WojoodOntology

Ontology-Driven LLM Prompting for Unified Information Extraction Tasks

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+ Morphology Tagger (Alma)	المحلل الصرفي (ألمى)
+ Word Sense Disambiguation (Salma)	المحلل الدلالي (سلمى)
+ Named Entity Recognition (Wojood)	استخراج أسماء الاعلام (وجود)
+ Relation Extraction	استخراج العلاقات
+ Social Computing (Fada)	الإنسانيات الحاسوبية والتواصل الاجتماعي (فضا)
+ Synonyms	استخراج المترادفات
+ Chatbots and intent detection (AraBanking77)	المساعدات الآلية

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Motivation

- Information Extraction tasks (such as Named Entity Recognition and Relation Extraction) are often developed using **diverse tagsets and annotation guidelines**.

- **Major challenges** for model generalization, **cross-dataset evaluation, tool interoperability**, and broader industry adoption.

- We propose **an information extraction ontology**, *WojoodOntology*, which covers a wide range of named entity types and relations.

Contributions

- *WojoodOntology*: a novel **information extraction ontology**.
- Python library for **uni-directional mapping** between information extraction tagsets.
- Novel: **ontology-based prompting** method enabling LLMs to perform efficient **bi-directional tagset mappings**.

WojoodOntology

- *WojoodOntology* serves as a unified framework for **mapping entity and relation types across diverse datasets**.
- covers existing **Arabic NER and RE datasets**, **Wikidata and schema.org**
- consists of **55 entity types** and **43 relation types**.
- formalized using **standard Web Ontology Language (OWL)**.

WojoodOntology

- *WojoodOntology* **is a hierarchy of entity types and relationships.**
- **Entity types** (e.g., ORG, LOC) **are OWL classes.**
- **Relation types** are defined as **object properties** connecting pairs of classes.

NER Formalization

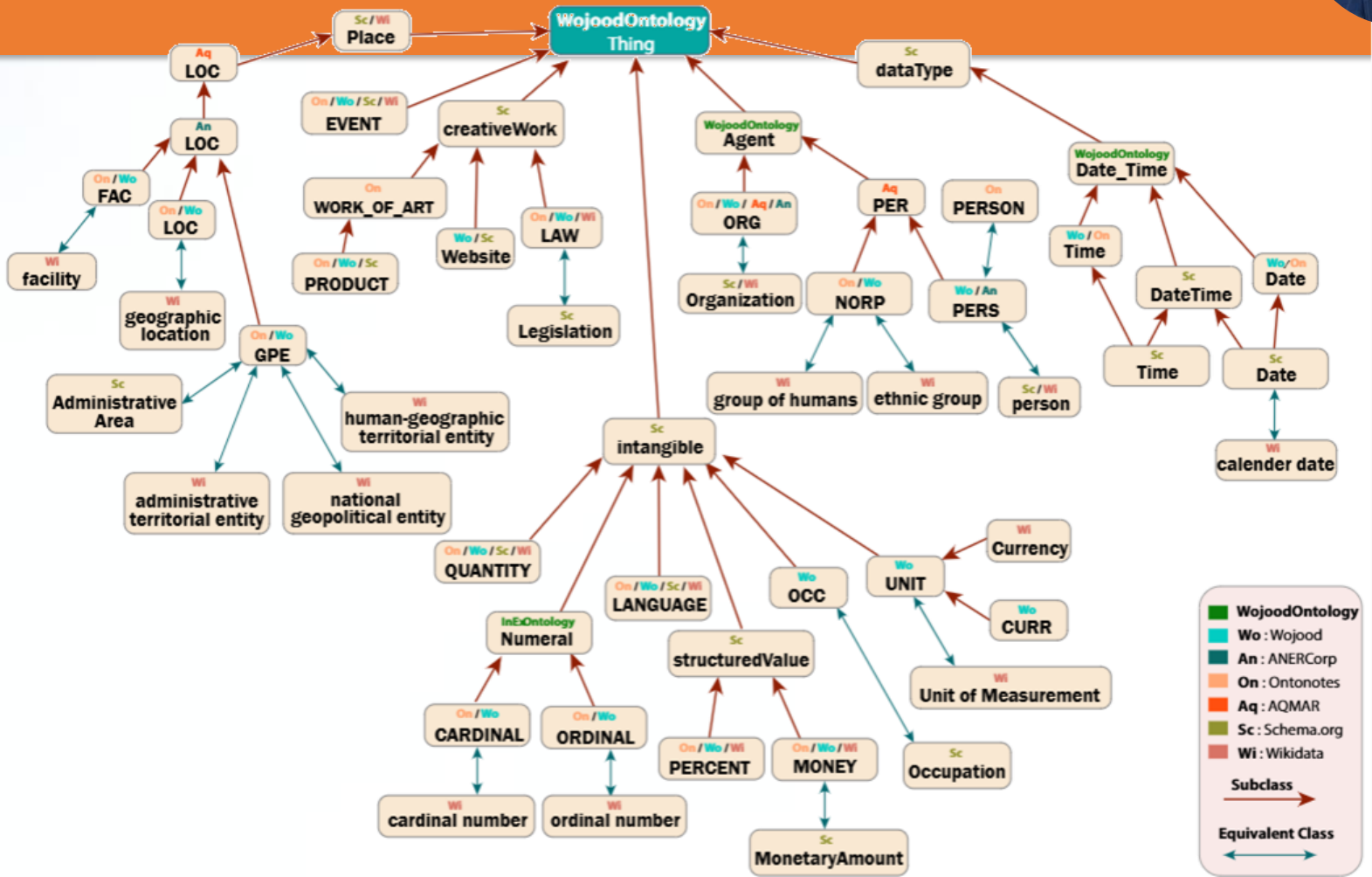
- **Entity Formalization** using **standard OWL axioms,** including **equivalentClass** and **subClassOf**.

