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HAEE: Low-Resource Event Detection with Hierarchy-Aware Event Graph Embeddings

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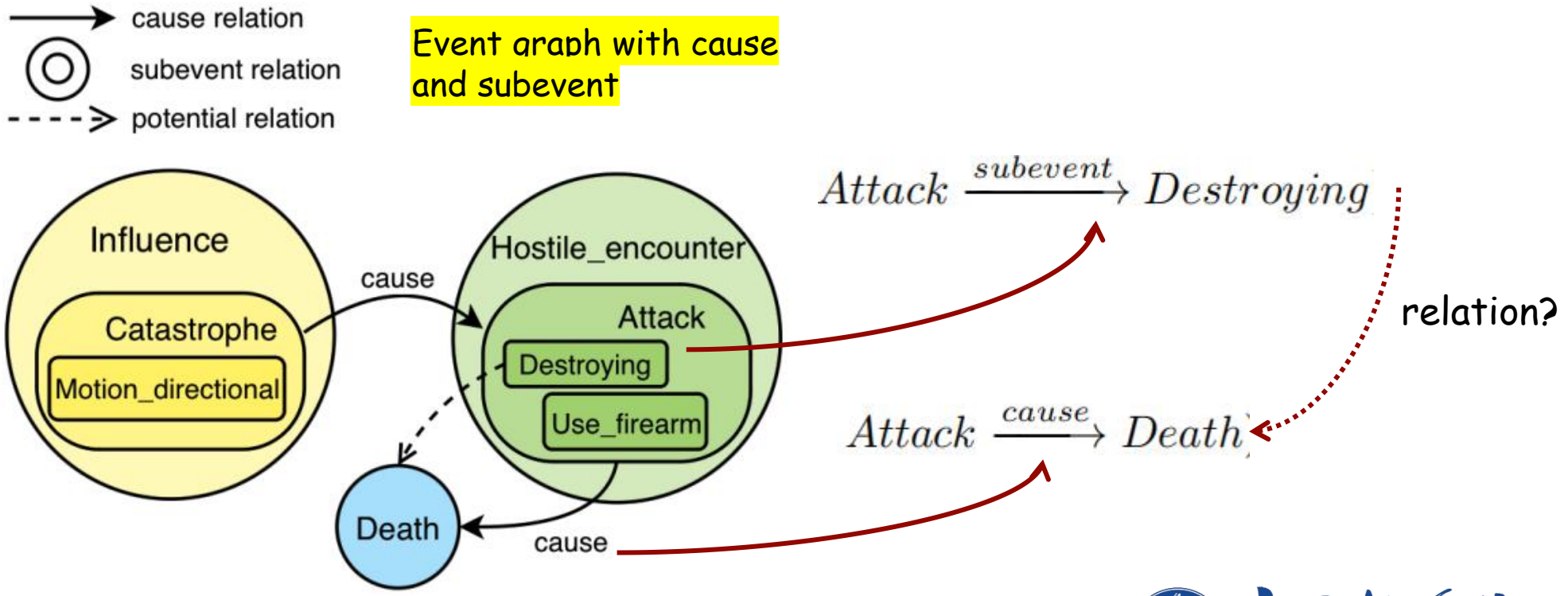
Events and Event Relations

➢**More abstract connections**:

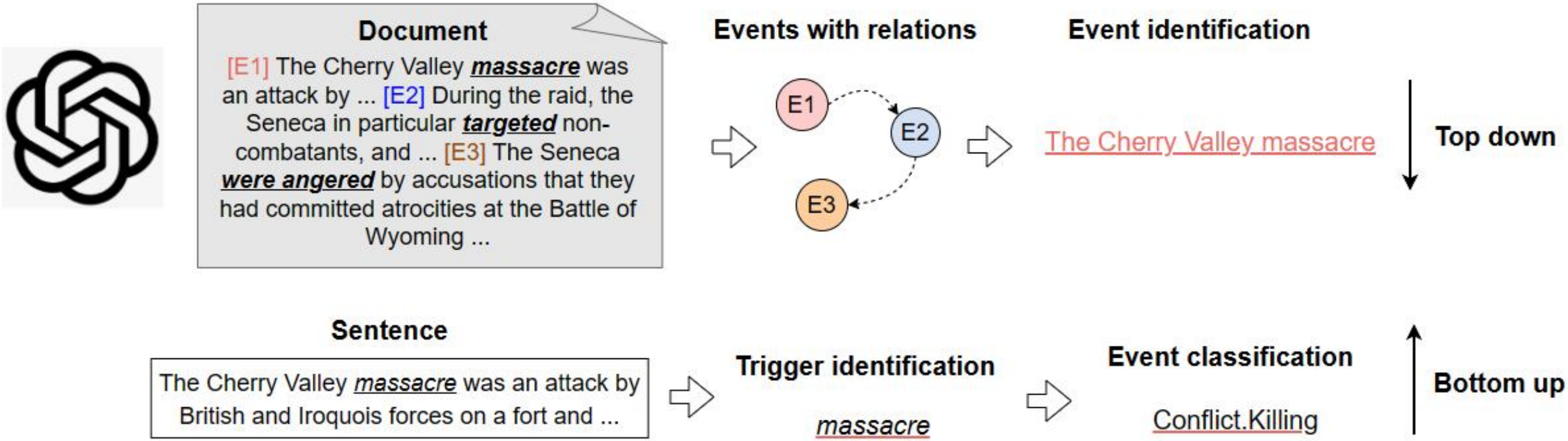
Event relations connect individual events together to form a logical group of events.



Maven-ere: A unified large-scale dataset for event coreference, temporal, causal, and subevent relation extraction. (2022)

Different Direction in Event Detection

➢**LLM:** Events are connected and dynamic



➢**Before LLM:** Events are isolated and static

missing event relations?

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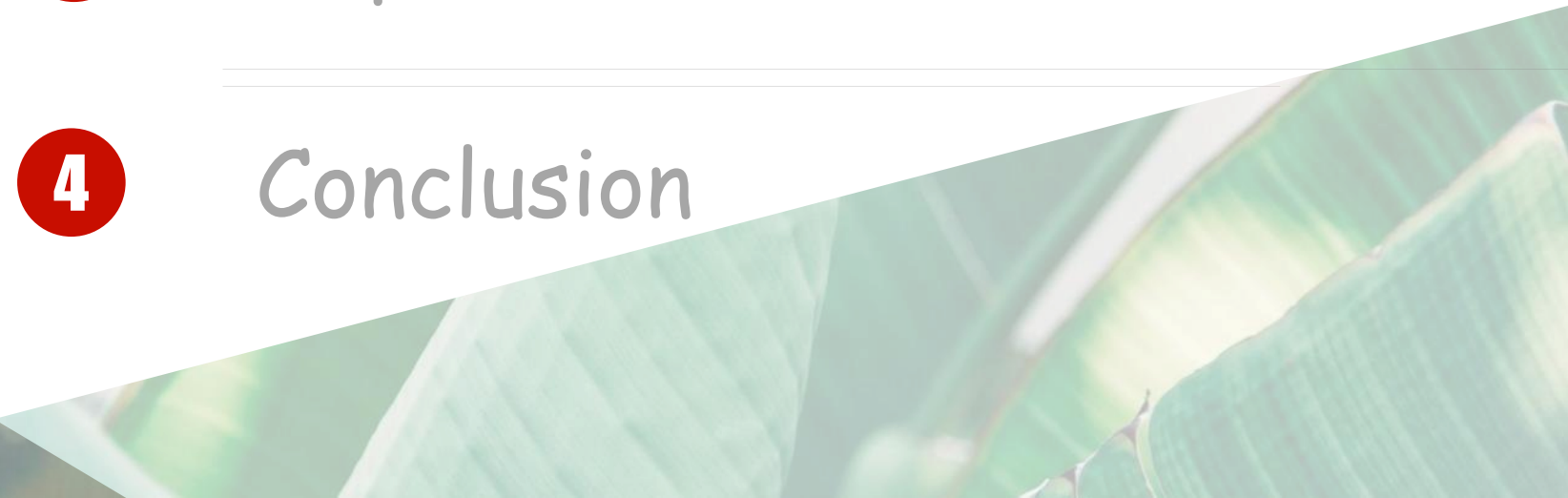
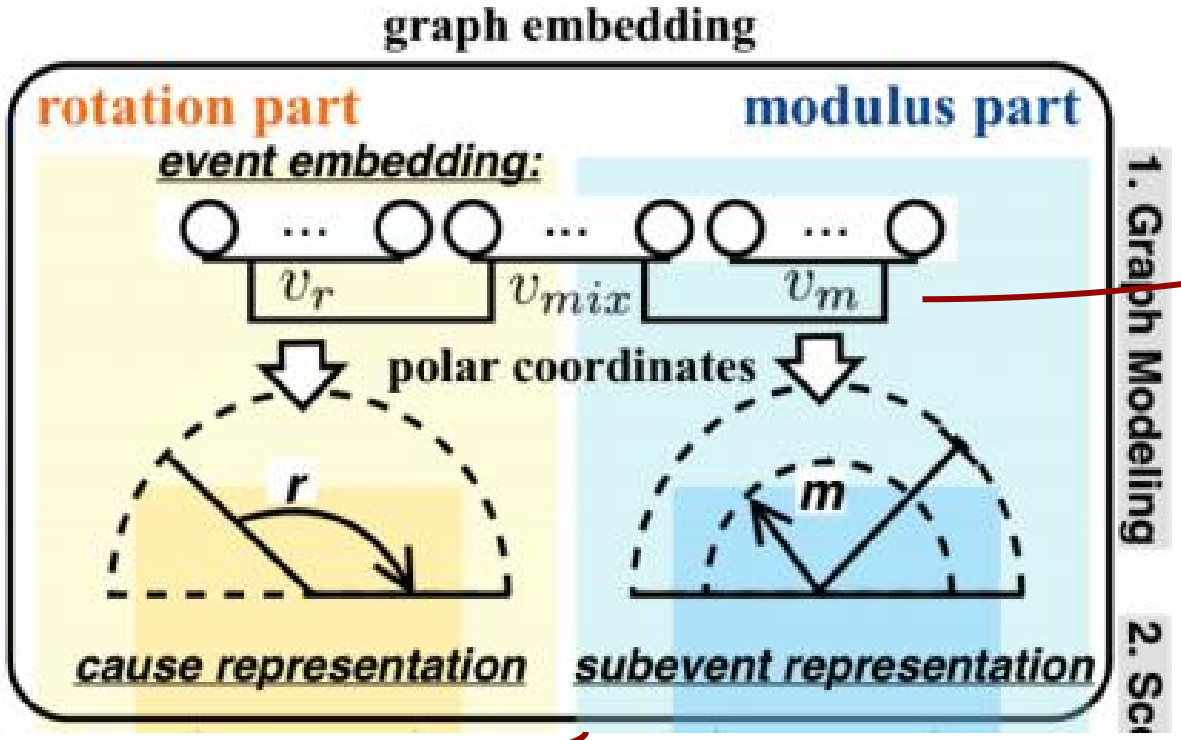


