UDC 004.021; 612.08; 681.5

Ihor TITOV [1]**,** PhD student,
Nataliia TITOVA [2]**,** DSc, Professor,
Natalia MANICHEVA [2]**,** PhD, Assoc Professor
[1] ISCTE – Instituto Universitário de Lisboa, Lisboa, Portugal, e-mail: titov.need@gmail.com
[2] Odessa Polytechnic National University, Odessa, Ukraine, e-mail: titova.n.v@op.edu.ua, vmanichev@ukr.net

MACHINE LEARNING IN MEDICINE, BINARY LOGISTIC REGRESSION

Abstract. The article shows the use of ROC analysis for building models in medicine and conducting clinical trials. Examples of the use of a binary logistic model for medical purposes are given. The ROC curve (receiver operator characteristic) is the most commonly used curve to represent binary classification results in machine learning.

Key words: machine learning, binary logistic regression, dichotomous variables, ROC analysis, ROC curve.

Introduction

The introduction of machine learning technologies in medicine is one of the main trends in the healthcare world. To do this, you need to use data analysis.

Logistic regression is a useful classical tool for solving the problem of regression and classification. The so-called ROC analysis is a tool that is used to analyze the quality of models. Both algorithms are actively used to build models in medicine and conduct clinical trials.

Logistic regression is useful for situations where you want to be able to predict the presence or absence of a feature or outcome based on the values of a set of predictor variables. It is similar to a linear regression model, but is suitable for models where the dependent variable has only two values. Logistic regression coefficients can be used to estimate the odds ratio for each dependent model variable. Logistic regression is applicable to a wider range of situations than discriminant analysis.

A typical example of using binary logistic regression: consider lifestyle characteristics that are risk factors for coronary heart disease. Given a sample of patients with measures of smoking, diet, physical activity, alcohol use, and coronary heart disease, you can build a model that uses four lifestyle characteristics to predict the presence or absence of coronary heart disease in a sample of patients. This model can then be used to generate odds ratio estimates for each factor, which will show you how much more prone smokers are to coronary heart disease than non-smokers [1].

With the help of logistic regression, it is possible to estimate the probability of an event occurring for a particular subject – sick / healthy.

All regression models can be written as a formula:

$$y = F(x_1, x_2, \ldots, x_n).$$

In multiple linear regression, the dependent variable is assumed to be a linear function of the independent variables, that is:

$$y = a + b_1 x_1 + b_2 x_2 + \ldots + b_n x_n.$$

The ROC curve (receiver operator characteristic) is the most commonly used curve to represent binary classification results in machine learning. The name comes from signal processing systems. Since there are two classes, one of them is called a class with positive outcomes, the second - with negative outcomes. The ROC curve shows the dependence of the number of correctly classified positive examples on the number of incorrectly classified negative examples [2].

In machine learning, current research is gone from simply presenting the results of accuracy while performing empirical testing of new algorithms. This is especially relevant in the evaluation of output algorithms probabilities of class values. It is recommended that you use receiver operator (ROC) performance curves when evaluating binary solution problems, which show how the number of correctly classified positive examples varies depending on the number of incorrectly classified negative examples [2].

The clinical performance of a laboratory test can be described in terms of diagnostic accuracy, or the ability to correctly classify subjects into clinically relevant subgroups. Diagnostic accuracy refers to the quality of the information provided by the classification device and should be distinguished from the usefulness, or actual practical value, of the information. Receiver-operating characteristic (ROC) plots provide a pure index of accuracy by demonstrating the limits of a test's ability to discriminate between alternative states of health over the complete spectrum of operating conditions. Furthermore, ROC plots occupy a central or unifying position in the process of assessing and using diagnostic tools. Once the plot is generated, a user can readily go on to many other activities such as performing quantitative ROC analysis and comparisons of tests, using likelihood ratio to revise the probability of disease in individual subjects, selecting decision thresholds, using logistic-regression analysis, using discriminant-function analysis, or incorporating the tool into a clinical strategy by using decision analysis [3].

