VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"Jnana Sangama", Belagavi-18, Karnataka, India

INTERNSHIP REPORT

BACHELOR OF ENGINEERING

in

MEDICAL ELECTRONICS ENGINEERING

INTERNSHIP MONTHLY REPORT

during academic year 2024 – 2025

By

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Accredited by National Board of Accreditation (NBA)

DAYANANDA SAGAR COLLEGE OF ENGINEERING

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INTERNSHIP REPORT 2

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    - CNN and LSTM
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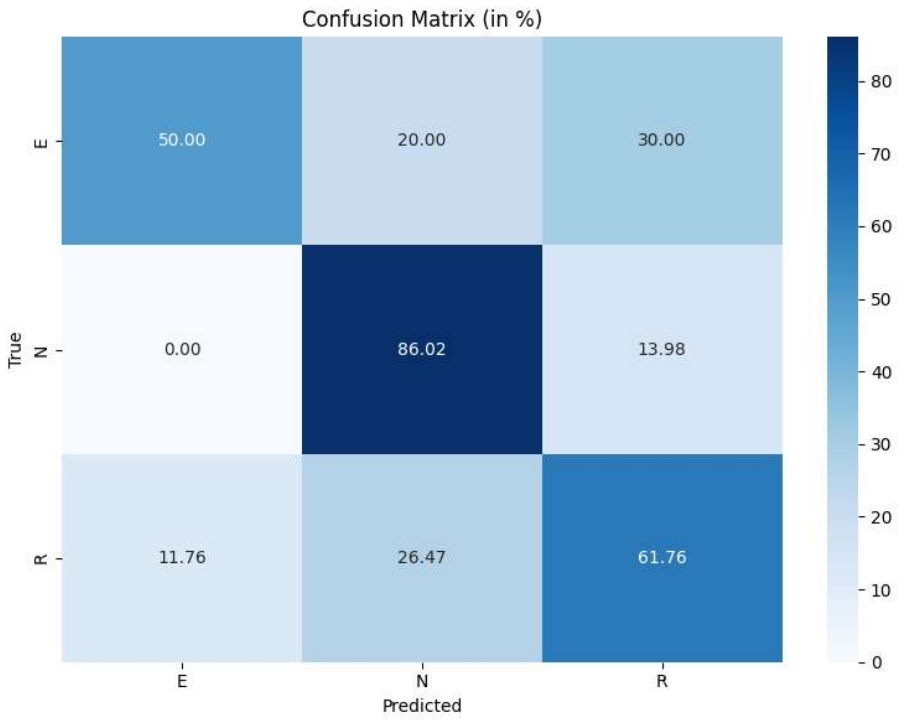
    - CNN and Transformer
2. Customized model

Hybrid Models –

- CNN and LSTM –



This is the confusion Matrix of CNN and LSTM models, Wherein:

1. Class E – This is Endurance class
    - ➔ True Positives = 50 % .
    - ➔ False Positives = 0%+11.76% = 11.76 %.
    - ➔ False Negatives = 20%+30% = 50 %.
    - ➔ True Negatives = 86.02% + 13.98% +26.47 + 61.76 = 188.23 %
2. Class R – This is Recovery Class
    - ➔ True Positive = 61.76.%
    - ➔ False Positives = 30 %
    - ➔ False Negatives=11.76 + 26..47 = 38.23%.
    - ➔ True Negatives = 50%+20%+86.02%=156.02%.

3. Class N – This is Normal class
    - ➔ TP = 86.02%.
    - ➔ FP = 20%+26.47%=46.47%.
    - ➔ FN = 13.98%
    - ➔ TN = 50% + 30%+11.76+61.76=153.52.

Class	TP	FP	FN	TN
E	50%	43.98%	50%	188.23%
N	86.02%	46.47%	13.98%	153.52%
R	61.76%	43.98%	38.23%	156.02%

CALCULATIONS:

