Conversations Based on Search Engine Result Pages

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A bit of background

• University professor of AI & IR at University of Amsterdam
  • Lead a team of around 50 researchers on technology to connect people to information, as well as the implications

• Co-founder and director of national Innovation Center for AI
  • Built around labs in which universities collaborate with companies or NGO’s around a shared research agenda
Today’s talk
Joint work in progress with

Maartje ter Hoeve

Pengjie Ren

Maarten de Rijke

Svitlana Vakulenko

Nikos Voskarides

Yangjun Zhang
Information retrieval

- Technology to connect people to information
  - Search engines
  - Recommender systems
  - Conversational assistants
Landscape is changing

• More mobile queries
  • At the start of 2019, over 60% of all queries submitted to a major web search engine were mobile

• Spoken queries
  • Exceeding 50% in some parts of the world
  • Spoken queries longer, sessions longer

Conversational search

- Idea of **search as conversation** has been around since early 1980s (Belkin, CJIS 1980)

- Making information retrieval interfaces feel more natural and convenient for their users (Radlinski & Craswell, CHIIR 2017)

- Ongoing research and development efforts heavily skewed towards **task-oriented dialogue systems** and **(factoid) question answering tasks**
There’s more than factoids ...
Talk with a document

- Conversational agents to increase productivity
- Document-centered assistance — e.g., to help an individual quickly review a document
  - What type of functionality?
  - What type of questions?
- Recognizing and answering document-centered questions

Talk with structured information

- Talk with a dataset
- Using conversations to browse large collections of information objects
- User model maintains knowledge state, information goal, navigation strategy
Talk with a collection of items

- Talk to support exploration
  - Educational, entertainment purposes
  - Serendipitous discoveries of cultural artifacts – users often look for inspiration, surprises, novel ideas
  - E-commerce
Informational goals

- There is more than task oriented dialogue systems and question answering

- Navigational, informational, and resource goals

- Informational goals consistently 40–60% of all goals

Addressing informational goals
SERP-based conversations

- As our mode of interaction changes, how can we support conversations based on search engine result pages with all the diversity and uncertainty there is in SERPs?
Where are we ...?
Mostly work in progress
money made by <movie>
That's redundant because it is a Ben Stiller movie. Clearly my expectations for this movie were not high and, maybe because of that, I found "Meet the Fockers" quite funny. Do you remember when big box office $279,167,575 awards ASCAP Film and Television Music Awards 2005 Top Box Office...
what did you think of the title?
what did you think of the title?

the title pretty much describes the level of the humor in this Ben Stiller movie.
what did you think of the title?

the title pretty much describes the level of the humor in this ben stiller movie.

haha, i agree! do you know if it made any money?
what did you think of the title?

the title pretty much describes the level of the humor in this ben stiller movie.

haha, i agree! do you know if it made any money?

yeah, it made $279,167,575. pretty good.
...being captured by Boris and Onatopp, Bond arrives in St. Petersburg and meets his CIA contact, Jack Wade (Joe Don Baker). Wade agrees to take Bond to the hideout of a Russian gangster, Valentin Zukovsky (Robbie Coltrane), whom Bond had shot in the leg and given a permanent limp years before...
that was a good scene
that was a good scene

what did you like about the movie?
that was a good scene

what did you like about the movie?

i liked his friend, jack wade.
that was a good scene

what did you like about the movie?

i liked his friend, jack wade.

i loved the part where bond arrives in st. petersburg and meets his cia contact, jack wade (joe don baker).
SERP-based conversation

Chat bot

Which is your favourite character in Spider-Man?

16:31

My favorite character was Tobey Maguire.

16:32

I thought he did an excellent job as peter parker, I didn’t see what it was that turned him into Spider-Man though.

16:33
Which is your favourite character in Spider-Man?

My favorite character was Tobey Maguire.

I thought he did an excellent job as Peter Parker; I didn’t see what it was that turned him into Spider-Man though.

