Ming-hui SHI, Chang-le ZHOU, Jun XIE, et al., 2018. Electroencephalogram-based brain-computer interface for the Chinese spelling system: a survey. *Frontiers of Information Technology & Electronic Engineering*, 19(3):423-436. https://doi.org/10.1631/FITEE.1601509

Electroencephalogram-based brain-computer interface for the Chinese spelling system: a survey

Front Inform Technol Electron Eng

Key words: Brain computer interface (BCI); Electroencephalography (EEG); Chinese speller; English speller

Corresponding author: Fei CHAO
E-mail: fchao@xmu.edu.cn

ORCID: Fei CHAO, http://orcid.org/0000-0002-6928-2638

Motivation

1. Although the EEG-based English speller (EEGES) has been studied widely in recent years, very little research has focused on the EEG-based Chinese speller (EEGCS).

2. The EEGCS is more difficult to develop than the EEGES, because the English alphabet contains only 26 letters, by contrast, Chinese contains more than 11 000 logographic characters.

Front Inform Technol Electron Eng

Goal

The goal of this paper is to survey the available literature on EEGCS systems:

1. to provide a guideline for novices who want to study EEGCS;

2. to provide a good reference for those who are interested in EEG-based English Spellers (EEGESs).

Front Inform Technol Electron Eng

Content

1. A taxonomy of current EEGCS systems is discussed to obtain the gist of the paper.

2. A common framework, unifying the current EEGCS and EEGES systems, is proposed, in which the concept of EEG-based choice acts as a core component.

3. A variety of current EEGCS systems are investigated and discussed to highlight the advancements, current problems, and future directions for EEGCS.

Front Inform Technol Electron Eng

Taxonomy of EEG-based Chinese Spellers

1. **Shape-based methods** :
   (1) stroke-based methods;
   (2) segment-based methods.

2. **Pronunciation-based methods**
   (1) Pinyin-based methods;
   (2) Zhuyin-based methods.

Front Inform Technol Electron Eng

Procedure of EEG-based Choice

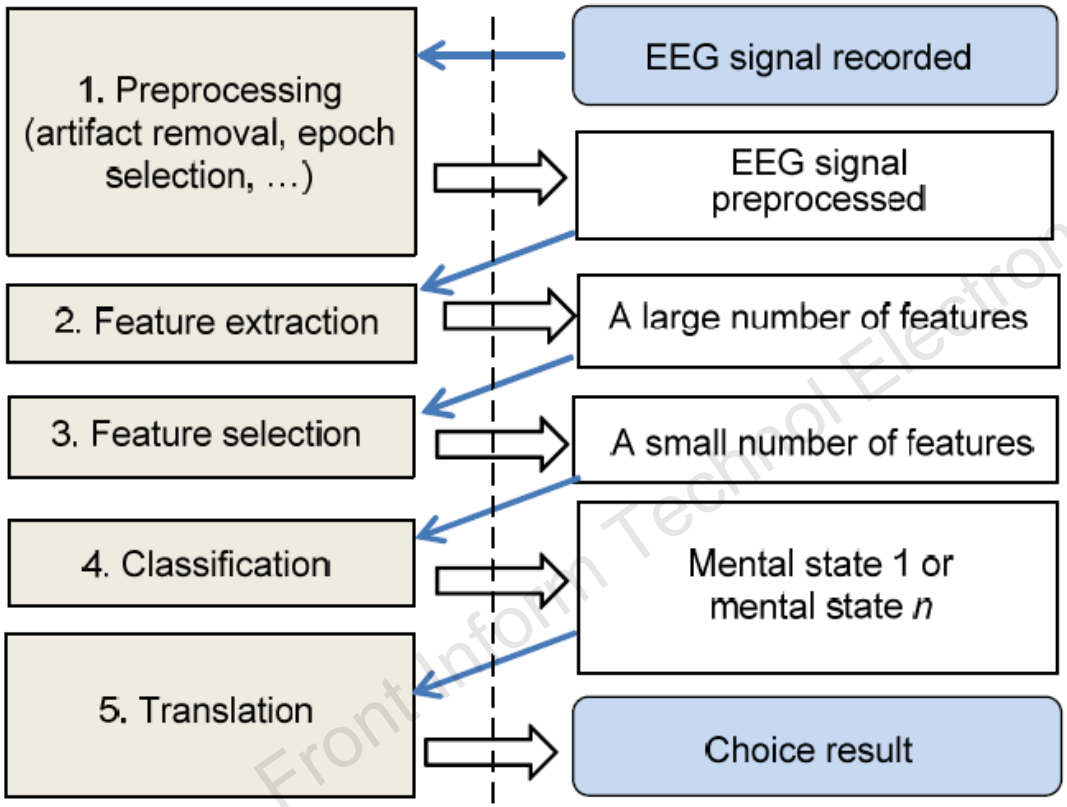


Fig. 2 Procedure of EEG-based choice

On the left side of the dotted line are five consecutive steps; on the right side are the corresponding results.

