Notebook

March 15, 2025

[1]:
```
import pandas as pd
import numpy as np
from sklearn.preprocessing import StandardScaler, OneHotEncoder
from sklearn.compose import ColumnTransformer
from sklearn.model_selection import train_test_split
from imblearn.over_sampling import RandomOverSampler
from sklearn.metrics import accuracy_score, precision_score, recall_score,␣
 ↪f1_score, roc_auc_score
import tensorflow as tf
from tensorflow.keras.layers import Input, Dense, BatchNormalization, Dropout
from tensorflow.keras.models import Model
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.callbacks import EarlyStopping, ReduceLROnPlateau

#1. Load & Clean Data

file_path = "C:/Users/CHUMKI/Desktop/AA/Diabetes.xlsx"
df = pd.read_excel(file_path, sheet_name='Data')

 #Drop specified columns
cols_to_drop = ["encounter_id", "patient_nbr", "max_glu_serum",
                "A1Cresult", "examide", "citoglipton",
                "acetohexamide", "troglitazone"]
df.drop(columns=cols_to_drop, inplace=True)

 #Handle missing values
num_cols = df.select_dtypes(include=['int64', 'float64']).columns
cat_cols = df.select_dtypes(include=['object']).columns
df[num_cols] = df[num_cols].fillna(df[num_cols].median())
df[cat_cols] = df[cat_cols].fillna(df[cat_cols].mode().iloc[0])
```

[3]:
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# ----------------------
# 2. Preprocessing
# ----------------------
X = df.drop(columns=["Readmission"])
y = df["Readmission"].astype(int)
```

```
# Categorical encoding
categorical_features = X.select_dtypes(include=['object']).columns.tolist()
preprocessor = ColumnTransformer(
    transformers=[
        ('onehot', OneHotEncoder(handle_unknown='ignore', sparse_output=False),␣
 ↪categorical_features)
    ],
    remainder='passthrough'
)

X_processed = preprocessor.fit_transform(X)

# Class balancing
oversampler = RandomOverSampler(sampling_strategy='minority', random_state=42)
X_resampled, y_resampled = oversampler.fit_resample(X_processed, y)

# ----------------------
# 3. Train/Val/Test Split
# ----------------------
# Split into labeled (train/val) and unlabeled (simulated for example)
X_labeled, X_unlabeled, y_labeled, _ = train_test_split(
    X_resampled, y_resampled,
    test_size=0.3, random_state=42  # 30% as unlabeled
)

# Split labeled into train and validation
X_train, X_val, y_train, y_val = train_test_split(
    X_labeled, y_labeled,
    test_size=0.2, stratify=y_labeled, random_state=42
)
# Split original data for final test
_, X_test, _, y_test = train_test_split(
    X_resampled, y_resampled,
    test_size=0.2, stratify=y_resampled, random_state=42
)
```

[5]:
```
# ----------------------
# 4. Feature Scaling
# ----------------------
scaler = StandardScaler()
X_train = scaler.fit_transform(X_train)
X_val = scaler.transform(X_val)
X_test = scaler.transform(X_test)
X_unlabeled = scaler.transform(X_unlabeled)  # Scale unlabeled data
```

[7]:
```
# 5. Model Architecture
# ----------------------
```

```
def build_enhanced_model(input_dim):
    inputs = Input(shape=(input_dim,))

    # Block 1
    x = Dense(256, activation='swish', kernel_initializer='he_normal',
          kernel_regularizer=tf.keras.regularizers.l2(5e-4))(inputs)
    x = BatchNormalization()(x)
    x = Dropout(0.3)(x)


    # Block 2 with residual
    residual = Dense(128, activation='swish')(x)
    x = Dense(128, activation='swish', kernel_regularizer=tf.keras.regularizers.
 ↪l2(1e-4))(residual)
    x = BatchNormalization()(x)
    x = Dropout(0.3)(x)

    # Block 3 with projected residual
    x = Dense(64, activation='swish')(x)
    res_proj = Dense(64)(residual)  # Project residual to match dimensions
    x = tf.keras.layers.add([x, res_proj])
    x = Dropout(0.3)(x)

    outputs = Dense(1, activation='sigmoid')(x)
    return Model(inputs, outputs)
model = build_enhanced_model(X_train.shape[1])
optimizer = Adam(learning_rate=1e-3, weight_decay=1e-4)
model.compile(optimizer=optimizer, loss='binary_crossentropy', metrics=['auc'])
```

[9]:
```
from tensorflow.keras.callbacks import ReduceLROnPlateau

lr_scheduler = ReduceLROnPlateau(
    monitor='val_auc',  # Reduce LR when val_auc stops improving
    factor=0.8,  # Reduce LR by 20%
    patience=5,  # Wait 5 epochs before reducing LR
    min_lr=1e-5,  # Don't reduce below this
    verbose=1
)
```

[11]:
```
from tensorflow.keras.callbacks import EarlyStopping

early_stopping = EarlyStopping(
    monitor='val_auc',  # Stop training when validation AUC stops improving
    patience=7,  # Wait 7 epochs before stopping
    restore_best_weights=True  # Load the best model after stopping
)
```

[13]:
```
from sklearn.utils import shuffle

