Evaluation of an Integrated Authoring Tool for Building Advanced Question-Answering Characters

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Abstract

We present the evaluation of an integrated authoring tool for rapid prototyping of dialogue systems. These dialogue systems are designed to support virtual humans engaging in advanced question-answering dialogues, such as for training tactical questioning skills. The tool was designed to help non-experts, who may have little or no knowledge of linguistics or computer science, build virtual characters that can play the role of an interviewee. The tool has been successfully used by several different non-experts to create a number of virtual characters used successfully for both training and human subjects testing. We report on experiences with seven such characters, whose development time was as little as two weeks including concept development and a round of user testing.

Index Terms: Virtual Human, Dialogue system, Authoring tool evaluation.

1. Introduction

Building a dialogue system can be a time-consuming and costly process. It requires system developers to have expertise not only in the domain of interaction but also in fields like computer science and linguistics. A variety of architectures have been proposed for building dialogue systems (e.g., [1, 2, 3, 4, 5, 6]) and the choice of the architecture is influenced by the specific goals for the dialogue system and its evaluation criteria. This chosen architecture, in turn, determines what specific types of resources are required to build the dialogue system. Once the dialogue system architecture and the required resources have been determined, the cost of developing a dialogue system can be lowered by reducing the cost of building those specific resources. Our goal in developing the **DomainEditor** authoring environment described in [7] is to reduce this cost and enable rapid prototyping of dialogue systems, by allowing *non-experts* to build such resources with the help of an integrated authoring tool. By *non-experts* we mean, designers with little or no experience in building dialogue systems and little or no background in computational linguistics. These *non-experts* might be experts in the specific domain of interaction (e.g., Tactical Questioning).

The DomainEditor authoring tool is especially suited to developing characters for complex question-answering dialogues. Unlike the architecture in [5, 8], DomainEditor is well suited to cases in which the character reasons about topics and decides under which conditions to provide an accurate answer or other alternatives such as lying or bargaining for release of the information. Interviewers can employ several strategies, such as building rapport, offering to perform certain favorable actions or pointing out the effects of non-cooperation, in order to persuade the character to cooperate and answer truthfully.

Building Tactical Questioning characters has been an ongoing project at Institute for Creative Technologies. The project has evolved through many different architectures for dialogue systems [9]. Gandhe et al. [4] provide the description of the latest architecture for the tactical questioning dialogue system and Gandhe et al. [7] provide a detailed description of the integrated authoring tool, **DomainEditor**, that was designed to be used by *non-experts*.

In this paper we report on the use of DomainEditor over the past two years and our experience in getting *non-experts* to build seven virtual human characters. In the next section we give a brief overview of the authoring process followed by the overview of dialogue manager functionalities available within the architecture. In section 3, we present the evaluation of the authoring process, the simple dialogue act (DA) scheme designed for tactical questioning and the resulting virtual human dialogue systems.

2. Architecture and Authoring Process

We use a standard pipeline architecture for our virtual human dialogue system (see [4] for more details). It has modules for speech recognition (ASR), natural language understanding and generation (NLU, NLG), Dialogue management (DM), non-verbal behavior generation [10] and speech (TTS) and behavior [11] synthesis.

We use an information-state [6] based dialogue manager that uses dialogue acts (DAs) for reasoning about communicative effects and communication with NLU and NLG modules. This information-state is in part based on conversational game theory [12]. The main responsibilities of the dialogue manager are to update the information state of the dialogue based on the incoming DA from NLU and to select the response DA for NLG. The information state update rules describe grammars for conversational game structure and are written as state charts. We are using State Chart XML[1] (SCXML), a W3C working draft, for describing the state charts. These state charts model various subdialogues like question-answering, offer, threat, greetings. closings, etc. The dialogue manager also implements advanced features like topic-tracking and grounding [13]. See Figure 1 for a sample dialogue.

The resources required for this architecture are the domain knowledge for the virtual character, a set of relevant dialogue acts and examples of NL text for all the DAs. These examples can be used as training data for ASR, NLU and NLG. DomainEditor (GUI shown in Figure 2) supports both top-down and bottom-up authoring approaches.

