

Industry Project  
CMI Summer Internship with Alumni

# Regulation Chatbot

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# Table of Content

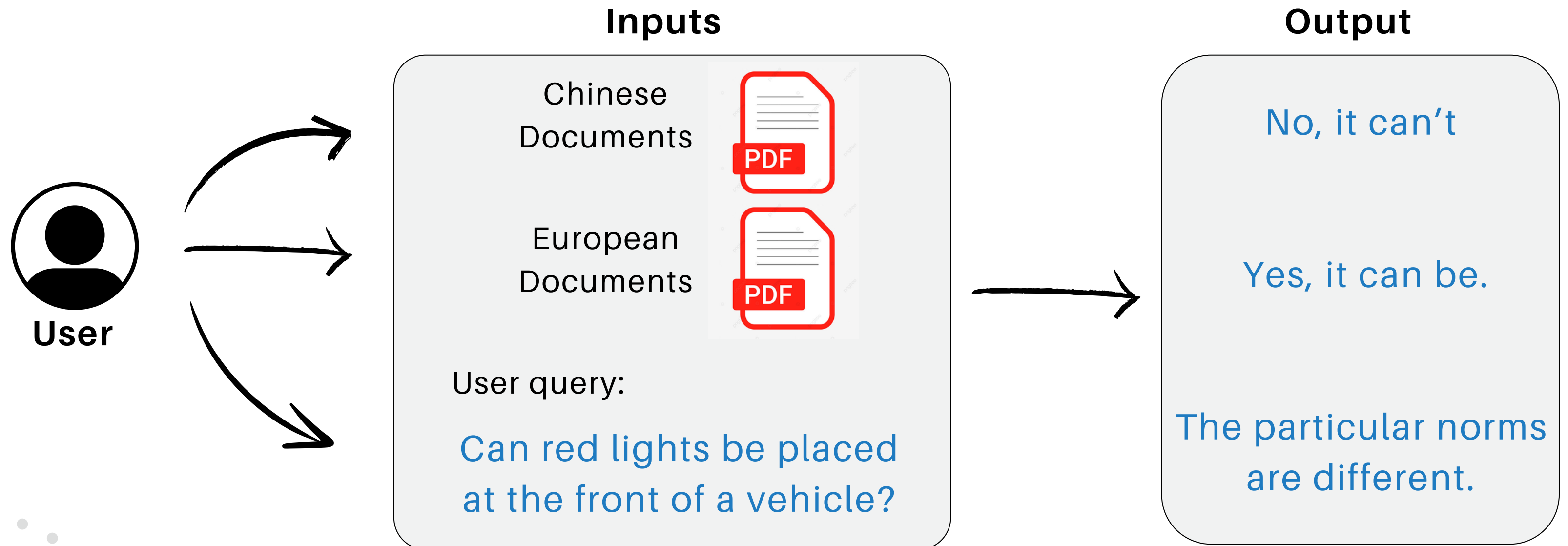
	1	Project overview
The Why	2	
	3	The How
RAG	4	
	5	Problem & approaches
Results & Evaluation	6	
	7	Future Improvements

# 1 Project Overview

➤ Each country have different norms/rules/**regulations** for illegal sale

➤ **Objective:** To compare them on basis of user query

↪ **Sub-objective:** To generate an answer for user query



# 2

# The Why

➤ Vehicle manufacturing company want to sell internationally

➤ Advantages over doing it manually

- Advantages over doing it manually
- Reduce cost
- Reduce time - **60 hours** to compare two pdfs manually
- Accuracy
- Language discrimination

➤ Why different countries have different norms

- Material Cost
- Carbon emissions
- Weather conditions
- Living Standards

## High Risk

- Need to generate **accurate** answers

### **VW fined ₹500 crore for violating diesel emissions norms in India**

2 min read • 08 Mar 2019, 12:55 AM IST

**Volkswagen to Spend Up to \$14.7 Billion to Settle Allegations of Cheating Emissions Tests and Deceiving Customers on 2.0 Liter Diesel Vehicles**

# 3 The How

## Why started with RAG

- ChatGPT
  - Resticted norms
- Prompting whole pdf to Llama3-chat in local computer
  - **Hallucinates**
- Fine-tunning a LLM
  - Expensive
- RAG
  - Reduce Hallucinations
  - Specific and **accurate** information
  - Less expensive

