Enhance Feature Representation of Electroencephalogram for Seizure Detection

Danyang Wang, Yuchun Fang*, Yifan Li

Changfeng Chai

School of Computer Engineering and Science Shanghai University, China ycfang@shu.edu.cn

Changhai Hospital Shanghai, China chaicf0206@126.com



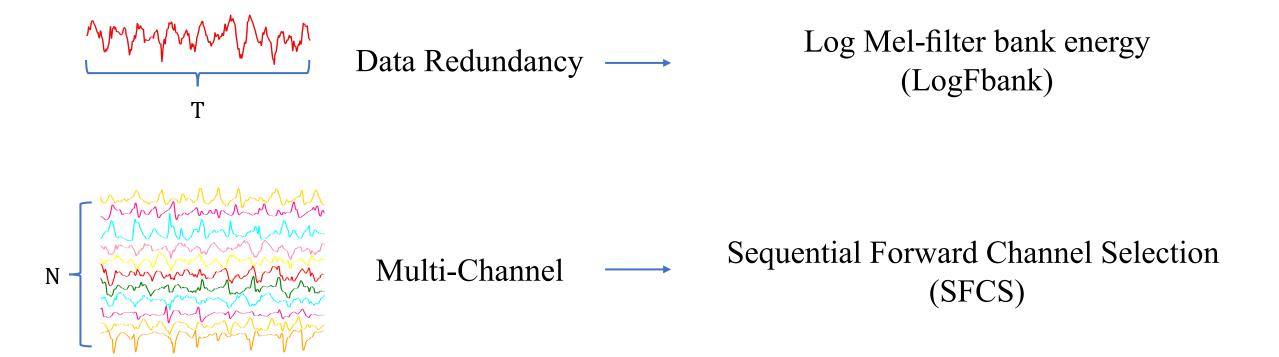


Background

- Epilepsy affects over 65 million individuals, nearly 1% of the global population
- Seizure detection is necessary for those patients who cannot be cured through surgery and medicine
- EEG data is a kind of important signal.

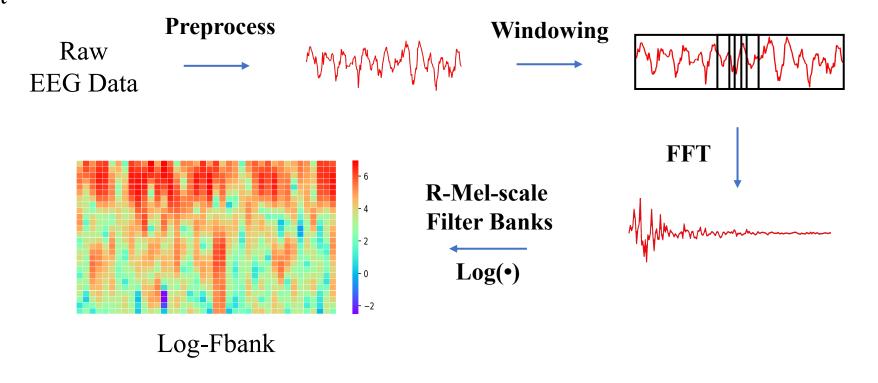
How to enhance feature representation of EEG for seizure detection?