Framework of the EEG-based spelling system

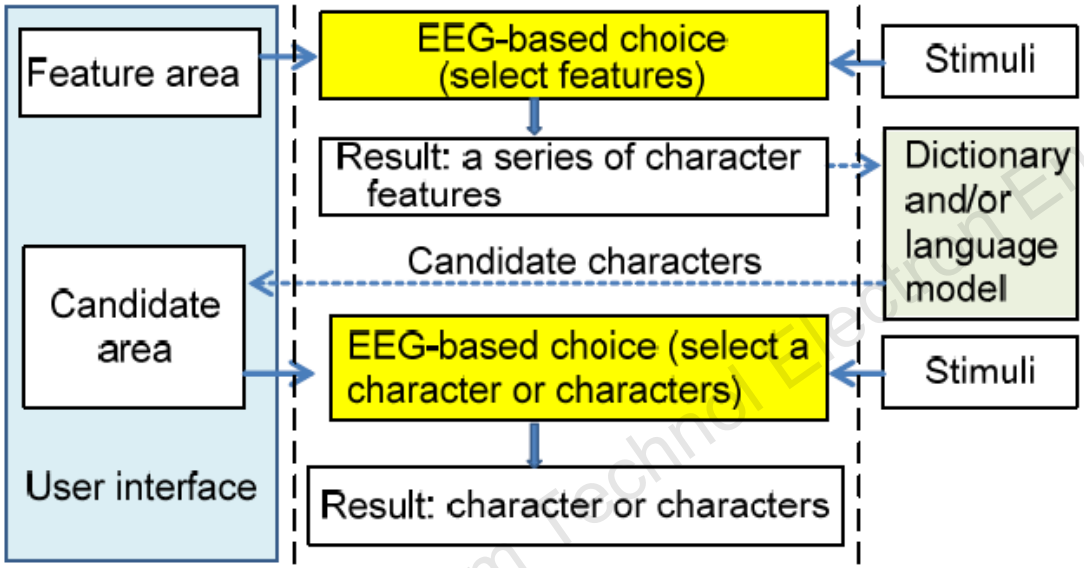


Fig. 3 Framework of the EEG-based spelling system

The framework is divided into three parts by two vertical dashed lines: user interface area (left), EEG-based choice area (center), and auxiliary area (right)

Using the two vertical dotted lines, the framework shows three parts: user interface area (left); EEG-based choice area (center); and auxiliary area (right). In the center part, there are the two phases of the EEG-based choice, one is for features, the other for characters.

Applications in each category

Table 2 Applications in each class (optimized by PSO)

Type	Year	Number of subjects	Component	Number of electrodes	Filter (Hz)	Time interval (ms)	Classifier	Accuracy (%)	Speed	Reference
Stroke	2009	4	P300	4	–	200–600	Template	38–84	1.23–8.80 bits/min	Wu et al., 2009
	2010	11	P300	Optimized by PSO	0.1–12	0–500	BLDA	38.7–93.0	–	Jin et al., 2010
	2012	2	SSVEP	1	4–30	2000	Threshold	65–72	–	Zhao, 2012
Segment	2010	30	P300	5	0–40	−100–400	FLDA	>80	14.5 bits/min	Minett et al., 2010
	2012	24	P300	32	0.1–40	800	FLDA	63.5–82.8	12.93 bits/min	Minett et al., 2012
	2013	1	P300 +N200	1	0–6	–	N2P3	95.8	136.6 bits/min	Huang et al., 2013
Pinyin	2015	4	P300	19	1–15	0–700	SVM	–	1.13 sino-grams/min	Xu and Fang, 2015
	2013	3	MI	13	5–30	–	SVM	96.33	30.86 bits/min, 5.53 letters/min	Chen et al., 2013

Front Inform Technol Electron Eng

Discussions

1. The methods for constructing EEGCS systems include shape-based methods and pronunciation-based methods, which are mutually complementary. Shape-based methods do not require users to know the pronunciations of Chinese characters, whereas pronunciation-based methods do not require users to know the form of Chinese characters.

2. Among the shape-based methods, segment-based methods are more efficient than the stroke-based methods, because segment-based methods can input several strokes as one segment with each EEG-based choice.

3. Among the pronunciation-based methods, both Pinyin-based and Zhuyin-based methods are useful and mutually complementary, because Pinyin was adopted in mainland China while Zhuyin was adopted in Taiwan.

Front Inform Technol Electron Eng

Discussions (Con.)

1. P300, N200, SSVEP, and MI have been used to develop EEGCS systems already. Among such systems, the most frequently used method is P300.

2. Researchers have realized the necessity and the possibility of employing hybrid components.

3. Different classification algorithms, such as FLDA, BLDA, SVM, and template-matching methods have already been employed, and the issue of electrode selection or channel selection has also been investigated.

Front Inform Technol Electron Eng

Discussions (Con.)

4. Components except the P300 have not been investigated as thoroughly as in the EEGES research.

2. Target users and the evaluation metric of systems are worthy of mention for consideration in further research.

3. Many assistant technologies, which do not depend on EEG-based choices, may be independently developed and improve greatly the system performance.

4. Many novel technologies, such as channel selection for preprocessing, ensemble classifiers for enhancing classification accuracy, and language models for improving, etc., have been employed efficiently in the EEGES systems.

Front Inform Technol Electron Eng

Conclusions

1. We reviewed most of the current literatures on EEGCS systems. A common framework to unify the current EEGCS and EEGES systems is proposed, followed by a presentation and discussion of the state-of-the-art work in EEGCS systems.

2. When developing EEGCS systems, the intrinsic difference between EEGCS and EEGES systems means that more issues should be considered than simply developing EEGES systems.

3. Many methods, such as other paradigms and EEG signal processing methods, which have been employed by the current EEGES systems, could be very useful for developing EEGCS systems.

4. Research on EEGCS systems is a promising field with potential for rapid development in the coming years.

Front. Inform. Technol. Electron. Eng.