Towards conversational interfaces to web applications

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ABSTRACT

Today's conversational interfaces are largely based on the paradigm of information retrieval from databases. In this position paper, we propose a radically different approach: building CIs on top of existing web applications. Such a system will draw together research in task modeling, web usage mining, information extraction, as well as the vast amount of existing research on traditional CIs.

1. INTRODUCTION

Conversational interfaces are an alternative to traditional graphical interfaces as a means for people to interact with computers. As computing moves to smaller mobile devices with limited I/O capabilities, conversational interfaces increase users' ability to access information while on the move – anytime, anywhere. Moreover, conversational interfaces could also enable persons with disabilities access to IT services that they were formerly unable to access.

Much past work on conversational interfaces has focused on the information retrieval task of selecting and filtering records from a database [21]. In this position paper, we propose a radically different approach to creating conversational interfaces: building them *on top of* existing web applications. Unlike databases, web applications are designed for humans to interact with. Web user interfaces provide a vocabulary and structure with which to describe tasks that can be accomplished online: getting traffic information, finding product reviews, signing up for a newsletter, or paying bills. Therefore, we believe that it will be possible to create general-purpose conversational interfaces that enable users to do anything they could do on the web, through conversation.

At first glance, creating conversational interfaces for arbitrary web applications is tremendously challenging. Every website is different; there is a enormous variation in the types of tasks that can be accomplished using the web. The web is designed for people to use visually; the state of the art in screenreaders for blind users [5] is still very cumbersome. Crafting easy-to-use conversational interfaces seems to require custom programming specific to each website.

Yet the design of web applications leads us to believe that automatic construction of conversational interfaces (CIs) for arbitrary websites may be possible. For example, web applications make use of common visual structures for menus or navigation bars; these structures can be reverse engineered using heuristics that rely on page geometry and layout [6]. As another example, the labels of links and buttons on web applications (e.g., "find flights" or "buy ticket") give clues as to the tasks that can be accomplished. All of this is possible due to the open standards on which the web is based, which allow programs to examine the structure of web applications. We believe that this open model, combined with recent advances in web usage mining, information extraction, and task modeling, enable the creation of rich, interactive CIs based on existing web applications.

The remainder of this paper is organized as follows. First we provide a brief overview of prior work in database-oriented conversational interfaces. Then we explore in more depth the differences between database-backed CIs and web-based CIs. Finally, we conclude with observations and directions for future work.

2. PRIOR WORK

Conversational interfaces have been around for a long time; Zue and Glass [21] provide a good survey of the literature. Due to the difficulty of developing general-purpose CIs, they tend to be targeted at a specific domain, such as train schedules [1], restaurants [18], job listings [19], or call routing [8].

The predominant paradigm for CIs assumes that they are interfaces to a database and that the user is performing an information retrieval task from the database. Early research in CIs investigated how to make them easily *transportable* across arbitrary databases with little programming effort [9]. Systems such as SpeechBuilder [7] proposed a framework to make CIs easier to develop by plugging together existing components. Despite such efforts, CIs are still not in wide use for general-purpose tasks such as those found on most websites.

More recently, conversational interfaces such as Siri[1] (the basis for Apple's iPhone Assistant), Google's Talk Guru[2], and Vlingo[3] provide chat-based interfaces to a handful of services such as weather forecasts, movies, and restaurants.

[1]http://siri.com
[2]http://guru.googlelabs.com
[3]http://vlingo.com

Similar to traditional CIs, these systems provide access to only a limited set of services, rather than arbitrary web tasks.

Several research efforts have focused on developing parallel webs that facilitate voice-based access via conversational interfaces. The Spoken Web [12] creates a parallel telephone-based "web" of information based on audio recordings. VoiceXML [4] is a W3C standard for specifying interactive voice dialogues, analagous to HTML for GUI applications. The Semantic Web [3] will enable agents to semantically interact with semi-structured information on the web, without having to interpret human-readable web pages. However, for the time being, the vast majority of services today are only accessible via the web. Therefore, we believe that conversational interfaces can and should be built on top of existing websites to give them the broadest impact.

3. CONVERSATIONAL INTERFACES FOR THE WEB

The most important component in a CI is the *task model*, which defines what a user can do using the interface. Related to the task model are components for understanding the user's *input* and generating *output* in response. In traditional CIs, all of these components leverage the structure and contents of a database. For example, the input component can use the names of tables and columns in the database schema in order to understand a user's query for "French restaurants near downtown" as referring to cuisine=French, object=restaurants, and location=downtown.