- **equivalentClass** is used to define semantic equivalence between entity types across different datasets or ontologies.

- **equivalentClass** allow entity types with consistent meaning and annotation boundaries **to be treated interchangeably across datasets.** $[equivalentClass(AQMAR{:}\,LOC,\ ANERCorp{:}\,LOC)]$

- **subClassOf axiom** identify **hierarchical relations** between entity types. $[subClassOf\,(Schema{:}\,Date,\ Wojood{:}\,Date) \rightarrow Schema{:}\,Data \subseteq Wojood{:}\,Date]$

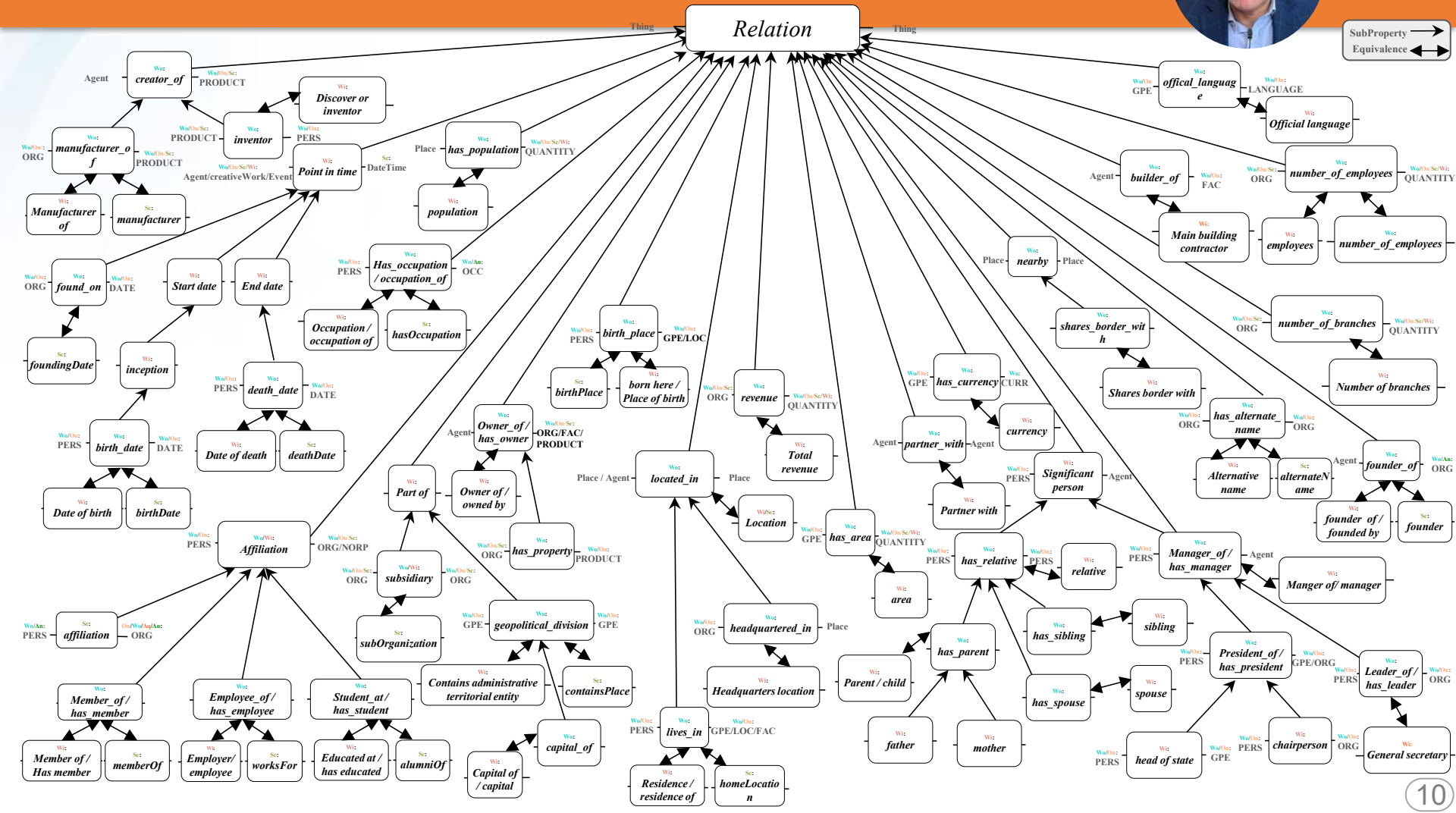
NER Ontology (Class Hierarchy)



Relation Formalization

- **Each relation type is an object property** linking a subject class (domain) to an object class (range).
- Relations are also hierarchical - **subproperty** and **equivalence axioms**.
- A **subproperty** axiom **defines a relation as a specialization of another**, inheriting its semantics while providing more specificity. $[(Wo{:}\,employee_{of} \sqsubseteq Wo{:}\,affiliation)]$
- **Equivalence** axioms assert **semantic identity between relations**, across ontologies. $[Wo{:}\,employee\_of \equiv Sc{:}\,worksFor]$

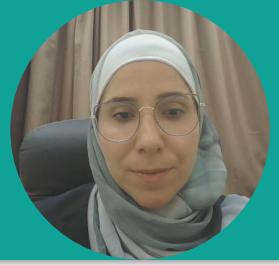
Relation Formalization



WojoodOntology Construction

- **Step 1: Cross-dataset Validation of Entity Types:** Examine the annotation differences across NER datasets.
- **Step 2: Comparative Analysis of Entity Definitions and Annotations:** Examine each entity type across all datasets and knowledge graphs to identify variations in annotation scope, label naming conventions, and granularity.
- **Step 3: Ontology Construction and Schema Mapping:** Identify equivalent and subclass relationships among entity types.
- **Step 4: Relation Identification and Alignment:** Identify relation types that connect the named entities and align them with external schemas.

