



Masters Thesis

Prompt-Based Contrastive Pre-Training for Unified Aspect Based Sentiment Analysis

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Dissecting the Title!

Contrastive Pre-Training

For



Aspect Based Sentiment Analysis

- **Self-Supervised** and task independent deep learning technique that enables learning by contrasting samples
- Principle of contrasting samples against each other to pull together similar samples in the embedding space.

- **Aspect Based Sentiment Analysis** or ABSA is a term used to define a broad umbrella of 7 tasks.
- Essentially these tasks focus on obtaining sentiment from reviews at an **aspect (fine-grained) level**.

Aspect Based Sentiment Analysis

- Aspect Extraction (AE)
- Opinion Extraction (OE)

Mono Extraction

7 Seven Subtasks

- Aspect and Opinion Pair Extraction (AO) (Pair)
- Aspect Term Extraction and Sentiment Classification (AESC)

Pair Extraction

- Aspect-oriented Opinion Extraction (AOE)
- Aspect-level Sentiment Classification (ALSC)

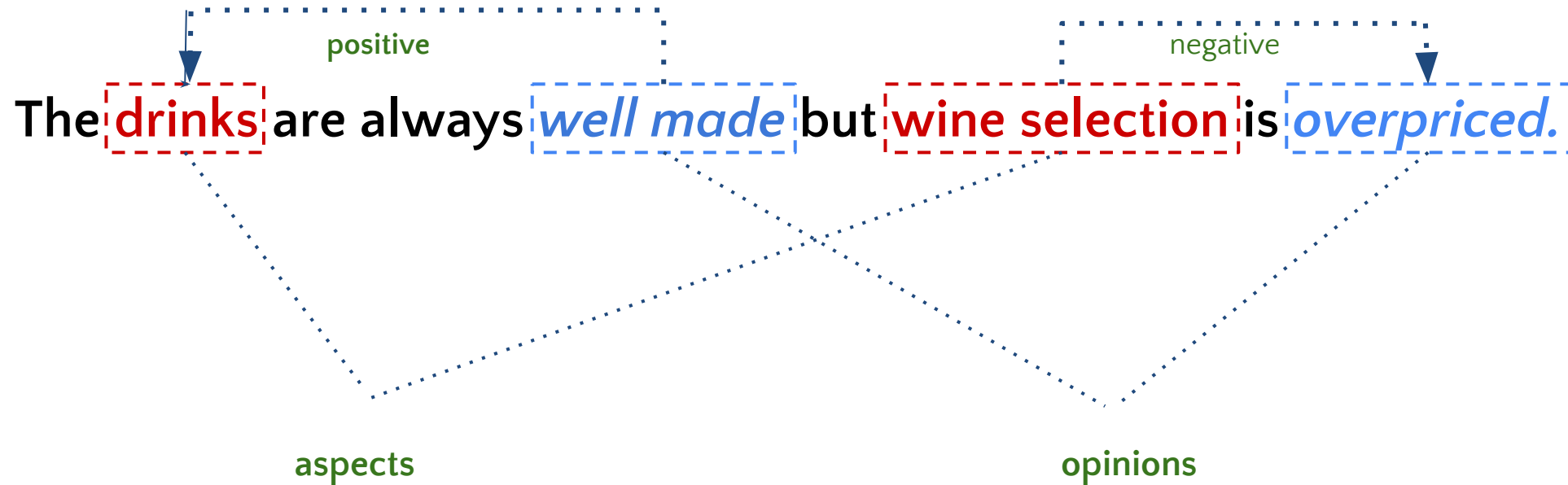
Aspect-oriented
Classification

- Aspect Sentiment Triplet Extraction (ASTE) (Triplet)

