Moving Toward an Intelligent Interactive Social Engagement Framework for Information Gathering

Cindy L. Bethel, Zachary Henkel
Dept. of Computer Science & Engineering
Mississippi State University
Mississippi State, MS 39762 USA
Email: cbethel@cse.msstate.edu,
zhenkel@gmail.com

Deborah K. Eakin
Dept. of Psychology
Mississippi State University
Mississippi State, MS 39762 USA
Email: deakin@psychology.msstate.edu

David C. May, Melinda Pilkinton
Dept. of Sociology
Mississippi State University
Mississippi State, MS 39762 USA
Email: DMay@soc.msstate.edu,
Pilkinton@socialwork.msstate.edu

***Abstract*—The objective of this research is to investigate the use of robots as intermediaries to gather sensitive information from children. The research is multidisciplinary in nature. The goals will be accomplished through the development of an integrated robotic framework that includes a novel architecture and an interactive user interface to gather information using methodologies recommended for forensic interviews with children. The Interactive Social Engagement Architecture (ISEA) is designed to integrate behavior-based robotics, human behavior models, cognitive architectures, and expert user input to increase social engagement between a human and system (e.g., robot, avatar, etc.). ISEA provides for the autonomous generation of robot behaviors for self-preservation and to convey social intelligence. The framework is designed to be modular and adaptable to different applications and domains; however for this project, the focus is on social engagement for information gathering. The interactive user interface provides interviewers with the ability to use a robot as an intermediary for gathering this information. The interface and framework have been iteratively improved through observations from user studies conducted to date with 186 children ages 8-12. This project compares the effectiveness of robot versus human interviewers to gather sensitive information from children using situations in which this would commonly occur – cases of child eyewitness memory and child reports of bullying. This research has the potential to transform how sensitive information is gathered as it relates to criminal investigations and proceedings.**

I. Introduction

The purpose of this research is to investigate the use of robots as intermediaries to gather sensitive information from children. The research goals include the development of an integrated robotic toolkit that includes a novel robotic architecture (see Fig. 1), the interactive social engagement architecture (ISEA), designed to generate autonomous non-verbal and self-preservation robot behaviors, and the investigation and implementation of an interactive user interface designed to improve forensic interviews with children (Fig. 2) [1]. This project compares the effectiveness of robot versus human interviewers to gather sensitive information from children using situations in which this would commonly occur – cases of child eyewitness memory and child reports of bullying. Despite the fact that more false reports are gathered from adults, particularly authority figures (see [2] for a review), the typical interviewer continues to be an adult interviewer. Not only are children more susceptible to misleading suggestions than adults, they also tend to endorse misleading information when it is presented by an adult versus another child [3]. Even well meaning interviewers could bias the gathering of sensitive information by inadvertently alerting the child to their own beliefs, a factor known as *social demands*. Social demands, or demand characteristics, occur when participants have a desire to comply with what they perceive the interviewer expects. This project explores using a robot to interview children to reduce each of these problems caused by human interviewers with the expectation of gathering of more accurate information than adult interviewers in both cases of child eyewitness memory and bullying.

II. Related Work

This project involves the design of robotic systems, which support the forensic interview process. Our work is informed by findings related to child forensic interview protocols and related to the use of social robotic systems. The toolkit currently in development includes a hybrid architecture that is based on cognitive architectures and behavior-based robotics as a foundation.

A. Forensic Interviews

Child maltreatment is a worldwide problem, which is often further complicated by an inability to reliably gather accurate information from children about their experiences [4], [5]. One of the largest challenges is that children often attempt to provide answers that they believe an interviewer would like to hear, meaning investigator biases may affect the responses of children and in turn affect the outcomes of these cases [6], [7], [5]. A forensic interview, which Newlin et al. [8] defines as: *"A forensic interview of a child is a developmentally sensitive and legally sound method of gathering factual information regarding allegations of abuse or exposure to violence. This interview is conducted by a competently trained, neutral professional utilizing research and practice-informed techniques as part of a larger investigative process."* is a standardized protocol, which has been shown to be effective for gathering factual information from children [7], [9], [10], [11]. While the use of a standardized protocol removes many

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interviewer biases, many human-related biases are still unable to be controlled. This project investigates how a social robot might further benefit the forensic interviewing process by providing additional levels of control over the interviewer.

