Workshop on impacts of blending on LSST science: Goals and Overview

Sarah Brough (UNSW) and Jim Bosch (Princeton)

Plenary Session, Tuesday morning, August 14, 2018

Workshop supported by LSSTC Enabling Science Program
My Science Driver

Diffuse Light in Virgo

Mihos et al. 2005
My Science Driver
Scientific Organizing Committee

Sarah Brough (Galaxies SC)
Patricia Burchat (DESC)
David Kirkby (DESC)
Alexie Leauthaud (DESC)

Active Galactic Nuclei SC: Niel Brandt
Galaxies SC: Mike Cooper, Harry Ferguson, Brant Robertson, Graham Smith, Sugata Kaviraj
Solar Science SC: Wes Fraser, Henry Hsieh
Stars, Milky Way, LV SC: John Gizis
LSST DESC + DM: Peter Melchior, Fred Moolekamp
Transients/Variable Stars SC: Rachel Street
Strong Lensing SC: Aprajita Verma

(Italics indicate those present)
Workshop Sessions (Presidio III/IV)

Tuesday
- 11am-12:30pm - #1 Challenges, Current Status and Future Plans for Addressing Blending in LSST Data Release Pipelines
- 1:30-3pm - **#2 Overview of Blending Challenges for LSST Science**
- 3:30-5pm - #3 Hands-on Deblending: Simulations and Pipeline Tutorial

Wednesday
- 11am-12:30pm - #4 New Concepts for Object Detection and Deblending
- 1:30-3pm - #5 Tools and Data Sets for Developing and Evaluating Algorithms for Blended Objects
- 3:30-5pm - ??UNCONFERENCE??

Thursday
- 11am-12:30pm - #6 Clues About Blending in the LSST Object Catalog
- 1:30-3pm - #7 Solar System Objects, Crowded Fields, and Other Specialized Blending Challenges
- 3:30-5pm - **#8 Workshop Closeout**
Workshop Session #2

We will start with 5-min presentations (+2 min for questions) from the Science Collaborations (SCs):

1. Galaxies SC (Brant Robertson)
2. AGN SC (Niel Brandt)
3. Strong Lensing SC (Phil Marshall)
4. Dark Energy SC (David Kirkby / Pat Burchat)
5. Transient/variable stars SC (Federica Bianca)
6. Solar System SC (Henry Hsieh)
7. Stars, Milky Way and Local Volume SC (John Gizis)

Expected outcomes of this session:

- An inventory of challenges.
- Identified overlaps or common challenges between SCs.
- Identified ideas for unconference sessions.
## DESC Blending Task Force Presentations

<table>
<thead>
<tr>
<th>DATE</th>
<th>PRESENTER</th>
<th>Title</th>
<th>Slides</th>
<th>VIDEO</th>
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</thead>
<tbody>
<tr>
<td>10/02/2017</td>
<td>Jim Bosch</td>
<td>LSST Data Release Pipelines; Big Questions for Blending</td>
<td>animated google presentation, pdf</td>
<td>Zoom</td>
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<tr>
<td>10/16/2017</td>
<td>Peter Melchior, Fred Moolekamp</td>
<td>Multi-band deblending for LSST (also see 05/07/2018 presentation on Scarlet [arXiv:1708.09066])</td>
<td>Peter (pdf), Fred (pdf)</td>
<td>Zoom</td>
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<tr>
<td>10/23/2017</td>
<td>Gary Bernstein</td>
<td>Shear estimation with Bayesian Fourier Domain (BFD) method; thoughts on blending at LSST depths</td>
<td>pdf</td>
<td>Zoom</td>
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<tr>
<td>10/30/2017</td>
<td>Simon Samuroff</td>
<td>Im3shape and blending in DES</td>
<td>pdf</td>
<td>Zoom</td>
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<tr>
<td>11/06/2017</td>
<td>Erin Sheldon</td>
<td>The MOF deblender used in DES + discussion of interplay with metcalibration</td>
<td>pdf</td>
<td>Zoom</td>
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<tr>
<td>11/20/2017</td>
<td>Robert Lupton</td>
<td>Failure modes due to blended objects, at LSST depth (e.g., HSC), in detection, photometry, shape measurements, etc.</td>
<td>pdf</td>
<td>Zoom</td>
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<tr>
<td>11/27/2017</td>
<td>Rachel Mandelbaum</td>
<td>Shear estimation and blending in HSC</td>
<td>pdf</td>
<td>N/A</td>
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<tr>
<td>12/04/2017</td>
<td>Ian Dell’Antonio, Shinning Fu, Binyang Liu</td>
<td>Effects of blending on cluster shear profiles</td>
<td>google presentation (updated Aug 2018)</td>
<td>N/A</td>
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<tr>
<td>12/18/2017</td>
<td>Laurence Perreault Levasseur</td>
<td>Convolutional neural networks and independent component analysis of multi-filter imaging data (continued on Jan 29) [arXiv:1708.08842]</td>
<td>pdf</td>
<td>N/A</td>
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<tr>
<td>01/22/2018</td>
<td>David Kirkby</td>
<td>Image simulations for blended objects</td>
<td>pdf</td>
<td>Zoom</td>
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<tr>
<td>01/29/2018</td>
<td>Laurence Perreault Levasseur</td>
<td>Convolutional neural networks and independent component analysis of multi-filter imaging data (continued)</td>
<td>pdf</td>
<td>N/A</td>
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### Season 1

