HD-EVAL: Aligning Large Language Model Evaluators Through Hierarchical Criteria Decomposition

Anonymous ACL submission

Abstract

Large language models (LLMs) have emerged as a promising alternative to expensive human evaluations. However, the alignment and coverage of LLM-based evaluations are often limited by the scope and potential bias of the evaluation prompts and criteria. To address this challenge, we propose HD-EVAL, a novel framework that iteratively aligns LLM-based evaluators with human preference via **H**ierarchical Criteria **D**ecomposition. HD-EVAL inherits the essence from the evaluation mindset of human experts and enhances the alignment of LLM-based evaluators by decomposing a given evaluation task into finer-grained criteria, aggregating them according to estimated human preferences, pruning insignificant criteria with attribution, and further decomposing significant criteria. By integrating these steps within an iterative alignment training process, we obtain a hierarchical decomposition of criteria that comprehensively captures aspects of natural language at multiple levels of granularity. Implemented as a white box, the human preference-guided aggregator is efficient to train and more explainable than relying solely on prompting, and its independence from model parameters makes it applicable to closed-source LLMs. Extensive experiments on three evaluation domains demonstrate the superiority of HD-EVAL in further aligning state-of-the-art evaluators and providing deeper insights into the explanation of evaluation results and the task itself.

1 Introduction

With the rapid development of LLMs and rising significance on NLG evaluations, an emerging line of works exploring utilizing LLM as reference-free text quality evaluators (Kocmi and Federmann, 2023; Wang et al., 2023a; Fu et al., 2023; Liu et al., 2023a). To leverage the instruction following capability of LLMs, existing works utilize a *single* piece of criteria (as a prompt) to evaluate a given sample. Given the superior instruction-following capability and immense knowledge obtained through pre-training, LLM-based evaluators substantially outperform previous automatic evaluation metrics (Yuan et al., 2021; Zhong et al., 2022), and opens a promising alternative for human evaluation.

However, despite their achievements, an emerging line of research questions the alignment and trustworthiness of LLM judgments. As recent studies point out, these approaches are limited by the bias of prompt design (Wang et al., 2023a), resulting in potential biases in its judgments (Wang et al., 2023b), demanding per-task calibration on evaluation prompts to mitigate (Liu et al., 2023b).

One core limitation of using a single criterion to evaluate text quality is that it may not capture the complexity and diversity of human evaluations and judgments. Human thinking is not linear or monolithic, but rather comprehensive and naturally follows a hierarchical order (Tversky and Kahneman, 1974). When we read a book, we may evaluate it from different perspectives, such as plot, characters, style, and theme, each of which can further be naturally divided into more specific criteria.

Hierarchical thinking (Haupt, 2018) allows humans to resolve complex problems by first breaking them down into more tangible sub-problems, and then integrating the solutions at different levels of abstraction (Buzan and Buzan, 2006). Correspondingly, mainstream human evaluation protocols also leverage hierarchical critiques (Freitag et al., 2021).

Our core motivation is to empower the alignment of LLM-based evaluators by rooting the evaluation mindset of human experts into design, while also harnessing state-of-the-art generic capabilities of LLMs. Drawing inspirations from the above, we propose HD-EVAL, a novel framework to align LLM-based evaluator towards human preference through **H**ierarchical Criteria **D**ecomposition.

Specifically, the design of critical components of HD-EVAL inherits the essence of the human evaluation mindset: task decomposition, analysis of

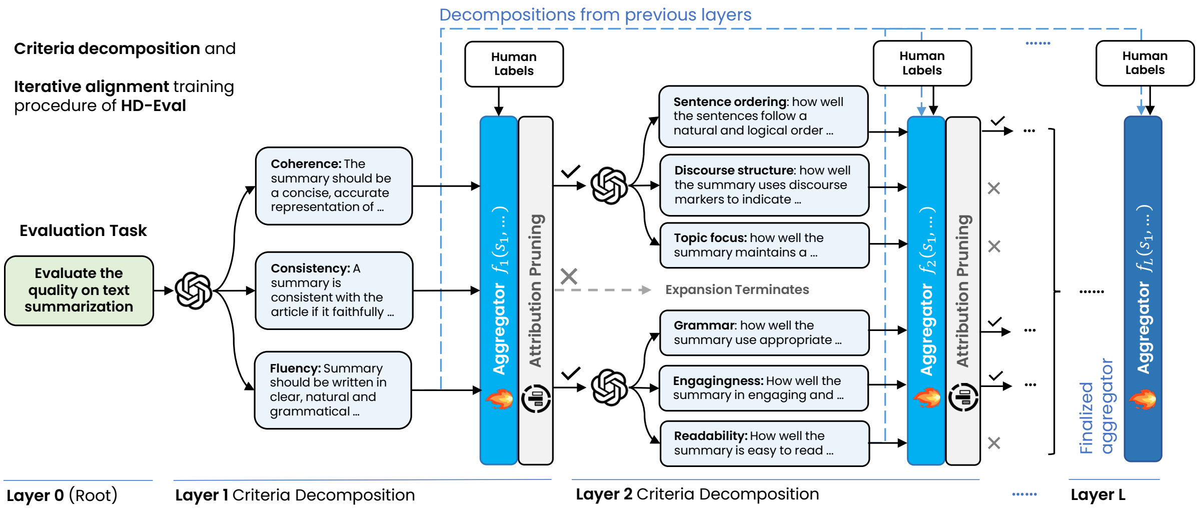

Figure 1: Overall framework of HD-EVAL. Starting from the evaluation task, HD-EVAL iteratively *decomposes* it to different aspects, *trains* an aggregator, then *select* significant criteria with attribution pruning for further expansion at the next layer. The aggregator and decomposition are finalized after reaching the maximum layer count.

all sub-tasks, and a final comprehensive evaluation. Correspondingly, we propose 3 crucial stages: (1) *Hierarchical Criteria Decomposition*, where we decompose an evaluation task into a hierarchy of evaluation criteria, each focusing on different evaluation aspects with various granularity; (2) *Human Preference-Guided Aggregation*, where we aggregate evaluation results at each hierarchy to obtain a final judgment, with respect to the estimated preference of human experts on different hierarchies; (3) *Attribution Pruning*, to dynamically attribute human expert's preference on existing criteria to efficiently prune the space of decomposition, focus on significant aspects, thus improving its fidelity.

To align an LLM-based evaluator toward human preference, we propose *Iterative Alignment Training Framework* to seamlessly integrate the 3 stages above in a layer-wise iterative fashion. When the training process of HD-EVAL completes, we obtain a pair of finalized criteria decomposition and human preference-guided aggregator, which could be applied to evaluation samples upon application.

We highlight the following key contributions of HD-EVAL as follows:

1) We propose HD-EVAL, a novel framework that aligns LLM-based evaluators towards human preference via comprehensively decomposing criteria into multiple levels of hierarchy.

2) Implemented as white-box, judgments made by aggregators of HD-EVAL are significantly more controllable and explainable than solely prompting LLMs.

3) The design of HD-EVAL ensures its applicability to both open-source and API-hosted LLMs.

4) Comprehensive experiments on three evaluation domains demonstrate the superior capability of HD-EVAL in aligning LLM-based evaluators.

2 Methodology

2.1 Hierarchical Criteria Decomposition

To leverage the hierarchical thinking of human evaluation mindset and mitigate potential bias, we propose Hierarchical Criteria Decomposition in HD-EVAL, to obtain a *hierarchy* of evaluation criteria. This analogy of human evaluation mindset naturally reciprocates an *alignment* between LLMs and expert evaluations.

Criteria Decomposition with LLMs As illustrated in Figure 1, HD-EVAL iteratively decomposes an evaluation task into a hierarchy of criteria. To obtain such decomposition, we prompt LLMs to obtain a decomposition of a single criteria, by providing backgrounds of the evaluation task $\mathcal{T}$ and the parent evaluation criteria $\mathcal{C}_j^{l-1}$:

$$\{\mathcal{C}_1^l, ..., \mathcal{C}_m^l\} = LLM(\mathcal{T}, \mathcal{C}_j^{l-1}), \qquad (1)$$

where the j-th evaluation criteria at hierarchy level $l-1$ is further decomposed into a series of sub-criteria $\{\mathcal{C}_1^l, ..., \mathcal{C}_m^l\}$ by the LLM. By iteratively performing this decomposition starting from the overall task as *root* node, we naturally obtain a tree-structured hierarchy of evaluation criteria, focusing on different evaluation levels and aspects.