B. Cognitive Architectures and Behavior-Based Robotics

As part of this research, an integrated robotic toolkit that includes an Interactive Social Engagement Architecture (ISEA) is in development that aims to make use of findings from prior research related to cognitive architectures, behavior-based robotics, expert input, and models of human behavior to build a modular framework for use in forensic interviewing. Existing cognitive architectures use symbolic, non-symbolic, or hybrid approaches to model cognitive processes. Architectures like SOAR or ACT-R have traditionally taken a symbolic approach, modeling a problem space and seeking to find a path from one state to another using knowledge available to the system [12], [13]. Extensions of these architectures and newer architectures, like the Psi Architecture, have also incorporated non-symbolic components that make use of fuzzy logic, spreading activations, and Bayesian reasoning to aid in processing data [14]. Non-symbolic architectures often excel at sensorimotor tasks, while symbolic architectures perform well at representing language and logic. As ISEA is responsible for making plans related to the interview's content and direction as well as environmental perceptions and behaviors exhibited through the robot, a hybrid approach is being used. This involves using techniques from behavior-based robotics (e.g., reflexive sense-act) as well as rule-based techniques for modeling an interview's structure [15], [16].

III. Integrated Robotic Toolkit

An essential aspect of this research effort is the investigation and development of an integrated robotic toolkit that is adaptable, generalizable, and modular (refer to Fig. 1). This toolkit applies to interactions of social engagement between a human and a system (e.g., robot, avatar, etc.). The integrated robotic toolkit includes a novel robotic architecture developed as part of this effort, called the Interactive Social Engagement Architecture (ISEA), and a unique interactive user interface (refer to Fig. 2). ISEA provides a framework for the autonomous generation of robot behaviors for self-preservation and to convey social intelligence. The interactive user interface will provide expert forensic interviewers with the ability to use the robot as an intermediary for gathering sensitive information.

A. Interactive Social Engagement Architecture (ISEA)

The ISEA framework integrates behavior-based robotics [15], [16], [17], human behavior models, cognitive architectures [18], and expert user input (refer to Fig. 1). The design is modular and can be adapted to different applications and domains; however for the purpose of this effort, the focus is on social engagement for information gathering, especially with children.

The ISEA framework is comprised of eight modules that include *knowledge, user input, sensor processing, perceptual, memory, behavior generation, behavior arbitration,* and *behavior execution modules*. This architecture has three primary parallel paths for processing behaviors: (1) verbal behaviors based on expert user input from the interactive user interface, (2) self-preservation behaviors if the robot is threatened that consist of both verbal and non-verbal responses, and (3) non-verbal autonomous behaviors generated from sensor data coming from the environment, prior internal state of the robot, user input, and prior knowledge from the knowledge base/long-term memory. The non-verbal behaviors use a hybrid reactive/deliberative architecture [15], [16], with the base reactive behaviors exhibited as aliveness (e.g., eyes blinking, scanning the environment, small movements, etc.) unless a stimulus warrants the display of a more complex behavior, which requires a deliberative approach to determine the non-verbal behavior(s) displayed (refer to Fig. 1). If the robot is being threatened, for example a child getting too close, the robot will perform a protective behavior such as holding up its hands and making a verbal announcement for the child to stop.

The **knowledge module** models human behaviors obtained from observations of forensic interviewers and children during interviews and stores this information in long-term memory. The knowledge module is adaptable and allows knowledge data to be added or exchanged to adapt to other applications, for example protocols for obtaining health information. The **user input module** involves the development of a user interface that will allow an interviewer to ask questions of children following established forensic interview protocols.