# ----------------------
# 6. Semi-Supervised Training
# ----------------------
pseudo_history = []
best_auc = 0

for epoch in range(100):
    # Phase 1: Supervised Warmup
    if epoch < 10:
        model.fit(
            X_train, y_train,
            validation_data=(X_val, y_val),
            batch_size=64,
            epochs=1,
            verbose=0
        )
        continue

    # Phase 2: Generate Pseudo-Labels
    pseudo_probs = model.predict(X_unlabeled, verbose=0).flatten()
    conf_threshold = 0.7 + min(0.15, epoch/200)
    mask = (pseudo_probs > conf_threshold) | (pseudo_probs < (1 -␣
↪conf_threshold))

    # Create pseudo-labels
    pseudo_labels = (pseudo_probs[mask] > 0.5).astype(int)
    X_pseudo = X_unlabeled[mask]


 # Balance pseudo-labeled data
    n_pos = np.sum(pseudo_labels == 1)
    n_neg = np.sum(pseudo_labels == 0)
    n_samples = min(n_pos, n_neg)
    if n_samples == 0: continue

    idx_pos = np.random.choice(np.where(pseudo_labels == 1)[0], n_samples,␣
↪replace=False)
    idx_neg = np.random.choice(np.where(pseudo_labels == 0)[0], n_samples,␣
↪replace=False)
    X_balanced = np.concatenate([X_pseudo[idx_pos], X_pseudo[idx_neg]])
    y_balanced = np.concatenate([np.ones(n_samples), np.zeros(n_samples)])

    # Combine with labeled data
    X_combined = np.concatenate([X_train, X_balanced])
    y_combined = np.concatenate([y_train, y_balanced])
    # Shuffle combined data
    X_combined, y_combined = shuffle(X_combined, y_combined, random_state=epoch)

    # Phase 3: Train on Combined Data
history = model.fit(
    X_combined, y_combined,
    validation_data=(X_val, y_val),
    batch_size=64,
    epochs=100,  # Maximum, but early stopping will stop earlier
    verbose=0,
    callbacks=[early_stopping, lr_scheduler]  # Add the callbacks here
)
```

```
Epoch 6: ReduceLROnPlateau reducing learning rate to 0.000800000037997961.

Epoch 11: ReduceLROnPlateau reducing learning rate to 0.0006400000303983689.

Epoch 16: ReduceLROnPlateau reducing learning rate to 0.0005120000336319208.

Epoch 21: ReduceLROnPlateau reducing learning rate to 0.00040960004553198815.

Epoch 26: ReduceLROnPlateau reducing learning rate to 0.00032768002711236477.

Epoch 31: ReduceLROnPlateau reducing learning rate to 0.0002621440216898918.

Epoch 36: ReduceLROnPlateau reducing learning rate to 0.00020971521735191345.

Epoch 41: ReduceLROnPlateau reducing learning rate to 0.00016777217388153076.

Epoch 46: ReduceLROnPlateau reducing learning rate to 0.00013421773910522462.

Epoch 51: ReduceLROnPlateau reducing learning rate to 0.00010737419361248613.

Epoch 56: ReduceLROnPlateau reducing learning rate to 8.589935605414213e-05.

Epoch 61: ReduceLROnPlateau reducing learning rate to 6.871948717162013e-05.

Epoch 66: ReduceLROnPlateau reducing learning rate to 5.497558740898967e-05.

Epoch 71: ReduceLROnPlateau reducing learning rate to 4.398046876303852e-05.

Epoch 76: ReduceLROnPlateau reducing learning rate to 3.518437442835421e-05.

Epoch 81: ReduceLROnPlateau reducing learning rate to 2.8147498960606756e-05.
Epoch 86: ReduceLROnPlateau reducing learning rate to 2.25179988774471e-05.

Epoch 91: ReduceLROnPlateau reducing learning rate to 1.8014399392995985e-05.