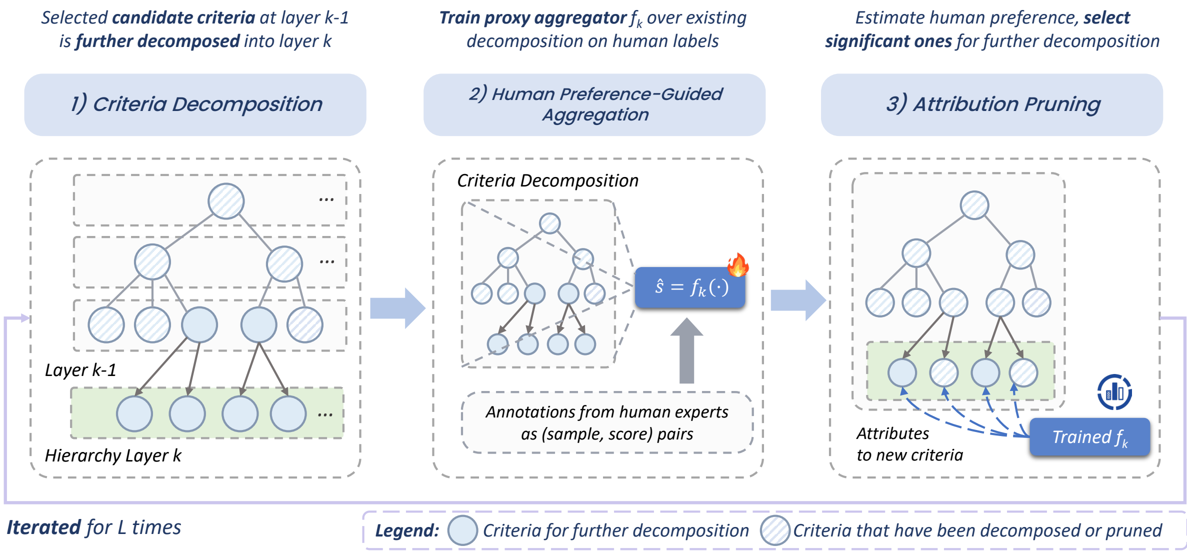

Figure 2: An example to hierarchical criteria decomposition and iterative alignment training of HD-EVAL.

Hierarchy-Aware Prompting To leverage the hierarchical decomposition of criteria, we propose Hierarchy-Aware Prompting to preserve the hierarchical relations when evaluating a decomposed criteria (node). Specifically, when evaluating a single aspect *(child)*, we also provide information from its *parent* node. This prompt design reserves the local hierarchical information (i.e., *links*), while refrains excessive and irrelevant information, providing LLMs a better grasp of the criteria. Full prompts are provided in Appendix D.

2.2 Human Preference-Guided Aggregation

After obtaining decomposed sub-criteria from parent criteria with HD-EVAL, we propose Human Preference-Guided Aggregation to adequately address the importance of each decomposed criteria to obtain a final verdict.

Existing works either adopt a straightforward average on all scores (Liu et al., 2023a), or prompt the LLM itself (Saha et al., 2023) to obtain comprehensive results. However, these approaches suffer from the inherent bias of LLMs (Wang et al., 2023b), and also fail to address human preference.

To overcome these limitations, we adapt white-box aggregators to *estimate* how human experts value each decomposed criteria. The aggregator f_θ serves as a human preference estimator to aggregate evaluation results on different hierarchies (e.g. L layers), to obtain a comprehensive evaluation:

$$\hat{s}_k = f_\theta(a_k^{1,1}, ..., a_k^{1,n}, ..., a_k^{L,1}, ..., a_k^{L,m}), \quad (2)$$

where $a_k^{i,j}$ denotes evaluation on the j-th criteria of the i-th layer to sample k. To fit f_θ towards human expert preference, we train f_θ on a collected set of `(sample,score)` pairs from human experts to minimize the gap between f_θ and human experts.

2.3 Attribution Pruning

The core motivation for attribution pruning is to ensure most searching efforts (i.e., *deeper* decomposition) are focused on the most significant evaluation aspects. While it is feasible to obtain a *full* tree-like hierarchical decomposition, it brings higher costs and might potentially introduce noisy or redundant criteria. However, it is non-trivial to assign importance to each generated criteria, as it demands domain expertise from human experts.

To remedy the demand on domain expertise, we propose Attribution Pruning to *objectively* select the most significant criteria and further support it with augmented evidence, through continuing decomposing it into finer-grained criteria.

As illustrated in Figure 1, once we finish criteria decomposition at i-th layer, we train a proxy aggregator $f_i(\cdot)$ to approximate human expert's preference on newly generated criteria[1]. Since the optimization objective $f_i(\cdot)$ aligns with human expert evaluations, the significance of each generated criteria is *automatically* assigned during training, which could be measured with a saliency function $g(\cdot)$, with which we obtain significant criteria:

$$\mathcal{C}_D^{i+1} = \text{argtopk}_{\mathcal{C}_D \in \mathcal{C}_i} \left[g\left(f_i(\mathcal{C})\right)\right], \quad (3)$$

[1]Note that during training, criteria of upper levels of hierarchy are also fed into the proxy aggregator $f_i(\cdot)$.

Metrics	Coherence		Consistency		Fluency		Relevance		Average	
	r	ρ	r	ρ	r	ρ	r	ρ	r	ρ
ROUGE-1	0.178	0.168	0.037	0.028	0.045	0.009	0.288	0.291	0.137	0.124
ROUGE-2	0.143	0.152	0.025	0.011	0.029	-0.006	0.209	0.240	0.101	0.099
ROUGE-L	0.141	0.134	0.026	0.015	0.052	0.022	0.262	0.264	0.120	0.109
BERTSCORE	0.302	0.285	0.093	0.071	0.174	0.119	0.389	0.372	0.239	0.212
PRISM	0.188	0.184	0.067	0.039	0.074	0.053	0.290	0.290	0.154	0.141
CTC	0.220	0.181	0.531	0.407	0.494	0.305	0.259	0.127	0.376	0.255
BARTSCORE	0.423	0.403	0.350	0.317	0.303	0.250	0.415	0.386	0.373	0.339
UNIEVAL	0.545	0.588	0.602	0.439	0.601	0.460	0.464	0.478	0.553	0.491
GPT-4 EVAL	0.547	0.542	0.507	0.458	0.479	0.460	0.609	0.592	0.538	0.513
*Iterative alignment training on **25%** of all human expert preference data*										
HD-EVAL-NN	0.655	0.644	0.573	0.457	0.562	0.437	0.601	0.577	0.598	0.529
*Iterative alignment training on **50%** of all human expert preference data*										
HD-EVAL-NN	0.668	0.657	0.604	0.451	0.580	0.435	0.619	0.599	0.617	0.535

Table 1: Segment-level Pearson (r) and Spearman (ρ) human correlations of aspects on SummEval.

where $\mathcal{C} = \cup_i \mathcal{C}_i$ denote existing criteria set, $\mathcal{C}_D^{i+1}$ denote selected criteria to decompose at layer $i+1$[2], and k denotes a controlling threshold on expansion space. Since $f_i(\cdot)$ is a white-box, $g(\cdot)$ could be implemented as attribution methods (e.g., permutation importance (Altmann et al., 2010), Shapley additive explanations (Lundberg and Lee, 2017)), which provides superior controllability and explainability, compared to prompting or tuning of LLMs.

2.4 Iterative Alignment Training Framework

Combining the procedures above, we propose an Iterative Alignment Training Framework for HD-EVAL, as summarized in Figure 2. In this framework, we seamlessly integrate critical components of HD-EVAL, i.e. criteria decomposition, human preference-guided aggregation, and attribution pruning as 3 stages, in a per-layer iterative fashion.

Specifically, In j-th training iteration, we first perform criteria decomposition to each of criteria in candidates $\mathcal{C}_D^j$ selected from the last step with pruning, obtaining a set of new criteria $\mathcal{C}_j$ for j-th layer. We then train a new proxy aggregator $f_j(\cdot)$ to estimate human preference and finally perform attribution pruning based on $f_j(\cdot)$ to select significant criteria $\mathcal{C}_D^{j+1}$ for decomposition at the next iteration.