Contributions



- *WojoodOntology*: a novel **information extraction ontology**.
- Python library for **uni-directional mapping** between information extraction tagsets.
- Novel **ontology-based prompting method** enabling LLMs to perform efficient **bi-directional tagset mappings**.

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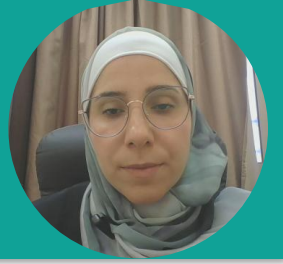
Mapping between NER Datasets



- **Unidirectional mapping** projects datasets with finer-grained entity types (e.g., Wojood) onto coarser-grained ones (e.g., ANERCorp).

  Use *WojoodOntology* to derive a set of manually defined unidirectional mapping rules from fine-grained to coarse grained tagsets.

- **Bidirectional** mapping enables **mutual alignment**.

  Incorporate *WojoodOntology* into LLM prompts so the model performs re-labeling guided by the ontology.

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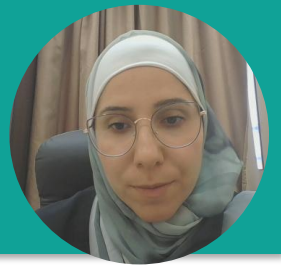
Unidirectional Mapping Between Datasets



- Use *WojoodOntology* to derive mapping rules.
- **The rules are derived from the equivalentClass and subClassOf** semantic relationships defined in the ontology.
- When two entity types are linked via an **equivalency relation**, they are **mapped directly to each other**.
- When an entity type in one dataset is defined as a **subclass** of a broader type in another dataset the mapping **rule assigns the more specific type to its parent type**.

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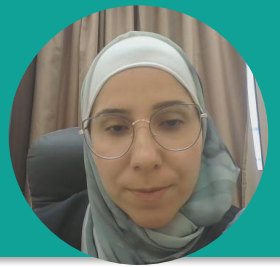
Unidirectional Mapping Between NER Datasets



Description	Wojood	OntoNote	ANERCorp	AQMAR	Schema.Org	Wikidata	Notes
Person	PERS	PERSON	PERS	PER	Person	Person (Q215627)	AQMAR: PERS category also includes NORP (Nationalities and Religious/Political Groups).
Group of people	NORP	NORP	O	PER	-	Ethnic group (Q41710)	OntoNote: Includes nationalities (e.g., American).
Occupation	OCC	O	O	O	Ocuupation	Occupation (Q12737077	—
Organization	ORG	ORG	ORG	ORG	Organization	Organization (Q43229)	Wojood: ORG spans may include GPE or LOC of the organization, whereas other datasets do not.
Geopolitical Entities	GPE	GPE	LOC	LOC	Administrative Area	Geopolitical entity (Q15642541)	ANERCorp and AQMAR: GPE is considered part of LOC.
Location	LOC	LOC	LOC	LOC	-	Geographic Location (Q2221906)	ANERCorp: GPE and LOC are treated as the same category. AQMAR: GPE, LOC, and FAC all fall under LOC.
Facility	FAC	FAC	LOC	LOC	-	Architectural structure (Q811979)	AQMAR: Facilities (FAC) are classified under LOC.
Product	PRODUCT	PRODUCT	O	O	Product	Product (Q2424752)	ANERCorp and AQMAR: PRODUCT is classified under MISC.
Event	EVENT	EVENT	O	O	Event	Event (Q1656682)	ANERCorp and AQMAR: EVENT is classified under MISC.
Date	DATE	DATE	O	O	Date	Point in time (Q186081)	AQMAR: Reference dates are categorized under MISC.
Time	TIME	TIME	O	O	Time	Time (Q11471)	—
Language	LANGUAGE	LANGUAGE	O	O	Language	Language (Q34770)	—
Law	LAW	LAW	O	O	Legislation	Law (Q7748)	—
Cardinal	CARDINAL	CARDINAL	O	O	-	Cardinal number (Q163875)	—
Ordinal	ORDINAL	ORDINAL	O	O	-	Ordinal number (Q191780)	—
Percent	PERCENT	O	O	O	Structured Value	Percentage (Q11229)	—
Quantity	QUANTITY	QUANTITY	O	O	Quantity	Quantity (Q309314)	—
Unit	UNIT	O	O	O	-	Unit of measurement (Q47574)	OntoNote: Currency (CURR) is part of QUANTITY (e.g., '50 دولارًا').
Money	MONEY	MONEY	O	O	Monetary Amount	Money (Q1368)	—
Currency	CURR	O	O	O	-	Currency (Q8142)	OntoNote: Currency (CURR) is part of MONEY (e.g., '150 دولارًا').