Embedding with Rotation and Modulus

➢**Polar coordinates consisting of rotation and modulus**



Embeddings are divided into **Rotaion** part and **Modulus** part

Rotation part presents ***cause*** relation and **Modulus** part presents ***subevent*** relation

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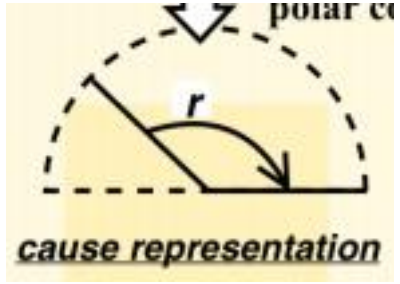
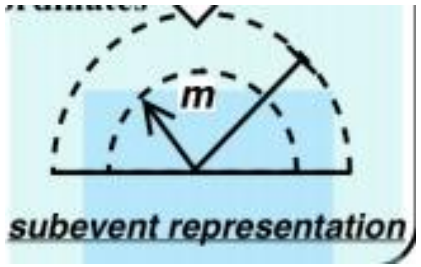
The Calculation of Rotation and Modulus

- **Rotation Part -** rotation-based approach
  - The event pairs are set at **opposite positions** on the circle: $(\boldsymbol{v} - \boldsymbol{v}_c)\, mod\, 2\pi = \pi.$
  - The **distance** between events: $D(e_h, e_t) = \|sin((\boldsymbol{v}_h - \boldsymbol{v}_t + \pi)/2)\|_1$
  - The rotation loss: $\mathcal{L}_r = \sum_{e_c \in \mathcal{E}_c} -log\sigma(\lambda - D(e, e_c))$