Triplet Extraction

Aspect Based Sentiment Analysis

Aspect and Opinion Extraction

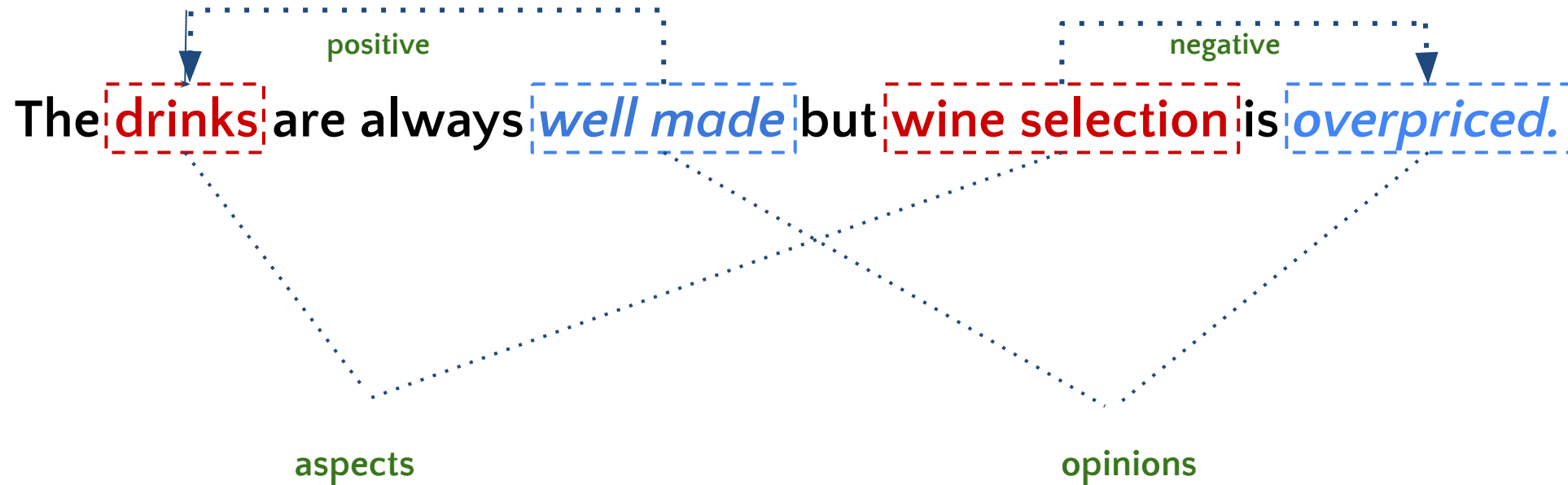


Aspect Extraction Targets: **drinks** | **wine selection**

Opinion Extraction Targets: *well made* | *overpriced*

Aspect Based Sentiment Analysis

Pair Extraction

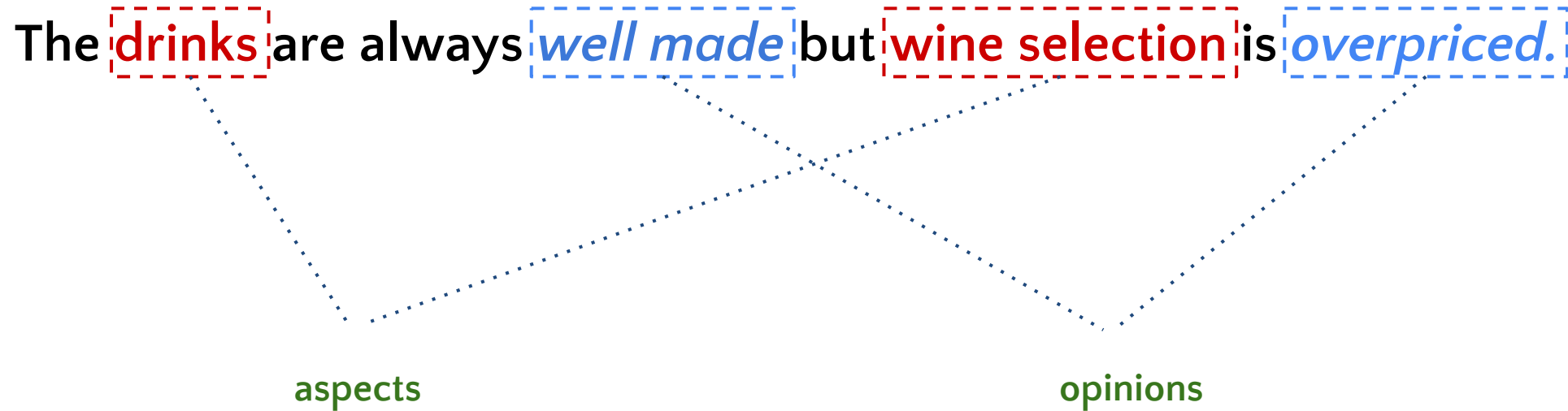


Aspect and Opinion Pair Extraction: **drinks** , *well-made* | **wine selection** , *overpriced*

Aspect Extraction and Sentiment Term Classification: **drinks** , *positive* | **wine selection** , *negative*

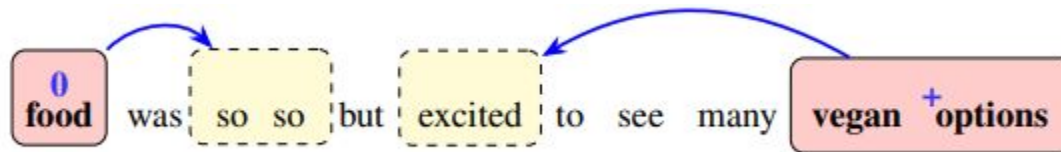
Aspect Based Sentiment Analysis

Triplet Extraction



Aspect Sentiment Triplet Extraction: **drinks** , *well-made*, positive | **wine selection** , *overpriced*, negative

