TriG-NER: Triplet Grid Framework for Discontinuous Named Entity Recognition

Rina Carines Cabral, Soyeon Caren Han, Areej Alhassan, Riza Batista-Navarro, Goran Nenadic, Josiah Poon

The University of Sydney · The University of Melbourne · The University of Manchester

Paper *Code*

Introduction

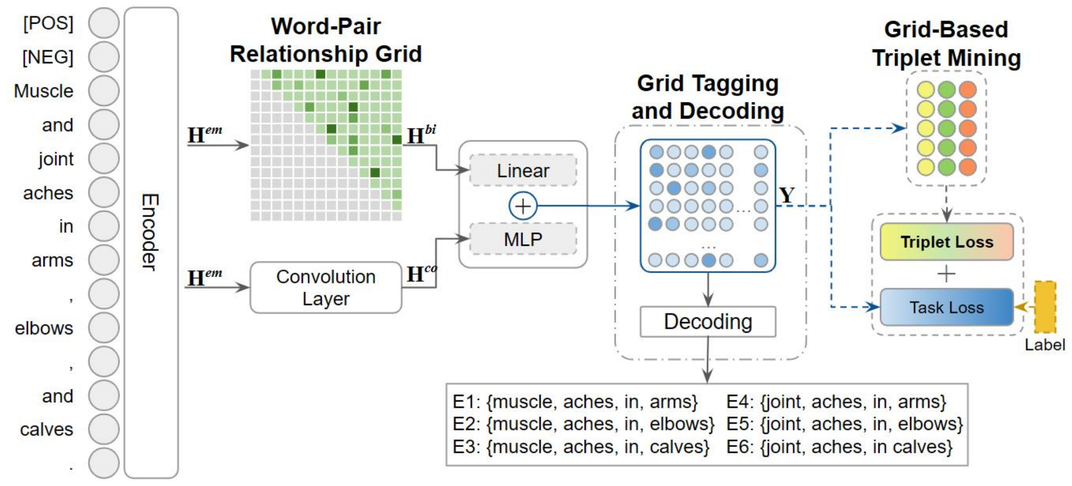
Background

- *Discontinuous Named Entity Recognition (DNER) is a more complex type of NER where entity mentions are interrupted by non-entity tokens within the sequence.*
- *Existing studies focus on different types of schemes which requires specialised models heavily reliant on the chosen tagging strategy.*
- *Grid-tagging scheme shows SOTA performance, however, existing models lack mechanisms to **differentiate between similar and dissimilar word-pairs**.*

Research Aim and Contributions

- *To introduce a novel **token-based triplet loss** that learns fine-grained token-level representations for discontinuous entity extraction, contrasting with existing methods that use sample-based triplet-loss.*
- *To propose a **grid-based triplet loss** that defines word-pair **similarity based on co-occurrence** within the same entity, enhancing the model's ability to capture non-adjacent entity segments.*
- *Extensive evaluations and qualitative analyses against existing baselines and prompted large language models.*

TriG-NER Framework



Grid-based NER

NER as a word-to-word relation classification problem

- $X = \{x_1, x_2, ..., x_n\}$
- $Y = \{y_{1,1}, y_{1,2}, ..., y_{n,n}\} \in R^{n \times n \times c}$

Classes/Tags:

- *Next-Neighboring-Word (NNW)*
- *Tail-Head-Word (THW)*
- *None*

Word-Pair Relationship Grid

Explicitly models word-pair relationship using contextualised representations for each word and applying a biaffine transformation.

Grid-based Triplet Mining

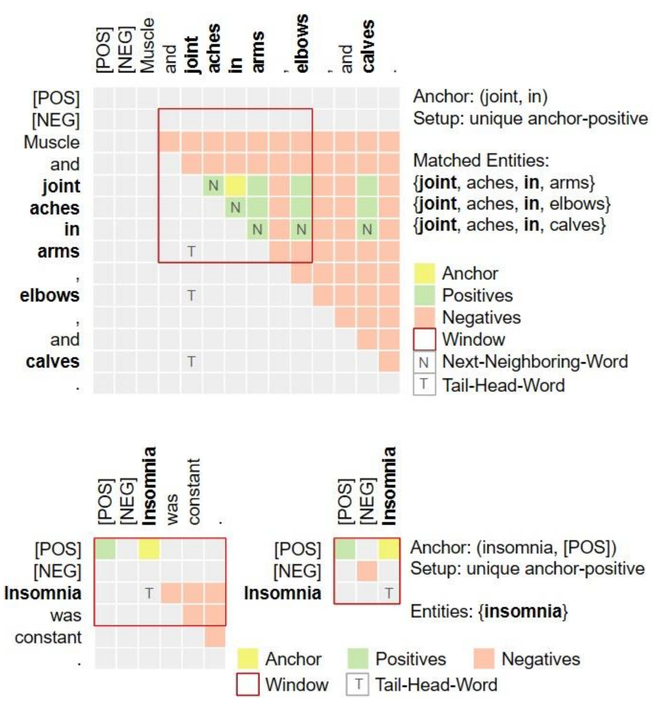
Triplet candidates based on word-pair co-existence within entities.

