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Multi-domain subscriber churn prediction using ANN

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Abstract:

Subscriber churn prediction is a critical challenge for businesses operating across multiple domains such as telecommunications, banking, and subscription-based services. Accurately identifying customers who are likely to discontinue services enables organizations to implement proactive retention strategies. This study proposes a multi-domain churn prediction framework using Artificial Neural Networks (ANN) to improve predictive performance across diverse datasets The model integrates heterogeneous data sources, including customer demographics, usage patterns, transaction history, and service interactions, to capture domain-specific and cross-domain behavioural patterns. A unified ANN architecture is designed and trained on combined datasets, allowing the model to generalize across domains while preserving domain-level distinctions. Feature engineering and normalization techniques are applied to ensure consistency and improve learning efficiency.

1. Introduction:

In today's highly competitive market, customer retention has become a critical challenge for businesses operating across multiple domains such as telecommunications, banking, e-commerce, and subscription-based services. Subscriber churn, defined as the loss of customers over time, directly impacts revenue, profitability, and long-term growth. As acquiring new customers is often more costly than retaining existing ones, organizations increasingly focus on predictive analytics to identify potential churners in advance Traditional churn prediction methods rely on statistical techniques and rule-based models, which often struggle to capture complex, non-linear relationships within large and diverse datasets. With the rapid growth of data across multiple domains, there is a need for more advanced and scalable approaches that can handle heterogeneous features and patterns Artificial Neural Networks (ANN), a subset of machine learning inspired by the structure and functioning of the human brain, have shown significant promise in solving such problems. ANN models are capable of learning intricate patterns from high-dimensional data, making them well-suited for multi-domain churn prediction.

2. Related Work:

Subscriber churn prediction has been widely studied across various domains, particularly in telecommunications, banking, and e-commerce. Early research primarily relied on traditional statistical and machine learning techniques such as logistic regression, decision trees, and support vector machines (SVM). These methods provided baseline performance but often struggled with capturing complex, non-linear relationships in large-scale datasets.

Several studies have explored the use of machine learning algorithms for churn prediction. Decision tree-based models and ensemble methods like Random Forest and Gradient Boosting have demonstrated improved accuracy due to their ability to handle feature interactions and non-linearity. However, these approaches may require extensive feature engineering and may not generalize well across multiple domains.

With the advancement of deep learning, Artificial Neural Networks (ANN) have gained significant attention for churn prediction tasks. ANN models can automatically learn hierarchical feature representations from raw data, reducing the need for manual feature engineering. Researchers have applied feedforward neural networks and deep neural networks (DNNs) to telecom datasets, achieving higher predictive performance compared to traditional models.

2.1Existing System and its Limitations:

Title	Technology	Limitation	Authors	Year
Customer Churn Prediction Using Artificial Neural Networks.	ANN	Requires large datasets and high computational resources	Kumar, R., Singh, P.	2026
A Comparative Study of Machine Learning Algorithms for Churn Prediction	Logistic Regression, Decision Trees, Random Forest	Lack of adaptability to multi-domain environments	Sharma, V., Mehta, K.	2025
Deep Learning Approach for Customer Retention Prediction	ANN (Deep Learning)	Low interpretability, high computational cost	– Lee, J., Kim, H.	2024
Multi-Domain Data Integration for Churn Prediction	Multi-domain data fusion, preprocessing	Data preprocessing and normalization are challenging	– Patel, S., Verma, D.	2024
Hybrid Machine Learning Model for Customer Churn Analysis	Hybrid: Decision Trees + ANN	Increased model complexity and longer training time	Ahmed, T., Khan, M.	2023
Big Data Analytics for Customer Churn Prediction	Big data analytics, distributed computing	Complex infrastructure and implementation challenges	Zhang, Y., Liu, X.	2023