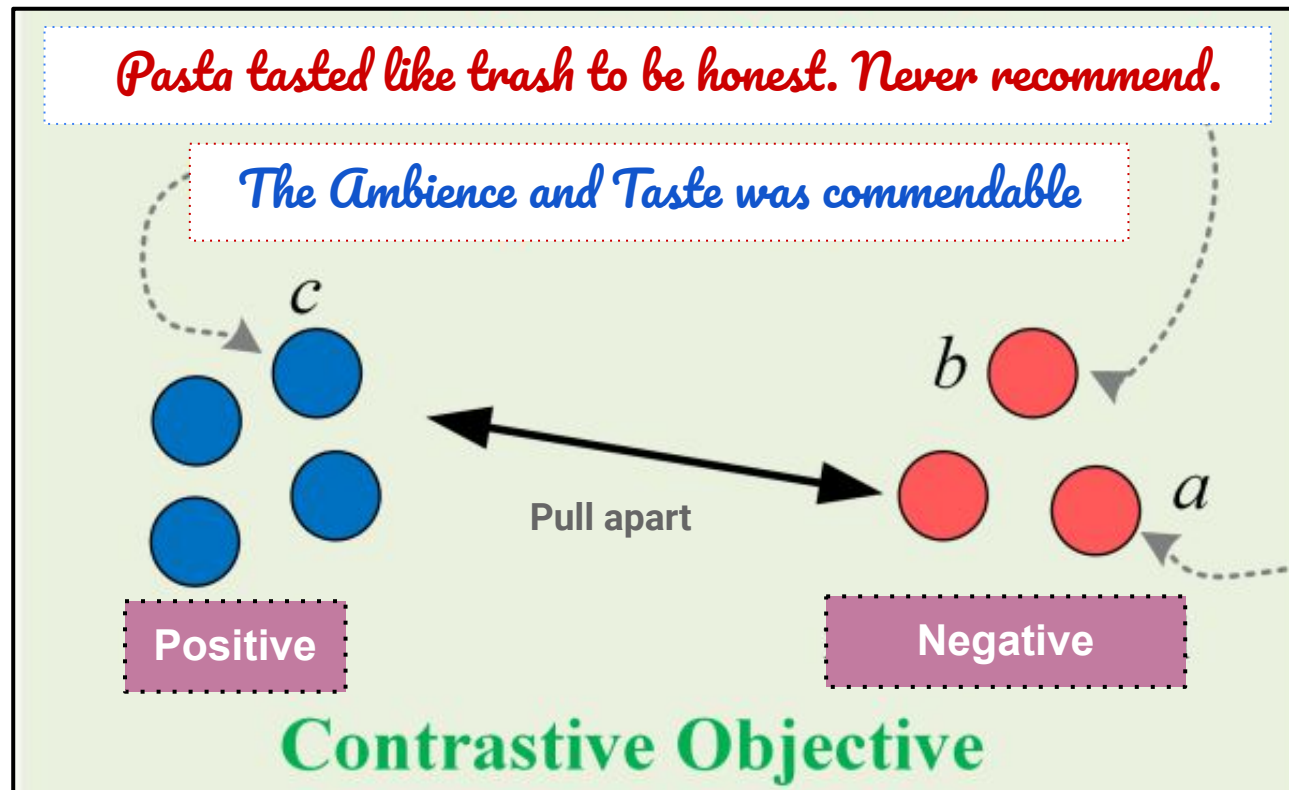
Aspect Sentiment Triplet Extraction



Sent 1:	The film was good , but could have been better .
Triplets	[Aspect ; Opinion ; Sentiment] (1) film ; good ; positive (2) film ; could have been better ; negative
Sent 2:	The weather was gloomy , but the food was tasty .
Triplets	(1) weather ; gloomy ; negative (2) food ; tasty ; positive

- Aspect Sentiment Triplet Extraction falls under the broad category **Aspect Based Sentiment Analysis**.
- It is the hardest of the seven ABSA tasks and is an end-to-end information extraction task.
- The task is to extract **Aspect** Terms, their corresponding **Opinion** Terms and the **Sentiment** which together form a triplet.
- A single sentence may contain multiple triplets of contrasting sentiments.

Contrastive Learning



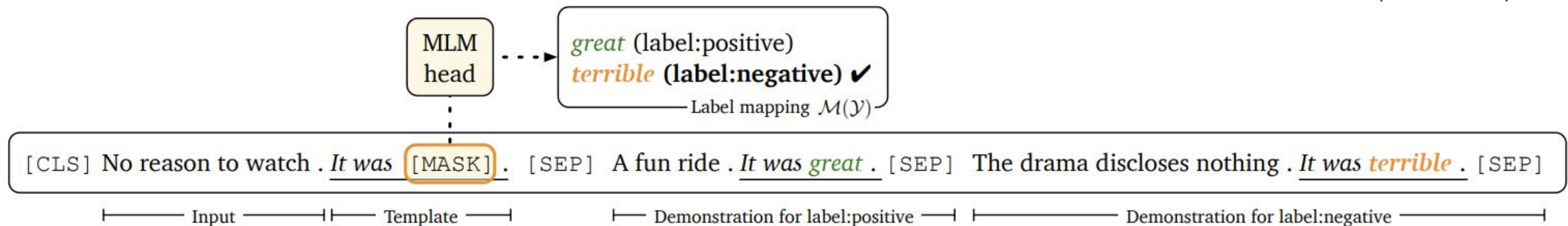
$$P_B^{sup}(i, c) = \frac{\exp(\text{sim}(s_i, s_c)/\tau)}{\sum_{b \in B, b \neq i} \exp(\text{sim}(s_i, s_b)/\tau)}$$

Contrastive Learning requires labels at the sentence level

Prompting

Task	Template	Label words
SST-2	$\langle S_1 \rangle$ It was [MASK] .	positive: great, negative: terrible
SST-5	$\langle S_1 \rangle$ It was [MASK] .	v.positive: great, positive: good, neutral: okay, negative: bad, v.negative: terrible
MR	$\langle S_1 \rangle$ It was [MASK] .	positive: great, negative: terrible
CR	$\langle S_1 \rangle$ It was [MASK] .	positive: great, negative: terrible
Subj	$\langle S_1 \rangle$ This is [MASK] .	subjective: subjective, objective: objective
TREC	[MASK] : $\langle S_1 \rangle$	abbreviation: Expression, entity: Entity, description: Description human: Human, location: Location, numeric: Number
COLA	$\langle S_1 \rangle$ This is [MASK] .	grammatical: correct, not_grammatical: incorrect

src: (Chen et. al.)



Drawbacks of Prior Approaches

- Earliest papers addressing structured ABSA tasks like ASTE resorted to a **tagging approach** which caused a problem for overlapping triplets. For ex, grid tagging [1]. No generative approach proposed so far introduced a pre-training mechanism for ABSA.
- **Unified ABSA** [2] proposes a framework to handle all the seven ABSA tasks, however it does not train a single model to handle all the ABSA sub-tasks
- **PARAPHRASE** [3]: An interesting perspective to solve ASTE. However entertains generation of syntactically incorrect sentences. Cannot generalize to multilingual.

