Three-hop Reasoning for Emotion Cause Analysis in Context

Nicolay Rusnachenko

Outline

- 🧠 How to reason emotion states and causes by using LLMs

- 🤝 How to align emotion state and causes within a single model

- 📺 How to quick start with pretrained models

Conversations from F.R.I.E.N.D.S. TV-show
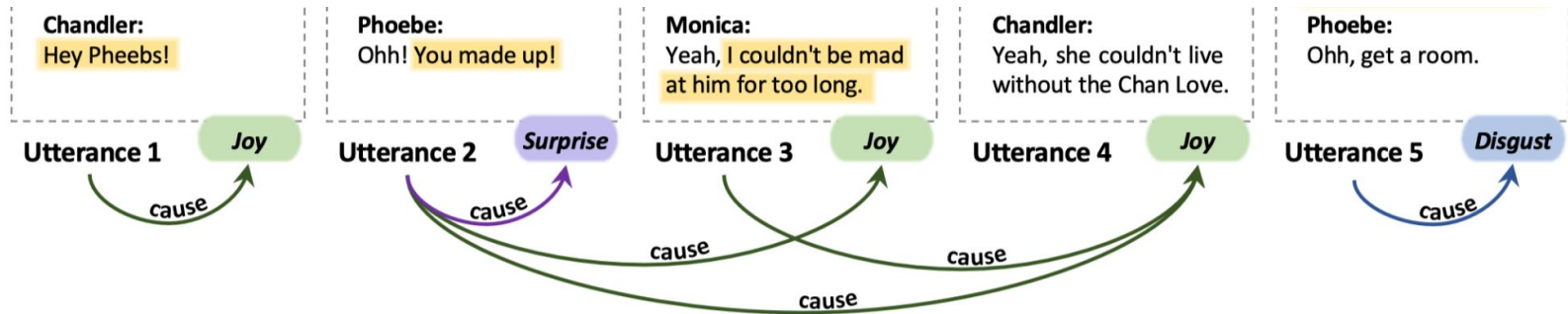
Source of Data: SemEval-2024 (ECAC-2024) Competition

ECF dataset: https://arxiv.org/pdf/2110.08020

1.3K conversations and **13.5K** utterances, **9.2K** emotion-cause pairs are annotated, covering three modalities (text, visual, speech)

Dialogue Structures (Textual Modality)

Chandler:
Hey Pheebs!

Phoebe:
Ohh! You made up!

Monica:
Yeah, I couldn't be mad at him for too long.

Chandler:
Yeah, she couldn't live without the Chan Love.

Phoebe:
Ohh, get a room.

Utterance 1 — *Joy*
Utterance 2 — *Surprise*
Utterance 3 — *Joy*
Utterance 4 — *Joy*
Utterance 5 — *Disgust*

cause

Emotion classes: joy, surprise, anger, sadness, disgust, fear, and neutral

$u_{state} \backslash e^{u \rightarrow *}$	JOY	SUR	ANG	SAD	DIS	FEA
total	2653	2092	1984	1336	518	296
JOY	.89	.06	.03	.01	.01	.00
SURPRISE	.07	.78	.07	.03	.03	.02
ANGER	.01	.07	.83	.06	.02	.02
SADNESS	.02	.09	.06	.81	.01	.01
DISGUST	.03	.07	.14	.06	.70	.01
FEAR	.02	.13	.08	.05	.04	.68
NEUTRAL	.24	.38	.22	.08	.04	.03

Emotion caused by person mostly **driven by** the *emotional state* of the speaker

Going with history of 3 utterances would cover **95% of emotion causes** in ECAC-2024

Parameter	future	past				
$\delta = u_{id}^{tgt} - u_{id}^{src}$	< 0	0	1	2	3	4
Causes count	377	4605	2759	810	332	160
Average per δ	0.12	3.35	2.01	0.59	0.24	0.12
Covering (%)	–	51.9	82.9	92.1	**95.8**	97.6

🔗 Reasoning

🔗 Zero-shot Chain-of-Thought (CoT)

💡 Common sense reasoning domain

step-by-step reasoning for gaining the task answer

https://arxiv.org/abs/2205.11916

(c) Zero-shot

Q: A juggler can juggle 16 balls. Half of the balls are golf balls, and half of the golf balls are blue. How many blue golf balls are there?
A: The answer (arabic numerals) is