When building CIs on top of web applications, one cannot take advantage of that type of information. However, we argue that the web provides different types of information that make it possible to build CIs effectively. As we discuss in this section, recent advances in algorithms for understanding and manipulating web applications make this possible.

3.1 Task models

Task models are used in conversational interfaces to guide users through performing their task. In traditional CIs, this phase includes refining search results, presenting intermediate options, and helping the user navigate to the information they are seeking.

More generally, for web-based applications where the set of tasks is more varied than the classic database search problem, we need to have a task model in order to guide the user through performing their task, the same way traditional CIs guide users through finding information. Yet how are we going to get task models for arbitrary web applications?

If those task models already existed, building CIs would be easier. Research on model-based UI design [17] argues that task models should be the basis for designing and developing applications. If all designers and developers followed this approach, we would have the task models we needed. One promising direction could be to crowdsource the design of task models for arbitrary web applications, engaging a crowd via platforms such as Amazon's Mechanical Turk [5] to provide a low-cost way of acquiring task models.

Yet even without explicit task models, the design of a web application imparts a lot of information which can be leveraged to infer task models. Because web applications are designed for humans to understand and use, their user interfaces codify designers' beliefs about what can be done using the application – their task models. By examining the user interfaces, it should be possible to reverse engineer the task models of applications.

The structure of web applications often gives a clue to their semantics. Well-designed web applications use consistent visual cues to enable users to quickly understand the site's contents [20]. For example, link text provides a description of the link destination, such as "flights" or "hotels". Moreover, links with similar functionality tend to be grouped together, such that links for "books" and "movies" and "CDs" are displayed physically close to each other. These design practices encode valuable information about the categories of objects that can be manipulated using this application. For example, a conversational interface should be able to analyze the navigation bar on the Google front page and determine that this website is organized according to Web, Images, Videos, Maps, News, and more.

Similarly, buttons on web pages often indicate actions that can be done using the application, such as "find a flight" or "search prices" or "download music". These buttons provide verbal cues for the types of tasks possible on the site.

More generally, websites today make use of a set of common UI patterns, such as user registration/login, search results, and shopping carts. For example, the search result pattern typically involves the user entering a query into a search textbox, to which the system responds with a list of summarized search results. The user clicks on one of the search results, and the system shows a page with more details about that specific item. Similarly, a shopping cart pattern has affordances to add/remove/update items in the cart and invoke the checkout process. While the actual rendering of these patterns changes from site to site, they share a common interaction flow that can be recognized.

The FindThis system [16] leveraged the search result pattern to provide a limited conversational interface for retrieving item-property information from e-commerce sites. With more research, we believe it should be possible to infer general task models from arbitrary web sites in order to support dialogue management in CIs.

3.1.1 Usage information

We believe that what people have done in the past is a good predictor for what they will do in the future. Therefore, by examining past web interaction history, we ought to be able to build good task models.

The prevalence of web interaction logging makes it very easy to capture user interaction with web applications. Platforms such as Coremetrics[6] and CoScripter Reusable History [14] capture fine-grained user activity at the level of interaction with elements on each web page. This user interaction data could be analyzed to identify common paths through the application. If many users tend to follow the same navigational path through the application, this "path well travelled" could form the basis of a task model.

For example, the CoCo system [13] mined personal usage logs to suggest automated web tasks that could be invoked through a conversational interface.

In the future, we envision an agent that has full knowledge of what the user has done in the past, and which can access the web on the user's behalf. The user should be able

[4]http://en.wikipedia.org/wiki/VoiceXML
[5]http://mturk.com
[6]http://coremetrics.com

to converse with this agent in order to ask it to do tasks on the web, using that user's interaction logs as the basis for performing those tasks. When the user makes a request of the agent, the agent should be able to search through the user's past interaction history and identify interaction sequences that could be reused in order to accomplish the same task again. Through conversation, the agent can determine which steps to take to accomplish the desired goal, perhaps customizing them to the user's current need.

3.1.2 Parameters

Part of the dialogue management process in traditional CIs is to help users refine their query by providing additional search parameters or filters. The dialogue management component in traditional CIs includes strategies for prompting the user to provide this information based on current results.