For example:

Template : It is **GREAT/BAD** because **ASPECT** is **OPINION**

Triplet: {chef, innovated, POS}

Paraphrase: It is great because chef is innovated

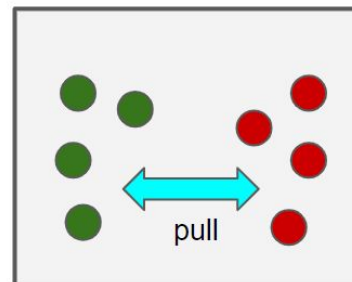
Our Remedies

- We resort to a Generative framework for Unified ABSA inspired from recent ASTE literature.
- Our unified ABSA methodology creates a single multi-task model for all the ABSA tasks.
- Finally, we propose a novel prompt-based contrastive pre-training mechanism to enhance aspect-sentiment understanding.

4. Remedies and Possible Solution

- To overcome the **shortcomings of a tagging**-approach, we fallback to the **Generative frameworks** from recent ABSA literature. Different from these, we propose a **single framework** that addresses all of the seven ABSA tasks trained using a **mixture-of-tasks** approach.
- Next, in addition to the improved fine-tuning scheme, we propose a novel **pre-training strategy** inspired from Contrastive Learning that is expected to improve the **aspect-level sentiment understanding**.
 - This is done using by minimizing an in-batch **contrastive loss function**.
 - The model learns better representations this way, especially in tasks that have contrasting labels (positive, negative).
 - **First work proposing a pre-training strategy** for structured ABSA tasks like ASTE, AO.

But how can we get aspect level sentiment representation?



Our Contributions

- We propose a novel **unified generative scheme** that can handle all of the seven ABSA sub-tasks. More specifically we propose a **single model** for all the ABSA tasks using **task-specific prompts** and **mixture-of-tasks training**. This is the first work to propose a **single model** to address all the ABSA tasks.
- We propose a novel **prompt-based contrastive learning** framework called CONTRABSA that enhances ABSA performance by enabling the model to better comprehend the **aspect-level sentiments**. We propose a novel and elegant prompting technique to obtain **aspect-specific sentence embeddings** for contrastive learning.
- Our claims are based on extensive experimentation over SemEval-14 datasets and comparing our approach with popular benchmarks. We achieve **new state-of-the-art** on several ABSA tasks. We also report **ablation studies** on the ASTE task to help better understand the impact of the components in our framework. Our code is released for the benefit of research