(Output) 8 ✗

(d) Zero-shot-CoT (Ours)

Q: A juggler can juggle 16 balls. Half of the balls are golf balls, and half of the golf balls are blue. How many blue golf balls are there?
A: **Let's think step by step.**

(Output) There are 16 balls in total. Half of the balls are golf balls. That means that there are 8 golf balls. Half of the golf balls are blue. That means that there are 4 blue golf balls. ✓

Question: How this could be applied in Emotion Causes extraction?
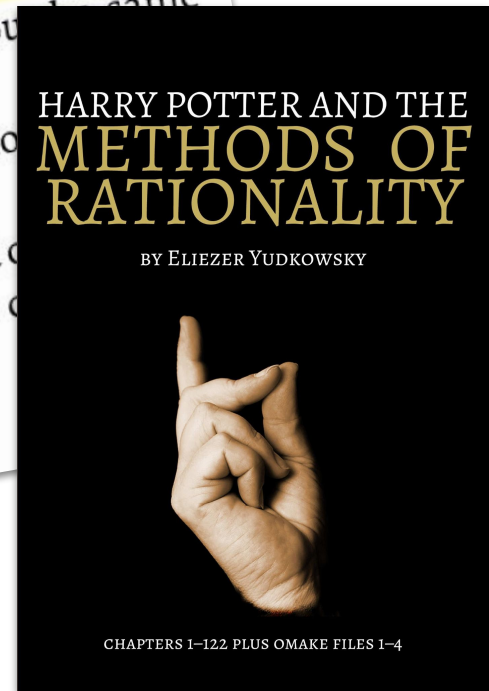
Concept of Robust Reasoning

"I ask the fundamental question of rationality: why do you believe what you believe? What do you think you know and how do you think you know it? What makes you think Lucius wouldn't sacrifice you the same way he'd sacrifice anything else for power?"

Draco shot Harry another odd look. "Just what do you kno... ther?"

"Um...seat on the Wizengamot, seat on Hogwarts' Board o... incredibly wealthy, has the ear of Minister Fudge, has the c...

