Lens Classification Report

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Space-Based Entry

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description: Convolution neural network - 8 layers of convolution 3x3 -, decaying batch normalization

We have received 100003 classifications.

The ROC curve

First lets get some terminology clear. The true positives are the number of lenses that are classified as lenses. The true negatives are the number of non-lenses classified as non-lenses. The false positives are the number of non-lenses classified as lenses. The false negatives are the lenses the are classified as non-lenses.

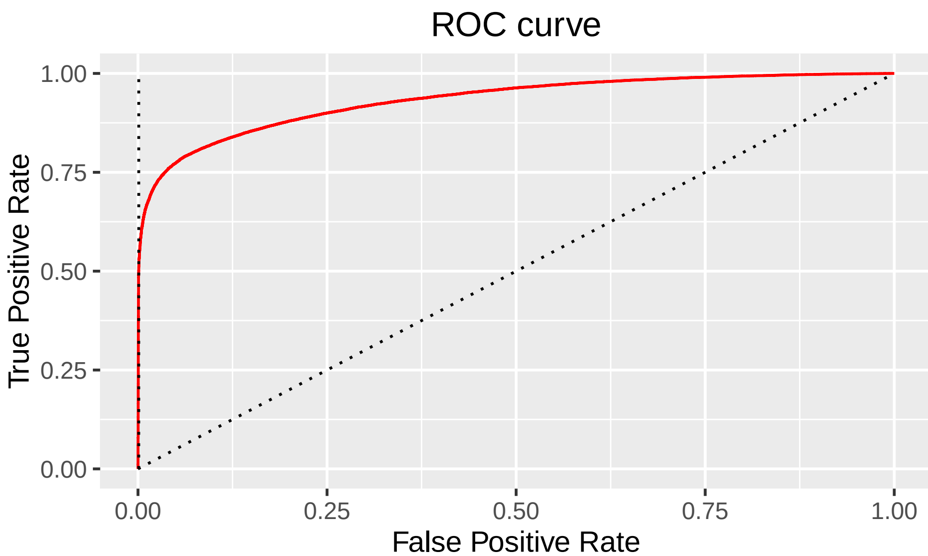
The **false positive rate** (also called fall-out) is the fraction of non-lenses that are classified as lenses. In this case

$$FPR = \frac{FP}{(FP + TN)} \tag{1}$$

The **true positive rate** is the fraction of true lenses that where classified as lenses. This is a measure of how well the method can pick out the population of lenses.

$$TPR = \frac{TP}{TP + FN} \tag{2}$$

The ROC curve is a plot of the true positive rate and the false negative rate evaluated on the test set for different threshold probabilities, p_t. We calculated the rates for 100 evenly separated p_t's between 0 and 1. If your entry had only a 1 or 0 rating then $0 < p_t < 1$ will all give the same point on the ROC. If your entry had a real number rating then there will be multiple points on this curve. A random classifier that just guesses at random will have an ROC that follows the diagonal dotted line in the ROC plot.



The **area under the ROC** (AUROC) is a measure of how good the classifier is. In this case it is:

AUROC = 0.9325338

A perfect classifier would give 0.5 and a random classification 0.0. The standard deviation is calculated by bootstrapping the entry. There were multiple challenge sets so the standard deviation will be used to judge if two entries actually perform differently.

$\mathbf{TPR_0}$ and $\mathbf{TRP_{10}}$

Gravitational lenses are rare things, but in the simulated test set the proportion of lenses was much higher. In real data we would expect about a 1,000 to 1 ratio of non-lenses to lenses. The fraction of objects classified as lenses that are not lenses will be

$$\frac{\text{number of non} - \text{lenses}}{\text{number of lenses}} \frac{FPR}{TPR} \sim 1000 \times \frac{FPR}{TPR} \tag{3}$$

This can result in a high contamination of the lens sample if the FPR is not very small. As a measure of this we introduce two quantities. We determine the lowest p_t level for which there are not false positives. The true positive rate at this level will be TPR_0. Then we determine the lowest p_t level for which there are 10 or fewer false positives and call the true positive rate at this level TPR_{10}. In this case they are:

