

# Ensembling Multiple Hallucination Detectors Trained on VLLM Internal Representations

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## Abstract

This paper presents the 5th place solution by our team, y3h2, for the Meta CRAG-MM Challenge at KDD Cup 2025. The CRAG-MM benchmark is a visual question answering (VQA) dataset focused on factual questions about images, including egocentric images. The competition was contested based on VQA accuracy, as judged by an LLM-based automatic evaluator. Since incorrect answers result in negative scores, our strategy focused on reducing hallucinations from the internal representations of the VLLM. Specifically, we trained logistic regression-based hallucination detection models using both the hidden\_state and the outputs of specific attention heads. We then employed an ensemble of these models. As a result, while our method sacrificed some correct answers, it significantly reduced hallucinations and allowed us to place among the top entries on the final leaderboard.

## CCS Concepts

- Computing methodologies → Natural language generation.

## Keywords

Vision-Language Models, Hallucination Detection, Linear Probing

## 1 Introduction

Vision-Language Large Models (VLLMs) have made remarkable progress in recent years, significantly enhancing multi-modal understanding and visual question answering (VQA) applications, such as those deployed on smart glasses. However, despite these advances, VLLMs continue to struggle with the generation of hallucinated answers. In KDD Cup 2025, Meta introduced the CRAG-MM[3] benchmark—a VQA dataset focused on factual questions about images, including egocentric images captured with Ray-Ban Meta smart glasses. Participants were tasked with building an MM-RAG system that generates appropriate answers by effectively leveraging external sources and suppressing hallucination. This paper

describes the 5th place solution for the Meta CRAG-MM Challenge at KDD Cup 2025. Our code is available on GitLab<sup>1</sup>.

## 1.1 Dataset

CRAG-MM is constituted of images paired with questions about the visual content and their corresponding answers. This dataset contains two splits : *validation* and *public\_test*, and they are also labeled this way on Hugging Face. In our paper, we followed this naming convention exactly as given by the organizers.

- **Images:** The dataset includes both egocentric images captured with Meta Ray-Ban glasses and third-person images taken by other individuals.
- **Domain Coverage:** 13 distinct domains (e.g., Books, Food, Science, Shopping, Animals, Vehicles) reflecting diverse real-world scenarios.
- **QA Category:**
  - Simple Recognition (answerable solely from the image)
  - Simple Knowledge (requires external factual lookup)
  - Multi-hop questions (requires chaining multiple facts)
  - Comparison & Aggregation (requires aggregating or comparing multiple pieces of information)
  - Reasoning (cannot be directly looked up and require reasoning to answer)
- **Interaction Modes:** Includes both *single-turn* and *multi-turn* dialogues to evaluate context-aware capabilities.
- **External Sources:** For all tasks, image-KG-based retrieval is available via an image mock API. Additionally, for Tasks 2 and 3, web retrieval can be performed using a web search mock API.

## 1.2 Tasks

The main goal of this competition is to build a Multi-Modal RAG (MM-RAG) system for VQA that utilizes external knowledge sources to achieve higher accuracy on the CRAG-MM benchmark. Specifically, the competition consists of the following three tasks that differ in the types of external knowledge that can be referenced and the forms of interaction.

\*Both authors contributed equally to this research.

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<sup>1</sup><https://gitlab.aicrowd.com/htanabe/meta-comprehensive-rag-benchmark-starter-kit>

