Towards a Believable Social Robot

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Abstract. Two perspectives define a human being in his social sphere: appearance and behaviour. The aesthetic aspect is the first significant element that impacts a communication while the behavioural aspect is a crucial factor in evaluating the ongoing interaction. In particular, we have more expectations when interacting with anthropomorphic robots and we tend to define them believable if they respect human social conventions. Therefore researchers are focused both on increasingly anthropomorphizing the embodiment of the robots and on giving the robots a realistic behaviour.

This paper describes our research on making a humanoid robot socially interacting with human beings in a believable way.

Keywords: Believability, social robots, human-robot interaction.

1 Introduction

Believable characters have always been a central issue since the first attempts in the entertainment industry for making attractive movies, cartoons and games. From 1970s to the present days, with the rapid advances in computer graphics, robotics technology and artificial intelligence, many fictional characters are becoming reality. The type of interaction is definitely based on the nature of the robot itself and on the aim which guided its development.

Social robots represent an emerging field of research focused on developing a "social intelligence" in order to maintain the illusion of dealing with a real human being. The term "social intelligence" implies the ability to interact with other people, to interpret and convey emotional signals and to perceive and react to people's intentions. On first encounter, the believability of a robot is communicated through its physical embodiment which strongly influences people's expectations about how it behaves. Later on the perception of believability of the robot is given by its expressiveness, behaviour and reactions to external stimuli which can make a human-robot interaction more or less natural and lifelike.

The purpose of this article is to show the architecture of a system for controlling a social robot in a believable human-like way. In particular, we focus the attention on integrating a reactive system to quickly respond to external signals in real time with a more expressive deliberative model to deal with complex situations and to plan actions compatible with the knowledge base of the robot.

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2 Towards a Hybrid Architecture

FACE (Facial Automaton for Conveying Emotions) is a humanoid female robot, developed in collaboration with Hanson Robotics, used as an emotion conveying system. It consists of an artificial skull covered by a porous elastomer material called Frubber^{TM} and a passive mannequin body. Inside the skull, 32 servo motors are positioned as the major facial muscles making the robot capable to simulate realistic facial expressions. Fig. 1 shows the current architecture for controlling FACE and its future implementations.

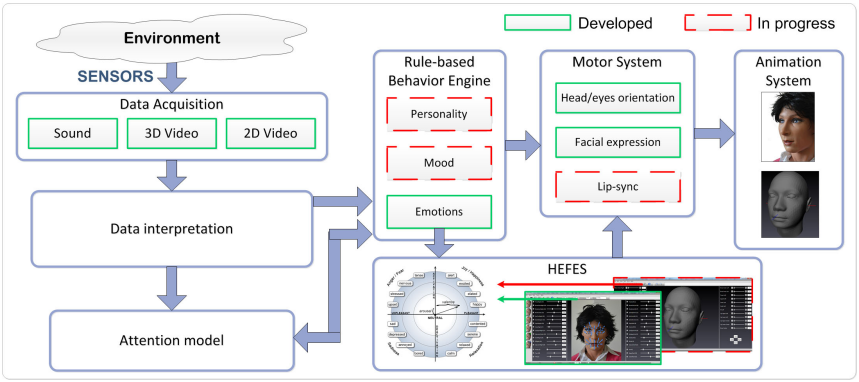

Fig. 1. The general architecture for controlling FACE

A set of sensors are used to capture and extract verbal/non-verbal cues of the people in the surrounding environment such as facial expressions, gestures, position, and speaker's position, and features of the scene such as colour and intensity. This information is processed by the data interpretation module to create a meta-scene, i.e. a description of the current scene which results from the integration of social relevant cues coming from the people analysis and the saliency map based on the pixel-based analysis [1]. Based on the meta-scene, the attention model determines what is the target point towards which the gaze attention of the social robot should be directed and how this target point should be looked at by the robot in terms of eyes and head movements.

The behaviour engine is based on CLIPS [2], a rule-based expert system which includes: a *working memory* which defines the affective status of the robot in terms of emotions and mood and describes the scene in terms of asserted facts; the *knowledge base* which is applied as if-then-else rules (deliberative behaviour) and functions (reactive behaviour) and represents the reasoning and planning capability of the robot; an *inference engine* which connects the working memory with the knowledge base to perform the actions coherently with the status of the robot and with what is happening in the surrounding environment.

If "behaviour" indicates a purely reflexive action in a reactive paradigm, the term is nearer to the concept of "skill" in a deliberative paradigm. The first

paradigm is a world of reflexive behaviours which control the reactive aspects while the second paradigm is the world of symbolic reasoning which controls the deliberative aspects. For example, the information "I have detected a person in the scene" in the first paradigm could become "There is John, I have already seen him" in the second one. Indeed detecting a person means to only store the coordinates of the subject in the first paradigm or to predicate something more starting from the knowledge base and applying the rules in the second paradigm. Therefore, in order to make the robot socially believable, its behaviour has to emerge from the combination of the reaction to external stimuli in real time, through functions which transform sensor data into actuator commands, with the a priori knowledge of its world, through rules which operate on symbolic information.

At the same time the behaviour engine influences the attention model as our attitude affects the point and the way we look at [3]. The output of the behaviour engine is a configuration of different actions which include facial expressions, the orientation of the head and eyes and in the future lip-sync motions. All the possible expressions performable by FACE are generated by HEFES [4], an engine for synthesizing new expressions and interpolating them in an emotional space.

3 Conclusion and Discussion

Starting from a pure reactive system [5] we moved towards a hybrid structure in which the reactive behaviour is integrated with a deliberative reasoning taking into account the current status, the social context and the environmental conditions. The reactive level ensures that the robot can handle the real time challenges of its environment appropriately while the deliberative level endows the robot with the ability to perform more complex tasks that require reasoning.

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