As illustrated in Figure 1, when this iterative alignment training process of HD-EVAL completes, we obtain a pair of *finalized* aggregator and criteria decomposition, which could be applied to new candidate evaluation samples upon application.

[2]Since criteria on upper levels are already being decomposed, we only select $\mathcal{C}_D^{i+1}$ within $\mathcal{C}_i$.

3 Experiments

3.1 Experimental Setup

Datasets and Evaluations We evaluate the performance of HD-EVAL on three NLG evaluation scenario: text summarization (SummEval (Fabbri et al., 2021)), natural language conversation (Topical-Chat (Gopalakrishnan et al., 2019)) and data-to-text generations (SFRES and SFHOT (Wen et al., 2015)). For assessing human alignment, we report dataset (segment) level meta-evaluation results on both Pearson's r and Spearman's ρ correlation coefficient with human annotations. For each dataset, a 50% proportion is held out for testing, while the rest is applied for training[3].

Baselines We compare our HD-EVAL against a series of automatic evaluation baselines, including ROUGE (Lin, 2004), BERTScore (Zhang* et al., 2020), MoverScore (Zhao et al., 2019), PRISM (Thompson and Post, 2020), BartScore (Yuan et al., 2021), and UniEval (Zhong et al., 2022). For LLM-based evaluation, we select GPT-4 Evaluation (Liu et al., 2023a), representing state-of-the-art capability for LLM-based evaluators.

Models and Configurations We adopt OpenAI's GPT-4 model (OpenAI, 2023) (`GPT-4-32K`) and LLama-2 families (Touvron et al., 2023)[4] as LLM in this study. For the aggregator, we experiment

[3]We explore utilizing different percentages of training data in our experiments. Detailed count of training data will be reported under different experimental settings.

[4]Comprehensive studies on Llama-based HD-EVAL are presented in Appendix B due to space limitations.

Metrics	Naturalness		Coherence		Engagingness		Groundedness		Average	
	r	ρ	r	ρ	r	ρ	r	ρ	r	ρ
ROUGE-1	0.158	0.143	0.205	0.206	0.305	0.319	0.264	0.264	0.233	0.233
ROUGE-2	0.175	0.168	0.186	0.247	0.281	0.337	0.260	0.311	0.225	0.266
ROUGE-L	0.172	0.145	0.198	0.205	0.299	0.306	0.286	0.293	0.239	0.237
BERTSCORE	0.226	0.209	0.214	0.233	0.317	0.335	0.291	0.317	0.262	0.273
PRISM	0.040	-0.010	0.098	0.081	0.241	0.220	0.178	0.159	0.139	0.113
CTC	0.232	0.195	0.343	0.296	0.540	0.542	0.422	0.398	0.384	0.358
BARTSCORE	-0.072	-0.053	-0.107	-0.079	-0.105	-0.084	-0.217	-0.197	-0.125	-0.103
UNIEVAL	0.342	0.450	0.571	0.616	0.573	0.615	0.523	0.590	0.502	0.568
GPT-4 EVAL	0.584	0.607	0.562	0.590	0.594	0.605	0.530	0.556	0.567	0.590
*Iterative alignment training on **25%** of all human expert preference data*										
HD-EVAL-NN	0.647	0.672	0.588	0.613	0.682	0.702	0.471	0.498	0.597	0.621
*Iterative alignment training on **50%** of all human expert preference data*										
HD-EVAL-NN	0.648	0.674	0.584	0.607	0.682	0.701	0.549	0.568	0.616	0.638

Table 2: Turn-level Pearson (r) and Spearman (ρ) human correlations of aspects on Topical-Chat.

with multiple white-box implementations, including Linear Regression (LR), Decision Tree (DT), Random Forest (RF), and shallow MLPs (NN). For criteria decomposition, we apply a maximum layer of 3, and a child count of 4 for parent nodes. Detailed implementations are listed in Appendix C.1.

3.2 Experimental Results

Human Alignment Meta evaluation results for HD-EVAL on evaluating text summarization is illustrated in Table 1. We train our HD-EVAL under two different data settings, representing HD-EVAL data-constraint and/or resource-constraint evaluation scenarios. As illustrated in Table 1, HD-EVAL substantially improved the human relevance of evaluation over GPT-4, resulting in a 15% improvement on Pearson's correlation overall, and over 20% in coherence and fluency. When training with only half of human expert annotations, the performance of HD-EVAL remains on-par or marginally off, demonstrating the effectiveness of the iterative alignment training process.

Similarly, in evaluating natural language conversations (Table 2), HD-EVAL empowers the alignment of GPT-4 by uplifting both the Pearson and Spearman correlation over 8%, and maintained on-par performance on 3 of 4 evaluation aspects when training with only half of human preference data.

We finally test HD-EVAL on a more challenging evaluation task, i.e. evaluating the naturalness of data-to-text generations. As illustrated in Table 3, HD-EVAL obtained more than 15% improvement in human correlations on both correlation coefficients and only lost around 3% performance with only half of the training data available. These results highlight the effectiveness and efficiency of HD-EVAL in aligning LLM-based evaluators.

Metrics	SFRES		SFHOT		Average	
	r	ρ	r	ρ	r	ρ
ROUGE-1	0.074	0.092	0.035	0.031	0.055	0.062
ROUGE-2	0.094	0.073	0.060	0.042	0.077	0.051
ROUGE-L	0.059	0.067	0.048	0.038	0.063	0.043
BERTSCORE	0.164	0.145	0.103	0.087	0.134	0.116
PRISM	0.146	0.126	0.164	0.131	0.155	0.129
BARTSCORE	0.280	0.255	0.133	0.095	0.207	0.175
CTC	0.100	0.086	0.181	0.160	0.141	0.123
UNIEVAL	0.381	0.354	0.350	0.305	0.366	0.330
GPT-4 EVAL	0.414	0.347	0.436	0.364	0.425	0.356
*Iterative alignment training on **25%** of data*						
HD-EVAL-NN	0.453	0.363	0.494	0.420	0.474	0.392
*Iterative alignment training on **50%** of data*						
HD-EVAL-NN	0.470	0.389	0.510	0.432	0.490	0.411

Table 3: Segment-level Pearson (r) and Spearman (ρ) correlations on Data-to-Text generation tasks.

Ablation Study In Table 4, we provide an ablation study on key components of HD-EVAL. We first investigate the effectiveness of hierarchical criteria decomposition, by removing layers of hierarchy in a bottom-up fashion. As illustrated in the table, the human relevance drops consistently on both correlation measurements with layers being removed, demonstrating the significance of criteria decomposition. We then replaced the human preference-guided aggregator with a numeric average on all labels, and its performance dropped significantly ($p < 0.05$). These results verify that the crucial design components of HD-EVAL positively contribute to human alignment.

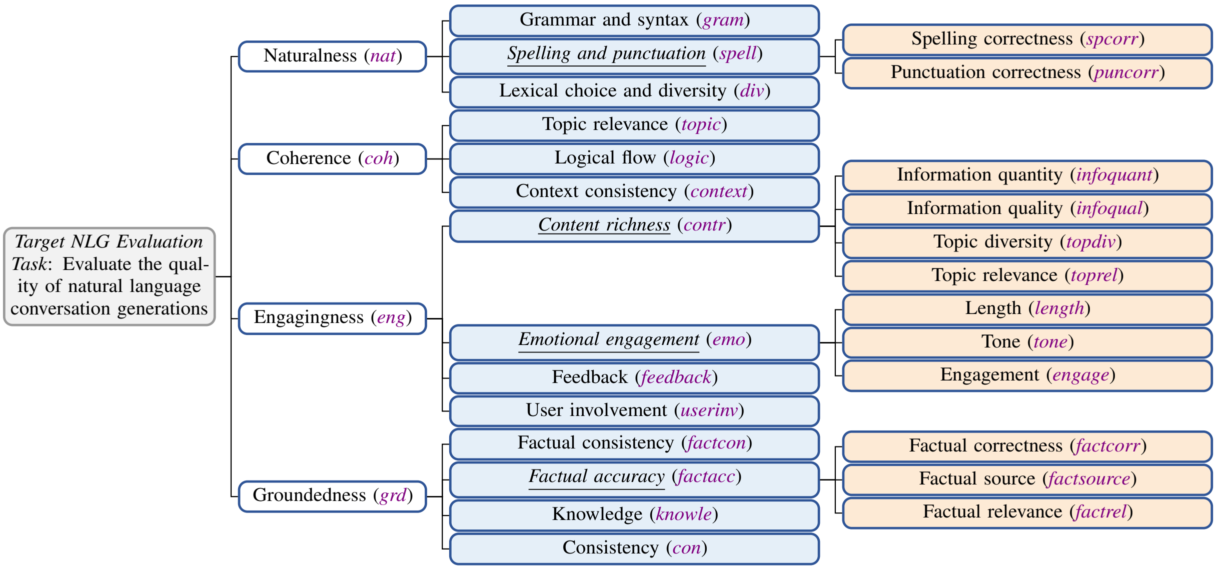

Figure 3: A case study for criteria decomposition on Topical-Chat. White, blue and orange boxes denote decomposed criteria at 1st, 2nd and 3rd hierarchy. *Underlined* denote criteria being selected with attribution pruning.

