There's no difference: Convolutional Neural Networks for transient detection without template subtraction

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Abstract

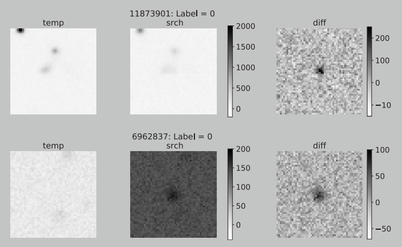
- **Real astrophysical transients** like supernovas (explosion of stars) are **rare events** compared to the **large amount of artifacts or bogus** that surveys and machines generate in the pre-process steps of the data. This fact and the **large amount of data** that surveys collect every year create the necessity of an **automatic classification of astrophysical images**.
- We present a **Convolutional Neural Network (CNN)**-based model for the separation of astrophysical transients from image artifacts, a task known as **real-bogus** (RB) classification, that does not rely on template subtraction (or Difference Image Analysis, DIA).
- We compared the efficiency of **two models** with similar architectures, one that uses **image triplets** composed of template (**temp**), search (**srch**), and difference image (**diff**), and one that takes as **input the temp and srch *only***.
- Although we notice a **small performance decrease removing diff**, our work demonstrated that research in this direction can produce a CNN RB classification model that performs at the state of the art **bypassing the DIA entirely, the most computationally expensive step in the detection of astrophysical transients**.
- We investigate what information is used by each model by **exploring the models' maps of pixel importance**.

Difference Image Analysis (DIA)

Currently the way "real" transients are discovered:

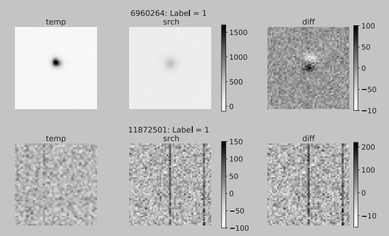
- High-quality image composed by multiple night images: ***temp***.
- Single night image: ***srch***.
- Point Spread Function matching: Degrade ***temp*** to "match" ***srch***.
- Difference between images: ***diff*** .

Computational expensive and time consuming.
Example of real objects



Difference Image Analysis (DIA)

DIA processes produce artifacts or bogus objects:

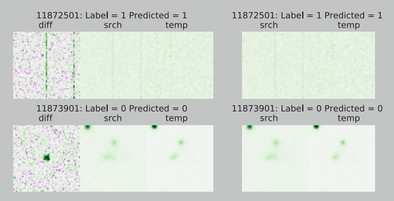


CNNs vs feature-based models

"Real" and "Bogus" could have similar behaviours, feature extraction, based on statistic values, would not represent correctly the data.

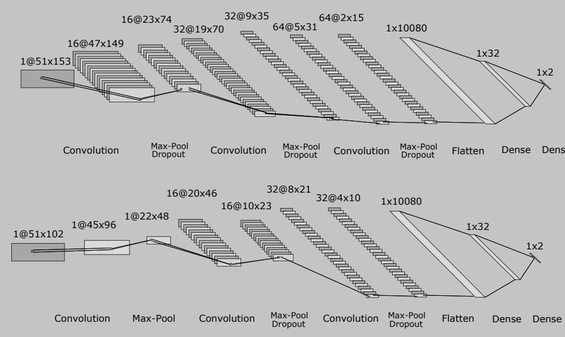
Data: 1st Season Dark Energy Survey

- 454,092: **"real" (0)**
- 444,871 artifacts as classified by human: **"bogus"(1)**

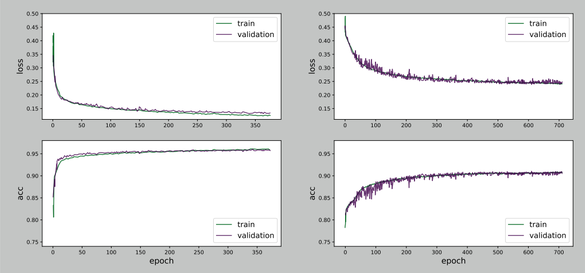


Architecture of DIA and noDIA CNNs

- Created two CNNs, one using the **diff**+**srch**+**temp** and other with **srch**+**temp**.
- Similar architecture to enable comparison.

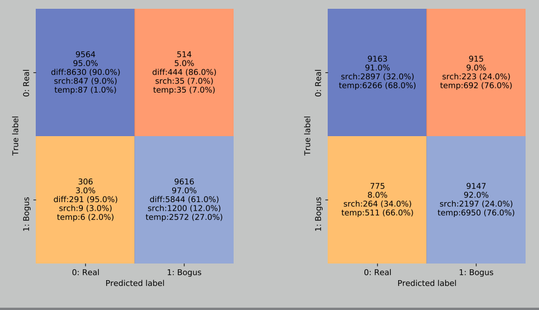


Accuracy and loss curve

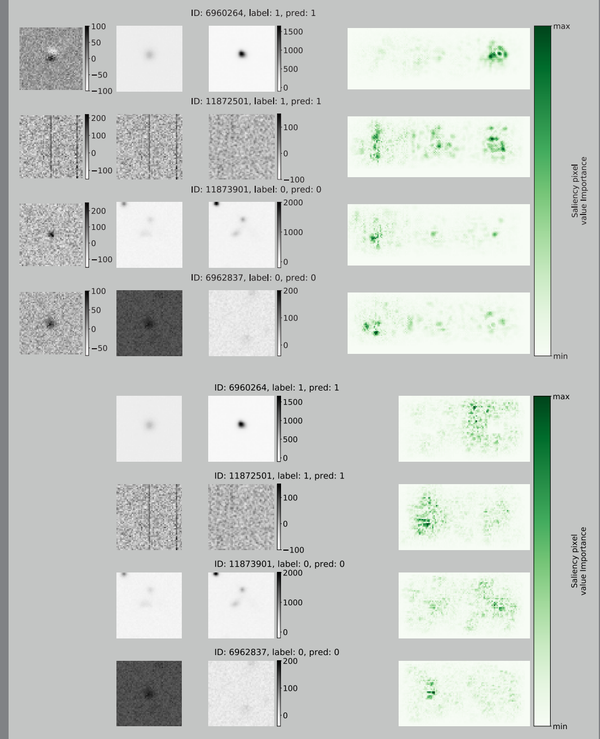


- For the noDIA model the input data contains less information, this model takes longer to learn features from the data to be able to classify them.

Confusion Matrices

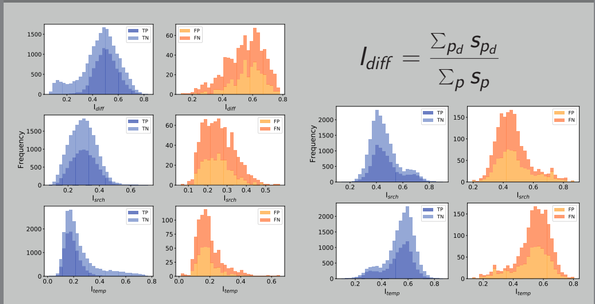


Maps of Pixel Importance (Saliency maps)



- These maps enable a visual understanding of the importance of each element of the combined image in the real-bogus classification.

Pixel Importance Metric



$$I_{diff} = \frac{\sum_{p_d} s_{p_d}}{\sum_p s_p}$$

- The distribution of I_{diff} (top) is the greatest than from I_{search} (middle), and I_{temp} (bottom) for the DIA model.