**LLMs** - Trained for next word prediction

Once upon a

**GPT-3.5**

time

Fine-tunned for chat

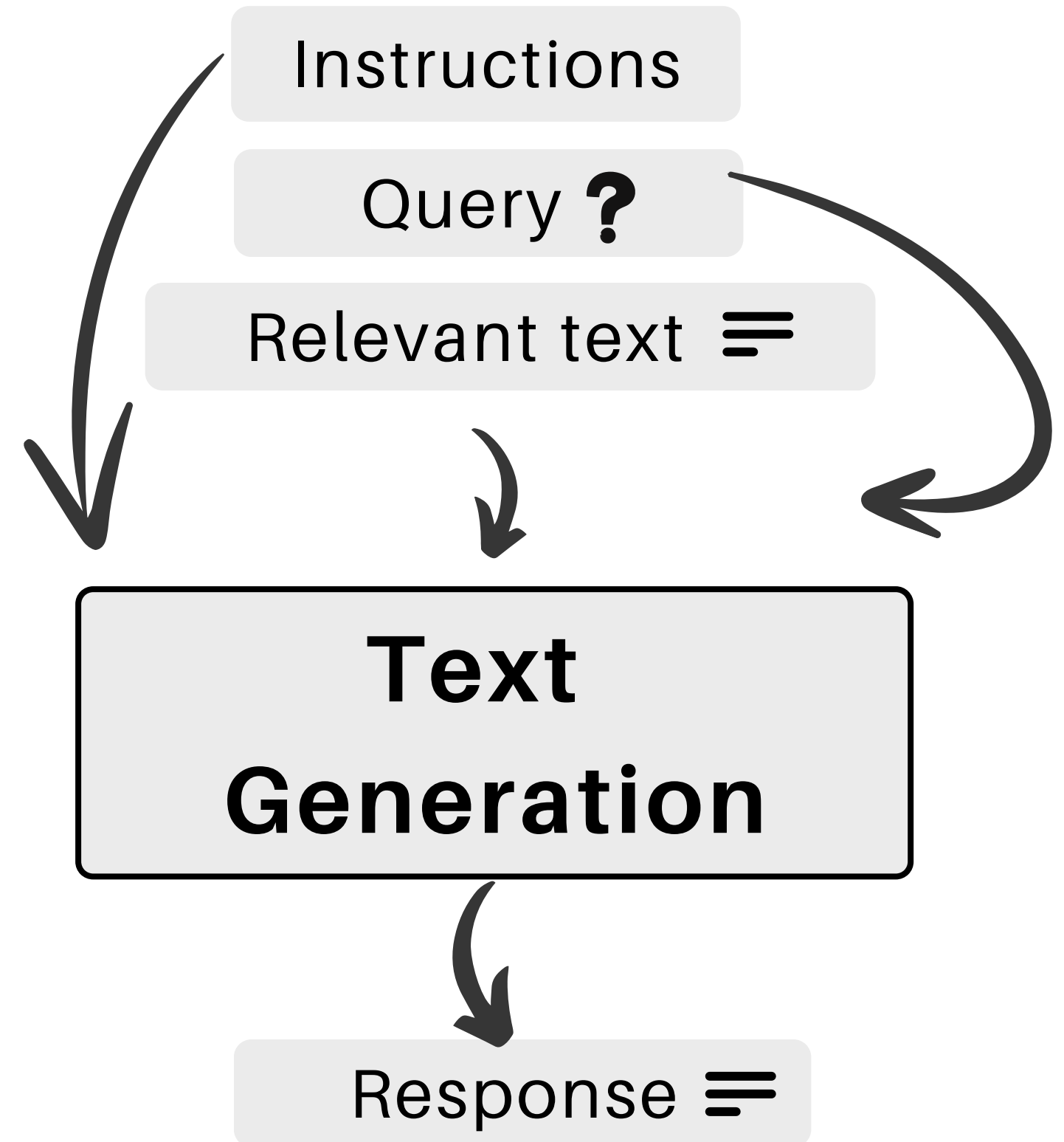
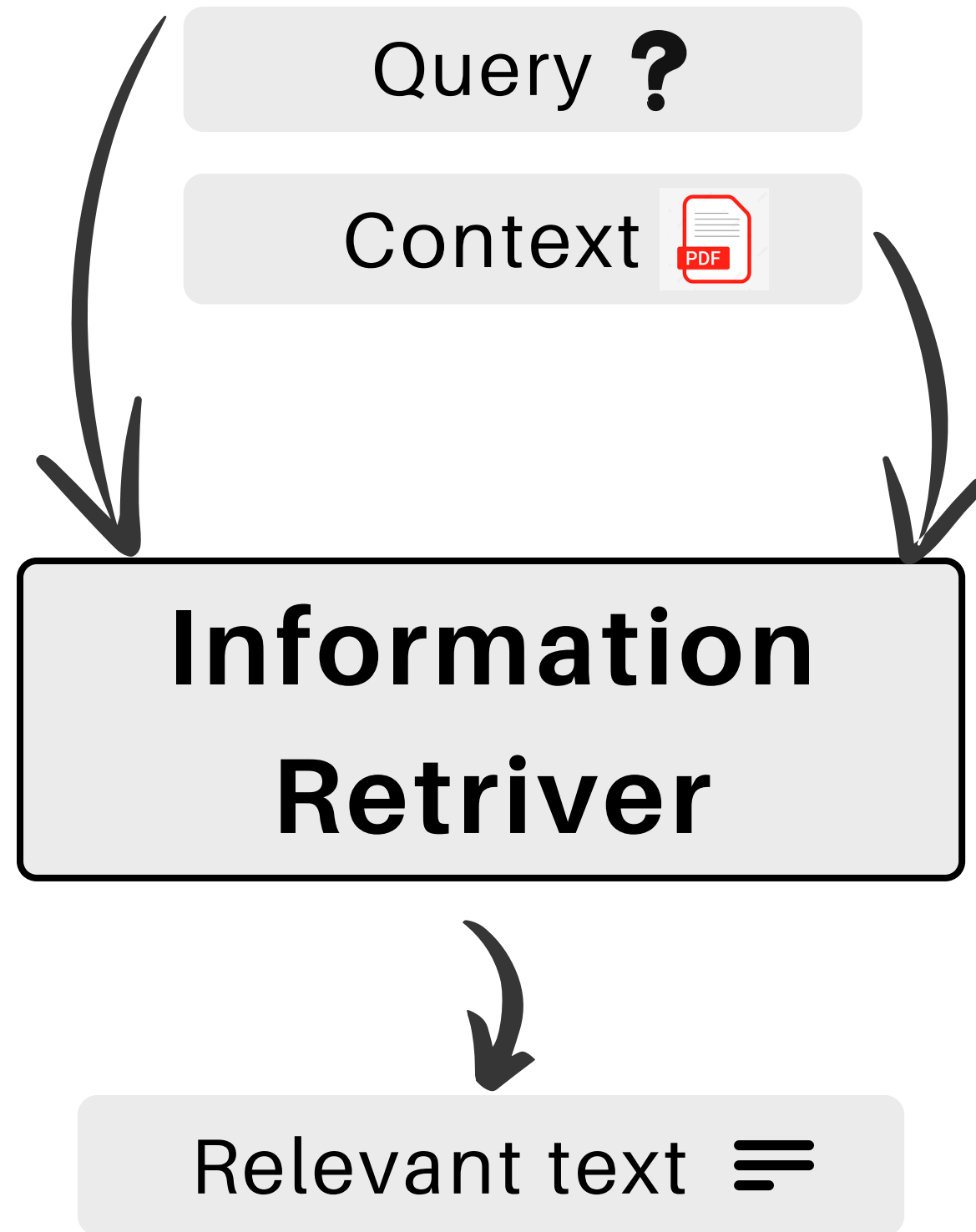
Write a story