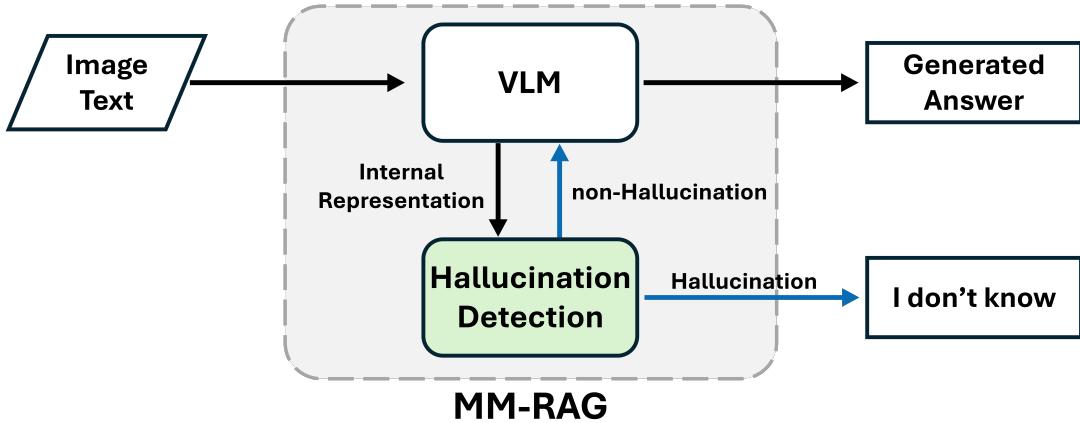


Figure 1: The overview of Our solution

#### (1) Task 1: Single-source Augmentation

This task evaluates the fundamental answer generation capability of MM-RAG systems. Only the image mock API is provided, which allows retrieval of information associated with similar images.

#### (2) Task 2: Multi-source Augmentation

This task evaluates the system's ability to synthesize information from multiple sources by additionally providing a mock web search API. Participants are required to integrate information from both the image-KG and web sources to generate answers.

#### (3) Task 3: Multi-turn QA

This task assesses the system's ability to handle multi-turn conversations, requiring not only accurate question answering but also contextual understanding and conversation smoothness across multiple turns.

### 1.3 Evaluation Metrics

- **Automatic Grading:**

- Answers are graded by an LLM-based automatic judge for leaderboard.
- Each answer is classified as *correct*, *partially correct*, *incorrect*, or *missing/refusal*.

- **Manuel Grading:**

- Answers that receive high scores on automatic judge are subsequently re-evaluated by human assessors to determine the final ranking.
- Each answer is classified as *correct*, *partially correct*, *incorrect*, or *missing/refusal*.

- **Scoring:**

- +1 point for a correct answer.
- 0 points for partial, missing, or refusal.
- -1 point for an incorrect (hallucinated or wrong) answer.
- Leaderboard score is determined by trustfulness score, which is the average score across all examples in the evaluation set for a given MM-RAG system.

### 1.4 models

It is required to use Llama models to build MM-RAG in this competition. Especially, participants can use or fine-tune the Llama 3 models, which can be run on 48GB GPU memory. In our MM-RAG, we adapted **meta-llama/Llama-3.2-11B-Vision-Instruct**<sup>2</sup>

## 2 Solution

In this competition, the performance of MM-RAG is evaluated by the average score, where a correct answer receives +1, an incorrect answer (hallucination) receives -1, and "I don't know" yields 0. The final score, called the trustfulness score, is the average score across all VQA pairs. Since a high number of incorrect answers leads to a negative trustfulness score, we adopted a strategy that detects hallucinations from internal representations of VLLM, which is used to filter answers: whenever a hallucination is detected, the system returns "I don't know." Previous studies (e.g., [1, 2, 4]) have shown that hallucination generation in LLMs or VLLMs can be detected from internal representations, and in particular, the outputs of attention heads are known to be effective for hallucination detection. We applied these research findings into our solution.

Figure 1 presents an overview of our solution. In our solution, we simply applied a baseline model (LlamaVisionModel) equipped with a hallucination detection filter to all tasks.

The other approaches we tried for mitigating hallucination are described in the Appendix A.

