Knowledge-Based Question Answering for DIYers

Doo Soon Kim (Adobe Research)
Zhe Feng (Bosch Research)
Lin Zhao (Bosch Research)
Introduction

- **High interest** on DIY (do-it-yourself)
Introduction

- DIY is **challenging**
  - limitation of DIY article

- **Difficult** Terminologies
- **Loose** descriptions
- **No adjustment** to competence level
- **No professional** helpers

---

Can 7 year-old do it?

What size of drill bits do I need?

What is a router?

---

... Start with the wide leg boards. Adjust the router with the 4-mm straight bit to a routing depth of 11 mm and rout the grooves at a distance of 15 mm from the longitudinal edges on the inside using the parallel guide;
Introduction

→ Question Answering for DIY projects (http://www.bosch-do-it.com)

Q: Can my 7 year-old son do it?

A: This project requires a router, and the use of a router by a 7 year-old is not recommended for a safety reason.

Classic oak dining table

- Set of wood drill bits
- Sanding paper, grits of 120–240, sponge
- Wood wax, cloth, brush
- Folding rule, soft pencil, rubber, pencil sharpener

... Start with the wide leg boards. Adjust the router with the 4-mm straight bit to a routing depth of 11 mm and rout the grooves at a distance of 15 mm from the longitudinal edges on the inside using the parallel guide; ...
## Domain Questions

- manual construction of semi-structured DB + retrieval-based QA

<table>
<thead>
<tr>
<th>Question Type</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>definition</td>
<td><em>What is the jigsaw?</em></td>
</tr>
<tr>
<td>action</td>
<td><em>How can I make a cut with a jigsaw?</em></td>
</tr>
<tr>
<td>tip</td>
<td><em>Is there any tip for using a jigsaw?</em></td>
</tr>
<tr>
<td>comparison</td>
<td><em>How does the jigsaw differ from the circular saw?</em></td>
</tr>
<tr>
<td>safety info</td>
<td><em>What is a safety tip for using a jigsaw?</em></td>
</tr>
<tr>
<td>tool operation</td>
<td><em>How does the jigsaw operate?</em></td>
</tr>
<tr>
<td>structural info</td>
<td><em>Please explain the parts of the jigsaw</em></td>
</tr>
</tbody>
</table>
# Project Questions

- Retrieval-based and reasoning-based QA

<table>
<thead>
<tr>
<th>Question Type</th>
<th>Sub-question type</th>
<th>Example</th>
</tr>
</thead>
</table>
| about entities| about the required entities, spec, amount  | *Which power tools do I need in the project?*  
                      |                | *What is the length of the drill bit needed in the project?*   |
|               | about alternative entities               | *Can I use a circular saw instead of a jigsaw in step 2?*             |
|               | about time / difficulty / cost            | *How long does the project take?*                                      |
|               | about operator’s qualification            | *Can a kid do this project?*                                            |
|               | about detailed explanation                | *Can you explain the sawing step in more detail?*                     |
|               | about alternative actions                 | *Can I paint it with a brush rather than using a spray?*              |
| about actions | about choosing a product                  | *Which products are available for the required entities?*              |
|               | about choosing an action                  | *Can you compare different products?*                                  |
|               | about choosing a product                  | *Between nailing and screwing, which one is better for step 2?*       |

Table 1: Types of project questions
System Architecture

natural language question → structured question → structured answer → multi-modal answer

Question Understanding → Retrieval/Reasoning → Answer Generation

KB (stardog)

Taxonomy of Concept
Project KR
Domain KR
Product KR
User/Context KR
Knowledge Base (1)

Concept Taxonomy
- ~300 entities (tool, accessory, material)
- ~150 actions
- concept-to-phrase mappings

Project KR
- encoded in a semi-automated manner
Knowledge Base (2)

Domain KR
- definition, related actions, structural information, comparison, safety tip
- almost manual efforts

Product KR
- 597 categories
- 85k products
- ~1G RDF triples
Q: What is the total price of the power tools needed in the project?
Q: What is the total price of the power tools needed in the project?

**Question Understanding**
- question type detection
- slot filling
- grounding

**Structured Question**
- question type: cost_inquiry
- entity_concept: Power-Tool
- action/project_name: _project05

**Answer Generation**
Q: What is the total price of the power tools needed in the project?

"answer": (200,500)
"jigsaw": (30,150)
"driver": (50,200)
...

natural language question
structured question
structured answer
multi-modal answer

Question Understanding
Retrieval/Reasoning
Answer Generation

SELECT ?entity, ?entity_price
WHERE {
  <project_id> required_entity ?entity .
?entity rdf:type ?entity_type .
?entity_type rdfs:subClassOf* <concept> .
?entity_type estimated_price ?entity_price.}

Step 2: Predrill a hole before driving screws (diameter: 5 mm)

Q: Explain the pre-drilling in step 2 in details

A: Choose a drill bit of 4 mm. Since the target material is wood, choose a wood drill bit such as (Bosch product).
Reasoning-based QA

- Questions about alternatives
  - e.g., can I use table saw instead of jigsaw?

Yi Wang, Joohyung Lee and Doo Soon Kim, *A Logic Based Approach to Answering Questions about Alternatives in DIY Domains*, IAAI 2017

Answer Set Programming Solver

- domain
- project
- common-sense

Not recommended. Table-saw does not support curve cutting.
Preliminary Evaluation

- User study with 20 DIYers on 5 questions
- Compare our QA system against web search

<table>
<thead>
<tr>
<th></th>
<th>Failure Rate (%)</th>
<th>Total Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Web Search</td>
<td>34.0</td>
<td>3.22</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Web Search</th>
<th>Our QA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satisfaction score (0~5)</td>
<td>2.9</td>
<td>4.8</td>
</tr>
</tbody>
</table>

Eval on web search

Satisfaction over web search vs our QA
Discussion and Summary

- NLP-based IE helps but manual knowledge engineering still matters

- Retrieval-based QA useful but many questions require reasoning
  - questions about alternatives

- Not only answer but providing explanation is important