UNIVERSITÀ DEGLI STUDI DI TRIESTE

SMOTE VARIANT FOR UNBALANCED DATA IN CLASSIFICATION PROBLEMS

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Data Generation Process

Parameter	Values	Description
n_{train}	600, 1000, 5000	Train set size
n_{test}	600	Test set size
π	0.10, 0.05, 0.025	Proportion of rare examples
IR	9, 19, 39	Imbalance ratio

Table: Parameters of the simulation

$$(\mathbf{X}, y) \text{ s.t. } \begin{cases} \mathbf{X} \sim N_2\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}\right) & \text{if } y = 0, \\ \mathbf{X} \sim N_2\left(\begin{pmatrix} 1 \\ 1 \end{pmatrix}, \begin{pmatrix} 1 & -0.5 \\ -0.5 & 1 \end{pmatrix}\right) & \text{if } y = 1. \end{cases}$$

Data Generation

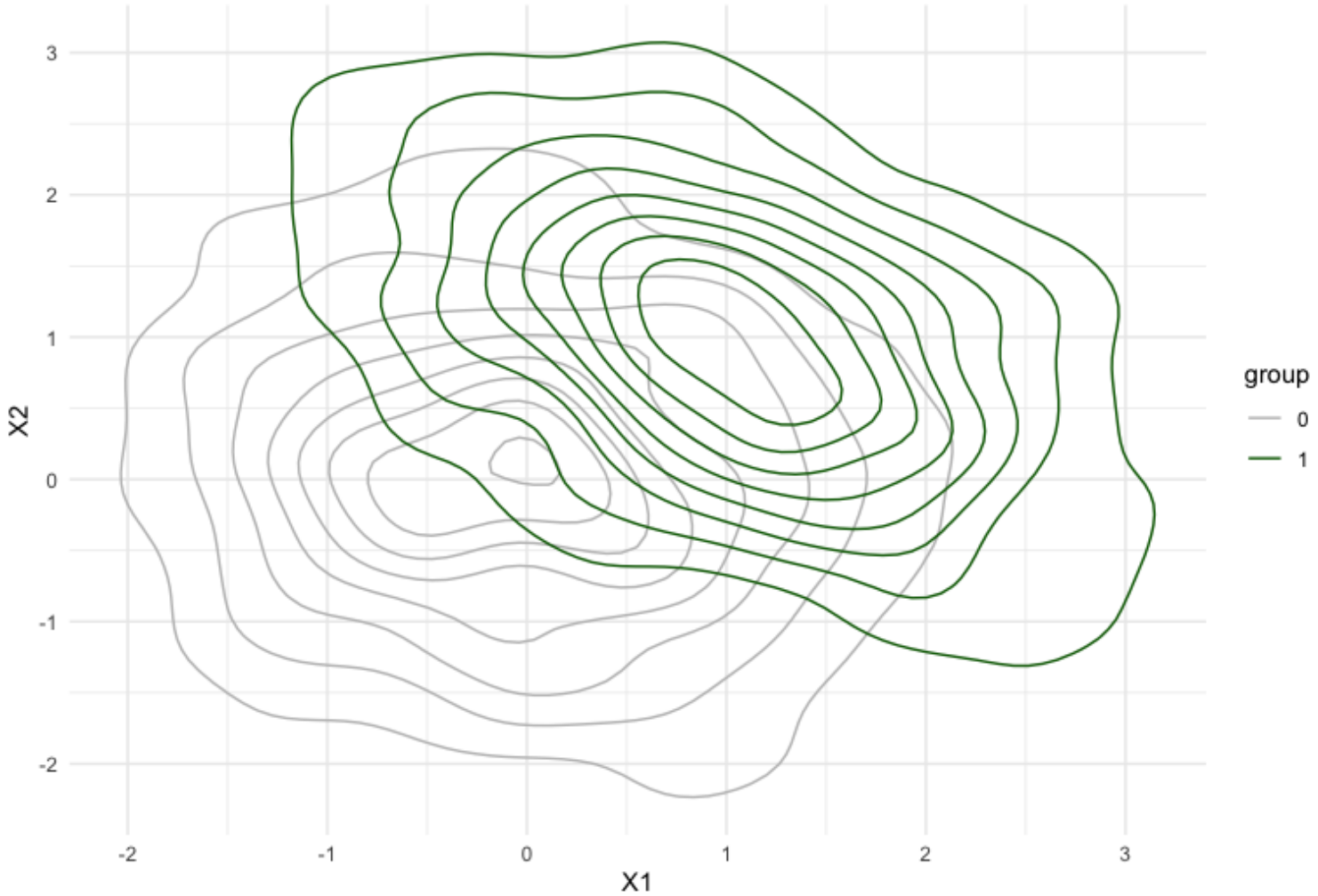


Figure: Contour plot of the data distribution

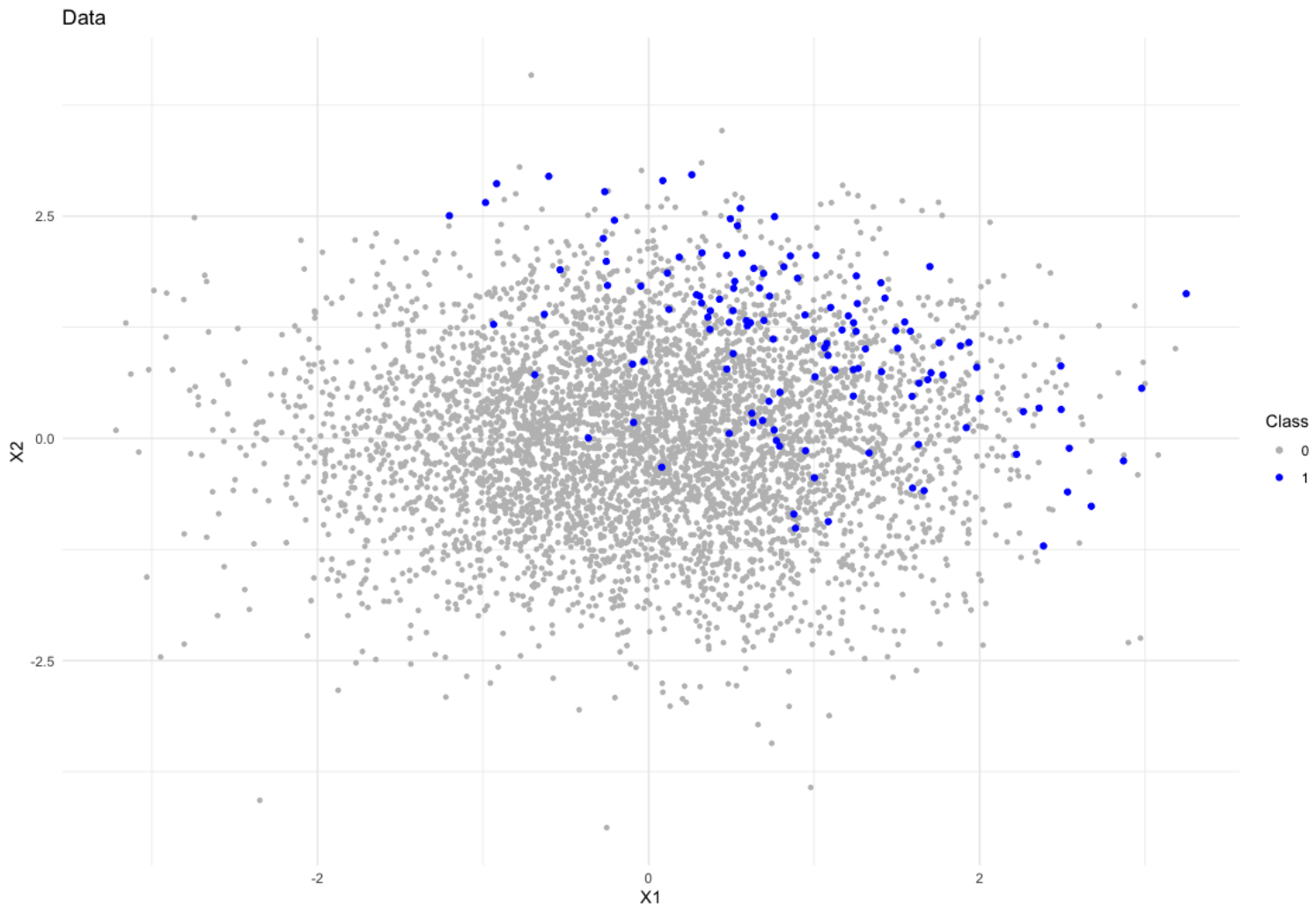


Figure: Data generated with $size = 5000$ and $prop = 0.025$

Assessment Method

- 100 Static Train/Test Division (test size = 600)
- Metrics: Balanced Accuracy, F1 Score
- Models: Decision Tree, Logistic Regression
- Comparisons with Boxplots