$\mathbf{TPR_0}$ **:** 0.004773626

$\mathbf{TPR_{10}}$ **:** 0.07796922

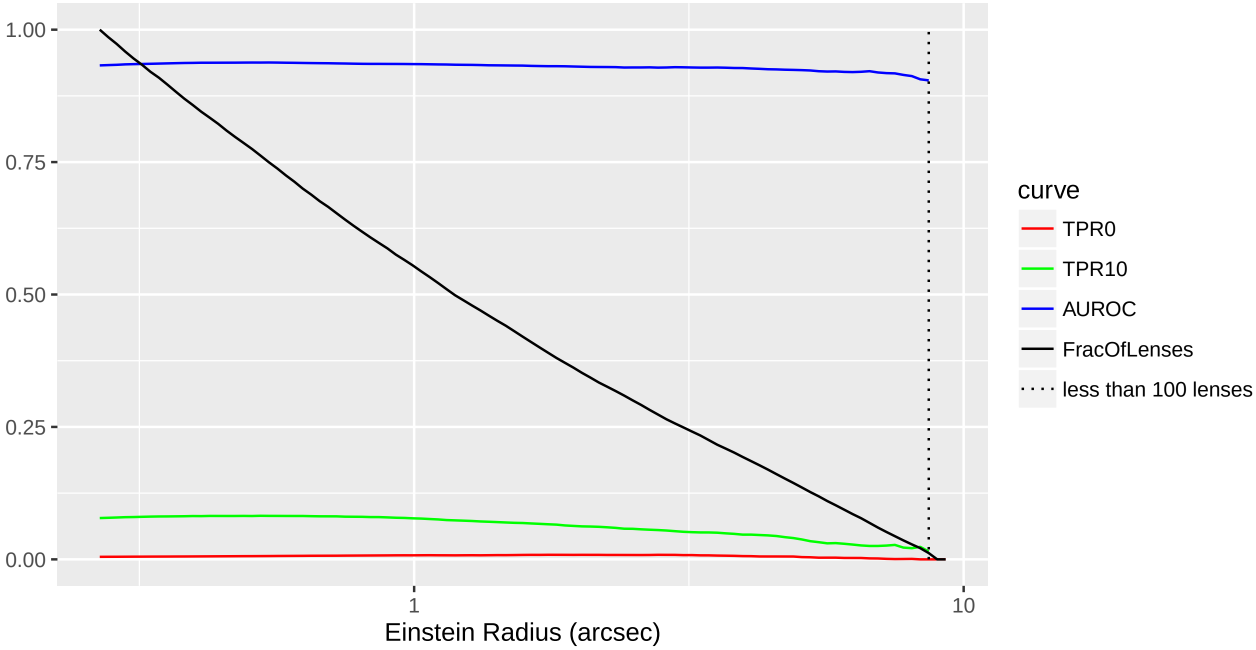
To construct a confusion matrix a threshold for the classifier needs to be set. At the p_t level for TRP_0 (if it existed) the confusion matrix for this entry was:

```
##
##                classified as not lens classified as lens
##   Is Not Lens                   59742                 40
##   Is Lens                       20957              19264
```

