

Churn Prediction Using Neuro-Symbolic Artificial Intelligence

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Abstract

Customer churn prediction is a critical task for telecom companies. In this project, I built a hybrid Neuro-Symbolic Artificial Intelligence model that combines neural networks with symbolic rule-based logic. This model helps not only in predicting customer churn but also in explaining why a particular prediction was made. I used the Telco Customer Churn dataset and achieved high accuracy with improved interpretability.

1 Introduction

Customer churn refers to the phenomenon where customers stop using a company's service. Predicting churn is crucial for companies to proactively retain customers. While machine learning models can predict churn effectively, they often lack interpretability. In this project, I used a Neuro-Symbolic AI approach, combining the learning power of neural networks with the clarity of symbolic rules.

2 Project Objective

The main objectives of my project were:

- To build an accurate churn prediction model using a neural network.
- To integrate symbolic reasoning to explain predictions.
- To visualize key insights using plots.

3 Dataset

I used the publicly available **Telco Customer Churn Dataset**. It contains customer information such as:

- Demographics: Gender, Senior Citizen, Partner

- Services: Internet, Streaming, Phone
- Charges: Monthly and Total Charges
- Target Variable: **Churn (Yes/No)**

4 Methodology

4.1 Data Preprocessing

- I removed the irrelevant column: `customerID`
- Categorical variables were encoded using one-hot encoding
- Missing values were handled using imputation
- The target variable 'Churn' was converted to binary (Yes = 1, No = 0)

4.2 Model: Multi-Layer Perceptron (MLP)

I trained a neural network using scikit-learn's `MLPClassifier`. The model learns complex patterns in the data to predict churn.

4.3 Symbolic Reasoning

I wrote custom symbolic rules in Python to explain each prediction. Examples:

- If tenure \geq 12 months and MonthlyCharges \leq 80 \rightarrow likely to churn
- If Contract = Two year \rightarrow unlikely to churn

5 Neuro-Symbolic Algorithm

[H] Neuro-Symbolic Churn Prediction [1] Preprocessed dataset with features and churn label Train an MLP neural network classifier Define symbolic rules based on domain knowledge each input customer Predict churn using the neural network Apply symbolic rules for explanation Churn prediction with explanation

6 Visualizations and Results

6.1 Correlation Heatmap

6.2 Churn Distribution

6.3 Model Performance

- Accuracy: 80%
- Precision: 78%
- Recall: 74%

6.4 Explainability Example

7 Conclusion

This project demonstrates the integration of symbolic reasoning with neural networks for customer churn prediction. My Neuro-Symbolic model maintained high accuracy while improving interpretability. This can help businesses understand *why* a customer is likely to churn and take preventive actions accordingly.

8 Future Work

In the future, I plan to:

- Use Large Language Models (LLMs) to generate symbolic rules dynamically
- Deploy this model into CRM dashboards for real-time predictions
- Add feedback loops to adjust symbolic rules with data

References

- [1] Scikit-learn: Machine Learning in Python,
<https://scikit-learn.org>
- [2] Neuro-symbolic AI: The state of the art,
<https://arxiv.org/abs/2005.06038>