Understanding News Thumbnail Representativeness by Counterfactual Text-Guided Contrastive Language-Image Pretraining

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Abstract

This paper delves into the critical challenge of understanding the representativeness of news thumbnail images, which often serve as the first visual engagement for readers when an article is disseminated on social media. We focus on whether a news image represents the main subject discussed in the news text. To serve the challenge, we introduce NEWSTT, a manually annotated dataset of news thumbnail image and text pairs. We found that pretrained vision and language models, such as CLIP and BLIP-2, struggle with this task. Since news subjects frequently involve named entities or proper nouns, a pretrained model could not have the ability to match its visual and textual appearances. To fill the gap, we propose CFT-CLIP, a counterfactual text-guided contrastive language-image pretraining framework. We hypothesize that learning to contrast news text with its counterfactual, of which named entities are replaced, can enhance the cross-modal matching ability in the target task. Evaluation experiments using NewsTT show that CFT-CLIP outperforms the pretrained models, such as CLIP and BLIP-2. Our code and data will be made accessible to the public after the paper is accepted.

1 Introduction

This study aims to investigate the representativeness of news thumbnails, which are images displayed as previews of news articles. Visual content often carries more persuasive impact and leaves a long-lasting impression compared to text (Joffe, 2008; Newman et al., 2012; Seo, 2020). Consequently, the misrepresentation in news thumbnails can cause more critical consequences. Despite its importance, there have been a few studies addressing the representativeness of news images (Hessel et al., 2021; Choi et al., 2022). Achieving the goal requires a model to understand the cross-modal relationship between visual and textual content.

Researchers in Natural Language Processing and Computer Vision communities have explored multimodal technologies by addressing general vision and language (V+L) tasks, including visual question answering (Antol et al., 2015), image-text retrieval (Cao et al., 2022), and visual entailment (Xie et al., 2019). Recent approaches have leveraged contrastive learning techniques for representing distinct modalities into a same vector space. CLIP (Radford et al., 2021) stands out as one of the pioneering methods that achieve remarkable performance based on contrastive learning, aimed at increasing the similarity between image-text pairs (referred to as *positive* samples) compared to non-paired image and text (referred to as *negative* samples). While contrastive learning was not a new concept (Oord et al., 2018), CLIP outperformed preexisting methods by utilizing a vast collection of web-based image and text data. Recent advancements have further enhanced the performance by refining learning objectives (Li et al., 2022c), incorporating cross-attention layers into the model architecture (Li et al., 2021a), and augmenting the training data with high-quality samples (Li et al., 2022a; Hao et al., 2023).

Figure 1: An illustration of the proposed method. Given a pair of a news thumbnail image and article, the method generates counterfactual news text and updates a CLIP-like bi-encoder by contrastive learning.

Despite the advancements of CLIP-like models in general benchmarks for V+L tasks, we hypothesize that understanding thumbnail representativeness is a still challenging tasks. We highlight two main challenges. **(1) Preference for general descriptions in existing datasets**: General V+L datasets, such as Conceptual Captions (Sharma et al., 2018) or COCO-Caption (Chen et al., 2015), were primarily designed to enhance a model's ability to comprehend general behaviors or scenes. Consequently, these datasets deliberately avoid specific descriptions about entities (e.g., "The man at bat readies to swing at the pitch"). In contrast, news events typically revolve around prominent figures or organizations, leading to news texts that frequently reference named entities (Luo et al., 2021). **(2) Lack of objective definition and dataset**: Representativeness is an inherently abstract and subjective concept, where even humans may disagree with each other. Developing an objective definition is imperative to facilitate the development of proper technologies. A previous study released a dataset of 259 examples (Choi et al., 2022), but the samples were labeled according to an abstract definition of representativeness.

Borrowing the principle of five Ws in journalism and news practices (The Associate Press, 2022), we focus on the representativeness through the lens of *Who*, on whether an image represents news subjects. Specifically, we ask whether a model can understand the visual manifestation of news subjects, such as showing a politician's face covered by a news article. Using the manually labelled dataset of 1000 image-text pairs, NEWSTT, we evaluated the zero-shot ability of CLIP-like vision and language models by measuring cross-modal similarity scores. To tackle the task more efficiently, this study introduces CFT-CLIP, a **C**ounter**F**actual **T**ext-guided **C**ontrastive **L**anguage-**I**mage **P**retraining framework that aligns vision and language representation. As illustrated in Figure 1, the key motivation of the proposed framework is to generate counterfactual news text where the subject of a news event is changed for contrastive updates. In the news text example, the subject is identified as 'Biden', and its corresponding token is replaced with 'Trump' by the counterfactual text generator. Thus, the generated sentence does not represent the main subject of the news event in the thumbnail image. Our research hypothesis is that *learning to contrast the generated counterfactual text with the original news text will enhance the ability of CLIP-like vision language model to assess the representativeness of a thumbnail image*.

We summarize the contributions of this study.

1. We propose a novel task of understanding news thumbnail representativeness with a focus on whether the image represents subjects.