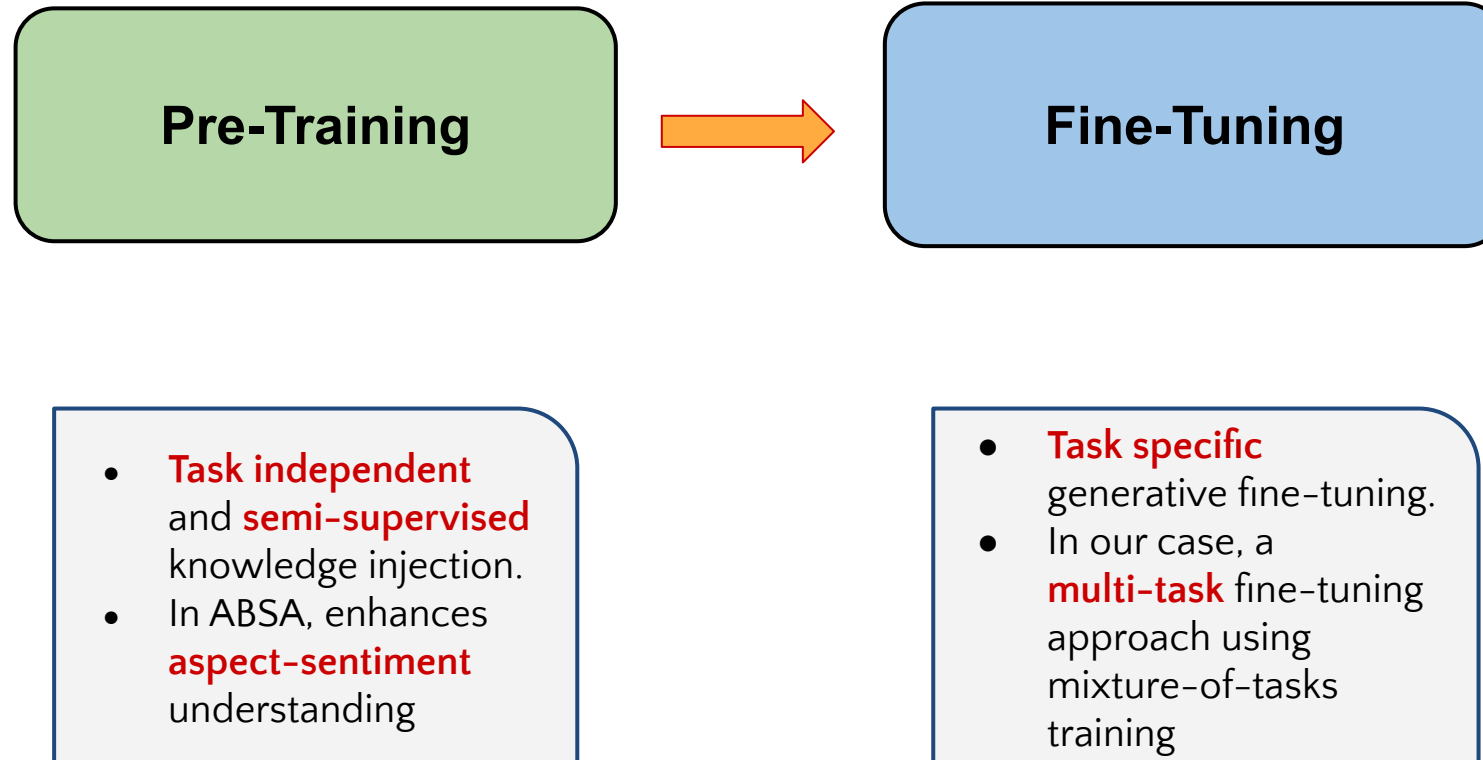


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Our Framework

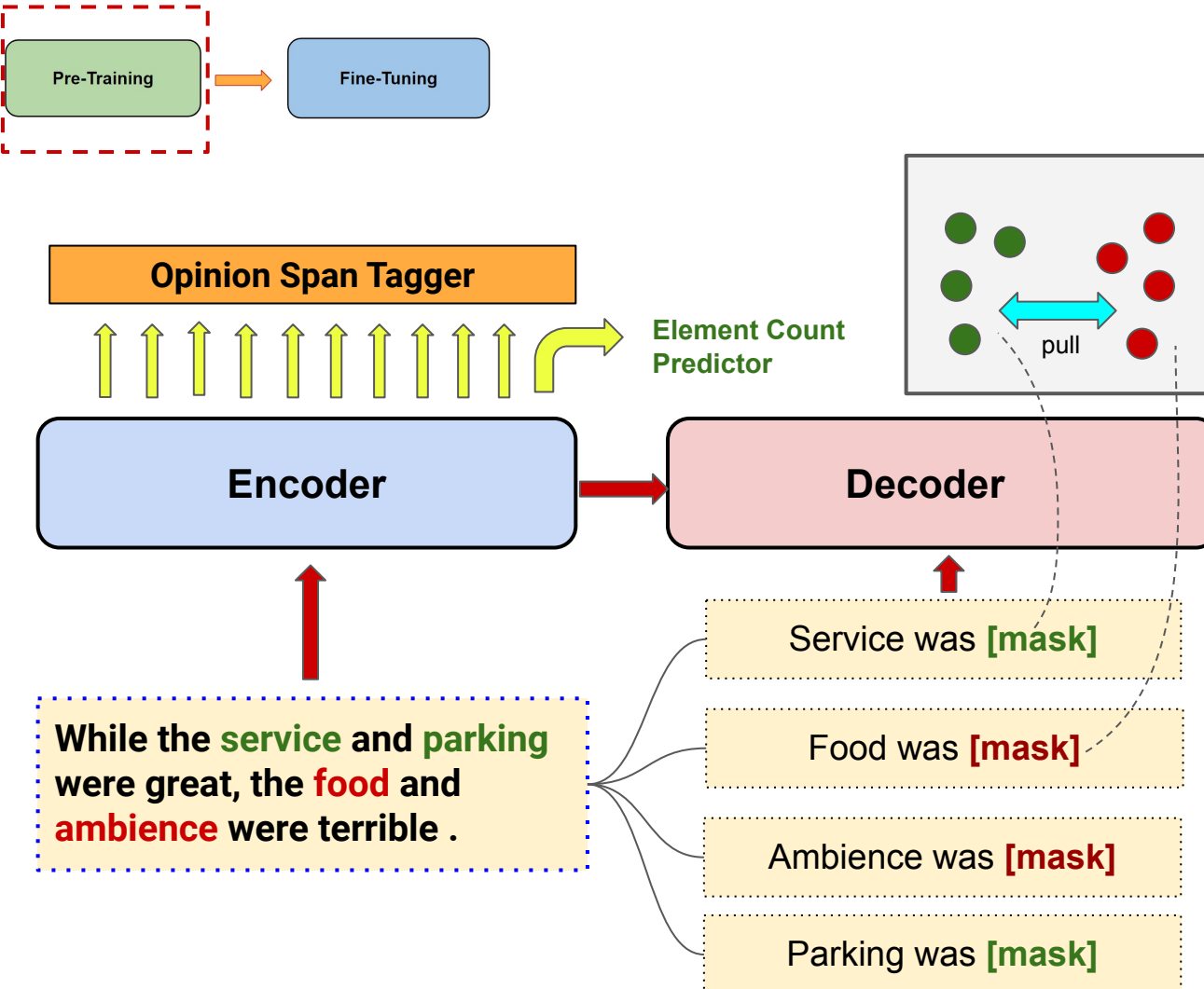


High Level Overview



7. Pre-Training: CONTRABSA

CONTRASTIVE ASPECT BASED SENTIMENT ANALYSIS

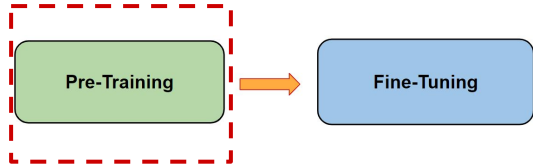


Four Salient Features

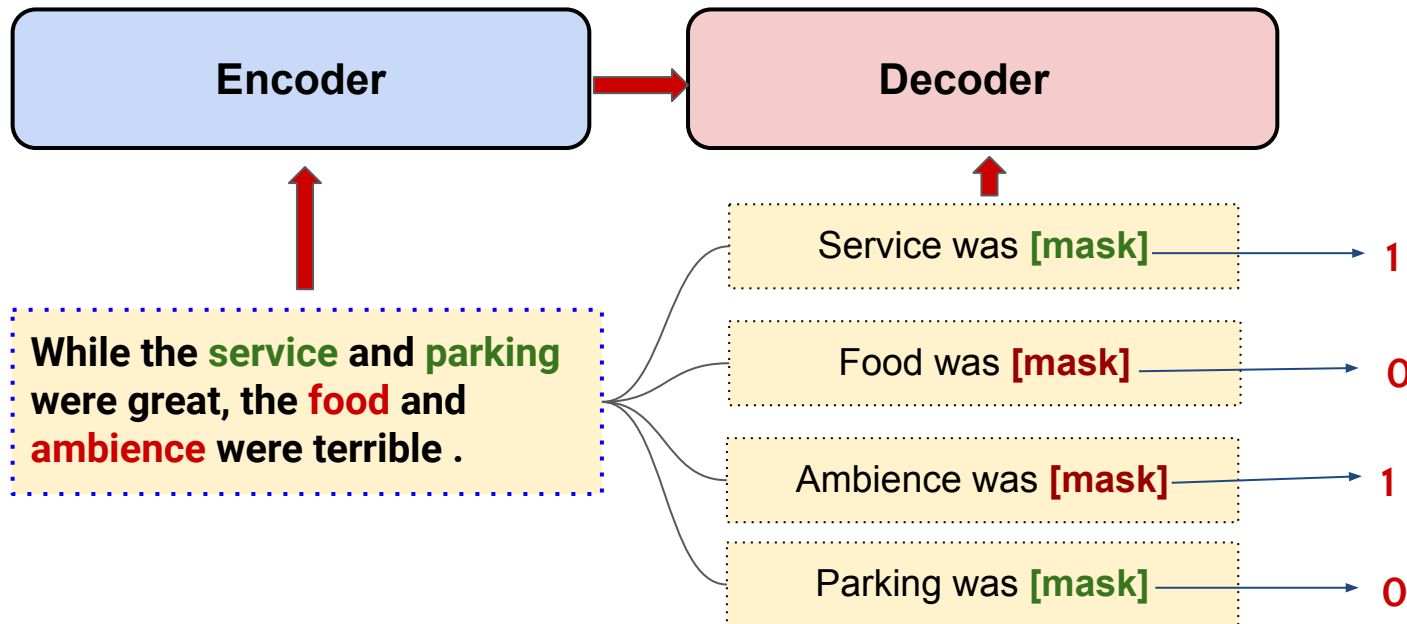
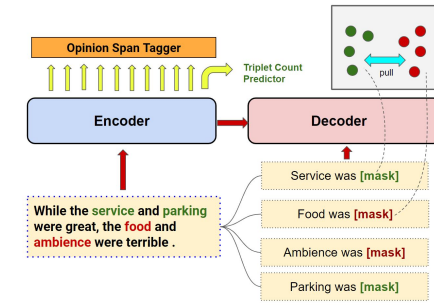
- Template Generation scheme for ASTE along the lines of previous works
- Novel Prompt-Based Contrastive Pre-Training
- Opinion Span Tagger
- Triplet Count Regressor

We use T5 as the backbone of CONTRABSA

CONTRABSA



- We use aspect specific prompts with a [mask] token that provides sentence representation
- The input + prompt combination together now has a single sentiment label



