Conversational Interfaces for Information Search

Keynote talk@CONVERSATIONS 2020

Q. Vera Liao
IBM Research
What this talk is about...

Conversational Interfaces for Information Search

Q. Vera Liao, Werner Geyer, Michael Muller, Yasaman Khazaeni

Abstract Recent progress in Machine Learning has given rise to a plethora of tools and applications that rely on conversational interactions, from chatbots, speech-controlled devices to robots and virtual agents. Conversational interfaces are becoming widely accepted for utility tools, where a common function is to serve users’ information needs. Albeit with much excitement, we are only starting to understand how users’ information-seeking behaviors and design opportunities may transform moving from traditional graphical user interfaces to conversational user interfaces. In this chapter, we start by reviewing recent work in the emerging area of conversational interfaces, and lay out their opportunities for supporting information search tasks. We then present insights from our experience deploying a chatbot supporting information search in a large enterprise, demonstrating how a conversational interface impacts user behaviors and offers new opportunities for improving search experience, in particular for user modeling.

A perspective to conceptualize the design space of conversational search

Our research exploring the design space

Conversational agents have come a long way
From a romanticized view...
to utility applications for information tasks
Information-seeking via web pages v.s. chatbots
Conversational agents for information seeking ≈ Conversational search

Search in a broad sense: statistical IR, ML, rule (intent) based, etc.
Conversational agents for information seeking \approx \text{Conversational search}
Is it mandatory to purchase collision coverage?

Collision coverage pays for repair or replacement costs if your car crashes into an object or another car. This coverage is designed to fix up or replace your own car after a collision. Our customers will need to have comprehensive coverage before adding collision coverage. You can have comprehensive and not collision on your policy, just not the other way around. If you lease or finance your car, collision may be required by your leasing or financing company. Like comprehensive coverage, collision coverage will pay for damages to your car as long as they don't exceed the car's actual cash value...
Is it mandatory to purchase collision coverage?

Collision coverage pays for repair or replacement costs if your car crashes into an object or another car. This coverage is designed to fix up or replace your own car after a collision. Our customers will need to have comprehensive coverage before adding collision coverage. You can have comprehensive and not collision on your policy, just not the other way around. If you lease or finance your car, collision may be required by your leasing or financing company. Like comprehensive coverage, collision coverage will pay for damages to your car as long as they don't exceed the car's actual cash value...
Is it mandatory to purchase collision coverage?

Collision coverage pays for repair or replacement costs if your car crashes into an object or another car. This coverage is designed to fix up or replace your own car after a collision. Our customers will need to have comprehensive coverage before adding collision coverage. You can have comprehensive and not collision on your policy, just not the other way around. If you lease or finance your car, collision may be required by your leasing or financing company. Like comprehensive coverage, collision coverage will pay for damages to your car as long as they don't exceed the car's actual cash value...

Lengthy and imprecise output
Hi agent, I need some help

Sure! How can I help you?

Do I need to buy coverage for my own car?

Are you considering collision coverage or comprehensive coverage?

What is collision coverage?

If your car crashes into an object or another car, collision coverage is designed to fix up or replace your own car.

How is it different from comprehensive coverage?

Collision coverage is to cover your own car after a collision, while comprehensive coverage pays for damage in events that are not collision-related, such as theft and vandalism.

I see. Am I required to purchase collision coverage then?

Collision coverage is optional. But if you lease or finance your car, it may be required by your leasing or financing company.

Okay thanks.

You are welcome!
Hi agent, I need some help

Sure! How can I help you?

Do I need to buy coverage for my own car?

Are you considering collision coverage or comprehensive coverage?

What is collision coverage?

If your car crashes into an object or another car, collision coverage is designed to fix up or replace your own car.

How is it different from comprehensive coverage?

Collision coverage is to cover your own car after a collision, while comprehensive coverage pays for damage in events that are not collision-related, such as theft and vandalism.

I see. Am I required to purchase collision coverage then?

Collision coverage is optional. But if you lease or finance your car, it may be required by your leasing or financing company.

Okay thanks.

You are welcome!
Conversational interfaces for information search

Conversational interfaces play an **intermediary role** between the information seeker and the computational information sources.
How to make search conversational?

How do conversational interactions fit and extend search behavior models?

What have we learned about designing conversational search systems?