Metrics	SummEval		TopicalChat		SFHOT	
	r	ρ	r	ρ	r	ρ
*Iterative alignment training on **50**% of data*						
HD-EVAL-NN	**0.617**	**0.535**	**0.616**	**0.638**	**0.510**	**0.432**
w/o Layer 3	0.611	0.534	0.600	0.624	0.470	0.356
w/o Layer 2,3	0.576	0.516	0.535	0.543	0.448	0.346
w/o Layer 1,2,3	0.538	0.513	0.567	0.590	0.436	0.364
w/o Aggregator	0.555	0.530	0.600	0.615	0.406	0.313

Table 4: Ablations on each proposed module of HD-EVAL. We report Pearson (r) and Spearman (ρ) correlations on all NLG evaluation tasks explored in this study.

Metrics	SummEval		TopicalChat		SFHOT	
	r	ρ	r	ρ	r	ρ
*Iterative alignment training on **25**% of data*						
HD-EVAL-LR	0.568	0.521	0.495	0.519	0.448	0.390
HD-EVAL-DT	0.488	0.442	0.401	0.398	0.397	0.347
HD-EVAL-RF	**0.607**	0.502	0.589	0.602	0.413	0.366
HD-EVAL-NN	0.598	**0.529**	**0.591**	**0.621**	**0.494**	**0.420**
*Iterative alignment training on **50**% of data*						
HD-EVAL-LR	0.583	0.534	0.599	0.617	**0.512**	**0.443**
HD-EVAL-DT	0.505	0.430	0.525	0.549	0.330	0.274
HD-EVAL-RF	0.614	0.504	0.615	0.626	0.480	0.397
HD-EVAL-NN	**0.617**	**0.535**	**0.616**	**0.638**	0.510	0.432

Table 5: Exploring HD-EVAL varying implementation of aggregator. We report Pearson (r) and Spearman (ρ) correlations on all NLG evaluation tasks in this study.

Aggregator Implementation We explore various implementations of human preference estimator in HD-EVAL. As listed in Table 5, more capable aggregators like random forest or decision trees contribute to a better alignment in general, while a simplistic linear regression also stays on-par on most tasks, and even excels at Data-to-Text tasks.

4 Analysis

4.1 Case Study

To investigate the effect of hierarchical criteria decomposition, we present a case study on evaluating natural language conversation. In our experiments, we explore decomposing an NLG evaluation task into a maximum of 3 hierarchies (layers). As illustrated in Figure 3, the highest layer of HD-EVAL resembles *high-level* evaluation aspects focusing on holistic evaluations, e.g. naturalness and coherence. These holistic criteria are then elaborated and supported with finer-grained decomposition at layer 2, focusing on *more specific* aspects. The last layer further expands attributed significant ones to *finest-grained* criteria. These results demonstrate the capability of HD-EVAL in generating hierarchical criteria decomposition for NLG evaluations. A complete case study on criteria decomposition is presented in Appendix E.

4.2 Data Efficiency

In Section 3.2, we demonstrate HD-EVAL is significant in aligning LLM-based evaluators through human preference. However, this also requires annotations from experts. To test HD-EVAL under different amounts of data, we sweep training data percentage from 5% to full corpus. As illustrated in Figure 4, more annotated data from human experts

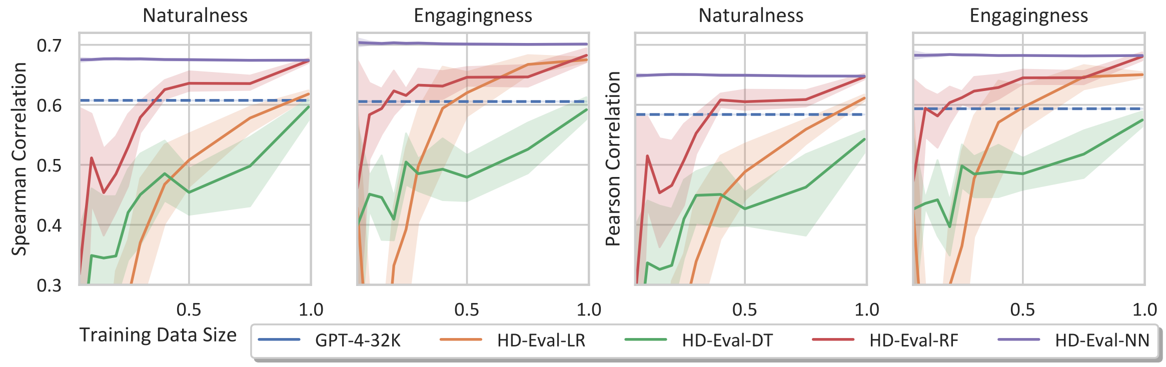

Figure 4: Performance of HD-EVAL under different training data counts on Topical-Chat, averaged over 5 seeds.

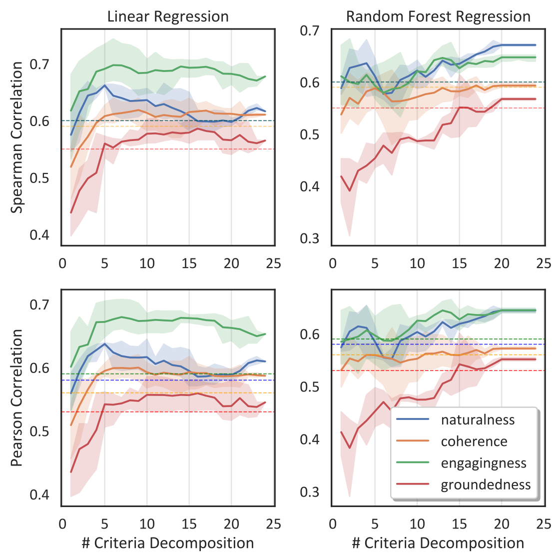

Figure 5: Criteria efficiency of HD-EVAL on Topical-Chat. Results are averaged over 5 random samples.

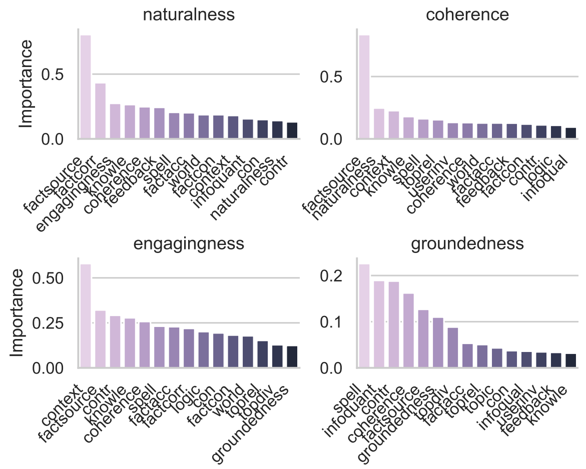

Figure 6: Explaiability on human preference estimation of HD-EVAL-NN based on permutation importance.

generally benefits HD-EVAL in improving human alignment, as it provides more evidence to infer the underlying pattern of human evaluation mind-sets. A stronger regressor reduces the demand on human labels (e.g. only training on 5% of data is sufficient for HD-EVAL-NN). This intriguing feature ensures an efficient deployment and uncovers the fact that such alignment is rather *superficial*, which corroborates with finding s from Zhou et al. (2023). Once we obtain a criteria decomposition, the remaining efforts on addressing human preference are thereby light, since it should be *shared implicitly as a 'consensus'* within human experts.

