The Robot Head "Flobi": A Research Platform for Cognitive Interaction Technology

Sven Wachsmuth, Simon Schulz, Florian Lier, Frederic Siepmann, and Ingo Lütkebohle

Center of Excellence Cognitive Interaction Technology (CITEC), Bielefeld University, Universitätsstr. 25, 33615 Bielefeld, Germany
{swachsmu,sschulz,flier,fsiepmann,iluetkeb}@cit-ec.uni-bielefeld.de
http://www.cit-ec.de

Abstract. Founded on a vision of a human-friendly technology that adapts to users' needs and is easy und intuitive for ordinary people to use, CITEC has established an exciting new field: *Cognitive Interaction Technology.* It aims to elucidate the principles and mechanisms of cognition in order to find ways of replicating them in technology and thus enable a new deep level of service and assistance. In order to proceed in this highly interdisciplinary field, appropriate research platforms and infrastructure are needed. The anthropomorphic robot head "Flobi" combines state-of-the-art sensing functionality with an exterior that elicits a sympathetic emotion response. In order to support several lines of research and at the same time ensure the maintainability of the software and hardware components, a virtual realization of the Flobi head has been proposed that allows an efficient prototyping, systematic testing, and software development in a continuous integration framework.

Keywords: Human-Robot Interaction, Demonstrator Engineering

1 Introduction

Classic AI is very much focussing on the modeling of a rational mind including agents that rationally react on environmental changes or human actions. Starting from these insights many systems have been constructed that show intelligent behavior and are intelligently interacting with humans. However, the general approach does not care if the behavior is realized in a text-based dialogue, a virtual character, or a physical robot – it concentrates on the modeling of the mind in the first place.

The field of *Cognitive Interaction Technology* takes a different approach placing the interaction that takes place in the physical world in the first place. If we understand how this interaction is shaped, what ascriptions and expectations between interlocutors are provoked by which factors, which processes initiate, maintain, and re-establish an interaction over time, then cognitive processes can

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be more easily modeled that replicate the smooth interaction between humans for human-machine interfaces. At CITEC[1] groups from informatics, biology, linguistics, psychology, and sport science are working together along these lines in an interdisciplinary research environment. The research is rooted in a number of research platforms and will be exemplified in the following for the anthropomorphic head "Flobi". Flobi is a robotic head that integrates powerful sensing with social expressiveness [13]. The scientific insight behind it is that the social impact of a robot cannot be devided from its function, i.e. a function like the motion of a directed sensor is interpreted socially as well as an anthropomorphic face raises expectations about possible functions and means of interaction. So far, most robot heads reported in the literature either focused on active sensing capabilities or on social expressiveness. Examples of the first category are POP-EYE [7], Cog [5], or the Karlsruhe Humanoid Head [1]. The second category includes robots like Kismet [4], iCub [3], WE-4RII [17], or Nexi [11]. These also integrate several sensor capabilities but still have limitations in providing less degrees of freedom and lower velocities, in having a bigger size or holes in the exterior design, or in seperating camera sensors from the eyes. Thus, any current hardware solution is a compromise between both requirements: being functional and socially expressive. This has consequences for research that experimentally deals with human-robot interaction. The Flobi robot head that is developed at Bielefeld University is a very good compromise in this field providing the right basis for experimental research.

Having interaction in the first place, it is essential to start with a physical platform because – as discussed before – its presence and limitations already shapes and influences the interaction between agents. Nevertheless, a physical platform limits the testability and accessability for experimental studies and system development. On the one hand, new algorithms should be tested first on a simulation model due to safety reasons. On the other hand, the accessability of a simulation model increases the available testing time making also automated offline test cycles possible, as e.g. required in continous integration (CI) approaches [8]. Therefore, a simulated robot model has been implemented for Flobi that is coupled with an integrated development environment [12]. As already notices in, e.g., the USARSim approach [6], there are typically large differences between the actual robot and its corresponding simulation [14], so that a validation step needs to be integrated into the development cycle. Therefore, in our approach special care has been taken at considering the physical limitations and certain limits of the platform dynamics by using an iterative validation approach that considers the actual configuration and control algorithms. As a result, the simulated robot model and integration approach provides a strong extension of the tool chain leading to efficient research on interaction analysis, modeling, and evaluation.