What are the properties of conversations to make search conversational?
Query formulation

Results exploration

Query reformulation
Query Formulation

Do I need to buy coverage for my own car?

Are you considering collision coverage or comprehensive coverage?

What is collision coverage?

If your car crashes into an object or another car, collision coverage is designed to fix up or replace your own car.

How is it different from comprehensive coverage?

Collision coverage is to cover your own car after a collision, while comprehensive coverage pays for damage in events that are not collision-related, such as theft and vandalism.

I see. Am I required to purchase collision coverage then?

Reveal
- Disclose
- Revise
- Refine
- Expand

Inquire
- Extract
- Elicit
- Clarify

Result exploration: Decompose documents for conversations

Document v.s. conversational style

- Break paragraphs down to their parts
  - Definition
  - Elaboration
  - Examples
- Limit agent utterance to short sentence(s)
- Let users control the level of details

What is collision coverage?

How is it different from comprehensive coverage?
Query reformulation/repair

Coverage for my own car

I am looking for insurance that covers my own car

I mean when I have an accident

Natural user-initiated repair is often a bad fit for NLU
A theory-informed framework for conversational repair: acknowledging, assisted repair, system repair

No acknowledging

• **Output top (wrong) answer:** “Comprehensive coverage is a coverage that helps pay to replace or repair your vehicle if it's stolen or damaged in an incident …”

Acknowledging

• **Repeat/rephrase:** “I don’t quite understand what you are looking for. How can I help you?”

• **Confirmation:** “Sounds like you are inquiring about comprehensive coverage, is that right?”

Acknowledging, assisted repair

• **Keywords explanation:** “My understanding is that you are asking about comprehensive coverage for your own car. Is that correct?”

• **Out-of-vocabulary explanation:** “Sorry I don’t understand the word **coverage**. Can you please rephrase?”

Acknowledging, system repair

• **Options:** Are you considering collision coverage or comprehensive coverage?

• **Defer:** “Sorry I don’t understand your request. I will defer you to a human agent”

How to make conversational interfaces work for search?

How do conversational interactions fit and extend search behavior models?

What have we learned about designing conversational search systems?

What are the properties of conversations to make search conversational?
<table>
<thead>
<tr>
<th>Search behavior model</th>
<th>Efficiency</th>
<th>Common ground</th>
<th>Recipient design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Query formulation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Results exploration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Query reformulation/repair</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Principle 1: Efficiency

Speakers prefer achieving necessary informativeness with less effort
## Principles of human conversations

<table>
<thead>
<tr>
<th></th>
<th>Efficiency</th>
<th>Common ground</th>
<th>Recipient design</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Query formulation</strong></td>
<td>• Extract system input from natural language</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Optimize elicitation dialogue flow</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Maintain context and user model for inference</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Results exploration</strong></td>
<td></td>
<td>• Minimize complexity</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Start from summarization or low granularity, with navigational paths for details</td>
<td></td>
</tr>
<tr>
<td><strong>Query reformulation/repair</strong></td>
<td></td>
<td>• Maximize system initiative for repair</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Support incremental repair</td>
<td></td>
</tr>
</tbody>
</table>
Principle 2: Common Ground

Conversation is a form of collective action to achieve mutual understanding
Disclose and assess understanding + grounding
## Principles of human conversations

<table>
<thead>
<tr>
<th></th>
<th>Efficiency</th>
<th>Common ground</th>
<th>Recipient design</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Query formulation</strong></td>
<td>• Extract system input from natural language</td>
<td>• Clarification to bridge user input and system model</td>
<td>• Incrementally suggest and elicit feedback</td>
</tr>
<tr>
<td></td>
<td>• Optimize elicitation dialogue flow</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Maintain context and user model for inference</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Results exploration</strong></td>
<td>• Minimize complexity</td>
<td>• Make capabilities and navigational paths discoverable</td>
<td>• Support follow-up inquiries</td>
</tr>
<tr>
<td></td>
<td>• Start from summarization or low granularity, with navigational paths for details</td>
<td>• Suggest alternate information</td>
<td>• Suggest alternate information</td>
</tr>
<tr>
<td><strong>Query reformulation/repair</strong></td>
<td>• Maximize system initiative for repair</td>
<td>• Signal breakdown</td>
<td>• Make system model and status transparent</td>
</tr>
<tr>
<td></td>
<td>• Support incremental repair</td>
<td></td>
<td>• Suggest reformulation</td>
</tr>
</tbody>
</table>
Principle 3: Recipient Design