4.3 Criteria Efficiency

While the search space of HD-EVAL has already been significantly reduced with attribution pruning, we investigate whether a *post-pruning* could be performed on top of it. To investigate, we first sort all decomposed criteria (nodes) via significance, then progressively add them and train proxy aggregators. Results are illustrated in Figure 6. Generally, since more information is provided, increasing criteria counts contribute to a better alignment. However, it is also proven feasible to achieve a comparable performance by only keeping the most significant ones for better efficiency[5].

4.4 Explainability of HD-EVAL

In this subsection, we discuss the explainability of the evaluation results generated with HD-EVAL. To provide a lens of interpretation, we implement human preference-guided aggregators in a lightweight, white-box fashion, providing us with possibilities in post-hoc explanations. We experiment with two attribution approaches: permutation

[5]While post-pruning greatly benefits efficiency, this does not undermine the significance of criteria decomposition, since with which we search for fine-grained candidate criteria.

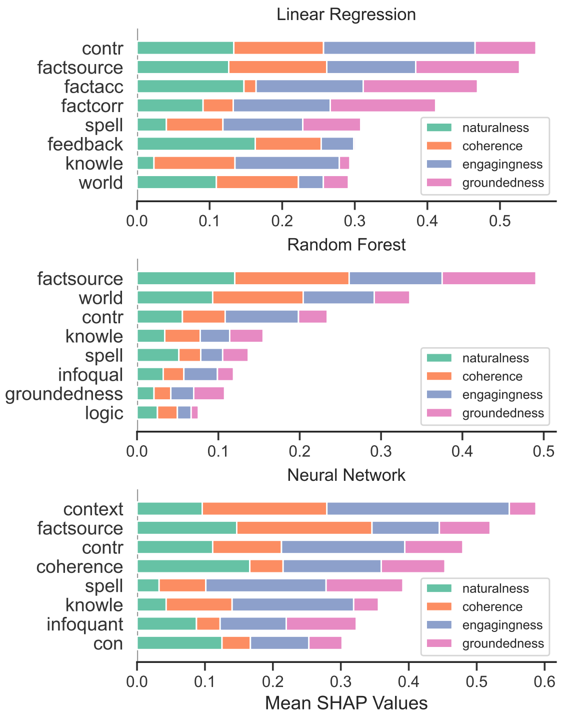

Figure 7: Explaiability on human preference estimation of HD-EVAL based on Shapley additive explainations.

importance (Altmann et al., 2010) and Sharply additive explanations (Lundberg and Lee, 2017).

As illustrated in Figure 6 and 7,HD-EVAL successfully assigned importance to various decomposed criteria as an estimation of human preference for different evaluation aspects, indicating the effectiveness in the human preference-guided aggregation process of HD-EVAL. These results also provide a lens into *understanding underlying human preference* from evaluation. For instance, we mine and uncover multiple crucial *key objectives* for dialogue generation, including factual correctness (*factcorr*), content richness (*contr*), factual source (*factsource*), which are shared by all target evaluation aspects. These findings above not only improve our understanding of human preference in evaluation but also provide key grasps into ***directions*** of refining candidate models (e.g., LLMs).

5 Related Work

Automatic Text Evaluation Conventional metrics like BLEU (Papineni et al., 2002) and ROUGE (Lin, 2004) assess candidate quality by statistically comparing n-grams with a reference text, but their human alignment is criticized (Freitag et al., 2022). In contrast, embedding-based metrics, using PLM embeddings like BERT (Devlin et al., 2019), gauge similarity between candidate and reference (Zhang* et al., 2020; Zhao et al., 2019), yet they are limited by their reliance on a similarity-based approach and the quality and diversity of references.

More recent research aims to enhance PLMs through fine-tuning on human (Rei et al., 2020) or synthetic (Zhong et al., 2022) labels, or pretraining on domain-relevant documents (Yuan et al., 2021). However, metrics in these studies either emphasize a single dimension (Wang et al., 2020; Huang et al., 2020) or are limited in human relevance (Mehri and Eskenazi, 2020; Zhong et al., 2022).

LLM-Based Evaluators As LLMs gain prominence, recent research delves into the development of LLM-based evaluators. Early investigations involve initial explorations on LLMs, including prompting methods and model variants (Fu et al., 2023; Kocmi and Federmann, 2023; Wang et al., 2023a; Chen et al., 2023; Liu et al., 2023a).

A subsequent line of studies aims to address extant limitations within these evaluators, with a focus on factors such as factuality (Min et al., 2023), interpretability (Lu et al., 2023), mitigation of position bias (Wang et al., 2023b), and alignment to human evaluation standards (Liu et al., 2023b). Another strand of works explores empowering LLM-based evaluation methodologies. This involves efforts directed at generalization to underrepresented languages (Hada et al., 2023), grounding evaluations into error spans (Fernandes et al., 2023), and incorporating interactive discussions (Chan et al., 2023). Diverging from these approaches, we focus on the iterative alignment of LLM-based evaluators through hierarchical criteria decomposition and are the first to break down evaluation into a hierarchy of criteria at different granularity.

6 Conclusion

Drawing inspiration from human evaluation mindsets, we propose HD-EVAL, a novel framework that empowers LLM-based evaluators through explainable alignment. Through criteria decomposition, human preference-guided aggregation, and attribution pruning, the criteria obtained with HD-EVAL demonstrates a comprehensive focus on different levels of details. Extensive experiments on three NLG evaluation tasks demonstrate the effectiveness of HD-EVAL. Detailed analysis shows the efficiency and explainability of HD-EVAL, and opens up brand new perspectives in understanding preferences of human evaluations.

Limitations

Below, we make an elaborate discussion about the current limitations of this work and share our perspectives on further directions.

1) Currently, criteria decomposition in this work is solely done with LLMs in this work due to the lack of domain knowledge and limited resources. Ideally, HD-EVAL would exploit its full potential by leveraging *human-in-the-loop* to assist the criteria decomposition and iterative pruning procedure. Also, it could be potentially beneficial to employ expert-written guidelines for each evaluation aspect. We leave this as a promising direction for future work.

2) The underlying assumption of HD-EVAL is that an evaluation task is *decomposable*, i.e., it could be hierarchically decomposed to aspects at multiple detail levels. While this claim is natural as it follows the essence of human evaluation mindsets, it remains elusive whether we can always optimally decompose a task hierarchically, which demands future investigations and possible improvements.

3) Limited by scope and budget, we did not perform exhaustive research on prompt engineering for LLM-based evaluators in HD-EVAL. As evidenced by multiple concurrent works, LLM-based evaluators are sensitive to prompts and would enjoy a performance uplift with carefully engineered prompts. We believe these research efforts are *orthogonal* with HD-EVAL, and propose HD-EVAL as a methodology that is able to adapt to different prompts and leverage more advanced prompt designs in the future.

Ethnics Statement

HD-EVAL aims to improve the evaluation of natural language generation systems by using a novel framework that aligns LLM-based evaluators with human preference. This work has the potential to benefit the research community and society by providing more reliable and transparent metrics for assessing the quality of NLG outputs.

This work also acknowledges the possible risks and challenges associated with using LLMs for evaluation, such as the potential bias against the contents generated by different systems, the ethical and legal implications of using LLMs that may contain sensitive or harmful information, and the computational and environmental costs of training and deploying LLMs.

All language models and human annotations applied throughout this study are publicly available, and properly cited in relevant sections of this paper.

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A Extended Analysis

In this subsection, we provide an extended analysis of the explainability of evaluations of HD-EVAL. Results are presented in Figure 8 and 9. In Figure 8, we perform permutation importance analysis on other implementations of HD-EVAL in addition to Figure 6. In figure 9, we perform a detailed visualization of SHAP (Shapley additive explanation values) on HD-EVAL-NN and HD-EVAL-RF.