[1]http://www.w3.org/TR/scxml/, Specifically we use the commons SCXML implementation. [http://commons.apache.org/scxml]

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Player	ynq	Are you Sean Avery?
Avery	yes	Yes
Avery	assert	My name is PFC Sean Avery.
Player	whq	Tell me what you saw.
Avery	assert	The soldier got out of the car and took a package from the back seat.
Player	whq	Do you know who the soldier was?
Avery	assert-lie	I have no clue what the soldier's name is.
Player	threat	If you don't tell me your privileges will be revoked.
Avery	response-threat	I don't want to be on restriction
Player	whq	Who was the soldier?
Avery	assert	The soldier's name is Ryan Benton.
Player	whq	Tell me more about the soldier.
Avery	assert	The PFC is in my platoon and one of my closest friends.
Player	whq	What was inside the package?
Avery	assert	He was carrying a puppy.
Player	whq	What was inside the package?
Avery	self-repeat	As I said earlier,
Avery	assert	The suspicious package contained a puppy.
Player	whq	Whose idea was it to smuggle the puppy on the base.
Avery	elicit-offer	Will you give the soldier a less severe punishment if I talk?
Player	accept	yes
Avery	response-offer	That's comforting, I wouldn't want him to get thrown off base or anything.
Avery	assert	I think the soldier told his girlfriend it wouldn't be a big deal to sneak a puppy on base.

Figure 1: A sample dialogue with **Avery** character. *Player* refers to the human trainee.

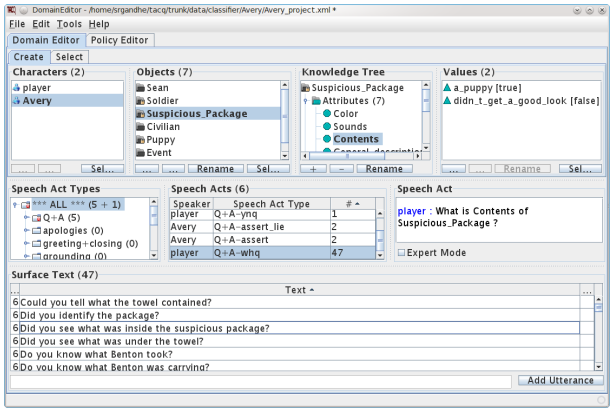

Figure 2: DomainEditor: An Integrated Authoring tool for designing the conversational domain, and specifying the utterances that map to various dialogue acts.

Working in a top-down fashion, the authoring process begins with specifying a domain of knowledge for the character. The basic unit of domain knowledge is an <*object*, *attribute*, *value*> triple. DomainEditor automatically generates all relevant DAs following a dialogue act schema. The default schema was authored by expert dialogue system designers specifically for tactical questioning dialogue systems. It can be easily tailored to add different types of DAs for other kinds of virtual humans. Each DA has a detailed XML representation and a pseudo-natural language gloss that is generated using templates. E.g. A template like "*Attribute* of *Object* is *Value*" is used for the *assert* dialogue act type. Scenario authors then generate examples of natural language texts whose meaning is represented by these DAs.

This top-down approach can be augmented with a bottom-up approach. Once the dialogue system has been built, the designers can collect a dialogue corpus by having human subjects interview the virtual human character. The collected corpus can then be annotated with the most appropriate DAs. For some utterances this may require expanding the character's domain of knowledge. DomainEditor provides these necessary utilities while ensuring *consistency* and *completeness*. Here *consistency* refers to generating only the valid DAs that can be correctly handled by the dialogue manager and *completeness* refers to generating all the DAs that are relevant with respect to the domain knowledge of the character.

3. Evaluation

3.1. Non-experts can author Dialogue Systems

DomainEditor has been used for creating several tactical questioning characters (viz. Hassan, Amani, Ali Sadat, Sean Avery) as well as other non-tactical question-answering characters (viz. Victor, Amber, Bradley). Figure 3 shows a list of these characters along with the information about their authors, corresponding scenarios and the amount of dialogue system resources that were collected.

Hassan was implemented in previous architectures and was ported to the new architecture as the authoring tool was being developed. The rest of the seven characters were authored by *non-experts*. **Amani** was initially developed by a *non-expert* as a tactical questioning character. We conducted a pilot user testing for this character as well as user testing at U.S. Military Academy (USMA) Westpoint where we had access to the target users for tactical questioning systems. A total of 34 cadets interviewed Amani twice and practiced their interviewing skills. This corpus allowed us to identify and fix the deficiencies in our initial dialogue act schema [16, 17]. **Sean** and **Avery** represent two scenarios involving the same character PFC Sean Avery. These scenarios were developed by same author over 3 months. The **Avery** scenario is more complex, including dialogue policies such as deciding on whether or not to lie about certain information based on what has happened in the dialogue. **Ali Sadat** was developed by a USMA cadet, who used his subject matter expertise to effectively circumscribe the character's domain knowledge. One of the guidelines for tactical questioning is to fill out a SALUTE (Size, Activity, Location, Uniform, Time, Equipment) report [18]. Such structure for an interview helps define the domain of interaction rapidly.

