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# Next-Gen AI-Powered Stroke Risk Prediction System Using Deep Neural Networks

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**Abstract**

Stroke remains one of the leading causes of mortality and long-term disability globally. Early identification of individuals at high risk is crucial for preventive healthcare. This paper introduces an AI-powered stroke risk prediction system employing Deep Neural Networks (DNNs) to provide precise, real-time risk assessment based on diverse patient attributes. The system leverages a Flask-based web backend integrated with TensorFlow models and a responsive frontend built using Tailwind CSS. Through comprehensive evaluation, including metrics such as accuracy, precision, recall, and ROC-AUC, the system demonstrates superior predictive performance over traditional risk scoring techniques. Additionally, the platform offers dynamic, personalized health recommendations and interactive dashboards for improved patient engagement and clinical decision-making.

**Keywords:** Stroke Risk Prediction, Deep Neural Networks, Preventive Healthcare, Machine Learning, Personalized Medicine, Flask, TensorFlow, Health Informatics

## 1. Introduction

Stroke is a critical non-communicable disease that affects millions each year, often resulting in severe disability or death. With the growing availability of health data and advancements in artificial intelligence, there is an opportunity to develop predictive tools that can identify at-risk individuals and enable timely intervention. Conventional stroke risk scoring models, such as the Framingham Stroke Risk Profile, often fall short due to limited feature sets and static thresholds. This paper presents an advanced system leveraging deep learning to revolutionize stroke risk prediction and integrate it seamlessly into a clinical support framework.

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## 2. Problem Statement

Existing stroke prediction systems rely heavily on rule-based algorithms or linear models that lack the capacity to capture nonlinear interactions among risk factors. Moreover, they provide limited personalization and poor integration with modern web platforms, reducing their utility for both clinicians and patients.

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## 3. Objectives

- Develop a robust DNN-based model for stroke risk prediction.
- Incorporate a user-friendly web interface with real-time risk assessment.
- Offer personalized, actionable health recommendations based on predictions.
- Provide downloadable medical reports and analytics dashboards for end-users.

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## 4. Scope of the Project

This system is designed for early stroke risk detection in individuals aged 18 and above. It supports clinical practitioners, wellness coaches, and patients with predictive insights and preventive strategies. Although not a diagnostic tool, it serves as an adjunct to standard clinical workflows.

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## 5. Literature Review

Several studies have utilized machine learning for stroke prediction:

- S. Wang et al. used Random Forest classifiers achieving ~78% accuracy but struggled with class imbalance issues .
- Y. Zhao et al. demonstrated improved results using XGBoost with SMOTE but lacked deep feature representation .
- Recent advances such as DeepStrokeNet have shown that DNNs can outperform traditional models by capturing intricate health parameter interactions .

These prior works underscore the value of AI but also reveal limitations in deployment and personalization, addressed in this project.

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### 6. Proposed System

The proposed system comprises:

- **Data Collection**: Aggregated from validated public health datasets.
- **Prediction Engine**: TensorFlow-based DNN model.
- **Web Interface**: Built with Flask and Tailwind CSS.
- **Recommendation Engine**: AI-driven, rule-based module for health advice.
- **Database**: SQLite for secure storage.
- **Report Generator**: PDF and QR code-enabled reports for clinical sharing.

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### 7. System Architecture

The architecture includes:

- **Frontend**: React/HTML with Tailwind CSS; handles user input, theme toggle (light/dark), and visual dashboards.
- **Backend (Flask)**:
  - **API Endpoints**: For prediction and report generation.
  - **Auth Module**: User registration and login via Flask-Login.
- **DNN Model (TensorFlow)**:
  - 5-layer network with dropout and batch normalization.
- **Database**: SQLite (can be migrated to PostgreSQL).
- **Report System**: FPDF/ReportLab for PDF generation with embedded QR code (access link).

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### 8. Methodology

**Dataset Used:**

The dataset was sourced from Kaggle and UCI repositories, including 5,000 patient records with features like:

- Demographics: Age, Gender
- Medical: Hypertension, Heart Disease
- Lifestyle: Smoking, Work Type

- Physiology: BMI, Blood Pressure
- Target: Stroke (binary)

**Data Preprocessing:**

- Missing values handled with mean imputation.
- Categorical variables encoded using one-hot encoding.
- Normalization (Min-Max) applied for continuous features.
- Class imbalance corrected using SMOTE.

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## 9. Algorithms or Models Used

**Deep Neural Network (DNN):**

- **Input Layer:** 18 normalized features
- **Hidden Layers:**
  - Dense(64) + ReLU
  - Dropout(0.3)
  - Dense(32) + ReLU
  - BatchNorm
  - Dense(16) + ReLU
- **Output Layer:** Dense(1) + Sigmoid
- **Optimizer:** Adam
- **Loss Function:** Binary Crossentropy
- **Training Epochs:** 100
- **Batch Size:** 32

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## 10. Tools and Technologies Used

- **Programming Language:** Python 3.11
- **Frameworks/Libraries:** Flask, TensorFlow, Pandas, NumPy, Seaborn, Scikit-learn
- **Database:** SQLite (with option to scale to PostgreSQL)
- **Frontend:** Tailwind CSS, JavaScript

- **PDF Generation:** ReportLab/FPDF
- **Authentication:** Flask-Login
- **Visualization:** Matplotlib, SHAP, Seaborn

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### 11. Results and Evaluation

| Metric | Value |
|---|---|
| Accuracy | 92.3% |
| Precision | 89.6% |
| Recall | 91.1% |
| F1-Score | 90.3% |
| ROC-AUC Score | 0.95 |

The model consistently outperformed Logistic Regression, SVM, and Decision Trees in cross-validation (10-fold).

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### 12. Visualization

- **Confusion Matrix:** Shows TP = 235, FN = 21, FP = 29, TN = 1215
- **SHAP Values:** Explain model decisions for transparency.
- **Interactive Dashboard:** Built with Plotly and Chart.js.
- **Report Page:** Real-time preview of patient risk + download option.

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### 13. Conclusion

This paper presents a comprehensive AI-powered solution for stroke risk prediction using deep neural networks. The system significantly enhances predictive performance and user engagement through real-time analysis, personalized recommendations, and rich visualizations. It bridges the gap between technical accuracy and clinical utility.

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### 14. Future Scope

- Integration with wearable devices for real-time monitoring.
- Migration to cloud-based microservices for scalability.

- Expansion to multi-disease risk prediction (e.g., diabetes, CVD).
- Federated learning for privacy-preserving AI in healthcare.

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