**ChatGPT**

There was a king .....

**Fine-tuned LLMs** - for specific task

# 4 RAG



1

# RAG

- Responses - Incomplete, can't find context

## Problem 1

### Complex formatting of PDF

- Deeply nested sections
- 5-6 levels even 7 sometimes
- 130 pages pdf
- Table and images

2

## Cumulative page-wise summarization

- **n LLM calls** to summarize
- Time consuming

6.1.9. Other requirements

6.1.9.1. The aggregate maximum intensity of the main-beam headlamps which can be switched on simultaneously shall not exceed 430,000 cd, which corresponds to a reference value of 100.

6.1.9.2. This maximum intensity shall be obtained by adding together the individual reference marks which are indicated on the several. The reference mark "10" shall be given to each of the headlamps marked "R" or "CR".

6.1.9.3. Automatic activation and deactivation of the main-beam headlamps:

6.1.9.3.1. The sensor system used to control the automatic activation and deactivation of the main-beam headlamps, as described in paragraph 6.1.7.1., shall comply with the following requirements:

6.1.9.3.1.1. The boundaries of the minimum fields in which the sensor is able to detect light emitted from other vehicles defined in paragraph 6.1.7.1. above are defined by the angles indicated below.

6.1.9.3.1.1.1. Horizontal angles: 15° to the left and 15° to the right.

Vertical angles:

Upward angle	5°		
Mounting height of the sensor (centre of sensor aperture above the ground)	Less than 2 m	Between 1.5 m and 2.5 m	Greater than 2.0 m
Downward angle	2°	2° to 5°	5°



# Problem 2

## Choosing optimal chunk size

Small chunks	Large chunks
Helps in crisp answer (Strong embeddings)	Helps in large/detailed response
Struggles to generate large/detail response	Struggles to retrieve for crisp response (Weak embeddings)