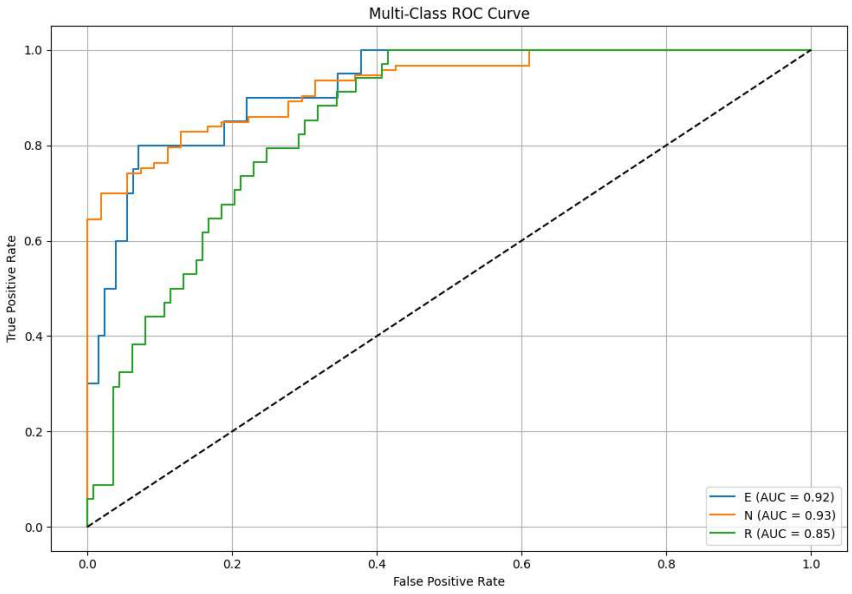
- ➔ **Precision** = TP/(TP+FP).
- ➔ **Recall =** TP/(TP+FN).
- ➔ **F1 – score** = 2 * (Precision * Recall) / (Precision + Recall).
- ➔ **Accuracy** = (TP + TN) / (TP + FP + FN +TN).
- ➔ **Loss** = 1 – Accuracy.

1. **Class E** – The TP = 50, FP = 11.76, FN = 50, TN = 188.23.
    - ➔ **Precision** = 50/ (50+11.76) = 0.809.
    - ➔ **Recall =** 50/(50+50) = 0.5.
    - ➔ **F1-score=** 2 *(0.809*0.5) / (0.809+0.5) =0.619.
    - ➔ **Accuracy =** (50+188.23)/300 = 0.793.
    - ➔ **Loss** = 1- 0.793 = 0.207.
2. **Class N** – The TP = 86.02, FP = 46.47, FN = 13.98, TN = 153.52
    - ➔ Precision = 86.02 / (86.02 + 46.47) = 0.649.
    - ➔ Recall = 86.02 / (6.02 + 13.98) = 0.860.
    - ➔ F1 Score = 2 * (0.649 *0.860) / (0.649 + 0.860) = 0.739.
    - ➔ Accuracy = (86.02 + 153.52) / 300 = 0.799.
    - ➔ Loss = 1- 0.799 = 0.201.
3. **Class R** – The TP = 61.76, FP =43.98, FN=38.23, TN = 156.02
    - ➔ Precision = 61.76/(61.76+43.98) = 0.584.
    - ➔ Recall = 61.76/(61.76+38.23)=0.618.
    - ➔ F1 score = 2*(0.584*0.618)/(0.584+0.618)=0.600.
    - ➔ Accuracy = (61.76 + 156.02)/300 = 0.727.
    - ➔ Loss = 1-0,727 = 0.273.

Model Performance Metric Table:

Metric	Class E	Class N	Class R
Precision	0.81	0.65	0.58
Recall	0.50	0.86	0.62
F1 Score	0.62	0.74	0.60
Accuracy	0.79	0.80	0.73
Loss	0.21	0.20	0.27

ROC Curve :



1. Class E (Endurance) –

Metric	Value	Explanation
True Positive (TP)	50.00%	Correctly predicted as E
False Negative (FN)	50.00%	Misclassified as N (20%) or R (30%)
False Positive (FP)	11.76%	R samples misclassified as E
True Negative (TN)	88.24%	All non-E correctly not classified as E

Score	Value	Notes
Precision	0.81	TP / (TP + FP) = 50 / (50 + 11.76)
Recall	0.50	TP / (TP + FN) = 50 / 100
F1 Score	0.62	Harmonic mean of Precision & Recall
Accuracy	~70% (est.)	Only 50% of E predicted correctly
AUC (ROC)	**0.92**	Excellent discrimination

2. Class N (Normal) –

Metric	Value	Explanation
True Positive (TP)	86.02%	Correctly predicted as N
False Negative (FN)	13.98%	Misclassified as R
False Positive (FP)	46.47%	E and R samples misclassified as N
True Negative (TN)	53.53%	Non-N correctly not predicted as N