Challenges & Solutions



Log Mel-filter bank energy

- MFCC
- Frequency analysis
- More discriminative
- Robust

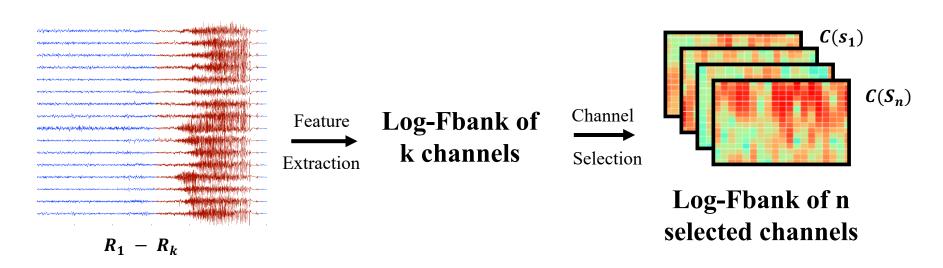


Sequential Forward Channel Selection

- a. Initialize $C = \{c_1, c_2, \dots, c_k\}, S = \emptyset$
- b. For all the channels in remainder subset $c_t \in (C S)$, compute $J(c_t)$
- c. Choose the maximum value of $J(c_t)$, denote as $J(c_{t_m})$. And computer $J(S \cup c_{t_m})$. If the result of $J(S \cup c_{t_m})$ is the best, recording the corresponding channel c_{t_m} , set $S = S \cup c_{t_m}$. If $(C S) = \emptyset$, stop, otherwise turn to Step b.

Criterion function as J

d. Output the target channel set.



Experiments

Table 2. Summary of results. Channel Set 1 is selected by SFCS and Channel Set 2 is top 3 channels by SFCS.