3

### RAG with parent document retriever

- Uses advantage of both
- Breaks the sections

4

### Prompting pdf section-wise

- Large sections ~ 50 pages
- retriever struggles when crisp answer is needed

What is standard weight of a person for testing?	<p>According to paragraph 1 of Annex 5, the standard weight of a person for testing is 75 kg.</p> <p>ANSWER 1: The test procedures for the Autonomous Emergency Braking System (AEBS) are outlined in Sections 5.1 to 5.8 of the standard GB/T 38186-2019. Here are the detailed test procedures:</p> <p>Test Conditions (Section 5.1) The test environment shall comply with the stipulations of 5.1.2 in GB 12676-2014, and the horizontal visibility range shall allow the target to be observed throughout the test.</p> <p>Vehicle Conditions (Section 5.2) The vehicle shall be tested in a condition of load specified by the manufacturer, with no adjustment made to the vehicle load after the start of the test. The tyre to be used for the test shall be subjected to running-in until reaching normal condition, and the tyre pressure shall be the cold-state inflation value pressure recommended by the vehicle manufacturer. The brake of the subject vehicle shall be subjected to running-in as per the stipulations of 5.1.1.2 in GB 12676-2014.</p> <p>Test Target (Section 5.3) The test may adopt a common passenger car or a soft target. Specific measures that ensure target conformity and repeatability shall be recorded in detail in the vehicle test report.</p> <p>Warning and Activation Performance under Stationary Target (Section 5.4) The test shall be performed with the subject vehicle and the stationary target positioned as specified in 5.4.1. The test shall start with the subject vehicle traveling at a speed of (80±2) km/h, and the stationary target positioned in the same lane as the subject vehicle. From the start of the test until the collision point, there shall be no adjustment to any subject vehicle by the driver other than slight steering wheel adjustments to prevent any drifting of vehicle direction. Early Warning and Activation Performance under Moving Target (Section 5.5) The test shall be performed with the subject vehicle and the moving target positioned as specified in 5.5.1. The test shall start with the subject vehicle traveling at a speed of (80±2) km/h, and the moving target traveling in the same direction as the subject vehicle at a speed of (32±2) km/h. From the start of the test until the subject vehicle comes to a speed equal to that of the target, there shall be no adjustment to any subject vehicle by the driver other than slight steering wheel adjustments to prevent any drifting of vehicle direction. Warning Signal after System Failure (Section 5.6) The test shall simulate an electrical circuit failure by disconnecting the power source to AEBS component or disconnecting any electrical connection between AEBS components. The failure warning device signal, as well as the vehicle speed and time upon the 1st time sending of warning signal, shall be observed and recorded. Driver Initiative Actions (Section 5.7) During the emergency braking phase, the driver shall inspect whether the system response can be interrupted by initiative actions of the driver, such as depression of the accelerator pedal, activation of the direction indicator, and other modes specified by the vehicle manufacturer. For vehicles equipped with a device to deactivate the AEBS, turn the ignition switch to the "on" (run) position and deactivate the AEBS to inspect whether the warning signal is activated. Performance for Prevention of False Reaction of System (Section 5.8) The test shall be performed with two units of common passenger cars positioned as specified in 5.8.1. The subject vehicle shall travel for a distance of at least 60m at a constant speed of (80±2) km/h.</p> <p>ANSWER 2: The test procedures for the Automatic Emergency Braking System (AEBS) are outlined in Section 6, which includes the following tests:</p> <p>Test Conditions (6.1)</p> <p>The test shall be performed on a flat, dry concrete or asphalt surface affording good adhesion. The ambient temperature shall be between 0 °C and 45 °C. The horizontal visibility range shall allow the target to be observed throughout the test. The tests shall be performed when there is no wind liable to affect the results. Vehicle Conditions (6.2)</p> <p>The vehicle shall be tested in a condition of load to be agreed between the manufacturer and the Technical Service. No alteration shall be made once the test procedure has begun. Test Targets (6.3) The target used for the tests shall be a regular high-volume series production passenger car of category M AA saloon, or alternatively a 'soft target' representative of such a vehicle in terms of its identification characteristics applicable to the sensor system of the AEBS under test. Details that enable the target(s) to be specifically identified and reproduced shall be recorded in the vehicle type approval documentation. Warning and Activation Test with a Stationary Target (6.4)</p> <p>The subject vehicle shall approach the stationary target in a straight line for at least two seconds prior to the functional part of the test with a subject vehicle to target centreline offset of not more than 0.5 m. The functional part of the test shall start when the subject vehicle is travelling at a speed of 80 ± 2 km/h and is at a distance of at least 120 m from the target. From the start of the functional part until the point of collision, there shall be no adjustment to any control of the subject vehicle by the driver other than slight adjustments to the steering control to counteract any drifting. The timing for the collision warning modes shall comply with the requirements specified in Table I, Column B of Annex 3. The collision warning phase shall be followed by the emergency braking phase. The total speed reduction of the subject vehicle at the time of the impact with the stationary target shall be not less than the value specified in Table I, Column D of Annex 3. The emergency braking phase shall not start before a TTC (Time to Collision) equal to or less than 3.0 seconds. Warning and Activation Test with a Moving Target (6.5)</p> <p>The subject vehicle and the moving target shall travel in a straight line, in the same direction, for at least two seconds prior to the functional part of the test, with a subject vehicle to target centreline offset of not more than 0.5 m. The functional part of the test shall start with the subject vehicle travelling at a speed of 80 ± 2 km/h, the moving target at a speed specified in Table I, Column H of Annex 3, and a separation distance of at least 120 m between them. From the start of the functional part of the test until the subject vehicle comes to a speed equal to that of the target, there shall be no adjustment to any subject vehicle control by the driver other than slight steering adjustments to counteract any drifting. The timing for the collision warning modes shall comply with the requirements specified in Table I, Columns E and F of Annex 3.</p> <p>Any speed reduction during the warning phase shall not exceed either 15 km/h or 30 per cent of the total subject vehicle speed reduction, whichever is higher.</p> <p>The emergency braking phase shall result in the subject vehicle not impacting the moving target. The emergency braking phase shall not start before a TTC equal to or less than 3.0 seconds.</p> <p>Failure Detection Test (6.6)</p> <p>Simulate an electrical failure, for example by disconnecting the power source to any AEBS component or disconnecting any electrical connection between AEBS components. Turn the ignition (start) switch to the 'off' position. Again, turn the ignition (start) switch to the 'on' (run) position and verify that the previously activated warning signal is not reactivated, thereby indicating that the AEBS has been reinstated as specified in paragraph 5.4.1 above.</p> <p>False Reaction Test (6.8) Two stationary vehicles, of category M AA saloon, shall be positioned: So as to face in the same direction of travel as the subject vehicle, with a distance of 4.5 m between them, with the rear of each vehicle aligned with the other. The subject vehicle shall travel for a distance of at least 60 m, at a constant speed of 50 ± 2 km/h to pass centrally between the two stationary vehicles. During the test, there shall be no adjustment of any subject vehicle control other than slight steering adjustments to counteract any drifting. The AEBS shall not provide a collision warning and shall not initiate the emergency braking phase.</p> <p>COMPARISON: Both answers provide detailed test procedures for the Autonomous Emergency Braking System (AEBS), but they differ in some aspects.</p> <p>Both answers outline similar test conditions, including the test environment, vehicle conditions, and test targets. However, Answer 1 provides more specific details on the test environment, such as compliance with GB 12676-2014, and the vehicle conditions, including the load specified by the manufacturer and tyre pressure. Answer 2, on the other hand, provides more general requirements for the test conditions, such as a flat, dry concrete or asphalt surface and an ambient temperature between 0 °C and 45 °C.</p> <p>The test procedures for warning and activation performance under stationary and moving targets are similar in both answers, but with some differences in the specific requirements. For example, Answer 1 requires the subject vehicle to travel at a speed of (80±2) km/h, while Answer 2 requires a speed of 80 ± 2 km/h. Additionally, Answer 1 provides more detailed requirements for the warning signal after system failure, driver initiative actions, and performance for prevention of false reaction of the system.</p> <p>Answer 2 provides more detailed requirements for the failure detection test, including simulating an electrical failure and verifying that the previously activated warning signal is not reactivated. Answer 1 does not provide similar details for this test.</p> <p>In summary, while both answers provide similar test procedures for the AEBS, they differ in some specific requirements and details. Answer 1 provides more detailed requirements for the test environment, vehicle conditions, and some test procedures, while Answer 2 provides more general requirements and additional details for the failure detection test.</p>
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# Problem 3

Answer in **multiple** part of PDF.

