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種別(和文)	論文要旨
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（博士課程）
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論 文 要 旨
THESIS SUMMARY

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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Electroencephalography (EEG) based emotion recognition enables computers to understand human emotions, which is a prosperous topic in the affective Brain-Computer Interface (a-BCI). Previous studies in EEG emotion recognition were sensory-dependent, the cross-sensory EEG emotion recognition under multimodal stimulation could not be achieved. However, human can perceive emotion using cross-sensory information. Since EEG is subjected to change from both sensory and emotion, sensory patterns and emotion patterns are not clear from EEG under multimodal stimulation by far. There was a lack of systematic study for cross-sensory EEG emotion recognition under multimodal stimulation. To address this challenge, in this study, the purpose was investigating and achieved cross-sensory EEG emotion recognition under multimodal stimulation as video. This thesis consisted of five chapters to investigate and solve cross-sensory EEG emotion recognition under multimodal stimulation.

In Chapter 1, this study had an in-depth investigation of the research background related to cross-sensory EEG emotion recognition under multimodal stimulation, the research issues involved in emotion recognition and previous study, a discussion of the EEG-based a-BCI system, as well as the purpose and research methods and strategies of this study.

In Chapter 2, studied the basic EEG fundamentals of emotion EEG analysis under multimodal emotion stimulation. A multimodal emotion stimulation experiment based on audio-visual (video) was designed and implemented with six experimental conditions in total through two types of emotion (pleasure/unpleasure) and three types of sensory (audio/visual/audio-visual). In Chapter 2, for the first time, a comparative study of emotion and sensory, two factors that affect cross-sensory emotion recognition, was conducted in emotion EEG analysis under multimodal stimulation. By using power spectral density (PSD)

based analysis, combined with brain functional area analysis and sub-band analysis, it comprehensively and systematically explored the relative emotion-related changes and sensory patterns of emotion pattern and sensory pattern under six experimental conditions. In this chapter, this study reveals for the first time the comparative feature analysis of spectral, spatial and quantitative characteristics of emotion and sensory-related patterns in emotion EEG analysis under multimodal emotion stimulation. In detail, as spatial features, emotion-related changes exhibited greater diversity in regional changes of the brain. As spectral features, emotion-related changes exhibited greater diversity in sub-bands of EEG. As quantitative features, sensory-related changes exhibited greater spectral impact quantitatively than emotion. Sensory and emotion analytic results brought EEG understanding for cross-sensory emotion perception. At the same time, the feature analysis in Chapter 2 also provides strong support for the subsequent implementation of cross-sensory EEG emotion recognition for Chapter 3.

In Chapter 3, this study focused on the method design and implementation of cross-sensory EEG emotion recognition from the experiment of Chapter 2. Through the feature analysis of emotion pattern and sensory pattern based on Chapter 2, combined with the specific feature methods of EEG-related features from past related research, it could achieve the extraction and recognition of emotional components of cross-sensory EEG under multimodal stimulation. That is, for emotion changes showed frequency-varied, filter bank (band decomposition) with ensemble learning (sub-band results ensemble) effectively could capture varied emotional components; emotion changes showed regional diversified, Riemannian feature extraction from covariance matrix (channel covariance calculation) could capture these diversities; also sensory-related changes showed greater spectral impact quantitatively, adversarial domain adaptation could reduce the influence from sensory-related changes. Therefore, this study proposed a method with Filter Bank Riemannian Feature and Adversarial Domain Adaptation (FBADR) for cross-sensory emotion recognition. In this chapter, it is described the specific process of how to implement FBADR and the processing and application details of the cross-sensory EEG data. In the experiments of Chapter 3, mainly through comparative classification, baseline methods comparison and robustness verification, the SOTA results as 89.01%±5.06% accuracy of the proposed FBADR method for cross-sensory emotion recognition and its applicability in the a-BCI field were obtained.

In Chapter 4, it comprehensively discussed the separate and comprehensive roles played in solving the cross-sensory EEG emotion recognition problem in Chapter 2 and Chapter 3. That is, compared with past studies, this study had achieved end-to-end cross-sensory EEG emotion recognition for the first time, and in this chapter, it discussed the feature analysis of cross-sensory EEG emotion recognition under multimodal stimulation and the effectiveness of the proposed modal. Moreover, the significance of this study could also be beneficial for investigating a wide range of cross-sensory processing.

In Chapter 5, it gave the conclusion of this research. Generally, this research provided a comprehensive idea for inspecting and realizing the cross-sensory EEG emotion recognition under multimodal stimulation from Chapter 2 and 3, for understanding the neurological evidence of emotion and sensory patterns under multimodal stimulation and achievement of cross-sensory EEG emotion recognition, widening the potential application for EEG-based a-BCI.