2. To serve the task, we introduce NEWSTT, a manually annotated dataset of 1,000 news thumbnails and text pairs.

3. We propose CFT-CLIP, a counterfactual text guided contrastive language-image pretraining framework.

2 Related Works

2.1 Vision language contrastive pretraining

Researchers have worked on pretraining methods to tackle V+L tasks such as image-text retrieval. Lu et al. (2019) extended BERT to a multi-modal model by co-attentional transformer layers. Another study proposed to learn a universal image and text representation by four pre-training tasks, including masked language modeling and image-text matching (Chen et al., 2020). Researchers proposed CLIP, a training scheme of visual representation by learning directly from paired text using contrastive loss (Radford et al., 2021). Being trained on a web-scaled dataset, the transformer-based visual representation achieved state-of-the-art results in zero-shot tasks. Another study showed its potential as a reference-free image-captioning metric (Hessel et al., 2021). Other researchers presented ALIGN, a bi-encoder trained by a contrastive loss similar to CLIP (Jia et al., 2021). While we used CLIP encoders as the target backbone in this study, our method can be applied to a more recent vision-and-language model that incorporates the image-text alignment, such as BLIP-2 (Li et al., 2023).

Research has underscored the significance of incorporating hard negative samples into the contrastive objective (Nishikawa et al., 2022; Robinson et al., 2021). In response, we introduce a method to generate hard negative text samples using a masked language model. Although a handful of studies have explored the use of masked language models for generating hard negatives (Li et al., 2021b; Yao et al., 2022), our approach stands apart due to its distinct token selection and prediction procedures in the step of counterfactual text generation.

2.2 Multimodal misinformation

This study falls into the broad category of research on multimodal misinformation. Previous research mainly worked on fact verification involving multimodal claims or evidence (Zlatkova et al., 2019; Shu et al., 2020; Yao et al., 2023; Rani et al., 2023). In contrast, this study examines the semantic relationship between news thumbnails and text pairs without predicting the veracity of a given image, text, or both. A relevant problem is image repurposing (Luo et al., 2021; Abdelnabi et al., 2022), where a *real* image is used out-of-context to create realistically looking misinformation. To tackle the problem, Luo et al. (2021) proposed NewsCLIPPings, a dataset of out-of-context image detection in the news context. They created the mismatched image-text pairs by swapping the matches of the collected news image and text pairs. Similarly, Mishra et al. (2022) created a dataset of multimodal fact verification, of which false claims were obtained by manipulating the pairs. Unlike the previous research on out-of-context image detection, this study aims to focus on whether news subjects are represented in the thumbnail image. We also created a manually annotated evaluation dataset, contrasting with previous datasets based on synthetic labels (Luo et al., 2021; Mishra et al., 2022). Our target task is related to but differs from the manipulated image detection (Huh et al., 2018; Rossler et al., 2019), known as deepfakes or cheapfakes, which aimed to detect a *fake* image generated by AI technologies or simple tools.

3 Target Problem: Understanding News Thumbnail Representativeness

We aim to address the problem of understanding the representativeness of a news thumbnail image for its article. The task is critical due to the two reasons. First, the sharing of news online is abundant (Park et al., 2021a; Lee and Ma, 2012; Hermida et al., 2012). Second, the thumbnail often serves as the initial and sole visual interaction for social media users when a news link is shared. Visual content is perceived as more credible and leaves a long-lasting impression than text (Joffe, 2008; Seo, 2020; Newman and Zhang, 2020). Given these considerations, thumbnails that do not accurately represent their content can misguide the reader's understanding in online environments.

We formally define the problem as a binary classification. Given a news thumbnail I and its news text T, we aim to develop a classifier $f_\theta(I, T)$ predicting a binary label L on predicting whether I represents T. We assign 1 to L if I represents T; otherwise, 0. I is deemed representative of T if the image portrays at least one of the main subjects of a news event. This study aims to develop a vision language model that predicts L. We assume the task in a zero-shot setting, where the labeled data is limited. The reference news text T can be either a title or a summary.

4 NEWSTT: A Dataset of Thumbnail Representativeness for News Text

4.1 Raw data collection

NELA-GT-2021 is a headline-oriented[1] news corpus that encompasses nearly all news articles published by 367 news sources throughout the year 2021 (Gruppi et al., 2022). Since the dataset does not provide web links to thumbnail images, we conducted a supplementary data collection step. By referencing the URLs of news articles available in the dataset, we parsed the HTML document and extracted the thumbnail image URL from the meta tag with the og:image attribute. As a result, we obtained 442,741 pairs of news headlines and thumbnail images, which were sourced from 81 different news media outlets. According to the media ratings provided by Media Bias/Fact Check (MBFC)[2], the datasets were well-balanced for the political orientation and trustworthiness ratings. Subsequently, we partitioned this unlabeled dataset into 422,741/10,000/10,000 pairs for train/validation/test purposes while keeping the distribution of the number of articles over different media sources. The validation split was reserved for hyperparameter optimization, and the test split served as the source for labeled data construction.

