Answering Complex Questions by Joining Multi-Document Evidence with Quasi Knowledge Graphs

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SIGIR 2019, Paris
Question Answering: Vital for Search

★ Direct answers to questions
★ Saves time and effort
★ Natural in voice UI
★ Fact-centric, entity-seeking
★ Relies on knowledge graphs
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What are the Oscar nominations of Nolan?

Christopher Nolan Academy Awards

- Best Picture
  2018 · Dunkirk

- Best Director
  2018 · Dunkirk

- Best Picture
  2011 · Inception
Question Answering: Vital for Search

★ Direct answers to questions
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Question Answering: Vital for Search

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Which Nolan films won an Oscar?

Interstellar
Academy Awards / Winners /...
Question Answering: Vital for Search

★ Direct answers to questions
★ Saves time and effort
★ Natural in voice UI
★ Fact-centric, entity-seeking
★ Relies on knowledge graphs

Which Nolan films won an Oscar but missed a Golden Globe?

Here you go. The first result is from Wikipedia

List of awards and nominations received by...
https://en.m.wikipedia.org...

Won. 2010, Best Director of the Year ... Main article: Hochi Film Award .... (2002) Nominees and...
Direct Answers Today

★ Works for simple questions

★ Misses additional conditions

★ Depends upon KG completeness
What’s new?

★ **Entity** answers to **complex** questions directly from **text**

★ **Unsupervised method** using **Group Steiner Trees**

★ Handles **ungrammatical** constructs

★ **Robust** to high degrees of noise

★ Provides **explanatory** evidence
**Approach Outline**

1. Construct noisy quasi-KG on-the-fly
2. Augment with alignments and types
3. Spot question cornerstones
4. Compute Group Steiner Tree
5. Rank answer candidates

**QUEST: Question Answering with Steiner Trees**
Multi-document Evidence

Question: Which Nolan films won an Oscar but missed a Golden Globe?

The 2011 Oscar award just announced that Inception is the winner of the Best Sound Editing award. Other winners of the day...

Nolan directed the movie Inception and other science thrillers...

Inception narrowly lost to The Social Network for Best Screenplay at the 68th Golden Globe Awards, which were declared in the afternoon...

This illustrates “joining evidence”
Semi-structuring Text with Open IE

<Nolan, directed, Inception>
<Inception, won, Best Sound>
<2011 Oscars, announced, Best Sound>
<Inception, nominated, Best Actor>
<The movie Inception, missed out, Golden Globe Awards>
<Chris Nolan, director of, The movie Inception>
<Inception’s script, edited by, Chris Nolan>
<Inception, lost to, The Social Network>
<Best Actor, declared at, 83rd Academy Awards>
<The Social Network, winner of, Best Screenplay>
<Golden Globes, announced, Best Screenplay>
Question: Which Nolan films won an Oscar but missed a Golden Globe?
Question: Which Nolan films won an Oscar but missed a Golden Globe?

Form noisy quasi-KG that joins evidence from multiple documents on-the-fly.
Question: Which Nolan films won an Oscar but missed a Golden Globe?

- Inception
  - Nolan directed
  - Chris Nolan director of
  - Nolan won
  - Nolan directed
  - Nolan edited
  - Inception’s script
  - 2011 Oscars announced
  - 83rd Academy Awards declared at
  - Best Sound
  - Best Actor
  - nominated
  - lost to

- The movie Inception
  - The Social Network
  - announced Golden Globe Awards
  - announced Golden Globes
  - The movie Inception
  - Best Screenplay
  - winner of
  - Best Sound
  - Best Actor
Question: Which Nolan films won an Oscar but missed a Golden Globe?
Question: Which Nolan films won an Oscar but missed a Golden Globe?

Add types:

★ Hearst patterns

X and other <TYPE>

(TYPE) such as X

★ From KG

The movie Inception

The Social Network

Best Screenplay

Best Actor

film

type

director of

 billions

decided at

announced

missed out

Golden Globes

Golden Globe Awards

Best Sound

Nolan

Chris Nolan

type

science thriller

announced

winner of

2011 Oscars

83rd Academy Awards

Best Sound

Nolan

Chris Nolan

type

science thriller

announced

missed out

Golden Globes
Question: Which Nolan films won an Oscar but missed a Golden Globe?
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Question: Which Nolan films won an Oscar but missed a Golden Globe?
Inception

The movie Inception

The 83rd Academy Awards

2011 Oscars

Best Sound

Nolan

Chris Nolan

directed

announced

The Social Network

type

science thriller

Golden Globe Awards

Best Screenplay

announced

won

lost to

nominated

declared at

Best Actor

film

type

question: Which Nolan films won an Oscar but missed a Golden Globe?

simplify by considering edges as homogeneous and undirected
Question: Which Nolan films won an Oscar but missed a Golden Globe?
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Question: Which Nolan films won an Oscar but missed a Golden Globe?

