DEMONSTRATION

# NLQxform-UI: An Interactive and Intuitive Scholarly Question Answering System

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# NLQxform-UI: An Interactive and Intuitive Scholarly Question Answering System

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## Abstract

Most scholarly search services only provide basic text-matching or similarity-based searches, with limited operations that require manual configuration, such as sorting and filtering by specific metadata attributes. These capabilities are insufficient for researchers who often have queries that involve complex constraints and operations, such as "enumerating the authors of a given paper along with the venues where they have published other papers." In this work, we develop an interactive and intuitive scholarly question answering system called NLQxform-UI, which allows users to pose complex queries in the form of natural language questions. It is capable of automatically translating these questions into SPARQL queries that can be executed over the DBLP knowledge graph to retrieve expected answers. Furthermore, the users can interact with each step of the answering process and browse the final results in a web-based interface. A video recording of our system is available at https://youtu.be/elq8CPykiyk. Additionally, the system has been completely open-sourced: https://github.com/ruijie-wang-uzh/NLQxform-UI.

## CCS Concepts

• **Information systems** → **Question answering**; **Search interfaces**; • **Human-centered computing** → **Natural language interfaces**.

## Keywords

Natural Language Interface, Knowledge Graph Question Answering, SPARQL, Language Model


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## 1 Introduction

Existing widely-used scholarly search systems, such as Google Scholar,[1] DBLP,[2] and the ACM Digital Library,[3] primarily rely on text-matching and similarity-based searches. These systems are often designed for retrieving a certain type of resource in each querying process, such as papers, scholars, and publication venues, based on keywords, paper titles, or specific names of scholars and venues. Furthermore, most of them only support limited operations based on predefined metadata attributes, such as filtering based on time and resource type. However, researchers often have complex queries that involve multiple types of resources as well as complex constraints and operations over them. For example, researchers may ask: "*enumerate the authors of Attention is All You Need along with the venues where they have published other papers*," or "*how many papers has SIGIR published in the past 5 years*" in their daily research and literature reviewing. These existing search systems are unable to handle such complex queries, especially when the queries are freely expressed in natural language.

In this paper, we aim to develop and demonstrate a scholarly question answering system that can automatically answer these queries in an interactive and intuitive manner. The system is named **NLQxform-UI**, standing for transformation**(xform)**-based **N**atural **L**anguage **Q**uerying **U**ser **I**nterface. It is based on the DBLP knowledge graph (DBLP KG),[4] which organizes the rich resources and information on DBLP in the form of a knowledge graph (KG) and enables accessing with the standard query language SPARQL [11].

[1] https://scholar.google.com/
[2] https://dblp.org/
[3] https://dl.acm.org/
[4] https://blog.dblp.org/2022/03/02/dblp-in-rdf/

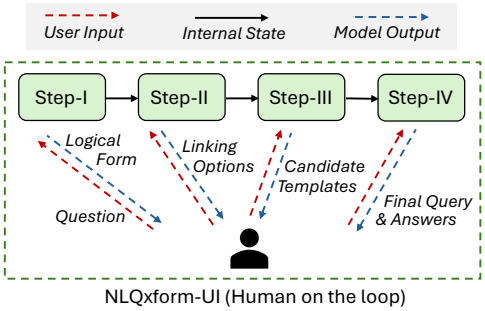


**Figure 1: The human-on-the-loop interaction between NLQxform-UI and the user.**

Specifically, NLQxform-UI answers a given question in four steps: In **step-I question transformation**, the system transforms the question into a logical form [13] that resembles the target SPARQL query with presumably correct structures and semantics. This transformation is based on a transformer model—BART [9]—that we fine-tuned in our previous work [13]. Please note that the logical form is not yet a valid query, as it partially consists of natural language expressions, particularly entity mentions (e.g., "*Attention is All You Need*" for the above example question). In **step-II entity linking**, the system links these natural language expressions to their corresponding resources in the DBLP KG (e.g., linking "*Attention is All You Need*" to *https://dblp.org/rec/conf/nips/VaswaniSPUJGKP17*). In **step-III query correction**, the system utilizes a pre-constructed SPARQL template base to correct potential minor errors in the generated logical form, such as missing or redundant punctuations. Finally, in **step-IV answer retrieval**, the system generates final SPARQL queries and executes them over DBLP KG to retrieve answers.

