OVERCOMING IMBALANCED AND OVERLAPPING DATA IN MULTICLASS CLASSIFICATION

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SUMMARY

DESSY ROTUA NATALINA SIAHAAN. Overcoming Imbalanced and Overlapping Data in Multiclass Classification. Supervised by ANWAR FITRIANTO and KHAIRIL ANWAR NOTODIPUTRO.

Classification is a predictive model that groups data based on algorithms with categorical response variables. In binary classification, there are two class categories, while in multiclass classification, there are three or more class categories. Multiclass classification is more challenging than binary classification because of complex interaction patterns. This problem becomes even more complicated if the data contains imbalanced data issues, meaning that some classes have many observations while others have fewer. Complexity increases if the data to be modeled also overlaps because no boundaries separate the existing categories, making the classification process difficult.

This research aims to address the problem of imbalanced and overlapping data in multiclass classification. To achieve this, research was conducted on simulated and empirical data. The simulated data consisted of 10,000 observations with four predictor variables, including two numerical and categorical variables, and a response variable with three class categories. Overlap conditions are controlled using three distance scenarios (High, Medium, Low) calculated based on Euclidean distance. The distance determination is used as each class' middle value (centroid) for generating data that follows a normal distribution. The data generation process for each class controls imbalanced conditions with six scenarios based on data proportions (High, Medium, Low) and the number of minority classes. The combination of all these conditions produces 18 simulation scenarios.

Multiclass classification is encountered in everyday life, making the problem of imbalanced and overlapping data increasingly urgent to be handled appropriately. Poverty is used as a case study for overcoming imbalanced and overlapping data. Poverty is a classification problem where the data has to be integrated with the focus object (Poor) being in the minority class. The poverty status develops from binary (Poor and Not Poor) to multiclass with the addition of Extremely Poor. Overlapping variables were also found, for example, two households with heads of household with the same gender, age, and education level but different poverty statuses. The Secondary Data from the National Socio-Economic Survey (SUSENAS, *Survei Sosial Ekonomi Nasional*) in West Java in 2021 by Statistics Indonesia (BPS, *Badan Pusat Statistik*) is used, where the poverty status category is generated from the average household expenditure in a month.

The One Versus One (OVO) decomposition technique is used to simplify multiclass classification by transforming it into binary subclasses so that the binary classifier method can be applied. The final prediction results are determined by Majority Voting. The problem of imbalanced data is overcome by applying the Synthetic Minority Oversampling Technique (SMOTE) method, which adds data to the minority class by generating new synthetic data. A combination of two classification methods, a Multiple Classifier System with sequential combination, is used to overcome the problem of overlapping data. The single classifier combined is the Logistic Regression and K-Nearest Neighbour (KNN) method. The prediction

output results from the Logistic Regression method are input into the classification process using the KNN method. Combining all methods is applied to all simulation scenarios and empirical data.

The evaluation model measurements are Balanced Accuracy, Weighted F1 Score, and G-Mean. The results of the simulated data show that the proposed model is able to overcome the problem of imbalanced and overlapping data in multiclass classification. Based on all simulation scenarios, the model is able to provide satisfactory performance in both the overall model and in classifying minority classes. The model with the lowest performance is in the High-2 scenario, where the amount of data for the majority class and minority class has a huge difference and has two minority classes. The model performance works better when the imbalance proportion decreases, and there is only one minority class. Model performance is also influenced by distance scenarios that represent the degree of overlap. The High-distance scenario has the lowest performance where the data is highly overlapping. As the distance increases, the model performance improves because the data overlap decreases.

Model comparison is done to ensure that the performance of the proposed model is better than the others. The models used for comparison are the Logistic Regression Model with SMOTE, the KNN Model with SMOTE, the MCS Model without SMOTE, the Logistic Regression Model without SMOTE, and the KNN Model without SMOTE. Model comparison is carried out by comparing existing evaluation measures. As a result, the proposed model gave the best and superior performance compared to the other five models; some models were even unable to classify the minority class well, so it was found that the F1 Score and G-Mean evaluation measures produced 0.

The results of poverty data classification also show good performance. The Balanced Accuracy obtains 80%, and the F1 Score is 0.8. Meanwhile, the G-Mean value needs to be optimized; it only gets 0.3 because the poverty data is similar to the High-2 Scenario with a High distance. This simulation scenario has the lowest performance among the other scenarios because of the high level of imbalance and overlap. However, other models are entirely unable to classify minority classes.

Keywords: Imbalanced Data, Multiclass, Multiple Classifier System, Overlapping Data, Simulation

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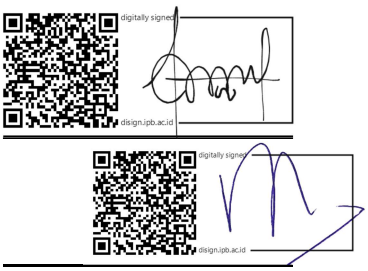

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Dessy Rotua Natalina Siahaan

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