* 82 *

HARRY POTTER AND THE
METHODS OF
RATIONALITY
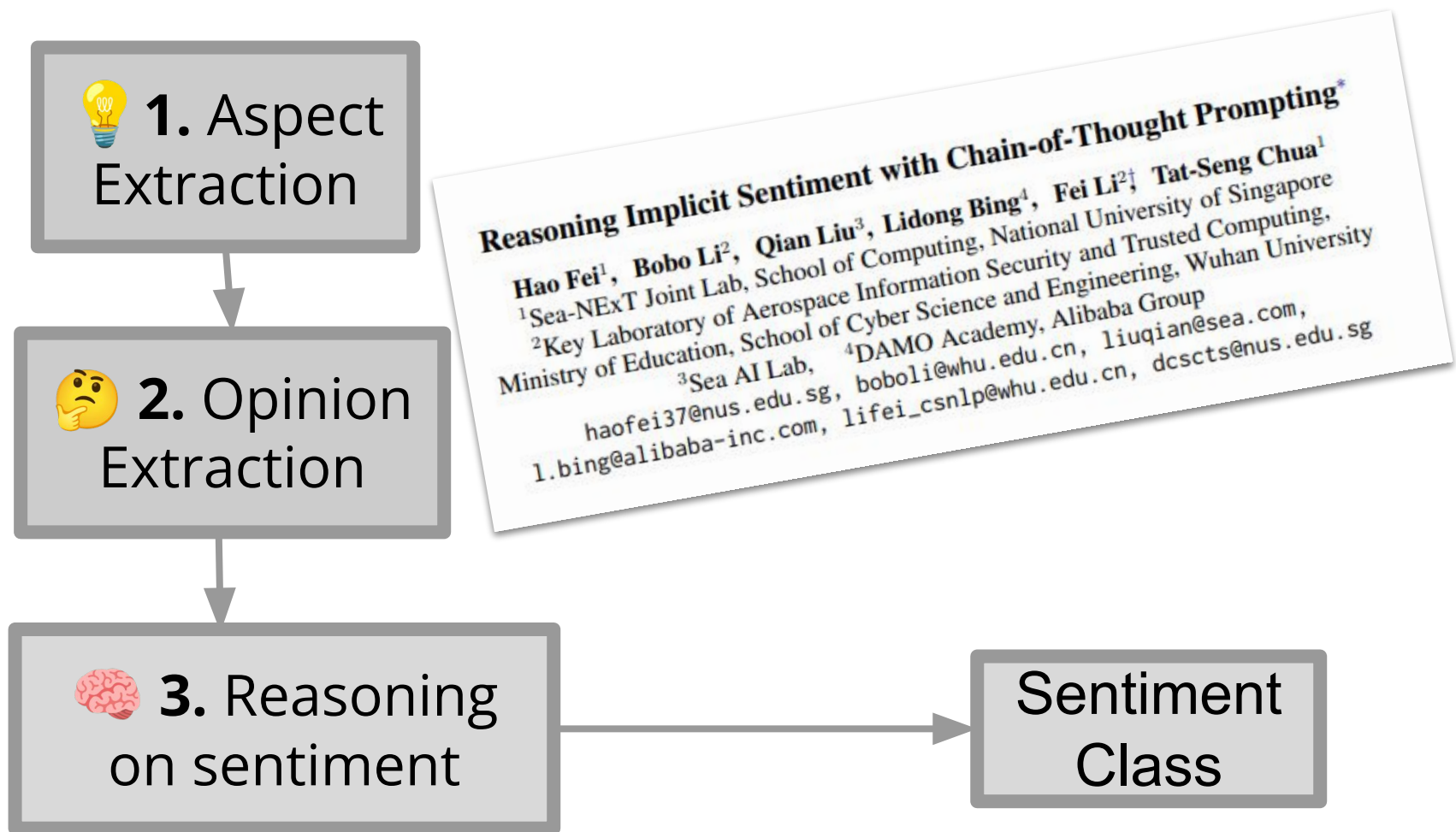BY ELIEZER YUDKOWSKY

CHAPTERS 1–122 PLUS OMAKE FILES 1–4

What and how if you breakdown the fundamental question of rationality.

- 💡 **Fact** (What do you think you know)
- 🤔 **Opinion on it?** (how do you think you know it).

Concept of Three-Hop Reasoning

💡 **1.** Aspect Extraction

🤔 **2.** Opinion Extraction

🧠 **3.** Reasoning on sentiment

Sentiment Class

Reasoning Implicit Sentiment with Chain-of-Thought Prompting*

Hao Fei[1], Bobo Li[2], Qian Liu[3], Lidong Bing[4], Fei Li[2†], Tat-Seng Chua[1]

[1]Sea-NExT Joint Lab, School of Computing, National University of Singapore
[2]Key Laboratory of Aerospace Information Security and Trusted Computing,
Ministry of Education, School of Cyber Science and Engineering, Wuhan University
[3]Sea AI Lab, [4]DAMO Academy, Alibaba Group
haofei37@nus.edu.sg, boboli@whu.edu.cn, liuqian@sea.com,
l.bing@alibaba-inc.com, lifei_csnlp@whu.edu.cn, dcscts@nus.edu.sg
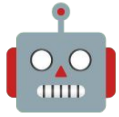
🤖 Methodology

Methodology in Three Parts

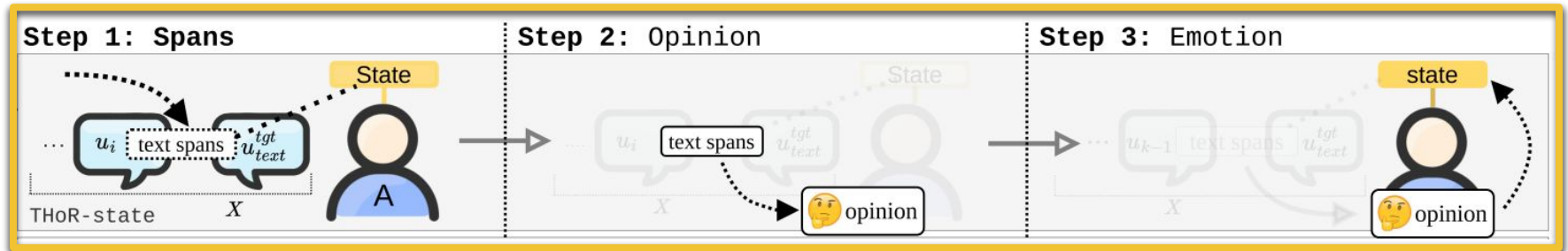For a conversation that involves speaker A and speaker B in conversation further:

Part 1: Reasoning Emotion State of Speaker A

Part 2: Reasoning Emotion Cause of Speaker A towards the speaker B

Part 3: Revise Reasoning about speaker's A emotion state while Reasoning on Emotion it causes to B

🤖 PART 1: Speakers Emotion States

Step 1: $s_1' = [C_1(X)$, which text spans are possibly causes emotion on u_{text}^{tgt}?]

Step 2: $o_1' = [C_2(C_1, s_1')$. Based on the common sense, what is the implicit opinion towards the mentioned text spans that causes emotion on u_{text}^{tgt}, and why?]
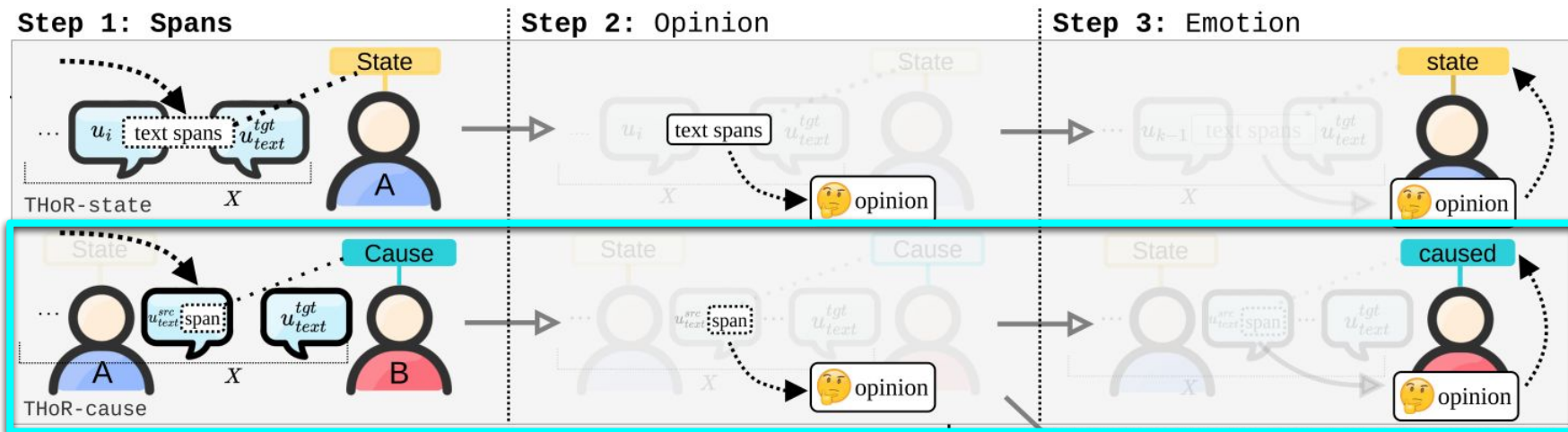
Step 3: $e_1' = [C_3(C_2, o_1')$. Based on such opinion, what is the emotion state of u_{text}^{tgt}?]

Context (X):

Text spans + target

We refer to u_{text} (target) as the last conversation utterance.