The **perceptual module** receives sensor data from the environment (e.g., visual images, auditory sounds, sonar readings, etc.) through the **sensor processing module** and it also receives the current internal state of the robot. It interprets all of this data and sends the results to working memory within the **memory module**. Working memory also receives verbal commands from the user interface and human behavior models from long-term memory. Once this information is processed in working memory, it transmits the results to the *behavior manager* within the **behavior generation module**. The behavior manager receives behavior data from working memory and calculates a behavior activation value and assigns a selection value to each behavior. A gain parameter is set that determines whether specific verbal, non-verbal, and/or self-preservation behaviors should be strengthened or weakened and sets a priority for each behavior. The activated behavior data is transmitted to the coordination function for behavior arbitration. The behavior manager also determines the overall intensity of the next emergent behavior(s) generated and sends that intensity value to the *coordination function*. The coordination function provides a mechanism for arbitrating behavior selection (e.g., ensures that two different opposing commands are not activated for the arm motors) and it sets the intensity value of the emergent behavior displayed by the robot and sends that information to the **behavior execution**

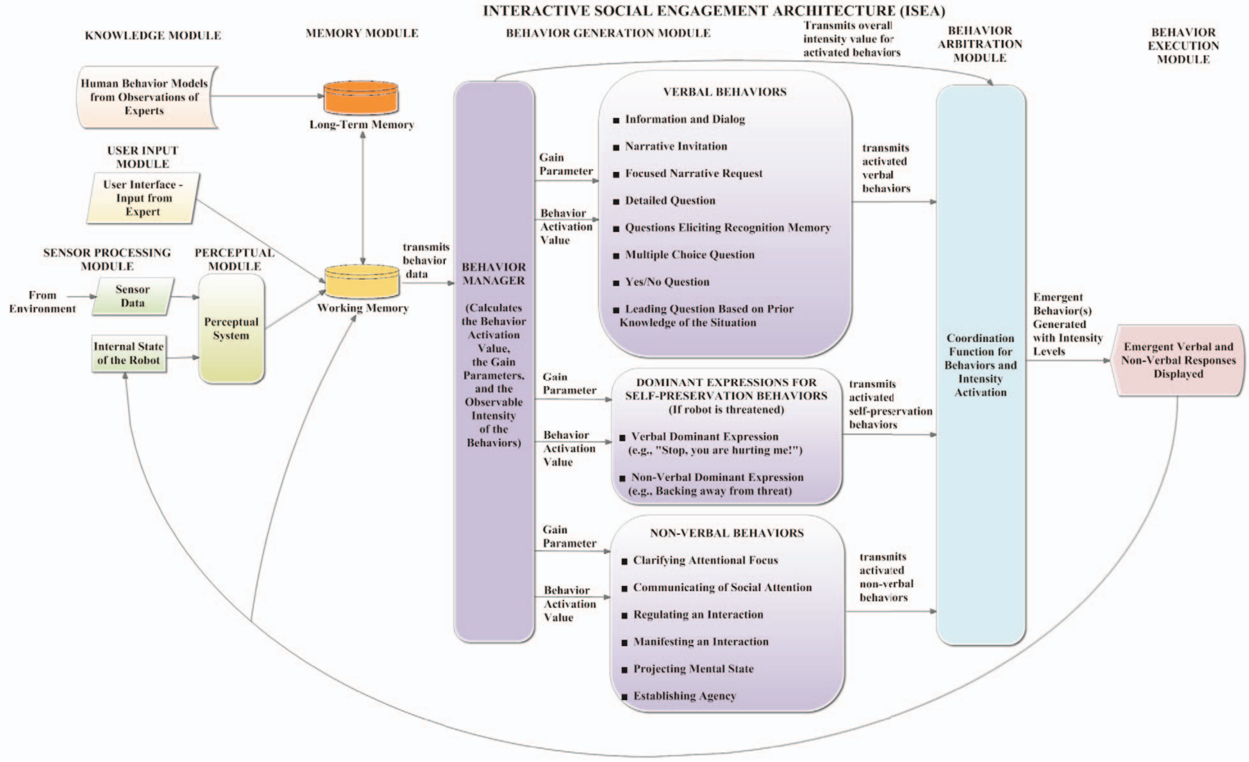

Fig. 1. The Interactive Social Engagement Architecture (ISEA)

module, which activates the emergent verbal and non-verbal responses and displays them for social engagement.

