EEG　　　　　-

KM Shahin Bano[1,*], Prachet Bhuyan[1], Abhishek Ray[1]

[1]*School of Computer Engineering, KIIT Deemed to be University, Bhubaneswar, Odisha, India.*

*　　　: 2050014@kiit.ac.in

Abstract—　　(EEG)　　　　　　　　　　-
　　　　　　　　　　　　，
　　　　　　．EEG　　　　　　　　　，
，　　　　　　　　　　　　　　　　　　．
　　　　EEG
．EEG　　　　　　　　，　　，
．　　　　　　　　　　　　EE
G　　　　　　　　　　　　　　　(RN
N)　　　　　(GRU)　　　．　　，4
　　(TP9, AF7, AF8, TP10)　　Muse EEG
　　　　　　　．
　　　　　　　，
　　　1　　　　　　．EEG　　　2　(　　1，
1　)　　　　3　　　　　(　　，
，　　)[5]．　　　-　　　　　　EEG
．

Index Terms—　　　，EEG，　　，RNN, GRU，　，EEG
，　-　　　　(BCI), MUSE EEG-　　．
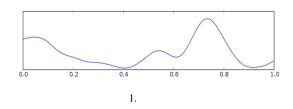
I.

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，　-
，　，
．
．

．　(EEG)
．BCI

[1].

A. Electroencephalography

(EEG)

．
．　，　，

．EEG

EEG
[3].

．

(δ)
0~4Hz　　　．　　　　　　　100
．

1.

(θ)　4~8Hz　　　　　　　　　．

．　　　　　　　　　　　　　　．

2.

(α)   8~13Hz   .
                                          .

[3].

3.

(β)
                              .

4.

(γ)   30~100
  .
                    .

5.

B. *Our Contribution*

- EEG-   (5
)   .
-
                        (RNN   GRU)
-
                                    ,

        (   ),   (   ),   (   )
                                          .

- Kaggle   EEG
    ,
          EEG
                                          .

•
                                          .

C. *Problem Definition*
   EEG   ,
                          .
                                              ,
                                      ,
                                  .   EEG

                          .

D. *Research aims*
   EEG
                          .   ,
   EEG   .

E. *Objectives*
                              ,   ,
                                      ,
                                  .

F. *Motivations*
                          EEG(   )
                                  .
                          .
                                              .
   EEG   ,   -   ,
                          .

II.

                                      ,
                          .
                                      EEG
                          .   SVM
                                      . EEG
                          .
87.53%   . [4].

                  EEG
Random Forest Approach
                                  MUSE EEG
4
              .
                                          .
94.89%   . [5].
                                          .

. DOC   ,   ,   Coma Re

covery Scale-Revised

.

. [6].

Feed Forward Neural Network   Nave Bay

es

[7].

,

.

[13].

EEG

.   ,

-

EEG

.[14].

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.   Sarlo et al.

.[15

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.[16]

.[17].   6. EEG-

.Anderson   McOwan

.[18] Ang

[19].

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III.

EEG

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GRU

. GRU

.

A. Methodology

.   EEG

,

.   EEG

,

.   6

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EEG Signal Acquisition

Collecting Raw EEG data from
EEG Muse-headband

EEG Signal Pre-processing

Sampling, filter, denoising,
changing the raw data into
a clean data set

Feature Extraction

Extracting useful information by
using Fast fourier transform

Emotion Classification

Classifying human emotion
by using RNN, GRU.

Positive, Neutral, Negative

End

EEG Muse-Headband,
4 Channels, Brainwaves

Stimuli

.

1) Signal acquisition:

. EEG

(   )

.   EEG

EEG

. [9].

2) Signal Pre-processing:

EEG

,   E

EG   . EEG

(SNR)   .

,   .

, EOG, ECG   E

MG   . EOG

EMG

[10].

3) Feature extraction: EEG

EEG   .

EEG

.