Epoch 96: ReduceLROnPlateau reducing learning rate to 1.4411519805435093e-05.
```

[14]:
```
 # Phase 4: Validation & Early Stopping

# Early stopping logic inside the training loop
for epoch in range(100):
    # Training phase
    history = model.fit(X_train, y_train, validation_data=(X_val, y_val),␣
 ↪batch_size=64, epochs=1, verbose=0)

    # Phase 4: Validation & Early Stopping
    val_auc = history.history['val_auc'][0]
    pseudo_history.append(val_auc)

    # Save best model weights
    if val_auc > best_auc:
        best_auc = val_auc
        model.save_weights('best_model.weights.h5')

    # Early stopping condition
    if len(pseudo_history) > 10 and np.argmax(pseudo_history[-10:]) == 0:
        print("Early stopping triggered")
        break  # This is now correctly placed inside the loop

# Load best weights after training completes
model.load_weights('best_model.weights.h5')
```

```
Early stopping triggered
```

[17]:
```
# ----------------------
# 7. Evaluation
# ----------------------
y_pred = model.predict(X_test).flatten()
y_pred_class = (y_pred > 0.5).astype(int)

# Compute evaluation metrics
accuracy = accuracy_score(y_test, y_pred_class)
precision = precision_score(y_test, y_pred_class)
recall = recall_score(y_test, y_pred_class)
f1 = f1_score(y_test, y_pred_class)
auroc = roc_auc_score(y_test, y_pred)

# Print results
```

```
print(f"Accuracy: {accuracy:.2f}")
print(f"Precision: {precision:.2f}")
print(f"Recall: {recall:.2f}")
print(f"F1-score: {f1:.2f}")
print(f"AUROC: {auroc:.2f}")
```

```
1131/1131           3s 3ms/step
Accuracy: 0.93
Precision: 0.90
Recall: 0.98
F1-score: 0.94
AUROC: 0.98
```

[19]:

```
# Training Set Performance
y_train_pred = model.predict(X_train).flatten()
y_train_class = (y_train_pred > 0.5).astype(int)
print(f"Train Accuracy: {accuracy_score(y_train, y_train_class):.2f}")
print(f"Train AUC: {roc_auc_score(y_train, y_train_pred):.2f}")

# Validation Set Performance
y_val_pred = model.predict(X_val).flatten()
y_val_class = (y_val_pred > 0.5).astype(int)
print(f"Validation Accuracy: {accuracy_score(y_val, y_val_class):.2f}")
print(f"Validation AUC: {roc_auc_score(y_val, y_val_pred):.2f}")

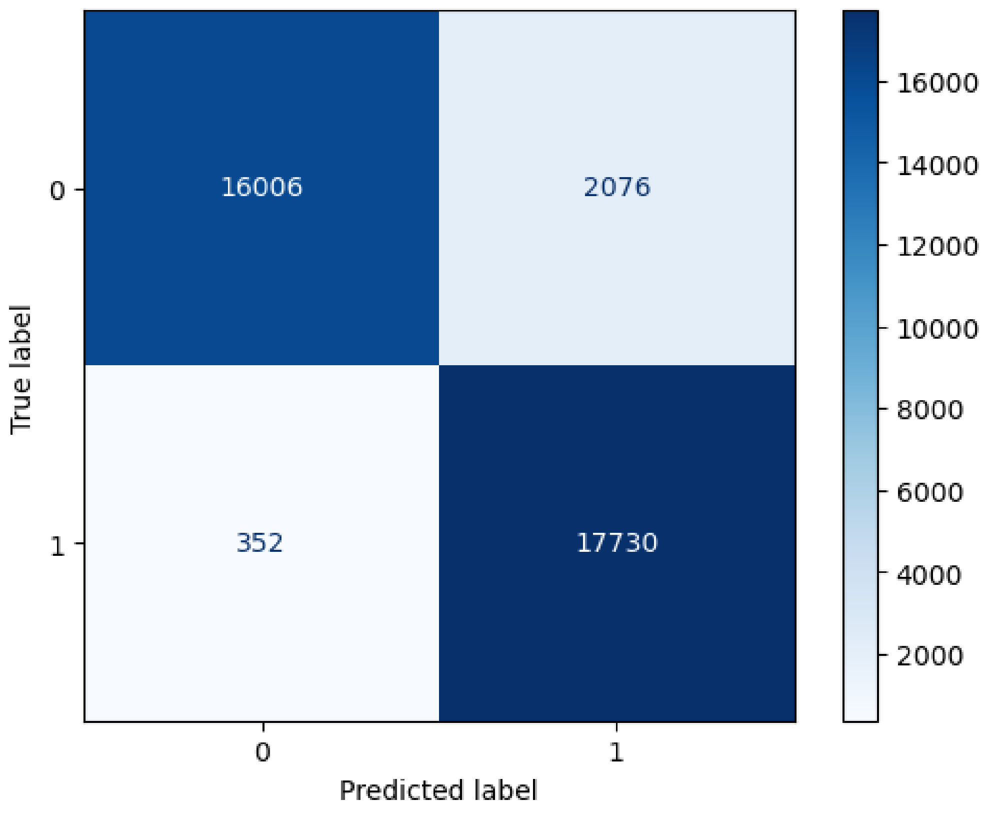
# Test Set Performance
y_test_pred = model.predict(X_test).flatten()
y_test_class = (y_test_pred > 0.5).astype(int)
print(f"Test Accuracy: {accuracy_score(y_test, y_test_class):.2f}")
print(f"Test AUC: {roc_auc_score(y_test, y_test_pred):.2f}")
```