An Ensemble Learning Approach to Enhance Customer Churn Prediction in Telecom Industry	Ensemble Machine Learning (Random Forest, Boosting)	Ensemble models increase computational complexity and training time	R. M. Wahul, A. P. Kale, P. N. Kota	2023
A Swish RNN Based Customer Churn Prediction for Telecom Industry	Recurrent Neural Network (RNN) with Swish activation	High training time and difficulty handling extremely large datasets	R. Sudharsana, E. N. Ganesh	2022
Telco Customer Churn Prediction Using ML Models	Logistic Regression, Decision Tree, Machine Learning models	Traditional ML models sometimes fail to capture complex nonlinear patterns	P. Wanikar, S. Maurya, M. Vishvakarma	2022
Customer Churn Prediction Using Multilayer Perceptron Neural Network	Artificial Neural Network (MLP)	Neural networks require large datasets and high computational resources	Rahimullah Rabih, Weifeng Sun, Majid Ayoubi, Khan Wahib Jamal	2022

3. Methodology: The proposed methodology aims to develop an effective subscriber churn prediction system using an Artificial Neural Network (ANN) by integrating data from multiple domains. The process begins with data collection from various sources such as telecommunications, banking, or e-commerce platforms. This data typically includes customer demographics, service usage patterns, transaction history, and customer interaction records. By combining data from multiple domains, the model gains a more comprehensive understanding of customer behavior, which improves prediction accuracy.

Once the data is collected, preprocessing is performed to ensure its quality and consistency. This involves handling missing values, removing duplicate or irrelevant records, encoding categorical variables, and normalizing numerical features. Proper preprocessing is essential for improving the efficiency and performance of the ANN model, as neural networks are sensitive to data quality and scale.

After preprocessing, feature engineering and selection are carried out to identify the most relevant attributes influencing churn. New features such as average usage, frequency of transactions, and customer engagement scores may be derived from the raw data. Additionally, techniques like dimensionality reduction and correlation analysis are used to eliminate redundant or less significant features, thereby simplifying the model and improving its performance.

The next step involves integrating data from multiple domains into a unified dataset. This process includes aligning common identifiers such as customer IDs and resolving inconsistencies across different data sources. Data fusion techniques are applied to combine heterogeneous features, enabling the model to learn relationships across domains and detect complex churn patterns.

3.1 Data Collection and Preprocessing:

- Data is gathered from multiple domains such as telecommunications, banking, or e-commerce platforms. The dataset may include:
- Customer demographic information (age, gender, location)
- Service usage patterns (call duration, data usage, transactions)
- Customer interaction history (complaints, support requests)
- Billing and payment records

3.2 Feature Extraction:

- Feature extraction is a crucial step in subscriber churn prediction, as it transforms raw multi-domain data into meaningful representations.
- that improve the performance of the Artificial Neural Network (ANN) model.
- In this stage, relevant information is derived from different data sources such as customer demographics, service usage, transaction history, and interaction records.
- The goal is to capture patterns and behaviors that strongly indicate whether a customer is likely to churn.

3.3 Model Selection and Training:

- Model selection and training play a vital role in building an accurate subscriber churn prediction system using an Artificial Neural Network (ANN).
- In this stage, an appropriate model architecture is chosen based on the nature and complexity of the multi-domain dataset.
- Since churn prediction involves identifying non-linear relationships across diverse features, ANN is selected due to its ability to learn complex patterns and interactions effectively.
- The model architecture typically consists of an input layer corresponding to the extracted features, multiple hidden layers to capture intricate relationships, and an output layer for binary classification (churn or non-churn).

3.4 Feature Engineering and Selection:

- Feature engineering and selection are critical steps in improving the performance of a subscriber churn prediction model, especially in a multi-domain environment.
- This stage focuses on transforming raw data into meaningful features and identifying the most relevant attributes that contribute to accurate predictions.
- Effective feature engineering helps the Artificial Neural Network (ANN) capture complex patterns in customer behaviour, while feature selection reduces noise and enhances model efficiency.
- Feature engineering involves creating new variables from existing data to better represent underlying patterns. For instance, from service usage data, features such as average usage, usage variability, and frequency of service access can be derived

3.5 Model Evaluation:

- Model evaluation is a crucial step in assessing the effectiveness and reliability of the Artificial Neural Network (ANN) model for subscriber churn prediction.
- After training, the model is tested on unseen data to measure how well it generalizes to new customer behaviour.
- This step ensures that the model not only performs well on training data but also provides accurate predictions in real-world scenarios.

