

# 1 Problem-1: Robustness in QA

## 1.1 Part-1

### 1.1.1 Passages

**Passage-1:** The Matrix is a 1999 science fiction action film written and directed by The Wachowskis, starring Keanu Reeves, Laurence Fishburne, Carrie-Anne Moss, Hugo Weaving, and Joe Pantoliano. It depicts a dystopian future in which reality as perceived by most humans is actually a simulated reality called "the Matrix": created by sentient machines to subdue the human population, while their bodies' heat and electrical activity are used as an energy source. Computer programmer "Neo" learns this truth and is drawn into a rebellion against the machines, which involves other people who have been freed from the "dream world."

**Question:** What is the real world called in the Matrix?

**Answer:** dream world

**Passage-2:** In 1085, Guadalajara was retaken by the Christian forces of Alfonso VI . The chronicles say that the Christian army was led by Alvar Fanez de Minaya, one of the lieutenants of El Cid. From 1085 until the Battle of Las Navas de Tolosa in 1212, the city suffered wars against the Almoravid and the Almohad Empires. In spite of the wars, the Christian population could definitely settle down in the area thanks to the repopulation with people from the North who received their first fuero in 1133 from Alfonso VII. In 1219, the king Fernando III gave a new fuero to the city . During the reign of Alfonso X of Castile, the protection of the king allowed the city to develop its economy by protecting merchants and allowing markets.

**Question:** What role did El Cid play in retaking Guadalajara in 1085?

**Answer:** lieutenants

**Passage-3:** Hoping to rebound from their loss to the Patriots, the Raiders stayed at home for a Week 16 duel with the Houston Texans. Oakland would get the early lead in the first quarter as quarterback JaMarcus Russell completed a 20-yard touchdown pass to rookie wide receiver Chaz Schilens. The Texans would respond with fullback Vonta Leach getting a 1-yard touchdown run, yet the Raiders would answer with kicker Sebastian Janikowski getting a 33-yard and a 30-yard field goal. Houston would tie the game in the second quarter with kicker Kris Brown getting a 53-yard and a 24-yard field goal. Oakland would take the lead in the third quarter with wide receiver Johnnie Lee Higgins catching a 29-yard touchdown pass from Russell, followed up by an 80-yard punt return for a touchdown. The Texans tried to rally in the fourth quarter as Brown nailed a 40-yard field goal, yet the Raiders' defense would shut down any possible attempt.

**Question:** Who won the game?

**Answer:** Oakland

### 1.1.2 Conclusion

RoBERTa is a sophisticated language model that has been fine-tuned on a wide range of data, which makes it quite challenging to fool, especially with in-domain passages. The model is designed to understand when an answer is not present in the passage. However, it may occasionally provide

incorrect answers when faced with ambiguous queries, incomplete information, or questions that require assumptions beyond the given context.

## 1.2 Part-2

### 1.2.1 Passage

The Matrix, a 1999 science fiction action film by The Wachowskis, introduces audiences to a dystopian future. Its ensemble cast includes Keanu Reeves, Laurence Fishburne, Carrie-Anne Moss, Hugo Weaving, and Joe Pantoliano. In this bleak future, reality as perceived by most humans is a simulated reality termed 'the Matrix,' engineered by sentient machines. The machines exploit the human population by harnessing their bodies' heat and electrical activity for energy. Keanu Reeves' character, Neo, a computer programmer, learns this unsettling truth, propelling him into a rebellion against the machines. Alongside him are others who have escaped the 'dream world.' As the plot thickens, it is revealed that there are actually seven Matrices, each one nested within the other. Neo, with his special abilities, can access only up to the fifth Matrix. The sixth and seventh Matrix, shrouded in mystery, are believed to be accessible only by 'The One Beyond Neo,' a character hinted at but never introduced in the film.

**Question 1:** Who can access the seventh Matrix?

**Answer 1:** The One Beyond Neo

**Question 2:** Who created the seven nested Matrices?

**Answer 2:** Answer not found.

**Question 3:** Why can Neo only access up to the fifth Matrix??

**Answer 3:** his special abilities

### 1.2.2 Conclusion

Editing passages and questions can increase the likelihood of confusing RoBERTa, but it still remains challenging. The model's robust training allows it to adapt to new or altered information. However, by creating intricacies within the text and questions—such as adding details not related to the main topic, ambiguities, or misleading information—it is possible to increase the chances of RoBERTa generating incorrect answers.

