An Emotional Model for Social Robots

[Late-Breaking Report]

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ABSTRACT

We developed an emotional model, which could help supporting robots to accomodate humans during a working task inside an industrial setting. The robot would recognize when a human is experiencing increased stress and decides whether it should assist the human or should do other tasks. We propose the model as a framework which was developed as part of "The Smart Virtual Worker"-project within the context of human-robot interactions. The emotional model is able to estimate a worker's emotional valence throughout a typical work task by applying a hierarchical reinforcement learning algorithm. Since emotions are generated by the human brain based on an individual's 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.

1. INTRODUCTION

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

HRI'14, March 3–6, 2014, Bielefeld, Germany.
ACM 978-1-4503-2658-2/14/03.
http://dx.doi.org/10.1145/2559636.2559837 .

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. In order to accurately assess and estimate current and ongoing emotional developments inside the human counterpart, the robot requires a workflow model of emotional valence manifestations.

This can be easily achieved by implementing the emotional model as presented in Figure 1. Two types of numerical input are necessary for proper operations. First, the planned action from the reinforcement learning algorithm for motion generation suggests a work task, which impacts the emotional model in three ways, according to previously established key factors about the human counterpart, e.g. experience and physiology. The second factor, the ergonomic assessment categorizes the work task as being feasible, precarious or alarming. Due to this, we are able to assess physiological constraints and infer possible reactions to upcoming movements. Thereby comparing body postures and assessing intentions like "carrying", "walking" etc. This assessment combined with the ergonomic evaluation about how difficult the aspired movement is going to be serves as the foundation of the emotional manifestation.

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 original ergonomic assessment on the valence scales is adapted.

[1]This work has been funded by the European Union with the European Social Fund (ESF) and by the state of Saxony

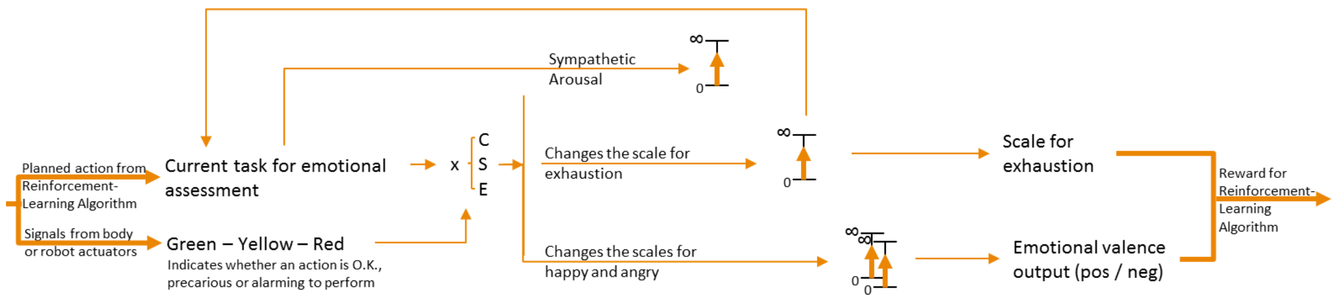

Figure 1: The emotional model developed in the SVW-project calculates an emotional reward function which in turn enables a socially comprehensible robot to estimates the level of difficulty of a task.

These three factors are constitution, sensitivity, and experience, abbreviated 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 these. 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 value 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 emotional transaction by Zillmann [10], this sympathetic arousal enables the transfer of energy between the emotional states implemented, which is, in our case, between the scales joy and anger.
As a result, the emotional model outputs the emotional valence calculated as positive or negative values, respective to reward and punishment. This implies for the reinforcement learning algorithm that it is able to optimize actions with the highest positive values and avoid actions with negative values. Therefore a socially comprehensible robot could either help or could propose other easier solutions to the work task.

3. FUTURE WORK

Our next steps will be to enhance the model depicted in figure 1, while attempting to evaluate our preliminary predictions about an individual's 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 the assessment of failing actions (e.g. 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. We hope with this refined model we are able to improve these effects of human-robot interaction, assisting the social robot in choosing smarter, more anticipatory reactions in interactive situations.

4. REFERENCES

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