| | proposed method | | | | Truc | Hills [11] | | |
|--------------|--|---|---|--|--|--|---|---|
| Full Channel | Channel Set 1 | | Channel Set 2 | | Full Channel | Channel | Set | Full Channel |
| 98.67 | (10) | 98.78 | (10) | 98.78 | 98.44 | (4, 10, 12) | 98.78 | 99.63 |
| 99.56 | (6,7,8,12) | 100.00 | (8,12) | 99.77 | 96.30 | (1, 9, 12) | 98.92 | 96.86 |
| 98.16 | (1,2,3,4,6,7,8,10,11,13,14) | 98.18 | (3,7,8) | 96.02 | 98.88 | (7, 13, 14) | 95.45 | 98.47 |
| 100.00 | (1,7,12,16) | 100.00 | (7,12,16) | 99.74 | 94.26 | (7, 8, 15) | 99.05 | 99.61 |
| 98.54 | (19, 56) | 100.00 | (19,56) | 100.00 | 93.49 | (19, 27, 30) | 97.50 | 99.32 |
| 94.95 | (1, 6, 8, 9, 14) | 95.96 | (1,6,8) | 95.23 | 98.72 | (1, 2, 3) | 94.60 | 99.73 |
| 99.92 | (5,6,13,45,55) | 99.94 | (6,45,55) | 99.64 | 94.68 | (5, 6, 26) | 98.29 | 95.01 |
| 100.00 | (2) | 100.00 | (2) | 100.00 | 100.00 | (37, 45, 66) | 100.00 | 67.50 |
| 96.94 | (1,2,15,17) | 99.43 | (1,2,17) | 98.42 | 83.83 | (9, 18, 25) | 93.05 | 96.75 |
| 98.64 | (16,17,24) | 99.82 | (16,17,24) | 99.82 | 99.61 | (15, 23, 24) | 99.27 | 99.86 |
| 98.91 | (26,27,28,30,31,32,33) | 99.23 | (27,30,31) | 98.14 | 94.24 | (26, 28, 36) | 99.06 | 99.99 |
| 96.37 | (11,13) | 98.25 | (11,13) | 98.25 | 97.71 | (3, 10, 11) | 96.52 | 98.15 |
| 98.39 | | 99.13 | | 98.65 | 95.85 | | 97.54 | 95.91 |
| | 98.67 99.56 98.16 100.00 98.54 94.95 99.92 100.00 96.94 98.64 98.91 96.37 | 98.67 (10) 99.56 (6,7,8,12) 98.16 (1,2,3,4,6,7,8,10,11,13,14) 100.00 (1,7,12,16) 98.54 (19, 56) 94.95 (1, 6, 8, 9, 14) 99.92 (5,6,13,45,55) 100.00 (2) 96.94 (1,2,15,17) 98.64 (16,17,24) 98.91 (26,27,28,30,31,32,33) 96.37 (11,13) | 98.67 (10) 98.78 99.56 (6,7,8,12) 100.00 98.16 (1,2,3,4,6,7,8,10,11,13,14) 98.18 100.00 (1,7,12,16) 100.00 98.54 (19,56) 100.00 94.95 (1,6,8,9,14) 95.96 99.92 (5,6,13,45,55) 99.94 100.00 (2) 100.00 96.94 (1,2,15,17) 99.43 98.64 (16,17,24) 99.82 98.91 (26,27,28,30,31,32,33) 99.23 96.37 (11,13) 98.25 | 98.67 (10) 98.78 (10) 99.56 (6,7,8,12) 100.00 (8,12) 98.16 (1,2,3,4,6,7,8,10,11,13,14) 98.18 (3,7,8) 100.00 (1,7,12,16) 100.00 (7,12,16) 98.54 (19,56) 100.00 (19,56) 94.95 (1,6,8,9,14) 95.96 (1,6,8) 99.92 (5,6,13,45,55) 99.94 (6,45,55) 100.00 (2) 100.00 (2) 96.94 (1,2,15,17) 99.43 (1,2,17) 98.64 (16,17,24) 99.82 (16,17,24) 98.91 (26,27,28,30,31,32,33) 99.23 (27,30,31) 96.37 (11,13) 98.25 (11,13) | 98.67 (10) 98.78 (10) 98.78 99.56 (6,7,8,12) 100.00 (8,12) 99.77 98.16 (1,2,3,4,6,7,8,10,11,13,14) 98.18 (3,7,8) 96.02 100.00 (1,7,12,16) 100.00 (7,12,16) 99.74 98.54 (19,56) 100.00 (19,56) 100.00 94.95 (1,6,8,9,14) 95.96 (1,6,8) 95.23 99.92 (5,6,13,45,55) 99.94 (6,45,55) 99.64 100.00 (2) 100.00 (2) 100.00 96.94 (1,2,15,17) 99.43 (1,2,17) 98.42 98.64 (16,17,24) 99.82 (16,17,24) 99.82 98.91 (26,27,28,30,31,32,33) 99.23 (27,30,31) 98.14 96.37 (11,13) 98.25 (11,13) 98.25 | 98.67 (10) 98.78 (10) 98.78 98.44 99.56 (6,7,8,12) 100.00 (8,12) 99.77 96.30 98.16 (1,2,3,4,6,7,8,10,11,13,14) 98.18 (3,7,8) 96.02 98.88 100.00 (1,7,12,16) 100.00 (7,12,16) 99.74 94.26 98.54 (19,56) 100.00 (19,56) 100.00 93.49 94.95 (1,6,8,9,14) 95.96 (1,6,8) 95.23 98.72 99.92 (5,6,13,45,55) 99.94 (6,45,55) 99.64 94.68 100.00 (2) 100.00 100.00 100.00 100.00 96.94 (1,2,15,17) 99.43 (1,2,17) 98.42 83.83 98.64 (16,17,24) 99.82 (16,17,24) 99.82 99.61 98.91 (26,27,28,30,31,32,33) 99.23 (27,30,31) 98.14 94.24 96.37 (11,13) 98.25 (11,13) 98.25 97.71 | 98.67 (10) 98.78 (10) 98.78 98.44 (4, 10, 12) 99.56 (6,7,8,12) 100.00 (8,12) 99.77 96.30 (1, 9, 12) 98.16 (1,2,3,4,6,7,8,10,11,13,14) 98.18 (3,7,8) 96.02 98.88 (7, 13, 14) 100.00 (1,7,12,16) 100.00 (7,12,16) 99.74 94.26 (7, 8, 15) 98.54 (19, 56) 100.00 (19,56) 100.00 93.49 (19, 27, 30) 94.95 (1, 6, 8, 9, 14) 95.96 (1,6,8) 95.23 98.72 (1, 2, 3) 99.92 (5,6,13,45,55) 99.94 (6,45,55) 99.64 94.68 (5, 6, 26) 100.00 (2) 100.00 (2) 100.00 (37, 45, 66) 96.94 (1,2,15,17) 99.43 (1,2,17) 98.42 83.83 (9, 18, 25) 98.64 (16,17,24) 99.82 (16,17,24) 99.82 99.61 (15, 23, 24) 98.91 (26,27,28,30,31,32,33) 99.23 (27,30,31) | 98.67 (10) 98.78 (10) 98.78 99.56 (6,7,8,12) 100.00 (8,12) 99.77 96.30 (1,9,12) 98.92 98.16 (1,2,3,4,6,7,8,10,11,13,14) 98.18 (3,7,8) 96.02 98.88 (7,13,14) 95.45 100.00 (1,7,12,16) 100.00 (7,12,16) 99.74 94.26 (7,8,15) 99.05 98.54 (19,56) 100.00 (19,56) 100.00 93.49 (19,27,30) 97.50 94.95 (1,6,8,9,14) 95.96 (1,6,8) 95.23 98.72 (1,2,3) 94.60 99.92 (5,6,13,45,55) 99.94 (6,45,55) 99.64 94.68 (5,6,26) 98.29 100.00 (2) 100.00 100.00 (37,45,66) 100.00 96.94 (1,2,15,17) 99.43 (1,2,17) 98.42 83.83 (9,18,25) 93.05 98.91 (26,27,28,30,31,32,33) 99.23 (27,30,31) 98.14 94.24 (26,28,36) 99.06 |