Score	Value	Notes
Precision	0.65	TP / (TP + FP)
Recall	0.86	TP / (TP + FN)
F1 Score	0.74	High recall, moderate precision
Accuracy	~84% (est.)	Very high correct predictions
AUC (ROC)	**0.93**	Highest among all classes

3. Class R (Recovery) –

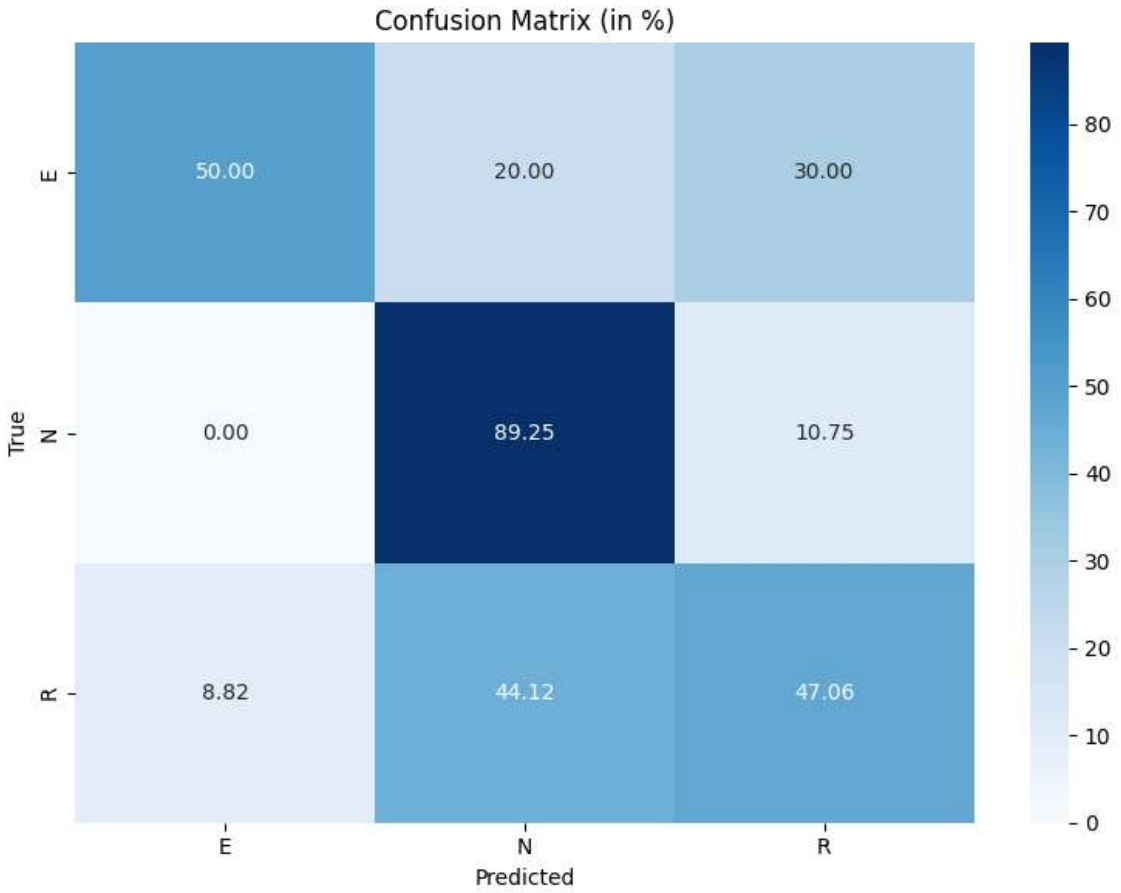
Metric	Value	Explanation
True Positive (TP)	61.76%	Correctly predicted as R
False Negative (FN)	38.24%	Misclassified as E (11.76%) or N (26.47%)
False Positive (FP)	43.98%	E and N samples misclassified as R
True Negative (TN)	56.02%	Non-R correctly not predicted as R

Score	Value	Notes
Precision	0.58	TP / (TP + FP)
Recall	0.62	TP / (TP + FN)
F1 Score	0.60	Lowest among all classes
Accuracy	~70% (est.)	Weaker separation of R class
AUC (ROC)	**0.85**	Decent, but room for improvement

Overall Summary:

Class	Precision	Recall	F1 Score	AUC	Notes
E	0.81	0.50	0.62	0.92	Needs recall improvement
N	0.65	0.86	0.74	0.93	Strongest overall
R	0.58	0.62	0.60	0.85	Needs precision boost

- **LSTM AND TRANSFORMER-**



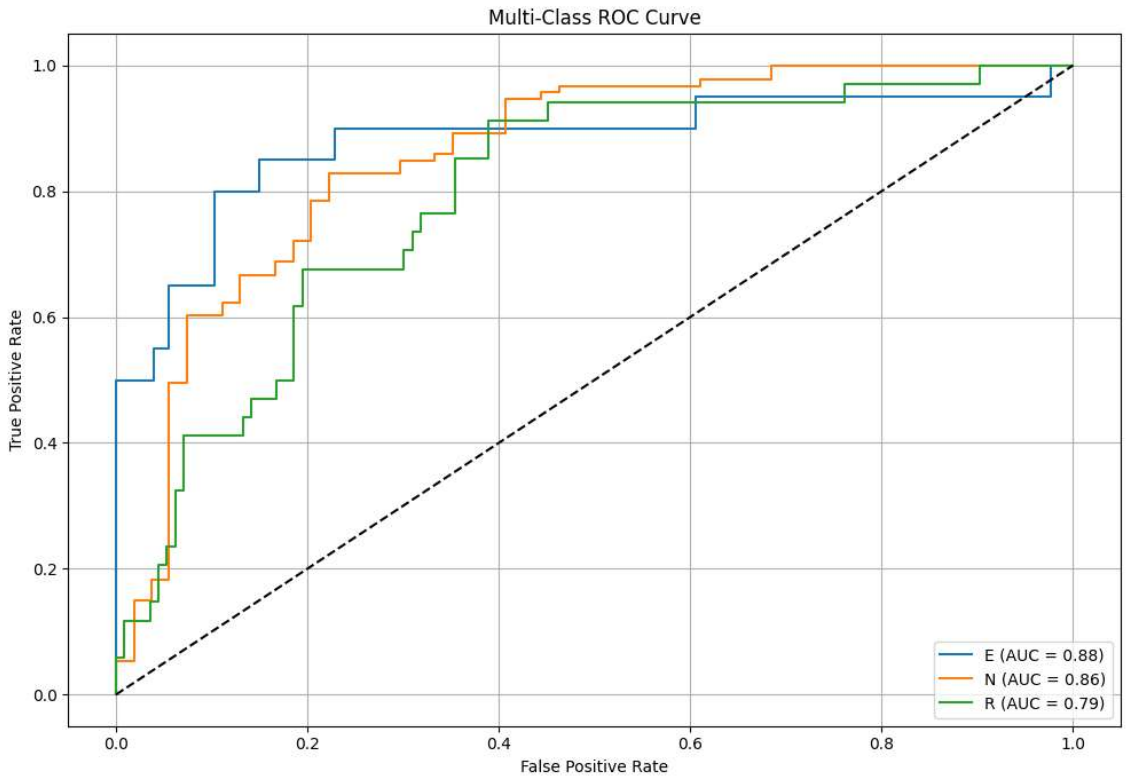
This is the confusion Matrix of CNN and LSTM models, Wherein:

1. Class E – This is Endurance class
   - ➔ True Positives = 50 % .
   - ➔ False Positives = 0%+11.76% = 8.82 %.
   - ➔ False Negatives = 20%+30% = 50 %.
   - ➔ True Negatives = 86.02% + 13.98% +26.47 + 61.76 = 180.43 %
2. Class R – This is Recovery Class
   - ➔ True Positive = 47.06%
   - ➔ False Positives = 40.75 %
   - ➔ False Negatives=11.76 + 26..47 = 52.94%.
   - ➔ True Negatives = 50%+20%+86.02%=159.25%.
3. N – This is Normal class
   - ➔ TP = 86.02%.
   - ➔ FP = 20%+26.47%=46.47%.
   - ➔ FN = 13.98%
   - ➔ TN = 50% + 30%+11.76+61.76=153.52.

Class	Precision	Recall	F1-Score	TP	FP	FN	TN
E	0.8501	0.5000	0.6273	50.00	8.82	50.00	180.43
N	0.5820	0.8925	0.7044	89.25	64.12	10.75	135.88
R	0.5357	0.4706	0.5007	47.06	40.75	52.94	159.25

Model Performance Metric table

ROC Curve –



Class: E

- Curve Colour: Blue
- AUC (Area Under Curve): 0.88
- Interpretation:
  This class has the highest AUC among all three. The classifier performs very well in distinguishing class E from the others, with a high true positive rate and a low false positive rate.

