Human-Robot Partnership: A Study on Collaborative Storytelling

Clarice Jiaying Wong*, Yong Ling Tay*, Ruohan Wang† and Yan Wu†
*Raffles Girls' School (Secondary), Singapore 259978
Email: {Clarice.Wong00, yongling.tay00}@student.rgs.sg
†A*STAR Institute for Infocomm Research, Singapore 138632
Email: {wangrh, wuy}@i2r.a-star.edu.sg

***Abstract*—This paper describes the current work on using humanoid robot to augment traditional storytelling for educational and entertainment purposes in casual contexts such as home and classroom. We explore a novel method of Human-Robot Collaboration (HRC) for storytelling and address the question how robots may best augment storytelling. In the pilot study, a humanoid robot, Aldebaran's Nao, was programmed to recite a story to 60 students aged 14 to 15. Nao delivered the performance as either an independent storyteller, or as a collaborator with a human storyteller. We assessed the effectiveness of HRC by comparing the participants' preference over the two settings. We found that 1) most participants prefer HRC over the robot-only performance (RO) and considered HRC effective; and 2) the preference in HRC is explained by the complementary strengths of the robot and human storyteller in interacting with the participants. These results, provide a first step towards effective use of robots for collaborative storytelling in daily situations.**

I. Introduction

Education and psychology research has recognized storytelling as an important technique for skill development in children. Robot storytelling, as an extension to traditional storytelling, has been explored in human-robot interaction. It is considered a promising application for near-term success, because scripted performance in a controlled setting reduces the requirement for sensing and responding to environment stimuli [1].

In this work, we explore human-robot collaboration (HRC) in storytelling, compared to robot-only (RO) storytelling found in previous literature. We aim to address the research question how robots may best augment storytelling in daily situations such as home and classroom settings. We attempt to find out if interaction between human and robot storyteller provides more engaging experiences. Additionally, the presence of a human allows for responding to unforeseen situations and monitoring children's engagement. For instance, parents may collaborate with robots to improve bonding with their children while teaching language skills.

In the pilot study, we conducted an experiment with secondary school students (N=60, native English speaking) aged 14 to 15, A humanoid robot, Aldebaran's Nao, was programmed to recite "Lamb to the Slaughter" [2]. Building upon existing work on robot storytelling [1], [3], we programmed Nao with various gestures and gaze behavior to shape desired outcomes such as information recall and engagement, Nao's speech is generated through its text-to-speech (TTS) system. We used different voice pitches for different characters in the story. The story was told in both HRC and RO settings. A survey was given to all participants after the experiment to measure their preferences between HRC and RO storytelling and to give justifications for their preferences.

Our experimental results show that 1) most participants preferred HRC storytelling and considered it effective; 2) the preference of HRC storytelling is explained by the complementary strengths of the robot and human storytellers in interacting with the participants.

II. Experiment Design

60 students aged 14 to 15 from a secondary school were recruited to participate in the experiment. They were randomly divided into two equal groups. The experiment consists of two storytelling sessions that corresponds to HRC and RO settings respectively. Each session lasts 10 minutes and uses the story "Lamb to the Slaughter". In RO setting, Nao, a humanoid robot, narrates the story while performing the story scenes independently with gestures and gaze behavior. In HRC setting, Nao narrates the story while collaborating with a human storyteller to perform the scenes. The robot's predefined actions are advanced by a wizard in sync with the human ones.

In a counter-balanced manner to measure context effect, both groups attend the two sessions. A classroom setting is chosen to minimize the effects of group experience shift by limiting the interaction among the audiences or with the robot. The groups receive the same post-experiment survey, including questions on background, general perceptions about robots, evaluation of HRC storytelling, and comparison between robot and human storytellers.

Nao's speech for the story was generated by its TTS system. The high, mid and low pitches correspond to voices for female lead, narration and male lead respectively. We implemented Nao's gestures using Choregraphe. Most gestures depicts actions from the story, such as putting things aside. We also included gestures like pointing and hand waving during narration. Gestures are aligned to the beginnings of appropriate sentences from the speech. We also hand-coded the robot gaze. Nao turned its head towards the human collaborator when performing story scenes. It also turned its head from side to side at regular interval to gaze at audiences during narration.