- **Modulus Part -** contrastive learning
  - The distance **between child events** is as close as possible compare to the distance **from child events to their parents**
  - The **distance** between events: $D(e_h, e_t) = \|\boldsymbol{v}_h - \boldsymbol{v}_t\|_2$
  - The modulus loss: $\mathcal{L}_m = \sum_{(e,e_i)\in\mathcal{P}_d} \sum_{(e_i,e_j)\in\mathcal{P}_s} max(D(e, e_i) - D(e_i, e_j) + \gamma, 0).$

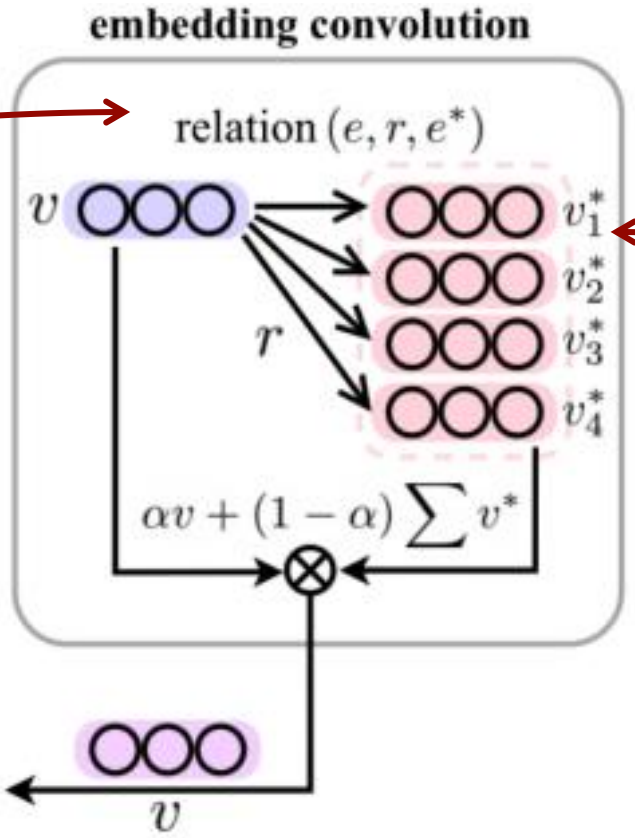


Embedding Convolution

- **Enhance the representation of events**

  further and hierarchical relation knowledge between events can be learned

For the given embedding e and relation r



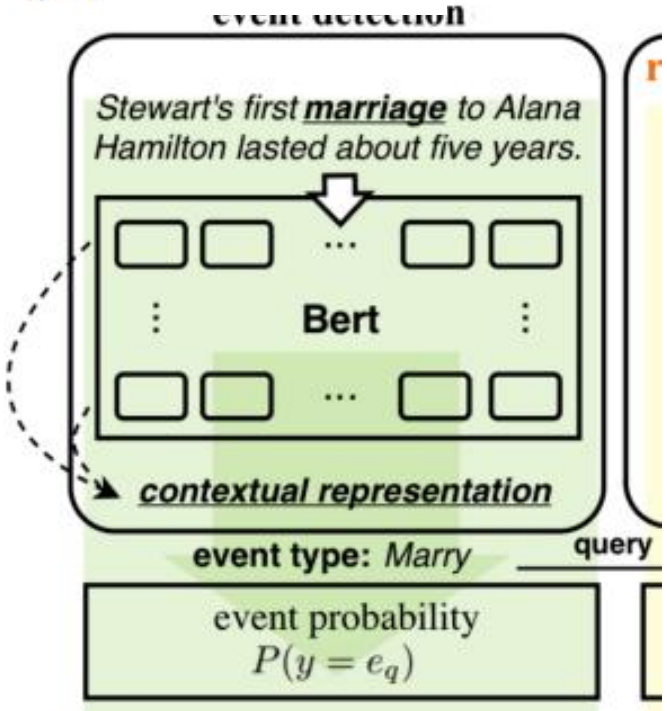
Find all e^* that satisfy (e, r, e^*)

Form the event embedding

Event Detection

- Event **probability**: $P(y = e_k) = \frac{exp(-||\boldsymbol{X}_i - \boldsymbol{v}_k||)}{\sum_{j=1}^{|\mathcal{E}|} exp(-||\boldsymbol{X}_i - \boldsymbol{v}_j||)}$
- Event detection loss: $\mathcal{L}_e = -\sum_{k=1}^{|\mathcal{E}|} ylogP(y = e_q)$