Experiments

Table 2. Summary of results. Channel Set 1 is selected by SFCS and Channel Set 2 is top 5 channels by SFCS.

| | proposed method | | | | Truong et al | | [10] | | Hills [1] | |
|----------|-----------------|-----------------------------|--------|------------|--------------|--------------|-----------|----------|-----------|---------------------|
| Subject | Full Channel | Channel Set 1 | | Channel | Set 2 | Full Channel | C | hannel S | et | Full Channel |
| Dog1 | 98.67 | (10) | 98.78 | (10) | 98.78 | 98.44 | (4, 10, | 12) | 98.78 | 9).63 |
| Dog2 | 99.56 | (6,7,8,12) | 100.00 | (8,12) | 99.77 | 96.30 | (1, 9, 1) | 2) | 98.92 | 9 <mark>6.86</mark> |
| Dog3 | 98.16 | (1,2,3,4,6,7,8,10,11,13,14) | 98.18 | (3,7,8) | 96.02 | 98.88 | (7, 13, | 14) | 95.45 | 9 <mark>8.47</mark> |
| Dog4 | 100.00 | (1,7,12,16) | 100.00 | (7,12,16) | 99.74 | 94.26 | (7, 8, | 5) | 99.05 | 9 <mark>9.61</mark> |
| Patient1 | 98.54 | (19, 56) | 100.00 | (19,56) | 100.00 | 93.49 | (19, 2' | , 30) | 97.50 | 9.32 |
| Patient2 | 94.95 | (1, 6, 8, 9, 14) | 95.96 | (1,6,8) | 95.23 | 98.72 | (1, 2, 1) |) | 94.60 | 9 <mark>).73</mark> |
| Patient3 | 99.92 | (5,6,13,45,55) | 99.94 | (6,45,55) | 99.64 | 94.68 | (5, 6, 2) | 6) | 98.29 | 9 5.01 |
| Patient4 | 100.00 | (2) | 100.00 | (2) | 100.00 | 100.00 | (37, 4: | , 66) | .00.00 | 6 7.50 |
| Patient5 | 96.94 | (1,2,15,17) | 99.43 | (1,2,17) | 98.42 | 83.83 | (9, 18, | 25) | 93.05 | 9 <mark>6.75</mark> |
| Patient6 | 98.64 | (16,17,24) | 99.82 | (16,17,24) | 99.82 | 99.61 | (15, 2: | , 24) | 99.27 | 9.86 |
| Patient7 | 98.91 | (26,27,28,30,31,32,33) | 99.23 | (27,30,31) | 98.14 | 94.24 | (26, 2 | , 36) | 99.06 | 9 <mark>).99</mark> |
| Patient8 | 96.37 | (11,13) | 98.25 | (11,13) | 98.25 | 97.71 | (3, 10, | 11) | 96.52 | 98.15 |
| Average | 98.39 | | 99.13 | | 98.65 | 95.85 | | | 97.54 | 95.91 |
| | | | | | | | | | | |

Conclusions

- Propose the frequency domain feature LogFbank
- Propose SFCS for automatic channel selection

Thanks!