The ISEA allows for multiple behaviors to be activated as an emergent behavioral response. The ISEA may also generate novel emergent behaviors by programmatically combining newly generated behaviors with stored behaviors. The displayed behavior data will update the internal state of the robot and working memory, and if a new emergent behavior is created it is stored along with the associated state data in long-term memory to enhance the knowledge base used by the system. The toolkit developed is comprised of the ISEA, an interactive user interface for information gathering, human behavior models, and knowledge bases that when combined can be used by any agent (e.g., robot, virtual avatar, etc.). The toolkit is adaptable and can be used to display reactions or to react through the agent for social engagement and/or information gathering.

B. Interactive User Interface

An important aspect of the Integrated Robotic Toolkit is the user interface design and the development for use by forensic interviewers to obtain critical information without producing cognitive overload or response delay from the robot (refer to Fig. 2). The simple approach would be to allow the interviewer to speak through the robot to ask questions; however research has demonstrated that having a human voice spoken through a robotic platform causes people to become uncomfortable [19] and perceive the robot as "creepy" [20]. The design of a user interface for information gathering needs to be modular so it can be adapted to the age and background of the person being interviewed and the protocol the interviewer is trained to use [10], [11]. The creation of an adaptable user interface that extends to different types of information gathering will be beneficial to different communities that require user interfaces for social engagement. Participatory design principles have been used to obtain requirements and assess the needs of the user [21]. This approach should improve user experience ratings and reduce the cognitive workload of the interviewer. The interface is designed to address the various question types involved in gathering information (e.g., narrative invitation, focused narrative requests, detail questions, recognition prompts, etc.) [1]. For the purposes of this research, because it is not possible to fully automate this process, the human interviewer would still be responsible for the selection and asking of the questions, but it would occur through the user interface and spoken by the robot. An emphasis will be on the reduction of response delay from the robot intermediary.

IV. Approach

This research compares the impact of a human versus a robot interviewer for gathering information from children. Different approaches have been used as part of this exploration such as using traditional controlled interview questions compared with using forensic interview techniques that rely heavily on open ended questions. The next phases of this research include an investigation on the impact of interviewer's gender and the social intelligence of the interviewers.