Components:

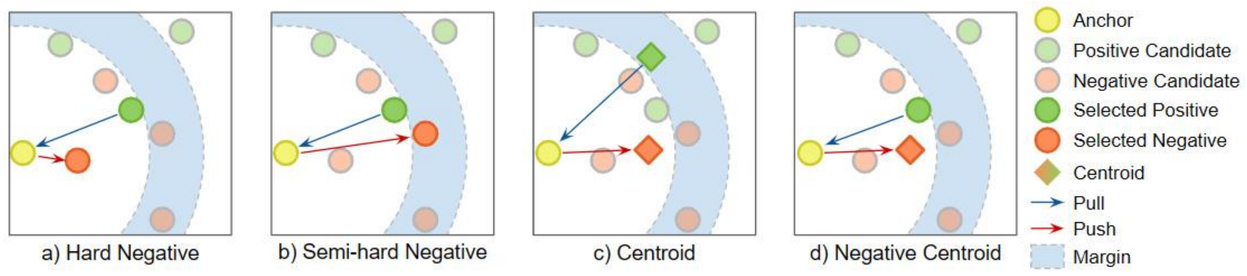
- ***Anchors** - any word-pair that appears in any entity*
- ***Positive Candidates** - co-existing with the anchor in any entity*
- ***Negative Candidates** - does not belong to any entity the anchor is a part of*

Special considerations:

- *Reserved tokens [POS] and [NEG] for special cases.*
- *Candidate window*
- *Unique anchor-positive pair*



Triplet Mining Methods:



Datasets

Three biomedical datasets:

- ***CADEC** - online forum posts*
- ***ShARe13 & 14** - clinical notes*

- *Only around 10% are DNEs*
- *CADEC has longer entities despite having similar range of start-end distances with the ShaRE datasets*

	CADEC	ShARe13	ShARe14
Total Sentences	7,597	18,767	34,618
Total Entities	6,318	11,148	19,073
Continuous Entities	5,639	10,060	17,417
- Percentage	89.25%	90.24%	91.32%
- Number of tokens	1-36	1-9	1-9
Disc. Entities	679	1,088	1,658
- Percentage	10.75%	9.76%	8.68%
- Number of tokens	2-13	2-7	2-7
- Start-End Distance	3-20	3-23	3-23

Results and Analysis

Overall Performance

- *Overall best models shows improvement of 0.76-1.23% compared to baselines*
- *Greater improvements from best model setups for subsets of instances with at least one discontinuous entity (DiscSent) and of discontinuous entities only (DiscEnt)*

	Overall			DiscSent	DiscEnt
CADEC	F1	P	R	F1	F1
MAC [36]	71.50	70.50	72.50	69.80	44.40
W²NER† [15]	72.67	72.02	73.33	69.25	45.78
TOE† [16]	72.24	74.28	70.30	67.98	40.00
Corro [3]	71.90	-	-	-	35.90
Ours	**73.43**	**75.35**	**71.62**	**70.59**	**49.71**
ShARe13	F1	P	R	F1	F1
MAC [36]	81.20	84.30	78.20	68.10	55.90
W²NER† [15]	82.16	84.13	80.29	68.46	57.38
TOE† [16]	81.92	85.05	79.02	67.82	57.06
Corro [3]	82.00	-	-	-	52.10
Ours	**83.22**	**86.44**	**80.24**	**69.09**	**60.06**
ShARe14	F1	P	R	F1	F1
MAC [36]	81.30	78.20	84.70	69.70	54.10
W²NER† [15]	81.31	78.93	83.84	63.08	52.70
TOE† [16]	80.67	78.67	82.78	61.04	49.29
Corro [3]	81.80	-	-	-	49.80
Ours	**82.54**	**80.36**	**84.83**	**72.89**	**59.23**

Triplet Selection

Centroid (CE) consistently shows promising results. Semi-hard Negative (SN) and Hard Negative (HN) shows better performance for DiscEnt subset but sacrifices overall performance.