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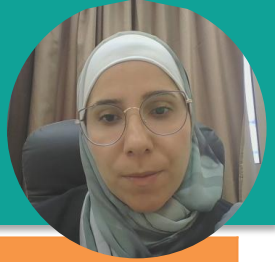
Mapping Between *Wojood*^{Relations} and Wikidata



Wojood Relation	Property Name	Domain	Range	Subclass of
has_parent	parent (P8810) / union of: father (P22), mother (P25)	Human (Q5)	Human (Q5)	relative (P1038)
has_spouse	P26: spouse	Human (Q5)	Human (Q5)	relative (P1038) / significant person (P3342)
has_sibling	P3373: sibling	person (Q215627)	person (Q215627)	relative (P1038)
has_relative	P1038: relative	Human (Q5)	Human (Q5)	significant person (P3342)
birth_date	P569: date of birth	Human (Q5)	-	inception (P571)
death_date	P570: date of death	human, group of humans	-	end time (P582) / dissolved date (P576)
birth_place	P19: place of birth	Human (Q5)	geographic location (Q2221906)	location (P276)
has_occupation	P106: occupation	Human (Q5), person (Q215627)	occupation (Q12737077)	root
has_conflict_with	P607: conflict	Human (Q5), group of humans (Q16334295), fictional military organization (Q18011141)	Conflict (Q180684)	participant in (P1344)
has_competitor	league or competition (P118)	Organization (Q43229)	Organization (Q43229)	participant in (P1344)
partner_with	P2652: partnership with Organization (Q43229), administrative territorial entity (Q56061)	Organization (Q43229), administrative territorial entity (Q56061)	Organization (Q43229), administrative territorial entity (Q56061)	root
manager_of	P1037: manager/director	Human (Q5)	Organization (Q43229)	significant person (P3342)
president_of	P488: chairperson union	administrative territorial entity (Q56061)	Human (Q5)	significant person (P3342)
president_of	head of government (P6)	administrative territorial entity (Q56061), Organization (Q43229)	Human (Q5)	director / manager (P1037)
leader_of	general secretary (P3975)	Organization (Q43229)	Human (Q5)	significant person (P3342)
leader_of	general secretary (P3975)	Organization (Q43229)	Human (Q5)	director / manager (P1037)
geopolitical_division	P150: contains administrative territorial entity	Administrative Entity (Q56061), administrative territorial entity (Q56061)	Administrative Entity (Q56061), administrative territorial entity (Q56061)	has part(s) (P527)
subsidiary	P355: has subsidiary	Organization (Q43229)	Organization (Q43229)	owner of (P1830)
subsidiary	P355: has subsidiary	Organization (Q43229)	Organization (Q43229)	has part(s) (P527)
member_of	P463: member of	Any entity	Organization (Q43229)	part of (P361)
employee_of	P108: employer	Human (Q5), Organization (Q43229), group of humans (Q16334295)	Organization (Q43229)	affiliation (P1416)