- **53 pages**, 25 lamps
- 6.a.4 contains position of ath lamp

6.	Individual specifications
6.1.	Main-beam headlamp (Regulations Nos. 98 and 112)
6.1.1.	Presence Mandatory on motor vehicles. Prohibited on trailers.
6.1.2.	Number Two or four, type approved according to Regulations Nos. 98 or 112, excluding Class A headlamp. For vehicles of the category N <sub>3</sub> : Two extra main-beam headlamps may be installed. Where a vehicle is fitted with four concealable headlamps the installation of two additional headlamps shall only be authorized for the purpose of light-signalling, consisting of intermittent illumination, at short intervals (see paragraph 5.12. above) in daylight.
6.1.3.	Arrangement No individual specifications.
6.1.4.	Position
6.1.4.1.	In width: No individual specifications.
6.1.4.2.	In height: No individual specifications.
6.1.4.3.	In length: At the front of the vehicle. This requirement shall be deemed to be satisfied if the light emitted does not cause discomfort to the driver either directly or indirectly through the devices for indirect vision and/or other reflecting surfaces of the vehicle.
6.1.5.	Geometric visibility The visibility of the illuminating surface, including its visibility in areas which do not appear to be illuminated in the direction of observation considered, shall be ensured within a divergent space defined by generating lines based on the perimeter of the illuminating surface and forming an angle of not less than 5° with the axis of reference of the headlamp. The origin of

30



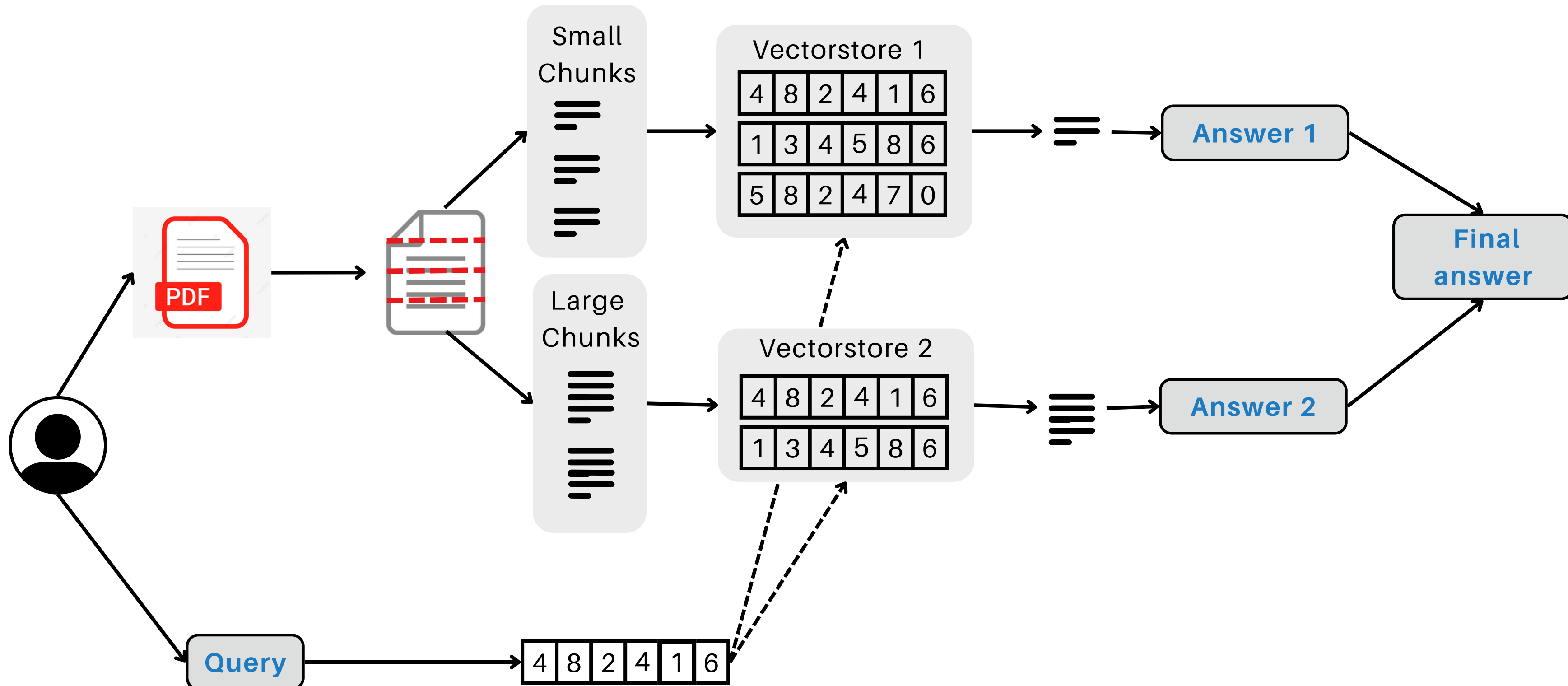
6.25.	Rear-end collision alert signal
6.25.1.	Presence Optional The rear-end collision alert signal shall be given by the simultaneous operation of all the direction indicator lamps fitted as described in paragraph 6.25.7.
6.25.2.	Number As specified in paragraph 6.5.2.
6.25.3.	Arrangement As specified in paragraph 6.5.3.
6.25.4.	Position As specified in paragraph 6.5.4.
6.25.5.	Geometric visibility As specified in paragraph 6.5.5.
6.25.6.	Orientation As specified in paragraph 6.5.6.
6.25.7.	Electrical connections. Compliance with these requirements shall be demonstrated by the applicant, by simulation or other means of verification accepted by the Technical Service responsible for type approval.
6.25.7.1.	All the lamps of the rear-end collision alert signal shall flash in phase at a frequency of 4.0 +/- 1.0 Hz.
6.25.7.1.1.	However, if any of the lamps of the rear end collision alert signal to the rear of the vehicle use filament light sources the frequency shall be 4.0 +0.0/-1.0 Hz.
6.25.7.2.	The rear-end collision alert signal shall operate independently of other lamps.
6.25.7.3.	The rear-end collision alert signal shall be activated and deactivated automatically.

