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LETTER TO THE EDITOR

Use of artificial neural networks to predict anterior communicating artery aneurysm rupture: possible methodological considerations

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Key Points

- *Use of algorithms to generate synthetic cases might result in a misrepresentation of the entire population.*
- *Training an artificial neural network with a mix of real and synthetic data might lead to non-realistic prediction precision.*

Dear editor,
With great interest, we read the publication of Liu et al [1] regarding the rupture risk prediction of anterior communicating artery aneurysms with a feed-forward artificial neural network (ANN). We greatly support the use of ANNs clinically, especially when they can aid clinicians with complex tasks such as rupture risk predictions for intracranial aneurysms.

Intrigued by their excellent predictive values, we questioned the exact effect of the adaptive synthetic (ADASYN) sampling approach on the predictive accuracy of the ANN. Especially since the ADASYN approach seemed to perform worse with increasingly imbalanced datasets [2, 3]. Although the authors briefly touch on this topic and identify it as a possible limitation of their study, they did not further specify the magnitude of the possible effect. We therefore conducted an experiment in which we investigated the possible effect of generating synthetic data using the ADASYN approach on ANN prediction accuracy.

We randomly generated a synthetic dataset for a total of 1080 subjects (Fig. 1). For each subject, 17 variables (10 continuous, 4 dichotomous, and 3 nominal) were generated in order to mimic the dataset structure of Liu et al [1]. We subsequently defined a multifactor randomly generated relationship between 13 of these variables (9 continuous, 2 dichotomous, and 2 nominal) and the outcome, which resulted in a 50/50 distribution of all subjects in outcome group 1 (negative) and outcome group 2 (positive). We then selected 10% of all the subjects from assigned to group 2, thereby creating an imbalanced dataset on purpose and used the ADASYN approach to add synthetic subjects around the boundary regions to reach an imbalance ratio of 1:2.1, similar to the approach of Liu et al [1] (Fig. 1). This results in a considerable mismatch between synthetically generated data using the ADASYN algorithm (Fig. 1, *green dots*) and the original population from which these synthetically cases were generated (Fig. 1, *red dots*).

We then used an ANN similar to the one described by Liu et al [1]. We randomly divided data samples into training, validation, and testing set, which included 70%, 15%, and 15% of the total number of samples, respectively. We then performed three different experiments using an ANN trained with the imbalanced dataset + synthetically generated cases. This resulted in three different receiver operating characteristics (ROCs) with an accompanying area under the curve (AUC). The experiments are described below:

1. Use the trained ANN to predict the outcome using the imbalanced dataset + synthetically generated cases. The overall AUC of this prediction was 99.7% (Fig. 2, *blue line*)
2. Use the trained ANN to predict the outcome using the imbalanced dataset without the synthetically generated cases. The overall AUC of this prediction was 98.9% (Fig. 2, *red line*)
3. Use the trained ANN to predict the outcome on the full dataset. The overall accuracy of this prediction was 85.8% (Fig. 2, *yellow line*)

Response to Liu J, Chen Y, Lan L et al (2018) Prediction of rupture risk in anterior communicating artery aneurysms with a feed-forward artificial neural network. Eur Radiol. https://doi.org/10.1007/s00330-017-5300-3.