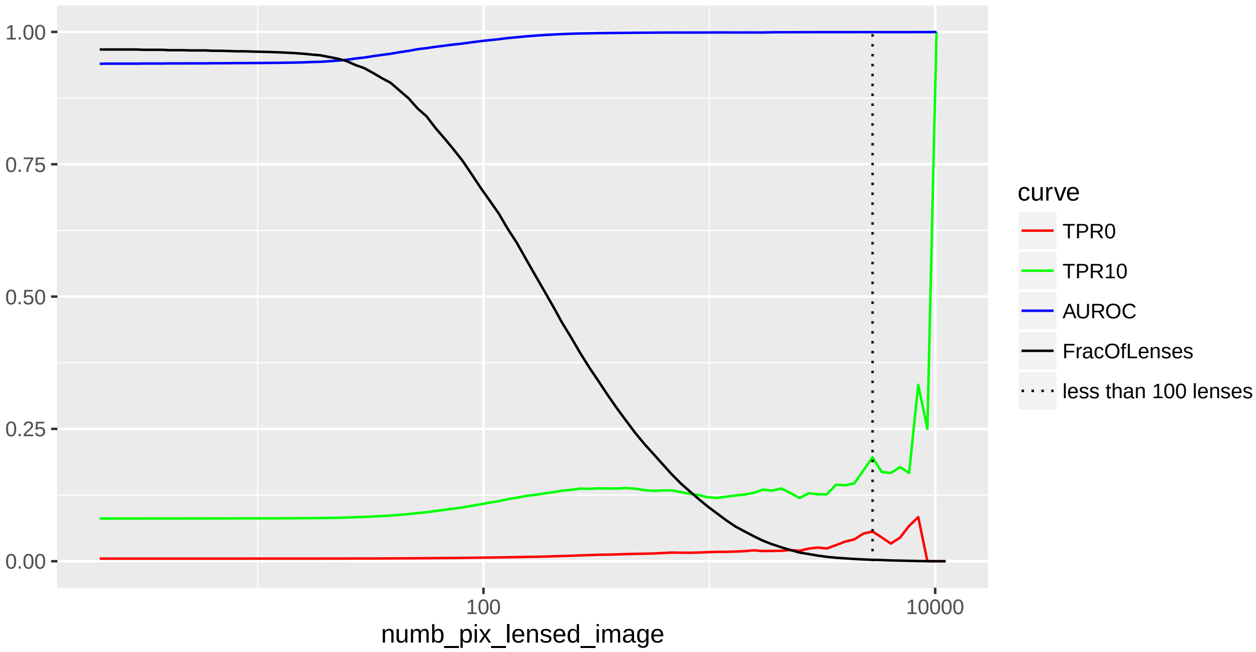
This is the number of cases that fall into combinations of the categories shown.

Performance as a function of lens properties

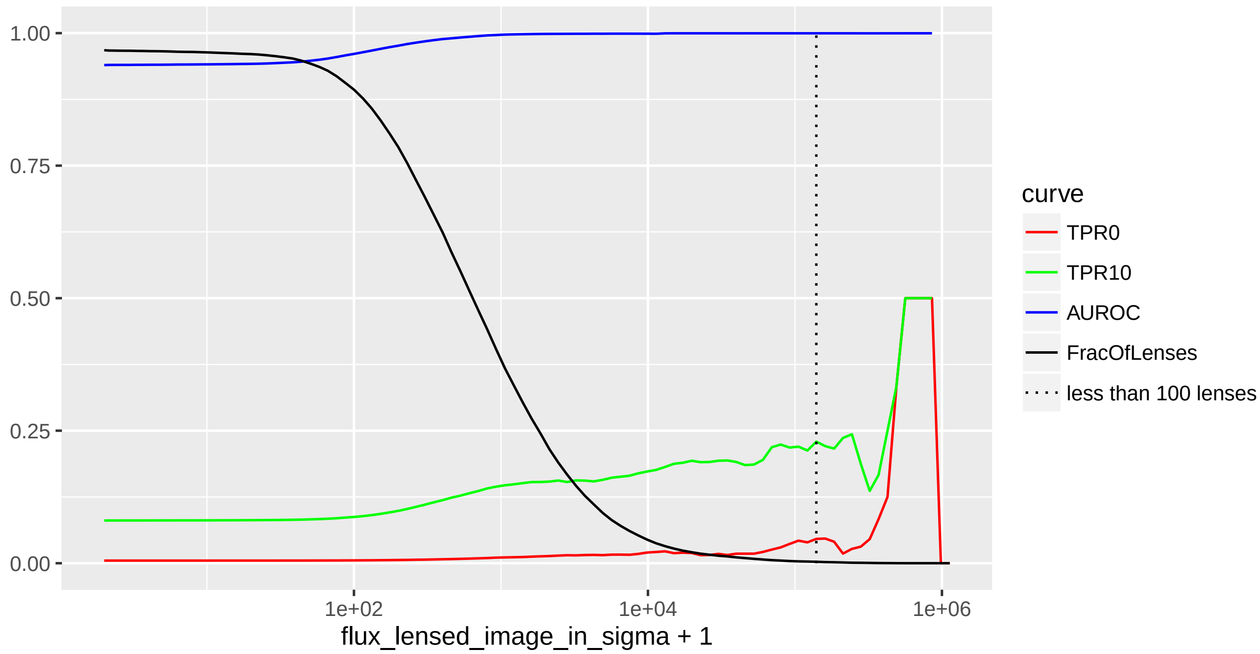
Some properties of the lens system might make a lens difficult or impossible to detect. We cannot expect a classifier to detect a lens if the source has an undetectably low luminosity for example. For this reason we plot the AUROC, TRP_0 and TRP_{10} as a function of some properties of the lens system.