Search engine

The lab works on spiders and has even managed to create new species of spiders through genetic manipulation. While Peter is taking photographs of Mary Jane for the school newspaper, one of these new spiders lands on his hand and bites him. Peter comes home feeling ill and immediately goes to bed.
SERP-based conversation

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Search engine

SERP-based conversational agent

SERP
SERP-based conversation

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I thought he did an excellent job as Peter Parker, I didn’t see what it was that turned him into Spider-Man though.
16:33

Well this happens while Peter is taking photographs of Mary Jane for the school newspaper, one of these new spiders lands on his hand and bites him.
16:34

Type message...

Search engine

SERP-based conversational agent

The lab works on spiders and has even managed to create new species of spiders through genetic manipulation. While Peter is taking photographs of Mary Jane for the school newspaper, one of these new spiders lands on his hand and bites him. Peter comes home feeling ill and immediately goes to bed...
SERP-based conversation

What is a physician's assistant? 16:31

What are the educational requirements required to become one? 16:33

In this article, we will discuss the career prospects of an orthopedic physician assistant and show students what they need to do in order to launch themselves in a career as an orthopedic physician assistant. The most common educational requirements are the completion of an OPA program or a course in related education. The degree specialization can be a nurse practitioner, primary care physician assistant or orthopedic physician assistant. The NBCOPA certifies OPAs who are required licensure in some states.
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SERP-based conversation

What is a physician's assistant?

What are the educational requirements required to become one?

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SERP-based conversation

What is a physician's assistant?

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Most often, you can be a physician's assistant after finishing a related OPA program. Then, you can specialize to be a nurse practitioner, primary care practitioner, or orthopedic physician assistant.

Search engine

Question understanding

Passage generation

Passage summarization

Passage selection

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Let’s simplify things …

- **Cut out the retrieval step** and assume that an oracle has given a single document that may be used to inform the response.

- **Background based conversation (BBC):** Given some background knowledge (e.g., an article in the form of free text) and a conversation, the BBC task is to generate responses by referring to the background knowledge and considering the dialogue history context at the same time.

Background-based conversation

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Scary Movie 3

From Wikipedia, the free encyclopedia

This article needs additional citations for verification. Please help improve this article by adding citations to reliable sources. Unsourced material may be challenged and removed.

Scary Movie 3 is a 2003 American horror sci-fi comedy film, which parodies the horror, sci-fi, and mystery genres. It is the third film in the Scary Movie franchise, and the first to be directed by David Zucker.

The film stars Anna Faris and Regina Hall reprising their roles as Cindy Campbell and Brenda Moks, respectively. New cast members include Charlie Sheen, Simon Rex, Anthony Anderson, Kevin Hart, and Leslie Nielsen. It is the first film in the series to have no involvement from the Wayans family. The characters of Shorty Meeks and Ray Wilkins, previously played by Shawn and Marlon Wayans, do not appear, nor are they referenced.

The film's plot significantly parodies the films The Ring, Signs, The Matrix Reloaded and 6 Mile. The film grossed $220.7 million worldwide. It is the last film in the series to be released by The Walt Disney Company's subsidiary Miramax Films, under the brand Dimension Films. It was named the 2004 Teen Choice Awards in the category of Choice Movie: Your Parents Didn't Want You to See.[2]

Plot

Kate (Jenny McCarthy) and Becca (Pamela Anderson) talk about what Katie believes is a sex tape, but Becca calls it a cursed tape. After several odd occurrences, and an almost atomic wedge, they both die. Meanwhile, in a town outside Washington, D.C., widower Tom Logan (Charlie Sheen) and his clumsy brother George (Simon Rex) discover a crop circle, saying "Attack Here!", after noticing the dog's strange activity (such as driving a tractor or getting stolen).

Cindy Campbell (Anna Faris), now a blonde news reporter, announces the crop circles on the news. She interviews Tom Logan, who believes it is the work of aliens. Meanwhile, a couple is seen making love and ends up dead. The crop circles continue and end up with a plane flying through them.