NLQxform-UI is designed as a human-on-the-loop system, as depicted in Fig. 1. By default, the system autonomously processes a given question and retrieves final answers for the user. Nevertheless, the intermediate results of each step, including the generated logical form in Step-I, entity linking options in Step-II, candidate SPARQL templates in Step-III, and final generated queries as well as final answers in Step-IV, are presented to the user in an intuitive and interactive way. The system allows the user to adjust these intermediate results and, once adjusted, automatically updates the following steps in real time.

## 2 Related Work

This section briefly introduces related question answering (QA) interfaces and scholarly QA systems.

**QA Interfaces** NeuralQA [6] is a library that provides a visual interface for entering questions and presenting gradient-based answer explanations. While it leverages BERT [5] to support a range of helpful QA functions (e.g., contextual query expansion), it does not support interactive adjustment in entity linking, which is supported in NLQxform-UI. IQA [14] is another system that allows the user to resolve entity linking by answering yes or no for generated candidates. However, its applicability to the scholarly search scenario is unclear. Instead of developing a specific system, UKP-SQUARE [4] aims to provide researchers with an online platform to choose different available QA pipelines in a unified interface. PKGQA [10] is a personal mobile QA system that can integrate information from multiple applications. QUINT [1] is an interpretable QA system that leverages query templates to provide answer explanations. However, it lacks the real-time intermediate interaction that our system supports.

**Scholarly QA** Giglou et al. [7] propose to employ large language models to answer scholarly questions based on NFDI4DS Gateway [7]. As far as we know, NLQxform-UI is the first interactive QA interface over DBLP. Nevertheless, there are several methods potentially applicable for this purpose. Jiang et al. [8] propose a prompt-based approach that uses a pre-trained large language model to generate the structure and content of SPARQL queries for scholarly questions. BERTologyNavigator [12] answers a question by navigating over the DBLP KG to extract correct relations and, consequently, answers. PSYCHIC [2] uses a neuro-symbolic approach to generate SPARQL queries for given questions.

## 3 The NLQxform-UI System

In this section, we introduce NLQxform-UI with a specific use case—answering the example question:
"*please enumerate the authors of 'BERT: Pre-training of Deep Bidirectional Transformers for Language Understanding' along with the venues where they have published other papers.*"

The user interface of NLQxform-UI is presented in Fig. 2, where the web page is split in the middle to accommodate the paper layout. The field for question input (i.e., **Question**) is at the top of the web page. Next to the input field, we also offer a few example questions (i.e., **Examples**) that the user can directly click on to use. Given the above question, after clicking on the **Ask** button, the page will be redirected to the **Results** field, where the final answers are presented. The first column (i.e., **first answer**) enumerates the URLs of the requested authors in DBLP (e.g., the URL of the second author of the BERT paper [5]—https://dblp.org/pid/69/4618). The second column (i.e., **second answer**) lists the corresponding venues where the authors have published other papers (e.g., "ICESS" and "ACL"). Next to the results, an inline frame is provided for the user to preview the answer URLs. By default, the first URL is automatically previewed. Furthermore, the preview would update in real time when the user ticks a different URL. Also, the user can freely scroll and open external links in the previewed page to explore other pages through the inline frame.

Then, the user can scroll up to check other intermediate results to better examine the validity of the returned answers. Under ❶ **Logical Form**, the result of the first step is presented:[5]

```
SELECT DISTINCT ?firstanswer ?secondanswer WHERE
{
    the_BERT_paper <authoredBy> ?firstanswer <dot>
    ?x <authoredBy> ?firstanswer <dot>
    ?x <publishedIn> ?secondanswer FILTER
    ( ?x <isnot> the_BERT_paper )
}
```

Please note that we use `the_BERT_paper` to denote the long title of the BERT paper shown in Fig. 2. The logical form has the same structure and semantic as the target SPARQL query and can be

[5]Due to the size limitation, it is only partly displayed in Fig. 2.