ROC graphs are a very useful tool for visualizing and evaluating classifiers. They are able to provide a richer measure of classification performance than accuracy or error rate can, and they have advantages over other evaluation measures such as precision-recall graphs and lift curves [4].

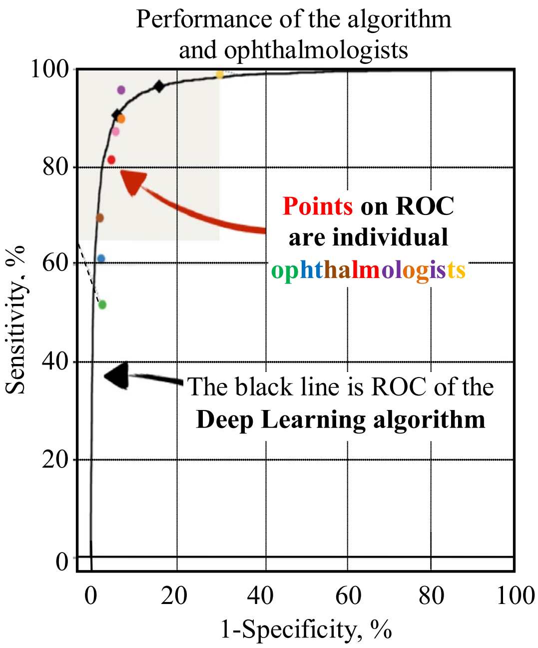

Fig. 1. ROC curve of the obtained algorithm [5]

An example of the use of ROC analysis in medicine. In their study "Development and Validation of a Deep Learning Algorithm for Detecting Diabetic Retinopathy in Retinal Fundus Images" [5], the authors decided to apply deep learning methods to determine if an eye is healthy or has a certain degree of diabetic retinopathy.

The authors used a dataset consisting of 128, 125 choroid images. Data labeling involved 54 licensed ophthalmologists. In the case when experts assigned different labels to the same image (different degrees of the disease, most often, if the eye is healthy, the experts unanimously assigned the label "healthy").

The result of the study can be expressed as follows: "The algorithm gives a slightly better forecast compared to a real specialist". What does it mean? To explain the result, we need to look at the ROC curve of the resulting algorithm (Fig. 1).

For different levels of significance, the algorithm can give both a more accurate forecast and less, and it cannot be concluded that, on average, the algorithm is better than a real specialist. However, the advantage of the algorithm is that it can work at different levels of "ensitivity" at once – by varying the parameters of the algorithm, you can make it make a prediction only if the probability of correctly belonging to the class is large enough. Medical professionals usually give predictions at a constant level of significance. One way or another, this system and others like it are already helping to improve the quality of diagnostics among ophthalmologists around the world.

Conclusion. Deep learning methods on spatial structures are already bringing interesting and positive results in the field of medicine.

References

1. https://www.ibm.com/docs/ru/spss-statistics/beta?topic=regression-binary-logistic.
2. Davis J., Goadrich M. The Relationship Between Precision-Recall and ROC Curves // Proc. Of 23 International Conference on Machine Learning, Pittsburgh, PA, 2006.
3. Zweig M.H., Campbell G. ROC Plots: A Fundamental Evaluation Tool in Clinical Medicine // Clinical Chemistry, Vol. 39, No. 4, 1993.
4 awcett T. ROC Graphs: Notes and Practical Considerations for Researchers // 2004 Kluwer Academic Publishers.
5. Gulshan, V., Peng, L., Coram, M., Stumpe, M.C., Wu, D., Narayanaswamy, A., Venugopalan, S., Widner, K., Madams, T., Cuadros, J. and Kim, R., 2016. Development and validation of a deep learning algorithm for detection of diabetic retinopathy in retinal fundus photographs. Jama, 316(22), pp.2402–2410.