```
3165/3165           9s 3ms/step
Train Accuracy: 0.97
Train AUC: 1.00
792/792           2s 3ms/step
Validation Accuracy: 0.89
Validation AUC: 0.96
1131/1131           3s 3ms/step
Test Accuracy: 0.93
Test AUC: 0.98
```

[23]:

```
from sklearn.metrics import confusion_matrix, ConfusionMatrixDisplay
import matplotlib.pyplot as plt

cm = confusion_matrix(y_test, y_test_class)
disp = ConfusionMatrixDisplay(confusion_matrix=cm)
disp.plot(cmap='Blues')
plt.show()
```



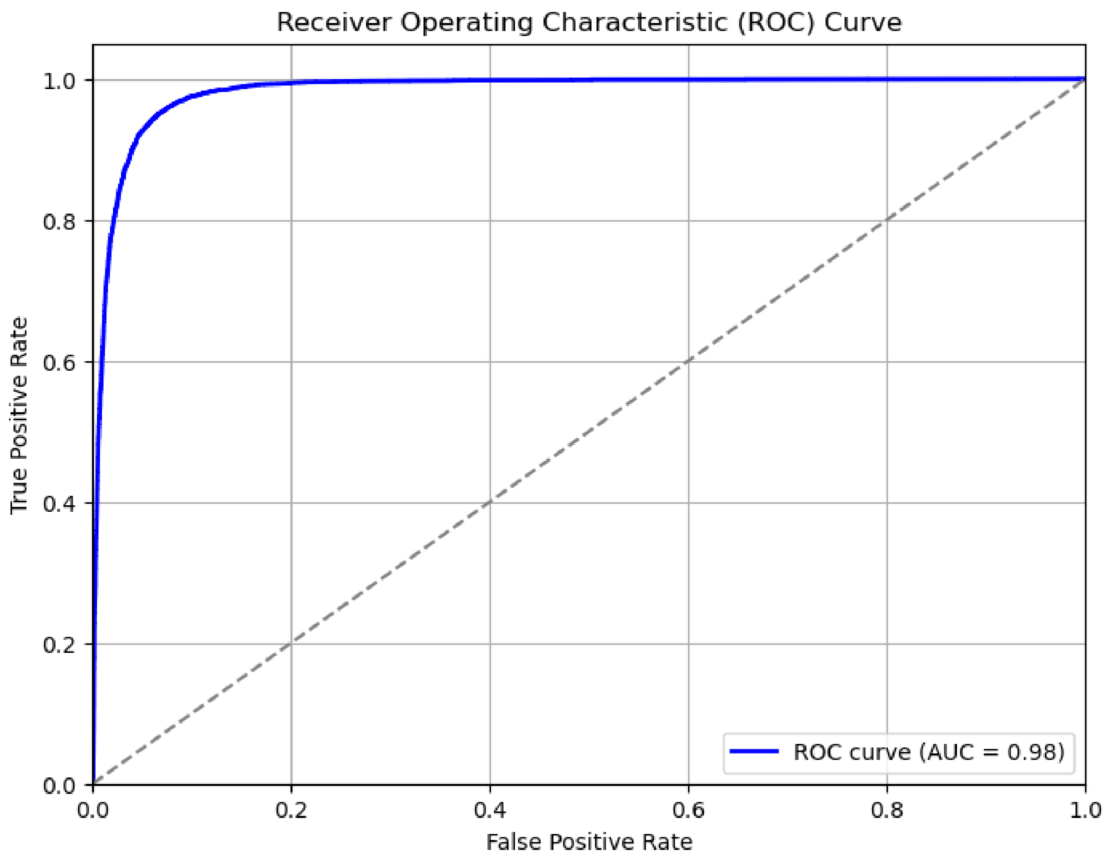
[25]:
```
import matplotlib.pyplot as plt
from sklearn.metrics import roc_curve, auc

