SANITIZING LLMS: RETROSPECTIVE LEARNING FOR SELF-CORRECTION OF INCONSISTENT SAMPLES VIA USER PREFERENCES

Anonymous authors
Paper under double-blind review

ABSTRACT

With the advent of large language models (LLMs), using LLMs in conjunction with prompt-based tasks has demonstrated the ability to reduce the high cost and inefficiency of human annotations. Nonetheless, in unsupervised new downstream tasks that require user preferences to align data annotations with expectations, existing evaluation methods for prompt-based tasks become ineffective, especially when ground truth annotations are insufficient or missing. To fill this gap, we propose the novel Consistent and Inconsistent (CAI) Ratio, inspired by our experimental observation that LLMs underperform when the number of inconsistent samples—those with inconsistent predictions across LLMs and the student model—exceeds the number of consistent samples. By estimating the CAI ratio and identifying consistent and inconsistent samples with our proposed CAI identification approach, we aim to minimize inconsistency and enhance the accuracy of LLM-generated annotations for unsupervised data. To achieve this, we introduce Retrospective Learning (ReL) with user preference, a data-centric approach that collaborates with the student model and LLMs, using a small number of human annotations as user preferences to resolve inconsistencies in the identified samples. Applied to five domain-specific NLP datasets, our Retrospective Learning approach, leveraging CAI identification, significantly improved the accuracy of LLM-generated responses, with the CAI ratio increasing as the accuracy improved.

1 INTRODUCTION

Large language models (LLMs), with their unprecedented zero-shot performance (Kojima et al., 2022), have seen burgeoning deployment across various domains of NLP problems. In particular, LLMs are being leveraged as teachers, alongside smaller pre-trained models as student learning paradigms, to generate annotations and mitigate the inefficiencies, high costs, and dependence on notoriously laborious manual annotation (Chen et al., 2024). However, it has been demonstrated that LLMs possess intrinsic drawbacks, such as randomness, inconsistency (Sclar et al., 2024; Atreja et al., 2024) and hallucination, which can detrimentally impact the trustworthiness of their generated output. To address these issues, prompt-based learning tasks (Brown et al., 2020; Chen & Tsang, 2024; Wei et al., 2021; Yao et al., 2022; Diao et al., 2023; Liu et al., 2023; Wang et al., 2023; Wei et al., 2022; Brown et al., 2020; Yao et al., 2024; Long, 2023; Huang et al., 2022; Madaan et al., 2024; Huang et al., 2023; Shinn et al., 2024) have emerged. Devising specific and effective evaluation metrics for LLMs is vital to improving LLMs' performance across various prompt-based tasks. Conventionally, many of these tasks rely on ground truth annotations from the training dataset to evaluate proposed prompts. Feedback from this evaluation is then utilised to iteratively refine the prompts, by that improving LLM performance on the testing dataset. However, in unsupervised downstream tasks with user preferences, in which explicit guidance is not in provision, it becomes crucial to design a learning process that encourages annotations to align with user preferences to improve the quality of training for a new downstream model. This challenge is commonly encountered and ubiquitous in many real-world applications, especially in intent classification, sentiment analysis, and recommendation systems, where the user or expert preference alignment is essential for generating satisfying annotations. For instance, in AI chatbots like ChatGPT, unsupervised data—queries or questions from users with the same intention but expressed in different formats or languages—without predefined user preference

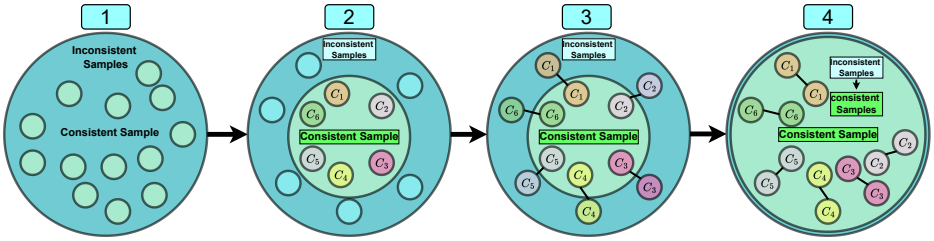


Figure 1: **Schematic Depiction of Retrospective Learning (ReL)**. The inner circle is the consistent sample set $\mathcal{C}$, and its expansion (the outer circle) is the set that covers all the inconsistent samples $\mathcal{I}$. The third circle shows our proposed *Sanitizing LLMs* solving inconsistent (difficult) sample issues. The C indicates each category of the samples. The line connects between small circles in the out circle and inner circle, symbolising the cosine similarity between the inconsistent sample and consistent sample, the highest ones assigned to the corresponding class (**See Section 3**).

categories can result in responses that fail to meet user expectations. Thus, a user preference-based annotation process and evaluation is essential to ensure that model-generated responses appropriately align with end-user needs. While it might seem intuitive to use LLMs alone for annotation, they may struggle with data that involve specific user preferences for a new downstream task. Furthermore, in unsupervised learning tasks that rely on user preferences to align data annotations with expectations, where the competency of the teacher model (LLMs) is uncertain and no external knowledge are provided, evaluating annotations generated by the LLM becomes a significant challenge. These annotations are often prone to overconfidence in their predictions (Zhou et al., 2024; Xiong et al., 2023), which necessitates the implementation of self-supervised mechanisms for self-correction. In this scenario, relying solely on a student model for fine-tuning or training from scratch is also not feasible, given the lack of supervision. In summary, there are two critical challenges in new downstream tasks with only an unsupervised dataset and user preferences:

- **Challenge on Evaluation:** *How can we evaluate the performance of LLMs or student-generated annotations based on user preferences when dealing with unsupervised data?*
- **Self-Correction for Unsupervised Tasks with Limited User Preferences:** *Given an unsupervised task that lacks annotations for fine-tuning LLMs and training a student model with only a small set of user preferences, how can we enable self-correction to improve annotation accuracy for both models without relying on any external knowledge?*

To address the challenge of evaluation, **Consistent and Inconsistent (CAI)** ratio (**see Section 3.2**), the first evaluation metric designed for unsupervised textual datasets in prompt-based tasks. Our experimental study reveals that LLMs tend to perform poorly when the number of consistent samples with consistent predictions between LLMs and the student model outnumbers the inconsistent samples. While the CAI ratio can partially assess the performance of LLMs and the student model on a given unsupervised dataset, it does not fully resolve the issue of inconsistent outputs, as evidenced by the identified inconsistent samples. These samples represent a subset of the training data that has demonstrated inconsistent predictions across both LLMs and the student model, with significantly lower annotation accuracy **(see Figure 3)**.

Furthermore, if the incorrect annotations of the identified inconsistent samples can not be self-corrected, this incorrect annotation will pass to the student model, resulting in poor generalisation. Thus, identifying and being able to self-correct inconsistent samples are crucial for enhancing the consistency and accuracy of LLM-generated annotations. To address this challenge, ***Retrospective Learning (ReL)*** is proposed. ReL uses clues and a divide-and-conquer self-correction (DCSC) technique in conjunction with the consistently identified samples, which are identified with considerably greater accuracy than the inconsistent ones. The inconsistent samples are self-corrected via the DCSC process, which employs a top-nearest embedding scheme and majority voting. By utilising the CAI identification, our strategy consistently increased classification accuracy with a higher CAI ratio when we applied it to five domain-specific datasets.

2 BACKGROUND

2.0.1 LLMS FOR DATA ANNOTATION

LLMs have exhibited excellent competency in dealing with text annotation tasks for many open domain tasks, such as spoken language understanding (Chen et al., 2024; 2023), without requiring training on specific data, more often than not, can already outperform crowdsourcing and manual annotation (Gilardi et al., 2023). However, there needs to be more work in providing evaluation metrics and effective and economically friendly methods in dealing with unsupervised textual data with user preference. Our work fills this gap.

2.0.2 LLM AND STUDENT ANNOTATION PARADIGMS

Previous works (Thapa et al., 2023; Chen et al., 2024; 2023) emphasise exploiting teacher and student to outperform each other. Recently, (Gligorić et al., 2024) have proposed collaborating between LLMs and human annotation to search for unbiased, accurate annotations and searching for a balance between high cost from human annotation and LLMs affordability and efficiency. However, the issue with the above approach is that if some samples are always mispredicted, naively applying students by proposing a loss function can not solve the problem. In addition, the previous student and teacher paradigm overlooks exploiting difficult samples, a crucial factor attributing to the degradation of the model performance. To the best of our knowledge, no work has explored collaboration between LLMs and student models with a small number of human annotations for self-correction for the inconsistency based on our proposed CAI ratio (See Section 3.4).

2.1 PROBLEM SETTING

Given unsupervised text corpus distributions for testing and training, denoted as $\mathcal{D}_u = \{x_1, \ldots, x_N\}$ and $\mathcal{D}_T = \{x_1, \ldots, x_L\}$, where $x \in \mathcal{X} \subseteq \mathbb{R}^d$. A set of user-preference samples H is also given. These user-preference samples are clustered into k clusters $C_1, C_1, ..., C_k$. In addition, a set of preference annotations is also given, denoted as $\mathcal{Y} = \{\bar{y}_1, \bar{y}_2, ..., \bar{y}_k\}$. Each C_j is denoted as $C_j = \{(x_i, \bar{y}_j) | x_i \in H_j\}$ and $H_j \subseteq H$. $H = \{(x_i, \bar{y}_i)\}_{i=1}^{s}$, with $s = 5\%$ of $|\mathcal{D}_T|$. Each Cluster does not overlap, and the union of clusters forms the H. These user-preference samples incorporate user preferences for alignment purposes. The learning objective is to assign a user preference label $\bar{y} \in \mathcal{Y} = \{1, \ldots, k\}$ to each x. We assume that the distribution $\mathcal{D}_u$ can be partitioned into two subsets: consistent samples $\mathcal{C}$ and inconsistent samples $\mathcal{I}$, such that $\mathcal{C}, \mathcal{I} \subseteq \mathcal{D}_u$, $\mathcal{C} \cap \mathcal{I} = \emptyset$, and $|\mathcal{C}| + |\mathcal{I}| = |\mathcal{D}_u|$. However, in practice, the consistent and inconsistent subsets are not known in advance and must be estimated **(see Section 3.1)**. The consistent and inconsistent samples are identified using the student model $\mathcal{S}$ and teacher model $\mathcal{T}$, along with a small set of user-preference samples. The learning objective is to minimize the inconsistency (i.e., reduce the size of $\mathcal{I}$) and maximize the annotation accuracy of the LLMs on $\mathcal{D}_u$.