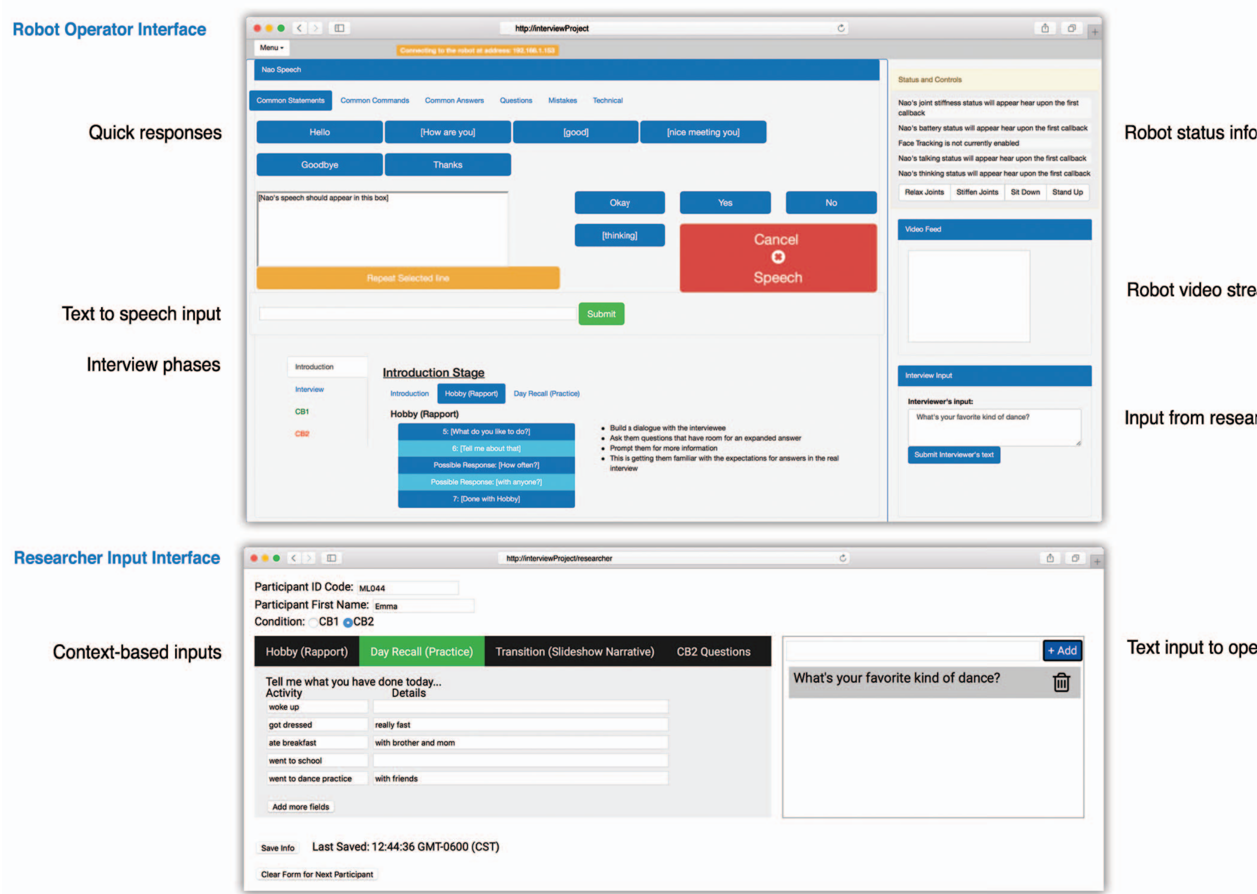

Fig. 2. Robot and researcher interfaces

A. Robots

For this research, three different robotic platforms are being used (see Fig. 3). The first step was to perform studies with a mostly gender-neutral humanoid robot, called NAO from Aldebaran SoftBank Robotics[1]. This robot is toy-like in appearance and the children seem to relate well to this robot. The next phase will explore interviewer gender and to accomplish this, a male and female robot were developed by Hanson Robokind for this project[2]. The male robot, Milo or Zeno, is commercially available; however the female robot, Alice, was custom-made for this project. The literature is mixed when it comes to information gathered based on the gender of the interviewer and the interviewee [22], [23].

B. Forensic Interview Space

This project has a traditional investigative setup for the interviews (see Fig. 4). There is one room in which the interviews are conducted that has child-sized furniture, a round table with chairs, a television to view study information, and an easel for the children to draw items if needed. The room has a one-way observation window and multiple cameras and microphones for recording data from the investigative studies. In another room next door, there is a robot control station, chairs for observers, recording equipment for the data collected from the video cameras and microphones, and an encrypted RAID storage system to maintain privacy of the data stored. A large monitor is used to view all camera angles from the four cameras located in the interview room.

Fig. 3. Robotic platforms used in the project (Nao and Robokind R25)

[1]https://www.ald.softbankrobotics.com/en/cool-robots/nao
[2]http://www.robokindrobots.com/robots/

Fig. 4. Human and Robot Interviewers.

C. Eyewitness Memory

Our current and past efforts have included studies which focus on eyewitness memory and the differences between a human and robot interviewer. Previous work found that college students were more likely to be misled by a human interviewer in comparison to a robot interviewer when performing a memory recall task in which both the human and robot interviewers injected the same misinformation [24] as part of the interview process. We are currently conducting studies which examine this with children using both a traditional interview approach and a forensic interview approach. The participants, children ages 8-12, are presented a slide show that depicts the events of a crime. After watching the slide show, the children perform an interval task to distract them to overcome the effects of short-term memory. Then they go through an interview process that includes both factual information and misinformation. The children will then perform another interval task for approximately 10 minutes, and then they will take a memory test to determine how accurately they recall the details of the slide show. The National Child Advocacy Center protocols are followed when a forensic interview process is used in this research [1].

D. Experiences with Bullying

To examine the differences between the likelihood of children reporting information to human interviewers in comparison to robot interviewers, we have conducted and continue to conduct studies in which children are interviewed about their experiences with bullying at school and outside of school. We have completed studies using a closed form interviewing style, and identified that children were more likely to report being teased about their looks to the robot interviewer in comparison to the the human interviewer [25]. The next phase of this work will examine reports of bullying using a forensic interview protocol with more open ended prompts [1] and looking at male versus female human and robot interviewers (see Fig. 3).