The first and last layers of BERT's transformer



Loss Function

- **Uncertainty to Weigh Losses multi-task optimization strategy (UWL)**

  Combine three loss function

Rotation loss

$$\mathcal{L} = \frac{1}{2\sigma_1^2}\mathcal{L}_e + \frac{1}{2\sigma_2^2}\mathcal{L}_r + \frac{1}{2\sigma_3^2}\mathcal{L}_m + log\sigma_1\sigma_2\sigma_3$$

Event loss

Modulus loss

Multi-task learning using uncertainty to weigh losses for scene geometry and semantics. (2018)

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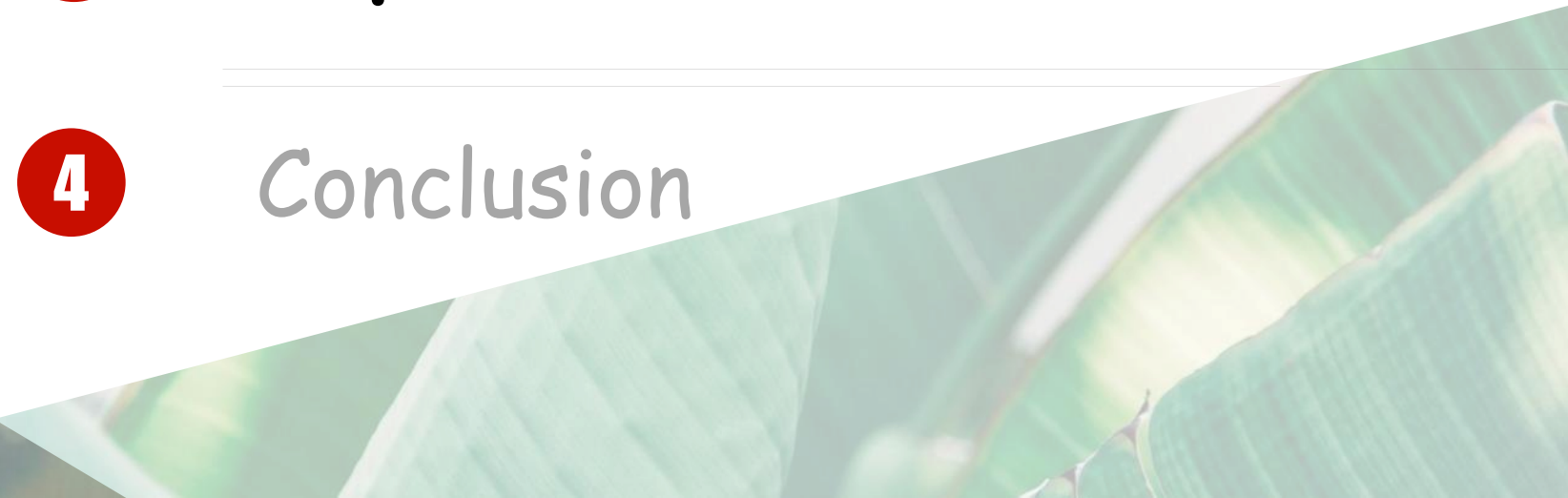

Datasets and Baselines

- **Datasets**
  - OntoEvent
  - MAVEN-Few

Dataset	#Doc	#Train	#Valid	#Test	#Class	#Caus-Rel	#Sub-Rel
OntoEvent [5]	4115	48436	6055	6055	100	9	-
MAVEN-Few	-	4416	552	551	71	277	83

-Selected from **MAVEN** datasets according to event types in OntoEvent.