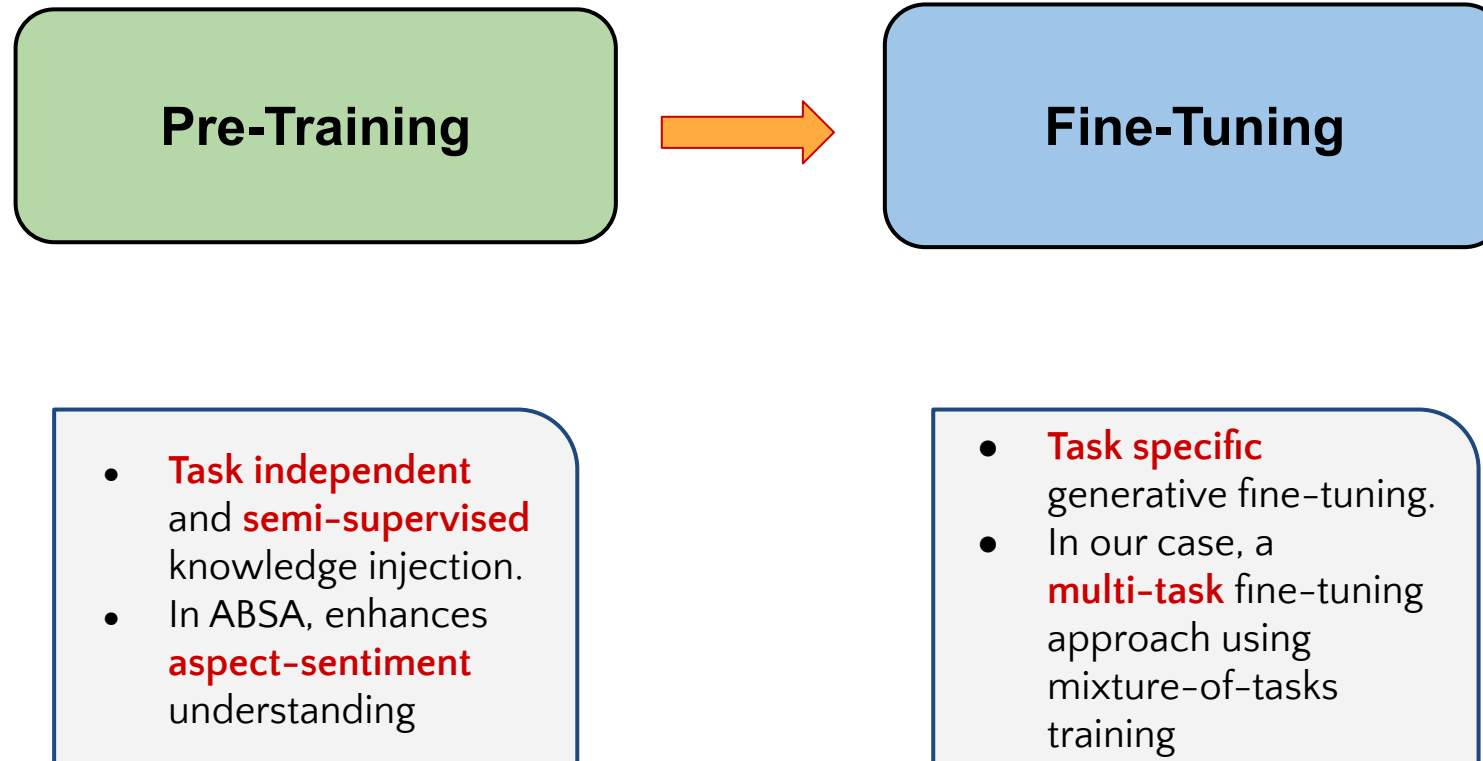
Prompts

Natural Language : Food was [MASK]

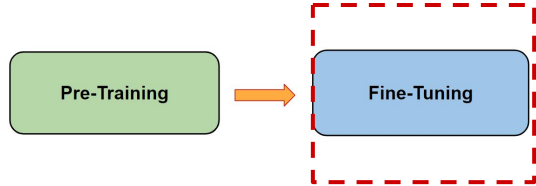
Template : <triplet> Food <sentiment> [MASK]



High Level Overview



Fine-tuning:Template-Based Generation



Special Placeholder Tokens

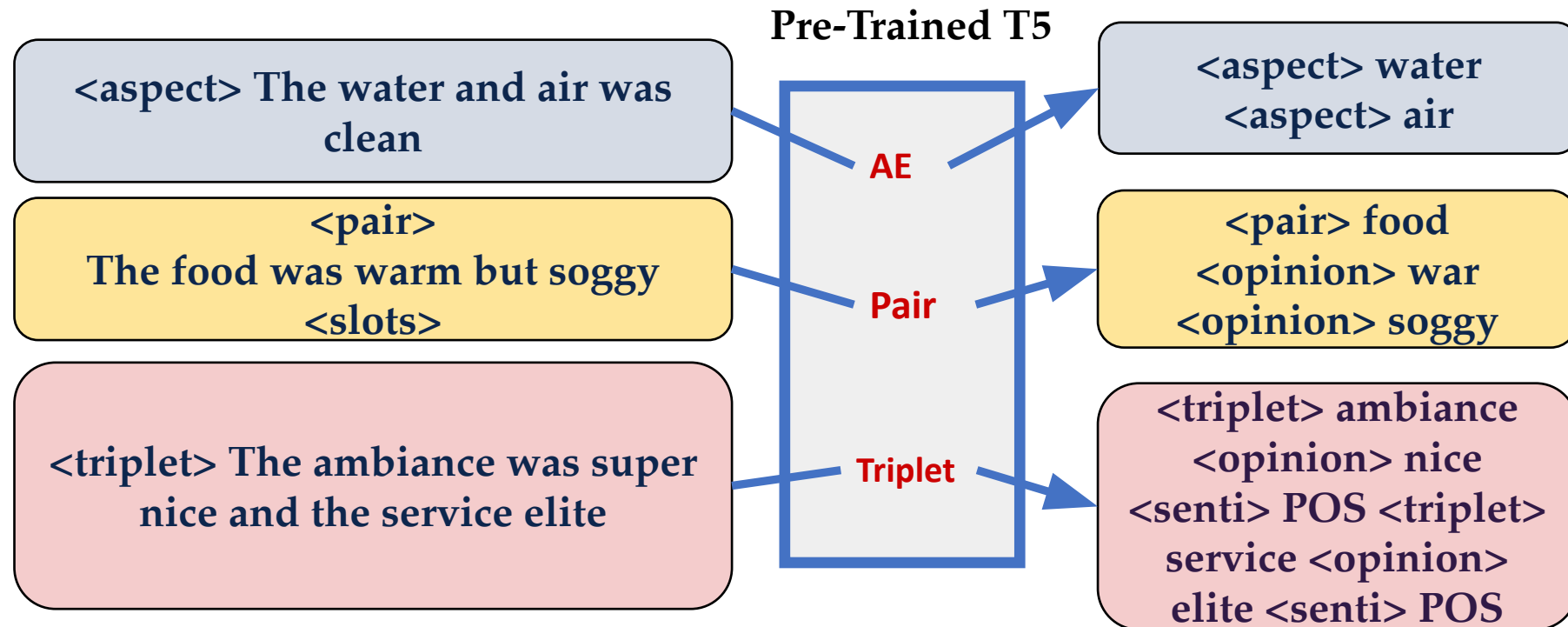
- <triplet> - start of triplet followed by aspect term
- <opinion> - opinion term placeholder following aspect
- <sentiment> - sentiment polarity placeholder
- <aspect> - aspect term placeholder