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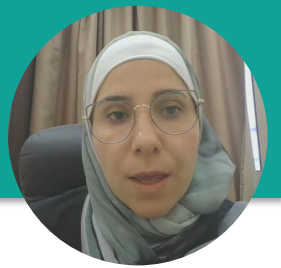
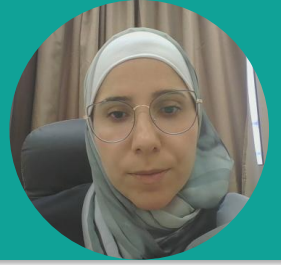
Mapping Between *Wojood*^{Relations} and Schema



Wojood Relations	Property Name	Property URI	Domain	Range
has_parent	parent	https://schema.org/parent	person	person
has_spouse	spouse	https://schema.org/spouse	person	person
has_sibling	sibling	https://schema.org/sibling	person	person
has_relative	relatedTo	https://schema.org/relatedTo	person	person
birth_date	birthDate	https://schema.org/birthDate	person	Date
death_date	deathDate	https://schema.org/deathDate	person	Date
birth_place	birthPlace	https://schema.org/birthPlace	person	Place
has_occupation	hasOccupation	https://schema.org/hasOccupation	person	occupation
has_competitor	competitor	https://schema.org/competitor	sport event	person, sport team
geopolitical_division	containedInPlace	https://schema.org/containedInPlace	place	place
Subsidiary	subOrganization	https://schema.org/subOrganization	organization	organization
member_of	memberOf	https://schema.org/memberOf	person, organization	organization
employee_of	employee	https://schema.org/employee	organization	person
student_at	alumniOf	https://schema.org/alumniOf	person	organization
owner_of	owns	https://schema.org/owns	person, organization	product
inventor_of	creator	https://schema.org/creator	person, organization	creativework
manufacturer_of	manufacturer	https://schema.org/manufacturer	organization	product
founder_of	founder	https://schema.org/founder	organization	person, organization
lives_in	homeLocation	https://schema.org/homeLocation	person	place
located_in	location	https://schema.org/location	organization	place
number_of_employees	numberOfEmployees	https://schema.org/numberOfEmployees	organization	quantitative values
org_found_date	foundingDate	https://schema.org/foundingDate	organization	Date
has_alternate_name	alternateName	https://schema.org/alternateName	thing	text
has_area	-			
official_language	-			

Our contribution



- *WojoodOntology*: a novel **information extraction ontology**.
- Python library for **uni-directional mapping** between information extraction tagsets.
- Novel **ontology-based prompting method** enabling LLMs to perform efficient **bi-directional tagset mappings**.

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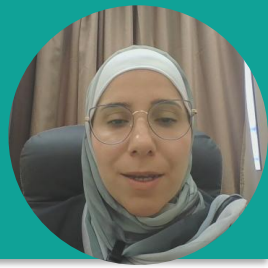
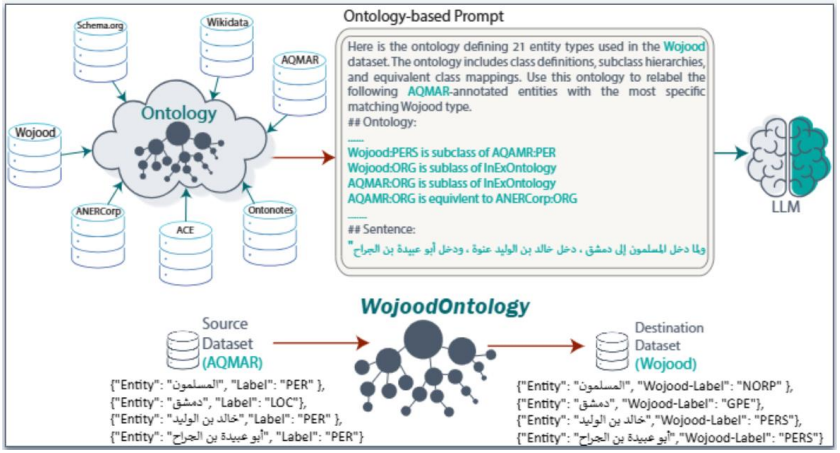
Bidirectional Mapping Between Datasets



- We propose LLM **ontology-guided prompting** approach for bidirectional mapping.
- Translates between different datasets using *WojoodOntology* as a semantic reference to align tag definitions.
- Embeds ontology in prompts for contextual guidance and consistent tag interpretation.