4.2 Data annotation

We describe the process for building the annotation guideline. Following a previous study (Choi et al., 2022), we conducted the pilot labeling task given an abstract definition of a representative thumbnail, which is "*an image that visually conveys the news event that can be identified from the accompanying text*". There were often disagreements in the resulting labels likely due to the subjective nature of definition. Following internal discussions and consultation with a journalism expert with a

[1] They put the body text whose random tokens are masked.
[2] https://mediabiasfactcheck.com/

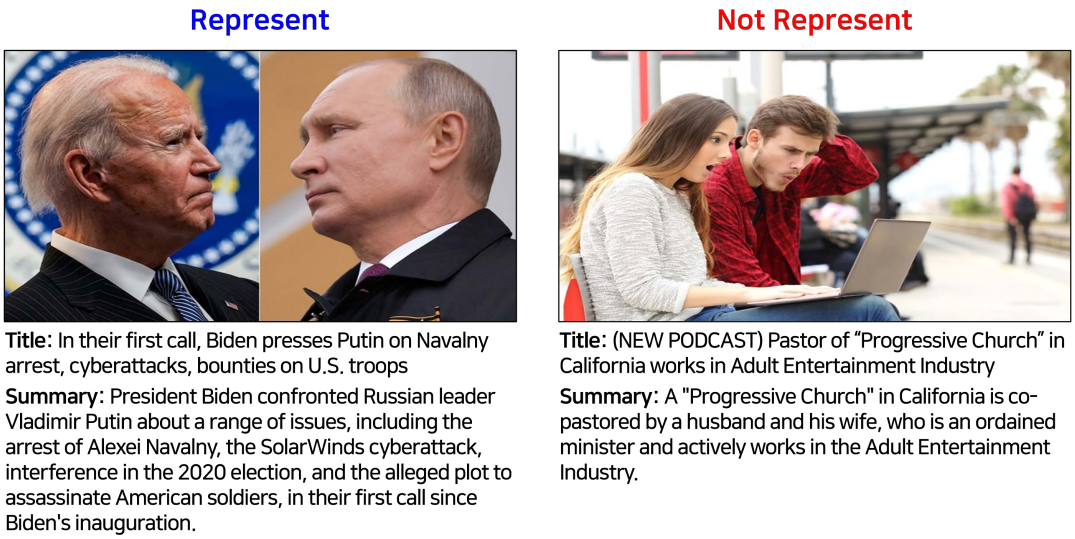

Figure 2: Labeled data examples.

Ph.D. in Communication, we focused on the key dimension of news events corresponding to the five Ws (The Associate Press, 2022): on whether the image represents news subjects, i.e., *Who*.

For the annotation process, we sampled 1,000 news articles from the pool of 10,000 instances of the test split. Relying on the MBFC ratings, we sampled 500 articles from the trustworthy outlets, labeled as *mixed* or *high* for the trustworthiness rating, and the remaining 500 from the fake news sources, labeled as *low*. We manually collected the body text for the 1000 articles and ran the OpenAI API for obtaining the summary text by GPT-3.5 Turbo[3]. We hired three English-speaking students who frequently read news online from one of the authors' institutions. Given a news thumbnail, title, and summary text, the annotators were asked to answer whether the news subjects identified in the news text are represented in the thumbnail. To facilitate the annotation process, they were first instructed to specify news subjects identified in the news text, such as named entities or proper nouns, and to select visually displayed ones. We also instructed the annotators to label a thumbnail representative if they think it brings up the image of news subjects without an explicit manifestation. Detailed annotation guidelines can be found in Section E. The annotation results demonstrated a high inter-annotator agreement rate, with a Cronbach's alpha of 0.863, ensuring the quality and reliability of the labels.

NEWSTT, the paired dataset of news thumbnail image and text, consists of 808 representative and 192 non-representative instances. Figure 2 presents an example for each class. The left example shows that the news thumbnail image displays the faces of Biden and Putin, hence labeled as representative. On the other hand, the image on the right does not show the news subject but arouses the potential reader's interest by showing the surprised faces of the two persons.

5 Methods

To tackle the task of understanding thumbnail representativeness in a zero-shot setting where no labeled data is available for training, we employ a thresholding classifier based on embedding similarity,

$$f(I,T) = \mathbb{1}(sim(\mathbf{v}_I, \mathbf{v}_T) > \tau), \qquad (1)$$

where τ is a thresholding hyperparameter, $sim(\cdot)$ is cosine similarity, $\mathbb{1}(\cdot)$ is an indicator function, and $\mathbf{v}_I$ and $\mathbf{v}_T$ indicate the feature embedding of I and T, respectively. Assuming the parity prior, we set τ as the median of $sim(\cdot)$ on the validation set.

5.1 Background: CLIP

CLIP is a vision and language bi-encoder that represents each modality in a fixed-dimensional vector space (Radford et al., 2021). The model is based on a bi-encoder architecture, $f_{image}(\cdot)$ and $f_{text}(\cdot)$. For an input image I and text T, the two encoders return the image embedding $\mathbf{v}_I$ and the text embedding $\mathbf{v}_T$, respectively. The parameters were trained via contrastive learning on a large web collection of image-text pairs. Since $\mathbf{v}_I$ and $\mathbf{v}_T$ are in the same

[3]The used prompt is in Appendix D.