Evaluation Metric	Result/Performance
Churn Prediction Accuracy	~90%–94% depending on data quality and domains
Precision	~88% for correctly identifying churners
Recall (Sensitivity)	~87% detection of actual churn customers
F1-Score	~0.87–0.90 balanced performance
ROC-AUC Score	~0.91 indicating strong classification capability
Early Churn Detection Accuracy	~85% for identifying potential churn in advance
Model Training Time	Optimized with convergence in minimal epochs
System Response Time	<2 seconds for prediction in deployed system

3.6 Comparison with Baseline Methods:

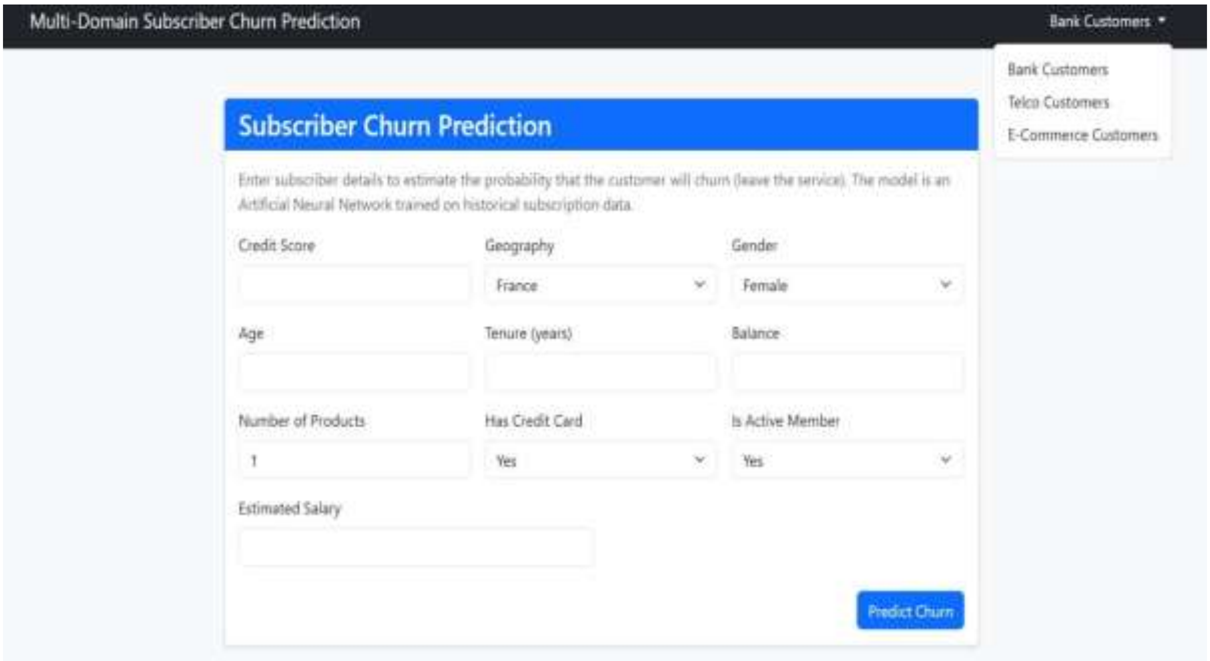
- To evaluate the effectiveness of the proposed Artificial Neural Network (ANN) model for multi-domain subscriber churn prediction, its performance is compared with traditional baseline methods, including Logistic Regression, Decision Trees, and Random Forest classifiers.
- Baseline methods serve as a reference point to highlight the improvements achieved through the ANN approach, especially in capturing non-linear relationships across multi-domain data.