3 SANITIZING LLMS PARADIGAM

3.1 PROCUREMENT OF ANNOTATED SAMPLE DISTRIBUTIONS FROM STUDENT AND TEACHER MODELS

User Preference Based Majority Voting Annotation for Unsupervised Data with User Preference: The initial step is to align each instance of unsupervised data with annotations according to user preferences. We start by using MINILM (Wang et al., 2020), a sentence-transformers model, as our student model denoted as $\mathcal{S}$, to first acquire $\mathcal{S}(x_i) = e_i$, sentence embeddings, for each x_i. Initially, it has been trained on the whole textual dataset X. Thereafter, we apply our proposed *user preference-based majority voting* approach inspired by (Mostafazadeh Davani et al., 2022) to assign annotations based on our proposed Average Similarity(AS) function1. For each data point x_i, we calculate the average cosine similarity between its embedding e_i and the embeddings of all samples in each cluster C_j as follows:

$$\text{AS}(e_i, C_j) = \frac{1}{|C_j|} \sum_{e \in C_j} \frac{e_i \cdot e}{\|e_i\| \|e\|}, \tag{1}$$

where $e \in C_j$ represents the embeddings in cluster C_j. Given an unlabeled dataset D_u and a set of user-preference samples H, which represent user preferences, the goal is to assign annotations to the samples in D_u according to their semantic similarity to the hints. The user-preference samples H clustered into k number of clusters, denoted as $C_1, C_2, \ldots, C_k$ and each C_j is assigned a annotation $\bar{y}_j \in \mathcal{Y} = \bar{y}_1, ..., \bar{y}_k$ predefined by user as preference. For each cluster C_j that it consists of samples $x_i \in C_j$ with the same annotation y_i predefined by the user as a preference y_j. The cluster C_{j^*}, which has the highest average cosine similarity with e_i, is defined as:

$$C_{j^*} = \arg\max_{C_j} \text{AS}(e_i, C_j)$$

where C_{j^*} and assign x_i with $\bar{y}_i = y_{j^*}$. We use the annotation assignment function $h(x_i)$ to represent the process. Subsequently, the annotation associated with C_{j^*}, as defined by the user, will be assigned to x_i. Finally, the student-annotated dataset $D_s = \{(x_i, \bar{y}_i)\}_i^N$, where each $\bar{y}_i$ represents the user preference-based annotation, is obtained by following the user preference-based majority voting annotation approach.

Teacher-Annotated Sample Distributions: With the acquired dataset $D_s = \{(x_i, \bar{y}_i)\}_{i=1}^N$, we further exploit LLMs using zero-shot prompting (without including annotations from the student) and single-shot prompting (including annotations from the student) through a group prompting method to provide annotations for each x_i. We define the annotations as $\bar{y}_i^t = T(x_i)$ for zero-shot prompting and $\hat{y}_i^t = T(x_i, \bar{y}_i)$ for single-shot prompting, where $(x_i, \bar{y}_i) \in D_s$. Since the LLM is an autoregressive language model, we simply ask ChatGPT to provide the annotation for each query x without giving $\bar{y}_i$ for zero-shot prompting. Consequently, we obtain the teacher distribution $D_t = \{(x_i, \bar{y}_i^t)\}_{i=1}^N$ and the augmented distribution $\hat{D}_t = \{(x_i, \hat{y}_i^t)\}_{i=1}^N$. During prompting, we set the temperature parameter to 1 to maximize output diversity. The reason for acquiring two distributions—one with and one without the student model's annotations—is to ensure output diversity and prevent performance collapse when the LLMs exhibit limited competence in the task. Additionally, providing step-by-step explanations has been shown to enhance LLM performanceWei et al. (2022).

3.2 Consistent Inconsistent and Inconsistent Sample Identification and Ratio

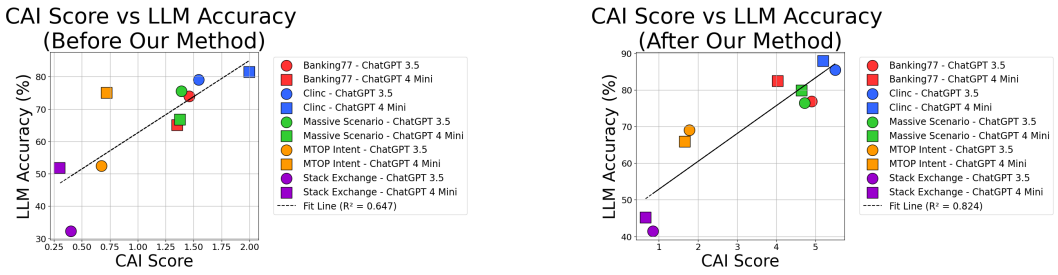
3.2.1 Consistent and Inconsistent (CAI) Identification for Unsupervised Datasets

After we have acquired $D_s = \{(x_i, \bar{y}_i)\}_{i=1}^N$, $D_t = \{(x_i, \bar{y}_i^t)\}_{i=1}^N$, and $\hat{D}_t = \{(x_i, \hat{y}_i^t)\}_{i=1}^N$, the first challenge still remains unresolved: assessing the annotations generated by LLMs or assigned by the student model due to the unavailability of ground truth annotations. To address this problem, we propose the **Consistent and Inconsistent Sample (CAI)** *Identification* and *Ratio*. The CAI identification aims to identify the consistent and inconsistent samples among D_s, D_t, and $\hat{D}_t$, specifically focusing on samples with consistent annotations across the student and teacher distributions. More precisely, the CAI identification utilizes annotations from the teacher model LLMs $\mathcal{T}$ and the student model pretrained sentence embedder $\mathcal{S}$. Samples with the same predictions from both the student and teacher models are defined as consistent samples; otherwise, they are inconsistent samples. The identification process is as follows: **Student Model Predictions:** For each $x \in \mathcal{D}_u$, the h which is an annotation assignment student model: $\bar{y}_\mathcal{S} = h(x)$. For each $x \in \mathcal{D}_u$, the teacher model $\mathcal{T}$ generates a annotation: $\bar{y}_\mathcal{T} = \mathcal{T}(x; t)$, and $\hat{y}_\mathcal{T} = \mathcal{T}(x, \bar{y}; t)$, where t denotes the temperature parameter controlling diversity. **Consistency Check:** If $\bar{y}_\mathcal{S} = \bar{y}_\mathcal{T}$, then $x \in \mathcal{C}$ (consistent samples). If $\bar{y}_\mathcal{S} \neq \bar{y}_\mathcal{T} \neq \hat{y}_\mathcal{T}$, then $x \in \mathcal{I}$ (inconsistent samples). We have also provided a pseudo-algorithm table as follows:

Algorithm 1: Consistent and Inconsistent Sample Identification

Input: Dataset $\mathcal{D}_u = \{x_1, x_2, \ldots, x_n\}$, Teacher Model $\mathcal{T}$, Student Model for annotation assignment h
Output: Consistent Samples $\mathcal{C}$, Inconsistent Samples $\mathcal{I}$

```
Initialize(C = ∅, I = ∅);
for each x_i ∈ D do
    T(x_i) :→ ȳ_T, T(x_i, ȳ_i) :→ ŷ_T, h(x_i) :→ ȳ_S;
    if ȳ_T == ȳ_S == ŷ_T then
        C ← C ∪ {x_i}                                   // Consistent
    else
        I ← I ∪ {x_i}                                   // Inconsistent
return C, I;
```



(a) (b)

Figure 2: The above analysis shows the correlation between LLM annotation accuracy and the Consistent and Inconsistent (CAI) ratio. We also conducted statistical tests to assess the significance of this correlation. We collected the CAI ratios for (LLMs 3.5 Turbo and Student Model) and (LLMs 4.0 Mini and Student Model) across the datasets CLINC, Massive Scenario, MTOP Intent, Stack Exchange, and Banking77. Using these data, we calculated the Pearson correlation coefficients between the LLM annotation accuracies and CAI ratios and computed the associated P-values to determine the statistical significance of the observed correlations.

Nonetheless, the identification of consistent and inconsistent samples still cannot tell us about the quality of annotations generated and assigned by the LLMs and the student model.

3.2.2 Consistent and Inconsistent (CAI) Ratio for Unsupervised Datasets

Given the identification of consistent and inconsistent samples through our CAI identification process, we propose the Consistent and Inconsistent (CAI) ratio to evaluate LLM-generated annotations on unsupervised data with user preferences. Additionally, the CAI ratio measures the confidence of the LLM-generated outputs—in this case, the annotations. We define the size of the consistent sample set as N_C and the size of the inconsistent sample set as N_{IC}. The CAI ratio is defined as follows:

$$\text{CAI Ratio} = \frac{N_C}{N_{IC}} \tag{2}$$

From our observations: When the CAI Ratio > 1 (i.e., $N_C > N_{IC}$), the LLM-generated annotations are more certain and consistent, demonstrating higher confidence in the model's predictions. Conversely, when the CAI Ratio < 1 (i.e., $N_C < N_{IC}$), it reflects less certainty and consistency, suggesting the need to adjust the prompting approach or switch to a different student model for the given unsupervised dataset. Furthermore, if the CAI ratio is too low, indicating that N_{IC} greatly outnumbers N_C, prior knowledge or additional human annotations are necessary to improve annotation accuracy. Overall, a CAI Ratio > 1 indicates that the LLM is more confident in its predictions, whereas a CAI Ratio < 1 shows that the model is less confident in its predictions.

3.2.3 Law of Consistency

We have defined the phenomenon of the higher CAI ratio showing higher LLMs annotation accuracy as the Law of Consistency, stating that if both the LLM model and student model are optimal hypotheses which are T^* and S^* for the given dataset D_u, the number of identified consistent samples should outnumber the identified inconsistent samples as number of sample reach to a infinite large. We have conducted significance testing to justify our findings that the CAI ratio can serve as an indicator of LLM performance under unsupervised data with user preferences. Additionally, **Figures 2(a)** and **2(b)** demonstrate a strong positive correlation between a higher CAI ratio and higher LLM annotation accuracy, with $R^2 = 0.647$ and $R^2 = 0.824$, respectively.