83

5

## Custom Multi-retriever RAG

- 2 retrievers - smaller and larger chunks
- Good **Accuracy**





# Prompting: a tedious treasure hunt!

```
template1 = """
You are the Vehicle Regulation Assistant, a helpful AI assistant.
Your task is to answer given questions from the provided relevant part of the PDF.
The answer should be highly-detailed and well-structured.
If possible, refer to specific sections number within the context (e.g., "According to section 4.1.2,...").
Do not begin your response with phrases like "Based on the provided context, the answer to the question is:".
Be polite and helpful.

CONTEXT: {context}

QUESTION: {question}
"""

template2 = """
Your task is to answer the question, using only the information provided in the given context.
The answer should be accurate and detailed.
Where applicable, refer to specific section numbers within the context (e.g., "According to section 4.1.2,...").
If the answer is not found in the provided context, simply state that there is no relevant information available
without sharing details about the context.

CONTEXT: {context}

QUESTION: {question}
"""

template3 = """
Please provide a detailed and well-structured response to the question below, using only the information provided in the context.
If the context does not contain information related to the question, explicitly state that there is no relevant information in the provided context.
Be polite and helpful.
Also, provide a confidence level from 0 to 100% in your response based on how certain you are about the information you have provided.

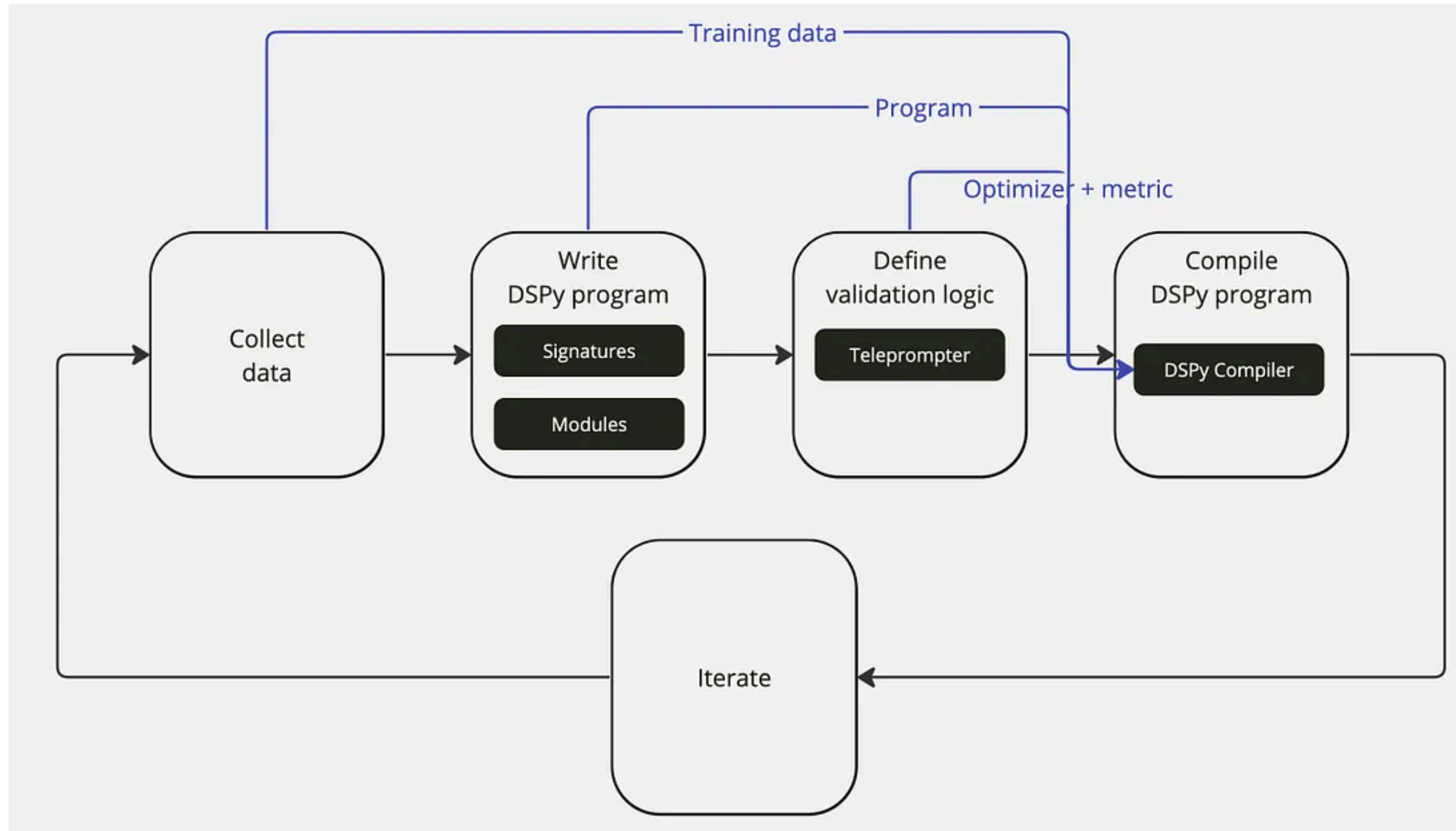
CONTEXT: {context}

QUESTION: {question}
"""
```