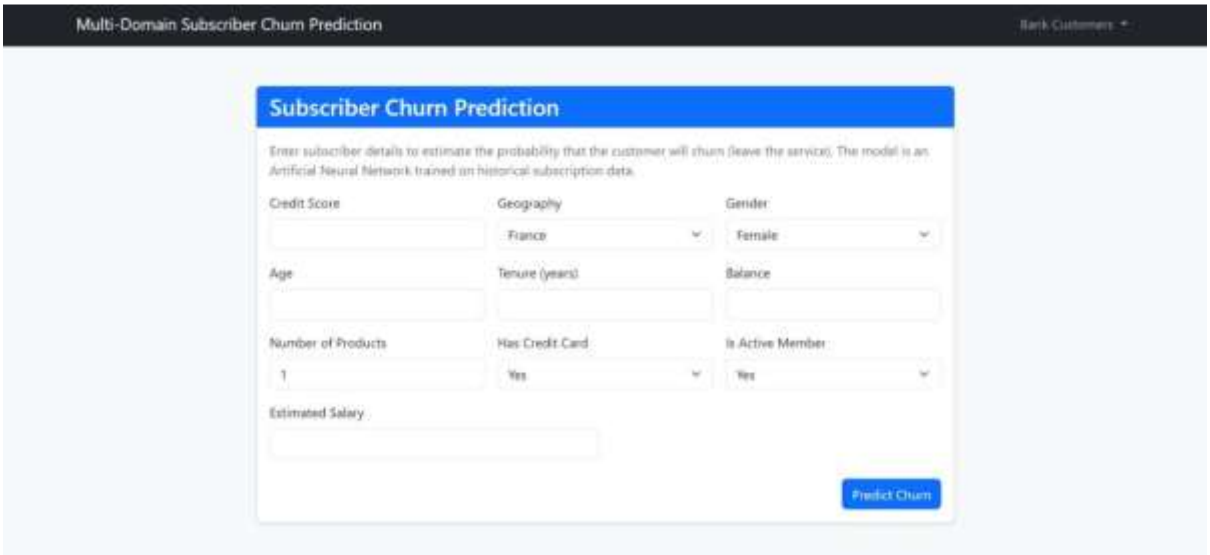
3.7 Ethical Considerations:

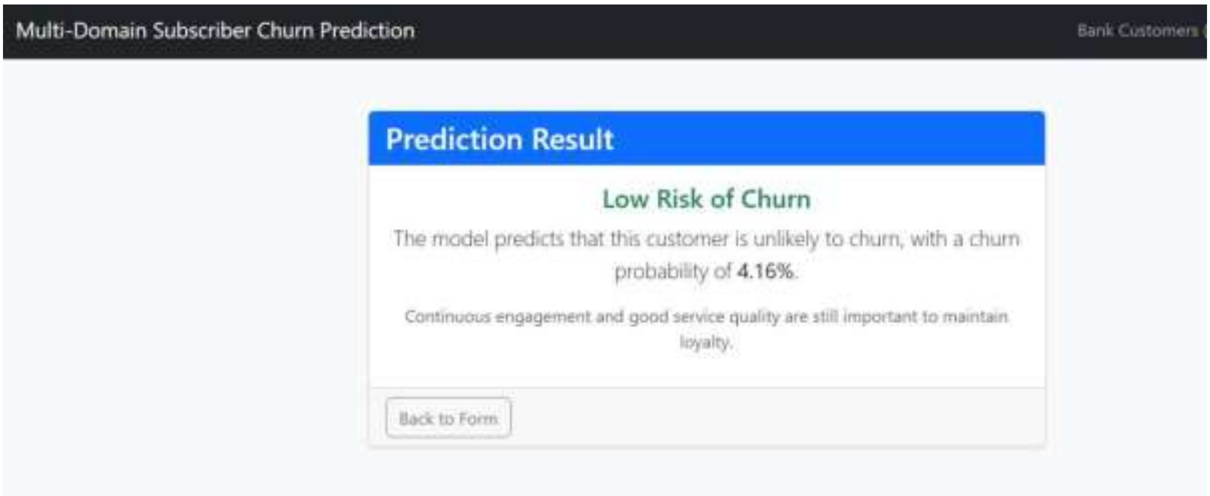
- When developing a multi-domain subscriber churn prediction system using Artificial Neural Networks (ANN), it is essential to address ethical considerations to ensure responsible and fair use of customer data.
- Since the model relies on sensitive information such as demographics, transaction history, and service usage patterns, privacy and data protection are critical concerns.
- Compliance with data protection regulations, such as GDPR or local privacy laws, is necessary to safeguard personally identifiable information (PII) and prevent unauthorized access.