However, in the web domain, tasks are not as structured as the traditional database search task. Instead of trying to find information, users may be applying for a scholarship, registering for a conference, or booking a vacation.

On the web, completing these tasks involves form filling. The web application designer has decided which parameters are needed for completion of a task, and has created a form to collect those inputs from the user.

These forms are natural points to engage in dialogue with the user to solicit their input. For example, the explicit task models authored for the CoCo system [13] included parameters which caused the dialogue manager to prompt the user for the values of those parameters before invoking the task.

More generally, we imagine a system that can automatically map a web form to a conversational dialogue with the user. For each input field in the form, the system can turn that into a dialogue prompt depending on the type of the input field (e.g., "what date would you like to leave?" and "what airport are you departing from?" and "do you want one-way or round trip?").

3.2 Input

Ultimately the problem of understanding a user's input reduces to the problem of understanding what they are asking the computer to do. The challenge of a CI system for the web is to interpret that input and map it to something that can be done on the web. Typically, this process involves selecting a website and deciding what to do on that website.

Operating a user interface is similar to a conversation: the system presents some information, the user selects an option from among the choices presented, and the system responds with both the reaction to the user's command, along with new options for what to do next. On the web, this conversation is conducted through web pages and interactions on web pages: the system generates some HTML content and the user responds by clicking buttons and links and typing into textboxes. The system responds by generating a new web page, and so on.

Accessible technologies for visually impaired users illustrate one extreme of mapping from web-based interfaces into a conversational interface [5]. Screenreaders orally read out the content on the web page, top to bottom, and the user can indicate which link to follow or can navigate through the DOM structure of the page using keyboard commands. However, since the interaction is at the very low level of individual elements on the page, the conversation is very lengthy and laborious.

We believe it ought to be possible to create conversational interfaces for web applications that function at a higher level than the individual elements on the page.

One insight is that the input widgets in a web application (buttons, links, etc.) usually correspond to goals the user can express in conversation. For example, a user who wants to check in for a flight on an airline website will likely click the "Check In" button. The TrailBlazer system [4] made use of this insight in a system which, given a goal expressed in natural language, guided blind users through a sequence of steps to accomplish that goal.

A different approach, taken by CoCo [13], is to allow end user programmers to define a library of tasks that can be accomplished via web applications. The user's query is interpreted relative to the available tasks and the appropriate task model is selected for the next phase of the conversation.

Yet we can also imagine more ambitious ways to map web applications to a conversation. Imagine the situation where you call a friend for help while travelling, and ask your friend to do something for you. If you know what you need to do, such as checking the train schedules for a particular route, your friend can interpret the contents of that website and perform the task for you, as you provide the information necsesary to complete that task.

What if we could create an agent that could take the place of that friend, interpreting the contents of the website and relaying the relevant information back to you so that you can guide the agent through the task? The friend/agent does not need to be an expert in performing the task; they only need to be able to communicate the contents of websites efficiently to a human and follow instructions on what to do next. Therefore, through conversation, it may be possible to enable people to direct agents to perform arbitrary tasks on web applications.

3.3 Output

One remaining problem for building CIs for the web is to map from the information available on web pages into the conversational modality. To build a CI based on a web application, the CI must be able to interpret arbitrary information contained on a web page in order to communicate it back to the user.

One approach to this problem is to create tools that let programmers manually specify how to extract content from web pages for use in the CI, along the lines of Highlight [15] (while designed for the creation of mobile interfaces, similar techniques could apply to CIs), Kapow[7], or Yahoo! Pipes[8]. Perhaps crowdsourcing could be leveraged here as well, similarly to how d.mix [10] let the crowd create and share API wrappers for existing web apps.

Another approach is to build on algorithms that automatically extract semantic structure from web pages, in the same way that Sifter [11] automatically extracts search results and repetitive content. On many sites, the content is output from a database using templates, leading to algorithms that can automatically infer the template and extract the database values [2]. Once extracted, search results could be communicated to the user via the CI using existing techniques for presenting structured result sets.

[7]http://kapowsoftware.com
[8]http://pipes.yahoo.com

4. CONCLUSION

We have proposed a new way to build conversational interfaces: by building them on top of existing web applications. Web applications, which have been designed for people to use, exhibit a lot of structure that can be automatically extracted and leveraged to create CIs. In this paper we have identified some of the relevant work in task modeling, web usage mining, information extraction, and end user programming which will make it possible to create conversation interfaces on top of arbitrary web applications.

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