Aspect Extraction (AE)	<aspect> cake <aspect> coffee
Opinion Extraction (OE)	<opinion> too creamy <opinion> nice
Aspect and Opinion Pair Extraction (AO)	<pair> cake <opinion> too creamy <pair> coffee <opinion> nice
Aspect Term Extraction and Sentiment Classification (AESC)	<aspect> cake <sentiment> negative <aspect> coffee <sentiment> positive
Aspect Sentiment Triplet Extraction (ASTE)	<triplet> cake <opinion> too creamy <sentiment> negative <aspect> coffee <opinion> nice <sentiment> positive

Mixture-of-Tasks Training

Pre-Training

Fine-Tuning



Multitasking Training Objective

Pre-Training



Fine-Tuning

BIO Tagging Scheme

Opinion Span Tagger



Triplet Count Predictor

Encoder

Primary Task benefits from related Secondary Tasks

Training Objective

:

Cross-Entropy

$L_{generation}$

+

α

*

Cross-Entropy

L_{tagger}

+

β

*

Mean Squared Error

$L_{regressor}$



Experiments

Experimental Setup

Datasets

English : ASTE-Data-V2 - Originally from SemEval 14 ABSA dataset

Dataset	14Lap			14Rest			15Rest			16Rest			Restaurant (All)		
	# Pos.	# Neg.	# Neu.	# Pos.	# Neg.	# Neu.	# Pos.	# Neg.	# Neu.	# Pos.	# Neg.	# Neu.	# Pos.	# Neg.	# Neu.
Train	817	517	126	1692	480	166	783	205	25	1015	329	50	3490	1014	241
Dev	169	141	36	404	119	54	185	53	11	252	76	11	841	248	76
Test	364	116	63	773	155	66	317	143	25	407	78	29	1497	376	120

src: (Mukherjee et.al.)

Results

Table II: Results of ASTE and AO extraction on the SemEval 14 datasets compared with the baselined

Task	Model	14res			15res			16res			lap14		
		P	R	F1	P	R	F1	P	R	F1	P	R	F1
AO (Pair)	GAS	-	-	0.687	-	-	0.650	-	-	0.705	-	-	0.626
	Unified ABSA	-	-	0.768	-	-	0.67	-	-	0.703	-	-	0.661
	Mixture-of-Task + CONTRABSA (Ours)	0.674	0.615	0.643	0.719	0.705	0.712	0.684	0.725	0.704	0.727	0.67	0.697
ASTE (Triplet)	PASTE + BERT	0.648	0.638	0.643	0.583	0.567	0.575	0.655	0.644	0.65	0.55	0.516	0.532
	Unified ABSA	0.655	0.65	0.652	0.591	0.593	0.592	0.666	0.686	0.676	0.614	0.561	0.587
	GAS	0.65	0.695	0.672	0.561	0.618	0.588	0.661	0.687	0.674	0.571	0.54	0.551
	PARAPHRASE	0.725	0.715	0.72	0.614	0.643	0.628	0.702	0.735	0.718	0.618	0.618	0.613
	CONTRABSA	0.722	0.732	0.727	0.646	0.670	0.658	0.696	0.763	0.728	0.636	0.617	0.622
	Mixture-of-Task + CONTRABSA (Ours)	0.721	0.732	0.726	0.644	0.681	0.662	0.7	0.77	0.734	0.636	0.618	0.623

baselines

Results

Table II: Results of Aspect Extraction and Opinion Extraction extraction on the SemEval 14 datasets. We present comparisons to show the improvement obtained from mixture-of-task-training.

Task	Model	14res			15res			16res			lap14		
		P	R	F1	P	R	F1	P	R	F1	P	R	F1
AE	CONTRABSA	0.890	0.812	0.849	0.91	0.856	0.882	0.852	0.89	0.871	0.873	0.891	0.873
	Mixture-of-Task + CONTRABSA (Ours)	0.914	0.819	0.864	0.916	0.9	0.908	0.869	0.91	0.889	0.904	0.912	0.908
OE	CONTRABSA	0.88	0.921	0.9	0.752	0.837	0.792	0.893	0.896	0.894	0.845	0.936	0.888
	Mixture-of-Task + CONTRABSA (Ours)	0.88	0.945	0.911	0.78	0.84	0.81	0.89	0.90	0.90	0.86	0.942	0.899

Ablation Study

Table III. Ablation Study on the ASTE task to highlight the individual component contributions.

Ablation	14res			15res		
	P	R	F1	P	R	F1
Ours (CONTRABSA + MoT)	0.721	0.732	0.726	0.644	0.681	0.662
Ours -w/Mixture-of-tasks	0.722	0.732	0.727	0.646	0.670	0.658
Ours -w/Contrastive Pre-T	0.69	0.697	0.698	0.613	0.666	0.638

Future Work

- We intend to perform additional experimentation on Few-Shot, Cross-Lingual and Cross-Domain settings by considering more languages for low-resource data.
- We will attempt to scale up the contrastive pre-training data by weak supervision over large-scale unsupervised review data.
- We wish to further scrutinize the benefits and the actual effects of Contrastive Learning in the context of ABSA. We may also try out different prompts along with CONTRABSA to see the effects
- Our work is currently planned for submission in a top-tier NLP/IR Conference. This work will be extended and continued for the preparation and submission of the manuscript.

Thank you ! **Questions?**

Please reach at
nithishkannen@gmail.com

Source Code available at: <https://github.com/nitkannen/MultiABSA>