

# Sentence Salience Classification Using Linguistic and Semantic Features in QA Systems

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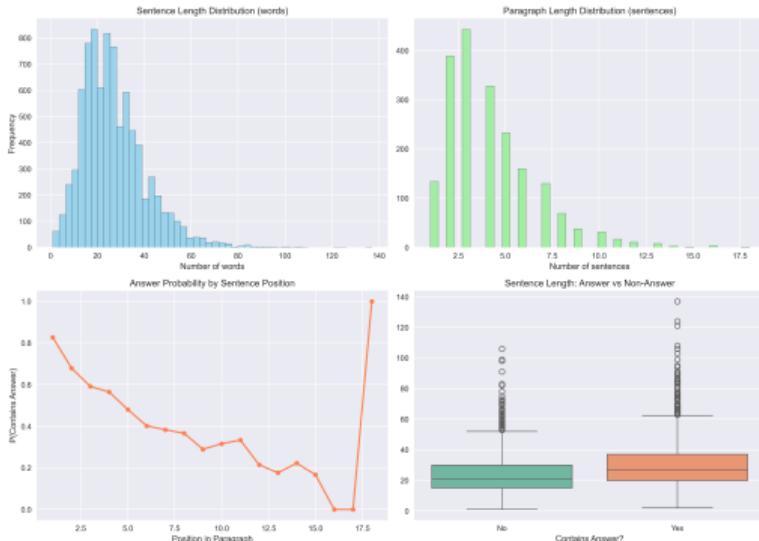


<https://github.com/MadduruNikhil-IIITH/Squad-Salience-Sentence-Detection>

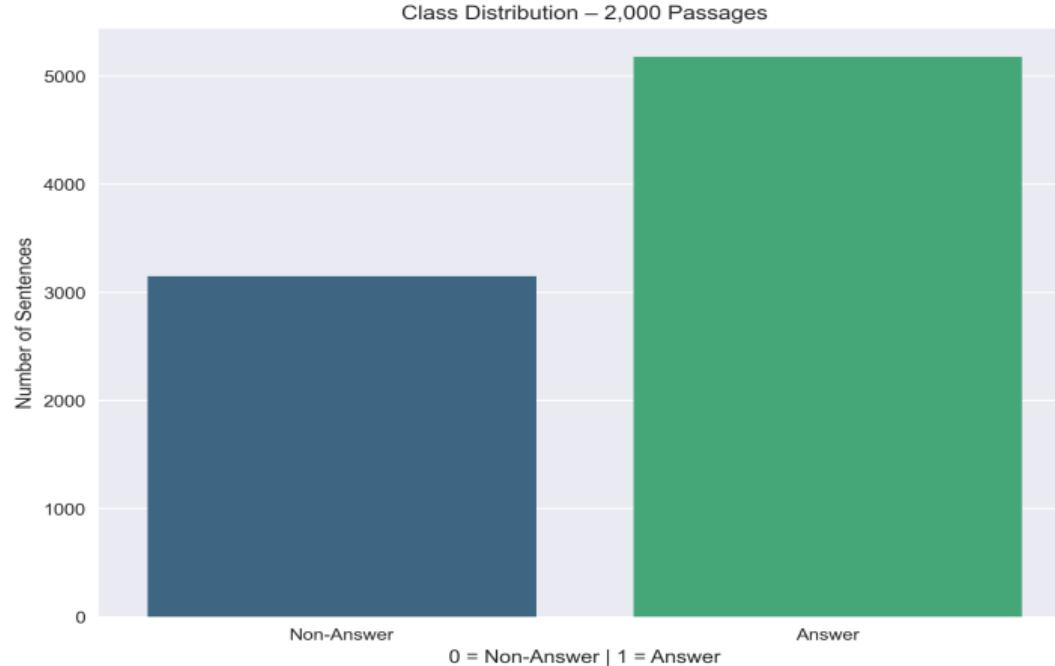
*"How can linguistic and semantic features such as word length, number of POS tags, sentence position, and surprisal estimations be extracted and utilized to enhance sentence salience classification in question-answering systems?"*

# Dataset — SQuAD v1.1 Training Set

- ▶ Source: SQuAD v1.1 **training set**
- ▶ Total passages: **19,035**
- ▶ Sampled: **2,000 passages**
- ▶ Total sentences: **8,328**
- ▶ Answer sentences: **5,178 (62.17%)**