.

reset gate

h$_{t-1}$ h$_t$

x

update gate

x$_t$

8.   .

X_t t $h_t - 1$

t   . H_t

. GRU

.

7.   .   .

,   [11].

.[10].
4) Classification: .

.   .

.   EEG   .

.   . $z = \sigma(W(X_t, h_{t-1}))$

.   , $h_t,$

σ .

.

B. Recurrent Neural Networks (RNN). $r = \sigma(W(X_t, h_{t-1}))$

r   z   .

.   7   RNN   .

.   [1, t + 1]   .

.   (h_t t

$h_t - 1)$ ($H_t = \tanh\left(W(X_t, r * h_{t-1})\right)$

O_t t $h_t)$ t

.Tanh   -1   1 H_t , X_t

.   , r   , z

RNN   [11].   , W   .

$$h_t = (1 - z) * h_{t-1} + z * H_t$$

C. Gated Recurrent Units (GRU).

GRU   LSTM h_t

EEG   . LSTM   GRU   . h_t

. GRU   8   . [11].

(h_t) $(x_t$ $h_t - 1)$

. h_t t   , $h_t - 1$ IV.

t   t   , x_t t

.   .   .

$X_t, h_{t-1} \rightarrow h_t$ 30/70

70%,   30%

GRU   . LSTM   R   . Adam

NN   GRU   .   ,

.   .

Classifier	Train test split	
	70-30	80-20
GRU	96.71%	95.78%
RNN	53.59%	49.53%

9.

confusion Matrix

10. GRU
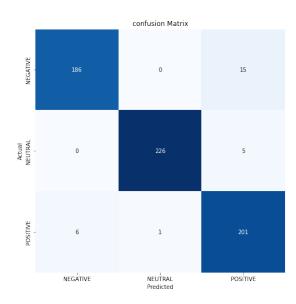
20%, 32 , 50 (
) x y
. 9 . 30/70
GRU 96.71%, RNN 53.59%
. 20/80 GRU 95.78%
, RNN 49.53% .

. 10 , 192 ,
186 , 6
.
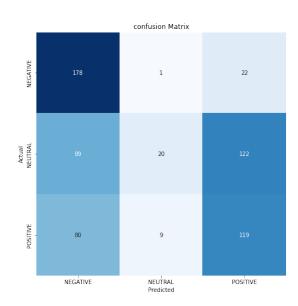
A. Model validation using confusion matrix

EEG , ,
, F- ,
(10
, 11
).

. 12 13

$$Accuracy = (TP + TN)/(TP + TN + FP + FN)$$

$$Precision = TP/(TP + FP)$$

$$Recall = TP/(TP + FN)$$

$$F - score = 2 * TP/(2 * TP * FP * FN)$$

$$ErrorRate = 1 - Accuracy$$

, ,
.
,
.

confusion Matrix

11. RNN

B. Discussion

6
. (RNN GRU)
. 4
, MUSE EEG
. 6
(1 , 1 , 20~22) 60
, 12
[5]. 36 EEG
, 6
.
,

Classification Report:

	precision	recall	f1-score	support
NEGATIVE	0.97	0.93	0.95	201
NEUTRAL	1.00	0.98	0.99	231
POSITIVE	0.91	0.97	0.94	208
accuracy			0.96	640
macro avg	0.96	0.96	0.96	640
weighted avg	0.96	0.96	0.96	640

12. GRU

Classification Report:

	precision	recall	f1-score	support
NEGATIVE	0.77	0.90	0.83	201
NEUTRAL	0.55	0.08	0.14	231
POSITIVE	0.39	0.69	0.50	208
accuracy			0.54	640
macro avg	0.57	0.56	0.49	640
weighted avg	0.56	0.54	0.47	640

13. RNN

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.   ,

.

3   .

V.

RNN   GRU

(EEG)

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. EEG

. EEG

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.

. EEG

. EEG

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