User-centered design of robot personality and behavior

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Abstract
Appropriate design of the interaction between humans and robots will be a crucial factor for the acceptance of domestic robots. A promising approach is to equip robots with life-like and social characteristics. A coherent personality expressed through behavior can help users to understand and predict the actions of a robot. We describe existing approaches for designing robot personality and argue that an integrated design process is needed.

Keywords
Robot personality, Robot behavior, Design method, User-centered design, human-robot interaction

ACM Classification Keywords
H5.2. User Interfaces

General Terms
Design, Human Factors

Introduction
Advances in technology allow robots to move from factories into more complex and dynamic environments such as homes, where they provide services directly to people [4]. Contrary to most industrial robots, domestic robots need to be very skilled in communicating with

humans. Currently, many products come with technical explanations in user manuals. But this will become more difficult with complex products such as robots. Users cannot be expected to learn about sensors, actuators and control architectures before interacting with the robot. Instead, a mental model could help the user to make sense out of the robot's behavior and to understand which actions are needed from his side. Appropriate design of the interaction between humans and domestic robots will be a crucial factor for the understanding and acceptance of these products [16]. Hence, this will be the focus of our paper.

Research has shown that robots will induce the perception of being life-like and having a certain personality through their appearance and behavior [9][12]. A promising approach in the field of Human-Robot Interaction is to make use of this phenomenon and to explicitly design robots with life-like and social characteristics [1][4]. Some examples of these life-like characteristics are the ability to express and perceive emotions, to maintain social relationships, to use natural cues in behavior, and to exhibit distinctive personality and character. A crucial requirement to enable the perception of these high level characteristics is a believable, life-like robot personality.

Dautenhahn et al. conducted a study to investigate what people expect from a robot companion [3]. They found that people's expectations of the robot's behavior match to a certain degree the expectations of a social communication partner's behavior. For example, the robot should move with similar speed as humans, it should not come too close, and it should be polite (e.g. by giving way). These expectations apply only to the communication with the device and not to its function, as only few participants wanted the robot to take social roles. Instead, the notion of an assistant or servant was preferred. Interestingly, the majority of participants reported a preference for predictable behavior. While this seems to contradict the notion of a believable social character on the level of behavior sequences (e.g. non-repetitive movements), it matches with higher level constructs such as personality traits. Intuitively, people know what to expect from another person even though the behavior is never exactly the same. Therefore, we believe that a coherent personality expressed through behavior can help users to understand and predict the behavior of a robot.

Personality and behavior

Personality is extensively studied in psychology. The Big-Five theory is supported by most empirical evidence and is a generally accepted theory[8]. It describes human personality in five dimensions: extraversion, agreeableness, conscientiousness, neuroticism, and openness to new experiences. We believe that the Big-Five can also be used as a framework to describe and design the personality of robots. Norman [11] describes personality as: "a form of conceptual model, for it channels behavior, beliefs, and intentions into a cohesive, consistent set of behaviors". This indicates that deliberately equipping a robot with a personality helps people understanding the behavior. Questions that arise when explicitly designing a robot personality in a given application are what kind of personality is appropriate and facilitates the interaction, and how to express the personality in the behavior of the robot?

Existing design methods

Several approaches to design personalities for robots have been reported. However, up to now there is neither a consensus on general design rules for personality design, nor a unified design process. Existing approaches can be clustered in three main perspectives: (1) technology-driven, (2) artistic design, and (3) user-centered.

Technology-driven

When the first robots were constructed, the behavior was fully determined from a technological, functional point of view. Hence, the behavior was a consequence of functional requirements (e.g. navigating via the shortest path), as well as hardware constraints (e.g. maximum speed). In the subsumption-architecture proposed by Brooks [2], the overall behavior of the robot is explicitly an emergent feature, composed from simpler basic actions and therefore difficult to control on a macro level. How the user perceives a certain behavior had only later been taken into account. For example, Kawamura et al. [6] stressed the necessity for ease of use of a service robot, but bases multiple design decisions on technical constraints of a particular robotic platform.

The technology-driven approaches focus on specific technical implementations. Even though the underlying technology is an essential factor for the feasibility of a robotic application, it tends to narrow the design space by technical limitations, rather than by user insights.

Artistic design

The artistic approach is mainly concerned with the expression of behavior. The underlying idea of conveying messages through expressive behavior is borrowed from the field of movies and animations [14]. Van Breemen [15] was one of the first to apply animation technology to the development of robots. He illustrated that the behavior of a robot appears to be more life-like by adhering to some of the animation principles. However, traditional animation guidelines cannot directly be translated to the design of robotic behavior [13]. For example, screen-based characters do not need to adhere to physical laws, which allow them to perform actions that are impossible for a robot.

Several guidelines have been developed that support the designer to make and justify choices. But these are not very specific or restrictive and rely on the artistic skills of the designer.

User-centered

User-centered approaches are commonly used in the field of human-computer interaction (HCI) and adopted to design robotic characters. The key principle is an iterative design cycle to evaluate and refine the system with a strong focus on the user needs. Many user-centered design approaches have been reported in literature. For example, Ljungblad et al. [7] used the concept of personas to guide the design process for creating personalities for artificial agents.

Despite the focus on the user, creativity of the designer still plays an important role. Höök [5] criticizes formal approaches of user studies, since they do no capture the fine grained facets of personality and affective design. She proposes a two-layer design approach. The first level focuses on the usability, by verifying whether basic design intentions such as emotional expressions are understood by the user. On the second level, it is verified whether affective aspects in the design

contribute to the user experience. The user becomes an integral part of the design process.

Integrated design approach

Although several approaches to design personalities for robots have been proposed, there is no practical unified process that integrates a user-centered, artistic, and technical perspective on robot personality. We believe that an integrated design process is needed and have developed a method to design personality and behavior for domestic robots. The method consists of four main steps, namely creating a personality profile, expressing a personality in behavior, specifying behavior in design rules, and implementing and evaluating the behavior with end-users. In these steps, a variety of tools and techniques are adopted from HCI. We will describe the method in detail in an upcoming book chapter [10].

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