MeerCRAB: Classification of Optical Transients at the MeerLICHT Telescope using Deep Learning

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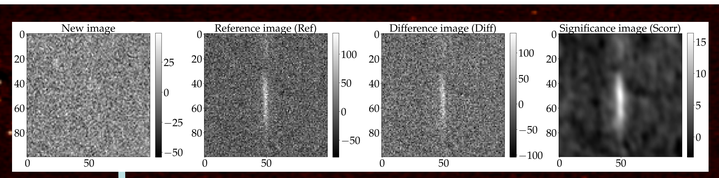
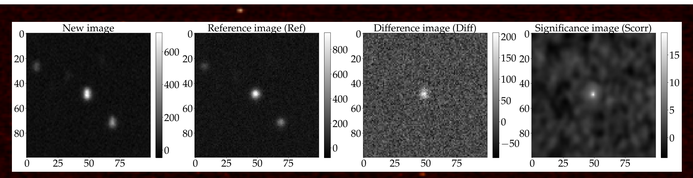
1. Input Data

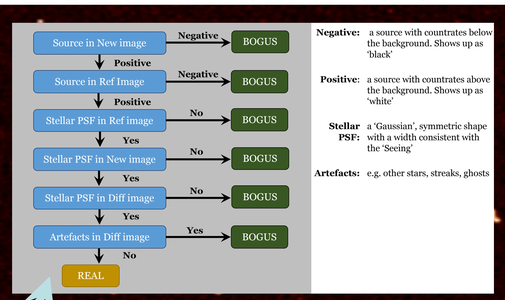
- MeerLICHT is an optical wide-field telescope that is operated robotically.
- There are four distinct forms of image inputs to MeerCRAB – the new (N) image, the reference (R) image, the difference (D), &the significance (S) image.

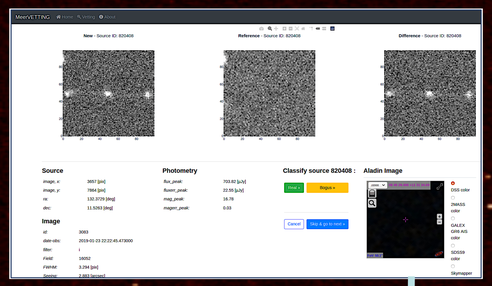


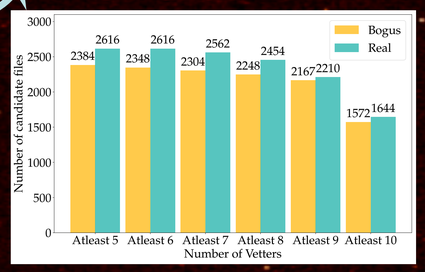


2. Constructing Training Data

- We construct a large representative training dataset (5000 candidates) for the Real-Bogus challenge.
- Manually vetting a selection of transients, using a web-interface, known as MeerVETTING.
- Each candidate is vetted by 10 volunteers, who are shown three images (N, R, D) during vetting.







Latent Class Model

3. Methods of Labelling

a. Latent class model (LCM) will try to detect the presence of latent classes (the candidates entities), generating patterns of association in the characteristics.

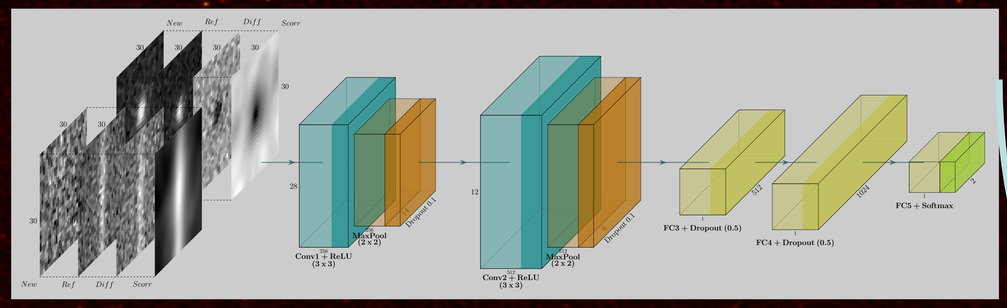
b. Thresholding Method

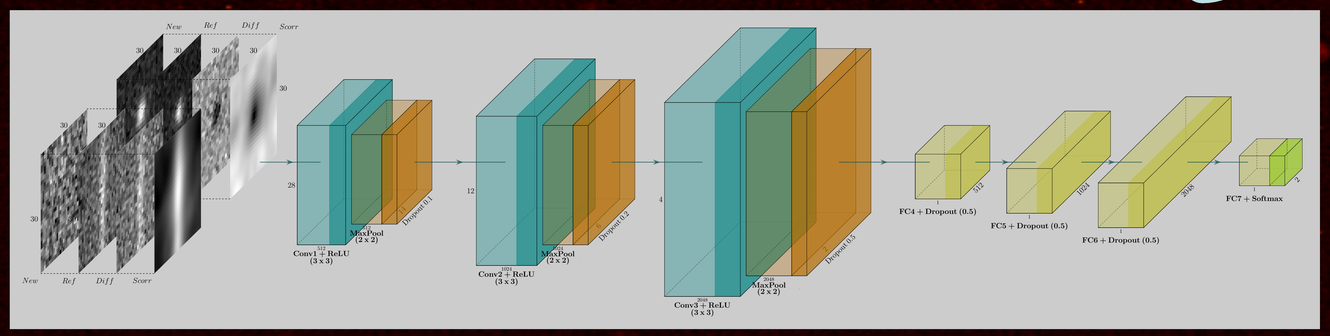
We assign a probability P (*Real*) and P (*Bogus*) to each vetted candidate as follows:

$$P(Real) = \frac{n(R)}{n(T)};\ P(Bogus) = \frac{n(B)}{n(T)}$$

4. MeerCRAB Models:

- During training, the binary cross-entropy loss function, Adam optimizer with a low lr = 0.0002 & a batch-size of 64 were used.
- We then split our data into 50% training, 25% validation and 25% testing.
- As input to the MeerCRAB models, we cropped the images from centre to a size of (30 × 30).





5. Results & Analysis

Effects of noisy data labelling on performance: As the threshold increased from T8 to T10, the accuracy of the model increases from 0.988 to 0.998. However, with L_{lcm} method, we note a significant drop in accuracy.

Input Images: Focusing on T9 and MeerCRAB3, the NRD input yields the best performance model with an accuracy of 99.2%.

Network architectures: With deeper networks (MeerCRAB2 and MeerCRAB3), we obtain a higher performance with an accuracy of 98.6% & 99.2% respectively.

Methods of labelling	Precision	Recall	Accuracy	MCC
	MeerCRAB1			
L_{lcm}	0.96	0.96	0.960	0.920
T8	0.98	0.98	0.980	0.958
T9	0.98	0.98	0.979	0.958
T10	0.99	0.99	0.991	0.983
	MeerCRAB2			
L_{lcm}	0.97	0.97	0.967	0.936
T8	0.99	0.98	0.977	0.953
T9	0.99	0.99	0.986	0.973
T10	0.99	0.99	0.994	0.988
	MeerCRAB3			
L_{lcm}	0.97	0.97	0.968	0.936
T8	0.99	0.99	0.988	0.976
T9	**0.99**	**0.99**	**0.992**	**0.984**
T10	1.00	1.00	0.998	0.995