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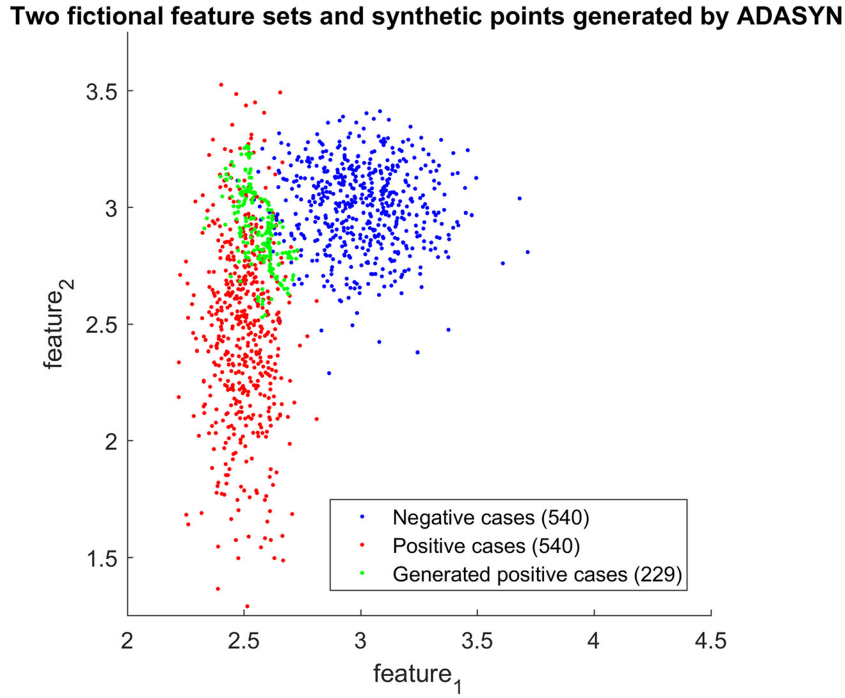

Fig. 1 Overview of all cases (blue and red dots) and the cases generated by the adaptive synthetic (ADASYN) sampling approach (green dots) for two variables

When comparing the outcome of experiment 1 to experiment 3, we see a 13.9% drop in overall accuracy. Although this drop still results in a relative accurate prediction in our case, it remains to be seen whether the ANN of Liu et al [1] will follow the same pattern as the mismatch between the actual population and the population with synthetically generated subjects remains unknown. We therefore strongly advise to interpret the results of Liu et al [1] with extreme caution before implementing the proposed ANN as a predictive tool in the clinic. We propose the use of other implementations to improve imbalanced data for use in ANNs, such as node drop-outs [4] and the use of Matthews correlation coefficient [5].

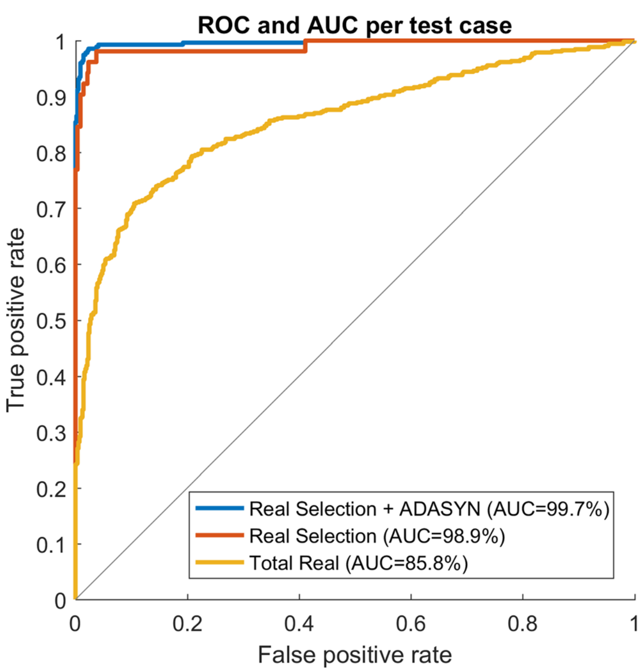

Fig. 2 Receiver operating characteristic curves of the three artificial neural network (ANN) experiments. The ANN used was trained with the imbalanced dataset + synthetically generated cases. Subsequent analyses were used to predict the outcome of the imbalanced dataset + adaptive synthetic (ADASYN) sampling approach (blue line), the imbalanced dataset alone (red line), and the total synthetic dataset (yellow line)

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Compliance with ethical standards

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Conflict of interest The authors of this manuscript declare no relationships with any companies, whose products or services may be related to the subject matter of the article.

Statistics and biometry No complex statistical methods were necessary for this paper.

Informed consent Written informed consent was not required for this study because data collection from human subjects was not needed.

Ethical approval Institutional Review Board approval was not required because synthetic data was generated for this study.

Methodology
• Performed at one institution

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