Directed by: David Zucker
Produced by: Robert K. Weiss, David Zucker
Written by: Craig Mazin, Pat Proft
Based on: Characters by Shawn Wayans, Marlon Wayans, Buddy Johnson

Theatrical release poster
Conversation

human 1: was it worth money?
human 2: cheesy and trashy, but very entertaining I bet it didn't win any awards?
Example BBC

Background
box office $ 110,000,082 awards bmi film & tv awards 2004 james l. venable mtv movie + tv awards 2004 best cameo taglines reload for a third shot great trilogies come in threes. this time it's personal. you're warned. 2003. similar movies scary movie 4 scary movie 2 scary movie a haunted house scary movie 5

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BiDAF : mtv movie + tv awards 2004 best cameo
Golden : you are wrong . mtv movie + tv awards 2004 best cameo
Key challenge in BBC is **knowledge selection**: finding appropriate background knowledge (e.g., a text fragment about a movie plot, or some basic facts about a movie) based on which the next response is to be generated.

- Two families of approaches
  - Extraction-based
  - Generation-based
Extraction-based BBC

- Responses produced by extraction-based methods are directly copied from background sentences.

- Learn two pointers to extract spans from background material as possible responses.

- Generated responses are often not natural due to their extractive nature.
Generation-based BBC

- Influence generation process using the background material
- Sequence-to-sequence models often have a hard time using the background model
- Natural responses but they often break semantic units
Advances in generation-based BBC

- Often based on **encoder-decoder** architecture
- Often adopt a **local** perspective, generating one token at a time based on current decoding state
- Recently proposed fixes
  - Teach decoder to select semantic units (instead of individual words)
  - Use structured knowledge from a knowledge graph (in addition to text) in which the background text is grounded
Advances in generation-based BBC

- Equip encoder-decoder with a global perspective
Advances in generation-based BBC

- Equip encoder-decoder with a **global** perspective
  - **Background & context encoders**
    - Encode background knowledge and conversational context

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P. Ren et al., 2020. Thinking Globally, Acting Locally: Distantly Supervised Global-to-Local Knowledge Selection for Background Based Conversation. AAAI.
Advances in generation-based BBC

- Equip encoder-decoder with a **global** perspective
  - **Background & context encoders**
    - Encode background knowledge and conversational context
  - **Local knowledge selection (LKS)**
    - Outputs response token from vocabulary or from background, based on GKS
Advances in generation-based BBC

- Equip encoder-decoder with a **global** perspective
  - **Background & context encoders**
    - Encode background knowledge and conversational context
  - **Local knowledge selection (LKS)**
    - Outputs response token from vocabulary or from background, based on GKS
  - **Global knowledge selection (GKS)**
    - Evaluates matching between background and context, and decides what to talk about next

P. Ren et al., 2020. Thinking Globally, Acting Locally: Distantly Supervised Global-to-Local Knowledge Selection for Background Based Conversation. AAAI.
Global knowledge selection

- Given knowledge and conversational context, encode them into latent representations.
- GKS module evaluates matching matrix between these representations.
- Based on matching matrix, GKS decides on "what to talk about next" by selecting continuous spans from the background K to form a "topic transition vector".
Local knowledge selection

- At each decoding time step, LKS outputs response token by either generating from vocabulary or selecting from background K under the guidance of the topic transition vector produced by the GKS module.

- Loss function a combination of three loss functions:
  - Maximum Likelihood Estimation loss, Distant Supervision loss, Maximum Causal Entropy loss.
Advances in generation-based BBC
Advances in generation-based BBC

**H1:** I loved all the tricks, and traps Kevin created.

**H2:** Me too, I loved when using a tape recorder, he tapes a message and slows down his voice, placing a hotel reservation.

**H1:** That was too funny, the hotel staff didn’t believe him though.

Dialogue context
Background: ... later that evening, he intends to access Kevin's room, but Kevin fools him into thinking that he has walked in on his father, causing the concierge to flee ... Home Alone 2 is a carbon copy, but it's also much better and more complex a movie than the first ... regardless it's a classic and I watch the first two movies every year ...