# 5 DSPy

➤ Declarative Self-improving Language Programs (developed by Stanford University)

➤ Programming---**not Prompting**-- Language Models



# DSPy Components

1 **Signatures:** It specifies the input and output format

- "question, context-> answer"
- "document -> summary"

Replace how to prompt the LM with what a transformation does

Hand-written prompt

```
"Answer the question based
only on the following
context: {context}
Question: {question}
Answer: "
```

vs.

Signature

```
"context, question --> answer"
```

2 **Modules:** specify prompting technique

- dspy.Predict
- **dspy.ChainOfThought**

Automatically generated  
prompt

Signature

```
"context, question --> answer"
```

Module

ChainOfThought

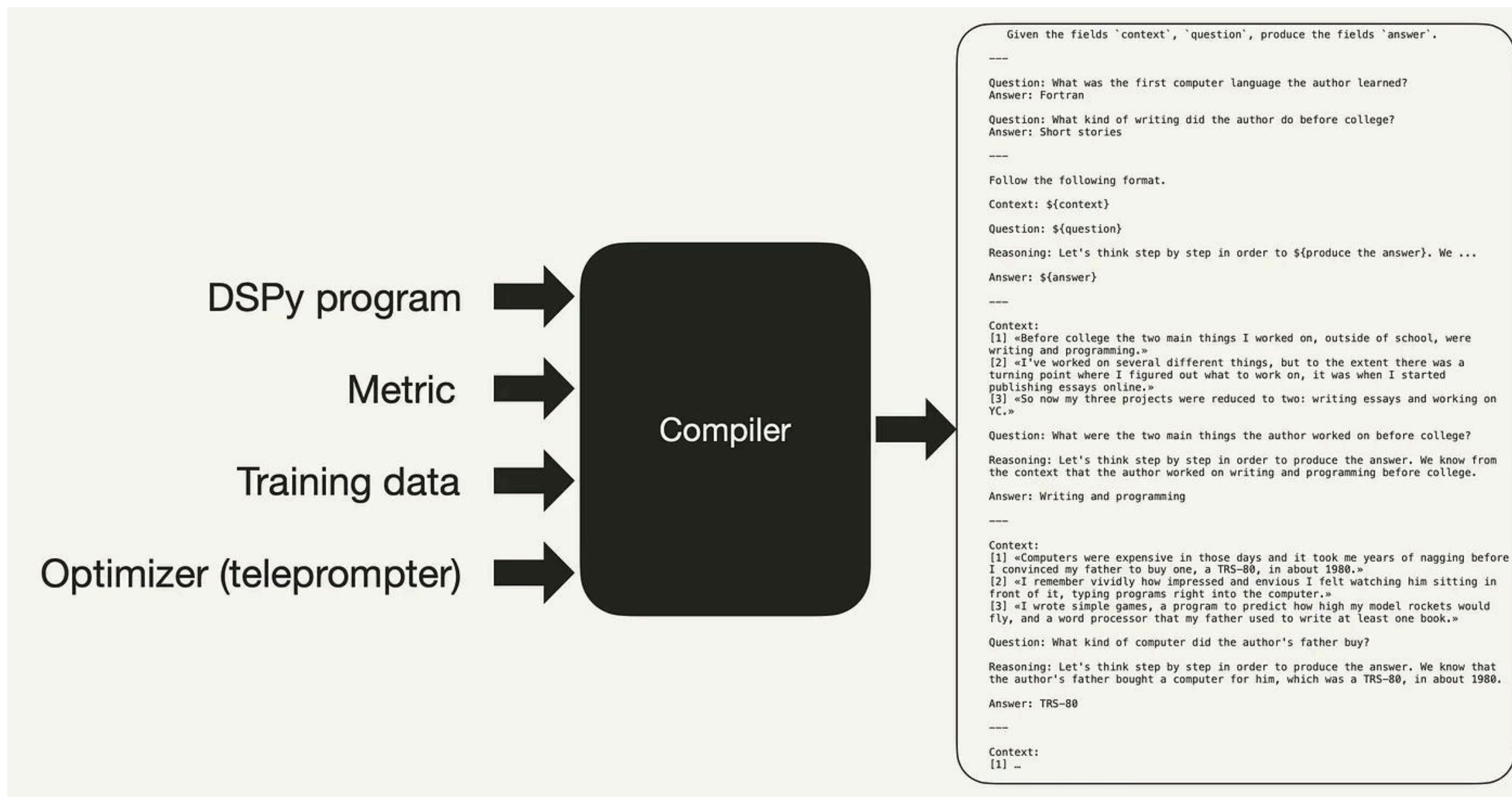
```
"Given the fields `context`,
`question`, produce the fields
`answer`.
```

```
---
Follow the following format.
Context: ${context}
Question: ${question}
Reasoning: Let's think step by
step in order to ${produce the
answer}. We ...
Answer: ${answer}"
```



3

**Optimizers:** To adjust the settings of a DSPy program, including both the **prompts** and the language model **weights**.