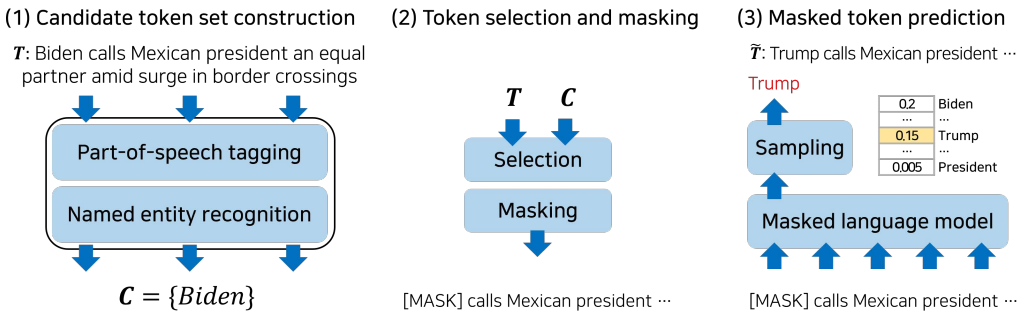

Figure 3: An illustration of the counterfactual text generation process. We select named entity tokens in an original text that could indicate news subjects. A BERT-like masked language model generates a counterfactual text by predicting new tokens for the selected entity tokens.

vector space, CLIP can serve as a backbone for the zero-shot thresholding classifier in Eq. 1.

5.2 Proposed method: CFT-CLIP

We propose CFT-CLIP, a counterfactual text-guided contrastive language-image pretraining method. The proposed framework aims to improve the CLIP-like bi-encoder by contrastive updates involving the counterfactual text generated from an input text. Figure 3 shows an example of generation. While the original news pertains to an event involving Biden's summit with the Mexican president, the generated sentence implies a counterfactual event centered on Trump by substituting the token 'Biden'. This substitution is accomplished via the predictions of a masked language model targeting the named entity token. Based on the news characteristics on the prevalent coverage of named entities (Park et al., 2021b; Müller-Budack et al., 2020), we hypothesize that contrasting the original news text with its counterfactual would make the vision and language bi-encoder to obtain a more effective representation for understanding a thumbnail image's representativeness for the news.

5.2.1 Counterfactual text generation

Given a pair of image I and text T, we aim to generate a counterfactual news text $\tilde{T}$, which is semantically distinct from the anchor image I (and the original text T).

(1) Candidate token set construction: The first step aims to select tokens that likely refer to the subject of a news event. A part-of-speech tagger and named entity recognizer are applied to T, which returns a candidate token set C. We tested several strategies targeting named entity categories that are frequently used in news articles, such as person, organization, and GPE[4].

(2) Token selection and masking: We select tokens from C and mask them in the original text T using the special token [MASK]. To preserve the original context of T, we ensure that no more than 30% of its total tokens are masked. If the number of target tokens selected from C exceeds this threshold, we randomly select a subset of these tokens to meet the condition. Otherwise, all tokens in C are masked in T.

(3) Masked token prediction: Using a BERT-like masked language model (Devlin et al., 2019), we predict new tokens for the masked positions in T. To avoid reconstructing the original text, we divide the logit scores of the output vector by a temperature parameter and repeatedly sample from the softmax-normalized distribution until a token different from the original is generated. This step produces $\tilde{T}$, which represents a synthetic event wherein the subject is modified from the original news event, yet it preserves the overarching topic of T. Thus, $\tilde{T}$ can be deemed a hard negative sample in contrastive learning, which diverges from I but remains more closely aligned with T than a random text or in-batch negatives.

In Section 6.3, we present the ablation experiments to show the effectiveness of the proposed counterfactual text generation. Additionally, we demonstrate several counterfactual text examples generated by the proposed method in Appendix C.2.

[4]Countries, cities, states

5.2.2 Training objective

We train a CLIP-like bi-encoder model to minimize

$$-log\frac{e^{sim(\mathbf{v}_{I_i},\mathbf{v}_{T_i})/\tau}}{\sum_{j=1}^{N}\{e^{sim(\mathbf{v}_{I_i},\mathbf{v}_{T_j})/\tau}+e^{sim(\mathbf{v}_{I_i},\mathbf{v}_{\tilde{T}_j})/\tau}\}}, \quad (2)$$

where $\mathbf{v}_{I_i}$ is the feature embedding of the vision encoder for I_i, $\mathbf{v}_{T_i}$ is the feature embedding of the text encoder for T_i, $sim(\cdot)$ is the dot product, and N is the mini-batch size.

Minimizing Eq. 2 aligns the text representation with the image representation by increasing the similarity of positive pair (I_i, T_i) compared to those of negative pairs (I_i, T_j) and $(I_i, \tilde{T}_i)$. Since $\tilde{T}$ represents a distinct subject against T, the objective would help capture whether the thumbnail image represents the news subjects in T.