🤖 PART 2: Reasoning Caused Emotion

Step 1: Spans — THoR-state / THoR-cause
Step 2: Opinion
Step 3: Emotion

Step 1: $s_2' = [C_1(X)$, which specific text span of u_{text}^{src} is possibly causes emotion?]
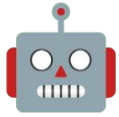
Step 2: $o_2' = [C_2(C_1, s_2')$. Based on the common sense, what is the implicit opinion towards the cause of mentioned text span of u_{text}^{src}, and why?]
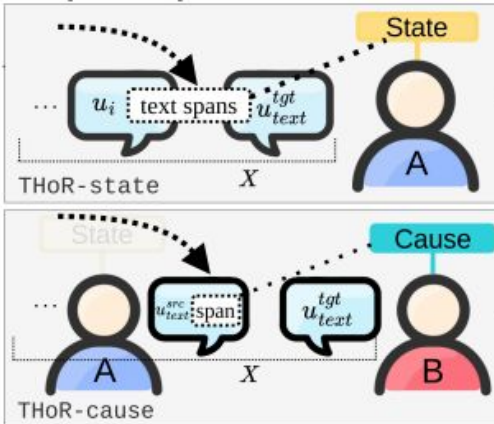
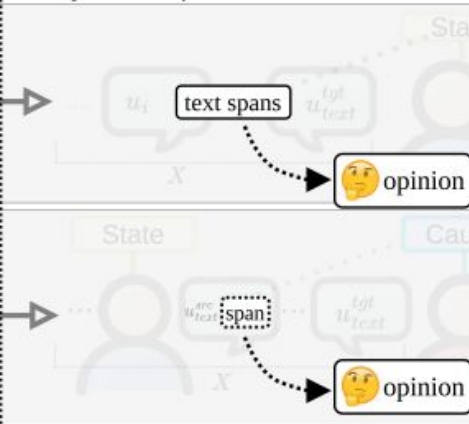**Step 3**: $e_2' = [C_3(C_2, o_2')$. Based on such opinion, what is the emotion caused by source towards the last conversation utterance?]

Context (X):

source + *span* + ***target***

We refer to u_{text} (target) as the last conversation utterance.

🤖 PART 3: Revise the Knowledge

Step 1: Spans

THoR-state

Step 2: Opinion

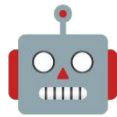**Step 3: Emotion**

THoR-cause

Reasoning Revision (Optional)
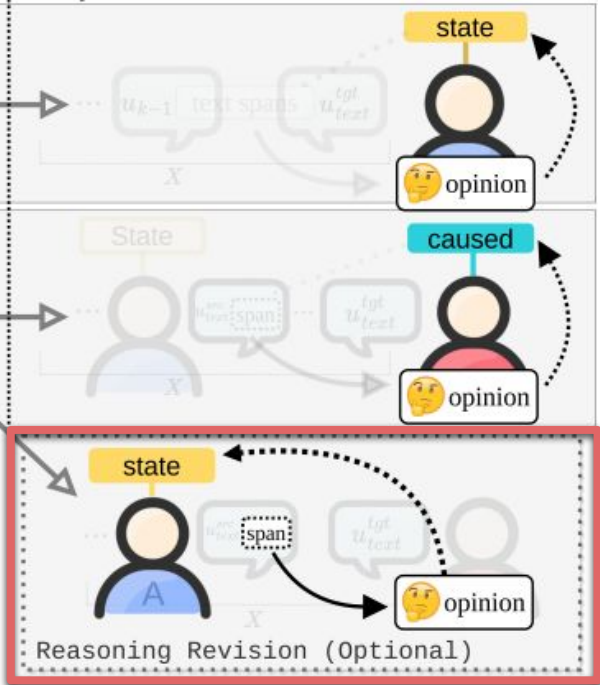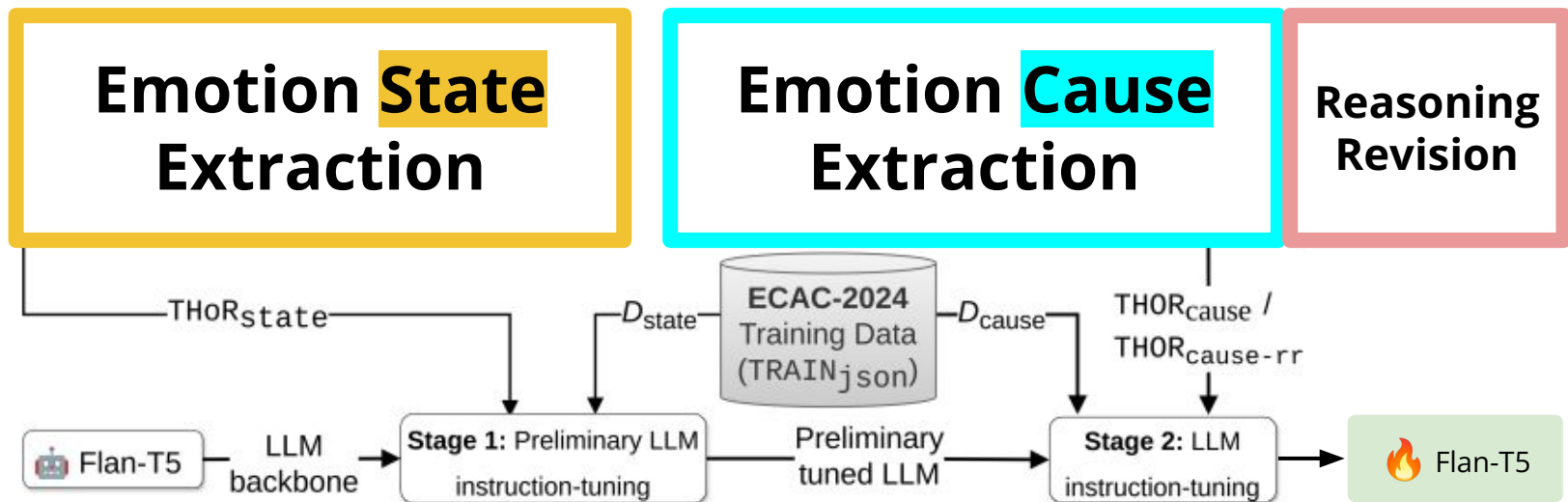
Context (X):