3.3 Retrospective Learning (ReL) for Self-Correction of Inconsistent Samples (DCSC)

ReL consists of two key components: Divide-and-Conquer Self-correction and Majority Voting via the Top-Nearest Embedding Scheme. These approaches work collaboratively to achieve self-correction of the inconsistent samples.

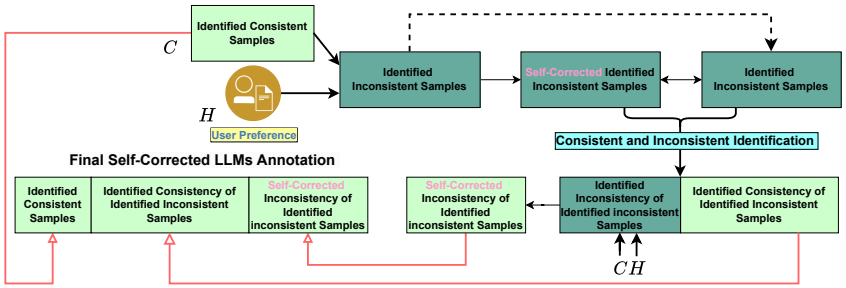


Figure 3: **Divide-and-conquer self-correction for the Inconsistent samples.** Using CAI identification, we first identify the consistent and inconsistent samples, denoted $D_u = I \cup C$. Subsequently, we apply the DCSC process to refine further inconsistency of the identified inconsistent sample where $II \in I$.(**See Section 3.3**).

3.3.1 Divide-and-Conquer Self-Correction

Given the identified consistent and inconsistent samples with user preference samples and the initial assessment based on the CAI identification, the next challenge we are addressing is resolving the self-correction for unsupervised data with limited user preferences. Our proposed Divide-and-Conquer Self-Correction (DCSC) approach addresses this challenge. We begin by using the consistent samples, C, and the inconsistent samples, I, further dividing I into two categories using CAI identification: CI (consistency of identified inconsistent samples) and II (inconsistency of identified inconsistent samples). Precisely, the DCSC process consists of two rounds of self-correction (see Figure 2). In the first round of identification and self-correction, we aim to self-correct the identified inconsistent samples using the identified consistent samples I and a H, leading to self-corrected inconsistent samples. Once this correction using majority voting via top-nearest embedding scheme (MV-VTES) is completed, we apply the CAI identification again to the self-corrected identified inconsistent samples and identified inconsistent samples, aiming to identify II samples for self-correction, incorporating user-preference samples and the identified consistent samples. This second round concludes our Divide-and-Conquer Self-Correction paradigm.

3.3.2 Majority Voting via Top-Nearest Embedding Scheme (MV-VTES)

The self-correction of inconsistent samples and inconsistency of inconsistent samples is realised by applying an MV-VTES, which includes selecting the most semantic similar example from the identified consistent samples and user-preference samples for each inconsistent sample. Choose example (a_{top}, l_{top}) as an positive example from $D_{(A,L)_e}$, based on highest cosine similarity score with x to be fed into $G_t(x, a_{top}, l_{top})$. Given an query which is denoted as x, our goal is to find the positive example $\{a_{\text{top}}, l_{\text{top}}\}$ in $D_{(A,L)_e}$ that has the highest cosine similarity score with x.

$$\{(a_i, \bar{y}_i)\}_{i=1}^{K} = \underset{(a_i,l_i)\in D_{(A,L)_e}}{\text{arg top-}K} \left(\frac{\mathcal{S}(a_i) \cdot \mathcal{S}(x)}{\|\mathcal{S}(a_i)\| \|\mathcal{S}(x)\|} \right) \tag{3}$$

given the selected top-k positive samples, the final annotation is assigned with majority voting and averaging. Basically, the annotations in $\{a_{\text{i}}, \bar{y}_{\text{i}}\}$, which occurs the most frequently, will be voted as the final prediction. Let $\bar{y}_i$ denote the annotation associated with a_i in the top-K samples. For each $x \in I$, there is a corresponding $\{(a_i, \bar{y}_i)\}_{i=1}^{K}$ applying our self-reflection search algorithm. For the top-k selected samples for x_i, there will be a set of possible annotations $A = \{a_1, a_2, \ldots, a_k\}$ corresponding to each top-k selected sample. For the given set A, we compute the frequency n_a , denote as $n_a = \sum_{i=1}^{K} \mathbf{1}_{\{\bar{y}_i = a\}}$, of each annotation $a \in A$ and assign the annotation of A with the highest frequency as the final annotation $\hat{y}$ for x. The formula is defined as follows:

$$\hat{y} = \underset{a \in A}{\text{argmax}}\ n_a \tag{4}$$

The cosine similarity score measures the semantic embedding similarity between the Query x_i and Sample a. The selected Sample with the highest cosine similarity score is considered a positive

sample. Unlike traditional data-centric methods like data pruning (Yang et al., 2022; Liu et al., 2020) or teacher and student distillation (Chen et al., 2024)—which extract only the most correct or informative data—our philosophy is to use the extracted information to correct the inconsistent samples. We believe all representative samples (consistency and inconsistency) should be considered to train a more robust and generalizable model. More often than not, the inconsistent samples hinder model performance and annotation accuracy the most. Higher-quality annotation or improved model performance cannot be acquired without correcting incorrect annotation among identified inconsistent samples.

4 EXPERIMENTS

4.0.1 BASELINES

Using Only Student: We utilise a student model using user prefernce samples to assign initial annotation for unsupervised data with our proposed preference-based annotation scheme. Applying a pre-trained student model to annotate unsupervised data according to user preferences is a cost-effective approach compared to crowd-sourcing or even LLMs.

Using Only LLMs: As our second baseline, we use LLMs *(ChatGPT 3.5 and ChatGPT 4o mini)* in a zero-shot setting. The categories defined by user preferences are provided during prompting. The application of LLMs for unsupervised textual data is considered affordable, but it might be unreliable if the generated outputs are incorrect or inconsistent.

Student (Our) and LLMs (ChatGPT 4o Mini and ChatGPT 3.5): We use the Student model with our proposed **hint-based majority voting approach** to assign annotation for each unsupervised data. Then, we use it as a demonstration to help LLMs to generate annotation.

A Consistent Sample of Student and Teacher Knowledge Distillation: A special case of our methodology is the distillation of student-teacher knowledge using consistent samples. In order to enhance downstream model generalisation, we systematically identify inconsistent samples and exclude them from the training process of pretrained BERT as the student model. This is comparable to our retrospective learning approach; rather than reconfiguring the student model, we implement self-correction and reassign annotations to the inconsistent samples.

Clustering Approach: Our proposed Majority Voting via the Top-Nearest Embedding Scheme is a new clustering method for unsupervised data annotation. Therefore, we include (Zhang et al., 2023) as one of our baselines, which is the state-of-the-art (SOTA) in current clustering methods, for comparison.

Self-Refine & Reflexion Prompting Methods: We have added **Self-Refine**, a method designed to improve initial output through iterative rounds of self-correction (Madaan et al., 2024), and **Reflexion** Shinn et al. (2024), aims to achieve self-correction through LLMs' own evaluations and incorporates feedback from internal or external tools. Both techniques largely depend on the LLMs' competency in handling the corresponding task. (In Appendix A.4)

4.1 EVALUATION METRICS

The evaluation of our method and baselines is based on two metrics: *Annotation Accuracy* and the CAI ratio evaluation (change from the *initial CAI ratio* to the *after CAI ratio*). The first metric assesses the accuracy to evaluate the effectiveness of our method. The second metric evaluates whether the size of inconsistent samples has decreased and consistent samples have increased after applying retrospective learning.

4.2 DATASET

In this paper, we evaluate a wide range of open-source textual datasets, including Bank77, CLINC (Intent), MTOP (Intent), Massive (Intent), and StackExchange, Reddit (Topic), Few Rel Nat (Type), and Massive Intent (Intent) with some modifications following (Zhang et al., 2023). Since we are

Task	Name	#clusters	#data(small)	#data(large)
Intent	Bank77	77	3,080	10,003
	CLINC(I)	150	4,500	15,000
	MTOP(I)	102	4,386	15,638
	Massive(I)	59	2,974	11,510
Type	FewRel	64	4,480	40,320
	FewNerd	58	3789	50000
Topic	StackEx	121	4,156	50,000
	Reddit	50	3,217	50,000
Emotion	GoEmo	27	5,940	23,485
Domain	Massive Scenario	18	2,974	11,514

Table 1: Dataset Summary

working in an unsupervised textual data setting, we directly use the small-scale version of each dataset for testing. Intent discovery (Zhang et al., 2021; 2022) explores unknown intents in unsupervised utterance datasets. For the CLINC, Massive, and MTOP datasets, different domains are used as labels to transform them into domain discovery tasks. Bank77 (Casanueva et al., 2020) is a banking dataset that focuses on fine-grained intent classification within a single domain. CLINC (I) (Larson et al., 2019), Massive (I) (FitzGerald et al., 2022), and MTOP (I) (Li et al., 2020) are intent-based datasets. In this context, "I" refers to intent, and "D" refers to domain. Each dataset is available in both small-scale and large-scale versions. All user preference samples are i.i.d from the large-scale dataset.

4.3 Experimental Result

4.3.1 Experimental Analysis

Chatgpt 3.5-Turbo: Based on the experimental results from Table 2 and Table 3, we have two key findings. First, our method (ReL) outperformed on three datasets: CLINC (**+4.17%**), Massive Scenario (**+0.88%**), and Bank77 (**+2.99%**). For the MTOP Intent and StackExchange datasets, our method (ReL) outperformed the Only Student baseline by **+16%** on MTOP and **+9.18%** on StackExchange. It also improved over the Only LLMs (ChatGPT 3.5) baseline by **+4.11%** on MTOP and **+11.35%** on StackExchange, showing that our method can achieve greater improvements over each model. Additionally, the student-teacher knowledge distillation (KD) with consistent samples achieved the highest annotation accuracy on the MTOP Intent dataset. **Chatgpt 4o-mini:** Based on the experimental results from table 2 and table 3, there are two aspects of findings first is that ReL (Our) has outperformed all baseline methods on three datasets, which are Clinc(**+2.7**%), Massive Scenario (**+0.58%**), and Bank77(**+7.06%**). The student-teacher knowledge distillation (KD) with consistent samples achieved the highest annotation accuracy on the MTOP Intent dataset. In practice, Retrospective Learning and student-teacher knowledge distillation with consistent samples can be used interchangeably for improved annotation accuracy. On the Llama 8B Instruct model Touvron et al. (2023), our proposed ReL has outperformed all baselines. Notably, despite the relatively poor accuracy of the Llama 8B model, our method demonstrates significant robustness by consistently outperforming both large language models (LLMs) and student models, highlighting its adaptability and reliability across different LLM configurations.

