Complex Temporal Question Answering on Knowledge Graphs

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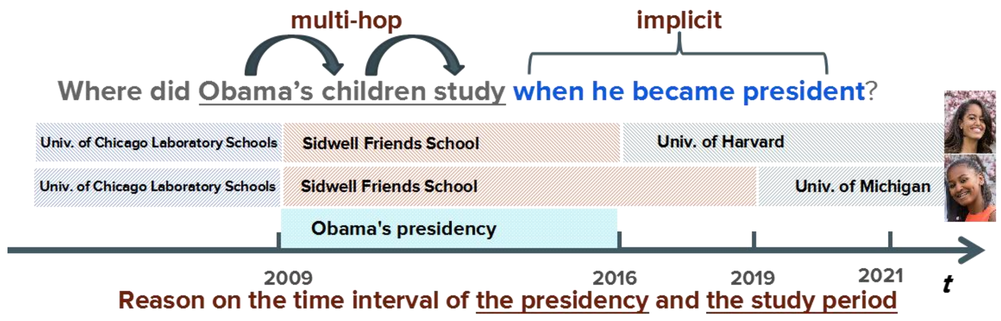
Motivation & Challenges



Motivation

Temporal question answering over knowledge graphs is an important topic but has not received much attention in research. We present EXAQT, the first end-to-end system for answering complex temporal questions that have multiple entities and predicates, and associated temporal conditions.

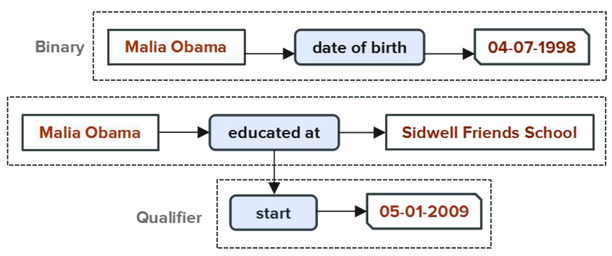
Challenges

- Contain explicit, implicit or ordinal temporal constraints
- Contain multi-hop constraints
- Need to identify and reason on the time

Concepts

Temporal fact & temporal predicate

- Temporal fact is one where the main object or any of the qualifier objects is a timestamp.
- Temporal predicate is one that can have a timestamp as its direct object or one of its qualifier objects.



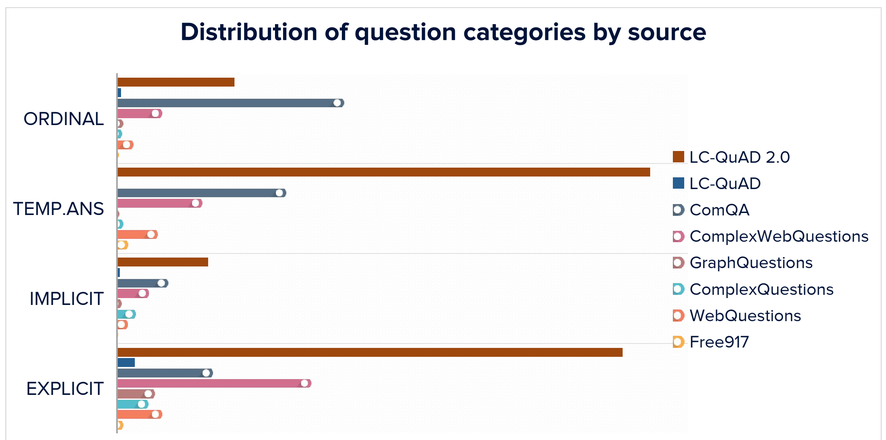
Temporal question

- A temporal question is one that contains a temporal expression or a temporal signal, or whose answer is of temporal nature.
- Temporal question categories: explicit, implicit, ordinal, and temporal answer
- Temporal question signals: BEFORE, AFTER, OVERLAP, START, FINISH, ORDINAL

TimeQuestions

Benchmark construction

- Collect temporal questions from 8 popular KG-QA benchmarks
- Contain 16181 <question, answers> pairs
- Label temporal categories and signals for each question
- Link answers to Wikidata and Wikipedia



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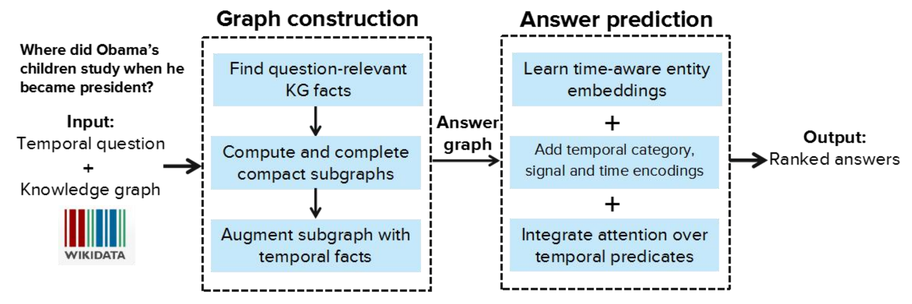
Demo: https://exaqt.mpi-inf.mpg.de
Code: https://github.com/zhenjia2017/EXAQT