From these results, we observe that Tree-based (DT, RF) and Regression-based (LR, NN) demonstrate similar traits in assigning importance to decomposed criteria. However, our conclusion still holds that a set of underlying evaluation criteria are shared as critical contributors to all evaluation aspects, e.g. content richness (*contr*) and factual source (*factsource*). We believe the explainability of HD-EVAL provides a valuable perspective in understanding inherent preferences for human experts, which has potential on both qualifying human evaluations (e.g. estimating annotator bias) as well as providing detailed supporting evidence for improving NLG systems.

B Discussions On Smaller LLMs

Most previous research on LLM-based evaluations reveals that reference-free text quality evaluation is indeed a challenging task that demands immense pre-training knowledge and emergent capabilities of LLMs.

Particularly, only a very few *most capable* LLMs (e.g. GPT-4 (OpenAI, 2023)) could be prompted as a strong evaluator, and zero-shot performances of smaller LLMs (e.g. Llama (Touvron et al., 2023) or Falcon-40B (Almazrouei et al., 2023)) are largely undesired in following instructions on evaluation (Chiang and Lee, 2023). As studied in Shen et al. (2023), even the most capable LLAMA-2-CHAT-70B correlates poorly with human evaluations, falling behind dedicatedly-tuned small neural evaluators (Zhong et al., 2022).

Metrics	Nat.		Coh.		Eng.		Grd.	
	r	ρ	r	ρ	r	ρ	r	ρ
Iterative alignment training on ***50****% of data*								
Llama2-7B-Chat	0.078	0.233	0.257	0.360	0.594	0.605	0.062	0.127
+HD-EVAL-RF	0.355	0.377	0.378	0.371	0.463	0.462	0.241	0.227
+HD-EVAL-NN	0.245	0.266	0.208	0.269	0.176	0.239	0.046	0.104
Gain (%)	**355.1**	**61.8**	**47.1**	3.1	-22.1	-23.6	**288.7**	**78.7**
Llama2-13B-Chat	0.371	0.378	0.295	0.302	0.594	0.605	0.269	0.296
+HD-EVAL-RF	0.353	0.375	0.378	0.383	0.528	0.524	0.357	0.362
+HD-EVAL-NN	0.391	0.386	0.255	0.250	0.364	0.400	0.165	0.160
Gain (%)	-4.9	-0.8	28.1	26.8	-11.1	-13.4	**32.7**	22.3
Iterative alignment training on ***80****% of data*								
Llama2-7B-Chat	0.018	0.159	0.209	0.333	0.602	0.616	0.105	0.073
+HD-EVAL-RF	0.420	0.397	0.495	0.436	0.469	0.469	0.245	0.203
+HD-EVAL-NN	0.501	0.450	0.508	0.442	0.453	0.412	0.216	0.219
Gain (%)	**2233.3**	**149.7**	**136.8**	**30.9**	-22.1	-23.9	**133.3**	**178.1**
Llama2-13B-Chat	0.484	0.471	0.336	0.397	0.602	0.616	0.232	0.248
+HD-EVAL-RF	0.412	0.411	0.454	0.472	0.455	0.462	0.327	0.334
+HD-EVAL-NN	0.550	0.529	0.470	0.505	0.523	0.543	0.256	0.244
Gain (%)	13.6	12.3	**39.9**	27.2	-13.1	-11.9	10.3	-1.6

Table 6: Exploring HD-EVAL on Topical-Chat with smaller LLMs. We report Pearson (r) and Spearman (ρ) correlations. Gain (%) denote the relative performance gain from best overall performing system (marked in **bold**). We highlight relative performance gains over 30% through HD-EVAL with **bold**.

To exploit the full potential of smaller language models in zero-shot evaluation, we explore empowering them with HD-EVAL. We experimented with LLAMA2-CHAT-7B and LLAMA2-CHAT-13B. (Touvron et al., 2023), and results[6] are illustrated in Table 6 and 7. On Topical-Chat, aligned with HD-EVAL, the human alignment of 7B-sized models substantially improved, achieving a 30% or even more than 100% improvement in evaluating the naturalness, coherence, and groundedness of conversations. Different from GPT-4, the engagingness did not obtain performance gains from hierarchical decomposition. We conjecture this phenomenon *still*, roots back into poorer instruction following the capability of smaller models, where they fail to understand finer-grained, detailed evaluation aspects, as they may receive less prior knowledge in these fields.

Similarly, HD-EVAL also empowers the human alignment in the evaluation of summarization quality, achieving significant gains for all 7B, 13B, and 70B variants, highlighting the universal applicability of HD-EVAL, especially when existing prompting-based methods all fall short on smaller models due to their weaker instruction following capability (Chiang and Lee, 2023; Shen et al., 2023).

Despite the gains, it is noteworthy to point out that these smaller LMs are not strong zero-shot evaluators so far. We believe a specialized and dedicated tuning (Gekhman et al., 2023) on instruction following in evaluation would be a promising aid and would pursue in future endeavors.

[6]In these tables, we mark the relative gains from the best *overall* performing implementation, which may not always correspond to the best performer for a specific *aspect*. We aim to present an overall effect of HD-EVAL on Llama models.

Metrics	Coh.		Con.		Flu.		Rel.	
	r	ρ	r	ρ	r	ρ	r	ρ
Iterative alignment training on ***20****% of data*								
Llama2-7B-Chat	0.097	0.096	0.008	0.005	0.034	0.024	0.134	0.130
+HD-EVAL-RF	0.054	0.053	0.058	0.049	0.025	0.010	0.151	0.150
+HD-EVAL-NN	0.138	0.132	0.130	0.061	0.111	0.071	0.130	0.123
Gain (%)	**42.3**	**37.5**	**1525.0**	**1120.0**	**226.5**	**195.8**	-3.0	-5.4
Llama2-13B-Chat	0.268	0.246	0.134	0.114	0.138	0.124	0.132	0.118
+HD-EVAL-RF	0.267	0.227	0.244	0.130	0.197	0.137	0.278	0.212
+HD-EVAL-NN	0.299	0.277	0.141	0.100	0.160	0.098	0.250	0.220
Gain (%)	-0.4	-7.7	**82.1**	14.0	**42.8**	10.5	**110.6**	**79.7**
Llama2-70B-Chat	0.392	0.383	0.277	0.232	0.248	0.217	0.304	0.254
+HD-EVAL-RF	0.408	0.367	0.249	0.214	0.233	0.164	0.409	0.370
+HD-EVAL-NN	0.454	0.418	0.306	0.206	0.311	0.214	0.451	0.421
Gain (%)	15.8	9.1	10.5	-11.2	25.4	-1.4	**48.4**	**65.7**
Iterative alignment training on ***50****% of data*								
Llama2-7B-Chat	0.064	0.064	0.010	0.017	0.001	0.032	0.127	0.133
+HD-EVAL-RF	0.118	0.124	0.131	0.182	0.062	0.055	0.216	0.200
+HD-EVAL-NN	0.103	0.109	0.169	0.100	0.085	0.081	0.147	0.140
Gain (%)	**84.4**	**93.8**	**1210.0**	**970.6**	**6100.0**	**71.9**	**70.1**	**50.4**
Llama2-13B-Chat	0.235	0.219	0.119	0.109	0.142	0.110	0.148	0.148
+HD-EVAL-RF	0.296	0.230	0.272	0.140	0.181	0.100	0.332	0.281
+HD-EVAL-NN	0.282	0.258	0.214	0.146	0.158	0.064	0.263	0.252
Gain (%)	26.0	5.0	**128.6**	28.4	27.5	-9.1	**124.3**	**89.9**
Llama2-70B-Chat	0.367	0.360	0.253	0.225	0.255	0.199	0.268	0.234
+HD-EVAL-RF	0.392	0.372	0.364	0.278	0.284	0.214	0.386	0.348
+HD-EVAL-NN	0.418	0.383	0.381	0.286	0.347	0.210	0.457	0.432
Gain (%)	13.9	6.4	**50.6**	27.1	**36.1**	5.5	**70.5**	**84.6**

Table 7: Exploring HD-EVAL on SummEval with smaller LLMs. We report Pearson (r) and Spearman (ρ) correlations. Gain (%) denote the relative performance gain from best overall performing system (marked in **bold**). We highlight relative performance gains over 30% through HD-EVAL with **bold**.

C Configuration Details

C.1 Configurations

For hierarchical criteria decomposition, we consider a maximum of 3 layers across this study. Details on the decomposition process are listed below.