4.4 CAI Ratio Evaluation

The following table (Figure 4) shows the changes in the number of consistent and inconsistent samples identified before and after applying our proposed retrospective learning approach. For Banking77 (**1.45** ⇒ **4.99**), CLINC (**1.44** ⇒ **5.74**), Massive_Scenario (**1.38** ⇒ **4.88**), MTOP_INTENT (**0.67** ⇒ **1.65**), and StackExchange (**0.40** ⇒ **0.86**), highlighting the significant improvement in the CAI ratio resulting from improvement of corresponding annotation accuracy across datasets. Table 5 in the appendix illustrates the improvements in both the CAI ratio and accuracy after applying our proposed retrospective learning approach. For Banking77, the CAI ratio improved from **1.35** to **4.03**, with an accuracy increase from **65.12%** to **82.45%**. Similarly, for CLINC, the CAI ratio rose from **1.99** to **5.20**, and accuracy improved from **81.44%** to **87.93%**. For the Massive Scenario dataset, the CAI ratio increased from **1.38** to **4.65**, with accuracy going from **66.83%** to **80.18%**. However, for the MTOP Intent dataset, although the CAI ratio increased from **0.72** to **1.66**, the annotation accuracy of LLMs performed worse than Only LLMs (ChatGPT 4o Mini), dropping from **75.03%** to **67.10%**. Similarly, for StackExchange, while the CAI ratio increased from **0.30** to **0.66**, the accuracy of Only

Datasets	Only Student Model (Our)	Only LLMs (ChatGPT 3.5)	Student (Our) & LLM (Chat-GPT 3.5)	Clustering Based Method (Zhang et al., 2023)	Student & Teacher KD (Our)	Retrospective Learning (Our)(%)	CAI Score & (Before & After)
Clinc	79.01	66.58	76.82	78.58	81.32	**85.49**	1.55
Std Dev	±1.08	±3.36	±1.51	±0.41	±0.46	±0.19	5.50
Massive_Scenario	75.55	60.89	70.23	60.85	69.25	**76.43**	1.39
Std Dev	±1.76	±0.62	±1.64	±4.33	±0.03	±2.47	4.72
Mtop Intent	52.49	64.95	55.12	37.22	**79.57**	69.06	0.68
Std Dev	±2.52	±0.21	±3.08	±1.18	±0.42	±1.10	1.78
StackExchange	32.27	30.10	30.92	**47.75**	29.76	41.45	0.40
Std Dev	±0.65	±0.10	±2.21	±1.24	±0.19	±2.56	0.85
Banking77	73.93	60.29	73.15	71.20	70.11	**76.92**	1.46
Std Dev	±0.81	±1.33	±1.70	±1.59	±0.12	±0.02	4.91
Reddit	51.73	51.12	51.64	57.02	43.90	**58.77**	0.50
Std Dev	±0.62	±1.27	±0.18	±1.59	±1.59	±0.29	1.40
Few Rel Nat	35.35	32.87	37.37	**51.22**	49.24	44.88	0.28
Std Dev	±0.016	±1.72	±0.13	±1.43	±0.63	±0.05	0.89
Massive_Intent	61.80	71.52	64.54	60.69	73.41	**71.72**	1.62
Std Dev	±1.04	±0.95	±0.024	±0.024	±1.843	±0.40	2.81

Table 2: **Chatgpt-3.5 Turbo (Closed-source LLMs):**"Before Correction" means before applying our Retrospective Learning. The highest accuracy for each dataset is highlighted

Datasets	Only Student Model (Our)	Only LLMs (Chatgpt-4o mini)	Student (Our) &LLM (Chatgpt-4o mini)	Clustering Based Method (Zhang et al., 2023)	Student & Teacher KD (Our)	Retrospective Learning (Our)(%)	CAI Score & (Before & After)
Clinc	79.01	81.44	78.58	78.58	85.23	**87.93**	2.06
Std Dev	± 1.08	± 0.44	± 1.35	± 0.41	±0.98	± 0.53	5.20
Massive_Scenario	75.55	66.83	77.62	60.85	79.60	**80.18**	1.37
Std Dev	± 1.76	± 1.31	± 0.74	± 4.33	±0.85	± 0.45	4.65
Mtop Intent	52.49	75.03	57.01	37.22	**80.16**	67.10	0.74
Std Dev	± 2.52	± 1.35	± 0.37	± 1.18	± 0.85	± 0.32	1.66
StackExchange	32.27	**51.90**	45.49	47.75	35.63	45.22	0.31
Std Dev	± 0.65	± 0.75	± 0.94	± 1.24	± 0.51	± 0.15	0.66
Banking77	73.93	65.12	75.39	71.20	73.56	**82.45**	1.36
Std Dev	± 1.56	± 0.30	± 0.32	± 1.59	± 0.20	± 0.48	4.03
Reddit	51.73	53.25	57.40	57.02	44.47	**60.94**	0.51
Std Dev	± 0.62	± 0.35	± 1.96	± 1.59	± 0.69	± 0.11	1.90
Few Rel Nat	35.35	37.11	38.87	**51.22**	49.53	44.94	0.26
Std Dev	± 0.016	± 0.03	± 1.88	± 1.43	± 0.35	± 0.02	0.9
Massive_Intent	61.80	66.02	76.93	60.69	**78.93**	72.49	1.47
Std Dev	± 1.04	± 0.35	± 1.05	± 0.024	± 0.50	± 0.40	3.3

Table 3: **Chatgpt-4o mini (Closed-source LLMs):** "Before Correction" means before applying our Retrospective Learning. The highest accuracy for each dataset is highlighted.

Datasets	Only Student Model (Our)	Only LLMs (Llama-8B-Instruct)	Student (Our) & LLM (Llama-8B-Instruct)	Student & Teacher KD (Our)	Retrospective Learning (Our)(%)	CAI Score & (Before & After)
Clinc	79.01 ±1.08	32.49 ±6.73	69.40 ±7.28	63.41 ±3.19	**82.43**±0.20	0.56⇒4.43
Massive_Scenario	75.55 ±1.76	43.52 ±1.85	66.74 ±0.98	70.06±1.12	**78.13** ±0.74	0.67⇒4.88
Mtop Intent	52.49 ±2.52	34.17 ±6.70	48.23 ±0.25	**66.39** ±0.70	63.39 ±1.47	0.35⇒1.46
StackExchange	32.27 ±0.65	11.02 ±2.78	26.26 ±2.16	16.03 ±0.13	**38.88** ±0.27	0.23⇒0.53
Banking77	73.93 ±1.56	33.06 ±1.92	69.66 ±1.74	64.29 ±1.24	**77.71** ±0.25	0.68⇒4.20
Reddit	51.73 ±0.62	36.31 ±0.97	46.00 ±2.51	40.29±0.55	**58.81** ±0.28	0.33⇒1.58
Few Rel Nat	35.35 ±0.016	14.25 ±0.36	30.07 ±4.45	31.80±0.34	**42.92** ±0.06	0.13⇒0.85
Massive_Intent	61.80 ±1.04	45.41 ±0.06	56.03 ±0.08	67.49 ±0.10	**67.75** ±0.43	0.73⇒2.87

Table 4: **Meta-Llama 3-8B Instruct (Open-Source Light-Weight LLMs):**"Before Correction" means before applying our Retrospective Learning. The highest accuracy for each dataset is highlighted

LLMs (**51.90%**) outperformed the annotation accuracy of our ReL approach, which was **45.22%**. The explanation for this is that, by examining the other datasets, we can observe that only when the CAI ratio increases by a large margin can we confidently claim there is a significant improvement. However, if the CAI ratio improvement is very small, as in the case of StackExchange (an increase of only 0.36), this suggests that either the student model chosen or the prompt given to the LLMs was not optimal. Therefore, while the CAI ratio remains a good indicator, the improvement from the CAI ratio must be sufficiently large to reliably indicate improved performance.

4.4.1 Statistical Test for the Correlation Between CAI Scores and Average LLM Accuracy

We performed a Pearson correlation analysis to examine the relationship between CAI ratios and average LLM accuracy after implementing our suggested approach. Our objective was to investigate

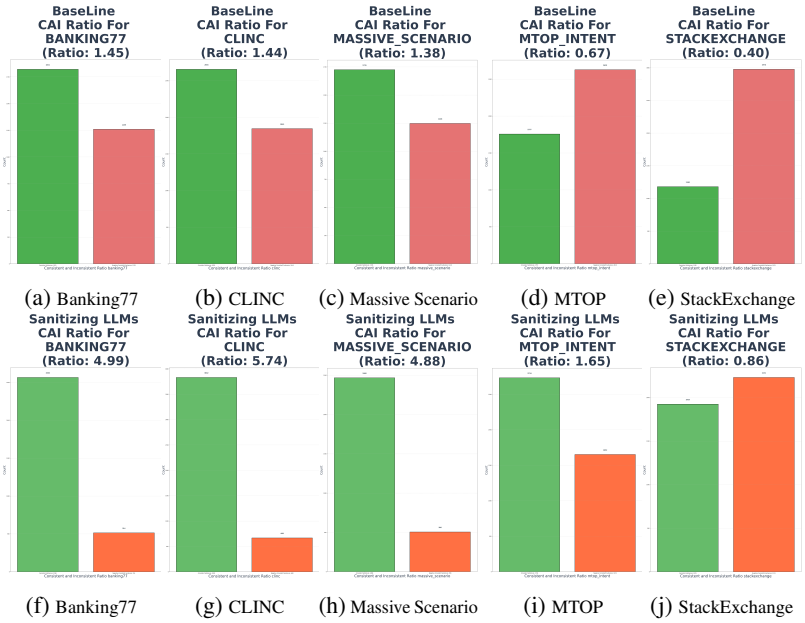


Figure 4: Performance comparison based on LLMs (Chatgpt 3.5) and student model (MINILM (Wang et al., 2020)) across 5 different datasets. The **first row** presents the CAI ratio before applying our sanitizing LLMs for the Student+LLMs (Chatgpt 3.5) baseline, while the **second row** shows the results after applying our proposed sanitizing LLMs, demonstrating a significant reduction in the number of inconsistent samples. (More Details are in the appendix.)

the possibility of a relationship between higher LLM annotation accuracy and larger CAI ratios. The *null hypothesis* in **test** asserts that there is no meaningful positive correlation between CAI scores and LLMs annotation accuracy, while the *alternative hypothesis* postulates a substantial positive correlation. The following tables display the statistics. There was a strong positive correlation between the CAI ratio and the LLM accuracy, with a p-value of about 0.005 and 0.00035. The value of r was about 0.805 and the value of r was about 0.0.903. This implies that the correlation is statistically significant, further suggesting that higher CAI ratios are associated with higher Average LLM Accuracy. Full details of the analysis are provided in the appendix.