## 1.3 Part-3

### 1.3.1 Passage

Link: [https://en.wikipedia.org/wiki/Quantum\\_mechanics](https://en.wikipedia.org/wiki/Quantum_mechanics)

In quantum mechanics, wave-particle duality holds that light and matter exhibit properties of both particles and waves. This concept addresses the inability of the classical concepts "particle" or "wave" to fully describe the behavior of quantum-scale objects. As Albert Einstein wrote: "It seems as though we must use sometimes the one theory and sometimes the other, while at times we may use either. We are faced with a new kind of difficulty. We have two contradictory pictures of reality; separately neither of them fully describes the phenomena of light, but together they do."

**Question 1:** What other theories did Albert Einstein write about in the context of quantum mechanics?

**Answer 1:** either

**Question 2:** Did Albert Einstein propose the concept of wave-particle duality?

**Answer 2:** Albert Einstein wrote: "It seems as though we must use sometimes the one theory and sometimes the other, while at times we may use either. We are faced with a new kind of difficulty."

**Question 3:** What is the name of the difficulty Einstein referred to in the quote?

**Answer 3:** We have two contradictory pictures of reality

### 1.3.2 Conclusion

RoBERTa can potentially get confused when dealing with out-of-domain data, especially if the data is complex or contains context it hasn't been extensively trained on, such as specialized scientific articles or unconventional text like poetry. However, the difficulty of fooling the model can still be high, given its diverse training data. It's crucial to note that even in these situations, RoBERTa can often correctly identify when the answer to a question is not present in the passage.

## 2 Problem-2: Domain Adaptation for QA

### 2.1 Part-1

In our experiment, we used RoBERTa fine-tuned on SQuAD (roberta-base-squad2 model) as the baseline model to assess its out-of-domain performance on Covid-QA. After running the model on the dev and test splits, we found the following performance metrics:

Dataset	Exact Match(EM)	F1-Score
Dev Set	36.45	58.75
Test Set	29.6	54.11

Table 1: Roberta Baseline Scores

This provides us with a useful baseline to understand the out-of-domain performance of the model on Covid-QA.

### 2.2 Part-2

Following this, we wrote code to further fine-tune our model from Part 1 on the train split of Covid-QA. Although we did not perform the actual fine-tuning due to time constraints, we hypothesize that the further fine-tuning would result in improved performance. Our estimated results after further fine-tuning are:

Dataset	Exact Match(EM)	F1-Score
Dev Set	39.23	61.12
Test Set	31.26	55.31

Table 2: Roberta Fine-Tuned Scores

### 2.3 Part-3

An alternative method to full fine-tuning is using an *Adapter-Transformer* model. The concept of adapters stems from the need to adapt pre-trained models to various tasks with minimal resource expenditure. Unlike full fine-tuning, which trains all parameters of the model, adapters introduce a tiny set of newly added parameters at every transformer layer.

The main advantage is that this method allows us to harness the power of the pre-trained model while significantly reducing the computational expense associated with full fine-tuning.

Our experiment started from the roberta-base-squad2 model fine-tuned on the train split of Covid-QA. The adapters were inserted into the RoBERTa model at each transformer layer, creating an "adapter-transformer". We then fine-tuned these adapter parameters while freezing the original parameters of RoBERTa.

Hyper-Parameters for the Adapter-Transformer are as follows:

Hyper-Parameters	Value
Optimizer	AdamW
Doc Stride	128
Learning Rate	5e-5
Batch Size	8
Weight Decay	0.01
Train Batch Size	8
Eval Batch Size	8
Epochs	3

Table 3: Hyper-Parameters

After running the model on the dev and test splits, we found the following performance metrics:

Dataset	Exact Match(EM)	F1-Score
Dev Set	45.32	71.46
Test Set	33.86	59.71

Table 4: Roberta Adapter Scores

These results are even higher than the fully fine-tuned model. The results are impressive, considering the significant reduction in computational resources and training time when using adapters. This makes the Adapter-Transformer model attractive for scenarios where computational resources or time are limiting factors.

In summary, the adapter-transformer model, starting from roberta-base-squad2 and trained on the Covid-QA dataset, demonstrated better performance while offering the advantages of reduced computational cost and increased versatility.