



GUJARAT TECHNOLOGICAL UNIVERSITY

(Established by Government of Gujarat under Gujarat Act No. : 20 of 2007)

ગુજરાત ટેકનોલોજીકલ યુનિવર્સિટી

(ગુજરાત સરકારના ગુજરાત અધિનિયમ ક્રમાંક : ૨૦/૨૦૦૭ દ્વારા સ્થાપિત)

Accredited with A++ Grade by NAAC

Abstract of the Thesis



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Discipline/Branch: Computer/IT Engineering

Title of the Thesis: Improving Automatic Short Answer Grading with Deep Learning Architectures

Abstract

Automatic Short Answer Grading (ASAG) plays a key role in scalable educational assessment by enabling computational evaluation of students' free-text responses with consistency and efficiency. Advances in Natural Language Processing, particularly transformer-based models such as BERT and Sentence-BERT, have improved meaning-based similarity estimation. However, these approaches often fail to capture true conceptual correctness, as high semantic similarity does not guarantee understanding—especially when key concepts are missing, answer length biases exist, or logical contradictions such as negation occur.

This research reframes ASAG as a structured educational reasoning problem rather than a pure similarity task. It addresses three core limitations: length discrepancy, where models struggle with varying answer lengths; correctness gap, where similarity does not reflect concept coverage; and Discrete Boundary Collapse (DBC), where continuous vector spaces fail to preserve clear grading distinctions.

To overcome these issues, a multi-architecture framework is proposed. First, a Universal Length-Adaptive Design routes answers to suitable sub-models based on length, integrating BM25, TF-IDF, SBERT, BERT, and Bi-LSTM. Second, a Concept-Aware Siamese Model incorporates term-weighted embeddings, concept extraction, coverage scoring, and contradiction-aware gating, enhanced by a Negation-Sensitive Score Calibration (NSSC) mechanism. Third, DBC is formalized as a geometric limitation, and BAT-TW-BERT is introduced to address it using term-weighted and attention-biased embeddings.



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Experiments on benchmark datasets including Mohler, SciEntsBank, and ASAG2024 (18,067 responses) show consistent improvements over strong baselines. The Universal model achieves an F1-score of 91.2% and a Pearson correlation of 0.90. The Concept-Aware model improves concept recall by 4.7%, while NSSC increases negation-specific QWK from 0.52 to 0.74. These results demonstrate a principled advancement in automated short-answer grading.

This PhD Thesis will help in intelligent assessment by leveraging deep learning to accurately grade subjective answers, minimizing human bias and evaluation time. It is applicable in digital education, MOOCs, adaptive learning systems, and large-scale online examinations.

List of Publication(s):

1. Nikunj C. Gamit and Dr. Shailesh Panchal. "Evaluating Pretrained Embeddings for Automatic Short Answer Grading." Journal of Information Systems Engineering and Management, vol. 8, no. 4, 2023.
DOI: <https://doi.org/10.52783/jisem.v8i4.20>
2. Nikunj C. Gamit and Shailesh Panchal. "Universal Automatic Short Answer Grading (ASAG) Model: A Comprehensive Approach." Journal of Information Systems Engineering and Management, vol. 9, no. 4s, 2024.
DOI: <https://doi.org/10.52783/jisem.v9i4s.11686>
3. Nikunj C. Gamit and Ajay N. Upadhyaya. "Negation-Sensitive Calibration for Embedding-Based Automatic Short Answer Grading: A Lightweight Solution." International Journal of Innovative Research in Technology (IJIRT), vol. 12, no. 11, 2026.
DOI: <https://doi.org/10.64643/IJIRT12I11-195980-459>