Speakers constantly adapt the way they talk according to the recipient's knowledge, social relation, personality, context, and many more.
## Principles of human conversations

<table>
<thead>
<tr>
<th><strong>Search behavior model</strong></th>
<th><strong>Efficiency</strong></th>
<th><strong>Common ground</strong></th>
<th><strong>Recipient design</strong></th>
</tr>
</thead>
</table>
| **Query formulation**     | - Extract system input from natural language  
- Optimize elicitation dialogue flow  
- Maintain context and user model for inference | - Clarification to bridge user input and system model  
- Incrementally suggest and elicit feedback | - Support different querying behaviors  
- Adapt elicitation dialogue flows |
| **Results exploration**   | - Minimize complexity  
- Start from summarization or low granularity, with navigational paths for details | - Make capabilities and navigational paths discoverable  
- Support follow-up inquiries  
- Suggest alternate information | - Adapt search algorithms  
- Adapt presentation and interaction styles |
| **Query reformulation/repair** | - Maximize system initiative for repair  
- Support incremental repair | - Signal breakdown  
- Make system model and status transparent  
- Suggest reformulation | - Adapt repair assistance strategies |
### Principles of human conversations

<table>
<thead>
<tr>
<th>Search behavior model</th>
<th>Efficiency</th>
<th>Common ground</th>
<th>Recipient design</th>
</tr>
</thead>
</table>
| **Query formulation** | - Extract system input from natural language  
- Optimize elicitation dialogue flow  
- Maintain context and user model for inference | - Clarification to bridge user input and system model  
- Incrementally suggest and elicit feedback | - Support different querying behaviors  
- Adapt elicitation dialogue flows |
| **Results exploration** | - Minimize complexity  
- Start from summarization or low granularity, with navigational paths for details | - Make capabilities and navigational paths discoverable  
- Support follow-up inquiries  
- Suggest alternate information | - Adapt search algorithms  
- Adapt presentation and interaction styles |
| **Query reformulation/repair** | - Maximize system initiative for repair  
- Support incremental repair | - Signal breakdown  
- Make system model and status transparent  
- Suggest reformulation | - Adapt repair assistance strategies |
Recipient design should take a more central role in conversational experience

• *What to adapt*: search functions and interaction styles
• *For whom to adapt*: “conversational signals” of recipients
### Case study: Recipient Design with a Conversational Search System

#### Results exploration
- Minimize complexity
- Start from summarization or low granularity, with navigational paths for details

#### Query reformulation/repair
- Maximize system initiative for repair
- Support incremental repair

#### Efficiency
- Make capabilities and navigational paths discoverable
- Support follow-up inquiries
- Suggest alternate information

#### Common ground
- Signal breakdown
- Make system model and status transparent
- Suggest reformulation

#### Recipient design
- Adapt search algorithms
- Adapt presentation and interaction styles
- Tailor repair assistance strategies

---

**Chip**: a conversational agent for employee QA

- Field deployment in 2017: 337 new hire, used for 6 weeks. 6000+ messages
- Now available to all IBMers

Liao, Q. V. et al. *All Work and No Play? Conversations with a Question-and-Answer Chatbot in the Wild. CHI 2018*
Recipient design: what to adapt?

**Search satisfaction**

- Low
- High

- Adapt ranking algorithms
- Provide targeted assistance
- “Low risk” groups to bootstrap new functions

**Interaction style: social playfulness**

- Utilitarian
- Social

- “Document” style
- Search engine features
- Conversational style
- Social chit-chat

Liao, Q. V. et al. Studying Social-Agent Orientation and Agent Proactive Interactions with an Agent for Employees. *DIS 2016*
Recipient design: *for whom to adapt?*

**Search satisfaction**

Low ← [Person] → High

**Interaction style:** *social playfulness*

Utilitarian ← [Person] → Social

Liao, Q. V. et al. Studying Social-Agent Orientation and Agent Proactive Interactions with an Agent for Employees. *DIS 2016*
User modeling: what conversational signals reveal user orientation?

Dependent variable
Self-reported *functional satisfaction* and *social playfulness* with Chip

**Independent variables**
*Dialogue acts features*: occurrences of 13 categories
*Lexical features*: uni-, bi-, tri-gram

---

What signals functional (dis)satisfaction?

