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Analysis of Active Learning Mechanism Applied to Language Models for Computer Assisted Short Answer Grading

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Motivation

In universities with an increase in number of student every semester, the number of tests conducted also increases. This means that:

- The professor spends more time in correcting student exams than preparing for lectures.
- If students are not assigned full scores for on a test, they expect a meaningful feedback from the professor.

Motivation

Consider the following dummy scenario:

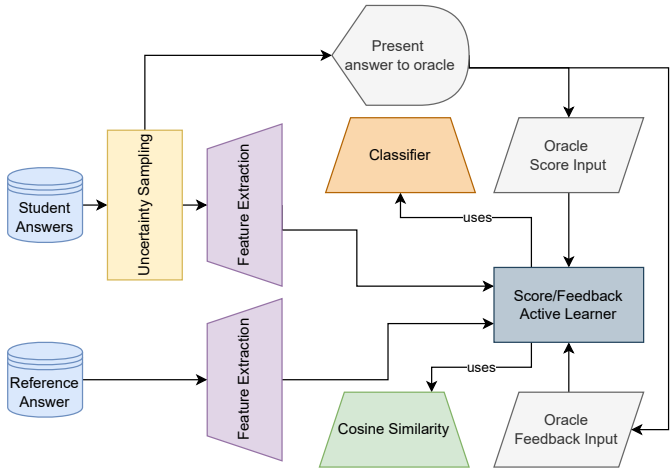
- 80 students enrolled in a class.
- Tests are conducted bi-weekly.
- Professor requires 15 minutes to evaluate one student test.
- Total time spent by the professor to evaluate all tests per week is 10 hours.

Problem Statement

- To automate the evaluation of student tests while still keeping the oracle/professor in the loop.
- Allow the assignment of meaningful feedback to student answers indicating their mistakes.

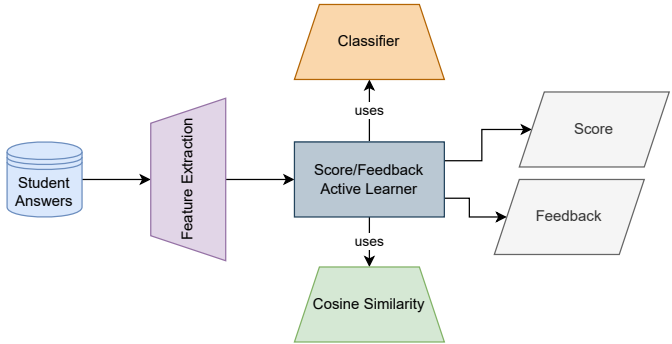
Approach

Training cycle



Approach

Prediction cycle



Approach

Uncertainty Sampling

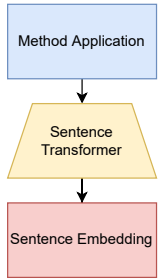
Uncertainty sampling is a query strategy that queries the instances about which it is least certain how to label. We use uncertainty sampling variant might query the instance whose prediction is the least confident:

$$x_{LC} = argmin_x P(\hat{y}|x;\theta) \tag{1}$$

Where x is the feature, y is the class label prediction, and $\hat{y} = argmax_y P(y|x;\theta)$ is the class label that has the largest posterior probability using model θ.