H1: I loved all the tricks, and traps Kevin created.
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**GTTP** it's a classic and I watch the first two movies every year.
Advances in generation-based BBC

Background: ... later that evening, he intends to access kevin’s room, but kevin fools him into thinking that he has walked in on his father, causing the concierge to flee ... home alone 2 is a carbon copy, but it’s also much better and more complex a movie than the first ... regardless it’s a classic and i watch the first two movies every year ...

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Generation-based

GTTP it’s a classic and i watch the first two movies every year.

Generation-based

RefNet that it was so sad when he intends to access kevin’s room, but kevin fools him into thinking that he has walked in on his father, causing the concierge to flee.
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RefNet that it was so sad when he intends to access kevin's room, but kevin fools him into thinking that he has walked in on his father, causing the concierge to flee.

LKS i know, it was a carbon copy, but it's also much better and more complex a movie than the first.

Background
Dialogue context
Generation-based
Generation-based
Generation-based, local only
# Advances in generation-based BBC

<table>
<thead>
<tr>
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</tr>
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<td>GLKS: so true, later that evening, he intends to access kevin's room, but kevin fools him into thinking that he has walked in on his father, causing the concierge to flee.</td>
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</table>

**Dialogue context**

**Generation-based**

**Generation-based, local only**

**Generation-based, global + local**
Advances in generation-based BBC
Recent results on BBC

- Holl-E dataset (Moghe et al., 2018)
  - Built for movie chats in which each response is explicitly generated by copying and/or modifying sentences from the background
  - Background consists of plots, comments and reviews about movies collected from different websites

P. Ren et al., 2020. Thinking Globally, Acting Locally: Distantly Supervised Global-to-Local Knowledge Selection for Background Based Conversation. AAAI.
What’s next?
Background-based conversations

What is a physician’s assistant? 16:31

What are the educational requirements required to become one?

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SERP-based conversations

1. Search engine
2. Question understanding
3. Passage selection
4. Passage summarization
5. Passage generation

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Query formulation

- Learning reformulations so as to obtain the best results
- Optimize for generating a response
- Dynamically update formulations as conversation unfolds and user issues questions, answers and interactions
- Query completion meets RL meets BERT

D. Odijk et al. 2015. Dynamic query modeling for related content finding. SIGIR
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Question understanding

- Inferring intent and shifts in intent
- Recognizing entities and relations
- Learning to ask in mixed-initiative setting

Passage selection

- Single passage may not be enough to answer question or generate response
- Taking broader context into account
- Consider low-ranked documents that are not immediately relevant, combining information from multiple documents, and reasoning over multiple facts from these documents to infer the answer/response

M. Dehghani et al., 2019. Learning to Transform, Combine, and Reason in Open-Domain Question Answering. In WSDM.
Passage summarization

- **Multi-document** summarization

- Summarize multiple **multi-modal** search results
  - Dealing with multiple intents
  - Text vs. image/video vs. knowledge cards vs. …
  - Structured vs. unstructured
  - Static blogs/articles vs. live news/reports

- Optimize for “ideal summary” vs for “successful interaction”
Response generation

- **Repetition** problem

- **Appropriateness** problem
  - Classifying responses into appropriate vs not-appropriate

- **No single correct response**
  - User inputs are not always questions with definitive answers or unique responses

- What to **talk about next**?
  - Support exploration, serendipity, …
Response generation

- Why did you so that?
  - Explainable for developers
    - Failure analysis
    - Identifying influential (online) training instances (Sharchilev et al., ICML 2018)
  - Reasoning path on knowledge graph as explanations (Moon et al., ACL 2019, Liu et al., arXiv 2019)
  - Explainable for users
    - Response/answer explanation

**Human:** which is your favorite character in this?
**Bot:** my favorite character was obviously the main character because through his perseverance he was able to escape a dangerous situation.
Wrap-up
Wrap-up

- SERP-grounded conversations
  - Bring the richness of SERPs to a conversational setting
- General idea, recent advances, challenges and ambitions
- Work in progress, a lot remains to be done
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