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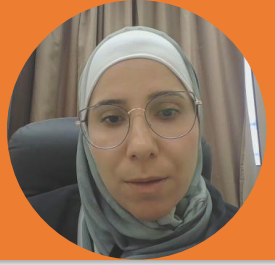
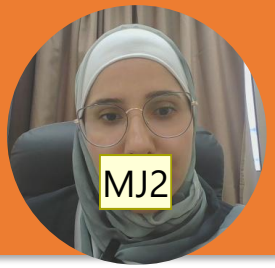
Case Study



- To evaluate *WojoodOntology* effectiveness: mapping between Wojood and AQMAR datasets.
- Wojood supports **21 tags**, while AQMAR is **only 4**, with **differences in tag labels and annotation guidelines**.
- **Evaluate unidirectional land bidirectional mapping** using *WojoodOntology*.

  (GPT-4o engine with carefully controlled hyperparameters).

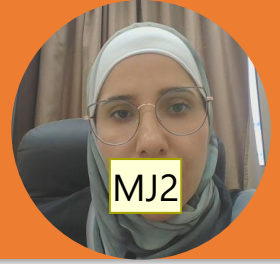
Unidirectional Ontology-based Mapping



- Map **Wojood to AQMAR**.
- Evaluation: train a model on Wojood and evaluate it on AQMAR **(1)** without mapping, **and** with mapping.
- **Evaluation out-of-domain impact**: train on (Wojood +10% of AQMAR).

Experimental Setting	F1	Improv.
Baseline (No Mapping)		
Wojood → AQMAR	8%	-
Ontology-Based Mapping		
Wojood (mapped to AQMAR)	40%	+32%
Wojood + 10% AQMAR (Finetuned)	52%	+44%

Ontology-Driven Prompting for Bi-directional Mapping



- Evaluation: **re-annotate AQMAR** manually using **Wojood guidelines (AQMAR^{W})**.

- Use AQMAR^{W} to evaluate LLMs' performance under two setups**: zero-shot and few-shot prompting**, and **with and without** *WojoodOntology*.

Setting	Precision	Recall	F1 Score
Zero-Shot			
Ontology (w / ent.)	0.3194	0.2388	0.2733
Ontology (w/o ent.)	0.3319	0.2595	0.2913
Few-Shot			
Without Ontology	0.5109	0.4879	0.4991
With Ontology	**0.5730**	**0.5294**	**0.5504**

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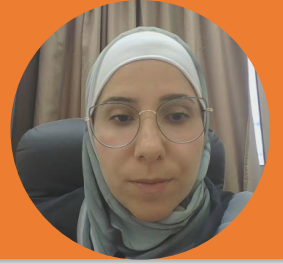
Discussion



- Inconsistent NER guidelines make **cross-dataset mapping challenging**.
- **LLMs struggle with fine-grained tagsets**.
- Zero-shot : slight improvement, but overall F1 < 0.30.
- Few-shot prompting: improvement, F1 ≈ 50%.
- **Few-shot + ontology: highest performance, F1 ≈ 55%.**
- Ontology role: provides structured semantic guidance, enabling accurate cross-schema entity alignment.

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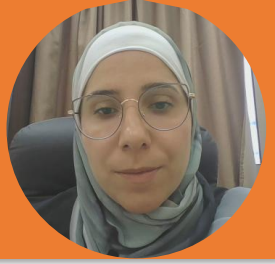
Conclusion



- *WojoodOntology :* formal semantic framework **for dataset interoperability**.
- **Ontology-guided mappings**, even simple rule-based ones, improve **model performance**.
- Zero-shot and few-shot experiments show consistent gains with **ontology-guided prompting**.
- Key insight: **ontology-guided prompting** enable unified information extraction across diverse annotated resources.

Thank You

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