An Iterative Method for Stroke Patients’ EEG Data Analysis

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Motor Functional Rehabilitation Paradigm

Training Model

Rehabilitation

Evaluation

BCI Task with FES

Visualization

Tagged Video

Analysis

Post Model
BCI-FES Rehabilitation Training

Three procedures:

1. Prior training offline:
   The first session data is used for training a prior model;

2. Training and rehabilitation tasks;
   With FES stimulations;

3. Post training for assessment.
Positions of the 19 selected channels. The two post-ear ones (marked blue in the figure) are averaged as the reference lead.

Positions of the 19 channels
Yellow —— ground
Blue —— reference
Data Acquisition

A Session

15-16 Trials

A Trial

4 S

2 S

Interval

A Trial

4 S

2 S

Trials...

total 25 sliding windows per trial
Prior - training

- Easy: 2-class motor imagery;
- Difficult: 3-class motor imagery;
- The motor imagery EEG data of the first prior session will be used for training a prior-model offline.
- In most cases, we will not insert FES stimulations in this session.
Prior - training

Two-class prior-training task

Trial Accuracy  

Sliding Time Window Accuracy

Artifacts Indication

Start  
Pause  
Stop
Rehabilitation tasks

- Subjects are asked to finish some motor imagery based games like balancing a beam or lifting balloons appeared randomly in the left or right part of the screen;
- FES is triggered and stimulates subjects’ muscles under an appreciate current when they get stuck, which causes real movement of their hands or arms;
BCI Rehabilitation Tasks

Basic

Daily Life

Cognition

Challenge

Complex

Score: 0
Time: 23.0s
BCI Rehabilitation Tasks

- Combinations of FES Stimulations and Mental Practice/Mental Imagery;
- The imagination-stimulation process reconstructs the neuroncircuit between paralysis limbs and corresponding pathological brain area of the subject and takes effects in the rehabilitation treatment.
- Multimodal stimulations like sight, auditory sense and touch sense could be inserted.
Post – training process

- A post-training session with 16 trials is finished for rehabilitation efficacy assessment;
- No FES stimulation;
Data Analysis Methods

Key Problems:

- Accuracy
- Mechanism
General CSP

Problems

1. Mix regular motor imagery signals with unexpected noise such as failed, missed or mistaken imagery caused by injuries on corresponding brain areas and mental maladjustments;
2. General CSP may detect a wrong orientation when applied directly on this kind of datasets under the interference of irregular patterns;
3. Features with low discrimination are put into SVM/LDA classifiers, which leads to poor classification accuracy.
Iterative CSP

Motivation

I. Two models:

1. Left Model: classify left and non-left;
2. Right Model: classify right and non-right.

II. Three parts of Stroke patients’ EEG data:

1. Pure part(75%): right motor imagery;
2. Chaotic part(15%~20%): miss/mixed ones;
3. Wrong part(5%~10%): wrong motor imagery.
Iterative CSP

Example (Left ones)

- Pure left imagery
- Chaotic mental states
- Wrong Imagery

Left motor imagery
Iterative CSP

Iteration process

- Pure left imagery
- Chaotic states
- Wrong imagery

$L_2$

- session data
  - $L_1/L_2$
  - $R_1/R_2$

- After rejection
- No changes

- Train

$L_2$
$R_1$

- right
- Non-right
- Non-right

- data being classified as right will be rejected

- leftmodel
Iterative CSP

\section*{Results}
1. Improve the classification accuracy for almost 10\% compared to general CSP;
2. In most cases, the iteration will converge, maintaining a relatively pure subset.

\section*{Problems}
1. Very sensitive to the original dataset (initialization);
2. Depend on a LARGE scale of EEG data for iteration.
Results

- Seven stroke patients from Zhejiang Taizhou Hospital participate in our study;
- Four of them remain well after 2 months’ training while no significant recovery appearances are discovered on the other 3 patients;
- We surmise that these 3 subjects may have missed the best rehabilitation period because all of them have suffered stroke for no less than 8 months;

<table>
<thead>
<tr>
<th>Subject</th>
<th>Age</th>
<th>Sex</th>
<th>Pathgenesis</th>
<th>1st week</th>
<th>2nd week</th>
<th>4th week</th>
<th>6th week</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>65</td>
<td>female</td>
<td>cortex injury</td>
<td>0.54</td>
<td>0.59</td>
<td>0.62</td>
<td>0.72</td>
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<tr>
<td>2</td>
<td>71</td>
<td>male</td>
<td>basal ganglia injury</td>
<td>0.47</td>
<td>0.61</td>
<td>0.68</td>
<td>0.79</td>
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<td>3</td>
<td>62</td>
<td>female</td>
<td>basal ganglia injury</td>
<td>0.52</td>
<td>0.63</td>
<td>0.62</td>
<td>0.66</td>
</tr>
</tbody>
</table>
Results

Subject 1

Subject 2

Subject 3

Accuracy (%)

Week
Rehabilitation effects

- A control group with another 3 stroke patients is observed and recorded during the experiment.
- The group is trained with ordinary medical treatments for 2 months;
- Compared with the experiment group, the clinical rehabilitation parameters of the control group is much lower after post assessment;
ERSP of Day 5 and Day 48

C3 ERSP when thinking right of day 5

C3 ERSP when thinking right of day 48
Thank you!