Methodology

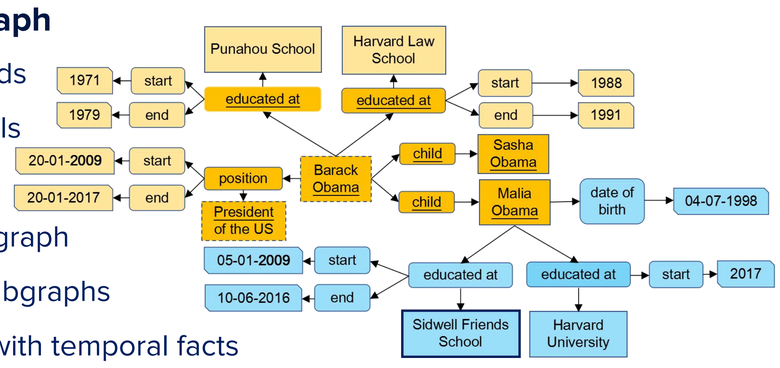


Outline

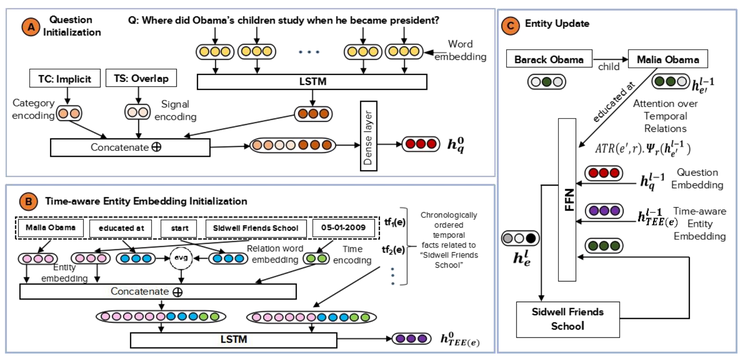
- Two-stage approach for explainable answering of temporal questions over KGs
- Explainability comes from GSTs, attention and graph visualizations
- Combination of BERT classifiers, GSTs and R-GCNs
- Methods for augmenting components with temporal features

Stage one: Answer graph

- Multiple NERD methods
- Fine tune BERT models
- Inject connectivity
- GSTs in compact subgraph
- Complete compact subgraphs
- Augment subgraphs with temporal facts

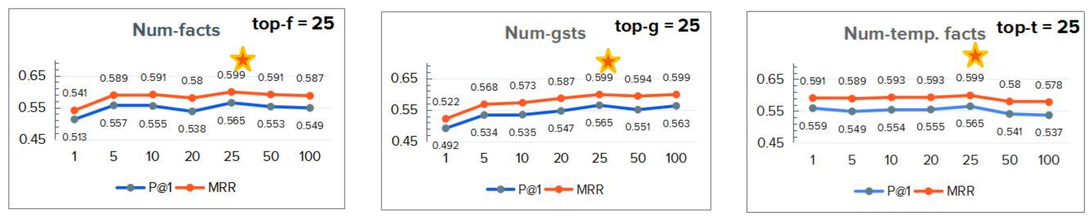


Stage two: Answer prediction



Experiments

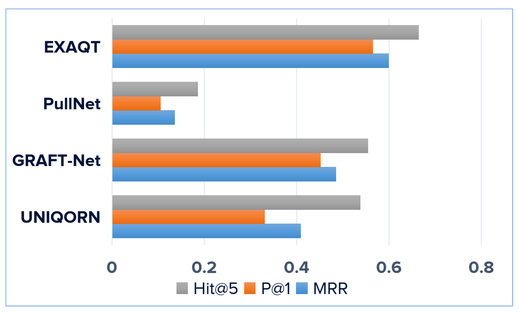
Parameter tuning in Stage one

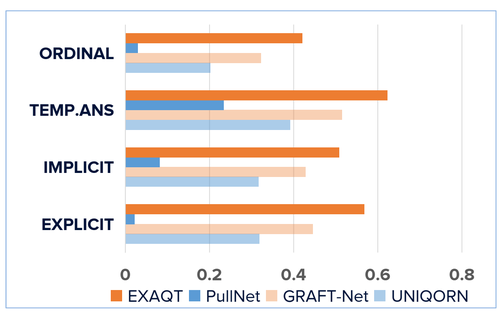


Understanding the recall-oriented Stage one

Step in EXAQT pipeline	Recall	#Candidates
All KG facts of NERD entities	**0.758**	**2491**
Facts selected by BERT	**0.719**	**48**
Shortest paths injected for connectivity	**0.720**	**49**
GSTs on largest component	**0.613**	**13**
Union of GSTs from all components	**0.640**	**14**
Completed GSTs from all components	**0.671**	**21**
Temporal facts added by BERT	**0.724**	**67**

Results in Stage two





Understanding the precision-oriented Stage two

Category	Overall	EXPLICIT	IMPLICIT	TEMP. ANS.	ORDINAL
EXAQT (Full)	**0.565**	**0.568**	**0.508**	**0.623**	**0.420**
EXAQT without TCE	0.545	0.556	0.481	0.590	0.406
EXAQT without TSE	0.543	0.545	0.465	0.598	0.411
EXAQT without TEE	0.556	0.564	0.475	0.614	0.413
EXAQT without TE	0.553	0.556	0.495	0.613	0.398
EXAQT without ATR	0.534	0.527	0.465	0.594	0.411