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>03/05/2018</td>
<td>Joachim Hamois-Deraps</td>
<td>Testing the blend-exclusion bias on cosmic shear with mocks lensing data [arxiv:1805.04511]</td>
<td>pdf</td>
<td>Zoom</td>
</tr>
<tr>
<td>03/19/2018</td>
<td>Erin Sheldon</td>
<td>Single object co-adds: implementations and testing</td>
<td>arXiv:1705.01599, SynPipe github</td>
<td>Zoom</td>
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<tr>
<td>04/30/2018</td>
<td>Raphael Shirley</td>
<td>Using the Bayesian Evidence for Source Extraction, Model Comparison and Deblending</td>
<td>pdf</td>
<td>N/A</td>
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<tr>
<td>05/07/2018</td>
<td>Peter Melchior, Fred Moolekamp</td>
<td>Improvements to SCARLET deblender, update on integration into the LSST stack, and future directions in deblending (including multi-survey) [arXiv:1802.10157]</td>
<td>Fred (pdf), Peter (pdf)</td>
<td>Zoom</td>
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<tr>
<td>05/21/2018</td>
<td>Sowmya Kamath</td>
<td>Quantifying effects of blending using simulated galaxy pairs + Hybrid use of the LSST science pipelines &amp; Scarlet</td>
<td>pdf</td>
<td>Zoom</td>
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<tr>
<td>06/18/2018</td>
<td>Jim Bosch</td>
<td>Co-addition algorithms and impacts of blending</td>
<td>animated google presentation</td>
<td>Zoom</td>
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<tr>
<td>07/02/2018</td>
<td>Cyrille Doux</td>
<td>Deblending galaxies with deep, convolutional, probabilistic neural networks</td>
<td>pdf</td>
<td>1st half of Zoom</td>
</tr>
<tr>
<td>07/02/2018</td>
<td>Sowmya Kamath</td>
<td>Addressing blending challenges with neural networks – A case study: Mask R-CNN</td>
<td>animated google presentation, pdf</td>
<td>Zoom</td>
</tr>
<tr>
<td>07/24/2018</td>
<td>Francois Lanusse</td>
<td>CMU DeepLens: Deep Learning For Automatic Image-based Galaxy-Galaxy Strong Lens Finding</td>
<td>N/A</td>
<td>Zoom</td>
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### Season 2
Specific Instructions for Hands-on Deblending Tutorial:

- Basically: Go to https://identity.lsst.org/join/4VYAMGK2E3 and hit the button for “Register a new user and join”

(Link in the slack channel #mtg-lsst2018 with instructions for obtaining an NCSA account to access the demo server (which contains the tutorials) or instructions are at: https://community.lsst.org/t/lsst-science-platform-demos-at-lsst2018/3116)
Some Terminology

**blended**: two or more objects are close enough that you can't accurately measure them independently.

**detection**: given images of a patch of sky, return above-threshold regions and the rough positions of objects within them.

**deblending (1)**: given images and the rough positions of blended objects, construct images or models that separate their flux so they can be measured separately.

**deblending (2)**: both detection and deblending (1)
DM and Community Roles in Blending

Most deblending happens in pipelines DM runs, in code DM nominally writes.

But deblending is *intrinsically impossible*, so:

- it's one of our most difficult algorithms to develop and test, and there's a broad range of classes of algorithm to consider;
- we don't have any simple ways to know when we've done a good job - subtle problems can probably only be caught by trying to do high-level science;
- our outputs may involve several mutually-exclusive interpretations of the true scene, and it'll be up to the community to determine which is best for any particular science analysis.
"Most deblending happens in pipelines DM runs"

But there will be some classes of blend we don't handle well. Those probably include:

- strong gravitational lenses
- supernova light echos
- galactic cirrus
- messy galaxy mergers

Our goals are to handle common classes of blend well, and do well enough on the rare cases to allow them to be found and handled by custom user processing.
"in code DM nominally writes"

...but if the community writes a better one, we'll absolutely use it.

The current deblender was written by DM.

- Derived from SDSS deblender (where the algorithm worked pretty well).
- Used in all HSC data releases to date (described in Bosch et al 2018).
- It's known not to be good enough at LSST depths.

The deblender we're integrating and evaluating for the future was partially written by DM: Scarlet (Melchior & Moolekamp 2018).

We're also considering at least one other deblender written completely outside DM.
DM's Goals for the Blending Workshop

- Help the community predict what blending and DM deblending will do to the astronomical objects they care about.
- Encourage and enable the community to help in evaluating Scarlet (and potentially other algorithms).
- Make sure DM deblending plans stay consistent with the community's needs and priorities.
- Make sure community algorithm/simulation/testing development proceed in ways that can feed back into DM.