- **Baselines**
  - Event Classification: AD-DMBERT, OneIE, PathLM, OntoED
  - Low-resource event classification: OntoED

OntoED: Low-resource Event Detection with Ontology Embedding (ACL 2021)
Maven-ere: A unified large-scale dataset for event coreference, temporal, causal, and subevent relation extraction. (2022)

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Event Classification

Model	Precision	Recall	F1 Score
AD-DMBERT† [25]	0.6735	0.7346	0.7189
OneIE† [15]	0.7194	0.6852	0.7177
PathLM† [13]	0.7351	0.6874	0.7283
OntoED‡ [5]	0.7756	0.7844	0.78
HAEE	**0.8882**	**0.8868**	**0.8875**

Use event relations as ontology learning

Model	OntoEvent				MAVEN-Few			
	Full	50%	25%	10%	Full	50%	25%	10%
OntoED [5]	0.78	0.7154	0.6198	0.4989	0.7725	0.6034	0.5195	0.2534
HAEE	**0.8875**	**0.8747**	**0.8634**	**0.831**	**0.8722**	**0.8577**	**0.8165**	**0.5993**

Hierarchy of Rotation

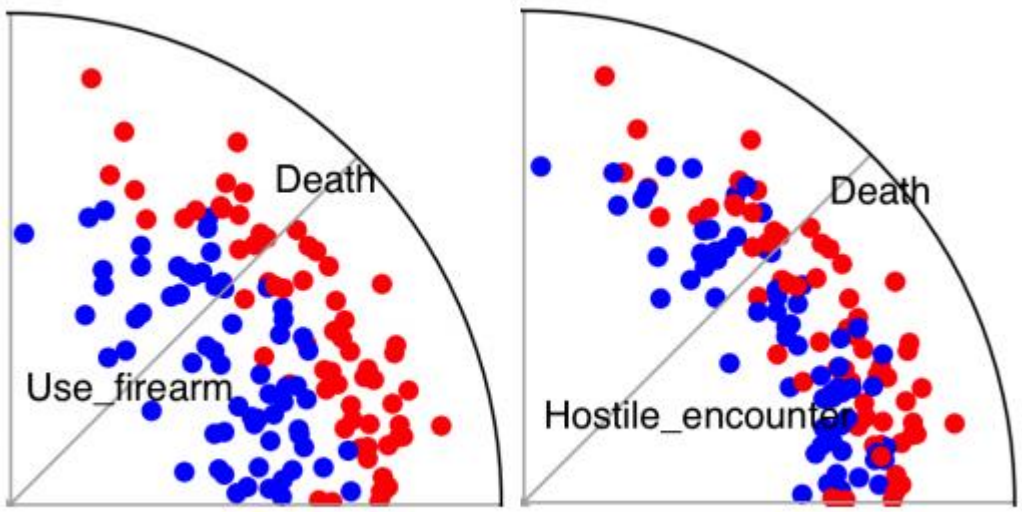
Table 4: The average rotation distance from each event to different groups. (p.g: positive group, b.g: blank control group, n.g:negative group. The bold numbers represent groups with a greater distance.)

Positive Events	Distance			Negative Events	Distance		
	p.g	b.g	n.g		p.g	b.g	n.g
come_together	0.45	0.55	**0.59**	destroying	**0.34**	0.23	0.24
elect	0.34	0.42	**0.47**	kidnapping	**0.30**	0.22	0.23
committing_crime	0.19	0.21	**0.28**	violence	**0.28**	0.21	0.22
employment	0.19	0.19	**0.23**	theft	**0.45**	0.32	0.33
award	**0.27**	0.20	0.21	robbery	0.18	0.19	**0.24**
arriving	0.31	0.38	**0.44**	hostile_encounter	0.18	0.20	**0.26**
contact	**0.51**	0.36	0.35	killing	0.23	0.29	**0.37**
recovering	0.21	0.19	**0.22**	terrorism	0.28	0.37	**0.45**
commerce_sell	0.28	0.34	**0.40**	conquering	**0.26**	0.20	0.22
exchange	0.19	0.20	**0.26**	arrest	0.19	0.19	**0.23**
marry	0.37	0.46	**0.51**	divorce	0.18	0.19	**0.25**