source + *span* + *target*

Step 3.1: $u_{state}^{\prime src} = [C_3(C_2, o_2'),$ Based on such opinion, what is the emotion state of u_{text}^{src}?]

🤖 Model Training Concept

Two stage approach for tuning 🔥 LLM (Flan-T5):

| Emotion **State** Extraction | Emotion **Cause** Extraction | Reasoning Revision |

THOR_state → D_state → **ECAC-2024 Training Data (TRAIN_json)** → D_cause → THOR_cause / THOR_cause-rr

Flan-T5 → LLM backbone → **Stage 1: Preliminary LLM instruction-tuning** → Preliminary tuned LLM → **Stage 2: LLM instruction-tuning** → 🔥 Flan-T5

Flan-T5: https://arxiv.org/pdf/2210.11416

🧪 Experiments

Resources Construction (ECAC-2024)

Size of context X equals to 3. ($k = 3$)

D$_{state}$ Resource Construction

D$_{cause}$ Resource Construction

For train/dev we adopt 9:1 proportion split

Source	TRAIN$_{json}$		TEST$_{json}$
Part	train	dev	test
D_{state} (total)	12144	1475	
NEUTRAL	5299	630	.
JOY	2047	254	.
SURPRISE	1656	184	.
ANGER	1423	192	.
SADNESS	1011	136	.
DISGUST	372	42	.
FEAR	336	37	.
D_{cause} (total)	30445	3612	15794
NEUTRAL	23750	2765	15794
JOY	2111	279	—
SURPRISE	1725	202	—
ANGER	1307	174	—
SADNESS	932	120	—
DISGUST	387	47	—
FEAR	233	25	—

* Amount of input contexts

Statistics of Flan-T5 fine-tuning
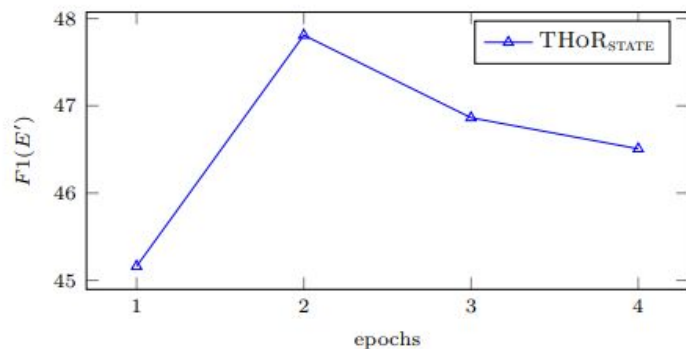
Flan-T5-BASE (248M parameters):

Figure 2: Result analysis of the preliminary fine-tuning of Flan-T5$_{\text{base}}$ on D_{state} dev using THOR$_{\text{STATE}}$ technique per epoch by $F1(E')$

Stage 1:

Emotion State Extraction

Stage 2:

Emotion Cause Extraction

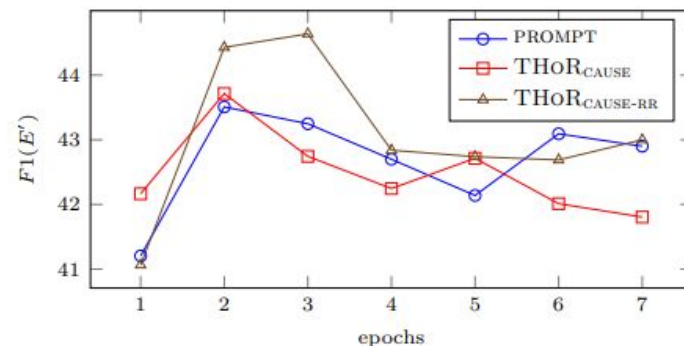On top of the pre-trained model from the STAGE 1.

Figure 3: Flan-T5$_{\text{base}}$† fine-tuning results comparison by $F1(E')$ on D_{cause} dev part per each epoch across fine-tuning techniques: PROMPT, THOR$_{\text{CAUSE}}$, and THOR$_{\text{CAUSE-RR}}$.

Results [Stage 2]

1. We compare the results with the PROMPT-based approach trained on D-cause.
2. The application of THoR-cause slightly surpasses / nearly similar to PROMPT-based
3. The application of Reasoning Revision **results in 2.1% performance increment** (dev) by F1(E')

Source	dev	test			
Model	$F1(E')$	$F1_s^w$	$F1_p^w$	$F1_s$	$F1_p$
PROMPT					
$FT5_{base}$‡	43.51	9.68	22.27	10.05	22.21
THORCAUSE					
$FT5_{base}$‡	43.72	—	—	—	—
THORCAUSE-RR					
$FT5_{base}$‡	44.64	9.74	23.54	10.33	23.94

Alignment

Worth to mention that result model has aligned emotion state and emotion causes after two-stage training process and Reasoning Revision Application

$u_{state} \setminus e^{u \to *}$	JOY	SUR	ANG	SAD	DIS	FEA
JOY	.87	.08	.02		.01	.00
SURPRISE	.09	.75	.06	.05	.03	.01
ANGER	.05	.14	.68	.08	.03	.01
SADNESS	.06	.11	.03	.76	.02	.02
DISGUST	.07	.11	.07	.05	.68	.01
FEAR	.00	.15	.09	.02	.00	.74
NEUTRAL	.36	.40	.07	.12	.03	.02

Table 8: Distribution statistics between speaker state (u_{state}) and emotion *speaker causes* ($e^{u \to *}$) for automatically extracted emotion-cause pairs by Flan-T5$_{base}$‡ (THOR$_{CAUSE-RR}$ technique) from the evaluation data (TEST$_{json}$); values in each row are normalized

$u_{state} \setminus e^{* \to u}$	JOY	SUR	ANG	SAD	DIS	FEA
JOY	.97	.01	.01	.00	.01	.00
SURPRISE	.04	.89	.04	.01	.01	.01
ANGER	.04	.05	.83	.05	.02	.01
SADNESS	.02	.02	.03	.89	.02	.01
DISGUST	.02	.04	.05	.07	.81	.01
FEAR	.00	.06	.07	.04	.03	.80
NEUTRAL	.60	.13	.03	.16	.05	.02

Table 9: Distribution statistics between speaker state (u_{state}) and emotion *caused on them* ($e^{* \to u}$), for automatically extracted emotion-cause pairs by Flan-T5$_{base}$‡ (THOR$_{CAUSE-RR}$ technique) from the evaluation data (TEST$_{json}$); values in each row are normalized

Demo

https://colab.research.google.com/github/nicolay-r/THOR-ECAC/blob/master/SemEval_2024_Task_3_FlanT5_Finetuned_Model_Usage.ipynb

Conclusion

- 🧠 How to reason emotion states and causes by using LLMs
    - Using Three-Hop reasoning concept
- 🤝 How to align emotion state and causes within a single model
    - Using Reasoning-Revision technique
- 📺 How to quick start with pretrained models
    - Demo and other materials (next slide)

Related Resources

Paper:

https://aclanthology.org/2024.semeval-1.4/

Github:

https://github.com/nicolay-r/THOR-ECAC

Trained Model:

https://huggingface.co/nicolay-r/flan-t5-emotion-cause-thor-base

Competition details:

https://codalab.lisn.upsaclay.fr/competitions/16141