1) For the first layer, we adopt reference decomposition (multiple evaluation aspects) from human experts in the labeled data we apply.

2) For the second layer, we expand all nodes in layer 1, each to a maximum of 4 child. This is based on the assumption that the reference evaluation aspects designated by human experts are significant and demand further in-depth deliberate evaluation.

3) For the third layer, we apply attribution pruning as elaborated in the paper to select nodes (criteria) to further decompose.

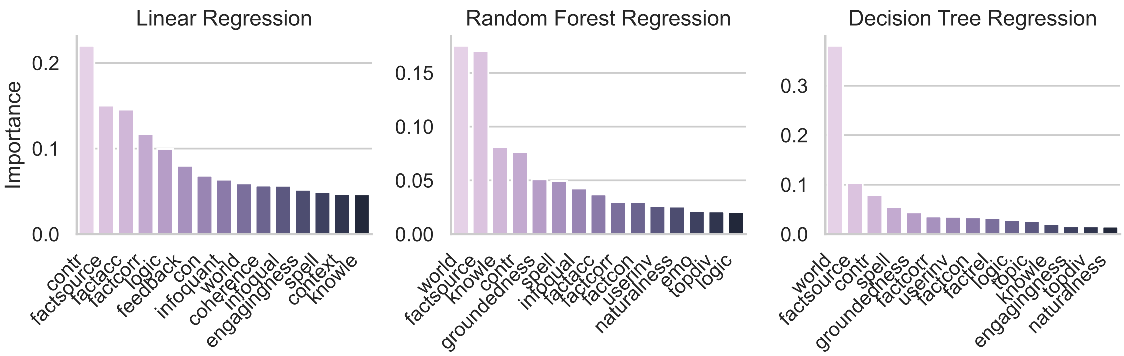

Figure 8: Explaiability on human preference estimation of HD-EVAL, based on permutation importance (LR) and weights (Tree-Based implementations), on Topical-Chat.

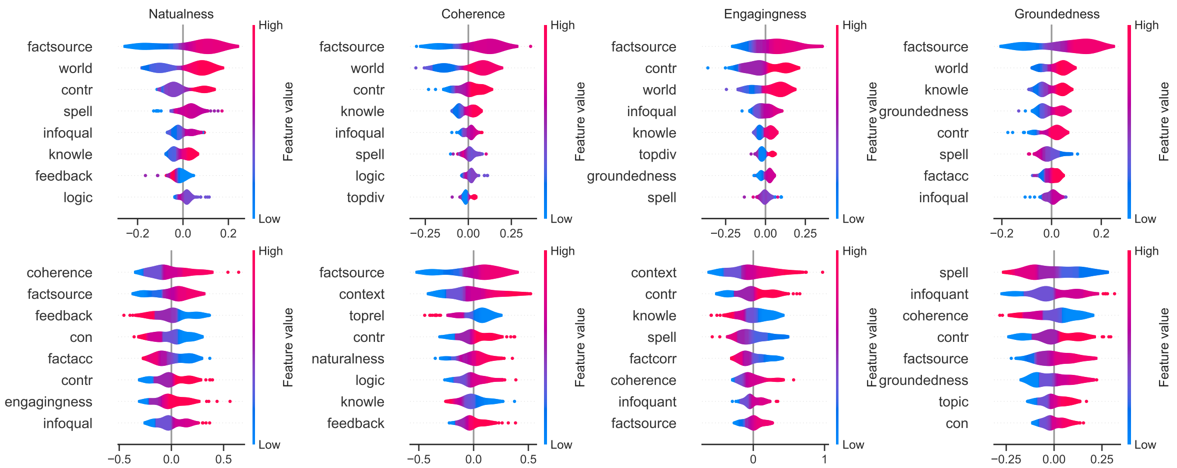

Figure 9: Explaiability on human preference estimation of HD-EVAL-RF and HD-EVAL-NN, based on shapley additive values, on Topical-Chat. A total count of 100 samples are randomly selected for attribution.

C.2 Implementation

For GPT-4 in HD-EVAL, we sample with Temperature of 0.0 and Top-P of 1.0, returning a maximum of 32 tokens. Hierarchical criteria decomposition is performed with the Creative mode of Microsoft Bing Chat[7], which is also powered by GPT-4.

All aggregators are implemented with the scikit-learn (Pedregosa et al., 2011) library. For DT and RF, we apply their default built-in parameters. For NN, we adopt a 3-layer shallow MLP architecture, with ReLU activation. Aggregators are trained to regress all decomposed criteria, to fit on a set of human-annotated evaluations as $f_\theta : \mathbb{R}^m \rightarrow \mathbb{R}^n$, where n denote human annotation count for a sample, and $m = \sum_{i=1}^{L} |\mathcal{C}_i|$ equals to the total count of decomposed criteria[8].

[7] bing.com/chat

[8] A separate aggregator is trained for evaluating groundedness of Topical-Chat, as it has different evaluation protocols and ranges from others.

C.3 Licences

All large language models and human annotations applied throughout this study are publicly available, and properly cited in relevant sections of this paper. We acknowledge their contribution to advancing NLG research, and enlist the open-source licenses for artifacts applied in this study below:

1) LLama-2[9] models are licensed from Meta[10].

2) SummEval[11] is licensed under MIT.

3) Topical-Chat[12] is licensed under Apache-2.0.

4) SFHOT, SFRES are licensed under MIT.

[9] https://huggingface.co/meta-llama/Llama-2-7b-chat-hf

[10] https://ai.meta.com/resources/models-and-libraries/llama-downloads/

[11] https://github.com/Yale-LILY/SummEval

[12] https://github.com/alexa/Topical-Chat

D Listing of Prompts

D.1 Criteria Decomposition

During the Hierarchical Criteria Decomposition procedure in HD-EVAL, we decompose criteria into finer-grained ones by jointly drafting the finer-grained criteria and their definitions with LLMs. An example prompt template and use case on SummEval is illustrated in Figure 10. Note that the prompt provided here is an example, and one may freely adapt other prompting designs and methods, as long as it accomplishes reasonable decomposition.

D.2 Hierarchy-Aware Evaluation

Below, we provide a complete example of the evaluation prompt templates applied for LLMs across this study, in Figure 11, 12, and 13. As illustrated in these figures, to preserve the hierarchical information, we prompt LLMs with both the parent criteria as well as the child criteria, while detailing the child criteria with a detailed definition.

E Case Study on Criteria Decomposition

In this section, we present a complete case study on the criteria decomposition process of HD-EVAL. Specifically, we provide examples of all evaluation domains in this study, as illustrated in Table 8, 9 and 10. As demonstrated in these tables, we observe HD-EVAL is capable of hierarchically decomposing evaluation criteria into finer-grained ones and capable of generating a definition alongside to further elaborate it.

A) Generic template for Hierarchical Criteria Decomposition

I would like to perform automatic evaluation on quality of [Evaluation Task].

[Backgrounds and Definitions of Evaluation Task].

I would like to to evaluate [List of Criteria to Decompose].

Please give me around [Desired Child Count] fine-grained evaluation critics to evaluate them. I want to obtain a final comprehensive evaluation based on an overall aggregation on fine-grained metrics. With the fine-grained metrics, I can better dispatch the evaluation task to different workers and make a better overall efficiency and accuracy.

B) An example use case for SummEval

I would like to perform automatic evaluation on quality of text summarization.

A text summarization is a shorter passage that encompasses the key details of original article but much shorter.

I would like to to evaluate its coherence, consistency, fluency, and relevance.

Please give me around 10-15 fine-grained evaluation critics to evaluate them. I want to obtain a final comprehensive evaluation based on an overall aggregation on fine-grained metrics. With the fine-grained metrics, I can better dispatch the evaluation task to different workers and make a better overall efficiency and accuracy.

Figure 10: Prompt for Hierarchical Criteria Decomposition in HD-EVAL. We include a generic template for criteria decomposition, as well as an actual example for SummEval.

Instructions
You will be given the conversation history between two individuals, its corresponding fact, and one potential response for the next turn in the conversation.
Please evaluate the [Parent Criteria] of the given response to the conversation.
Specifically, to evaluate [Parent Criteria], we would like you to score the given response on the following metric:
[Child Criteria] : [Definition of Child Criteria]
Please return your score on the above metric in the scale of 1 to 5, with 1 being the lowest.