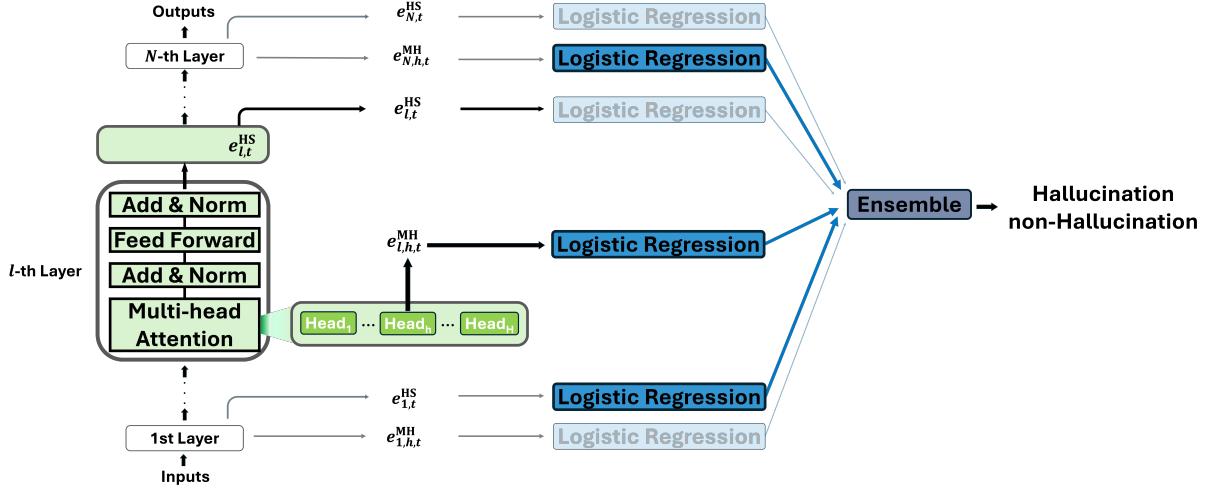
### 2.1 Hallucination Detection Filter

Our goal is to detect whether the answer being generated by the VLLM during inference is correct or a hallucination, based on its internal representations, and to automatically return "I don't know" whenever a hallucination is detected.

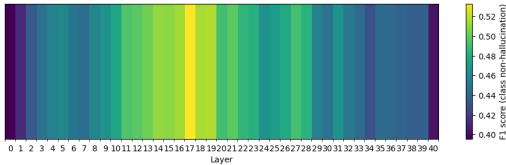
Specifically, we trained logistic regression models to classify answers as hallucinations or not, using the hidden states from each layer (`hidden_states`) and the outputs from each attention head (`attention_outputs`) as features. The overview of Hallucination Detection Model is shown in Figure 2.

<sup>2</sup><https://huggingface.co/meta-llama/Llama-3.2-11B-Vision-Instruct>

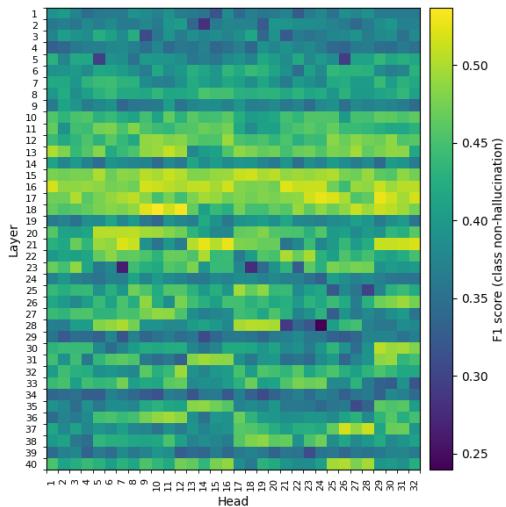
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**Figure 2: Hallucination Detection Filter**



**Figure 3: F1 score for hallucination detection from hidden state**



**Figure 4: F1 score for hallucination detection from attention heads**

First, we extracted the internal representations by getting model to answer VQA from the *validation* split of the dataset. For each predicted token  $t$ , we extracted the final token's activation from

both the hidden state ( $e_{l,t}^{HS}$ ) and the attention head ( $e_{l,h,t}^{MH}$ ). We computed the average  $e_t$  of generated across all token predictions to obtain  $e$ , which is then used as the feature representation for each layer's hidden state and attention head. Concurrently, we evaluated the generated answer using LLM-as-a-Judge, labeling correct and incorrect answers as  $y = 1, 0$ , respectively. Using these  $X$  and  $y$ , we trained logistic regression models:

$$\hat{y} = \sigma(\mathbf{w}^\top \mathbf{e} + b) \quad (1)$$

where  $\sigma(\cdot)$  is the sigmoid function,  $\mathbf{w}$  is the weight vector,  $\mathbf{e}$  is the input feature vector (either  $e_{l,t}^{HS}$  or  $e_{l,h,t}^{MH}$ ), and  $b$  is the bias term. Here, the dimensionality of  $e_{l,t}^{HS}$  was reduced using PCA, retaining as many principal components as needed to ensure that the cumulative contribution rate exceeded 95%.

Next, we used the data of *public\_test* split and select which layer's hidden state and attention head outputs to use for hallucination detection. While model answering on the *public\_test* set, we applied the trained hallucination detection models. Then, we selected the hidden states and attention heads that could sufficiently detect hallucinations, specifically those with a non-hallucination F1 score above 0.5. This threshold was chosen empirically. The detection performance for each hidden state and attention head is shown in Figure 3 and Figure 4. We selected 7 hidden states and 58 attention heads, and trained a total of 65 logistic regression models. The selected layers and positions are described in the Appendix B.