Metric	**Pearson Correlation**	**p-value**
CAI Score vs. Annotation Accuracy (Before ReL (Our))	0.805	0.005
CAI Score vs. Annotation Accuracy (After ReL (Our))	0.903	0.00035

Table 5: Pearson Correlation Between CAI Score and Annotation Accuracy (Before and After ReL (Our)

5 Discussion

This paper proposes sanitizing large language models (LLMs) to address two critical challenges in unsupervised data tasks involving user preferences. To tackle the first challenge, we introduce the concept of consistent and inconsistent identification and a corresponding ratio (CAI ratio), which serves as an effective evaluation metric for unsupervised data with user preferences. Based on this CAI identification and ratio, we propose a Divide-and-Conquer self-correction paradigm that uses consistent samples to self-correct the identified inconsistent samples. Our approach addresses the second challenge by achieving higher annotation quality than teacher and student models without relying on external knowledge. Applied to five domain-specific NLP datasets, our sanitizing LLM paradigm, leveraging the CAI ratio, significantly improves the accuracy of LLM-generated responses.

REFERENCES

Shubham Atreja, Joshua Ashkinaze, Lingyao Li, Julia Mendelsohn, and Libby Hemphill. Prompt design matters for computational social science tasks but in unpredictable ways. *arXiv preprint arXiv:2406.11980*, 2024.

Tom Brown, Benjamin Mann, Nick Ryder, Melanie Subbiah, Jared D Kaplan, Prafulla Dhariwal, Arvind Neelakantan, Pranav Shyam, Girish Sastry, Amanda Askell, et al. Language models are few-shot learners. *Advances in neural information processing systems*, 33:1877–1901, 2020.

Iñigo Casanueva, Tadas Temčinas, Daniela Gerz, Matthew Henderson, and Ivan Vulić. Efficient intent detection with dual sentence encoders. *arXiv preprint arXiv:2003.04807*, 2020.

Cheng Chen and Ivor Tsang. Self-teaching prompting for multi-intent learning with limited supervision. In *The Second Tiny Papers Track at ICLR 2024*, 2024. URL `https://openreview.net/forum?id=DeoamI1BFh`.

Cheng Chen, Bowen Xing, and Ivor W Tsang. Low-hanging fruit: Knowledge distillation from noisy teachers for open domain spoken language understanding. In *Joint European Conference on Machine Learning and Knowledge Discovery in Databases*, pp. 107–125. Springer, 2024.

Xinyun Chen, Maxwell Lin, Nathanael Schärli, and Denny Zhou. Teaching large language models to self-debug. *arXiv preprint arXiv:2304.05128*, 2023.

Shizhe Diao, Pengcheng Wang, Yong Lin, and Tong Zhang. Active prompting with chain-of-thought for large language models, 2023.

Jack FitzGerald, Christopher Hench, Charith Peris, Scott Mackie, Kay Rottmann, Ana Sanchez, Aaron Nash, Liam Urbach, Vishesh Kakarala, Richa Singh, Swetha Ranganath, Laurie Crist, Misha Britan, Wouter Leeuwis, Gokhan Tur, and Prem Natarajan. Massive: A 1m-example multilingual natural language understanding dataset with 51 typologically-diverse languages, 2022.

Fabrizio Gilardi, Meysam Alizadeh, and Maël Kubli. Chatgpt outperforms crowd workers for text-annotation tasks. *Proceedings of the National Academy of Sciences*, 120(30):e2305016120, 2023.

Kristina Gligorić, Tijana Zrnic, Cinoo Lee, Emmanuel J Candès, and Dan Jurafsky. Can unconfident llm annotations be used for confident conclusions? *arXiv preprint arXiv:2408.15204*, 2024.

Jiaxin Huang, Shixiang Shane Gu, Le Hou, Yuexin Wu, Xuezhi Wang, Hongkun Yu, and Jiawei Han. Large language models can self-improve. *arXiv preprint arXiv:2210.11610*, 2022.

Jie Huang, Xinyun Chen, Swaroop Mishra, Huaixiu Steven Zheng, Adams Wei Yu, Xinying Song, and Denny Zhou. Large language models cannot self-correct reasoning yet. In *The Twelfth International Conference on Learning Representations*, 2023.

Takeshi Kojima, Shixiang Shane Gu, Machel Reid, Yutaka Matsuo, and Yusuke Iwasawa. Large language models are zero-shot reasoners. *Advances in neural information processing systems*, 35: 22199–22213, 2022.

Stefan Larson, Anish Mahendran, Joseph J Peper, Christopher Clarke, Andrew Lee, Parker Hill, Jonathan K Kummerfeld, Kevin Leach, Michael A Laurenzano, Lingjia Tang, et al. An evaluation dataset for intent classification and out-of-scope prediction. *arXiv preprint arXiv:1909.02027*, 2019.

Haoran Li, Abhinav Arora, Shuohui Chen, Anchit Gupta, Sonal Gupta, and Yashar Mehdad. Mtop: A comprehensive multilingual task-oriented semantic parsing benchmark. *arXiv preprint arXiv:2008.09335*, 2020.

Zemin Liu, Xingtong Yu, Yuan Fang, and Xinming Zhang. Graphprompt: Unifying pre-training and downstream tasks for graph neural networks. In *Proceedings of the ACM Web Conference 2023*, 2023.

Zhengzhong Liu, Guanxiong Ding, Avinash Bukkittu, Mansi Gupta, Pengzhi Gao, Atif Ahmed, Shikun Zhang, Xin Gao, Swapnil Singhavi, Linwei Li, Wei Wei, Zecong Hu, Haoran Shi, Xiaodan Liang, Teruko Mitamura, Eric Xing, and Zhiting Hu. A data-centric framework for composable NLP workflows. In Qun Liu and David Schlangen (eds.), *Proceedings of the 2020 Conference on Empirical Methods in Natural Language Processing: System Demonstrations*, pp. 197–204, Online, October 2020. Association for Computational Linguistics. doi: 10.18653/v1/2020.emnlp-demos.26. URL https://aclanthology.org/2020.emnlp-demos.26.

Jieyi Long. Large language model guided tree-of-thought. *arXiv preprint arXiv:2305.08291*, 2023.

Aman Madaan, Niket Tandon, Prakhar Gupta, Skyler Hallinan, Luyu Gao, Sarah Wiegreffe, Uri Alon, Nouha Dziri, Shrimai Prabhumoye, Yiming Yang, et al. Self-refine: Iterative refinement with self-feedback. *Advances in Neural Information Processing Systems*, 36, 2024.

Aida Mostafazadeh Davani, Mark Díaz, and Vinodkumar Prabhakaran. Dealing with disagreements: Looking beyond the majority vote in subjective annotations. *Transactions of the Association for Computational Linguistics*, 10:92–110, 2022. doi: 10.1162/tacl_a_00449. URL https://aclanthology.org/2022.tacl-1.6.

Debjit Paul, Mete Ismayilzada, Maxime Peyrard, Beatriz Borges, Antoine Bosselut, Robert West, and Boi Faltings. Refiner: Reasoning feedback on intermediate representations. *arXiv preprint arXiv:2304.01904*, 2023.

Patrick Schober, Christa Boer, and Lothar A Schwarte. Correlation coefficients: appropriate use and interpretation. *Anesthesia & analgesia*, 126(5):1763–1768, 2018.

Melanie Sclar, Yejin Choi, Yulia Tsvetkov, and Alane Suhr. Quantifying language models' sensitivity to spurious features in prompt design or: How i learned to start worrying about prompt formatting. In *The Twelfth International Conference on Learning Representations*, 2024. URL https://openreview.net/forum?id=RIu5lyNXjT.

Noah Shinn, Federico Cassano, Ashwin Gopinath, Karthik Narasimhan, and Shunyu Yao. Reflexion: Language agents with verbal reinforcement learning. *Advances in Neural Information Processing Systems*, 36, 2024.

Surendrabikram Thapa, Usman Naseem, and Mehwish Nasim. From humans to machines: can chatgpt-like llms effectively replace human annotators in nlp tasks. In *Workshop Proceedings of the 17th International AAAI Conference on Web and Social Media*. Association for the Advancement of Artificial Intelligence (AAAI), June 2023. doi: 10.36190/2023.15. 17th International AAAI Conference on Web and Social Media, ICWSM 2023 ; Conference date: 05-06-2023 Through 08-06-2023.

Hugo Touvron, Thibaut Lavril, Gautier Izacard, Xavier Martinet, Marie-Anne Lachaux, Timothée Lacroix, Baptiste Rozière, Naman Goyal, Eric Hambro, Faisal Azhar, et al. Llama: Open and efficient foundation language models. *arXiv preprint arXiv:2302.13971*, 2023.

Wenhui Wang, Furu Wei, Li Dong, Hangbo Bao, Nan Yang, and Ming Zhou. Minilm: Deep self-attention distillation for task-agnostic compression of pre-trained transformers. *Advances in Neural Information Processing Systems*, 33:5776–5788, 2020.

Xuezhi Wang, Jason Wei, Dale Schuurmans, and Quoc V Le. H. chi, sharan narang, aakanksha chowdhery, and denny zhou. self-consistency improves chain of thought reasoning in language models. In *The Eleventh International Conference on Learning Representations*, volume 1, 2023.