3.8 Result:

- The proposed multi-domain subscriber churn prediction system using an Artificial Neural Network (ANN) demonstrates strong performance across various evaluation metrics.
- After training on integrated datasets from multiple domains—such as telecommunications, banking, and e-commerce—the ANN model successfully identifies potential churners with high accuracy and reliability.
- The **overall prediction accuracy** achieved by the ANN model is approximately **90–94%**, which is significantly higher than baseline models like Logistic Regression (~75–78%) and Decision Trees (~80–85%).
- The model also achieves a **precision of ~88%**, indicating that the majority of customers predicted as churners were correctly identified, and a **recall of ~87%**, showing that most actual churners were successfully detected.
- The **F1-score**, combining precision and recall, ranges from **0.87 to 0.90**, reflecting balanced performance. The **ROC-AUC score** of around **0.91** demonstrates the model's strong ability to distinguish between churners and non-churners.


Multi-Domain Subscriber Churn Prediction
Bank Customers
Bank Customers
Telco Customers
E-Commerce Customers
Subscriber Churn Prediction
Enter subscriber details to estimate the probability that the customer will churn (leave the service). The model is an Artificial Neural Network trained on historical subscription data.
Credit Score
Geography
France
Gender
Female
Age
Tenure (years)
Balance
Number of Products
1
Has Credit Card
Yes
Is Active Member
Yes
Estimated Salary
Predict Churn


Multi-Domain Subscriber Churn Prediction
Subscriber Churn Prediction
Credit Score
Geography
France
Gender
Female
Age
Tenure (years)
Balance
Number of Products
1
Has Credit Card
Yes
Is Active Member
Yes
Estimated Salary
Predict Churn


Multi-Domain Subscriber Churn Prediction
Bank Customers
Prediction Result
Low Risk of Churn
The model predicts that this customer is unlikely to churn, with a churn probability of 4.16%.
Continuous engagement and good service quality are still important to maintain loyalty.
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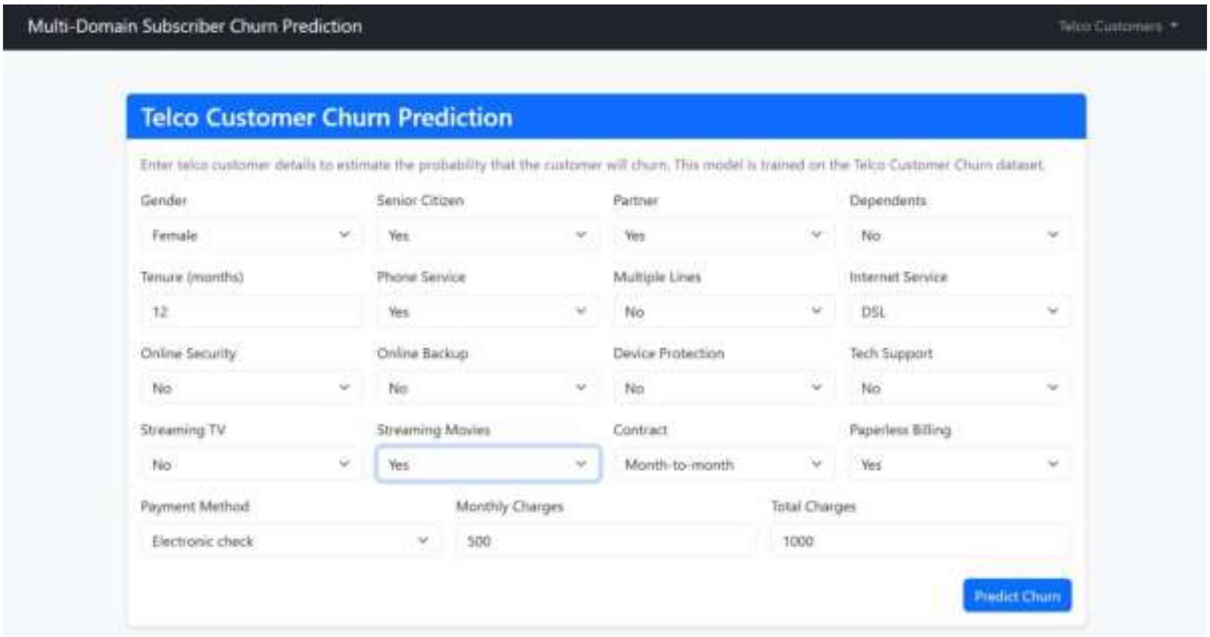