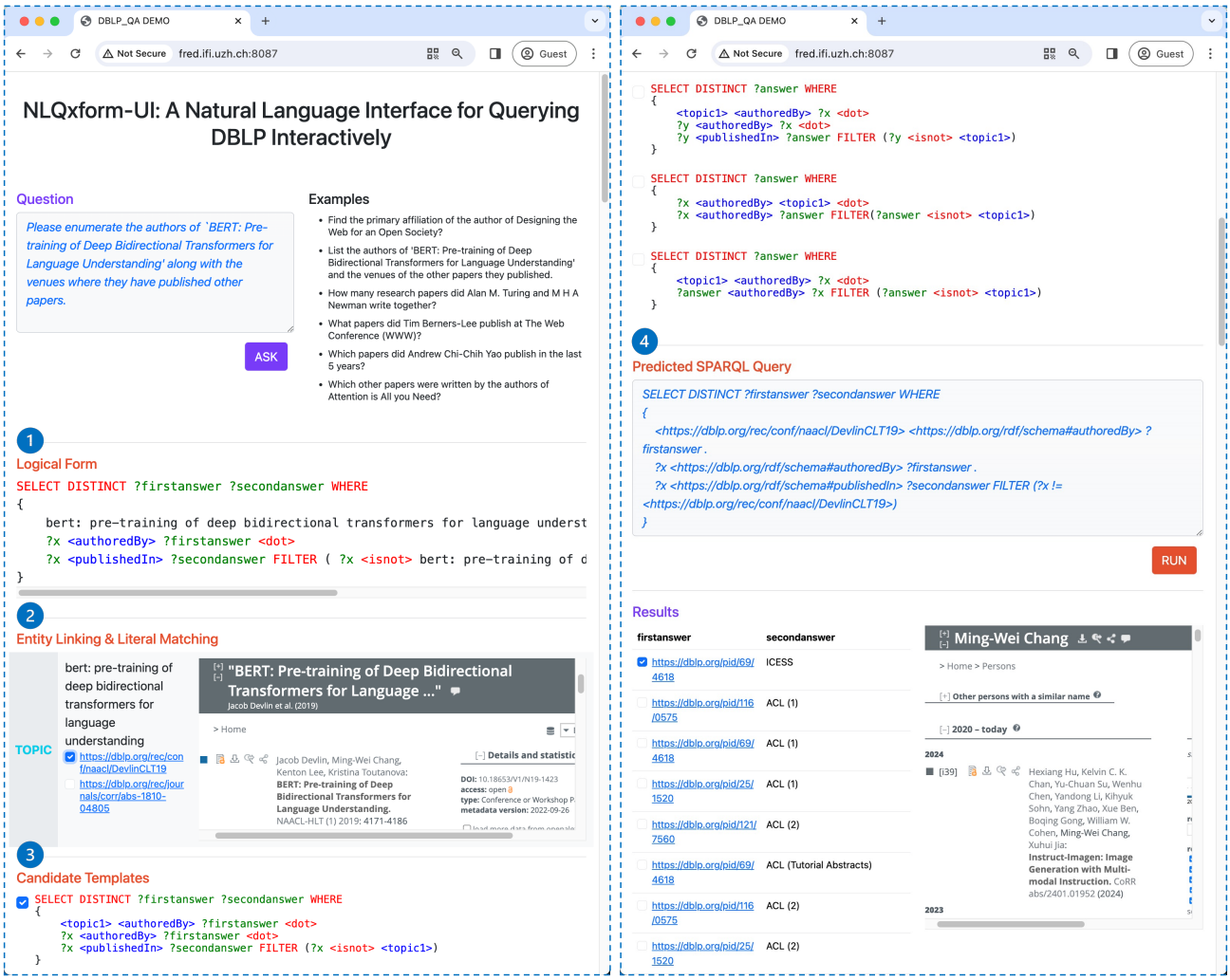


**Figure 2: The user interface of NLQxform-UI, demonstrating the four-step querying process for the question "*please enumerate the authors of 'BERT: Pre-training of Deep Bidirectional Transformers for Language Understanding' along with the venues where they have published other papers.*"**

used to check if the query intention is precisely interpreted by the system. It is generated by an adapted BART [9] model in a sequence-to-sequence text generation setup—translating given questions into logical forms. We fine-tuned the adapted BART model using the training set of DBLP-QuAD [3] dataset, which consists of 7,000 pairs of questions and SPARQL queries over the DBLP KG. The basic elements of the SPARQL syntax (e.g., "SELECT", "DISTINCT," and "WHERE"), the frequently-used characters (e.g., parentheses and the dot), and the relation set of DBLP KG are added to the tokenizer of the BART model. Therefore, we can see that the above logical form already encompasses the SPARQL syntax and relation linking results. However, the entities are still represented by their mentions in the given question.