Identify cornerstones by thresholding node weights
Question: Which Nolan films won an Oscar but missed a Golden Globe?

- Inception
  - won Best Sound at the 2011 Oscars.
  - directed by Chris Nolan, a science thriller type.
  - edited by Nolan himself.
  - Nolan's script won Best Screenplay at the 2011 Oscars.
  - lost to The Social Network for Best Actor.

- The movie Inception
  - nominated for Best Actor at the 83rd Academy Awards.
  - director of The Social Network

- The Social Network
  - winner of Best Screenplay at the 83rd Academy Awards.
The movie Inception won Best Sound at the 83rd Academy Awards. It was directed by Nolan and edited by Chris Nolan. Inception’s script missed out on a Golden Globe Award. Nolan directed Inception, which is a science thriller. The movie Inception lost to The Social Network at the 2011 Oscars, which was announced as the Best Actor film. The Social Network was also nominated for Best Screenplay at the Golden Globe Awards.
Question: Which Nolan films won an Oscar but missed a Golden Globe?

Best Sound announced

announced

2011 Oscars

83rd Academy Awards

directed

Nolan
directed

Chris Nolan
director of

Inception

Inception’s script

edited by

Golden Globe Awards

science thriller

type

Golden Globes

announced

Best Actor

declared at

winner of

Answers lie on paths connecting cornerstones
Question: Which Nolan films won an Oscar but missed a Golden Globe?

- Inception
- The Social Network

- Nolan
- Chris Nolan
- directed
- Inception’s script
- announced
- Best Sound
- Golden Globe Awards
- announced
- 83rd Academy Awards
- declared at
- Best Actor
- nominated
- film
- type
- science thriller
- Best Screenplay
- winner of
The movie Inception

- Best Sound: won at the 2011 Oscars
- Directed by: Chris Nolan
- Type: science thriller
- Announced at the 83rd Academy Awards

Inception’s script: nominated for Best Screenplay at the Golden Globes but missed at the 2011 Oscars.

Question: Which Nolan films won an Oscar but missed a Golden Globe?

- Inception: won Best Sound at the 2011 Oscars
- The Social Network: winner of Best Screenplay at the Golden Globes

Inception’s script: nominated for Best Screenplay at the Golden Globes but missed at the 2011 Oscars.
Question: Which Nolan films won an Oscar but missed a Golden Globe?
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Inception

- best sound
- announced
- won
- 2011 oscars
- 83rd academy awards
- declared at
- nominated
- lost to
- film
- type

Chris Nolan

- directed
- edits
- Inception's script
- the movie Inception

The Social Network

- type
- science thriller
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- winner of
- Best Actor
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- Golden Globe Awards
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Question: Which Nolan films won an Oscar but missed a Golden Globe?
Formalizing Intuitions: What we Have

★★ Quasi-KG: \( G = (N, E, M^T_N, M^T_E, M^W_N, M^W_E) \)

- Nodes and edges
- Mapping nodes and edges to types
- Mapping nodes and edges to weights

★★ Answers on paths connecting cornerstones

★★ Higher weight paths are preferred

★★ Shorter paths are preferred
Steiner Trees

★ Given:
   ○ Undirected and weighted graph \( G \)
   ○ Subset of vertices = Terminals

★ Find:
   ○ Minimum cost tree containing all terminals

★ Cornerstones = Terminals!

★ Costs = 1 - weights

\[
G = (N, E) \\
w_{ij} \geq 0 \\
T \subseteq N \\
\mathcal{T} = (N^*, E^*) \\
N^* \subseteq N, E^* \subseteq E \\
\min \sum_{i,j \in E^*} w_{ij} \\
T \subseteq N^*
\]
Question: Which Nolan films won an Oscar but missed a Golden Globe?
Question: Which Nolan films won an Oscar but missed a Golden Globe?

Inception

2011 Oscars

83rd Academy Awards

Best Sound

Nolan

Chris Nolan

directed

Inception

Inception’s script

Best Sound

announced

won

Best Actor

declared at

nomination

nominated

1.0

film

0.9

1.0

Best Actor

0.9

1.0

nominated

1.0

type

speech thriller

Golden Globe Awards

announced

missed out

1.0

Golden Globes

Best Screenplay

0.9

winner of

The movie Inception

The Social Network

Best Sound

announced

won

Best Actor

declared at

nomination

nominated

1.0

film

0.9

1.0

Best Actor

0.9

1.0

nominated

1.0

type

speech thriller

Golden Globe Awards

announced

missed out

1.0

Golden Globes

Best Screenplay

0.9

winner of

The movie Inception

The Social Network
The movie Inception
won the 2011 Oscars
for Best Sound
and the 83rd Academy Awards
for best Screenplay.

