Classification of sources in the Fermi-LAT 4 and 8 year catalogs using machine learning methods*

Aakash Bhat[1[0000−1111−2222−3333]] and Dmitry Malyshev[1[1111−2222−3333−4444]]

ECAP, Friedrich Alexander Universitaet Erlangen-Nuremberg, Germany
dmitry.malyshev@fau.de
aakash.bhat@fau.de

Abstract. We present the classification of AGNs and Pulsars using different machine learning algorithms in the Fermi-LAT 4 and 8 year catalogs. First we compare the traditional machine learning methods including boosted decision trees, Random forests, and Logistic regression. Then we move on to a nueral network based classification of known sources. Finally, we make predictions using the 8-year catalog for future studies.

Keywords: Fermi-LAT · Machine Learning · Neural Networks

1 Introduction

1.1 Fermi-LAT

Please note that the first paragraph of a section or subsection is not indented. The first paragraph that follows a table, figure, equation etc. does not need an indent, either.

Subsequent paragraphs, however, are indented.

Sample Heading (Third Level) Only two levels of headings should be numbered. Lower level headings remain unnumbered; they are formatted as run-in headings.

Sample Heading (Fourth Level) The contribution should contain no more than four levels of headings. Table 1 gives a summary of all heading levels.

2 Work

2.1 Machine Learning

We began our work by sorting the data into known and unknown sources. Since our work is supervised learning we only choose known sources for training. The known sources were a total of 1933, with 1739 AGNs and 166 pulasars, after cleaning up of the data. Then our work was sorted into two parts. The first was to train using tree based machine learning techniques and the second was to train using nueral networks.

* Supported by organization x.

Table 1. Table captions should be placed above the tables.

Heading level	Example	Font size and style
Title (centered)	**Lecture Notes**	14 point, bold
1st-level heading	**1 Introduction**	12 point, bold
2nd-level heading	**2.1 Printing Area**	10 point, bold
3rd-level heading	**Run-in Heading in Bold.** Text follows	10 point, bold
4th-level heading	*Lowest Level Heading.* Text follows	10 point, italic

3 Tree-based methods

We used the following tree based methods and developed simple scripts in python: Random Forests, Extra trees classifier, AdaBoost, Gradient boosting. The modules for tree-based methods were imported from sk-learn which is available in python. The primary parameters were the number of trees and the maximum depth of nodes.

As can be seen above the score tends to saturate around 1000 and 5000 trees

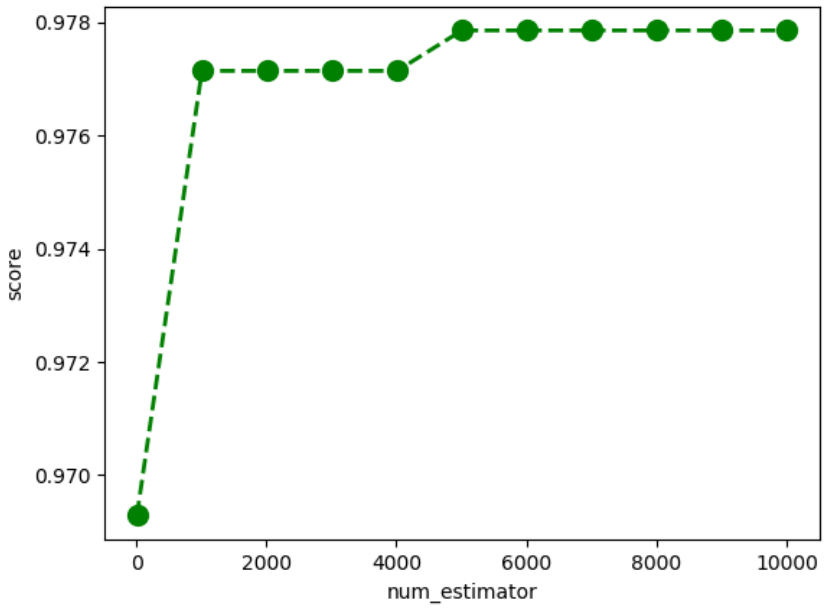

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Fig. 1. OOB score for random forest based learning vs. number of trees

respectively. A similar approach shows the following with regards to the maxi-

mum depth of trees for 50 trees.

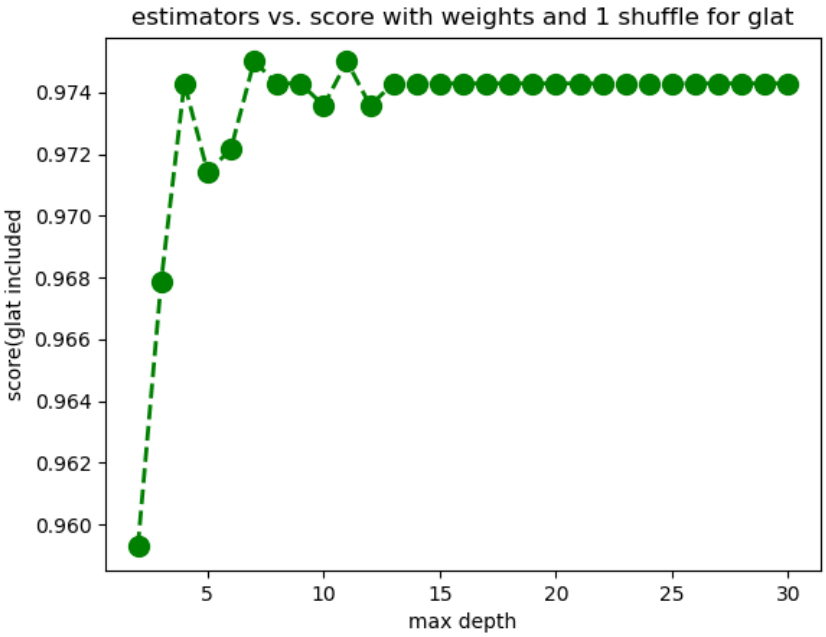

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Fig. 2. OOB score for random forest based learning vs. maximum depth of trees

Displayed equations are centered and set on a separate line.

$$x + y = z \tag{1}$$

Please try to avoid rasterized images for line-art diagrams and schemas. Whenever possible, use vector graphics instead (see Fig. **??**).

Theorem 1. *This is a sample theorem. The run-in heading is set in bold, while the following text appears in italics. Definitions, lemmas, propositions, and corollaries are styled the same way.*

Proof. Proofs, examples, and remarks have the initial word in italics, while the following text appears in normal font.

For citations of references, we prefer the use of square brackets and consecutive numbers. Citations using labels or the author/year convention are also acceptable. The following bibliography provides a sample reference list with entries for journal articles [1], an LNCS chapter [2], a book [3], proceedings without editors [4], and a homepage [5]. Multiple citations are grouped [1–3], [1, 3–5].

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