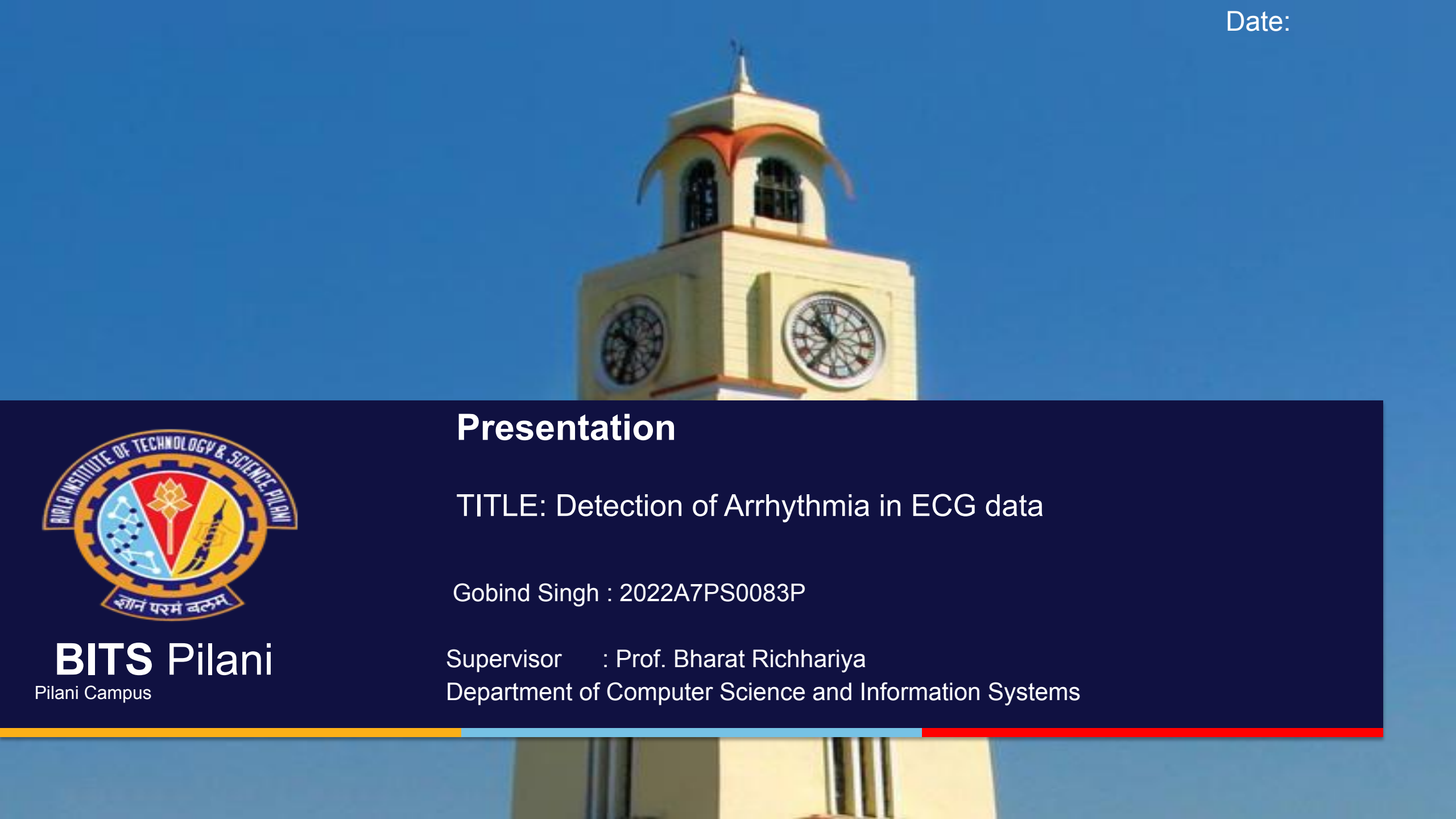
Date:



Presentation

TITLE: Detection of Arrhythmia in ECG data

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Introduction

Objective: Develop a model to detect arrhythmias in ECG signals using the MIT-BIH dataset.
Background:

- Arrhythmias are irregular heart rhythms that may indicate underlying cardiac issues.
- Accurate detection is critical for timely diagnosis and treatment.