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III. Results

The results shows that participants preferred HRC storytelling. 90% of the participants preferred HRC setting over RO setting. 90% of the subjects also considered HRC setting as an effective method for storytelling. Specifically, 75% of the participants think that Nao improved storytelling as an actor, while 86.7% of the participants think that Nao improved storytelling as a narrator. We found no significant context effect that the order of the two storytelling sessions influenced the two groups' responses on the above questions. 83.3% of Group I preferred HRC storytelling compared to 96.7% from Group II, z=1.22, $p = .11$. Similarly, 86.7% of Group I and 93.3% from Group II considered HRC storytelling effective. We therefore conclude that HRC is an effective method for storytelling and that it is preferred over RO storytelling.

Within the HRC storytelling, 76.6% of the respondents preferred the robot storyteller over the human. The participants were asked to indicate if the robot or human storyteller is more engaging in longer-term. 60% of the subjects still chose the robot storyteller. We found that the participants' preferences between the human and robot storyteller correlate strongly with their choices of storyteller for longer-term engagement, χ^2=24.45, $p < .001$.

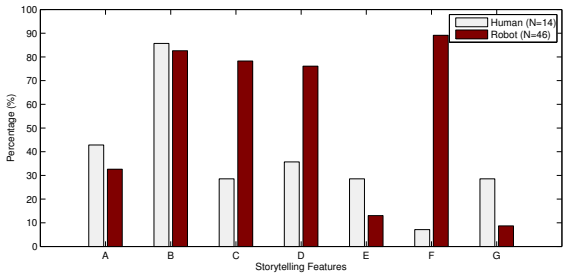
Subjects were asked to justify their choices from a list of key storytelling features. Figure 1a shows that 90% of subjects who prefer robot storyteller think that aesthetic appeal is the top feature. However, when subjects were probed about the features that affect a storyteller for longer-term engagement (Figure 1b), 85% choosing robot storyteller consider variation in pitch and gesture frequencies as top features. The significance of aesthetic appeal dropped to 72%. The reversal is statistically reliable, indicating a shift away from novelty factors such as appealing robots.

IV. Discussion

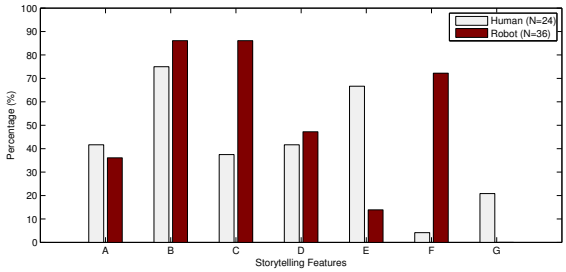
The results suggest that a robot storyteller has significant advantages due to its novelty and aesthetic appeal. Consistent with quantitative results, 86% of the participants indicated that the robot is cool/cute in the free text response to the question "what do you like about robot storyteller?". However, the advantage of aesthetic appeal drops when longer-term engagement is considered. Features like gestures and speech are considered more significant.

The results add to a growing body of evidences about the importance of robot gestures in shaping key outcomes human-robot interaction, such as perceived engagement. Many participants commented that the robot's frequent gestures sustained the level of interaction, while human storytellers may become tired and deliver inconsistent performance.

Speech in storytelling presents a trade-off between human and robot. Though robot is preferred for its varied pitch, and articulate speech, it lacks human emotions and tone variation appropriate to the story. Lastly, human storyteller has clear strength in areas such as eye contacts and other subtle areas, such as the ability to responding to audiences.



(a) Justification for Storyteller Preference: Human vs. Robot



(b) Justification for Longer-term Engagement: Human vs. Robot

Fig. 1. The Figure represents for each feature, the percentage of the participants who chose that feature, out of all participants who chose that feature to support either robot or human. A=Variation in Tone. B=Variation in Pitch. C=Frequency of Gestures. D=Types of Gestures. E=Eye Contacts. F=Aesthetic Appeal. G=Others. Y-axis measures the percentage of the participants who chose that particular reason, given all participants who chose that agent.

The above comparison reflects the complementary strengths of the human and robot storyteller, which could explain why HRC storytelling is preferred. Both human and robots mitigate each others' shortcoming and limitations to deliver more compelling storytelling. Specifically, HRC improves storytelling by combining the consistency of robot performance and the interactivity from human storyteller.

V. Future Work and Conclusion

The pilot study has two main limitations. It has limited generalizability based on 60 girls aged 14-15, due to project constraints. Future work is required to establish the extent to which they generalize to both genders and different age groups. Secondly, HRC should be compared to a robot collaboration scenario to further verify the efficacy of HRC.

We explored HRC storytelling, as an alternative to robot-only storytelling. Our results showed that HRC is preferred and effective. The pilot study identifies the relative strengths of human and robot storyteller. Our results provide a glimpse into further exploration of HRC in educational and entertainment applications, especially for home-based learning.

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