Opportunities and caveats in conversational feedback

- 42% users used “#fail”, and it was highly reliable, in contrast to “complaints” (“shut up”, “you are stupid”)
- Compliment (“you are smart!”) is not an indicator of functional satisfaction, but playfulness

Implicit dissatisfaction in conversations

- Checking agent ability (“what can you do?”)
- Closing chat (“bye”)

Satisfied users use more **QA structure keywords**

- Tracking formal questioning patterns (where/who/how..)
What signals social playfulness?

**Playful chitchat**, not habitual utterances
- Ask about the agent’s status (“how are you doing?”)
- Ask about the agent’s traits (“what do you like”, “who created you”)
- Talk about oneself (“what do you know about me?”)
- Not: opening, closing, acknowledging message (“ok”, “got it”)

**Agent oriented questions**
- Tracking *second-person pronouns*

**Casual testing** as playfulness
- “do you know…?” , “tell me…”, “search information about my manager”
Recipient design: *what to adapt?*

**Search satisfaction**

- Low
  - #fail feedback, implicit complaints
  - QA structure words
- High
  - “Low risk” groups to bootstrap new functions

**Interaction style: social playfulness**

- Utilitarian
  - “Document” style
  - Search engine features
- Social
  - Playful chitchat, second-person persona, casual testing
  - Conversational style
  - Social chit-chat
### Principles of human conversations

<table>
<thead>
<tr>
<th>Efficiency</th>
<th>Common ground</th>
<th>Recipient design</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Query formulation</strong></td>
<td><strong>Common ground</strong></td>
<td><strong>Recipient design</strong></td>
</tr>
<tr>
<td>• Extract system input from natural language</td>
<td>• Clarification to bridge user input and system model</td>
<td>• Support different querying behaviors</td>
</tr>
<tr>
<td>• Optimize elicitation dialogue flow</td>
<td>• Incrementally suggest and elicit feedback</td>
<td>• Adapt elicitation dialogue flows</td>
</tr>
<tr>
<td>• Maintain context and user model for inference</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Results exploration</strong></th>
<th><strong>Query reformulation/repair</strong></th>
<th><strong>Search behavior model</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Minimize complexity</td>
<td>• Maximize system initiative for repair</td>
<td><strong>Principles of human conversations</strong></td>
</tr>
<tr>
<td>• Start from summarization or low granularity, with navigational paths for details</td>
<td>• Support incremental repair</td>
<td><strong>Search behavior model</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Principles of human conversations</strong></td>
</tr>
<tr>
<td>• Make capabilities and navigational paths discoverable</td>
<td>• Signal breakdown</td>
<td><strong>Search behavior model</strong></td>
</tr>
<tr>
<td>• Support follow-up inquiries</td>
<td>• Make system model and status transparent</td>
<td><strong>Principles of human conversations</strong></td>
</tr>
<tr>
<td>• Suggest alternate information</td>
<td>• Suggest reformulation</td>
<td><strong>Search behavior model</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Principles of human conversations</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Search behavior model</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Principles of human conversations</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Query reformulation/repair</strong></th>
<th><strong>Search behavior model</strong></th>
<th><strong>Principles of human conversations</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Maximize system initiative for repair</td>
<td>• Adapt repair assistance strategies</td>
<td><strong>Search behavior model</strong></td>
</tr>
<tr>
<td>• Support incremental repair</td>
<td></td>
<td><strong>Principles of human conversations</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Search behavior model</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Principles of human conversations</strong></td>
</tr>
</tbody>
</table>
Principles of facilitator conversations

<table>
<thead>
<tr>
<th>Decision facilitation</th>
<th>Meeting facilitation</th>
<th>Social facilitation</th>
</tr>
</thead>
</table>

**Stage model of groups decision support systems**

- Decision criteria formulation
- Choice exploration
- Comparison

Thank YOU!

...and thanks to
Zahra Ashktorab, Rachel Bellamy, Praveen Chandar, Marco Patricio Crasso, Matthew Davis, Werner Geyer, Muhammed Mas-ud Hussain, Mohit Jain, Yasaman Khazaeni, Michael Muller, Sadat Shami, Dakuo Wang, Justin Weisz, Yunfeng Zhang

Q. Vera Liao
vera.liao@ibm.com
www.qveraliao.com
@QVeraLiao