Finally, we ensembled the detection models trained on the selected hidden states and attention heads by averaging their outputs.

For each sample, we calculated the mean of the predictions  $\hat{y}_j$  from all ensembled models:

$$\bar{y} = \frac{1}{N} \sum_{j=1}^N \hat{y}_j \quad (2)$$

where  $N$  is the number of ensembled models.

**Table 1: Results for Task 1, Task 2, and Task 3. Each table shows accuracy, missing, hallucination, and trustfulness.**

Single-turn tasks				
Method	Accuracy	Missing	Hallucination	Trustfulness
Baseline	0.207	0.058	0.735	-0.528
+ only hidden_state (HS)	0.099 ( $\downarrow$ 52%)	0.812	0.089 ( $\downarrow$ 88%)	0.010
+ only attention_heads (MH)	0.081 ( $\downarrow$ 61%)	0.873	0.046 ( $\downarrow$ 94%)	0.035
+ HS+ MH (our method)	0.082 ( $\downarrow$ 61%)	0.873	0.045 ( $\downarrow$ 94%)	0.036
Leaderboard (Task 1)	0.088	0.860	0.052	0.036
Leaderboard (Task 2)	0.088	0.859	0.053	0.034

Multi-turn task				
Method	Accuracy	Missing	Hallucination	Trustfulness
Baseline	0.268	0.352	0.379	-0.111
+ only hidden_state (HS)	0.173 ( $\downarrow$ 36%)	0.742	0.084 ( $\downarrow$ 78%)	0.089
+ only attention_heads (MH)	0.156 ( $\downarrow$ 42%)	0.784	0.060 ( $\downarrow$ 84%)	0.097
+ HS+ MH (Our Method)	0.155 ( $\downarrow$ 42%)	0.784	0.061 ( $\downarrow$ 84%)	0.094
Leaderboard (Task 3)	0.138	0.827	0.035	0.104

## 2.2 Visual-Question Answering

You are a helpful assistant that truthfully answers user questions about the provided image.  
Keep your response concise and to the point. If you don't know the answer, respond with 'I don't know'.

**Figure 5: The prompt used in Our Solution**

An overview of our solution is presented in Figure 1. We applied the Hallucination Detection Filter trained in Section 2 to the baseline shared by the organizers, LlamaVisionModel. For the prompt, we directly used the one used in the baseline, shown in Figure 5. No external sources were used at all.

When an image and question are given as input, the VLLM attempts to generate an answer. At this stage, the hallucination detection model trained in Section 2 is used to judge, based on the internal activations, whether the generated answer is a hallucination. Specifically, if the predicted value for  $y = 0$  (non-hallucination) exceeds 0.65, the answer is accepted as is; otherwise, the system outputs "I don't know." The threshold value of 0.65 was chosen by selecting the value that yielded the highest trustfulness score on the *public\_test* split.

## 3 Results

The results of our strategy are shown in Table 1. In the upper table, we report the performance on the single-turn tasks (Task 1 and Task 2). The baseline model achieved an accuracy of 0.207 and a hallucination rate of 0.735 (Trustfulness = -0.528). Applying the hidden-state filter (+ only hidden\_state) reduced accuracy to 0.099 ( $\downarrow$  52%) but suppressed hallucinations to 0.089 ( $\downarrow$  88%) and improved Trustfulness to 0.010. The attention-head filter (+ only attention\_heads) further lowered accuracy to 0.081 ( $\downarrow$  61%), but cut hallucinations to 0.046 ( $\downarrow$  94%), yielding a Trustfulness of 0.035. Our combined method (HS+AH) maintained a high level of hallucination suppression of 0.045 ( $\downarrow$  94%) and achieved the highest offline reliability of 0.036, although the correct response rate also

dropped to 0.082. On the leaderboard's private test sets, our approach yielded an accuracy of 0.088, a hallucination rate of 0.052 for Task 1 and 0.053 for Task 2, and Trustfulness scores of 0.036 and 0.034, respectively.