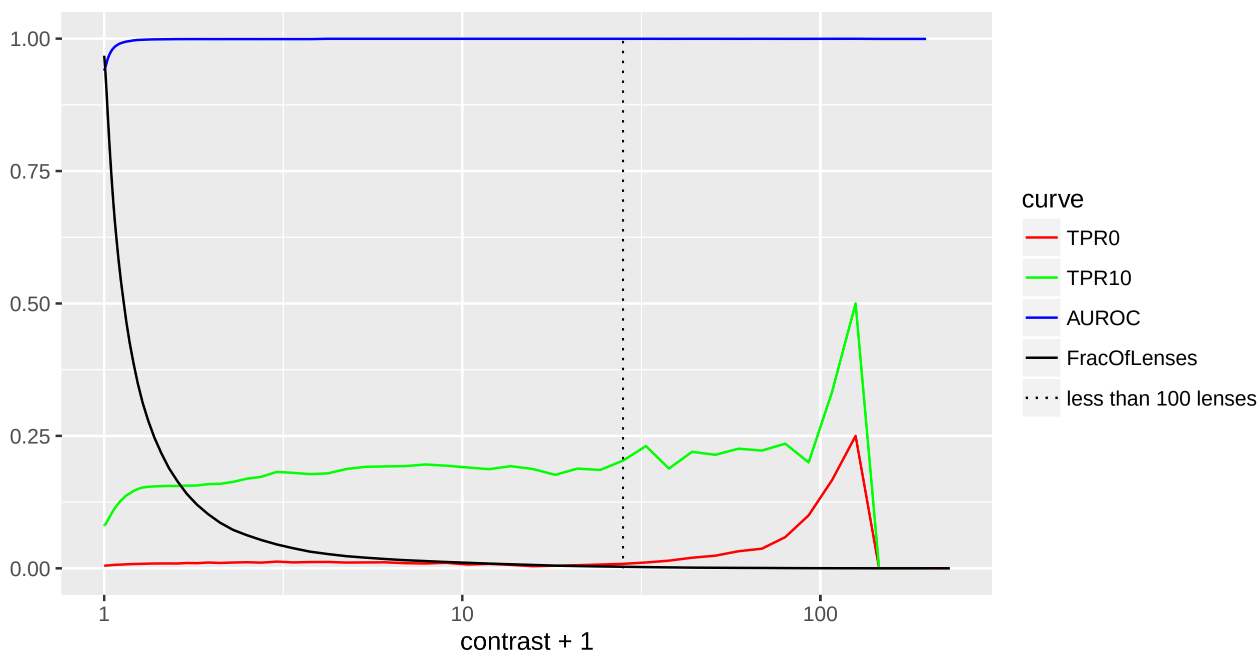
These are the quantities for the lenses considering only lenses with Einstein radii larger than given on the x-axis. The total fraction of lenses in the sample that meet this requirement is given by the black solid curve. The dotted curve marks where there are less than 100 lenses int the set that meet this requirement.



This is as a function of the number of pixels in the lensed source image that where above $1 \times \sigma$ where σ is the noise level in dark regions of the image.



This is as a function of the flux in pixels in the lensed sources image that where above $1 \times \sigma$ in units of σ.



This is the contrast defined as the flux in the lensed image in the pixels above σ divided by the total flux in the image above threshold.