Class: N

- Curve Colour: Orange
- AUC (Area Under Curve): 0.86
- Interpretation:
  Slightly below class E, but still strong performance. The model reliably identifies class N with good accuracy and minimal false positives.

Class: R

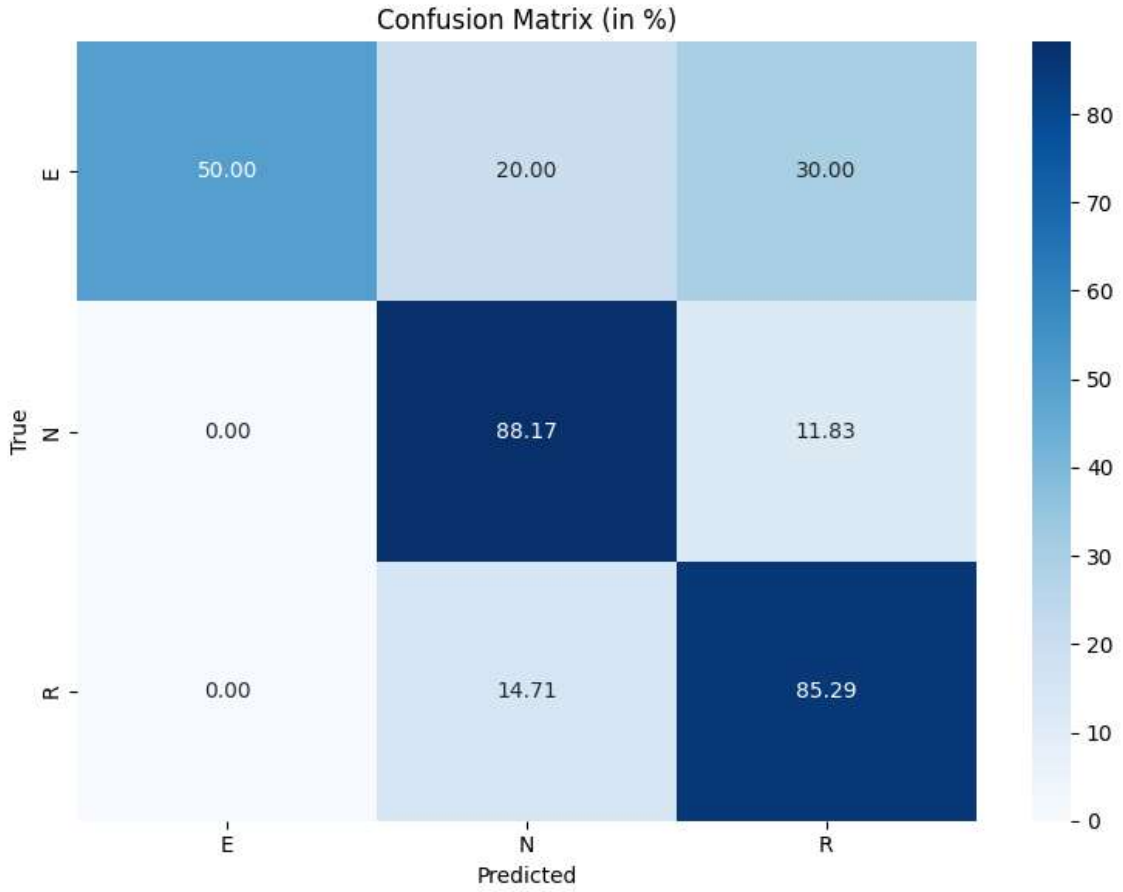
- Curve Colour: Green
- AUC (Area Under Curve): 0.79
- Interpretation:
  This is the weakest performing class of the three. While still better than random guessing, it has more overlap with other classes and a higher false positive rate.

Overall summary of ROC curve:

Class	Curve Colour	AUC (Area Under Curve)	Performance Summary
E	Blue	0.88	High accuracy; strong separation from other classes; low false positive rate.
N	Orange	0.86	Very good performance; slightly lower than class E; low false positive rate.