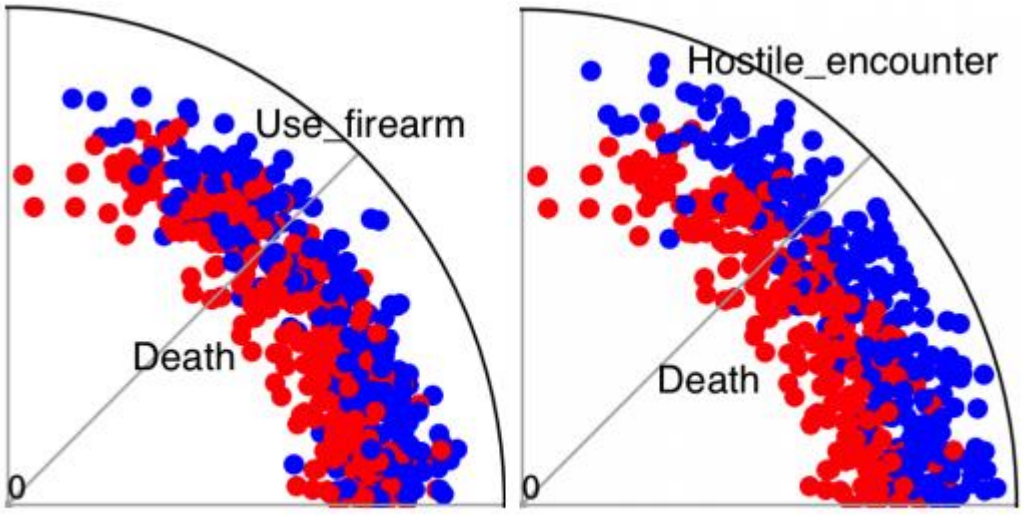
Tend to away from negative events

The clustering effect of events is more significant

Hierarchy of Modulus



(a) 100 dimension.



(b) 500 dimension.

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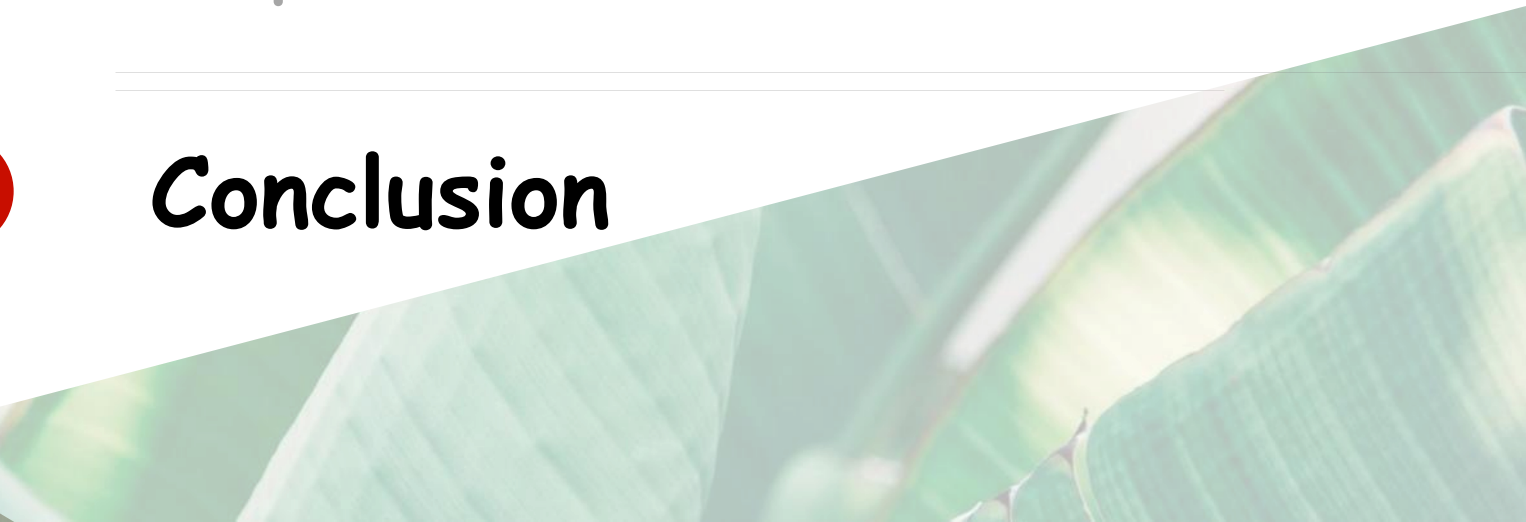

Conclusion

- **Summary**
  - We propose a new hierarchy-aware model HAEE, allowing knowledge to flow from high-resource events into the low-resource events.
  - Experimental results demonstrate that HAEE model can achieve better performance in low-resource ED task.
- **Outlook**
  - Exploring better graph embedding methods to introduce more event relations into event graphs
  - Applying event relations to other fields such as sentiment analysis and event reasoning.

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Thank You

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Project: https://github.com/cdmelon/HAEE

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