E. ISEA and Interface Progress

Our current progress includes the iterative design of the expert user interface, additional input interfaces, robot aliveness behaviors, and the establishment of a corpus of child responses and interviewer questions. The user interfaces have been developed using an iterative approach, with a focus on allowing the robot operator to respond quickly and interact effectively with children through the Nao robot. Since initial studies were conducted without any existing information on how children would respond, a full Wizard-of-Oz approach was used to generate the robot's responses. As the interview style moved to more open-ended questions, the main interface evolved to support the new demands while an additional interface was developed to allow multiple humans to collaboratively generate the robot's response. This approach distributes the workload of capturing what the child has conveyed to the robot, leading to faster response times. All interfaces are web-based, connecting to a central server over secure WebSockets, allowing for a quick and scalable collaboration during the interviews. As we transition toward the robot performing more tasks autonomously, the need for multiple input interfaces may dissipate. However, in the initial phases of inquiry, which lacked autonomous components, the ability to respond quickly required interface-based solutions.

In our upcoming studies, autonomously generated aliveness behaviors as well as content guided by the corpus of data collected thus far will be deployed. Additionally, we will transition from using the Nao robot to the Robokind R25 robot, which is capable of generating facial expressions. We are currently working to connect our existing interfaces to the additional features of the Robokind robot so that the robot operator's experience is the same regardless of the specific robot in use. Aliveness behaviors, such as eye-blinks and slight head movements are also being incorporated into the next phase of studies. The data we have collected from our studies to date is being used to design a tree-like structure which represents the flow of the interview and the possible branches that may occur at any step of a forensic interview. This data will be used to provide a suggested guide during interviews, which will be refined by recording the actual choices of the operator and responses of children. During this phase we will also collect new sensor data (RGB-D and sound localization data), which will be used to further expand the robot's autonomous abilities and provide more awareness to the robot operator.

V. Discussion

Although this research is only midway through the grant award period, the developments and results are promising. Data is still being analyzed on the most recent forensic interview study associated with eyewitness memory; however there is a significant effect noted that the children may be less likely to be misinformed by the robot interviewer compared with the human interviewer. The children are just as comfortable interacting with and sharing information with the robot interviewer as they are with the human interviewer. In general, the children are more likely to share sensitive information with the robot interviewer compared with the human interviewer when discussing their experiences with bullying inside or outside of the school environment.

By using a robot to conduct interviews, it is possible to control aspects that may influence the information obtained. The robot's questions and verbal interactions can be programmed and controlled, in addition to its behaviors displayed. Human interviewers, even those who are well trained, either consciously or unconsciously can influence the interview process through personal biases, facial expressions, body language, and verbal responses. Most of these factors can be controlled through the use of the intelligent interactive interface and the ISEA framework in development as part of this project.

The early results from this research for both the bullying and the eyewitness memory aspects are showing the benefits of using a robot as an intermediary for gathering sensitive information. The children are more comfortable sharing information with the robot but there is a concern regarding whether they realize that there is still a human behind the scenes that is learning this information and may take action if this was used in an actual interview for legal purposes. This needs to be further explored and determine how to best approach this possible ethical concern.

To be able to reach the full potential of this approach, it is critical to design and implement the Integrated Robotic Toolkit described in this paper. Based on the current state of technology, it is not likely that it will be possible to fully automate the interview process. It is not the goal of this research to replace the human interviewer, but rather to enhance the information obtained through the use of technology. Slow and steady progress is occurring with the development of this Integrated Robotic Toolkit, but there is still significant and ongoing work and research that needs to be explored with this approach.

VI. Conclusions

The use of the Integrated Robotic Toolkit that includes both the Interactive Social Engagement Architecture and Intelligent Interactive Interface can transform the investigative process for gathering sensitive information, especially from children. This technology will assist forensic interviewers but it is not expected to be fully automated to the point of replacing human interviewers. There are significant research questions remaining and extensive user studies are still needed to test and evaluate the developments of this artificial intelligence-based system. The results from early user studies have been positive and support the benefits of using a robot versus a human interviewer, primarily because the robot interviewer's responses and behaviors can be better controlled to limit the possible influence on memory for children and possibly adults.

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