SMOTE

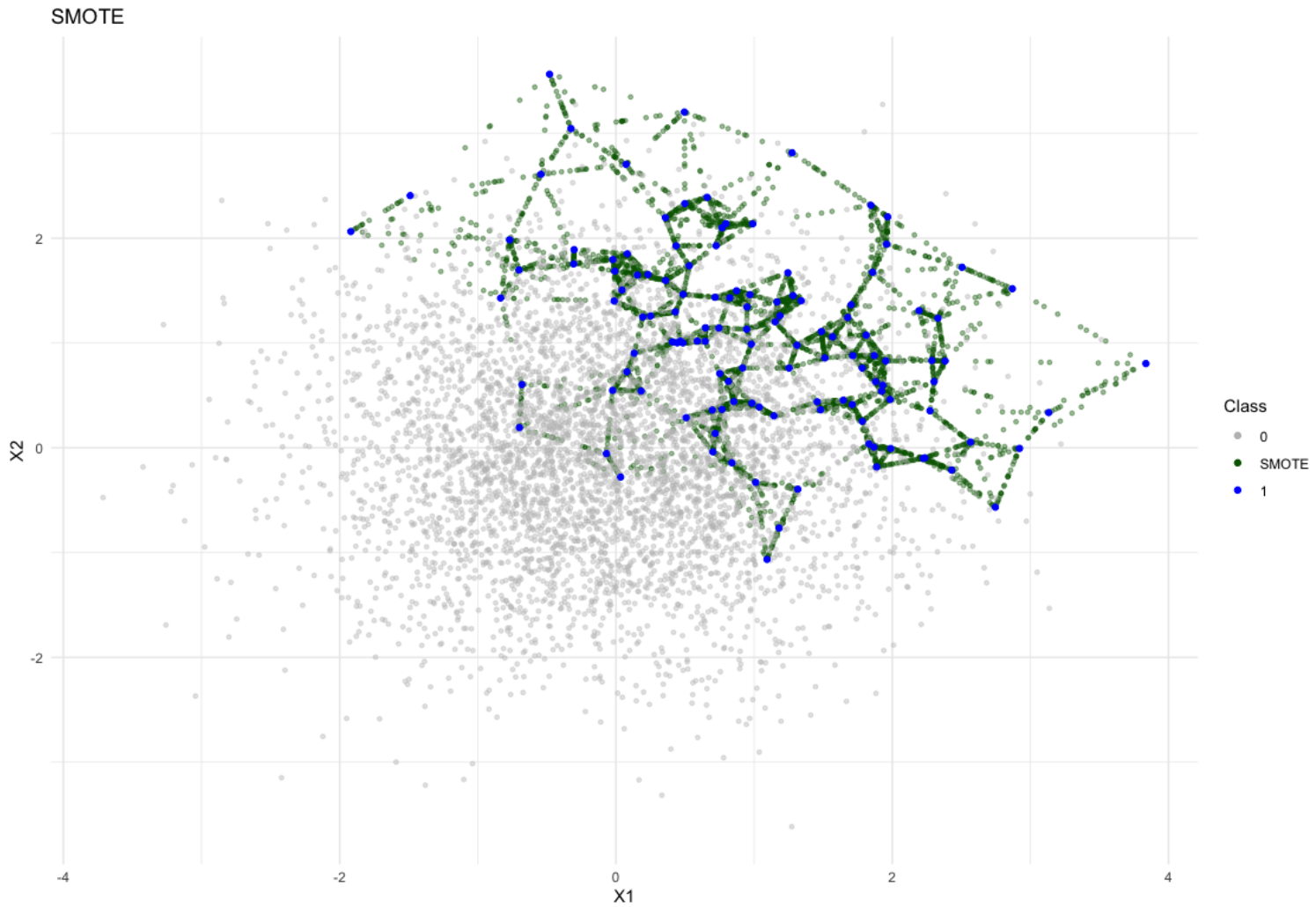


Figure: Synthetic data generated with SMOTE

Dirichlet SMOTE

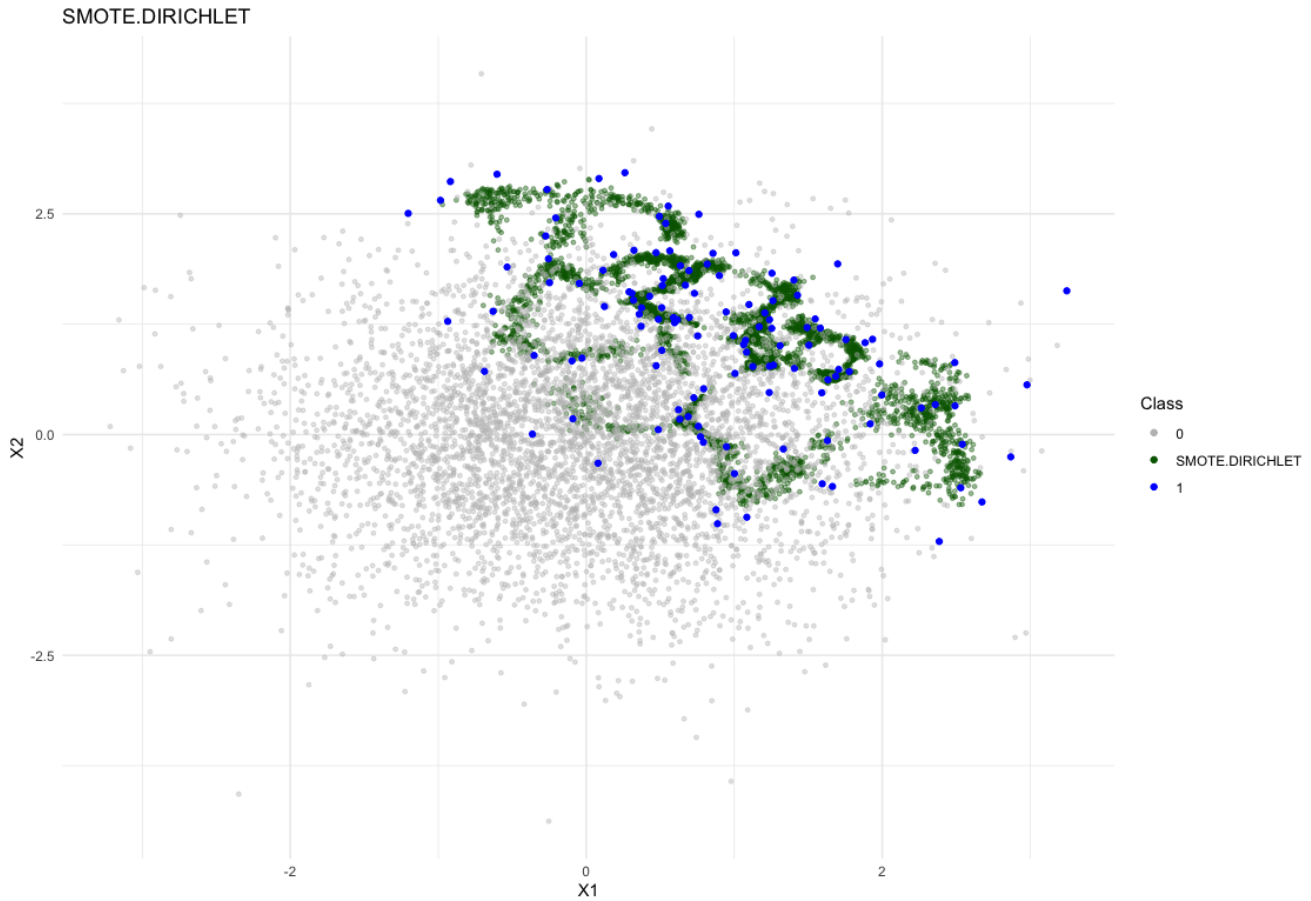
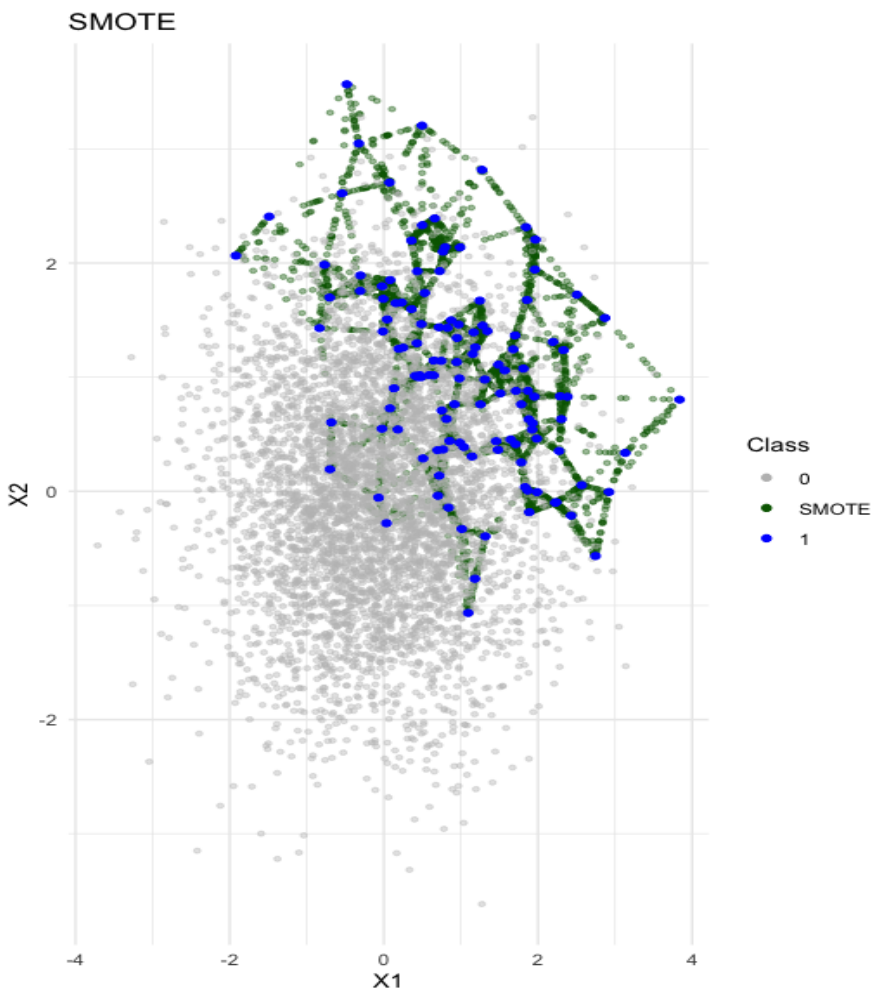
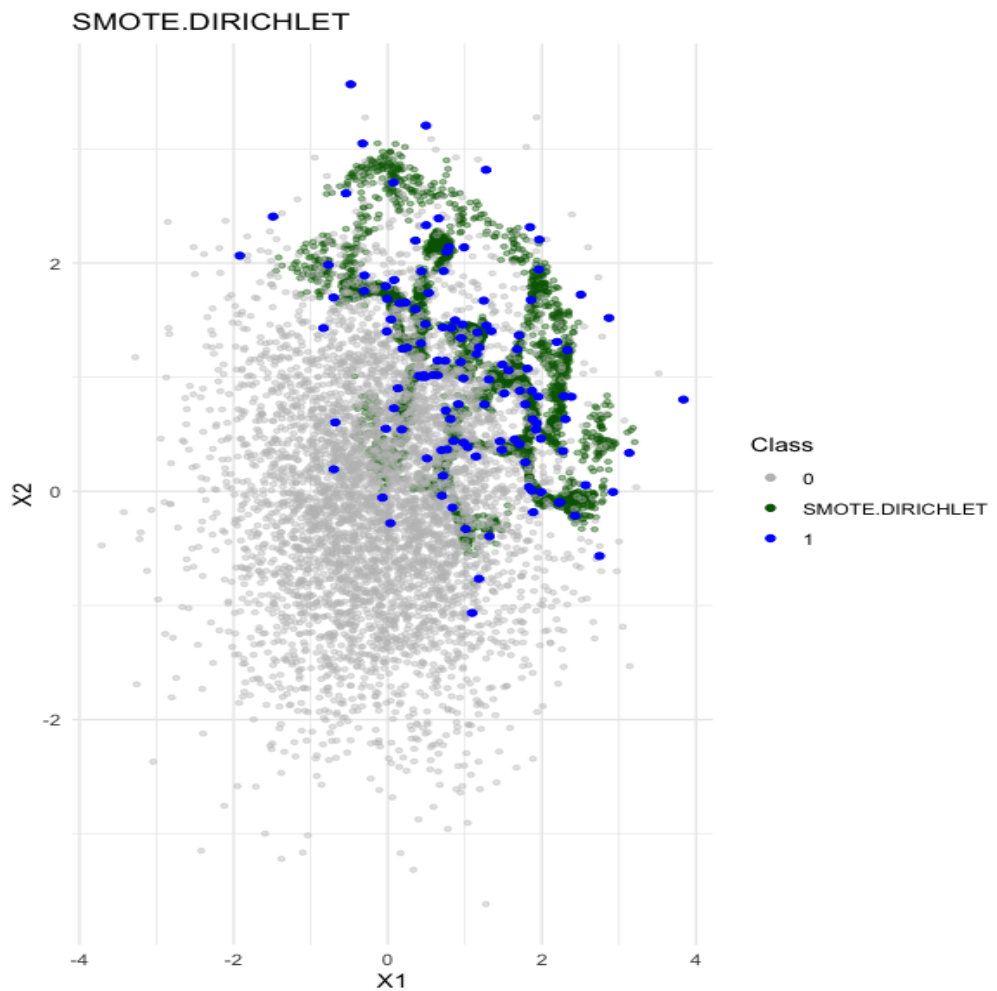


Figure: Synthetic data generated with Dirichlet SMOTE using Dirichlet distribution: $P(p|\alpha) \sim Dir(\alpha_1, ..., \alpha_k) = \frac{\Gamma(\sum_j \alpha_j)}{\Pi_j \Gamma(\alpha_j)} \Pi_{j=1}^{k} p_j^{\alpha_j - 1}$ [3]. $\alpha = 1$, $k = 3, 5$.

Comparison between SMOTE and Dirichlet SMOTE





References

- Chawla, Nitesh V et al. (2002). "SMOTE: synthetic minority over-sampling technique". In: *Journal of artificial intelligence research* 16, pp. 321–357.
- Lunardon, Nicola, Giovanna Menardi, and Nicola Torelli (2014). "ROSE: a package for binary imbalanced learning.". In: *R journal* 6.1.
- Matharaarachchi, Surani, Mike Domaratzki, and Saman Muthukumarana (2024). "Enhancing SMOTE for imbalanced data with abnormal minority instances". In: *Machine Learning with Applications* 18, p. 100597.
- Menardi, Giovanna and Nicola Torelli (2014). "Training and assessing classification rules with imbalanced data". In: *Data mining and knowledge discovery* 28, pp. 92–122.