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Carl Friedrich TUK; a Social Companion Robot

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Abstract— **With improvements in electronics and mechanics, robots have become more compact as well as more space and energy efficient. Hence, they are now a more integral part of our everyday lives. Thanks to Artificial Intelligence (AI) they are on the verge of entering our social lives too. Following this trend, Technische Universität Kiwi (TUK) is a family of social robots developed and under further development at the Institute of Computer Technology at TU Wien. The project deals with the design and creation of a companion robot. The main purpose of this work is to realize a relatable robot which can eventually serve in therapeutic applications, in particular for the children on the autism spectrum. To this end, the companion robot should be able to interact with the user and express emotions. The goal of the companion robot is to create a safe environment by serving as a safety blanket, in particular where other aids such as therapeutic pets cannot be used. Ultimately, we hope that by collecting helpful data, the companion robot can contribute to the therapy procedures as well as improvement of daily life interactions with family and friends. In this paper, we present Carl Friedrich, the first of TUK family.**

I. Introduction

Autism Spectrum Disorder (ASD) describes a variety of disorders including a wide range of symptoms, characteristics and levels of disability. The characteristics include, but are not limited to: social difficulties such as in communicating and interacting with others, repetitive behaviors and also a lasting, intense focus and interest in certain topics [8]. People with ASD may also show extreme sensitivity to the environment, including light, noise and temperature sensitivity. About 1 in 59 children is identified with ASD according to estimates from Centers for Disease Control and Prevention (CDC)'s Autism and Developmental Disabilities Monitoring (ADDM) Network [6] [2]. Thus, enabling them and better integrating them in the society would be advantageous not only for them, but also for the society.

Treatments and therapies can help in overcoming the individual's challenges while also helping them to learn new skills and build up on their strengths. Due to the wide spectrum of the disease there is no single best treatment. Therefore, working closely with a specialist is an important part of finding the right treatment. Using a companion, such as pets, has shown positive effects on the autistic individuals [3]. However, other than hygiene and allergic concerns, which prevents them from a constant companionship, a major issue with pets is their limited life time. Their death can have a significant negative effect on the emotional state of their companions, in particular for the people on the ASD who are often emotionally more sensitive. Moreover, the predictability of the robot provides an emotionally more secure environment for children with ASD. It can also help the children to understand and "learn" empathy [4]. Furthermore, a well designed robot can collect proper information, such as emotional trigger, improvements in behavior, and more detailed information of in-home therapy works, and provide it to the therapist to improve the therapy procedure. In addition, other than serving as a safety blanket and calming the individual which helps in their social interactions, the companion robot could learn about particular behaviors and habits of the autistic individual and communicate these to their family, friends, and colleagues to enable them to understand and interact better with the autistic individual.

Although, the final goals of project TUK is to create social robots for autistic children, its scope includes others who could benefit from a social companion robot as well. The first step of this project, which is presented here, is to create a robot which can show emotional expressions and interact with a user. To this end, different from other companion robots such as Milo [1], we have tried to avoid "Uncanny Valley" [7], while creating emotional expressions that are understandable for humans. We contend that this helps the user to accept the robot as a new being and as-is, and relate to it better, as opposed to consciously or unconsciously comparing it with real humans (as is the case for many humanoids). Thus, the unsettling negative feelings due to this comparison which impede the social bonding can be avoided. In the rest of this paper, we introduce Carl Friedrich who is the first member of TUK family.

II. Design and Expressed Emotions

The first prototype of TUK, as seen in Figure 1, is named Carl Friedrich. This prototype and the Technische Universität Kiwi (TUK) family, is inspired by the flightless birds called "Kiwis" which are native to New Zealand. Carl Friedrich consists of 6 sensors around its body, 8 servo motors and two VGA cameras in the eyes. The servo motors are responsible for the movement of the eyes and the eyelids. The eyes can move vertically and horizontally. The eyelids are not only able to close and open, but also to rotate inwards and outwards. Thus, acting as what would be eyebrows, and help in expressing emotions. The body and the head are fixed and covered in a green soft fabric. The eyelids are covered in purple fabric and the eyes in white fabric. This helps Carl Friedrich to look more like a stuffed animal rather than a robot. We believe that this facilitates bonding with it. For a fluffier experience there is also stuffing beneath the green fabric.