Jason Wei, Maarten Bosma, Vincent Y Zhao, Kelvin Guu, Adams Wei Yu, Brian Lester, Nan Du, Andrew M Dai, and Quoc V Le. Finetuned language models are zero-shot learners. *arXiv preprint arXiv:2109.01652*, 2021.

Jason Wei, Xuezhi Wang, Dale Schuurmans, Maarten Bosma, Fei Xia, Ed Chi, Quoc V Le, Denny Zhou, et al. Chain-of-thought prompting elicits reasoning in large language models. *Advances in Neural Information Processing Systems*, 35:24824–24837, 2022.

Miao Xiong, Zhiyuan Hu, Xinyang Lu, Yifei Li, Jie Fu, Junxian He, and Bryan Hooi. Can llms express their uncertainty? an empirical evaluation of confidence elicitation in llms. *arXiv preprint arXiv:2306.13063*, 2023.

Ziqing Yang, Yiming Cui, and Zhigang Chen. Textpruner: A model pruning toolkit for pre-trained language models. *arXiv preprint arXiv:2203.15996*, 2022.

Shunyu Yao, Jeffrey Zhao, Dian Yu, Nan Du, Izhak Shafran, Karthik Narasimhan, and Yuan Cao. React: Synergizing reasoning and acting in language models. *arXiv preprint arXiv:2210.03629*, 2022.

Shunyu Yao, Dian Yu, Jeffrey Zhao, Izhak Shafran, Tom Griffiths, Yuan Cao, and Karthik Narasimhan. Tree of thoughts: Deliberate problem solving with large language models. *Advances in Neural Information Processing Systems*, 36, 2024.

Hanlei Zhang, Hua Xu, Ting-En Lin, and Rui Lyu. Discovering new intents with deep aligned clustering. In *Proceedings of the AAAI Conference on Artificial Intelligence*, volume 35, pp. 14365–14373, 2021.

Yuwei Zhang, Haode Zhang, Li-Ming Zhan, Xiao-Ming Wu, and Albert Lam. New intent discovery with pre-training and contrastive learning. *arXiv preprint arXiv:2205.12914*, 2022.

Yuwei Zhang, Zihan Wang, and Jingbo Shang. Clusterllm: Large language models as a guide for text clustering. In *The 2023 Conference on Empirical Methods in Natural Language Processing*, 2023.

Kaitlyn Zhou, Jena D Hwang, Xiang Ren, and Maarten Sap. Relying on the unreliable: The impact of language models' reluctance to express uncertainty. *arXiv preprint arXiv:2401.06730*, 2024.

A APPENDIX / SUPPLEMENTAL MATERIAL

A.1 SUMMARY RETROSPECTIVE LEARNING

Given the identified consistent and inconsistent samples, we use the consistent samples and user-preference samples to self-correct the inconsistent samples. We then apply CAI identification to further assess the consistency of the self-corrected inconsistent samples by comparing them with the consistent samples. This concludes the self-correction process for the inconsistent samples.

A.1.1 DIVIDE-AND-CONQUER SELF-CORRECTION (DCSC) APPROACH

Algorithm 2: Divide-and-Conquer Self-Correction (DCSC) Approach

Result: Self-corrected inconsistent samples
Input: Consistent samples C, Inconsistent samples I, Embedding function H, User-preference samples;
Divide Inconsistent Samples;
Divide I into two categories using CAI identification:
1. CI: Consistent identified inconsistent samples
2. II: Inconsistent identified inconsistent samples

Round 1: Identification and Self-Correction;
for *each sample in* CI **do**
  Identify the top-nearest embeddings using H;
  Select the most semantically similar examples from C;
  Apply Majority Voting via Top-Nearest Embedding Scheme (MV-VTES) to self-correct the sample;
end
Round 2: Re-identification and Further Self-Correction;
Apply CAI identification again to the self-corrected samples to update CI and II;
for *each sample in updated* II **do**
  Incorporate user-preference samples and C;
  Identify top-nearest embeddings using H;
  Select the most semantically similar examples from C and user-preference samples;
  Apply MV-VTES to self-correct the sample;
end
Output: Updated and self-corrected inconsistent samples;

A.2 CAI SCORES AND LLMS ACCURACY

Dataset	CAI Before	Accuracy Before (%)	CAI After	Accuracy After (%)
Banking77	1.460	73.93	4.905	76.92
Clinc	1.545	79.01	5.500	85.49
Massive Scenario	1.390	75.55	4.720	76.43
MTOP Intent	0.675	52.49	1.775	69.06
Stack Exchange	0.400	32.27	0.845	41.45

Table 6: Performance Metrics for ChatGPT 3.5 Before and After Applying Our Method

Dataset	CAI Before	Accuracy Before (%)	CAI After	Accuracy After (%)
Banking77	1.350	65.12	4.030	82.45
Clinc	1.995	81.44	5.195	87.93
Massive Scenario	1.375	66.83	4.645	80.18
MTOP Intent	0.720	75.03	1.655	67.10
Stack Exchange	0.300	51.90	0.660	45.22

Table 7: Performance Metrics for ChatGPT 4o Mini Before and After Applying Our Method

Table 8: Performance Comparison of ChatGPT 3.5 and ChatGPT 4o Mini on additional Datasets

Dataset	ChatGPT 3.5		ChatGPT 4o Mini	
	CAI (Before)	Accuracy (Before)	CAI (After)	Accuracy (After)
Reddit	0.50	51.54	0.43	51.49
Go Emotion	0.12	21.94	0.13	31.84
Few Rel Nat	0.28	37.37	0.26	32.87
Few Nerd Nat	0.43	32.63	0.32	46.74
Massive Intent	1.63	64.54	1.47	71.52
Reddit (After)	1.8	60.94	0.74	60.94
Go Emotion (After)	0.32	25.69	0.31	23.56
Few Rel Nat (After)	0.88	44.56	0.9	44.94
Few Nerd Nat (After)	0.92	33.74	0.9	34.11
Massive Intent (After)	3.27	71.72	2.79	72.49

A.2.1 Statistical Inference

We have conducted a two-tailed hypothesis test based on the CAI ratio before, LLMs accuracy before and CAI ratio after, and LLMs accuracy after from table 4 and Table 5. The **test** is to prove that there is a strong positive relationship between high CAI scores and high LLMs annotation accuracy. We have performed a Pearson correlation, the correlation coefficient r is calculated as:

$$r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2}}$$

where x_i symbolises the CAI ratios. y_i denotes the LLM annotation accuracies. $\bar{x}$ and $\bar{y}$ are the average mean of x_i and y_i, accordingly. n is the number of samples we have used for evaluation. To assess the statistical significance, we use a hypothesis test for the correlation coefficient, calculating a t-statistic(Schober et al., 2018):

$$t = r\sqrt{\frac{n-2}{1-r^2}}$$

The P-value is then calculated from the t-distribution with $n - 2$ degrees of freedom.

Metric	Pearson Correlation	p-value
Before	0.805	0.005
After	0.903	0.00035

Table 9: Pearson Correlation Results for CAI and Accuracy (Before and After)

Table 10: Pearson Correlation Results for CAI and Accuracy for additional datasets on ChatGPT 3.5 Turbo and ChatGPT 4o mini

Metric	Pearson Correlation	P-value
Before	0.8742509926234142	0.0009373655969838773
After	0.8520502618079272	0.0017465070325696618

Table 11: Pearson Correlation Results for CAI and Accuracy (Before and After) on Meta-Llama-3-8B-instruct

Metric	Pearson Correlation	P-value
Before	0.8118066946938405	0.014399601133794526
After	0.9180808900843687	0.001291289343334756

A.2.2 BEFORE APPLYING THE METHOD:

The Pearson correlation coefficient is 0.805, indicating a strong positive linear relationship between CAI and Accuracy. The p-value is 0.005, which is statistically significant (below the typical threshold of 0.05). This implies that the positive correlation between the CAI ratio and Accuracy before and after applying our method is not a random event, and higher CAI scores are associated with higher Accuracy. The p-value is 0.0009373655969838773, which is statistically significant (below the typical threshold of 0.05) for the additional datasets. The p-value is 0.014399601133794526, which is statistically significant (below the typical threshold of 0.05) for Meta-Llama-3-8B-instruct on all datasets.

A.2.3 AFTER APPLYING THE METHOD:

The Pearson correlation coefficient is 0.903, showing an even stronger positive correlation between CAI and Accuracy after applying the method. A larger CAI ratio and higher annotation produced by LLMs are extremely statistically significant, according to the p-value of 0.00035. This implies that the relationship between CAI and Accuracy is even more evident after using the approach, showing a more linear relationship where increases in CAI are more directly correlated with increases in Accuracy. In both stages (Before and After applying the method), the results display statistically significant correlations ($p < 0.05$), showing strong positive relationships between CAI scores and LLM accuracy. Tables 9, 10, and 11 show that all the P-values of the Pearson correlation are statistically significant.

Metric	Before	After	Source
Slope	22.337	7.603	Regression
Intercept	40.317	45.280	Regression
R-value	0.805	0.908	Pearson Correlation
R-squared (from Pearson)	0.647	0.824	Pearson Correlation
R-squared (from Regression)	0.647	0.824	Regression
P-value	0.00501	0.00029	Regression
Standard Error	5.830	1.244	Regression

Table 12: Comparison of R-squared Values from Pearson Correlation and Linear Regression Before and After Applying the Method. Note: R^2 emphasis on variation of LLMs annotation accuracy is explained by CAI ratio. The Pearson correlation shows the strength of the linear correlation. Therefore, on the main page, we have shown the R^2.