Example
[Sample to be evaluated]

Evaluation Now, please evaluate the [Parent Criteria] of the provided response. (on a scale of 1-5, with 1 being the lowest). Please carefully read the conversation history, corresponding fact, generated response, and evaluate the sentence using the metric [Child Criteria]. Please first return your score, and then provide your reasoning for the score.

Score (1-5):

Figure 11: Hierarchy-Aware Evaluation Prompts for Topical-Chat.

Instructions
We would like to score the following summary of a news article on its [Parent Criteria].
Specifically, to evaluate [Parent Criteria], we would like you to score the given response on the following metric:
[Child Criteria] : [Definition of Child Criteria]
Please return your score on the above metric in the scale of 1 to 5, with 1 being the lowest.

Example
[Sample to be evaluated]

Evaluation Now, please evaluate the [Parent Criteria] of the provided response. (on a scale of 1-5, with 1 being the lowest). Please carefully read the conversation history, corresponding fact, generated response, and evaluate the sentence using the metric [Child Criteria]. Please first return your score, and then provide your reasoning for the score.

Score (1-5):

Figure 12: Hierarchy-Aware Evaluation Prompts for SummEval.

Criteria	**Criteria Decomposition and Definition**
	Layer 2 *Decomposition*
gram	Grammar and syntax: The response should follow the rules of grammar and syntax, without any ungrammatical or awkward constructions.
spell	Spelling and punctuation: The response should have correct spelling and punctuation, without any typos or errors.
div	Lexical choice and diversity: The response should use appropriate and varied words, without any repetition or misuse of vocabulary.
topic	Topic relevance: The response should be relevant to the topic of the dialogue.
logic	Logical flow: The response should have a logical flow of ideas, without any abrupt changes in topic or logic.
context	Context consistency: The response should be consistent with the context of the dialogue.
contr	Content richness: The response should provide rich and useful content, without any generic or vague statements.
emo	Emotional engagement: The response should be emotionally engaging, without any emotionally inappropriate statements.
feedback	Feedback: The responsiveness and attentiveness of the dialogues to the user's input and feedback.
userinv	User involvement: The response should involve the user in the dialogue, without any one-sided or self-centered statements.
factcon	Factual consistency: The response should be factually consistent, without any factual errors or contradictions.
factacc	Factual accuracy: The response should be factually accurate, without any without any false or misleading information.
knowle	Knowledge: The plausibility and reasonableness of the knowledge in the dialogues.
con	Consistency: The response should be consistent with the user's input and feedback.
world	World knowledge: The response should demonstrate knowledge of the world, without any statements that are inconsistent with the real world.
	Layer 3 *Decomposition*
infoquant	Information quantity: The response shoulf convey adequate information, without being too brief or too verbose.
infoqual	Information quality: The response should provide accurate, reliable, and credible content, and supported by evidence or sources.
topdiv	Topic diversity: The response should adequate cover topics of dialogue history, without any repetition or narrow focus.
toprel	Topic relevance: The response should match the user's query and dialogue context, without any inconsistent or off-topic statements.
spcorr	Spelling correctness: The response should have correct spelling, without any typos or errors.
puncorr	Punctuation correctness: The response should have correct punctuation, without any missing or incorrect punctuation.
factcorr	Factual correctness: The response should be factually correct, without any false or misleading information.
factsource	Factual source: The response should be supported by reliable and credible evidence or sources, without any unsupported information or hallucinations.
factrel	Factual relevance: The response should be relevant to the user's query and dialogue context, being helpful instead of distracting
length	Length: The response should be of adequate length, without being too brief or too verbose.
tone	Tone: The response should be polite, friendly, and empathetic, without any rude or offensive statements.
engage	Engagement: The response should be engaging and encourage further interaction, without any generic or vague statements.

Table 8: A complete case study for criteria decomposition on Topical-Chat.

Instructions
We would like to evaluate the [Parent Criteria] of data-to-text, a natural language sentence generated according to a structured data expression.
Specifically, to evaluate [Parent Criteria], we would like you to score the given response on the following metric:
[Child Criteria] : [Definition of Child Criteria]
Please return your score on the above metric in the scale of 1 to 5, with 1 being the lowest.

Example
[Sample to be evaluated]

Evaluation Now, please evaluate the [Parent Criteria] of the provided response. (on a scale of 1-5, with 1 being the lowest). Please carefully read the conversation history, corresponding fact, generated response, and evaluate the sentence using the metric [Child Criteria]. Please first return your score, and then provide your reasoning for the score.

Score (1-5):

Figure 13: Hierarchy-Aware Evaluation Prompts for Data-to-text tasks.

Criteria	**Criteria Decomposition and Definition**
	Layer 2 *Decomposition*
ord	Sentence ordering: how well the sentences in the summary follow a natural and logical order.
struc	Discourse structure: how well the summary uses discourse markers (such as however, therefore, etc.) to indicate the relations between sentences.
focus	Topic focus: how well the summary maintains a consistent topic throughout.
fact	Factuality: how well the summary preserves the factual information from the original article without introducing errors or distortions.
entcon	Entity consistency: how well the summary uses consistent names and references for entities (such as people, places, etc.) across sentences.
tmpcon	Temporal consistency: how well the summary uses consistent tense and aspect for events across sentences.
gram	Grammar: how well the summary use appropriate vocabulary, syntax and punctuation, and convey the main information and meaning of the article, without grammatical errors.
engage	Engagingness: how well the summary is engaging and interesting to read.
read	Readability: how well the summary is easy to read and understand by humans, without errors or awkward expressions.
cov	Coverage: how well the summary includes all or most of the important information from the original article.
red	Redundancy: how well the summary avoids repeating information that has already been mentioned or implied.
nov	Novelty: how well the summary introduces new information that is not explicitly stated in the original article but can be inferred or deduced.
	Layer 3 *Decomposition*
vocab	Vocabulary: how well the summary uses appropriate vocabulary and expressions, without mis-spelling.
syntax	Syntax: how well the summary uses appropriate sentence structure and word order.
punc	Punctuation: how well the summary uses appropriate punctuation.
len	Length and form: how well the summary is of appropriate length and form to encourage the readers, without being too brief of overly redundant.
smooth	Smoothness: how well the summary is smooth and natural to read, without awkward expressions.
logic	Logic: how well the summary is logical and coherent, without abrupt changes in topic or meaning. A good summary should accurately reflect the logical structure of the original article.
form	Form and genre: how well the summary is of appropriate form and genre to encourage the readers, without being a stack of bullet points.
clarity	Clarity: how well the summary is clear and easy to understand, without ambiguity or confusion.
nat	Naturalness: how well the summary is natural and fluent to read, without awkward transitions or wording.

Table 9: A complete case study for criteria decomposition on SummEval.

Criteria	**Criteria Decomposition and Definition**
	Layer 2 *Decomposition*
cov	Coverage: how well the text includes all or most of the important information from the data experssion.
prec	Precision: how accurate and faithful is the text to the data expression.
rel	Relevance: how relevant and salient is the information in the text to the data expression.
gram	Grammaticality: How well does the text follow the rules of grammar and syntax?
read	Readability: How easy is it to read and understand the text?
sty	Style: How well does the text follow the style of the data expression?
	Layer 3 *Decomposition*
datacmp	Data completeness: The proportion of data elements that are mentioned in the text.
datacrr	Data correctness: The accuracy of the information in the text compared to the data.
datared	Data redundancy: The absence of repeated or unnecessary information in the text.
lec	Lexical correctness: The appropriateness and diversity of the words and phrases used in the text.
num	Numerical correctness: The clarity and accuracy of the numerical values and units in the text.
ref	Reference correctness: The accuracy and consistency of the references to entities in the text.
contsel	Content selection: The selection and ordering of the most important and relevant information from the data expression.
contorg	Content organization: The coherence and organization of the information in the text.
contadp	Content adaptation: The adaptation of the information in the text to the target audience.
syn	Syntactic correctness: The correctness of the syntactic structure of the text.
punc	Punctuation correctness: The correctness of the punctuation in the text.
clar	Clarity: The simplicity and directness of the language and expressions in the text.
flu	Fluency: The smoothness and naturalness of the flow and rhythm of the text.

Table 10: A complete case study for criteria decomposition on Data-to-Text tasks.