Dance Choreography Design of Humanoid Robots using Interactive Evolutionary Computation

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Abstract—Our work deals with a usage of artificial intelligent techniques in humanoid robotics. The focus is on social robotics and how to improve the interaction between human and robot. We used the Interactive Evolution - this technique optimizes systems based on subjective human evaluation. The algorithm is applied to a system of design of robotic dance, in which the Evolutionary Algorithm helps user to create choreography of the robotic dance.

I. INTRODUCTION

The discipline of artificial intelligence (AI) builds computational systems inspired by various aspects of life. An evolutionary algorithm is an optimization algorithm which uses some mechanisms inspired by biological evolution coming out from Darwinian Theory. More and more AI researchers are trying to make robots dance. We used a form of evolutionary algorithm called Interactive Evolution to design a system of Robotic Dance for humanoid robots. User interactively cooperates with the System designing his own robotic dance choreography. We think that the interaction between humanoid robots and people is the key factor of their success, because they must exist in a human environment.

II. STATE OF THE ART

A. Research in humanoid robotics

According to Brooks [2], the implicit dream of Artificial Intelligence (AI) has been to build human level intelligence. Building a humanoid is the challenge par excellence for AI and robotic workers. AI tries to make programs or computers do things that, when done by people, are described as having indicated intelligence.

The goal of AI has been characterized as both the construction of useful intelligent systems and the understanding of human intelligence. Since AI’s earliest days there have been thoughts of building truly intelligent autonomous robots. In academic research circles, work in robotics has influenced work in AI and vice versa [2].

Recent generations of humanoid robots (HR) increasingly resemble human in shape and capacities. HR are robots that are at least loosely based on the appearance of the human body. In community of AI, by humanoid we mean not only a robot that has the physical appearance of a human, but also has a fairly advanced artificial intelligence, allowing it to reasonably approximate human behavior and interactions. New trends in research consider the robots ability to interact with people safely and in natural way. The current leading topics in HRs are so-called service and social robotics - where the target is getting robots closer to people and their social needs. There are many attempts to create robots capable of expressing emotions or communicating in a natural language. Research topics in human-robot interaction according to [3] include the following: Friendly human-robot interfaces, Safe human-robot interaction, Emotion expression and perception and Social learning.

B. Dance in humanoid robotics

Dance is a largely social activity - whether for aesthetic pleasure, entertainment, communication or ceremony - and is likely linked to our innate socially.

Numerous works on robotic dance systems are presented in [1]. Researchers at the University of Tokyo have developed the learning-from-observation training method, which enables a robot to acquire knowledge of what to do and how to do it from observing human demonstrations. At the Kyoto University they apply a method called intermodality mapping to generate robot motion from various sounds and also to generate sounds from motions using the back-propagation through-time algorithm. Other approach from Tokyo University is using Chaos to trade synchronization and autonomy in a dancing robot. Dancing Robot Partner built at the Tohoku University is well-known in the domain of robotics. Their robot acts as a female partner and

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Fig. 1. Possible output our system: generated motion. It is very difficult to show a demonstration of our final dance show in pictures but it is possible to watch a video of the output available on internet: youtube source.
realizes ballroom dances in coordination with a male human dancer by estimating his intention.

Although some of the mentioned systems are examples where interaction between human and robot is the key factor of their success, they are exceptions in the world of robotic dance. The majority of dance systems of robots are only pre-programmed motions and after a while user find them boring. The proposed system in this work interacts with human and the motion is evolving in accordance with his evaluation of the seen dance section.

III. DESIGN AND IMPLEMENTATION OF ROBOTIC DANCE EVOLVING SYSTEM

A. Interactive evolution

The Evolutionary Computation (EC) is a population-based searching algorithm and outputs multiple candidates, each called an individual, as system outputs. It is a probabilistic search algorithm based on the mechanics of natural selection and natural genetics. The space of all feasible solutions is called search space. Each point in the search space represents one feasible solution - each of them can be "marked" by its value or fitness for the problem. Crossover selects genes from parent chromosomes and creates a new offspring. To prevent falling all solutions in population into a local optimum of solved problem, mutation takes place, which changes randomly the new offspring.

There are two types of target systems for system optimization: systems whose optimization performances are numerically - or at least quantitatively - defined as evaluation functions and systems whose optimization indexes are difficult to specify. IEC is an optimization method that adopts EC among system optimization based on subjective human evaluation. It is a technology that embeds human preference, intuition, emotion, psychological aspects, or a more general term, KANSEI, in the target system.

The goal of dance choreography design is to create some 'nice dance performance'. However, there is no general standard of 'beauty of dance', and it is almost impossible to organize fitness function in regular EC. IEC might be a solution for this - it can reflect personal preference because it percepts fitness directly from user instead of computing using some function.

Humanoid robot Nao comes with 25 degrees of freedom for great mobility. The inertial sensor and closed loop control provide great stability while moving and enables positioning within space. Its state-of-the-art onboard actuators give Nao extreme precision in its movements [4]. Each phenotype represents one joint of Nao and his position in angles. The value of fitness in interactive evolutionary algorithm is obtained from user of the system. Users evaluate robotic dances and give them marks according to their preferences. After user evaluates the first, random generation of dances of the robots, the algorithm produces the next generation of dances.

IV. EXPERIMENTS

We used 20 people, mostly university students, as our subjects. The experiment consists of two parts: they had to design their dance choreography in simulation environment Webots, a 3-D simulator of many types of robots, and then try it on real humanoid robot Nao. First, the subjects were shown examples of how to create the choreography evaluating the postures and motions generated by the system. Then, they freely observed the robots in simulator and created their own dance. Subjects were evaluating the dances until they were satisfied with the generated dance or the algorithm converged to one dance. Many interactive EC tasks do not require a large number of generations to achieve satisfactory results [5].

The subjects answered a questionnaire about their subjective evaluations of the system. They estimated positively the easy use of the proposed system so we consider the GUI user-friendly. They also coincided that system is a helpful tool to create new robotic dance choreographies.

V. CONCLUSION AND FUTURE WORK

This work presented a multi-robot system capable of evolution of dance choreography using interactive genetic algorithm. Results showed that the interactive genetic algorithm approach to robotic dance choreography design aid system is promising. The robot Nao has a human-like appearance and various sensors for interacting with humans. We performed an experiment to evaluate the developed system and analyzed if it is a good aid for unexperienced observers to create their own robotic dance. We believe that the IEC will make interactive robots more personal in interacting with humans. The global idea is that every person can adapt the robots behaviour in accordance to his own expectations and preferences.

Our vision is for Nao to acquire its own mental model of people. Currently, he does not reason about the emotional state of others. It means that we want to extract the information about the own preferences of human during his evaluation of the behaviour of the robot in the interactive evolutionary algorithm and make this process autonomous. According to Brooks and Breazel [2] the ability to recognize, understand, and reason about another's emotional state is an important ability for having a theory of mind about other people, which is considered by many to be a requisite of adult-level social intelligence.

REFERENCES