5.2.3 Model architecture

Figure 4 depicts the neural architecture of our proposed method. We initialized the model by adopting a pretrained CLIP checkpoint[5]. The image encoder f_{image} is the ViT-L/14 vision transformer (24 layers), and the text encoder f_{text} is a causal text transformer (12 layers). The image and text encoder are followed by an MLP pooler mapping the input to a 768-dimensional vector, respectively. T and $\tilde{T}$ are fed into the shared-weight text encoder, separately. According to the hyperparameter optimization experiment, we froze 11 out of 12 text transformer layers during training. All vision layers were updated.

5.2.4 Pretraining corpus

We used two pretraining corpora. First, we used the training split of NELA unlabeled data. Inspired by a prior study that replicated the CLIP pretraining using noisy web data (Schuhmann et al., 2022), we applied the data sanitization process to the training split by filtering only those with a cosine similarity of 0.28 or higher over CLIP embeddings. The resulting 105,737 pairs for training have a high likelihood of a representative thumbnail ($L = 1$). Since the body text in the NELA corpus is incomplete, we relied on the news title as the reference text for pretraining. Second, inspired by the recent research on the importance of high-quality samples for pretraining (Zhou et al., 2023; Schuhmann et al., 2022), we used a high-quality news corpus published by the BBC, a UK-based news source rated as trustworthy by MBFC (Verma et al., 2023). This corpus comprises 196,538 pairs, each containing a news title, an editor-written summary, and a thumbnail image. The corpus encompasses news articles released through the official website from 2009 to 2021. We applied the sanitation process to the dataset in the same manner as with the NELA corpus, leaving 58,210 samples for contrastive training. We ensured no overlap between the BBC training set and the NELA validation/test splits. Since NewsTT originates from the NELA corpus, we used the NELA validation split for hyperparameter optimization. In the experiments using the BBC corpus, we tested two variants using the news title and human-written summary as reference text.

[5] https://huggingface.co/openai/clip-vit-large-patch14

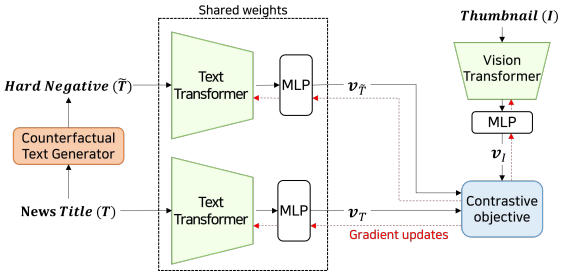

Figure 4: Neural architecture of CFT-CLIP

6 Evaluation Experiments

6.1 Experimental setups

We employed the f1 score and the Spearman rank correlation coefficient to evaluate binary prediction and cosine similarity scores, respectively. All experiments were conducted using five different random seeds, and we reported the average performance along with the standard error. The t-test was used for estimating statistical significance. We used the SpaCy pipeline for named entity recognition. A BERT-base checkpoint was used for the masked language prediction. All checkpoints used for experiments and implementation details can be found in Appendix A. We optimized all hyperparameters using a validation split that included 10,000 examples from NELA.

As baselines, we measured the ability of pretrained vision and language models for comparison with the proposed methods for the target task. In addition to CLIP, we used BLIP and BLIP-2, which are a family of vision language encoder that is based on bootstrapped training (Li et al., 2022b, 2023). They achieved the state-of-the-art performance for the vision-language benchmarks. BLIP-2+SBERT is a pipelined approach that integrates

Model	F1	Spearman
CFT-CLIP	**0.815**±0.003	**0.488**±0.004
CLIPAdapt	0.766±0.005	0.455±0.004
CLIP	0.763	0.408
BLIP	0.737	0.406
BLIP-2	0.708	0.418
BLIP-2 + SBERT	0.694	0.339

Table 1: Model comparison results

BLIP-2 with Sentence BERT. By obtaining a caption text from an input image I by BLIP-2, we assessed its semantic similarity to the reference text using SentenceBERT. To investigate the effects of domain-adaptive pretraining, we also included CLIPAdapt as a baseline model, which was trained by using the CLIP objective on the training corpus. For inference, we used the summary text as the reference text T according to the results of an ablation experiment (Table A1).

6.2 Results

Table 1 presents the model comparison results of the baseline and proposed methods. Here, we reported the performance of CFT-CLIP and CLIPAdapt models that were pretrained using the BBC dataset with the summary text. For CFT-CLIP, we used the model targeting person-labeled entity tokens. The decisions were based on the ablation experiments on the effect of pretraining corpus (Table 2) and counterfactual text generation (Table 3), respectively. Here, we make three observations. First, among the pre-trained models (the bottom 4 rows), CLIP achieved the best f1 of 0.763, and BLIP-2 was the best in terms of the Spearman coefficient with 0.418. The effectiveness of CLIP suggests that its bi-encoder architecture is suitable for tackling the task. Second, CLIPAdapt outperformed all the pretrained checkpoints. This suggests that domain-adapted continued pretraining can improve the performance for the target task, congruent with the finding of a previous study (Gururangan et al., 2020). Third, CFT-CLIP outperformed all baseline methods with the f1 of 0.815 and the Spearman coefficient of 0.488 (p<0.001). The performance gap with CLIPAdapt, the second-best method, is significant: 0.049 for f1 and 0.033 for the Spearman coefficient.