Approach:

- Based on the paper *"Cardiologist-Level Arrhythmia Detection with Convolutional Neural Networks"* (Source).
- Perform experiments and ablation studies with three models:
  - Convolutional Neural Network (CNN).
  - Support Vector Machine (SVM).
  - Autoencoder (AE).

Database

Dataset Details:

- Contains 48 half-hour-long two-channel ECG recordings from 47 subjects.
- Sample rate: 360 Hz.
- Annotated with arrhythmia labels by cardiologists.

Features Used:

- Signals: MLII, V1, V2, V4, V5.

Classes:

- Categories: Normal (N), Ventricular (V), Paced (/), Atrial (A), Fusion (F), and Noise (~).

Preprocessing

Steps:

1. **Data Download**: Fetch records and annotations from PhysioNet.
2. **Signal Standardization**:
   - Normalize signals using mean and standard deviation.
   - Handle missing values with default replacements.
3. **Peak Detection**:
   - Identify R-peaks for QRS segmentation using SciPy's `find_peaks` function.
4. **Windowing**: Extract fixed-length segments around peaks (256 samples).
5. **Annotation Alignment**: Map arrhythmia labels to corresponding segments.
6. **Class Balancing**: Downsample normal beats to reduce class imbalance.

Output: Cleaned datasets stored in HDF5 format for training and testing.

Parameters

Input Size: 256 (number of samples per segment).
Filter Length: 32 (initial number of filters in CNN layers).
Kernel Size: 16 (size of convolutional filters).
Dropout Rate: 0.2 (to prevent overfitting).
Training Settings:

- Batch Size: 256.
- Learning Rate: Adaptive optimizer settings with a minimum of 0.00005.
- Epochs: 1 (initial setting).
- Patience: 10 (for early stopping).

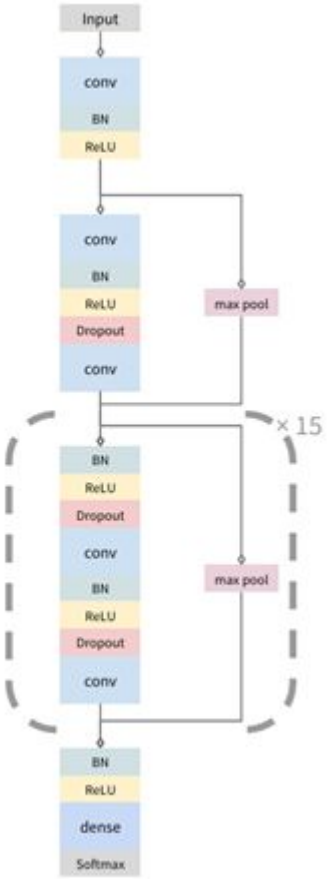
The parameters for the other models are mentioned in the respective model slides.

Model 1 - ECG_model from paper

Architecture:

- Input Layer: Accepts 256-sample segments.
- Initial Block:
  - 1D convolution with ReLU activation.
  - Batch normalization and max pooling.
- Main Blocks:
  - 15 residual blocks with increasing filter sizes.
  - Alternating downsampling every 4 blocks.
- Output Block:
  - Time-distributed dense layer with softmax activation for classification.

Optimizer: Adam with a learning rate of 0.1.
Loss Function: Categorical cross-entropy.



Model 2 - Traditional Classification with SVM

Overview:

- Feature extraction from ECG signals using statistical metrics (mean, standard deviation, etc.).
- Kernel-based classification to distinguish arrhythmia types.