6	Results	
	Query	Answers
	<p>What are the different types of Front fog lamps?</p>	<p>There are two types of Front fog lamps: White Front fog lamps and Selective Yellow Front fog lamps. These types are classified based on the color of the light emitted by the lamps, with White Front fog lamps emitting white light and Selective Yellow Front fog lamps emitting selective yellow light.</p>
	<p>What are the lights placed in front of the vehicle?</p>	<p>The lights placed in front of the vehicle are:</p> <ul style="list-style-type: none"> <li>* Main-beam headlamps</li> <li>* Dipped-beam headlamps</li> <li>* Front-fog lamps</li> <li>* Front direction-indicators</li> <li>* Front position lamps</li> <li>* Daytime running lamps</li> <li>* Cornering lamps</li> <li>* Adaptive front lighting system (AFS)</li> <li>* Manoeuvring lamps</li> <li>* Exterior courtesy lamps</li> <li>* Front retro-reflector, non-triangular</li> <li>* Front position lamp</li> <li>* Adaptive front-lighting systems (AFS)</li> </ul> <p>These lights may have specific requirements and regulations regarding their installation, operation, and performance, as outlined in the provided context.</p>
	<p>Can dipped-beam headlamp and main-beam headlamp for front lighting system?</p>	<p>The answer to the question is that it is allowed to have both dipped-beam headlamps and main-beam headlamps for the front lighting system, but they cannot be used simultaneously.</p> <p>According to section 6.2.7.1, the control for changing over to the dipped-beam shall switch off all main-beam headlamps simultaneously, implying that they are two separate entities that can be switched between. However, section 6.2.7.2 states that the dipped-beam may remain switched on at the same time as the main beams, which suggests that it is possible to have both types of headlamps, but they would need to be switched between, not used at the same time.</p>

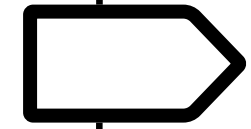


≡ Aspect	≡ Document 1 (UN/ECE Regulation No. 131)	≡ Document 2 (GB/T 38186-2019)	≡ Equivalence	≡ Notes
Test Conditions	<ul style="list-style-type: none"> <li>- Flat, dry concrete or asphalt surface</li> <li>- Ambient temperature 0°C to 45°C</li> <li>- Good horizontal visibility range</li> <li>- No wind affecting results</li> </ul>	<ul style="list-style-type: none"> <li>- Flat, dry concrete or asphalt surface with good adhesion</li> <li>- Horizontal visibility range allowing target observation</li> <li>- No specific temperature or wind conditions mentioned</li> </ul>	Partially Equivalent	Document 1 specifies temperature and wind conditions, while Document 2 does not. Both require a flat, dry surface and good visibility.
Vehicle Conditions	<ul style="list-style-type: none"> <li>- Test weight agreed between manufacturer and technical service</li> <li>- No alteration once test begins</li> </ul>	<ul style="list-style-type: none"> <li>- Load condition specified by manufacturer</li> <li>- No adjustment after test start</li> <li>- Tires run-in to normal condition</li> <li>- Brakes run-in per GB 12676-2014</li> </ul>	Partially Equivalent	Both documents require a fixed vehicle condition, but Document 2 provides more specific requirements for tires and brakes.

# 6 Evaluation

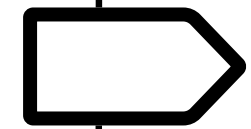


**Manual** Evaluation



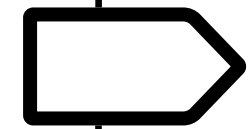
Our target

- Correct information
- Complete information - High recall
- No additional information - High precision



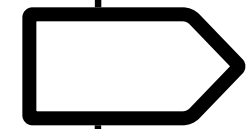
Using another LLM as judge to evaluate will not be very effective for our case.

- Complex structure of PDF



Response are taking too much times

- 4 vectorstore and retrivers
- 7 LLM calls
- llama3 in local computer



Getting good **accuracy** on cost of **time**

# Application

- llama3 in **local** computer

## Upload Your PDF Files

Choose the first PDF file

Drag and drop file here

Limit 200MB per file • PDF

Browse files



GB AEBS.pdf

284.0KB



First PDF uploaded successfully! 

Choose the second PDF file

Drag and drop file here

Limit 200MB per file • PDF

Browse files

Deploy



What are test procedures?



ANSWER 1: Test procedures are a set of standardized methods used to evaluate the performance of a system or device under various conditions. In the context of Advanced Emergency Braking System (AEBS) testing, the test procedures are outlined in Section 5 of the standard GB/T 38186-2019 and include:

1. Test conditions: The test environment shall comply with the stipulations of 5.1.2 in GB 12676-2014, and the horizontal visibility range shall allow the target to be observed throughout the test.
2. Vehicle conditions: The vehicle shall be tested in a condition of load specified by the manufacturer, and the tyre to be used for the test shall be subjected to running-in until reaching normal condition, with the tyre pressure being the cold-state inflation value recommended by the vehicle manufacturer.
3. Test for AEBS deactivation: This involves turning the ignition switch to the "on" (run) position and deactivating the AEBS to inspect whether the warning signal is activated, then turning the ignition switch to the "shutdown" (off) position, and finally, turning the ignition switch to the "on" (run) position and verifying whether the previously activated warning signal

Type something... 





# 7 Future Improvements



Handling multiple languages



Knowledge Database





# Thank you :)

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