Class	Curve Colour	AUC (Area Under Curve)	Performance Summary
R	Green	0.79	Lower performance; higher false positive rate; room for model improvement.

- **CNN AND TRANSFORMER:**



Class E:

Metric	Value	Explanation
TP	50	Correctly predicted E as E.
FP	0	N predicted as E = 0%, R predicted as E = 0%.
FN	50	E predicted as N (20) + R (30) = 50.
TN	200	All other correct classifications (N→N, N→R, R→N, R→R).

Class N:

Metric	Value	Explanation
TP	88.17	Correctly predicted N as N.
FP	34.71	E predicted as N (20) + R predicted as N (14.71) = 34.71.
FN	11.83	N predicted as R.
TN	165.29	All others correctly not predicted as N.

Class R:

Metric	Value	Explanation
TP	85.29	Correctly predicted R as R.
FP	41.83	E predicted as R (30) + N predicted as R (11.83) = 41.83.
FN	14.71	R predicted as N.
TN	158.17	All others correctly not predicted as R.

Model Performance metric table

Class E:

Metric	**Value**
TP	50
FP	0
FN	50
TN	200
Precision	50 / (50 + 0) = **1.0**
Recall	50 / (50 + 50) = **0.5**
F1 Score	2 × (1.0 × 0.5) / (1.0 + 0.5) = **0.6667**
Accuracy	(50 + 200) / 300 = **0.8333**
Loss (Error)	1 - 0.8333 = **0.1667**

Class N:

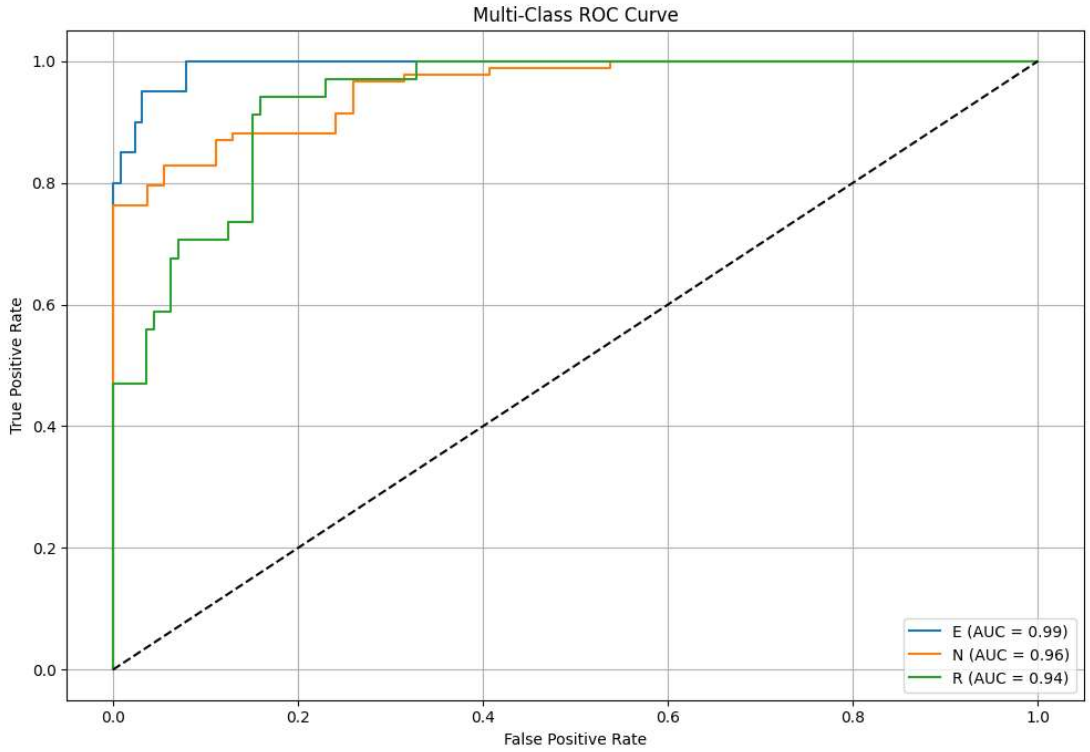
Metric	**Value**
TP	85.29
FP	41.83
FN	14.71
TN	158.17
Precision	85.29 / (85.29 + 41.83) ≈ **0.671**
Recall	85.29 / (85.29 + 14.71) ≈ **0.853**
F1 Score	2 × (0.671 × 0.853) / (0.671 + 0.853) ≈ **0.751**
Accuracy	(85.29 + 158.17) / 300 ≈ **0.811**