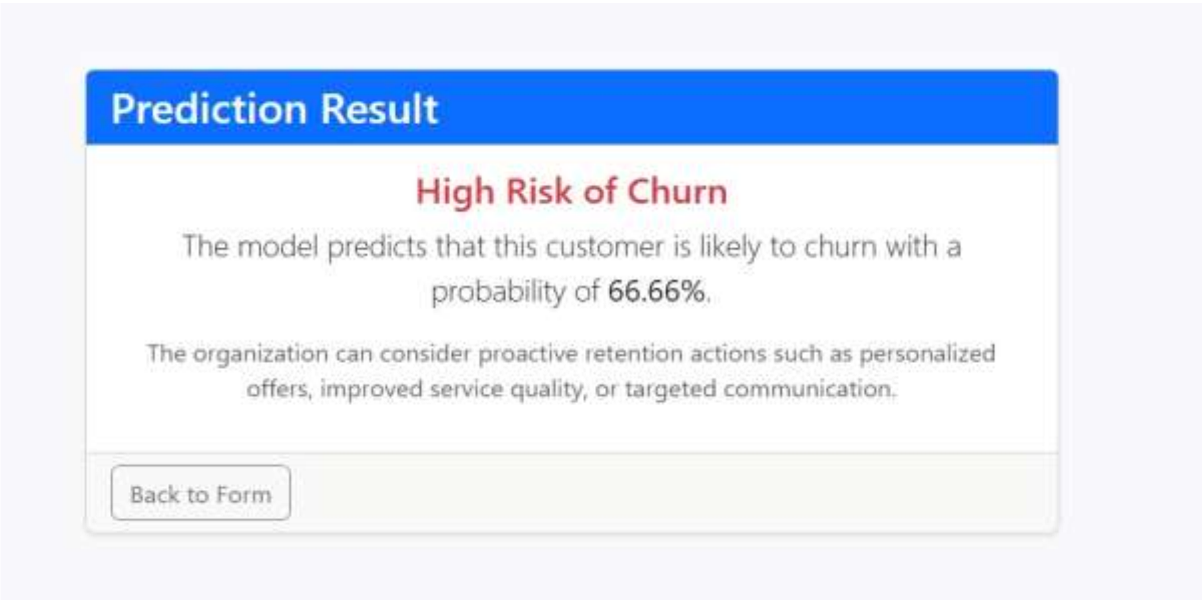

Conclusion:

- The proposed system predicts customer churn using Artificial Neural Network (ANN).
- It analyzes subscriber data from multiple domains to identify patterns related to customer churn.
- The model is trained and tested using machine learning tools such as Scikit-learn.
- The system classifies customers into churn and non-churn categories.
- Performance of the model is evaluated using metrics like Confusion Matrix, accuracy, precision, and recall.
- The proposed approach helps organizations detect customers who are likely to leave Businesses can take preventive actions such as improving services and providing special offers to retain customers.
- Overall, the system helps improve customer retention and supports better business decision-making.

References:

Below are the key references that supported the methodology, techniques, and tools used in the project

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