# Get the predicted probabilities
y_pred_prob = model.predict(X_test).flatten()

# Compute the ROC curve
fpr, tpr, thresholds = roc_curve(y_test, y_pred_prob)
roc_auc = auc(fpr, tpr)

# Plot the ROC curve
plt.figure(figsize=(8,6))
plt.plot(fpr, tpr, color='blue', lw=2, label=f'ROC curve (AUC = {roc_auc:.2f})')
plt.plot([0, 1], [0, 1], color='gray', linestyle='--')  # Random model line
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.05])
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic (ROC) Curve')
plt.legend(loc='lower right')
plt.grid()
plt.show()
```

```
1131/1131                3s 3ms/step
```



[49]:
```
from tensorflow.keras.utils import plot_model

# Assuming your model variable is named 'model'
plot_model(model, to_file="model_architecture.png", show_shapes=True,␣
  ↪show_layer_names=True)
```

```
You must install graphviz (see instructions at
https://graphviz.gitlab.io/download/) for `plot_model` to work.
```

[63]:
```
import matplotlib.pyplot as plt

def draw_neural_net(ax, layer_sizes):
    """Draw a neural network diagram."""
    if len(layer_sizes) < 2:
        raise ValueError("The model must have at least an input and one hidden/
  ↪output layer!")
```

```
    v_spacing = 1.0 / float(max(layer_sizes))
    h_spacing = 1.0 / float(len(layer_sizes) - 1)

    # Nodes
    for n, layer_size in enumerate(layer_sizes):
        layer_top = v_spacing * (layer_size - 1) / 2.0
        for m in range(layer_size):
            ax.add_patch(plt.Circle((n * h_spacing, layer_top - m * v_spacing),␣
↪v_spacing / 4.0, color='blue', ec='black'))

    # Edges
    for n, (layer_size_a, layer_size_b) in enumerate(zip(layer_sizes[:-1],␣
↪layer_sizes[1:])):
        layer_top_a = v_spacing * (layer_size_a - 1) / 2.0
        layer_top_b = v_spacing * (layer_size_b - 1) / 2.0
        for m in range(layer_size_a):
            for o in range(layer_size_b):
                ax.plot([n * h_spacing, (n + 1) * h_spacing], [layer_top_a - m␣
↪* v_spacing, layer_top_b - o * v_spacing], 'k-')

#  Fix: Ensure `layer_sizes` is correctly extracted from the model
layer_sizes = [model.input_shape[-1]] + [layer.output_shape[-1] for layer in␣
↪model.layers if hasattr(layer, 'output_shape')]

if len(layer_sizes) < 2:
    print("Error: Model does not have enough layers to plot.")
else:
    # Plot network
    fig, ax = plt.subplots(figsize=(6, 6))
    ax.axis("off")
    draw_neural_net(ax, layer_sizes)
    plt.show()
```

```
Error: Model does not have enough layers to plot.
```

[31]:
```
import nbformat
from docx import Document

# Load the Jupyter Notebook
notebook_path = "Updated Model.ipynb"  # Change to your notebook's filename
word_output_path = "Updated Model.docx"

# Read the notebook
with open(notebook_path, "r", encoding="utf-8") as f:
    nb = nbformat.read(f, as_version=4)
```

```
# Create a new Word document
doc = Document()
doc.add_heading("Extracted Code from Notebook", level=1)

# Extract and add code cells to the document
for cell in nb['cells']:
    if cell['cell_type'] == 'code':
        doc.add_heading("Code Cell", level=2)
        doc.add_paragraph(cell['source'])

# Save the document
doc.save("C:/Users/CHUMKI/Desktop/AA/Updated Model1.docx")

print(f"Notebook code saved to: {"C:/Users/CHUMKI/Desktop/AA/Updated Model1.
 ↪docx"}")
```

```
Notebook code saved to: C:/Users/CHUMKI/Desktop/AA/Updated Model1.docx
```

[5]:
```
import nbformat
from nbconvert import PDFExporter

# Corrected file reading with UTF-8 encoding
notebook_filename = "Updated Model.ipynb"
with open(notebook_filename, encoding="utf-8") as f:
    notebook_content = nbformat.read(f, as_version=4)

# Convert to PDF
pdf_exporter = PDFExporter()
pdf_data, _ = pdf_exporter.from_notebook_node(notebook_content)

# Save as PDF
with open("Updated_Model.pdf", "wb") as pdf_file:
    pdf_file.write(pdf_data)

print("Notebook successfully converted to PDF!")
```

```
Notebook successfully converted to PDF!
```

[ ]:
```
```