

Towards A Computational Method of Scaling A Robot's Behavior via Proxemics

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ABSTRACT

Humans regulate their social behavior based on proximity to other social actors. Likewise, when a robot fulfills the role of a social actor it too should regulate its interaction based on proximity. This paper describes work in progress to establish methods for autonomous modification of social behavior based on proximity and to quantify human preferences between methods of scaling a robot's social behaviors based on distance from a human. The preliminary results of a 72 participant human study examine the reaction to scaling with linear methods and perception-based methods. Results indicate significantly higher ratings in multiple areas (comfort, natural movement, safety, self-control, intelligence, likability, submissiveness $p < .05$) when using a perception-based scaling function, as opposed to a linear or no scaling function. Work in progress is analyzing the biometric measures collected.

Categories and Subject Descriptors

I.2.9 [Robotics]:

General Terms

Experimentation

Keywords

proxemics, scaling function, proximity

1. INTRODUCTION

The phrase “proxemics” was coined in 1966 by Edward Hall to describe the correlation between physical distance and human social behavior[4]. As suggested by the computers are social actors paradigm[6] and supported by human-robot interaction studies[2, 1], the same relationship exists in human-robot interaction scenarios. However, while studies have confirmed the existence of human-robot proxemics, none have suggested a computational method for generating proxemic behavior.

Our recent 72 participant study suggests a computational method which can be used to autonomously modify robot behavior in order to accomplish social competence. The method of scaling robot behavior (locomotion speed, head-gaze act speed and range, and lighting intensity) based on

proxemics was derived by exploring one physics and two psychology laws: the inverse-square law and Weber-Fechner's Law and Steven's Power Law. Participants strongly preferred scaling derived from physics and psychology laws.

2. EXPERIMENTAL APPROACH

In order to test the theory of proxemic scaling, a human-robot interaction study which examined three varying conditions was designed. The robot used in the study consisted of a Survivor Buddy robot mounted to an Inuktun Extreme robot. The robot travelled through a simulated disaster site, approaching participants who were acting as victims. As the robot approached the participant it engaged in a conversation complete with head gaze acts as well as fixations on objects in the environment. The robot used synthesized speech, followed a predefined motion path, and navigated its dialog script via a wizard of oz approach. In the final few minutes of the interaction, participants were asked to place their hand on the robot in order to allow the robot to take their pulse (simulated). The experiment was run using a



Figure 1: Simulated Disaster Site.

no scaling case, a *linear scaling* case, and a *perception-based scaling* case. In the no scaling case, the robot travelled at a medium velocity, used medium speeds and ranges for head gaze acts, and used medium intensity headlights throughout the entire interaction. In the linear and perception-based cases, the robot scaled its attributes, like speed, range and intensity based on its distance from the human participant. The difference between cases was the function used to determine the magnitude of each characteristic. In the linear case, a simple linear function was used, mapping slower speeds,

limited range, and low intensity lighting to the area closest to the participant and higher values to locations further away. In the perception-based case, a function derived from a combination of physics and psychology laws was used to map the robot's characteristics.

Pre-interaction and post-interaction questionnaires were administered. Questions which measured comfort, natural movement, safety, self-control, attentiveness, empathy, happiness, intelligence, likability, sensibility, submissiveness and trust were obtained from previous studies [3] [5].

In order to gain more insight into areas which concerned proxemic performance, questions were developed specifically for the area of personal space consideration. All items were on a one to seven Likert scale, with one being strong disagreement or strongly negative and seven being strong agreement or strongly positive.

Our primary measures of social consistency encompassed the attributes: comfort, natural movement, personal space consideration, safety, and self control. Additionally, the secondary attributes of attentiveness, empathy, happiness, likability, intelligence, sensibility, submissiveness, and trust play important roles in the interaction. We believe the primary attributes to be necessary for social consistency.

3. EXPERIMENTAL RESULTS

Results indicated that all of the primary attributes (comfort, personal space consideration, safety, natural movement and self-control), along with three of the secondary attributes (intelligence, likability and submissiveness) out of a total of 12 attributes proved to be significantly better in conditions which employed scaling as opposed to the condition which did not.

In all of the primary attributes (comfort, personal space consideration, safety, natural movement, and self-control) and three of the secondary attributes (intelligence, likability, and submissiveness), perception-based scaling proved to be significantly better than no scaling. Linear scaling indicated no significant difference opposed to no scaling, except in the cases of comfort and personal space consideration. In the area of comfort, a clear rank was demonstrated with significance between all conditions, and perception-based scaling being rated the highest of all conditions (See Figure 2). However, in the area of personal space consideration, both linear and perception-based proved to be significantly better than no scaling, while perception-based did not prove to be better than linear. This suggests that linear and perception-based scaling are both acceptable in the area of personal space consideration.

4. CONCLUSION

Our findings offer three important pieces of information for robot designers. First, our studies serve as a confirmation that modification of effectors as a function of proximity can create a more positive interaction. Though this has been touched on in previous work, we now are able to confirm through a multi-faceted and complex interaction task that proximity is an important factor in generating behavior. Second, we have illustrated that the choice of scaling function is critical in the modification of social behaviors. Our findings show clear and significant differences between the evaluated functions, meaning careful consideration must be given to the type of function selected for the implemen-

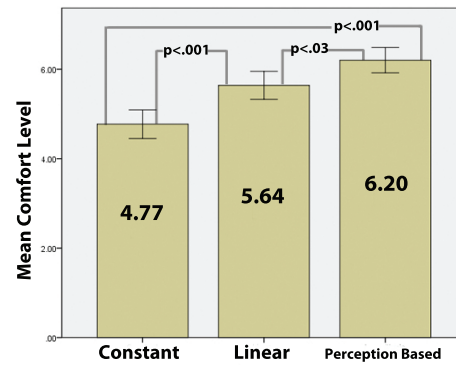


Figure 2: Comfort Level

tation of proxemic scaling. Finally, our work suggests that a perception-based function is the best starting point for further design or investigation of proxemic scaling of social robot behavior.

The criticality of scaling a robot's social behavior with respect to proxemics has been clearly illustrated. Through the examination of a 72 participant study the clear preference for perception-based scaling is evident. Through a multi-faceted interaction, not only has the benefits of proxemic scaling been illustrated, but also the critical nature of choosing the correct scaling function. These findings serve as a confirmation of the importance of proximity, as well as guide for future design of social robots.

5. ACKNOWLEDGMENTS

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