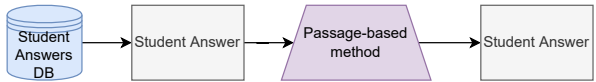
Approach

Feature Extraction: Overview



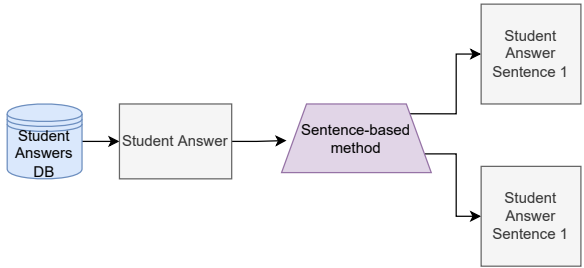
Approach

Feature Extraction: Passage-based method



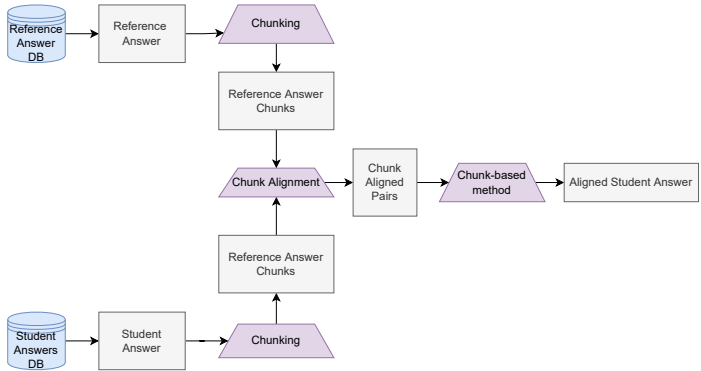
Approach

Feature Extraction: Sentence-based method



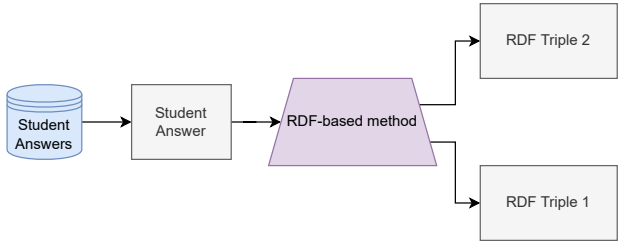
Approach

Feature Extraction: Chunk-based method



Approach

Feature Extraction: RDF-based method



Approach

Language Models

Model:	Base model	Number Training tuples
all-mpnet-base-v2[**?**]	microsoft/mpnet-base.	1.17B
all-distilroberta-v1[**?**]	distilroberta-base	1.12B
all-MiniLM-L12-v2[**?**]	microsoft/MiniLM-L12-H384-uncased	1.17B
multi-qa-distilbert-cos-v1[**?**]	distilbert-base	214M
all-MiniLM-L6-v2[**?**]	nreimers/MiniLM-L6-H384-uncased	1.17B

Table 1: Displays pre-trained language models with their base model used in training and number of training tuples used[**?**].

Evaluation

Score

- Pearsons Correlation

$$\rho(y, \hat{y}) = \frac{cov(y, \hat{y})}{\sigma_y \sigma_{\hat{y}}} \tag{2}$$

- RMSE Score

$$RMSE = \sqrt{\frac{1}{n} \Sigma_{i=1}^{n} (\hat{y}_i - y_i)^2} \tag{3}$$

Where y represents actual grade and $\hat{y}$ represents predicted grade with σ_y and $\sigma_{\hat{y}}$ computed as the standard deviation of y and $\hat{y}$

Evaluation

Feedback

Question	What is a variable?
Reference Answer	A location in memory that can store a value.
Student Answer	a value/word that can assume any of a set of values
Feedback A	correct
Feedback B	missing keywords: location in memory
Feedback C	A variable is a location in memory that stores a value

Table 2: Presented survey to participants.

Agreement Score = Participants agreed with most rated feedback/100

Results

Score: Pearson Correlation (Methods)

Dataset	M1	M2	M3	M4
Mohler []	**0.826**	**0.791**	**0.816**	0.782
NN Exam []	**0.941**	**0.828**	0.561	**0.846**
AMR Exam []	**0.658**	0.458	**0.640**	**0.428**

(a)

Dataset	M1	M2	M3	M4
Mohler []	0.689	0.627	0.687	**0.792**
NN Exam []	0.889	0.791	**0.638**	0.664
AMR Exam []	0.622	**0.474**	0.593	**0.428**

(b)

Table 3: Comparison of Pearson Correlation between Random Forest (a) and AdaBoost (b) classifiers. Where M1: Passage-based, M2: Sentence-based, M3:Chunk-based, and M4: RDF-based method.

Results

Score: Pearson Correlation (Language Models)

Dataset	LM1	LM2	LM3	LM4	LM5
Mohler []	**0.802**	**0.797**	**0.796**	**0.796**	**0.789**
NN Exam []	**0.732**	**0.670**	**0.705**	**0.755**	**0.760**
AMR Exam []	0.453	**0.518**	**0.525**	**0.523**	**0.503**

(a)

Dataset	LM1	LM2	LM3	LM4	LM5
Mohler []	0.659	0.673	0.211	0.544	0.499
NN Exam []	0.614	0.653	0.704	0.698	0.605
AMR Exam []	**0.502**	0.440	0.430	0.508	0.467

(b)

Table 4: Comparison of Pearson Correlation between Random Forest (a) and AdaBoost (b) classifiers with language models (LM).