Metric	Value
Loss (Error)	1 - 0.811 ≈ **0.189**

Class R:

Metric	Value
TP	85.29
FP	41.83
FN	14.71
TN	158.17
Precision	85.29 / (85.29 + 41.83) ≈ **0.671**
Recall	85.29 / (85.29 + 14.71) ≈ **0.853**
F1 Score	2 × (0.671 × 0.853) / (0.671 + 0.853) ≈ **0.751**
Accuracy	(85.29 + 158.17) / 300 ≈ **0.811**
Loss (Error)	1 - 0.811 ≈ **0.189**

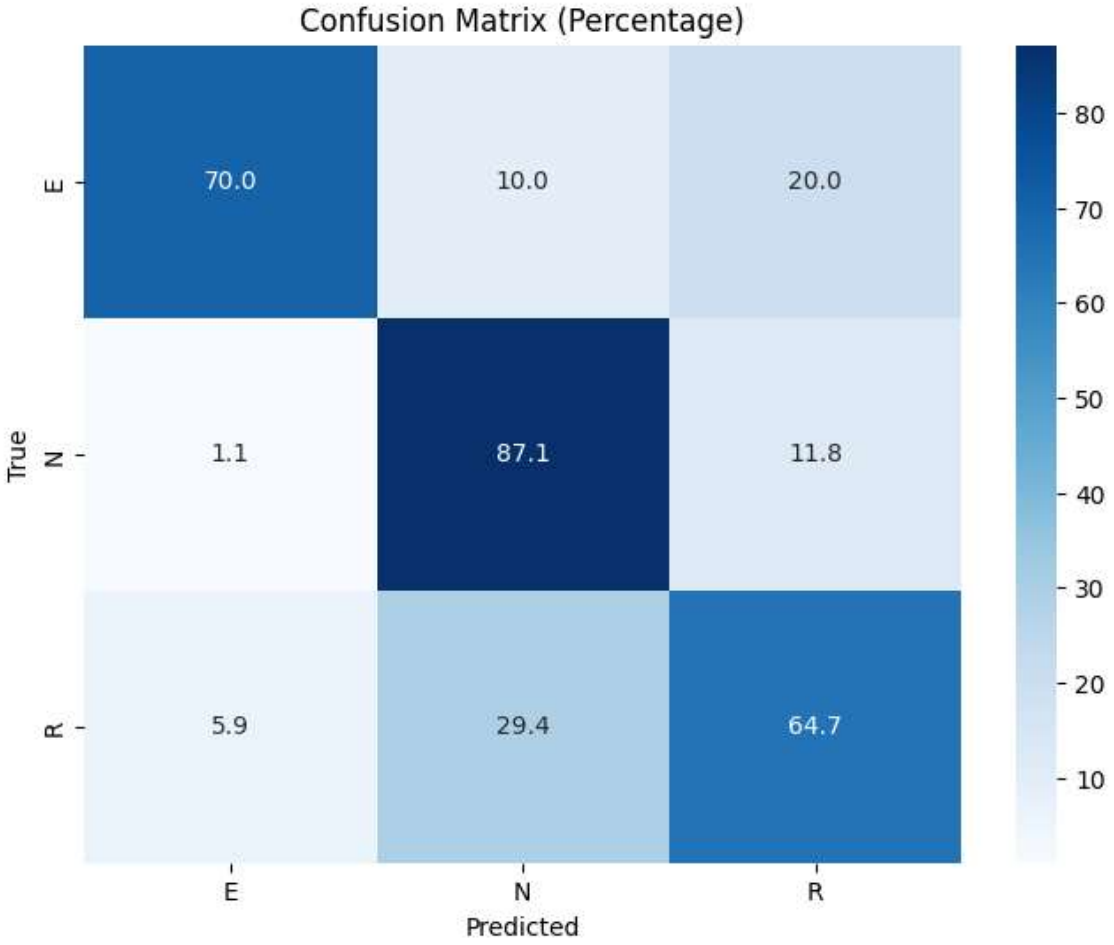
ROC Curve



Class	AUC Score	Interpretation
E	**0.99**	Excellent performance; model nearly perfectly distinguishes class E from others.
N	**0.96**	Very good performance; high distinction of class N.
R	**0.94**	Good performance; slightly lower than E and N but still strong.