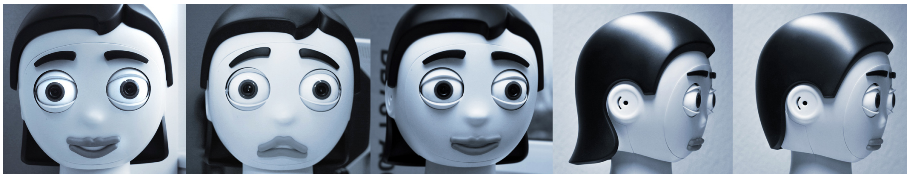

Fig. 1. The robot head Flobi showing emotional and gender variation.

2 The Anthropomorphic Robot Head Flobi

To achieve understandability, all previous social robots have used an exterior that alludes to what people already know. We anthopomorphize because it allows us to maximally approach human-like communication and increases human speculation about the robots intentions. The robot has been designed to use a comic-like human face (Fig. 1) in order to avoid unwanted reactions as predicted by the uncanny valley hypothesis [2]. Other requirements, like that there should not be any holes in the mask, lead to the development of an innovative magnetic actuation mechanism [13]. The hair part, eyebrows, lips and frontal face part are easily replacable in order to experiment with different character features. The platform features stereo vision, stereo audio and a gyroscope for motion compensation. The cameras are actuated and support at least 400/s saccade speed. Velocity control is provided by custom design motor control boards implementing the necessary control algorithms and real-time support. The complete robot head has 18 degrees-of-freedom (DoF) [13].

3 Iterative Model Validation

While the concept of Continuous Integration (CI) is well established in common software development processes, CI practices have only received little attention in robotics so far. One reason might be the typical deviations between the physical robot and its simulation in terms of the control interfaces as well as movement

[1] CITEC - Center of Excellence Cognitive Interaction Technology.

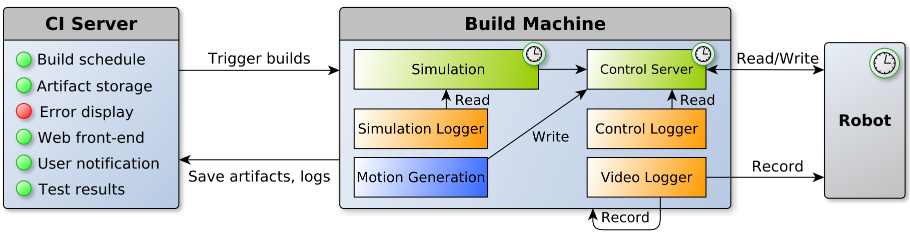

Fig. 2. Concept setup for the iterative validation approach [12].

dynamics and physical limitations. A second problem is that this match need not be established only once, but be maintained over the course of development of the robot, i.e. any change in calibration, model updates, manufactoring variation, firmware updates and control algorithms affect this match. With respect to these problems, we introduce a real robot into our CI setup for interative testing and validation of simulated robot models (Fig. 2). The robot model is based on MORSE [9]. The robot provides an instance for comparison with the simulated robot model as a motion generator component sends movement commands to a control server which actuates the physical and virtual robot [12]. Thus, the differences between the model and the real robot are tested on every change of control software or configuration using internal and external data capture support (like simulation, control and video logger). The movement profile that is tested with the robot head has been recorded from a real movement of a human head using motion capture techniques.

4 Flobi in the research cycle

Research using the Flobi platform is conducted on different levels. Hegel and Eyssel studied different appearances of the robot and what people associate with them [10]. Therefore, it was essential that people got the impression that they rate a physically existing platform. On the hardware side, Schulz et al. proposed a new mechanical construction of the robot eye [16]. Here, the robot simulation provides possibilities for prototyping experiments. On the software side, Lütkebohle et al. used Flobi in an interactive object learning task looking at multi-modal dialog [15]. They provide a complete system evaluation approach using the actual physical platform in a human-robot interaction study. Doing parallel research on the hardware, control, and system level especially requires an interative validation approach for the simulated robot model.

5 Conclusion

Research on human-robot interaction aims at the construction of artificial systems that smoothly interact with ordinary people in a human-style fashion. Thus, it directly contributes to the core of artificial intelligence. However, the research focus is on the interaction rather than the robot mind. This requires that the physical instance of a robotic system is not the end product but start of a new research cycle. In this paper, we have proposed how this process can be governed by appropriate research tools starting from a robot head with a modular exterior to a robot simulation model that is tightly integrated into the software development process using a continuous integration approach. The proposed strategy enables the decoupling of interdisciplinary research without loosing the grounding in a physical embodiment.

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