Advantages: Effective for smaller datasets with high dimensionality.
Limitations: Performance degrades on imbalanced datasets compared to deep learning.

```
# Experiments
experiments = [
    {"kernel": "linear", "C": 0.1, "add_noise_flag": False},
    {"kernel": "linear", "C": 1, "add_noise_flag": False},
    {"kernel": "linear", "C": 10, "add_noise_flag": True},
    {"kernel": "rbf", "C": 1, "add_noise_flag": False},
    {"kernel": "poly", "C": 1, "add_noise_flag": False}
]
```

Model 3 - AutoEncoder

Structure

- Two parts: **Encoder** (compresses data) and **Decoder** (reconstructs data).
- Uses Conv1D layers, ReLU activation, Batch Normalization, MaxPooling, and UpSampling.
- Latent dimension: Configurable (e.g., 32).

Training

- Evaluated loss functions: MAE, MSE, Huber, Cosine Similarity.
- Early stopping and a threshold based on the 95th percentile of reconstruction errors.

Performance

- **Validation Accuracy**: 16.26% (Cosine Similarity).
- **Validation Reconstruction Error**: 64.34.

Metrics

Confusion Matrix: Breakdown of predictions into TP, FP, FN, TN.
F1 Score:

- Balances Precision and Recall.
- Ideal for imbalanced datasets.

Area Under the Curve (AUC):

- Evaluates model's ability to distinguish between classes.
- AUC close to 1 indicates excellent performance.

Accuracy: Overall percentage of correct predictions.

Results.

```
Epoch 1: saving model to models/V1-latest.keras
75/75 ━━━━━━━━━━━━━━━━━━━━ 150s 2s/step - accuracy: 0.7401 - loss: 0.7644 - val_accuracy: 0.3819 - val_loss: 1.9912 - le
arning_rate: 0.0010
```

```
Epoch 30: saving model to models/V1-latest.keras
75/75 ━━━━━━━━━━━━━━━━━━━━ 112s 1s/step - accuracy: 0.9933 - loss: 0.0175 - val_accuracy: 0.9088 - val_loss: 0.4644 - le
arning_rate: 0.0010
```

	precision	recall	f1-score
0	0.87	0.88	0.88
1	0.85	0.94	0.89
2	1.00	0.98	0.99
3	0.16	0.04	0.06
4	0.00	0.00	0.00
5	0.24	0.31	0.27
accuracy			0.89
macro avg	0.52	0.52	0.51
weighted avg	0.89	0.89	0.89