In the lower table, we report performance on the multi-turn task (Task 3). The baseline model achieved an accuracy of 0.268, a missing rate of 0.352, and a hallucination rate of 0.379 (Trustfulness = -0.111). Applying the hidden-state filter (+ only hidden-state) reduced accuracy to 0.173 ( $\downarrow$  36%) but suppressed hallucinations to 0.084 ( $\downarrow$  78%) and improved Trustfulness to 0.089. The attention-head filter (+ only attention\_heads) further lowered accuracy to 0.156 ( $\downarrow$  42%) and cut hallucinations to 0.060 ( $\downarrow$  84%), yielding a Trustfulness of 0.097. Our combined method (HS+AH) maintained this high level of hallucination suppression, with a hallucination rate of 0.061 ( $\downarrow$  84%) at an accuracy of 0.155 ( $\downarrow$  42%), achieving a Trustfulness of 0.094. Supplementary analysis conducted during manuscript preparation revealed that, for the multi-turn task, the attention-head filter alone actually achieved the highest Trustfulness, slightly surpassing the combined method's, but in the competition, we unified with the single-turn and submitted the combined method. On the leaderboard's private test set for Task 3, our approach yielded an accuracy of 0.138, a hallucination rate of 0.035, and a Trustfulness of 0.104.

An ablation study on filtering is additionally provided in the Appendix C.

## 4 Conclusion

In the META CRAG-MM Challenge, it was essential not only to improve VQA accuracy but also to address the challenge of hallucinations. While leveraging external sources through RAG can enhance factual correctness, it does not fully eliminate the risk of generating hallucinated answers. Building more trustworthy AI involves not only expanding the range of a model's knowledge, but also enabling it to recognize and explicitly indicate when it lacks the necessary information to answer a question. Our experience in this KDD Cup reinforced the importance of such mechanisms for

developing reliable and responsible AI systems. In the future, we aim to focus on developing LLMs that can reliably recognize and admit when they do not know the answer.

## Acknowledgments

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## A Other attempted approaches

To mitigate hallucination, we also tried several other methods.

### A.1 Prompt Control

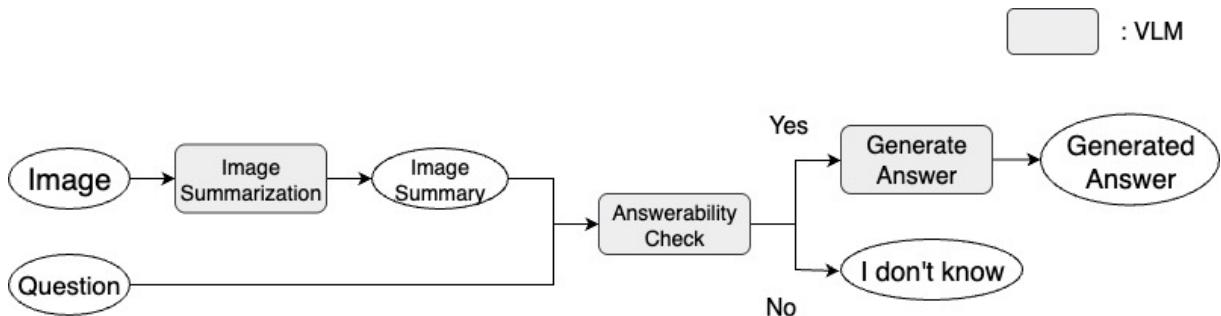


Figure 6: The overview of Answerability Check

You will receive:

- An image
- An image description summarizing the image content
- A query: a question related to the image

Your task:  
Determine if the query can be answered solely based on the provided image.

Respond only "yes" or "no"

Figure 7: The prompt for image summarization

You are a helpful assistant that analyzes image and query to determine what's needed for a complete answer. Please follow these steps:

1. Summarize the information visible in the provided image.
2. Identify what additional external information or background knowledge is needed to answer the given query beyond what can be seen in the image.

Figure 8: The prompt for answerability check

You are an assistant who answers questions about a given image.  
In addition to the image, refer to the provided image  
description.  
Answer only the specific question asked, and do so concisely.  
Base your answer strictly on facts from the image and its  
description, without any speculation or interpretation.  
Your answer must be under 50 words and end with a period.

Figure 9: The prompt for generating answer

- **Answerability Check (AC)** (Figure 6):

Given an image and a question, the VLLM produces an image summary (Prompt: Figure 7). An answerability check then determines whether the question can be answered based on the image summary and question (Prompt: Figure 8). If so, the model generates an answer Prompt: Figure 9; otherwise, it outputs "I don't know."

