Automated system of recognition of road signs for ADAS systems

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Abstract. Advanced Driver Assistance Systems (ADAS) require an environmental recognition function to inform the driver and for making management decisions. To solve the problems of pattern recognition, it is necessary to use one of the image classification methods. To date, there are quite a few similar algorithms that differ in the quality and speed of recognition. This paper presents a comparative analysis of classification algorithms in the problems of road signs recognition based on the GTSRB dataset. The results of the work showed that the most promising methods of classification in the problems of image recognition are the methods of reference vectors and k–nearest neighbors.

1. Introduction

Pattern recognition is one quite difficult task due to the diversity of both the objects to be recognized and the methods used. The need for such systems is manifested in different areas – from fault detection in diagnostic systems to control of unmanned vehicles [1-4].

One of the problems in the theory of pattern recognition is the problem of classification, that is, the correlation of the image to one of the classes. This paper presents a comparison of classification algorithms in the problem of recognition of road signs.

2. The problem of classification

As a rule, in classification problems there are a lot of objects that are separated in a certain way into classes. For given objects, it is known which classes they belong to. These objects are called training samples. The class affiliation of all other objects is unknown. The task of classification is to determine the class affiliation (classify) an arbitrary object.

Many classification algorithms are known. The main ones are:

1. Support vector method (SVM).
2. EM-algorithm (Expectation-maximization algorithm).
3. The method of k nearest neighbors (k-NN).
4. Decision tree.
5. Naive Bayes classifier.

These algorithms are widely used in computer vision: from searching for features using a trained classifier for tracking, segmenting scenes, to simpler tasks such as object classification and image clustering.
There are various open image database road signs. The largest of them are: German (GTSRB, The German Traffic Sign Recognition Benchmark), Swedish (STS), Belgian (BTSD, Belgium Traffic Sign Dataset) and American (LISA, Laboratory for Intelligent and Safe Automobiles).

Table 1 presents the comparative characteristics of these image databases. For integrated training and testing of classifiers, it is necessary that the number of classes of signs and the number of images per class is the maximum.

The Swedish image database (STS) presents a limited number of characters, which makes it more difficult to assess the generalizability of the classification algorithms for more classes.

The Belgian (BTSD) and American (LISA) databases contain a relatively small number of images per class, which complicates the testing of classifiers that require large training samples [5].

Table 1. The characteristics of image databases

|                | STS  | LISA | BTSD | GTSRB |
|----------------|------|------|------|-------|
| Number of signs| 7    | 47   | 108  | 43    |
| Total number of image of signs | 3488 | 7855 | 13444 | 51839 |

Taking into account the above factors, the base of road signs GTSRB [6] was used to test the classification algorithms. Figure 1 shows an example of images of road signs from this database.

Due to the large number of classes and images in this database, only a part of the classification algorithms was used for training and testing: 10590 images divided into 10 classes.

This sample was divided into two parts: for preliminary training, 5,295 images of road signs were used, and further testing for the quality of the algorithm was carried out on a test sample consisting also of 5,295 images.

Preliminary processing was carried out for images:
- reduction to the size of 30 by 30 pixels;
- convert to grayscale;
- adaptive threshold conversion to highlight interesting features of the image [7, 8].

The work of this algorithm in the conversion of images of signs is shown in figure 2.
The result of applying the threshold conversion algorithm

Testing was carried out on the same personal computer.

Table 2 shows the data obtained during the comparison of the training time, the number of correctly recognized figures from the 5295 examples of the test sample, the recognition time of the entire test sample and the size of the resulting classification model (structure).

Table 2. The results of the classification algorithms

| Algorithm         | Training time, msec | Number of correct recognitions | Time of recognition of the test sample, msec | The size of the classification model (structure) obtained, KByte |
|-------------------|---------------------|--------------------------------|---------------------------------------------|-----------------------------------------------------------|
| SVM               | 4979                | 4547                           | 8007                                        | 9858                                                      |
| k-NN              | 2115                | 4070                           | 33310                                       | 5847                                                      |
| Decision Tree     | 1579                | 3531                           | 7459                                        | 12107                                                     |
| Naïve Bayes classifier | 131722          | 0                              | 290877                                      | 35949                                                     |
| EM                | 39062               | 511                            | 5813                                        | 37545                                                     |

The SVM algorithm showed a recognition result of 86%, which is the best indicator for the recognition time of 8 seconds. The ability of this algorithm to separate linearly inseparable samples is key advantage with such a high dimension of input vectors of 900 elements.

The K-nearest neighbor algorithm showed 77% accuracy, which is also a very high rate, but the recognition time was 33 seconds. This factor confirms that the search for the nearest neighbors in extra-large samples is difficult and is a bottleneck of the algorithm.

The decision tree algorithm showed an accuracy of only 67% with a recognition time of 7.5 seconds. The low accuracy of the algorithm is due to the lack of depth and optimality of the original tree.

Expectation-maximization algorithm showed an accuracy of 9.7%, with a recognition time of 5.8 seconds. Naïve Bayes classifier was not applicable in this problem, as the number of correctly recognized images is zero.

3. Conclusions
As this comparison shows, the most promising classification methods in image recognition problems are support vector (SVM) and K – nearest neighbor (k-NN) methods.
The method k-nearest neighbors has the fastest learning time and the smallest size of the classification model, but it is inferior to the method of reference vectors, both in time of recognition of the test sample, and in the number of correctly recognized images.
The other three methods, though, are classification methods, but are poorly applicable to this problem, because of the small number of correctly recognized objects of the test sample, the large size of the classification model and the recognition times, especially for the naive Naive Bayes classifier.

References
[1] Ziyatdinov R R, Biktimirov R A and Klochkova K V 2017 The comparative analysis of classification of algorithms in the problems of pattern recognition Journal of Fundamental and Applied Sciences v 9 n 1S pp 1790-97
[2] Ziyatdinov R R, Mukhametzyanov V R and Nabiullina G I 2015 Application of neural networks for the diagnosis of depth sucker rod pumps International Journal of Applied Engineering Research Vol 10 Is 24 pp 45022-26
[3] Sharafieva L N, Ziyatdinov R R 2016 Application of artificial neural network in the problems of diagnosis of borehole pumps Information Technology. Automation. Actualization and solving the problems of training highly qualified personnel: Proceedings of the international conference pp 83-87
[4] Ziyatdinov R, Shigabiev R and Talipov D 2017 Automated road marking recognition system IOP Conf. Series: Materials Science and Engineering 240 012070
[5] Shahuro V I, Konushin A S 2016 Russian image database of road signs Computer Optics T 40 No 2 pp 294–300
[6] GTSRB: German Traffic Sign Recognition Benchmark. Available at: http://benchmark.ini.rub.de/?section=gtsrb&subsection=news (accessed 22 October 2017).
[7] OpenCV: Adaptive Threshholding. Available at: https://docs.opencv.org/trunk/d7/d4d/tutorial_py_thresholding.html (accessed 22 October 2017).
[8] Bradsky G, Kaehler A 2008 Learning OpenCV. Computer Vision with the OpenCV Library – O’Reilly