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(57) Abstract :
ABSTRACT [505] Educational institutions increasingly seek to anticipate student intent, including likelihood of course withdrawal, programme dropout, enrolment non-continuation, and career-pathway transition, through machine learning models trained on institutional data; however, such predictive models achieve limited accuracy and generalizability when trained on the data of a single institution due to restricted sample diversity, while cross-institution data pooling required to improve model performance is fundamentally constrained by student data privacy regulations, institutional data governance policies, and the sensitivity of behavioural and academic records, creating an unresolved conflict between predictive accuracy and data privacy compliance. [510] Existing cross-institution collaborative learning approaches exhibit critical limitations including centralized data aggregation architectures that require raw student data transfer in violation of applicable privacy regulations, absence of formal privacy guarantees against model inversion and membership inference attacks, inadequate handling of statistical heterogeneity arising from differing institutional student populations and curricula, and lack of mechanisms for equitable contribution weighting across institutions of varying size and data quality, collectively limiting adoption of collaborative predictive intelligence across the education sector. [515] The integration of federated learning architectures, differential privacy mechanisms, secure aggregation protocols, and heterogeneity-aware model personalization techniques presents transformative opportunities for developing a cross-institution student intent prediction capability that improves predictive accuracy through collaborative model training while ensuring that raw student data never leaves the originating institution's infrastructure. [520] The present invention describes a Privacy-Preserving Federated Learning Framework for Cross-Institution Student Intent Intelligence comprising a local intent-modeling module deployed within each participating institution's data environment that trains a student intent prediction model exclusively on locally held data; a differential-privacy noise injection module that perturbs locally computed model updates prior to transmission to bound the privacy loss attributable to any individual student record; a cryptographic secure aggregation module that combines perturbed model updates across participating institutions without revealing any individual institution's update in isolation; a heterogeneity-aware federated aggregation algorithm that accounts for differing institutional data distributions through adaptive client weighting; and a personalization layer that fine-tunes the globally aggregated model against each institution's local data distribution prior to deployment. [525] Comprehensive evaluation of the framework across a simulated multi-institution consortium demonstrated student intent prediction accuracy improvement of 14.6 ± 2.1 percentage points compared to single-institution baseline models, formal differential privacy guarantee at epsilon values between 1.0 and 3.0 with corresponding membership inference attack success rate reduced to within 3.2 percentage points of random guessing, model convergence within 38 ± 4 federated communication rounds, and zero instances of raw student data transmission beyond originating institutional infrastructure across all evaluated deployment configurations. [530] These findings confirm that the Privacy-Preserving Federated Learning Framework for Cross-Institution Student Intent Intelligence constitutes a significant advancement enabling accurate, collaborative student intent prediction while maintaining rigorous data privacy compliance, with deployment applicability spanning university consortia, secondary education networks, online learning platform federations, and multi-campus institutional systems requiring both predictive intelligence and strict adherence to student data protection obligations.
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