

Perceptive Test Portal: A Spring Boot Based Intelligent Online Assessment System Using Automated Question Generation

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Abstract

This paper presents the Perceptive Test Portal, an intelligent web-based assessment platform designed to automate academic examinations and reduce administrative workload. The system integrates Natural Language Processing (NLP) techniques and Transformer-based models for Automated Question Generation (AQG). The platform is implemented using a scalable Spring Boot architecture that provides secure role-based access control, RESTful API communication, efficient database management, and seamless integration with machine learning services. The AQG module employs Bidirectional Encoder Representations from Transformers (BERT) for Answer Span Identification (ASI) and Text-to-Text Transfer Transformer (T5) for context-aware question generation. Comparative analysis indicates that T5 provides superior inference speed and lower computational overhead compared to similar transformer architectures, making it suitable for real-time assessment generation. The proposed system improves scalability, maintainability, security, and assessment quality while reducing manual effort in examination management.

Keywords

Automated Question Generation, Spring Boot, Natural Language Processing, BERT, T5, REST API, Online Assessment, Deep Learning, Educational Technology.

1. INTRODUCTION

Examinations play a critical role in evaluating student learning outcomes. Traditional examination systems require extensive manual effort for question preparation, test administration, and evaluation. These approaches often suffer from scalability issues, inconsistency, and limited personalization.

Recent advances in NLP and Deep Learning have enabled intelligent educational systems capable of generating context-aware questions automatically. The proposed Perceptive Test Portal leverages BERT and T5 transformer models to dynamically generate assessment content while providing secure online examination facilities.

To improve system performance and maintainability, the platform is developed using Spring Boot. The framework offers dependency injection, auto-configuration, embedded server support, RESTful services, and simplified database integration, making it highly suitable for enterprise-grade educational applications.

2. LITERATURE REVIEW AND FOUNDATIONAL TECHNOLOGIES

Online examination systems have evolved from paper-based assessments to fully digital platforms. Existing systems improve accessibility and reporting but frequently depend on manually created question banks.

Automated Question Generation has progressed from rule-based approaches to deep learning models. BERT serves as a contextual language understanding model and is used for Answer Span Identification. Sequence-to-sequence models such as T5 are employed to generate grammatically correct and contextually relevant questions. Recent studies demonstrate that transformer-based AQG systems improve question quality, relevance, and scalability.

3. SYSTEM ARCHITECTURE AND IMPLEMENTATION DESIGN

The Perceptive Test Portal follows a layered Spring Boot architecture consisting of Controller, Service, Repository, and Database layers.

The backend utilizes:

- Spring MVC
- Spring Data JPA
- Spring Security
- REST APIs
- Embedded Tomcat Server
- Dependency Injection (IoC)

The Automated Question Generation module is implemented as a Python-based microservice using Hugging Face transformer models. Communication between Spring Boot and the AQG module is performed through REST APIs.

Role-Based Framework:

Student Module: Test participation, result viewing, performance analysis.

Department Module: Question generation, test creation, student monitoring.

Admin Module: User management, department management, system monitoring, approval workflows.

Database entities include Student, Department, Test, Question, Category, SubCategory, and Result.

4. PERCEPTIVE QUESTION GENERATION METHODOLOGY

The AQG workflow follows:

Input Text → Answer Span Identification (BERT) → Targeted Question Generation (T5) → Distractor Generation → Validation and Filtering → Database Storage.

The system adopts Answer-Aware Question Generation (AAQG), where identified answers are provided to the model to generate pedagogically meaningful questions. Generated questions are classified and tagged with metadata such as category, subcategory, and difficulty level for efficient retrieval and assessment assembly.

5. COMPARATIVE ANALYSIS OF AQG TRANSFORMER MODELS

Model selection focused on generation quality, latency, computational efficiency, and deployment feasibility.