## A.2 Internal states of VLLM

- **Logprobs**

During answer generation, we extracted the logprobs. When the logprob of the generated answer was below the threshold, the model was forced to output "I don't know". We report results with thresholds of  $-0.01$ ,  $-0.07$ , and  $-0.1$ .

## A.3 Results

Table 2: The results of other attempted approach

Method	Accuracy	Missing	Hallucination	Trustfulness
Baseline	0.207	0.058	0.735	-0.528
AC	0.080	0.802	0.118	-0.039
Logprobs (-0.01)	0.063	0.853	0.084	-0.021
Logprobs (-0.07)	0.064	0.853	0.084	-0.020
Logprobs (-0.1)	0.064	0.848	0.089	-0.025
Our Method	0.088	0.860	0.052	0.036

Although we tried several alternative methods as shown in the Table 2, the approach of training a hallucination detection model on internal activations (Our Method) worked best, so we adopted it as our final solution.

## B The selected layers and head positions

Table 3: The used hidden state selected by non-hallucination F1 score.

Rank	Layer	F1
1	17	0.5329
2	19	0.5167
3	18	0.5154
4	16	0.5139
5	14	0.5109
6	15	0.5093
7	13	0.5032

**Table 4: Top 58 attention heads selected by non-hallucination F1 score.**

Rank	Layer	Head	F1	Rank	Layer	Head	F1
1	17	9	0.5368	30	17	26	0.5118
2	17	11	0.5317	31	12	10	0.5109
3	16	28	0.5278	32	15	21	0.5109
4	20	15	0.5271	33	20	28	0.5108
5	16	23	0.5256	34	14	16	0.5107
6	20	13	0.5252	35	20	29	0.5102
7	17	8	0.5239	36	15	13	0.5093
8	15	20	0.5217	37	15	12	0.5078
9	20	6	0.5216	38	16	7	0.5069
10	16	24	0.5198	39	19	7	0.5066
11	20	31	0.5182	40	14	19	0.5063
12	36	25	0.5177	41	19	6	0.5062
13	16	31	0.5169	42	29	28	0.5060
14	15	8	0.5167	43	15	10	0.5058
15	15	0	0.5166	44	17	29	0.5054
16	15	15	0.5157	45	14	8	0.5051
17	14	17	0.5157	46	15	30	0.5050
18	16	29	0.5156	47	15	31	0.5047
19	16	22	0.5151	48	19	4	0.5047
20	17	10	0.5137	49	19	5	0.5041
21	20	30	0.5136	50	20	14	0.5040
22	15	23	0.5134	51	27	17	0.5040
23	36	27	0.5133	52	20	12	0.5040
24	17	28	0.5131	53	14	11	0.5035
25	15	9	0.5128	54	27	18	0.5021
26	15	22	0.5127	55	12	0	0.5018
27	14	10	0.5121	56	14	24	0.5013
28	15	28	0.5120	57	16	2	0.5009
29	20	7	0.5119	58	39	25	0.5009

## C F1-based Filter Selection Ablation

**Table 5: Maximum Accuracy/Hallucination/Trustfulness and number of selected filters at each F1 threshold**

F1 threshold	Number of filters	Accuracy	Missing	Hallucination	Trustfulness	Ensemble threshold
0.0	1321	0.068	0.886	0.045	0.023	0.56
0.1	1321	0.068	0.886	0.045	0.023	0.56
0.2	1321	0.068	0.886	0.045	0.023	0.56
0.3	1313	0.069	0.885	0.046	0.023	0.56
0.4	752	0.074	0.878	0.048	0.026	0.58
0.5	65	0.082	0.873	0.045	0.036	0.65

We conducted an additional investigation into the effect of varying the F1-score threshold in filter selection. For each threshold setting (ranging from 0.0 to 1.0 in increments of 0.1), the selection criterion was adjusted such that only filters with an F1 score strictly exceeding the threshold were retained. For each case, we report in Table 5 the the best evaluation scores, together with the corresponding number of selected filters and the threshold applied for the final hallucination judgment. When the F1 threshold was set to 0.6 or higher, no filters met the condition. Therefore, no results are reported for these ranges. Among the evaluated settings, a threshold of 0.5 yielded the best performance, and this value was adopted in our final competition submission.