Preparing the DESGW software pipeline for LVK's O4

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DESGW Group and DECam Instrument Overview

The Dark Energy Survey collaboration (DES) Gravitational Wave subgroup (DESGW) focuses on searching for optical emissions following gravitational wave detections by the LIGO, VIRGO, KAGRA (LVK) collaboration[2]. DESGW performs such searches using a difference imaging pipeline adapted from the DES single epoch and supernova difference imaging pipelines[1].

The CTIO, home of the Dark Energy Camera, one of the telescopes used by the DES. https://www.darkenergysurvey.org/the-des-project/instrument/

With LIGO starting its fourth observing run in 2022, DESGW would like its processing pipeline to need less long term technical support effort, and produce more accurate detection candidate lists in less time. Towards this goal, we worked on two projects. The first explored the possibility of using the LSST software stack as a replacement for the current processing pipeline. The second focused on upgrading the current pipeline by incorporating a Convolutional Neural Network into the workflow.

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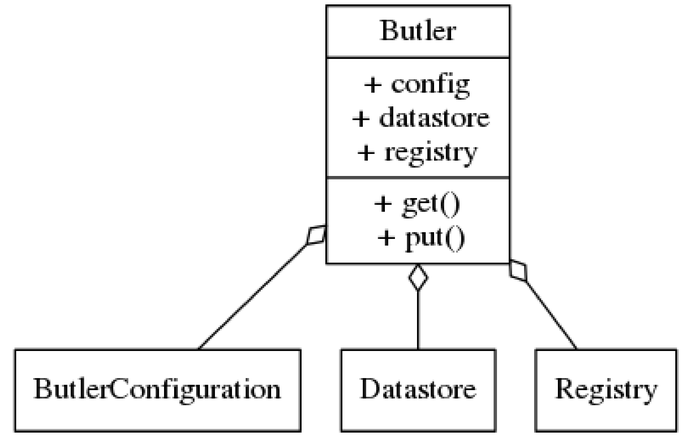
Project 1: Adapting the LSST Software Stack as an Alternative Processing Pipeline

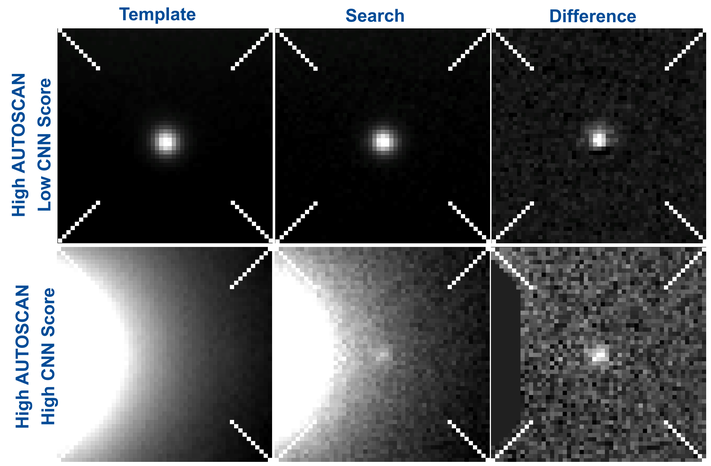
The Legacy Survey of Space and Time (LSST) software stack is a set of processing and analysis tools for telescope data. Because the LSST stack can perform most, if not all of the processing tasks done by the DESGW pipeline, it is a good candidate for an alternative pipeline, allowing most of the software development to be performed by the LSST team. However, the LSST software is still in development and many of its tools and documentation are incomplete. For example, its data management system, referred to as the Butler, struggles with ingesting some calibration files and their metadata into the Datastore and Registry respectively. Once the LSST stack is more stable and complete, its flexibility and improved long term support will make it a better choice than it is currently.

Project 2: Implementing a CNN to Improve Existing Pipeline Products

Convolutional Neural Networks (CNN) are a class of artificial neural networks that are often used in computer vision. Taking advantage of this ability, Shandonay et al[4] trained a CNN to score image stamps from the pipeline. Image stamps are smaller cutouts from the larger telescope image that the pipeline thinks may have an interesting feature. This CNN score can be used to improve the classification accuracy of the pipeline. By using a CNN, we can reduce the amount of human inspection time required to identify false-positives. We added this CNN to the existing DESGW pipeline and set it up to produce candidate lists that include the CNN scores and other image parameters.



Overview of the Butler Data Management System. The Datastore manages datafiles, the Registry stores and associates various group labels and metadata parameters of the datafiles. The Butler is an interface between the user and the datastore and registry.
LSST DM Technote 056, https://dmtn-056.lsst.io/butler.html



Two sets of stamps, both of which under the current sorting algorithm were labeled as likely candidates. The top set is a false-positive due to misaligned template and search images. The bottom is likely a true-positive.

References

1) Herner, K., et al, EPJ Web Conf. 245, 01008 (2020) https://doi.org/10.1051/epjconf/202024501008

2) Herner, K., et al, Astronomy and Computing 33, 100425 (2020) https://ui.adsabs.harvard.edu/abs/2020A%26C....3300425H/abstract

3) LSST Science Pipelines Documentation, https://pipelines.lsst.io

4) Shandonay, A., et al, arXiv:2106.11315 [astro-ph.IM] https://arxiv.org/abs/2106.11315