BERT:

- High linguistic fluency
- Higher inference latency
- Greater computational requirements

T5:

- Excellent generation quality
- Faster inference speed
- Lower computational overhead
- Better suitability for real-time web applications

Based on these factors, T5 was selected as the primary question generation model.

6. DISCUSSION AND VALIDATION

System validation was performed using both technical and educational metrics.

Technical Metrics:

- API Response Time
- Database Performance
- Concurrent User Handling
- Memory Utilization
- End-to-End AQG Latency

AQG Evaluation Metrics:

- BLEU Score
- ROUGE Score

Human Evaluation:

- Answerability
- Relevance
- Clarity
- Fluency

User Acceptance Testing (UAT) involving educators validates the academic quality and usability of the generated assessments.

7. ADVANTAGES OF SPRING BOOT IMPLEMENTATION

Compared to traditional Servlet/JSP architectures, Spring Boot provides:

- Auto-Configuration
- Embedded Server Deployment
- Simplified Dependency Management
- Enhanced Security through Spring Security
- Better Scalability
- Easier Maintenance
- Efficient Database Access through Spring Data JPA
- Seamless REST API Integration

These advantages significantly improve system reliability and development productivity.

Acronyms to Expand

1. **NLP** → *Natural Language Processing (NLP)*
2. **BERT** → *Bidirectional Encoder Representations from Transformers (BERT)*
3. **T5** → *Text-to-Text Transfer Transformer (T5)*
4. **MVC** → *Model-View-Controller (MVC)*
5. **AQG** → *Automated Question Generation (AQG)*
6. **ASI** → *Answer Span Identification (ASI)*
7. **AAQG** → *Answer-Aware Question Generation (AAQG)*
8. **UAT** → *User Acceptance Testing (UAT)*
9. **BLEU** → *Bilingual Evaluation Understudy (BLEU)*
10. **ROUGE** → *Recall-Oriented Understudy for Gisting Evaluation (ROUGE)*
11. **API** → *Application Programming Interface (API)* (not mandatory but safer to expand once)

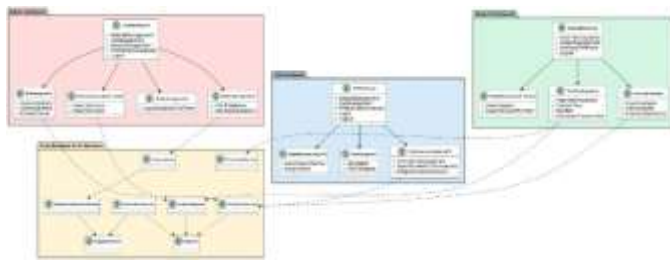


Figure 1

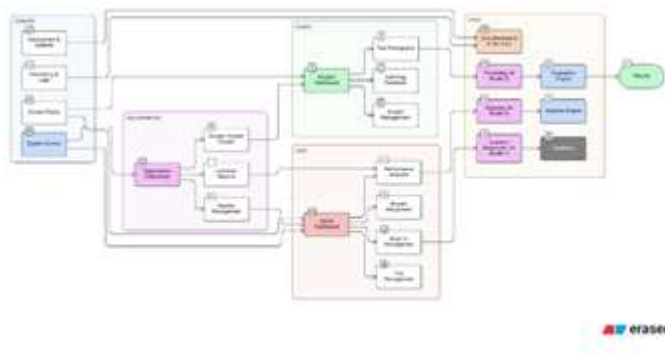


Figure 2

8. CONCLUSION

The Perceptive Test Portal integrates Spring Boot, Natural Language Processing, and Transformer-based Automated Question Generation techniques to create a secure and scalable online assessment platform. By utilizing BERT for Answer Span Identification and T5 for question generation, the system generates high-quality and context-aware assessment content. The adoption of Spring Boot enhances maintainability, security, scalability, and performance while supporting seamless integration with AI services. The platform reduces manual effort, enables adaptive testing, and improves the overall assessment experience for educational institutions.

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