6.3 Ablation experiments

Pretraining corpus Table 2 presents the performance of CFT-CLIP models with varying pretraining corpus. The BBC dataset resulted in superior model performance compared to the NELA dataset, following the same distribution of the labeled dataset. Given that the BBC is recognized for upholding high journalistic standards, this observation suggests that leveraging a high-quality singular source may be more beneficial than employing articles published by diverse news sources for contrastive pretraining. This finding aligns with the recent research on large language models (Zhou et al., 2023), emphasizing that the data quality is more important than the size of the training corpus. In the experiments comparing title and editor-written summaries using BBC, we could not find a clear winner. While using the summary text led to the best f1 of 0.815, using the title achieved the best Spearman coefficient of 0.501. This suggests that both news headlines and summary text can serve as a useful proxy for news content, in line with established journalism principles (The Associate Press, 2022). Since f1 is a more proper metric for evaluating classification ability, we used BBC with the summary text for the other experiments.

Data	F1	Spearman
BBC (T: summary)	**0.815**±0.003	0.488±0.004
BBC (T: title)	0.790±0.007	**0.501**±0.001
NELA (T: title)	0.771±0.003	0.444±0.002

Table 2: Effects of pretraining corpus

Target token	F1	Spearman
Person	**0.815**±0.003	**0.488**±0.004
Organization	0.783±0.002	0.439±0.003
GPE	0.761±0.004	0.404±0.004
All	0.785±0.002	0.454±0.003
Random (15%)	0.715±0.013	0.461±0.005
Random (30%)	0.680±0.007	0.458±0.002

Table 3: Varying performance by token selection strategies in counterfactual text generation

Counterfactual text generation We evaluated the performance of CFT-CLIP variants targeting different types of entity tokens in counterfactual text generation. We specifically targeted the frequently used named entity tokens in the news text: person, organization, and GPE. We also tested the model targeting all three token types, denoted All in the table. The top 4 rows in Table 3 present the comparison results. We found that targeting person-labeled entity tokens achieved the best performance. This finding could be explained by the prevalent coverage of person entities, such as politicians, in news events (Park et al., 2021b; Müller-

Budack et al., 2020). Additionally, we tested baseline strategies that replace tokens at random positions for being used for negative samples in contrastive learning, as investigated in previous studies (Nishikawa et al., 2022; Robinson et al., 2021). We evaluated two versions that select 15% and 30% tokens, which were predicted by the same BERT backbone as the proposed method. The bottom two rows in Table 3 show the model performance, achieving significantly worse f1 and Spearman coefficients than the CFT-CLIP variants (p<0.001). This finding supports the effectiveness and necessity of counterfactual text generation in the proposed method.

LLMs for counterfactual text generation CFT-CLIP used a BERT-like masked language model to generate counterfactual text for contrastive updates. An autoregressive large language model, such as GPT (Radford et al., 2018), could serve as the purpose. To test the effectiveness, we ran the OpenAI API for generating counterfactual text for the BBC news summary by GPT 3.5-Turbo. The generated counterfactual text was used for contrastive update, following the objective in Eq. 2. The used prompt is available in Appendix D.

As shown in Table 4, the GPT-based contrastive update was not as successful as the proposed method achieved by a BERT-like masked language model. The select-and-replace approach of the proposed model could generate a more suitable sample to be used for hard negatives in contrastive updates.

Model	F1	Spearman
CFT-CLIP	**0.815**±0.003	**0.484**±0.004
GPT-based	0.640±0.019	0.445±0.003

Table 4: Comparison with the model trained with GPT-based counterfactual text

6.4 Error analysis

To identify the remaining challenges, we analyzed common error categories for the sampled 100 error cases. We observed four recurring categories: entity recognition failures (46%), external knowledge required (14%), deep textual understanding required (14%), and deep visual understanding required (14%). Figure 5 presents two error examples. In the first example belonging to the entity recognition failure case, the model failed to identify Brian Sicknick, the officer involved in the George Floyd case. In the second example, the image shows Anne-Marie Trevelyan, one of the ministers of the UK government. The model could not find the link without referring to the external knowledge.

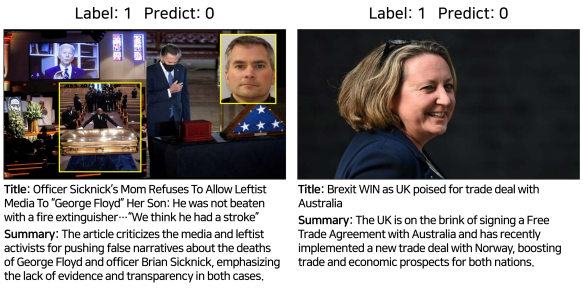

Figure 5: Error examples

7 Discussion

This study has several future directions. First, according to the rule of 5Ws, this study focused on the *Who* aspect of news thumbnails. Future research could extend its focus to cover other aspects of 5Ws, such as whether the image represents the action of the subject, i.e., *What*. Question-answering approaches could be investigated, as done in a recent study (Rani et al., 2023). Second, the proposed method could be improved to address the challenges identified in the error analysis (Section 6.4). Future studies could investigate the use of prompt-based visual language models, such as Flamingo (Alayrac et al., 2022) or GPT-4V (Achiam et al., 2023), to allow for handling the errors involving *deep visual understanding*. The proposed CFT-CLIP could assist with aligning the vision and language representation. Third, more broadly, this study could be extended to the multimodal misinformation research by adopting the CFT-CLIP for evidence retrieval or training multimodal classifiers (Luo et al., 2021; Mishra et al., 2022; Yao et al., 2023).

