SED and morph are non-negative
    & sc.MonotonicityConstraint(use_nearest=False)  # prox_g monotonicity
    & sc.DirectSymmetryConstraint()  # prox_f perfect symmetry
)

blend.recenter_fits()
Both objects detected when blending on and off.

Impacts:
- Imperfect deblending
- Selection effects if cut made on blendedness

X: True centers
O: Stack centers with blending on
Recognized Blends

- Both objects detected when blending on and off.
- Impacts:
  - Imperfect deblending
  - Selection effects if cut made on blendedness
Recognized Blends

- Both objects detected when blending off and on.
- Impacts:
  - Imperfect deblending
  - Selection effects if cut made on blendedness
**Unrecognized Blends**

- Only one object detected with blending on; both observed with blending off.
- Impacts:
  - Model bias: Wrong photo-z, shape, etc.
  - Reduction in number of observed objects
  - Exclusion bias

X : True centers
O: Stack center with blending on
Unrecognized Blends

- Only one object detected in blending on; both observed when blending off.
- Impacts:
  - Model bias: Wrong photo-z, shape, etc.
  - Reduction in number of observed objects
  - Exclusion bias
Unrecognized Blends
(Ambiguous blends in Dawson et al. 2014)

- Only one object detected in blending on, both observed when blending off
- Impacts:
  - Model bias: Wrong photo-z, shape, etc.
  - Reduction in number of observed objects
  - Exclusion bias
One object remains undetected in blending on and off

Impacts:

- Model bias: wrong photo-z, shape, etc.
Undetected Blends

- One object remains undetected in blending on and off
- Impacts:
  - Model bias: wrong photo-z, shape, etc.

X : True centers
O: Stack center with blending off
Undetected Blends

- One object remains undetected in blending on and off
- Impacts:
  - Model bias: wrong photo-z, shape, etc.
Iteratively Recognized Blends

- Unrecognized blend at detection stage; recognized as blended during deblending
  - Impacts:
    - Imperfect deblending
    - Objects may get shredded
Input to Scarlet = one Stack center (o)
Iteratively Recognized Blends

Input to Scarlet = one Stack center (o)
Iteratively Recognized Blends

Input to Scarlet = one Stack center (o)

Difference image run through Stack, source detected
Iteratively Recognized Blends

Input to Scarlet = two Stack centers (o)
Iteratively Recognized Blends

Input to Scarlet = two Stack centers (o)
Iteratively Recognized Blends

Input to Scarlet = two Stack centers (o)

Scarlet deblended images

Difference image run through Stack; NO source detected
Unrecognized blend at detection stage; recognized as blended during deblending.

Impacts:
- Imperfect deblending
- Objects may get shredded
Iteratively recognized blends (84 objects)
- Unrecognized blend at detection stage; recognized as blended during deblending
- Impacts:
  - Imperfect deblending
  - Objects may get shredded

Recognized Blends (142 objects)
- Both objects detected when blending on and off.
- Impacts:
  - Imperfect deblending
  - Selection effects if cut made on blendedness

Unrecognized Blends (898 objects)
- Only one object detected with blending on; both observed with blending off.
- Impacts:
  - Model bias: Wrong photo-z, shape, etc.
  - Reduction in number of observed objects
  - Exclusion bias

Undetected Blends (1008 objects)
- One object remains undetected when blending on and off
- Impacts:
  - Model bias: wrong photo-z, shape, etc.
Other blending effects not considered yet

- Shredding
- Detected *only* in blends: both objects undetected when blending off; detected as one object when blending on
- ....
Results: Values measured with Stack in i-band

1. \( x_0, y_0 \): ext_shapeHSM_HsmSourceMoments_x, ext_shapeHSM_HsmSourceMoments_y

2. Flux: base_SdssShape_flux

3. \( e_1, e_2 \): ext_shapeHSM_HsmShapeRegauss_e1

Ellipticity: \( \frac{(Q_{11}-Q_{22}+2iQ_{12})}{(Q_{11}+Q_{22})} \)
Display measurement performance as a function of true values of three quantities for detected object:

1. **ab_mag**: AB magnitude in i band

2. **sigma_m**: $|Q|^{0.25}$, Q second-moment tensor

3. Purity as defined in WLDDeblending (a quantity between 0 and 1)

\[
\frac{\sum_p s_{ip} \cdot s_{ip}}{\sum_p (s_{ip} \cdot \sum_j s_{jp})}
\]
Recognized blends: Stack with blending off - truth

Red points: objects with greater true flux in the blend
Recognized blends: Stack with blending on - blending off
Recognized blends: Scarlet + stack - blending off
Unrecognized blends: Stack with blending on - blending off
Undetected blends: Stack with blending on - blending off
1. \(x_0, y_0\)
2. Flux
3. \(e_1, e_2\)

Blending on

Measurement

True \(x_0, y_0\)
Recognized blends: Scarlet with true center vs Scarlet with stack centers

![Graphs showing comparisons between true center and stack center for Scarlet.](image)
Iteratively recognized blends: Scarlet with true center vs scarlet with blend centers
Potential “surrogates” for blending

- Distance between centers
- Normalized distance ("effective separation" in Dawson et al. 2014)
- Minimum purity
Potential “surrogates” for Blending

- Distance between centers

Distance between centers (D)
Potential “surrogates” for Blending

- Distance between centers
- Normalized distance (“effective separation” in Dawson et al. 2014)

\[
\frac{D}{\sigma_1 + \sigma_1},
\]

\(\sigma\): PSF convolved size
Potential “surrogates” for Blending

- Distance between centers
- Normalized distance (‘effective separation’ in Dawson et al. 2014)
- Minimum purity
Results

Recognized Blends

Iteratively recognized Blends

Unrecognized Blends

Undetected Blends
Future work

- Increase statistical sensitivity of the study
- More blended objects in single image
- More realistic morphology
- Study effect on measured colors, photo-z
- Study impact of blending on selection biases
- Iteratively recognized blends: disentangle how much benefit comes from multiband nature of Scarlet
Conclusions

- Some unrecognized blends can be recognized by iteratively deblending and detection steps.
- Errors in input coordinates do not significantly affect Scarlet output for recognized blends.
- Blending surrogates are not sufficient to determine type of blend.
- Effect of blending on measurements is more significant for dimmer objects, as expected.
- Lots more work to be done!