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GENERIC PATTERN RECOGNITION MODELS BASED ON EEG-MI BRAIN-COMPUTER INTERFACES FOR WHEELCHAIR STEERING CONTROL

ABSTRACT

The purpose of this study was to develop generic pattern recognition models (GPRMs) based on two-class EEG–MI brain-computer interfaces for wheelchair steering control. Initially, a preprocessing procedure was performed to remove unwanted signals and to identify the optimal duration of MI feature components. Then, feature extraction based on five statistical features, namely min, max, mean, median, and standard deviation were utilized for extracting the MI feature components in three signal domains, namely time, frequency, and time-frequency domains. Seven classification algorithms, namely LDA, SVM, KNN, ANN, NB, DT, and LR, were selected and tested to find the best algorithms that could be used for the development of hybrid classifiers. Two datasets were used, namely the BCI Competition dataset (which belonged to Graz University) and the Emotive EPOC dataset (which was collected in this study), with the former being utilized in the development, evaluation, and validation of the GPRM models and the latter being used for validation only. The research findings showed that GPRM models based on the LR classifier were highly accurate in the time and time-frequency domains in the range of 4 and 6 seconds and 4 and 7 seconds, respectively. In addition, GPRM models based on the MLP-LR classifier were highly accurate in the frequency domain in the range of 4 and 6 seconds. Furthermore, the validation of such models using the Emotive EPOC dataset showed that the LR-based GPRM model attained high classification accuracies of 90.2% and 85.7% in the time domain and time-frequency domain, respectively. The MLP-LR-based GPRM models achieved a classification accuracy of 84.2% in the frequency domain. In conclusion, the main findings showed that GPRMs were highly adaptable when deployed in the real-time application of the EEG-MI-based wheelchair steering control system. The implication of this study is that generic pattern recognition models based on EEG-MI Brain-Computer interfaces can be utilized to improve the effectiveness of wheelchair steering control.

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MODEL-MODEL PENGECAMAN CORAK GENERIK BERASASKAN ANTARA MUKA OTAK MANUSIA-KOMPUTER UNTUK KAWALAN PENGEMUDIAN KERUSI RODA

ABSTRAK

Tujuan kajian ini adalah untuk membangunkan model pengecaman corak generik (GPRM) berasaskan antara muka otak manusia-komputer (BCI) berdasarkan EEG-MI untuk kawalan pengemudian kerusi roda. Mula-mula, prosedur pra-pemprosesan dijalankan untuk menyingkirkan isyarat yang tidak diingini dan untuk mengenal pasti tempoh optimum bagi komponen-komponen ciri MI. Kemudian, penyarian sifat berdasarkan lima sifat statistik, iaitu minima, maksima, min, median, dan sisihan piawai digunakan untuk mengekstrak komponen-komponen ciri MI ke dalam tiga domain isyarat, iaitu domain masa, domain frekuensi, dan domain masa-frekuensi. Tujuh algoritma pengelasan, iaitu LDA, SVM, KNN, ANN, NB, DT, dan LR dipilih dan diuji untuk menentukan algoritma-algoritma yang terbaik yang boleh digunakan untuk membangunkan pengelas hybrid. Dua set data digunakan, iaitu set data *Competition BCI* (yang dipunyai oleh Universiti Graz) dan set data *Emotive EPOC* (yang dikumpulkan dalam kajian ini). Set data pertama digunakan untuk pembangunan, penilaian, dan pengesahan GPRM, sementara set data kedua digunakan hanya untuk pengesahan. Dapatan kajian menunjukkan model GPRM berasaskan pengelas LR adalah sangat berkesan dalam domain masa dan domain masa-frekuensi bagi julat masa antara 4 dan 6 saat dan julat masa antara 4 dan 7 saat, masing-masing. Tambahan pula, model GPRM berasaskan pengelas MLP-LR adalah sangat berkesan dalam domain frekuensi bagi julat masa antara 4 dan 6 saat. Di samping itu, pengesahan model berdasarkan set data *Emotive EPOC* menunjukkan model GPRM berasaskan pengelas LR memperoleh peratusan ketepatan pengelasan setinggi 90.2% dan 85.7% dalam domain masa dan domain masa-frekuensi, masing-masing. Model GPRM berasaskan pengelas MLP-LR memperoleh peratusan ketepatan pengelasan setinggi 84.2% dalam domain frekuensi. Sebagai kesimpulan, dapatan menunjukkan model GPRM adalah amat sesuai bila digunakan dalam sistem kawalan pengemudian kerusi roda berasaskan EEG-MI dalam masa nyata. Implikasi kajian ini adalah model-model pengecaman corak generik berasaskan antara muka otak manusia-komputer boleh digunakan untuk meningkatkan keberkesanan kawalan pengemudian kerusi roda.

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