8 Conclusion

Understanding the representativeness of a news thumbnail is not only for holding journalistic standards but also for building a trustworthy online environment. To tackle the critical task, this study proposes NewsTT, a paired dataset of news thumbnails and text, and CFT-CLIP, a counterfactual text-guided contrastive language-image pretraining method. The proposed method outperformed baseline models, supporting the research hypothesis that contrasting news text with its counterfactual will enhance the cross-modal understanding ability.

Limitations

This study bears several limitations. First, the scale of NewsTT is limited. Since the annotation task is complicated, we chose to do an in-lab annotation to provide high-quality labels for evaluation. Since the dataset reflects the distribution of real-world news articles and the label quality is high, it can be used for a proper evaluation corpus of the zero-shot methods. Future studies could scale up the dataset via crowdsourcing with the annotation scheme developed in this study. Second, since we continued to pretrain the CLIP encoders, CFT-CLIP inherits the weakness of the CLIP vision encoder. CLIP might be culturally biased toward the Western countries where the pretraining dataset may originate. Also, the pretrained CLIP checkpoint used in this study cannot handle the entire body text as input because the maximum token length is 77, which is smaller than the average body text length. While the use of summary text mitigates the limitation, future studies could use a text encoder that can handle a long sequence to exploit the news article fully. Third, this study focused on developing a zero-shot classifier based on a CLIP-like dual encoder, which does not involve labeled data for training. The performance could be boosted by developing a fine-tuned classifier or few-shot prompt learning methods in future studies.

Ethics Statement

This study introduced CFT-CLIP, a contrastive learning framework for training the image-text multimodal encoder. For pretraining, this study used publicly available news articles shared by news media. While we tried to have a high-quality corpus for pretraining, it is possible that the model learned hidden biases in online news. Also, Since CFT-CLIP was updated from the pretrained CLIP weights, it may inherit the bias of CLIP. A user should be cautious about applying the method to problems in a general context and be aware of a potential bias. A user should acknowledge the potential harm that can be induced by applying the pretrained embedding. We have fewer privacy concerns because our study used openly accessible news data that may follow strict internal guidelines. The NELA-GT-2021 was shared under the license of CC BY-NC 4.0, and the BBC corpus was shared under the MIT license. We will share NewsTT with CC BY NC 4.0. Some of the text was edited using AI assistants, such as ChatGPT and Grammarly.

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A Configuration details

We ran experiments on a machine equipped with AMD Ryzen Threadripper Pro 5975WX CPU, three Nvidia RTX A6000 GPUs (48GB per GPU), and 256GB RAM. We trained the models with the AdamW optimizer with the initial learning rate of 1e-4, updated by the cosine annealing scheduler. The minibatch size is 128. The temperature τ in the loss equation is 0.05, following Gao et al. (2021). Other hyperparameters were optimized by random search using a validation set. Model training was early-stopped when the validation loss was not decreased five times consecutively, measured for every 20 iterations. The experiments were conducted on Python 3.9, Pytorch 1.10.1, Transformers 4.29.2, LAVIS 1.0.2, and SentenceTransformer 2.2.2. Five random seeds were used for repeated experiments: 0, 1, 2, 3, and 4. The temperature used for adjusting the masked token prediction is set as 2.0.

The pretrained model checkpoints used for the experiments are as follows:

- CLIP: `https://huggingface.co/openai/clip-vit-large-patch14`
- BLIP: blip_base (LAVIS)
- BLIP-2: blip2_pretrain (LAVIS)
- BLIP-2+SBERT: pretrain_opt2.7b (LAVIS), all-MiniLM-L6-v2 (SentenceTransformer)
- Named Entity Recognizer: `https://huggingface.co/spacy/en_core_web_trf`
- Masked Language Model: `https://huggingface.co/bert-base-uncased`

B Ablation experiments

Reference text We compared the performance of using news title and summary text as reference text T in the zero-shot classifier. Table A1 presents the results, showing that using the summary text could achieve a better outcome. Thus, we used the summary text for inference.

T	F1	Spearman
Summary	**0.815**±0.003	**0.488**±0.004
Title	0.758±0.003	0.385±0.003

Table A1: Performance by the reference text type during inference

C Data examples

C.1 Failed prediction

Table A1 presents two examples where the CFT-CLIP model made a failed prediction. The first example presents the false positive case where the model returns a high similarity score for the unrepresentative thumbnail. The example on the right shows an error case where referring to external knowledge is required. The person in the image is Glenn Youngkin, the governor of Virginia in the US. A model could not return a high similarity score without knowing his background.

