

TRÍCH YẾU LUẬN ÁN/THE ABSTRACT OF DOCTORAL THESIS

a) Opening Summary:

- Author's Name: Nguyen Thi Quynh Hoa
- Thesis Title: Research and Development of Eye-Tracking Solutions Supporting Children with Developmental Disorders
- Scientific Major: Computer Science Major Code: 9480101
- Training Institution: University of Engineering and Technology, Vietnam National University, Hanoi

b) Abstract Content:

1. Objectives and Research Subjects of the Thesis:

- **Objective 1:** Propose a methodology for constructing multimodal datasets to serve as a quantitative foundation for modeling the cognitive and interactive behaviors of children with developmental disorders.
- **Objective 2:** Propose technical solutions for the automated extraction of visual behavior features from dynamic content (dynamic frame sequences) to support empirical evaluation workflows.
- **Objective 3:** Propose and implement personalized intervention methods based on visual behavior data, integrated into digital systems (web platforms and mobile applications) to automatically coordinate learning content and mitigate extraneous cognitive load for learners.

2. Research Methods Employed:

- **Quantitative Re-analysis of Public Datasets:** Implementing quantitative research methods through the standardization, synchronization, and re-analysis of existing public datasets regarding the visual behavior and system interaction of children with developmental disorders, rather than conducting direct experiments with live human subjects.
- **Hybrid Feature Extraction Method:** Integrating the Segment Anything Model (SAM), the PeyeMMV fixation detection algorithm, and optical flow techniques to automate the identification and tracking of Areas of Interest (AOIs) within dynamic frame sequences.
- **Modeling and Machine Learning:** Applying Multimodal Dynamic Bayesian Networks (M-DBN) and dual-loop graph architectures to quantify latent cognitive states. The system leverages Single-Case Experimental Designs (SCED) and Tau-U statistical analysis to evaluate the sustainability of acquired skills.

3. Key Results and Conclusions:

- **Systematized Dataset Construction:** Successfully constructed real-time synchronized multimodal datasets (including gaze coordinates, timestamps, and mouse operations) for children with developmental disorders, establishing a rigorous training and validation foundation for classification and diagnostic algorithms.
- **Automated Feature Extraction:** The proposed hybrid method completely replaces

manual labeling workflows on dynamic video streams. This framework maintains spatio-temporal consistency in identifying and analyzing unique information-processing patterns of children with developmental disorders.

- **Cognitive State Modeling:** Integrating real-world gaze data into the dynamic observation probability functions of the M-DBN framework fundamentally resolves the identifiability problem inherent in traditional Bayesian Knowledge Tracing (BKT) methods, precisely distinguishing between "knowledge gaps" and "format overload."
- Establishing a rule framework to support intervention: The system integrates eye-tracking technology into its inference rule framework. The results of the single-case design (SCED) dataset reanalysis and a Tau-U statistical index of 0.93 provided a quantitative basis for the ability to maintain skill stability after intervention. This data also confirmed the role of gaze trajectory in feature recognition and behavioral modification.
- **Deployment of a Personalized Intervention Ecosystem:** Deployed independent digital interaction sub-systems (such as EzMath and EzRead). These platforms employ micro-interface adjustments and closed-loop biofeedback mechanisms to significantly reduce extraneous cognitive load, thereby sustaining stable learning outcomes and skill retention.

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