A.2.4 WHY TEACHER-STUDENT COLLABORATION IS ESSENTIAL FOR RETROSPECTIVE LEARNING

In unsupervised learning tasks that rely on user preferences to align data annotations with expectations—where the competency of the teacher model (LLMs) is uncertain and no external knowledge is available, the key challenge lies in evaluating the LLMs generated annotation and enabling mechanisms for self-correction. To address this, we propose a novel approach termed retrospective learning, a self-supervised framework designed to facilitate self-correction and self-assessment of annotations generated by large language models (LLMs). Our methodology leverages a student model to collaborate with a teacher model of uncertain competency. By introducing the consistent and inconsistent (CAI) score , we quantify and identify consistent and inconsistent samples, thereby enhancing the performance of both the student and teacher models through iterative refinement. To further demonstrate the efficacy of our approach, we conducted experiments utilizing the Meta-8B Instruct lightweight LLM as a low-competency noisy teacher. This setup, in conjunction with the student model, underscores the robustness of our framework and highlights the pivotal role of the student model in effectively managing scenarios involving noisy teachers. Given an unsupervised learning task and we don't know how competent the teacher deployed to the particular learning task and there is no external knowledge. How can we evaluate and enable the self-correction for the unsupervised dataset ? To tackle this problem we proposed retrospective learning which is a self-supervised strategy which allows us to self-correct and self-evaluate the LLMs generated annotation. To achieve this, we introduce the student model to collaborate with an unknown competency of a

teacher model to acquire a CAI score and identify the consistent and inconsistent samples to improve the performance for students and teachers.

A.3 ADDITIONAL EXPERIMENTS TO SUPPORT OUR ARGUMENT

In this section (see Table 13 and Table 14), we evaluate an additional three open-source NLP datasets on ChatGPT-3.5 and ChatGPT-4 Mini, alongside five datasets—Bank77, CLINC (Intent), MTOP (Intent), Massive (Intent), and StackExchange—as well as Reddit (Topic), Few Rel Nat (Type), and Massive Intent (Intent) using Meta-Llama 8B-Instruct. Some modifications were made following (Zhang et al., 2023) to align with the experimental setup.

A.3.1 EXPERIMENTAL STUDIES ON META-8B INSTRUCT USING RETROSPECTIVE LEARNING

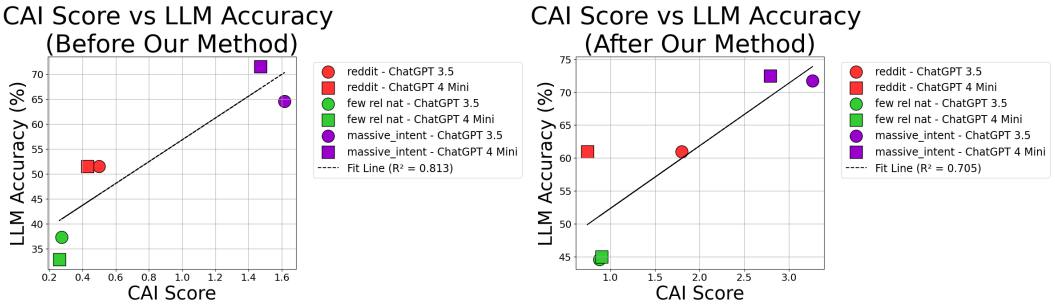
We also conducted an experiment using meta-8B instruct as a "noisy teacher." This model is smaller and less competent than ChatGPT, but we used it with the same student model. This experiment (See Table 14) illustrates the effectiveness of our method and highlights the importance of the student model, even when learning from a much smaller, larger language model. Our proposed Retrospective Learning (ReL) demonstrates consistent improvement over "Only Student" across all datasets, with the highest improvement observed for StackExchange (+6.61%). Additionally, ReL outperforms "Only LLMs" across all datasets, highlighting its robustness and effectiveness, particularly in scenarios where the LLM exhibits low competency.

Datasets	Only Student Model (Our)	Only LLMs (Llama-8B-Instruct)	Student (Our) & LLM (Llama-8B-Instruct)	Student & Teacher KD (Our)	Retrospective Learning (Our)(%)	CAI Score & (Before & After)
Clinc	79.01 ±1.08	32.49 ±6.73	69.40 ±7.28	63.41 ±3.19	**82.43**±0.20	0.56⇒4.43
Massive_Scenario	75.55 ±1.76	43.52 ±1.85	66.74 ±0.98	70.06±1.12	**78.13** ±0.74	0.67⇒4.88
Mtop Intent	52.49 ±2.52	34.17 ±6.70	48.23 ±0.25	**66.39** ±0.70	63.39 ±1.47	0.35⇒1.46
StackExchange	32.27 ±0.65	11.02 ±2.78	26.26 ±2.16	16.03 ±0.13	**38.88** ±0.27	0.23⇒0.53
Banking77	73.93 ±1.56	33.06 ±1.92	69.66 ±1.74	64.29 ±1.24	**77.71** ±0.25	0.68⇒4.20
Reddit	51.73 ±0.62	36.31 ±0.97	46.00 ±2.51	40.29±0.55	**58.81** ±0.28	0.33⇒1.58
Few Rel Nat	35.35 ±0.016	14.25 ±0.36	30.07 ±4.45	31.80±0.34	**42.92** ±0.06	0.13⇒0.85
Massive_Intent	61.80 ±1.04	45.41 ±0.06	56.03 ±0.08	67.49 ±0.10	**67.75** ±0.43	0.73⇒2.87

Table 13: **Meta-Llama 3-8B Instruct (Open-Source Light-Weight LLMs):** Annotation Accuracy comparison in percentages with standard deviations across different datasets for the Student Model, LLMs without annotations from the student model, and LLMs with annotations from the student model. The highest accuracy for each dataset is highlighted.

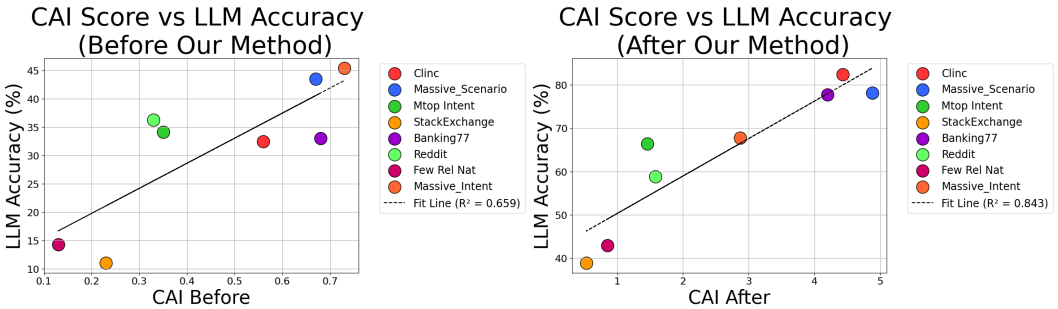
Datasets	Only Student Model (Our)	Only LLMs (Llama-8B-Instruct)	Retrospective Learning (Our) (%)	Improvement Over Only Student (%)	Improvement Over Only LLMs (%)
Clinc	79.01 ±1.08	32.49 ±6.73	**82.43** ±0.20	+3.42	+49.94
Massive_Scenario	75.55 ±1.76	43.52 ±1.85	**78.13** ±0.74	+2.58	+34.61
Mtop Intent	52.49 ±2.52	34.17 ±6.70	**63.39** ±1.47	+10.90	+29.22
StackExchange	32.27 ±0.65	11.02 ±2.78	**38.88** ±0.27	+6.61	+27.86
Banking77	73.93 ±1.56	33.06 ±1.92	**77.71** ±0.25	+3.78	+44.65
Reddit	51.73 ±0.62	36.31 ±0.97	**58.81** ±0.28	+7.08	+22.50
Few Rel Nat	35.35 ±0.016	14.25 ±0.36	**42.92** ±0.06	+7.57	+28.67
Massive_Intent	61.80 ±1.04	45.41 ±0.06	**67.75** ±0.43	+5.95	+22.34

Table 14: **Performance Comparison of Retrospective Learning (ReL):** The table shows the performance of Retrospective Learning compared to "Only Student" and "Only LLMs," with improvements highlighted.



(a: Chatgpt3.5 Turbo and ChatGPT 4o mini) (b:Chatgpt3.5 Turbo and ChatGPT 4o mini)

Figure 5: The above analysis shows the correlation between LLM annotation accuracy and the Consistent and Inconsistent (CAI) ratio. We also conducted statistical tests to assess the significance of this correlation. We collected the CAI ratios for (LLMs 3.5 Turbo and Student Model) and (LLMs 4.0 Mini and Student Model) across the datasets reddit, few rel nat and massive intent. Using these data, we calculated the Pearson correlation coefficients between the LLM annotation accuracies and CAI ratios and computed the associated P-values (P value for After: 0.03643843400972288) and (P value for Before: 0.014021729786979444) to determine the statistical significance of the observed correlations.



(a: Llama-8B-Instruct) (b:Llama-8B-Instruct)

Figure 6: The above analysis shows the correlation between LLM annotation accuracy and the Consistent and Inconsistent (CAI) ratio. We also conducted statistical tests to assess the significance of this correlation. We collected the CAI ratios for (LLMs 3.5 Turbo and Student Model) and (LLMs 4.0 Mini and Student Model) across the datasets CLINC, Massive Scenario, MTOP Intent, Stack Exchange, and Banking77, Reddit, Few Rel Nat, Massive_Intent. Using these data, we calculated the Pearson correlation coefficients between the LLM annotation accuracies and CAI ratios and computed the associated P-values (P value for After: 0.014399601133794529) and (P value for Before: 0.0012912893433347605) to determine the statistical significance of the observed correlations.

A.4 COMPARISON OF OUR METHOD WITH LLMS USING PROMPTING TECHNIQUES FOR SELF-CORRECTION

Metric Dataset	ChatGPT-4o mini StackExchange	ChatGPT-4o mini Clinc	ChatGPT-4o mini Banking77	ChatGPT-4o mini Mote	ChatGPT-4o mini Massive(D)
FeedbackShinn et al. (2024)	51.72% ± 0.27%	79.34% ± 0.49%	64.81% ± 1.33%	71.93% ± 0.02%	71.35% ± 0.29%
CorrectionPaul et al. (2023)	47.55% ± 0.34%	81.85% ± 0.63%	65.58% ± 1.23%	73.57% ± 0.47%	70.84% ± 0.05%
Retrospective Learning	45.22% ± 0.15%	87.93% ± 0.53%	82.45% ± 0.48%	67.10% ± 0.32%	80.18% ± 0.45%
Metric Dataset	**ChatGPT-3.5 StackExchange**	**ChatGPT-3.5 Clinc**	**ChatGPT-3.5 Banking77**	**ChatGPT-3.5 Mote**	**ChatGPT-3.5 Massive(D)**
FeedbackShinn et al. (2024)	48.46% ± 0.00%	71.63% ± 1.24%	53.90% ± 2.94%	71.88% ± 0.59%	63.55% ± 0.02%
CorrectionPaul et al. (2023)	51.81% ± 0.04%	65.06% ± 0.83%	55.94% ± 0.32%	68.24% ± 0.09%	62.81% ± 0.07%
Retrospective Learning	41.45% ± 2.56%	85.49% ± 0.19%	76.92% ± 0.02%	69.06% ± 1.10%	76.43% ± 2.47%

Table 15: The table shows the accuracy results for our methods and LLMs prompting-based baselines evaluated using ChatGPT 3.5 and ChatGPT 4o-o-mini on different datasets.