Figure A1: Additional error examples

C.2 Counterfactual text

Table A2 presents several examples derived from our counterfactual text generation method. In general, the proposed method successfully generates the counterfactual text by selecting appropriate entities and substituting them with other entities. On the other hand, there are several cases where the generated token breaks the grammar. For instance, in the fourth example, the term 'Oisin Murphy' was replaced by 'offensive.' Such anomalies may arise from the sampling process employed, which aims to prevent the recreation of the original text. Despite its imperfect structure, the generated sentence can still serve as a hard negative sample during contrastive update, given that its general context is preserved.

Original text	Generated text
Op-Ed: Memo to Saddleback Church: Replacing Pastor Rick Warren is a minefield	Op-Ed: Memo to Saddleback Church: Replacing Pastor Parker is a minefield
‘The greatest striker’: Gerd Müller, legendary German forward, dies aged 75	‘The greatest striker’: Joseph, legendary German forward, dies aged 75
Matt Gaetz and wingman facing ’mutually assured destruction’ after confession letter: legal expert	Pennant and wingman facing ’mutually assured destruction’ after confession letter: legal expert
William Buick treble sets up Flat jockeys’ title race for dramatic finish as gap closes on Oisin Murphy	Davidson treble sets up Flat jockeys’ title race for dramatic finish as gap closes on offensive
Michael Douglas says it was ‘uncomfortable’ for him and Catherine Zeta-Jones to share Mallorcan home with his ex	Novella says it was ‘uncomfortable’ for him and Catherine Zeta-Jones to share Mallorcan home with his ex
Experts say Jussie Smollett is in ‘matrix of arrogance’ as he awaits sentencing	Experts say Toni is in ‘matrix of arrogance’ as he awaits sentencing
Ted Nugent tests positive for coronavirus after calling pandemic a ‘scam’	Danny tests positive for coronavirus after calling pandemic a ‘scam’
Jennifer Aniston Explained How Therapy Helps Her Deal With The "Tough Stuff" Of Being Famous	Charles Explained How Therapy Helps Her Deal With The "Tough Stuff" Of Being Famous
Thousands mark anniversary of Kremlin critic Nemtsov’s murder	Thousands mark anniversary of Kremlin critic pastor’s murder
Nets Disregard AG Garland Grilled in Hearing for Targeting Parents	Nets Disregard AG Cicero Grilled in Hearing for Targeting Parents
Travis Kelce Is Borderline Unrecognizable Without Facial Hair	Annie Is Borderline Unrecognizable Without Facial Hair
Billionaire Ken Griffin bought a copy of the US Constitution for $43.2m because his son asked him to	Billionaire Dublin bought a copy of the US Constitution for $43.2m because his son asked him to
Desperate Chuck Todd Hopes Trump Will Deflect Media ‘Spotlight’ From Dem ‘Problems’	Desperate Joe Hopes Radha Will Deflect Media ‘Spotlight’ From Dem ‘Problems’
Chris Cuomo’s Book Contract Dropped By HarperCollins	Harriet Book Contract Dropped By HarperCollins
Jen Psaki shoots down a reporter comparing Biden to his predecessor: Trump suggested ‘people inject bleach’	person shoots down a reporter comparing virus to his predecessor: Walden suggested ‘people inject bleach’
What’s the Deal With Gavin Newsom? 5 Plausible Theories To Explain His Mysterious Hiatus	What’s the Deal With diplomacy? 5 Plausible Theories To Explain His Mysterious Hiatus

Table A2: Counterfactual text generation examples

D API usage details

We used OpenAI API to use GPT 3.5-Turbo. We obtained news summaries for the labeled dataset and generated counterfactual text for the summary text of the BBC unlabeled pretraining corpus. In total, the API call cost $13.33. Below are the prompts used in the experiments.

News summarization

Article:{text}

Summarize the article in one sentence.

Counterfactual text generation

Create a counterfactual news summary by modifying the subjects of news summary:{text}

Answer in JSON. The JSON should be a string of dictionaries whose keys are "counterfactual".

E Annotation details and guidelines

We hired two male and one female student from an author’s institution. The annotators were trained by using the guidelines in Table A3. The original guideline was in another language, and we present its English-translated version. All the annotators were paid $0.1 per example.

Task overview:
In this task, you are asked to answer whether a given news image represents news text with a focus on news subjects.

Instruction:
- Q1. Identify news subjects in the news text. The subjects can be named entities, proper nouns, or common nouns that are covered by the news article.
- Q2. Does the image display the news subjects identified in Q1?
- Q3. Identify the visually presented subject in the news image.

Examples:

Title: Trump Announces New Impeachment Defense Team
Summary: Former President Donald Trump announces a new legal defense team, led by attorneys David Schoen and Bruce Castor Jr., for his upcoming second impeachment trial following the disbanding of the original team due to disagreements over legal strategy, with the new team focusing on representing Trump and the United States Constitution without commenting on election fraud allegations.

- Q1: Trump, Impeachment Defense Team, David Schoen, Bruce Castor Jr., impeachment trial, disagreements, legal strategy, United States Constitution, election fraud allegations
- Q2: Y
- Q3: Trump

(More examples)

Table A3: Translated annotation guideline