Results

Score: Root Mean Square Error (Methods)

Dataset	M1	M2	M3	M4
Mohler []	**0.893**	**0.949**	**0.920**	0.942
NN Exam []	**0.296**	**0.520**	**0.433**	**0.522**
AMR Exam []	**0.596**	0.716	**0.596**	**0.736**

(a)

Dataset	M1	M2	M3	M4
Mohler []	1.218	1.226	1.169	**0.920**
NN Exam []	0.405	0.571	0.495	0.741
AMR Exam []	0.616	**0.707**	0.630	0.741

(b)

Table 5: Comparison of RMSE score between Random Forest (a) and AdaBoost (b) classifiers with methods (M).

Results

Score: Root Mean Square Error (Language Models)

Dataset	LM1	LM2	LM3	LM4	LM5
Mohler []	**0.931**	**0.941**	**0.941**	**0.941**	**0.956**
NN Exam []	**0.484**	0.591	**0.558**	**0.490**	**0.492**
AMR Exam []	0.735	**0.680**	**0.676**	0.684	**0.698**

(a)

Dataset	LM1	LM2	LM3	LM4	LM5
Mohler []	1.182	1.163	1.667	1.278	1.363
NN Exam []	0.632	**0.582**	0.587	0.587	0.650
AMR Exam []	**0.692**	0.748	0.718	**0.682**	0.736

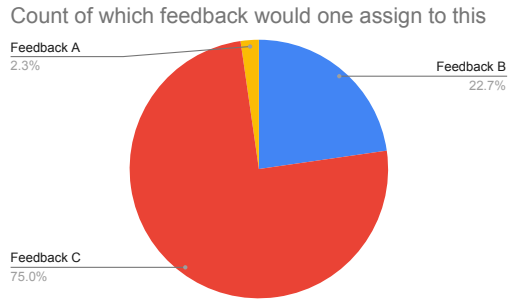
(b)

Table 6: Comparison of RMSE score between Random Forest (a) and AdaBoost (b) classifiers with language models (LM).

Results

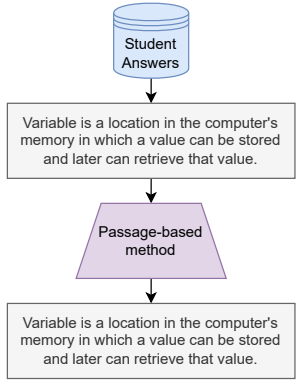
Feedback: Survey Results

Question	What is a variable?
Reference Answer	A location in memory that can store a value.
Student Answer	a value/word that can assume any of a set of values
Feedback A	correct
Feedback B	missing keywords: location in memory
Feedback C	A variable is a location in memory that stores a value



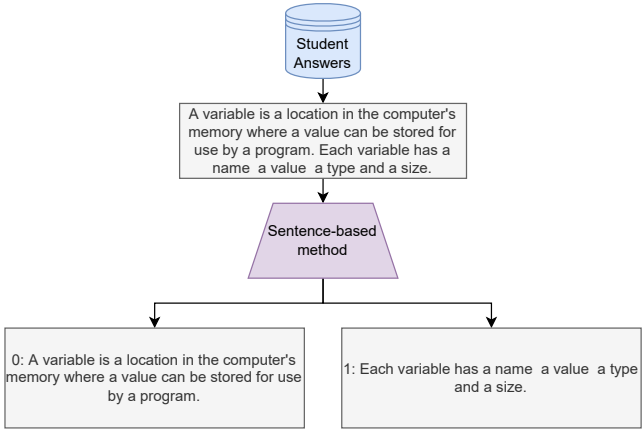
Approach

Feature Extraction: Passage-based method



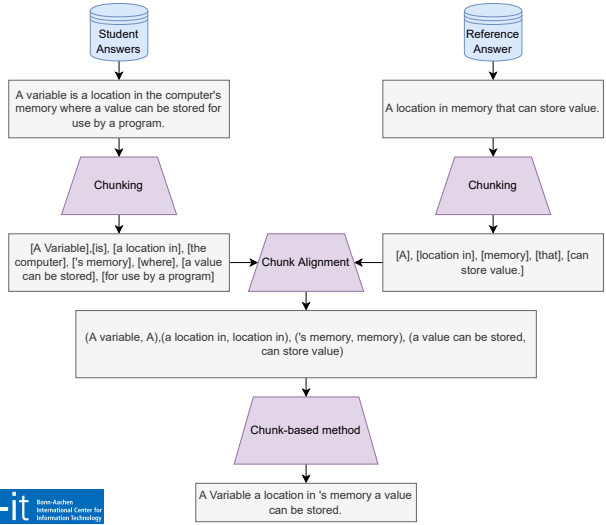
Approach

Feature Extraction: Sentence-based method



Approach

Feature Extraction: Chunk-based method



Approach

Feature Extraction: RDF-based method