NMC: Nearest Matrix Classification – A new combination model for pruning One-vs-One ensembles by transforming the aggregation problem

Mikel Galar
Estadística, Informática y Matemáticas
Universidad Pública de Navarra
Pamplona, España
mikel.galar@unavarra.es

Alberto Fernández
Ciencias de la Computación e Inteligencia Artificial, Universidad de Granada
Granada, España
alberto@decsai.ugr.es

Edurne Barrenechea
Estadística, Informática y Matemáticas
Universidad Pública de Navarra
Pamplona, España
edurne.barrenchea@unavarra.es

Humberto Bustince
Estadística, Informática y Matemáticas
Universidad Pública de Navarra
Pamplona, España
bustince@unavarra.es

Francisco Herrera
Ciencias de la Computación e Inteligencia Artificial, Universidad de Granada
Granada, España
herrera@decsai.ugr.es

***Abstract*—This is a summary of our article published in Information Fusion [4], which follows our previous works on the topic [1]–[3], presented to the Multi- Conference CAEPIA'18 - FINO'18 KeyWorks.**

***Index Terms*—Multi-class classification, Pairwise Learning, One-vs-One, Decomposition Strategies, Ensembles, Classifier Selection**

I. Summary

One way to address multi-class problems is by using decomposition strategies [5]. Among them, One-vs-One (OVO) excels as one of the most popular strategies. In OVO, the original multi-class problem is divided into as many subproblems as possible pairs of classes. Afterwards, an independent classifier is learned for each problem, whose outputs needs to be combined to obtain the class for a given test instance.

This final combination, also known as aggregation, is a key factor as in every classifier ensemble. In the literature, several methods have been proposed to carry out the combination in OVO [1]. Among them, the voting strategy is the most intuitive one, where each classifier gives a vote for its predicted class and that reaching the largest number of votes is finally predicted.

Although several combination methods have been proposed in the literature for combining classifiers in OVO, none of them have dealt with the possibility of reducing the number of classifiers in the ensemble. That is, ensemble pruning has not been considered as an option because all the classifiers are supposed to be necessary.

For this reason, in this work our objective is two-fold:

1) To propose a transformation of the aggregation step in such a way that new examples are classified on the basis of the similarities among score-matrices.
2) To take advantage of this problem transformation to introduce the possibility of reducing the number of classifiers in OVO strategy without affecting the final accuracy of the model.

Therefore, we will change the way we look at the combination phase. Furthermore, instead of avoiding non-competent classifiers as in previous works [2], [3], we try to take advantage of them. Specifically, the aggregation is transformed so that the outputs of the classifiers are used as new inputs to another classification problem, which is the one considered to determine the final class labels of the dataset. After obtaining the outputs for every training example (each one stored in a score-matrix), new examples are classified with the class of the examples with the most similar score-matrix. This is why we named it as *Nearest Matrix Classification* (NMC). This modification allows us to reduce the number of classifiers and examples used in the classification step by developing an evolutionary classifier and instance selection model.

Backed-up by a thorough experimental study, we will show that almost 50% of the classifiers from OVO can be safely removed (depending on the base learning being considered and the specific problem). Moreover, the quality of the confidence degrees given by the base classifiers have a strong influence on the number of classifiers that can be removed without losing accuracy.

Acknowledgements

This work was supported by the Spanish Ministry of Economy and Competitiveness under the project TIN2016-77356-P and TIN2017-89517-P (AEI/FEDER, UE).

References

[1] M. Galar, A. Fernández, E. Barrenechea, H. Bustince, F. Herrera, "An overview of ensemble methods for binary classifiers in multi-class

problems: Experimental study on one-vs-one and one-vs-all schemes," *Pattern Recognition* vol. 44, no. 8, pp. 1761–1776, 2011.

[2] M. Galar, A. Fernández, E. Barrenechea, H. Bustince, F. Herrera, "Dynamic classifier selection for one-vs-one strategy: Avoiding non-competent classifiers," *Pattern Recognition*, vol. 46, no. 12, pp. 3412–3424, 2013.

[3] M. Galar, A. Fernández, E. Barrenechea, F. Herrera, "DRCW-OVO: Distance-based relative competence weighting combination for one-vs-one strategy in multi-class problems," *Pattern Recognition*, vol. 48, no. 1, pp. 28–42, 2015.

[4] M. Galar, A. Fernández, E. Barrenechea, H. Bustince, F. Herrera, "NMC: nearest matrix classification – A new combination model for pruning One-vs-One ensembles by transforming the aggregation problem," *Information Fusion*, vol. 36, pp. 26–51, 2017.

[5] A.C. Lorena, A.C. Carvalho, J.M. Gama, "A review on the combination of binary classifiers in multiclass problems," *Artificial Intelligence Review*, vol. 30, no. 1-4, pp. 19–37, 2008.