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(54) Title of the invention : PRIVACY-PRESERVING ADVERSARIALLY ROBUST FEDERATED LEARNING SYSTEM AND APPARATUS FOR BRAIN-COMPUTER INTERFACE SIGNAL CLASSIFICATION

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(57) Abstract :

The present invention provides a privacy-preserving adversarially robust federated learning system (100) and apparatus for brain-computer interface signal classification comprising an EEG signal acquisition and preprocessing unit (110) with multi-channel electrode interface (111), signal conditioning circuit (112), artifact removal processor (113), and feature extraction engine (114), a local batch-specific normalization module (120) with batch statistics calculator (121), distribution alignment processor (122), and learnable transformation unit (123), an adversarial robustness module (130) with federated adversarial training unit (131) and adversarial weight perturbation unit (132), an adaptive self-optimizing control module (140), a hybrid hardware-software acceleration engine (150), a secure federated aggregation server (160), a predictive analytics module (170), and a fault-tolerant redundancy controller (180). The system achieves simultaneous optimization of decoding accuracy exceeding eighty-five percent, adversarial robustness improvement exceeding forty percent, and privacy protection without requiring calibration data from target subjects through integrated hardware-software cooperative processing.

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