Method	CADEC		ShARe13		ShARe14	
	Overall	DiscEnt	Overall	DiscEnt	Overall	DiscEnt
[15]†	72.67	45.75	82.16	57.38	81.31	52.70
HN	71.61	45.41	81.79	54.45	81.87	57.35
SN	72.21	49.35	82.56	56.30	82.19	53.79
CE	73.43	48.55	83.22	57.14	82.42	56.22
NC	73.33	46.75	82.43	56.22	**82.54**	54.40

Window Size

Implementing a window improves performance however, optimal window size varies based on the characteristics of the dataset.

Window Size	CADEC	ShARe13	ShARe14
None	71.49	81.74	81.78
1	71.65	81.21	81.91
5	72.77	82.02	**82.54**
10	72.88	**83.22**	81.19
15	70.84	81.26	80.81
20	70.67	81.79	81.33
25	**73.43**	81.83	81.83

Qualitative Analysis

TriG-NER's processing of similar and dissimilar word-pairs improves recognition of discontinuous entities in finetuned trained models. LLMs still present significant problems for DNER.

Input
['Pain', 'and', 'cramping', 'in', 'my', 'hands', 'and', 'lower', 'legs', '.']
Gold Standard
{'entity': 'Pain in my hands', 'index': [0, 3, 4, 5], 'type': 'ADR'}, {'entity': 'Pain in my lower legs', 'index': [0, 3, 4, 7, 8], 'type': 'ADR'}, {'entity': 'cramping in my lower legs', 'index': [2, 3, 4, 7, 8], 'type': 'ADR'}, {'entity': 'cramping in my hands', 'index': [2, 3, 4, 5], 'type': 'ADR'}
Ours - 4/4 (100%)
{'entity': 'Pain in my lower legs', 'index': [0, 3, 4, 7, 8], 'type': 'ADR'}, {'entity': 'Pain in my hands', 'index': [0, 3, 4, 5], 'type': 'ADR'}, {'entity': 'Pain in lower legs', 'index': [0, 3, 7, 8], 'type': 'ADR'}, {'entity': 'cramping in my hands', 'index': [2, 3, 4, 5], 'type': 'ADR'}, {'entity': 'cramping in my lower legs', 'index': [2, 3, 4, 7, 8], 'type': 'ADR'}, {'entity': 'cramping in lower legs', 'index': [2, 3, 7, 8], 'type': 'ADR'}
W²NER - 2/4 (50%)
{'entity': 'Pain in my hands', 'index': [0, 3, 4, 5], 'type': 'ADR'}, {'entity': 'cramping in my hands', 'index': [2, 3, 4, 5], 'type': 'ADR'}

Gemini Zero Shot CoT - 0/4 (0%)
{'entity': 'Pain', 'index': [0], 'type': 'ADR'}, {'entity': 'cramping', 'index': [2], 'type': 'ADR'}, {'entity': 'hands', 'index': [5], 'type': 'ADR'}, {'entity': 'lower legs', 'index': [7, 8], 'type': 'ADR'}
Gemini Few Shot CoT - 0/4 (0%)
{'entity': 'Pain and cramping', 'index': [0, 1, 2], 'type': 'ADR'}, {'entity': 'hands', 'index': [5], 'type': 'ADR'}, {'entity': 'lower legs', 'index': [7, 8], 'type': 'ADR'}
GPT-4o Zero Shot CoT - 0/4 (0%)
{"entity": "Pain", "index": [0], "type": "ADR"}, {"entity": "cramping", "index": [2], "type": "ADR"}
GPT-4o Few Shot CoT - 0/4 (0%)
{"entity": "Pain", "index": [0], "type": "ADR"}, {"entity": "cramping", "index": [2], "type": "ADR"}, {"entity": "Pain and cramping", "index": [0, 1, 2], "type": "ADR"}, {"entity": "Pain and cramping in my hands", "index": [0, 1, 2, 3, 4, 5], "type": "ADR"}, {"entity": "Pain and cramping in my hands and lower legs", "index": [0, 1, 2, 3, 4, 5, 6, 7, 8], "type": "ADR"}