The film
Inception
was also
directed
by
Chris Nolan.

Inception’s
script
was announced
as
a nominated
for
the Golden Globes,
but
missed out
as
the winner.

Question: Which Nolan films won an Oscar but missed a Golden Globe?
Group Steiner Trees (GST)

- Contains **at least one terminal** from each group
- **Compute Group Steiner Trees on quasi-KG**
- Method from Ding et al. [ICDE 2007]
- Dynamic programming exponential in #keywords
- \( O(n \log n) \) in graph size

\[
G = (N, E) \\
\quad \quad w_{ij} \geq 0 \\
T \subseteq N \\
\mathcal{T} = (N^*, E^*) \\
N^* \subseteq N, E^* \subseteq E \\
\min \sum_{ij \in E^*} w_{ij} \\
T \subseteq N^* \\
T = \{T_n\}, T_n \subseteq N \\
T_n \cap N^* = \emptyset, \forall T_n
\]
Question: Which Nolan films won an Oscar but missed a Golden Globe?
Question: Which Nolan films won an Oscar but missed a Golden Globe?
Question: Which Nolan films won an Oscar but missed a Golden Globe?

- **Best Sound**
- **Nolan**
- **announced**
- **won**
- **directed**
- **2011 Oscars**
- **Inception**

- **Golden Globes**
- **announced**
- **Best Screenplay**
- **The Social Network**
- **winner of**

- **Answers are nodes**
- **Cornerstones are not answers**
- **Answers are entities**
- **Answers respect type constraints**
- **Answers ranked by intuitive criteria**
Question: Which Nolan films won an Oscar but missed a Golden Globe?
Question: Which Nolan films won an Oscar but missed a Golden Globe?

★ Answers are nodes
★ Cornerstones are not answers
★ **Answers are entities**
★ Answers respect type constraints
★ Answers ranked by intuitive criteria

Best Sound
Inception

Best Screenplay
The Social Network
Question: Which Nolan films won an Oscar but missed a Golden Globe?

- Inception
- The Social Network

★ Answers are nodes
★ Cornerstones are not answers
★ Answers are entities
★ Answers respect type constraints
★ Answers ranked by intuitive criteria
**Question:** Which Nolan films won an Oscar but missed a Golden Globe?

- **Inception**
  - Sum of node weights: 9.75
  - Number of GSTs: 5
  - Sum of tree costs: 6.78
  - Distance to cornerstones: 19

- **The Social Network**
  - Sum of node weights: 8.56
  - Number of GSTs: 2
  - Sum of tree costs: 7.98
  - Distance to cornerstones: 27

- **Answers are nodes**
- **Cornerstones are not answers**
- **Answers are entities**
- **Answers respect type constraints**
- **Answers ranked by intuitive criteria**
Question: Which Nolan films won an Oscar but missed a Golden Globe?

- Answers are nodes
- Cornerstones are not answers
- Answers are entities
- Answers respect type constraints
- **Answers ranked by intuitive criteria**

<table>
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<tr>
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<th>Value</th>
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</table>

Inception
Experimental Results: Setup

★ Benchmarks
  ○ 150 Complex questions from WikiAnswers [Abujabal et al. 2017]
  ○ 150 Complex questions from Google Trends
  ○ Corpus: Google Top-10 / Stratified sampling from Web / News / Wikipedia

★ Metric
  ○ Mean Reciprocal Rank
  ○ Precision@1
  ○ Hit@5

★ Baselines
  ○ Neural QA
  ○ Graph methods
Experimental Results: Performance

- QUEST outperforms others

Bar chart showing MRR for:
- QUEST
- DrQA
- BFS
- ShortestPaths

QUEST has the highest performance indicated by the star.
Experimental Results: Performance

- QUEST
- DrQA
- BFS
- ShortestPaths

MRR

Cannot join multi-doc evidence
Experimental Results: Performance

QUEST: MRR = 0.45
DrQA: MRR = 0.38
BFS: MRR = 0.32
ShortestPaths: MRR = 0.28

GSTs help
Experimental Results: Anecdotes

★ Which Japanese baseball player was contracted for Los Angeles Angels who also played for Hokkaido Nippon-ham fighters?

★ Which aspiring model split with Chloe Moretz and is dating Lexi Wood?

★ Where did Sylvie Vartan meet her future husband Johnny Hallyday?
Contributions in QUEST

★ Entity answers to complex questions from multi-document quasi-KG

★ Design rationale: Allow noise and cope later

★ Unsupervised method using Group Steiner Trees

★ Robust to noise and ungrammatical constructs

★ No decomposition of question necessary

★ Provides explanatory evidence

Demo, code and data:  
http://qa.mpi-inf.mpg.de/quest/  

Thank you!