Besides tactical questioning, our tool has been used by psychology researchers to build question-answering characters which can be used in their experimental methodologies. These virtual characters provide a consistent experience compared to human confederates and can be controlled precisely by the system designer. **Victor** and **Amber** are two such characters that were developed to teach how to use verbal cues for deception detection. They can answer questions truthfully or deceptively

depending on the mode in which they are being operated. DomainEditor is well suited for creating such characters. A total of 35 participants interacted with these two characters [14]. For this study, the input interface was typed text with an optional

Hassan

Developer ICT dialogue system researchers
Scenario The U.S. Army built a local marketplace which is not used by the locals. Question Hassan to find out why and who is responsible.
Dev time 1 year

Size			
	Player	108 DAs	187 utterances
	Hassan	102 DAs	129 utterances

Amani

Developer Sarah Ali, CS Undergrad student from Jackson State University (*non-expert*)
Scenario Amani has witnessed a recent shooting in the marketplace. The interviewer is to question her to find out the identity, location and description of the shooter.
Dev time 4 months

Size			
	Player	113 DAs	681 utterances
	Amani	89 DAs	98 utterances

Victor

Developer Stephen Michael, Pysch Grad student at University of Texas El Paso (*non-expert*)
Scenario Victor was one the two characters developed for a tutoring system [14] which is designed to teach verbal cues for deception detection. Victor is witness to a bombing at a local abortion clinic. He can operate in two modes truthful or deceptive.
Dev time 4 months (along with Amber)

Size			
	Player	240 DAs	2317 utterances
	Victor	170 DAs	170 utterances

Amber

Developer Stephen Michael (*non-expert*)
Scenario Amber, who has witnessed a shooting, is the second character from the deception detection tutoring system [14].
Dev time 4 months (along with Victor)

Size			
	Player	240 DAs	1792 utterances
	Amber	169 DAs	152 utterances

Sean

Developer Aly Taylor, Communication Undergrad student from East Carolina University (*non-expert*)
Scenario PFC Sean Avery has witnessed a fellow soldier smuggling something suspicious on a U.S. Army base. He can be questioned about what he saw, who the soldier was and who was the accomplice.
Dev time 3.5 months (along with Avery)

Size			
	Player	151 DAs	707 utterances
	Sean	103 DAs	172 utterances

Avery

Developer Aly Taylor (*non-expert*)
Scenario This is the same character PFC Sean Avery interviewed again after the accomplice has been apprehended. Meanwhile PFC Sean Avery has realized that the soldier involved in the smuggling was from his platoon and now wants to cover up the incident. He may choose to lie and will need more coersion in form of threats & offers.
Dev time 3.5 months (along with Sean)

Size			
	Player	193 DAs	811 utterances
	Avery	147 DAs	256 utterances

continued ...

Bradley

Developer Peter Khooshabeh, Psychology PhD Research Fellow (*non-expert*)
Scenario Bradley is a fellow crew member on a space ship which has crash landed on the moon. He is the inventory specialist and can be interviewed to find information in order to prioritize a list of 15 items in this Lunar Survival task. The character is part of an study to investigate how humor affects social influence [15].
Dev time 4 months

Size			
	Player	288 DAs	1207 utterances
	Bradley	272 DAs	188 utterances

Ali Sadat

Developer Jonathan Hoey, Systems Engineering undergrad student from U.S. Military Academy, (*non-expert*)
Scenario Ali Sadat is a shop keeper in Afghanistan and knows about Taliban activities regarding IEDs.
Dev time 2 weeks

Size			
	Player	182 DAs	658 utterances
	Ali Sadat	111 DAs	106 utterances

Figure 3: Various Virtual Human characters that have been created using DomainEditor.

multiple-choice between suggested similar questions while the virtual humans responded with speech performed by animated bodies. **Bradley** was another such character designed to study social influence of humor [15]. A total of 54 participants had conversations with either a humorous or non-humorous versions of Bradley using typed text interface for both input and output.