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Fig. 1. First Prototype of TUK, named Carl Friedrich.

For sensing, capacitive sensors are used and each of the sensors trigger a different emotion. The sensors are located on the front, back, sides, head and nose. The processing and computation power are provided by two ATmega 328p micro-controllers. One is used for processing sensor information and the second one for decision-making and controlling the actuators.

The emotions used for Carl Friedrich are inspired by the six different basic facial expressions as identified by Paul Ekman [5]. All the emotions are displayed in Figure 2 and are described as follows:

1) Disgust: One eye is closing a bit.
2) Surprise: The eyelids are opening fast and remain high.
3) Sadness: The eyelids rotate outwards and open slightly.
4) Happy: The eyes are closing slowly to indicate pleasure.
5) Fear: In the current development stage, the same movement as surprise are performed.
6) Anger: Eyelids turn inwards and close a bit.

In addition to the facial expressions, Carl Friedrich also starts to blink after having no interactions for 15 seconds. This is an attempt to make it seem more realistic and alive. Furthermore, following the examples of real-life owls it is alternating the blinking eye. That is, when blinking, only one eye closes at a time and for the next blink the other eye will be closed. This has the advantage of not losing the visuals for the future image processing and facial recognition software.

III. Future Work

One of the future plans is to implement a facial recognition software, in order to have visual interactions as well. That is also the reason for installing the cameras. However, for this purpose additional hardware for processing is needed. Moreover, the robot can be used as a hub for collecting other physiological signals such as Electrocardiography (ECG), heart rate or skin temperature. Using those signals for better identification of the emotion, Carl Friedrich should react to the registered feelings by expressing emotions itself. The aim of adding additional features is to make Carl Friedrich more expressive. Moreover, using such additional devices TUK can be used for therapeutic games as well. In its current position, Carl Friedrich can only express itself with the help of its eyelids. We plan to enable future members of the TUK family to move their beak for more expressiveness. The beak should have the ability to move upwards and downwards, to amplify feelings like sadness or surprise, or shiver to express fear. Also Carl Friedrich should be able to differentiate between getting petted and getting hit, and react in different ways. For a more realistic behaviour the robot should be able to rotate its head. The possibility to feed the robot can both serve as a reinforcement mechanism for learning in the robot and also for improving the relationship between the user and the companion robot. Last but not least, a case study needs to be conducted to evaluate how children react to Carl Friedrich.

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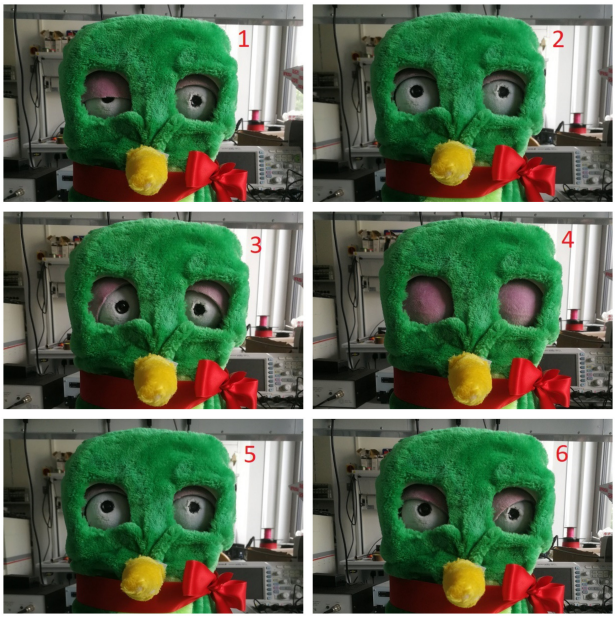

Fig. 2. The six emotions of TUK: 1) Disgust, 2) Surprise, 3) Sadness, 4) Happiness, 5) Fear, 6) Anger.