An emotional model for social robots

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ABSTRACT

We developed an emotional model supporting robots to accommodate humans during a working task inside an industrial setting. The the robot recognizes when a human is experiencing increasing stress and decides wether it should assist the human or it can attend other tasks. The emotional model is implemented in the project "The Smart Virtual Worker" and learns to estimate a worker's emotional feelings throughout a typical working task by a hierarchical reinforcement learning algorithm. Since emotions are generated by the human brain based on the individual interpretation of a stimulus, we linked the genesis of emotions to empirical findings of the sports sciences in order to infer an emotional reaction. Furthermore, the model reproduces sympathetic reactions of the human body and is capable of remembering past actions in order to include possible future time constraints as an initiator for emotional responses in the upcoming iterations. This capability is crucial for accommodating long-term experiences since the emotional reaction is not only based on the present situation, but on the whole experimental setting. This paper describes the concept of our model from a theoretical and practical point of view as well as a preliminary state of implementation and upcoming steps of the project.

Keywords

emotional model, emotion, social robot

1. INTRODUCTION

Employment of robots in private and public environments is increasing. Especially the sales figures of industrial robots are rising [9]. Robots are becoming not only faster, cheaper and more capable but also more flexible in attending different tasks and more interactive with humans [8]. Especially when robots and humans are executing working tasks cooperatively in a peer-to-peer group, a socially interactive robot is required [6]. For an effective execution of cooperative tasks the robot is required to "understand people's specific knowledge, strengths and weaknesses" [10] and to estimate and react to the peoples intentions and needs [5, 4] as well as the dynamics of object interaction with other robots and humans [3]. The ability of understanding an intention is intimately linked to an emotional understanding [7]. This important role emotions play in human-robot interaction is supported by many research results [1, 2].

2. THE EMOTIONAL MODEL

The "Smart Virtual Worker" (SVW)-project[1] presents an opportunity to easily replicate established workflow parameters inside a virtual simulation to establish alternative routes, storage, or construction methods during the stage of production planning. Since the SVW-project contains multiple individual modules, the emotional model is built as a standalone solution. This allows for a much wider array of possible implementation strategies like being an add-on component for already established system architectures. Especially as a reward function the emotional model will be relevant for reinforcement learning algorithm which calculate and predict human actions. Assuming the estimation and prediction of the cooperating humanś emotional state is necessarily the first step in the development of a well-performing and helpful robot, we put the emotional model in this context fulfilling this requirement.
Two types of numerical input are necessary for proper operation of the emotional model 1. First, the planned action from the reinforcement learning algorithm for motion generation suggests a work task, which impacts the emotional model in three ways. The ergonomic assessment characterizes the work task as being feasible, precarious or alarming. With the ergonomic system we are allowed to produce a signal from the body. Furthermore we are abled to decide which name had the current action. Thus the motion module detecting the humans with their body positions estimates in angles. The ergonomic tool compares this body angles with their description of task like "carrying", "walk" and so on. This description and the ergonomic evaluation how difficult the motion for the human established the foundation for the emotion evaluation for the task.
Since emotions heavily depend on a human's individual response to outer circumstances and since the goal of the simulation are individual recommendations for a better workflow, the emotional model contains an individualizing computation routine. Based on three assessed factors about the physiology of the worker in question, the impact of the orig-

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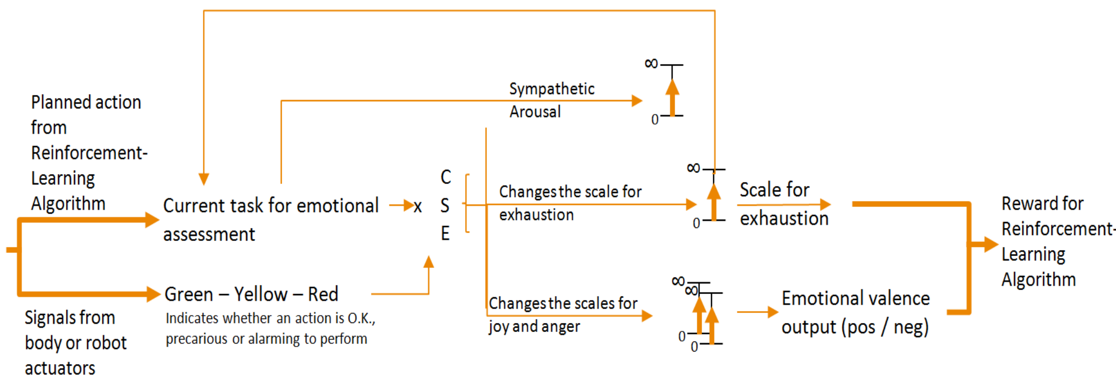

Figure 1: The emotional model for social robots

inal ergonomic assessment on the valence scales is adapted. These three factors are constitution, sensitivity, and experience, shortened in the model as C, S and E.

The emotional state is modeled using three valence scales labeled sympathetic arousal, joy and anger. While two scales are labeled after human feelings, we do not presume any direct correspondence to those. Instead, the scales joy and anger are increased by easy and difficult actions, respectively; and the emotional state is classified as positive or negative based on whether the valence of joy or anger dominates. Arousal is increased by any action that raises either joy or anger, and valence is reduced on all scales over time when no stimulus causes them to increase. Sympathetic arousal mirrors a form of energy the emotional state of the current action invokes in the agent. In addition, following the theory of emotion transaction by Zillmann [11], this sympathetic arousal enables the transfer of energy between the emotional states implemented, that is, in our case between the scales joy and anger.

As a result, the emotional model outputs three variables. The artificial intelligence module receives information about the chances for exhaustion and the current emotional classification, which is either positive or negative. Additionally, the assumed time requirement for a successful in-time work completion is input. The reinforcement learning algorithm will then rate the emotional output and repeat the procedure by initiating another planned action.

3. FUTUREWORK

Our next steps will be to further implement the model depicted in 1, while attempting to evaluate our preliminary predictions about the individual emotional responses within a real-world psychological experiment. Furthermore, we intend to expand the interaction between the human model and other objects, both passive and active. On one hand, this means that we want to improve assessment of failing actions (like a box being dropped) and on the other hand, simulate active objects (e. g. a robot). The latter incurs distinguishing between the robot carrying out actions expected or unexpected by the (modeled) human, leading to substantially different impacts on the (modeled) emotional state. With this refined model we hope being able to simulate these effects of human-robot interaction, assisting the robot in choosing smarter, more anticipatory reactions in interactive situations.

4. REFERENCES

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