Customized Model-

Confusion Matrix –



1.Class E -

Metric	Value (%)	Explanation
TP	70.0	Correctly predicted as E
FN	30.0 (10.0+20.0)	E instances misclassified as N and R
FP	7.0 (1.1 from N + 5.9 from R)	N and R misclassified as E
TN	193.0	All others correctly not predicted as E (normalized proportionally)

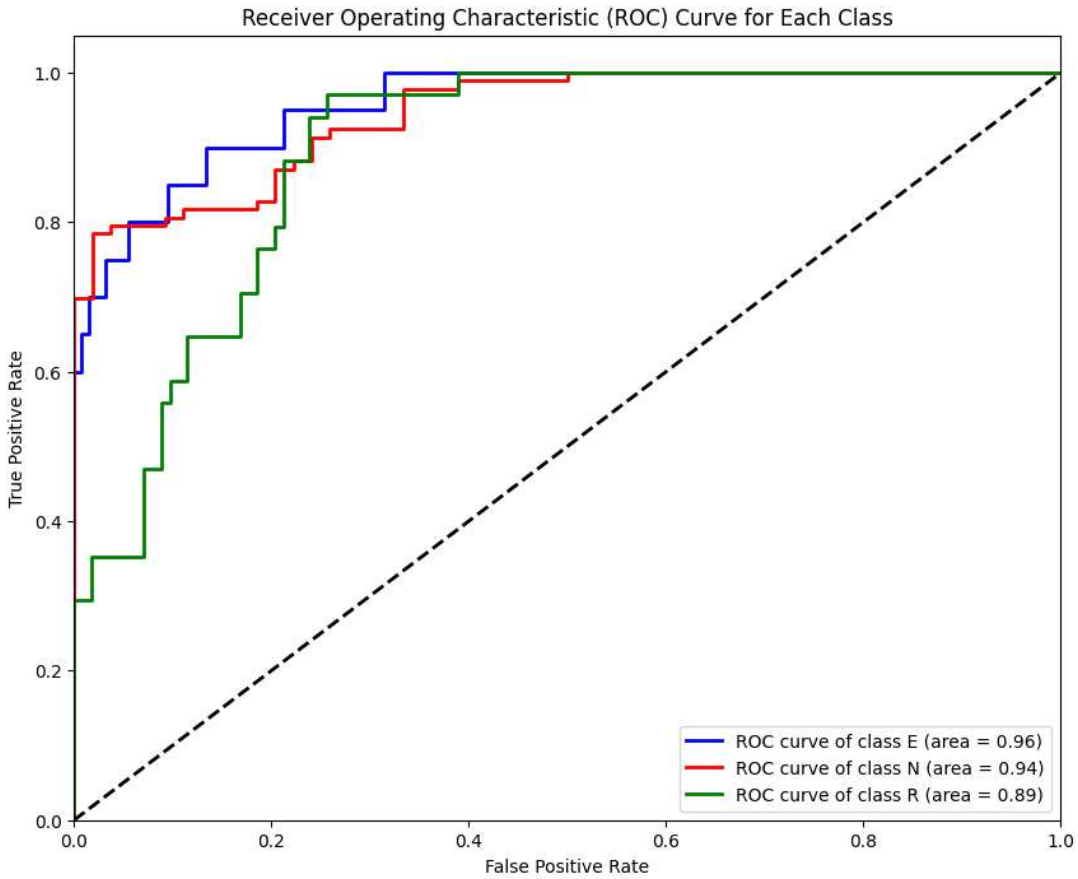
Class N-

Metric	Value (%)	Explanation
TP	87.1	Correctly predicted as N
FN	12.9 (1.1+11.8)	N misclassified as E or R
FP	39.4 (10.0 from E + 29.4 from R)	E and R predicted as N
TN	160.6	All others correctly not predicted as N

Class R-

Metric	Value (%)	Explanation
TP	64.7	Correctly predicted as R
FN	35.3 (5.9+29.4)	R misclassified as E or N
FP	31.8 (20.0 from E + 11.8 from N)	E and N misclassified as R
TN	168.2	All others correctly not predicted as R

ROC Curve-



Class	AUC (Area Under Curve)	Interpretation	Line Colour
E	0.96	Excellent discrimination ability	Blue
N	0.94	Very good performance	Red
R	0.89	Good, but relatively lower than others	Green