Next, the system employs DBLP Search APIs[6] to link the entity mentions in the logical form to DBLP URLs. The results are presented under 2 **Entity Linking & Literal Matching**. Two candidate URLs are provided for the BERT paper. The first links to the formal publication, while the second links to the pre-print version. The user can check (or tick) and preview the URLs in the inline frame next to the links and make corrections in case of wrong initial selections. Also, when choosing a different URL, the system automatically updates the following steps in real time.

As the training data of the BART model is limited, the logical form generated in Step-I may contain minor syntax errors, such as a missing or redundant parenthesis. The third step aims to utilize a pre-constructed template base [13] to fix these potential errors. We generated these templates by removing specific entities from the logical forms of the training questions in DBLP-QuAD. For the above example question, NLQxform-UI retrieves a few candidate templates that are similar to the above logical form and presents them under 3 **Candidate Templates**. From Fig. 2, we can see that

[6]https://dblp.org/faq/How+to+use+the+dblp+search+API.html

**Table 1: Comparison with related QA systems regarding the entity linking and final QA results (i.e., respective F1 scores).**

| | F1 - Entity Linking | F1 - Final QA |
|---|---|---|
| **NLQxform-UI** | **0.7961** | **0.8488** |
| Jiang et al. [8] | 0.0000 | 0.6619 |
| BERTologyNavigator [12] | 0.6235 | 0.2175 |
| PSYCHIC [2] | 0.7100 | 0.0018 |

the first one matches the logical form perfectly (`the_BERT_paper` is represented by the placeholder <topic1> in the template). Subsequently, NLQxform-UI utilizes the entity linking results to initialize the template, transforming it into an executable query shown under ❹ **Predicted SPARQL Query**. Furthermore, the user can manually edit the generated query in the input field and click on **Run** to execute it over DBLP KG through the query endpoint.[7] It is worth mentioning that other mismatching templates could also be useful for the user. For example, the last candidate template shown in Fig. 2 can be used to generate a query that retrieves other papers published by the authors of the BERT paper. NLQxform-UI enables the user to choose different candidate templates by ticking them, upon which the generated query would be updated instantly.

## 4 System Effectiveness and Usefulness

We demonstrate the effectiveness of NLQxform-UI by comparing it with related QA systems over 500 Scholarly QALD test questions.[8] NLQxform-UI and all the baselines are trained based on the DBLP-QuAD dataset [3], which includes 7,000 training questions and 1,000 validation questions with ground-truth answer and SPARQL query annotations. As reported in Table 1, NLQxform-UI achieved the highest F1 score regarding both entity linking and final QA, demonstrating its effectiveness and competitiveness. All the reported F1 scores in Table 1 are computed by the automatic evaluation system of Scholarly QALD[9] based on unreleased ground-truth entity linking and final QA results, considering both recall and precision. In addition, these results of NLQxform-UI are directly generated without any manual corrections in the intermediate steps.

Moreover, NLQxform-UI is not limited to the QA task. As presented in Section 3, the entity linking and intermediate query construction process are demonstrated to the user intuitively and interactively. NLQxform-UI can serve as a useful auxiliary tool for writing complex SPARQL queries—researchers can first use it to easily generate a draft query, then manually revise the draft, and finally check the results interactively in the interface.

## 5 Conclusion and Future Work

In this paper, we present NLQxform-UI, an interactive and intuitive scholarly QA system that enables users to express complex queries in natural language and conveniently obtain final answers in a web-based interface. NLQxform-UI processes a given question in four steps: question transformation, entity linking, query correction, and answer retrieval. Users are presented with the intermediate results of these steps and can adjust the answering process in real time. The system's superior effectiveness has been demonstrated in comparison with related QA systems on a benchmarking dataset. In future work, we aim to extend the system beyond the scholarly QA scenario to support open-domain QA.

[7] https://dblp-kg.ltdemos.informatik.uni-hamburg.de/sparql
[8] https://github.com/debayan/scholarly-QALD-challenge/blob/main/2023/datasets/codalab/finalphase/dblp-kgqa/dblp.heldout.500.questionsonly.json
[9] https://kgqa.github.io/scholarly-QALD-challenge/2023/

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