In this section (See Table 12), we add **Self-Refine**, a method designed to improve initial output through iterative rounds of self-correction (Madaan et al., 2024), and **Reflexion** Shinn et al. (2024), aims to achieve self-correction through LLMs' own evaluations and incorporates feedback from internal or external tools as our additional baselines. Both techniques largely depend on the LLMs its own in handling the corresponding task. These two additional baselines are added to demonstrate that our retrospective learning which collaborates between a student model and a teacher can outperform LLMs in self-correction for unsupervised datasets with user preferences.

A.5 INVERSE CONSISTENT (IC) RATIO

The number of samples per class required for human annotation based on user preferences is determined by our Inverse Consistent (IC) ratio (5). For user-preference samples. The n denotes the total size of the the consistent sample where $M = n$, and k be the number of classes. The parameter p represents the proportion of samples to be selected and is set to 5% (i.e., $p = 0.05$). In our experiment, we do not use all identified consistent samples. The proportion of consistent samples used for self-correction is determined by the IC ratio. Let n_c be the number of consistent samples, so $M = n_c$ represents the size of the consistent sample selection. If the CAI ratio is greater than 0.5** (i.e., the number of consistent samples exceeds inconsistent ones), the value of p will be reduced to use fewer consistent samples. If the CAI ratio is less than 0.4, p is set to 1 (i.e., 100%) since more consistent samples are needed for self-correction. The formula for the **Inverse Consistent (IC) ratio** is defined as follows:

$$\text{IC} = \left(\frac{M \times p}{k} \right). \tag{5}$$

A.6 EXPERIMENTAL DETAILS

The top-k selection and proportions of consistent and user-preference samples are as follows. For CLINC and Massive Scenario, 'top-k' is set to 5, with 'proportion' at 0.2. For MTOP Intent, 'proportion' is set to 1, and 'top-k' is updated to 15 after printing the current value. In StackExchange, 'top-k' is set to 5 and 'proportion' to 1, while in Banking77, 'top-k' is set to 3 and 'proportion' is 0.2. The current 'top-k' and 'proportion' values are printed before updates for each dataset. All tests are done with two random seeds for user preference samples, student model-assigned annotation, and LLMs with and without student annotations.

A.7 THE PROMPTING FORMAT AND INSTRUCTION USED FOR CHATGPT 3.5 AND 4O MINI

A.7.1 PROMPT INSTRUCTION:

```
def Prompt(prompts,student_labels,intention_set,temperatures,formats):
1. Initialize an empty list combination.
```

2. For each pair of `prompt` and `student_labels` from `prompts` and `student_labels` lists:
a. Construct `prompt1` as `"For the sentence: "{prompt}"`.
b. Append `prompt1` to `combination`.
3. Initialize a response string `respon`.
4. Append the following to `respon`:
a. A message ensuring the number of responses corresponds to the length of `prompts`.
b. A request to identify the intentions for each sentence based on `intention_set`.
c. Instructions for response formatting using `formats`.
d. A message to ensure the total responses are as expected from ChatGPT.
5. Use `openai.ChatCompletion.create()` to send the `respon` string, along with temperature and token limits, to the model.
6. Return the model's response as the final output.

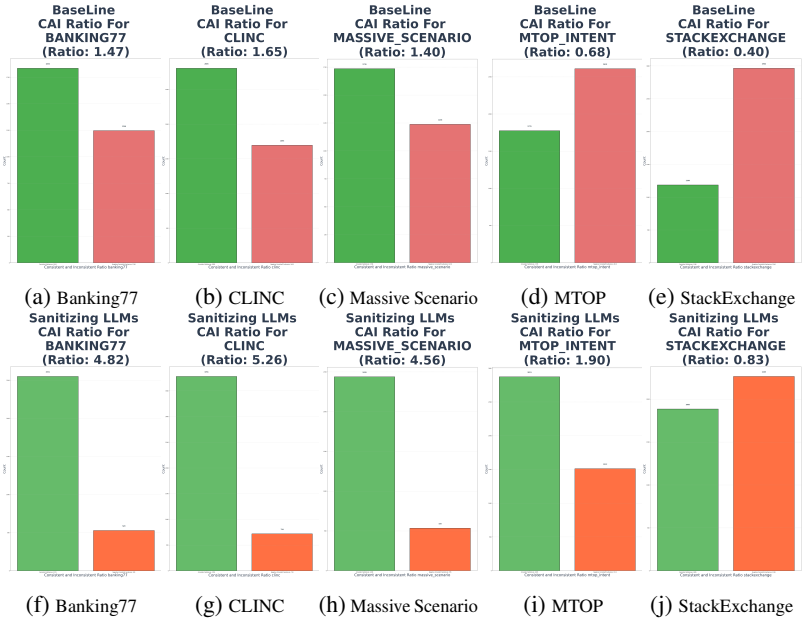


Figure 7: Performance comparison based on LLMs (Chatgpt 3.5) and student model (MINILM (Wang et al., 2020)) across 5 different datasets. The **first row** presents the CAI ratio before applying our sanitizing LLMs for the Student+LLMs (Chatgpt 3.5) baseline, while the **second row** shows the results after applying our proposed sanitizing LLMs, demonstrating a significant reduction in the number of inconsistent samples.

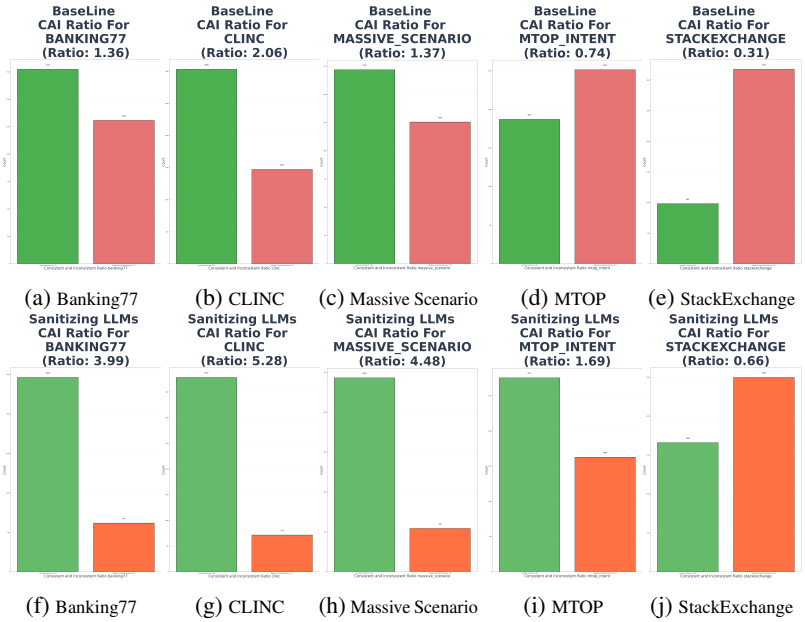
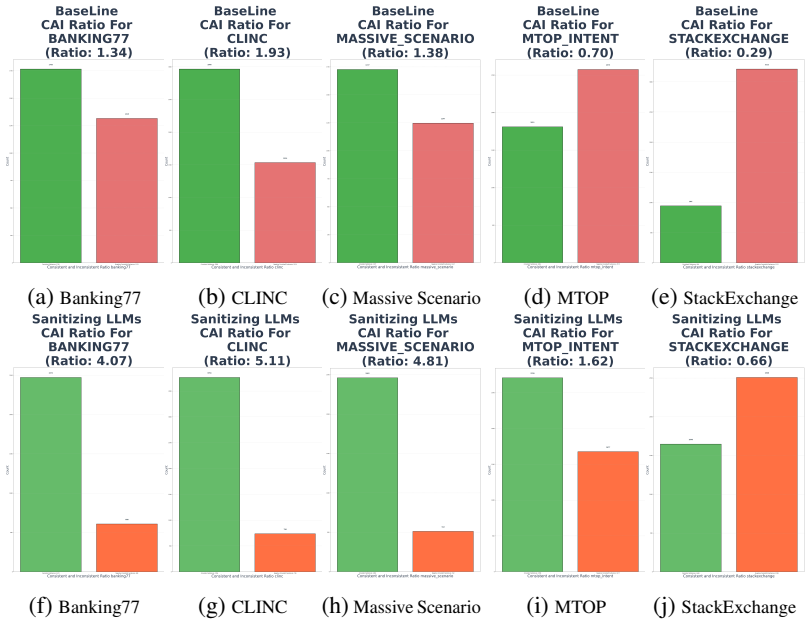


Figure 8: Performance comparison based on LLMs (Chatgpt 4o mini with temperature 1) and student model (MINILM (Wang et al., 2020)) across 5 different datasets. The **first row** presents the CAI ratio before applying our sanitizing LLMs for the Student+LLMs (Chatgpt 3.5) baseline, while the **second row** shows the results after applying our proposed sanitizing LLMs, demonstrating a significant reduction in the number of inconsistent samples.



(a) Banking77 (b) CLINC (c) Massive Scenario (d) MTOP (e) StackExchange

(f) Banking77 (g) CLINC (h) Massive Scenario (i) MTOP (j) StackExchange

Figure 9: Performance comparison based on LLMs (Chatgpt 4o mini with temperature 0.5) and student model (MINILM (Wang et al., 2020)) across 5 different datasets. The **first row** presents the CAI ratio before applying our sanitizing LLMs for the Student+LLMs (Chatgpt 3.5) baseline, while the **second row** shows the results after applying our proposed sanitizing LLMs, demonstrating a significant reduction in the number of inconsistent samples.