Results - SVM

```
Training SVM with kernel=linear, C=1, Noise=False
SVM Validation Accuracy: 0.6967123287671233
Classification Report:
              precision    recall  f1-score   support

           N       0.77      0.71      0.74      1305
           V       0.45      0.40      0.42       649
           /       1.00      0.88      0.94      1538
           A       0.01      0.01      0.01       127
           F       0.01      0.06      0.01        18
           ~       0.02      0.46      0.05        13

    accuracy                           0.70      3650
   macro avg       0.38      0.42      0.36      3650
weighted avg       0.77      0.70      0.73      3650

Confusion Matrix:
[[ 922  156    0   83  119   25]
 [ 137  257    6   43   11  195]
 [  37  142 1356    0    0    3]
 [  93   11    0    1   11   11]
 [   8    3    0    0    1    6]
 [   3    4    0    0    0    6]]
```

```
Feature: V1
Training SVM with kernel=linear, C=0.1, Noise=False
SVM Validation Accuracy: 0.7361643835616438
Classification Report:
              precision    recall  f1-score   support

           N       0.81      0.74      0.77      1305
           V       0.54      0.39      0.45       649
           /       1.00      0.95      0.97      1538
           A       0.00      0.00      0.00       127
           F       0.01      0.06      0.01        18
           ~       0.02      0.54      0.05        13

    accuracy                           0.74      3650
   macro avg       0.40      0.45      0.38      3650
weighted avg       0.80      0.74      0.77      3650

Confusion Matrix:
[[ 960  145    0   62   99   39]
 [ 111  254    5   37   18  224]
 [   8   61 1465    0    0    4]
 [ 101   10    0    0   15    1]
 [   8    2    0    0    1    7]
 [   4    2    0    0    0    7]]
```

```
Training SVM with kernel=linear, C=10, Noise=True
SVM Validation Accuracy: 0.6635616438356164
Classification Report:
              precision    recall  f1-score   support

           N       0.68      0.71      0.70      1305
           V       0.40      0.45      0.43       649
           /       0.99      0.78      0.87      1538
           A       0.01      0.01      0.01       127
           F       0.00      0.00      0.00        18
           ~       0.03      0.31      0.06        13

    accuracy                           0.66      3650
   macro avg       0.35      0.38      0.34      3650
weighted avg       0.74      0.66      0.69      3650

Confusion Matrix:
[[ 926  180    0   76  105   18]
 [ 213  295    7   37   11   86]
 [  98  238 1196    1    0    5]
 [  99    6    0    1   16    5]
 [  11    6    0    0    0    1]
 [   5    4    0    0    0    4]]
```

```
Training SVM with kernel=rbf, C=1, Noise=False
SVM Validation Accuracy: 0.8556164383561644
Classification Report:
              precision    recall  f1-score   support

           N       0.88      0.78      0.83      1305
           V       0.85      0.86      0.86       649
           /       1.00      0.99      1.00      1538
           A       0.15      0.05      0.07       127
           F       0.00      0.00      0.00        18
           ~       0.03      0.46      0.05        13

    accuracy                           0.86      3650
   macro avg       0.48      0.52      0.47      3650
weighted avg       0.89      0.86      0.87      3650

Confusion Matrix:
[[1021   76    0   30   30  148]
 [  26  561    0    3    3   56]
 [   1    8 1529    0    0    0]
 [ 112    4    0    6    2    3]
 [   4    4    0    1    0    9]
 [   0    7    0    0    0    6]]
```

```
SVM Validation Accuracy: 0.6616438356164384
Classification Report:
              precision    recall  f1-score   support

           N       0.87      0.42      0.57      1305
           V       0.95      0.52      0.67       649
           /       0.99      0.98      0.99      1538
           A       0.09      0.05      0.06       127
           F       0.00      0.00      0.00        18
           ~       0.01      0.62      0.02        13

    accuracy                           0.66      3650
   macro avg       0.49      0.43      0.38      3650
weighted avg       0.90      0.66      0.74      3650

Confusion Matrix:
[[ 554   10    1   39   10  691]
 [  30  335   11   15   13  245]
 [  11    6 1512    0    0    9]
 [  35    0    0    6    4   82]
 [   4    1    0    1    0   12]
 [   0    0    0    3    2    8]]

Performing Cross-Validation...
Cross-Validation Scores (kernel=linear, C=1): [0.81318395 0.80875456 0.80171965 0.8074518  0.80557727]
Average Accuracy: 0.8073374454024966
```

Results: AutoEncoder

Model: "auto_encoder_3"

Layer (type)	Output Shape	Param #
sequential_6 (Sequential)	(None, 47, 32)	6,816
sequential_7 (Sequential)	?	0 (unbuilt)

Total params: 6,816 (26.62 KB)
Trainable params: 6,624 (25.88 KB)
Non-trainable params: 192 (768.00 B)

```
2024-11-29 16:45:49.610490: E tensorflow/core/util/util.cc:131] oneDNN supports DT_INT32 only on platforms with AVX-512.
 Falling back to the default Eigen-based implementation if present.
108/108 ━━━━━━━━━━━━━━━━━━━━ 1s 8ms/step
348/348 ━━━━━━━━━━━━━━━━━━━━ 2s 5ms/step
Validation Accuracy using CosineSimilarity: 17.69%
Validation Reconstruction Error using CosineSimilarity: 111.079063289444443
Best Model uses CosineSimilarity with average validation error: 111.079063289444443
```

Conclusions

ECG Model: Achieved **89% validation accuracy**, showcasing robust arrhythmia detection with high AUC values for major classes. However, performance on minority classes remains a challenge.

SVM: Delivered **85.5% validation accuracy** with an RBF kernel, demonstrating strong performance in distinguishing arrhythmia patterns in flattened ECG data.

AutoEncoder: Effective for anomaly detection but limited in direct classification tasks, with a **validation accuracy of 16.26%** and significant reconstruction error.

Thank You