# Class Imbalance in the Data



## Observation

With 2,000 passages: **62.17% Answer sentences** → moderate positive skew  
Smaller samples (e.g. 100 passages) can exceed 70–75% → severe imbalance

# All 26 Features

Original Proposal Category	Actual Features Implemented (26 total)
Surface features	avg_word_length sentence_length_words sentence_position sentence_position_norm
Lexical features	type_token_ratio lexical_density
POS-based features	noun_ratio, verb_ratio adj_ratio, pronoun_ratio noun_verb_ratio
Discourse features	causal_marker_ratio contrast_marker_ratio named_entity_density
Surprisal (GPU/CUDA) — GPT-2	gpt2_surprisal_mean, sum, std gpt2_surprisal_var, min, max
Surprisal (GPU/CUDA) — BERT	bert_surprisal_mean, sum, std bert_surprisal_var, min, max

## Methodology & Final Results

- ▶ Model: Logistic Regression (`class_weight='balanced'`)
- ▶ Split: 80/20 stratified
- ▶ Main run: 2,000 passages

## Final Performance

Metric	Score
Accuracy	<b>69.27%</b>
F1	<b>0.7377</b>
Precision	<b>0.7860</b>
Recall	<b>0.6950</b>

## Ablation

Top-10 features only → 68.29% accuracy, 0.7360 F1, 0.7648 Precision, 0.6873 Recall

**No Suprisal features** → 69.21% accuracy, **0.7416** F1, 0.7756 Precision, **0.7104** Recall

## Top 10 Most Predictive Features

Rank	Feature	Coefficient
1	sentence_position	<b>-0.796</b>
2	gpt2_surprisal_sum	+0.663
3	gpt2_surprisal_var	-0.444
4	bert_surprisal_std	+0.364
5	noun_ratio	+0.331
6	bert_surprisal_var	-0.315
7	named_entity_density	+0.298
8	gpt2_surprisal_std	+0.283
9	sentence_position_norm	+0.257
10	lexical_density	-0.256

## Performance Scaling

Passages	Sentences	Answer %	Accuracy	F1
100	577	73.5%	70.7%	0.793
500	2,277	68.3%	66.0%	0.740
1,000	4,485	63.8%	69.1%	0.748
<b>2,000</b>	<b>8,328</b>	<b>62.2%</b>	<b>69.3%</b>	<b>0.738</b>

## Ablation Study — The Surprising Truth

Passages	Full Model	No Surprisal	Top-10
100	70.69% / 79.27%	67.24% / 75.95%	66.38% / 76.07%
250	63.31% / 70.93%	<b>67.74% / 75.16%</b>	64.11% / 71.20%
500	66.01% / 74.04%	65.57% / 73.43%	65.57% / 73.61%
1,000	69.12% / 74.80%	67.00% / 72.79%	66.78% / 72.76%
<b>2,000</b>	69.27% / 73.77%	<b>69.21% / 74.16%</b>	67.41% / 72.39%

(Accuracy / F1 %). Bold = best per row.

## Future Work — Including Class Imbalance Handling

### Planned Extensions

- ▶ **Semantic Role Labeling (SRL)** — AllenNLP
- ▶ **Rhetorical Structure Theory (RST)** annotations
- ▶ Question–sentence dependency paths
- ▶ Coreference resolution features.

### Specific Focus on Class Imbalance

- ▶ Future:
  - ▶ Undersampling / oversampling (SMOTE, NearMiss)
  - ▶ Cost-sensitive learning with dynamic weights

These improvements + discourse features expected to push  $F1 > 0.80$

## Conclusion

**Yes — hand-crafted features are highly effective!**

- ▶ Achieved **69.3% accuracy** and **0.738 F1** using only linguistic + surprisal features.
- ▶ **Sentence\_position** is the dominant signal — answers overwhelmingly appear in the first few sentences of SQuAD paragraphs.
- ▶ No BERT embeddings or neural encoders used.
- ▶ Despite large positive coefficients for GPT-2 surprisal features, removing all 12 surprisal features **improved performance**.
- ▶ The counter-intuitive result is due to **multicollinearity**: surprisal is highly correlated with linguistic features, introducing noise in linear models.
- ▶ Strong foundation for SRL, RST, and advanced imbalance handling.

# Thank You

Questions?