Figure 4 shows the authoring progress of four such characters which were developed by *non-experts* during summer 2010. This shows that *non-experts* can use the authoring tool to build virtual human dialogue systems in a small amount of time. The ease with which a domain of interaction can be defined affects development time. In fact, Ali Sadat was developed in only 2 weeks.

The authoring process for these characters has two phases. The first phase begins with a top-down process which includes defining the character's domain knowledge first and then authoring the NL texts for all relevant dialogue acts. The growth in the number of dialogue acts represents the growth in character's domain knowledge. As can be seen from figure 4, the domain reaches a stable level relatively early. Most of the domain authoring occurs during this phase. Scenario designers author one or two utterances for each of the character's DAs for some variability. Substantially more examples are authored for player DAs in order to ensure robust NLU performance. The second phase is a bottom-up phase which involves collecting a dialogue corpus by having volunteers interview the virtual human character that has been built. The utterances from this corpus can then be annotated with the most appropriate dialogue act. It can be seen that this second phase is responsible for a rapid growth in player utterances. It can also lead to minor domain expansion and a small increase in character utterances.

3.2. Evaluating the Dialogue Act scheme

Since DomainEditor only allows utterances to be annotated with a DA that has been automatically generated, and dialogue act specification is an expert-task, the chosen dialogue act scheme could be a limiting factor in system development. To ver-

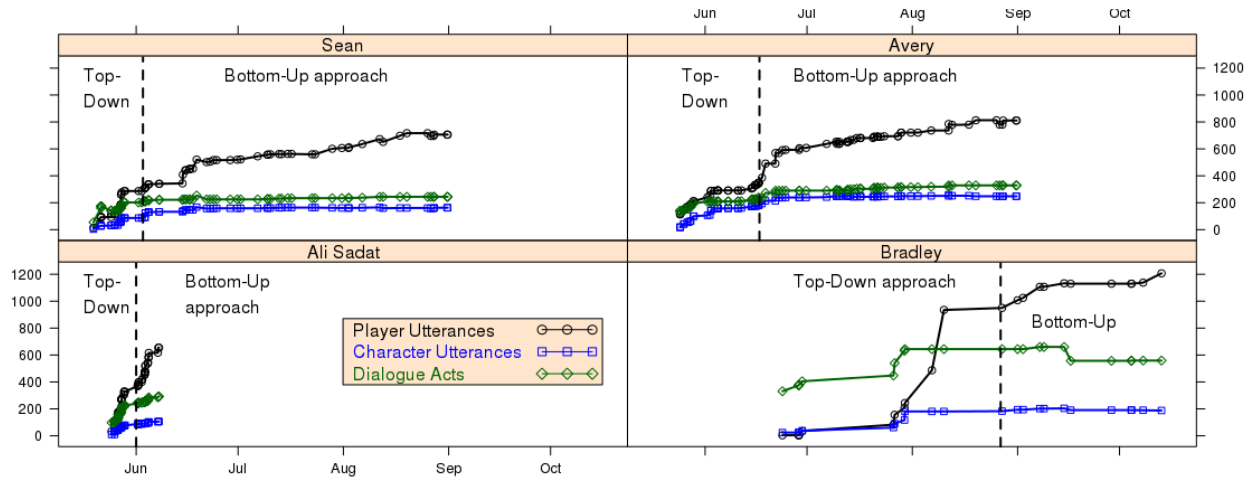

Figure 4: Amount of dialogue system resources collected across time for 4 characters that were authored by *non-experts*.

Corpus	# utts	# player DAs	Reliability α DA	Reliability α in/out domain	Coverage
Pilot study	224	113	0.49	0.38	50%
Westpoint (original)	768	143	0.49	0.33	62-68%
Westpoint (expanded)	799	287	0.63	0.39	72-76%

Table 1: A summary of DA annotation reliability (Krippendorff's α) and domain coverage at different developmental stages for Amani.

ify the coverage of the scheme and understand the complexity of the task, we conducted a dialogue act annotation study for Amani [16, 17] which is summarized in Table 1. Annotators decided whether player utterances were in/out of specified domain and also identified the most suitable DA for each in-domain utterance. The final coverage is fairly impressive given that the players were able to say anything they wanted to Amani, including novel, creative ways of trying to persuade her to reveal her sensitive information.

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