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Adapting Robot Behavior to User's Capabilities: a Dance Instruction Study*

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ABSTRACT

The ALIZ-E[1] project's goal is to design a robot companion able to maintain affective interactions with young users over a period of time. One of these interactions consists in teaching a dance to hospitalized children according to their capabilities. We propose a methodology for adapting both, the movements used in the dance based on the user's cognitive and physical capabilities through a set of metrics, and the robot's interaction based on the user's personality traits.

Categories and Subject Descriptors

H.1.2 [**Models and Principles**]: [User/Machine Systems]; I.2.9 [**Artificial Intelligence**]: Robotics—*Commercial robots and applications*

General Terms

Design, Measurement, Experimentation, Human factors

1. INTRODUCTION

When designing a robot that will interact with users while performing a task we must bear in mind two main aspects: (*i*) how will the robot perform the task, i.e. the engineering point of view (which actions is the robot going to perform?, how and when is it going to perform them?); and (*ii*) how will the robot interact with the user and how this interaction will modify the performance of the task, i.e. the social point of view (when should the robot start the interaction? what type of feedback to provide? when to stop the interaction?).

The goal of the ALIZ-E project is to design a robot companion able to maintain believable multimodal affective interactions with young users over an extended period of time. The robot will be tested at San Raffaele Hospital, providing support for hospitalized children with diabetes and obesity.

In the first stage, the robot is supposed to establish a bond with the child through verbal and non-verbal interaction. One of these interactions consist in having dance sessions with the hospitalized children according to his/her capabilities. Creative dance appears to be a valuable instrument for stimulating or enhancing physical and social/emotional growth in people [1]. On the one hand, it motivates exercise through a fun activity for children, and on the other hand, it also helps the development of social skills such as cooperation, self-confidence and communication. To this end, we have interviewed dance teachers to both, learn about dance teaching techniques (i.e., the engineering aspect of the task) and strategies to adapt the dance sessions based on the interaction with the user (i.e., the social aspect of the task). In both cases, the user's profile is taking into account as we describe in next sections.

This paper mainly focuses in the design of the dancing task based on the user's model, although we also propose the influence of social queues in the task performance. We conclude the work describing a first experience where the Nao robot teaches a dance to two children.

2. ADAPTING THE TASK

A common and simple technique to teach a choreography dance consists of a two-steps methodology. First the teacher shows the movements used in the choreography independently, focusing and evaluating whether they are correctly perform in technical terms (i.e., position and movement of the different body parts) – the *exploration* stage. Once these have been learned in a satisfactory way, the teacher proceeds to teach the choreography using the movements shown before – the *dancing* stage. The sequence is gradually enlarged including new movements as the sequence is memorized and correctly performed. If at a given point a movement is not correctly performed the teacher reviews that single motion and then continues with the rest of the sequence.

Two main questions have to be addressed in order to adapt the performance of the task to the user's cognitive and physical capabilities: (*i*) movement selection, i.e., which movements to include in the choreography and (*ii*) performance evaluation, i.e., how well the user has performed. In both cases we need to define metrics that will allow the robot to determine those movements that the user is able to perform (or would be able after practice) based on their complexity and to evaluate the user's performance within his/her own limitations.

Based on the literature on fundamental motor skills development [2, 1, 3] and after discussion with professional dance teachers[2] we propose the following measures:

- *balance*: how much effort is needed to balance the body to not to fall from a given position (e.g. two feet, one

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[1] http://www.aliz-e.org

[2] Language of Dance Centre (London, UK) and Scuola di danza Ida Petrullo (Costamasnaga, Italy).

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foot). Jumps correspond to a specific type of balance where there is no support during a short period of time.

- *flexibility*: how forced are the body joints when performing the motion (e.g. lean forward, somersault).
- *layered movement*: number of body parts moving in different ways (e.g. moving the arms and the legs at the same time would correspond to two layers). This measure can also be seen as self-coordination, where the coordination of the different body parts its more complex as more parts are implied.
- *synchronization*: synchronizing the self-movements with other partners (robot, other users).
- *strength*: how much strength from a body part is required to perform the motion (e.g. elevating the leg requires a strength in the thigh).
- *speed*: how fast the movement is performed. Some movements may be easier when being performed fast (lifting a leg), while others, when being performed slow (moving different body parts at the same time).

While the measures described above characterize movements individually, the following measures can determine the complexity of the overall choreography:

- *recall*: number of different movements the dance is composed of. The more movements it is composed of, the harder it will be to memorize.
- *rhythm*: following the rhythm is more complex than just performing the movements at any pace.

3. ADAPTING THE INTERACTION

Following the general ALIZ-E project methodology, affective aspects including personality and emotions will be considered for achieving an adaptive robot behavior in order to persuade and guide the user when performing the task. Based on the current state of the art (e.g. [4, 5]) we plan to adapt the following key-points in the teaching methodology:

- *movement selection*: the complexity of the movements varies from "easy" to perform to very "challenging" within the user's capabilities. Based on the user personality traits the robot may start the activity with simpler movements or with more challenging ones.
- *performance evaluation*: we define parameterized evaluation metrics that will allow to obtain outcomes ranging from "flexible", where a minimum effort of reproducing the motion will produce a positive evaluation, to "strict", where only correct motions, from a technical point of view, will be considered a success.
- *feedback*: different types of feedback should be provided to the user to assist the learning stage of the movements and the recalling phase when memorizing the dance sequences. Based on his/her cognitive capabilities verbal descriptions of the movements can be given in a technical way (e.g. raise both arms extending your arms to the maximum); in a pictorial fashion (e.g. stretch your arms as if you were trying to touch the sky); comparing movements with well known characters (e.g. fly like Superman); or even providing visual images (in this case additional resources as cards with pictures or a screen can be used).

Moreover, variations during the dance session are essential based on the current emotional state of the user. Thus, besides taking into account the general user's personality traits, in the project we also consider his/her current emotional state to fine tune the way the session will take place according to the aforementioned aspects, as well as the duration of the session (probably shorter sessions are more appropriate for non-motivated users).

4. CONCLUSION

A first experience with two children (7 and 11-years-old, both girls) has been performed with the Nao robot. The aim was to observe a first interaction of the dancing robot with them. The choreography has been designed by a dance teacher, and a short version of it (45 sec.) was tested with the children. It included four main movements: ranging from simple arm movements (single layer motion) to combination of arms and legs (layered motion), and two balancing motions (lifting one leg to the side). The dance included music, although for this first essay following the rhythm was not required. Both children enjoyed the session and did not get bored (even if the robot crashed at some point having to initialize it again).

We have confirmed the need of designing adaptable evaluation metrics, not only to base them on each person's capabilities, but also to consider differences on the robot's motions and the user's ones (e.g. closing the legs sliding is easy for the robot, but it seemed hard for the children to reproduce it –probably because the shoes were not appropriate as well–). Regarding the feedback provided to the user, the robot should dance along with the child and not only observe how he/she is doing after showing the motion for the first time. Children seem to mirror the robot's actions, and if it stops, the children stopped as well. Thus, giving continuous feedback (specially visual) will improve the child's comprehension about the action to perform, and will also increase his/her self-confidence for dancing.

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