Emotion Based Control Architecture for Robotics Applications

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Abstract. Assistance and service systems are one of the main research topics in robotics today. A major problem for creating these systems is that they have to work and navigate in the real world. Because this world is too complex to model, these robots need to make intelligent decisions and create an intelligent behavior without knowing everything about the current situation. For these aspects, the importance of emotion increases, because the emotional influence helps human beings as well as animals to make their decisions. To enable a robot to use emotions, a concept for an emotion based control architecture was designed. The basis of this architecture is a behavior based approach. This paper presents the developed architecture. Furthermore two application possibilities are presented, where parts of the architecture were already tested and implemented.

Key words: control architecture, behavior based control, intelligent robotic systems

1 Introduction

The realization of emotions should be a central aspect of any intelligent machine. Rational and intelligent behavior is needed in nearly every autonomous robot system. These robots have to make decisions depending on their sensor data. Neuroscience, psychology and cognitive science suggest that emotion plays an important role in rational and intelligent behavior [1]. Because of this it is very important to use the emotional component in a robot system that should work and decide autonomously.

Worldwide, several research projects focus on the development of emotional control architectures for robot systems, like e.g. [2] or [3]. In [**?**] a survey of artificial cognitive systems is presented. Different models, theories, and paradigms of cognition addressing cognitive approaches, emergent systems approaches, encompassing connectionist, dynamical, and enactive systems. Furthermore several cognitive architectures drawn from these paradigms are presented.

[0] Full size paper available by email at the authors.

2 Emotional Architecture

Depending on psychological theories [4] [5] an emotion based robot control architecture was designed. In the following section the concept of this architecture will be described in detail. The architecture consists of 3 main parts: behavior, emotion, and cognition. All possible movements of the robot from simple reflexes up to high level motor skills are located in the behavior group. These behaviors are activated in different ways, e.g. directly depending on sensor data, depending on the emotional state of the machine or deliberately by the cognition part.

Behavior Every single behavior is build out of the behavior nodes, described in [6]. Depending on these behavior-nodes all different kinds of behaviors can be realized. Low level behaviors that moves the different motors to one direction like e.g. reflexes or high level behaviors that represent complex motor skills. These behaviors are activated by different parts of the architecture. The more high level behaviors are mostly activated by the emotion and especially by the cognitive part. Whereas the low level behaviors are also activated directly by sensor input. These low level reflexes directly activated by the sensor perception build the reactive layer of our architecture. In the information flow of this reactive system is displayed.

Emotion The emotion group consists of 2 parts. The emotional state which is just for the representation of the actual internal emotional state of the robot and drives. The drives represent low level goals of the robots behavior like e.g. survival or energy consumption etc. A drive gets active if the discontent reaches a certain threshold. The drive than calculates parameters that change the emotional state and that select the behaviors of the robot. The aim of the drive is to reach a saturated state by the selection of the behaviors. If the saturation of the drive is getting higher the activity of the drive is getting lower. According to projects like e.g. [2] an emotional space for the representation of the emotional state was developed. The 3 axis of this emotional space are arousal (A), valence (V), and stance (S). That means every emotion is described by these 3 parameters. In most emotional spaces for every emotion a certain area in the emotional space is reserved. If the actual emotional space is in this area the corresponding emotion is activated. That means every emotion that should be used has to be defined. The problem is that psychologists say that there are a lot of emotions and they do not even know all of them. But most of them agree that all emotions are build out of the 6 basic emotions: anger, disgust, fear, happiness, sadness, and surprise.

Cognition The cognition should generate a plan to reach a certain goal by combining several behaviors of the system. Therefore it can use sensor information as well as emotional information and behavior information. As mentioned above, especially the emotional state is a main factor to create an intelligent decision.

According to a human the cognitive part is also able to suppress the emotional state for a while or to influence deliberately the expression of the emotional state to reach a certain goal. The cognitive layer then creates a chain of behaviors. Running this chain should lead to the goal. If something unexpected happens during this run the cognitive layer has to reschedule this chain. For this reschedule decision the emotional state is of enormous importance if the system should work in a real world environment.

3 Possible Applications of the Emotional Architecture

Fig. 1. The robot head ROMAN

Fig. 2. The mobile robot RAVON

Humanoid Robot Head ROMAN The emotional architecture was already used for the humanoid robot head ROMAN (see Fig. 1). Because of the actual emotional state the corresponding facial expressions are generated more details and experiments can be found in [7].

The architecture was also used to realize a drive-based behavior of the robot. That means within the architecture different drives like e.g. exploration and communication are defined. These drives determine the goals of the robots behavior and the emotional state of the robot (see [8]).

One of the next steps in this project will be the usage of the cognitive layer of the proposed architecture. The robot should use its expressions to reach a certain goal within an interaction.

Mobile Robot RAVON Another application possibility for the emotional architecture described in this paper arises in the path planning component of the mobile outdoor robot RAVON (Fig. 2). Here, the introduction of an 'emotional state' into the robots' navigational layer allows the system to solve the 'action-selection' type problem of choosing a path from the set of currently possible trajectories in a psychologically plausible way. Using the emotional state as an abstracted indication of the overall robot situation (considering navigational capabilities, battery state and/or available mission time), the path planner can weight the different factors that influence the path finding decision appropriately and select a solution that is globally optimal.

With the basic emotionally influenced cost model for path planning in place, the project currently focuses on adding the drives component described in this paper in order to adjust the motivational state of the robot according to success and failure in exploration and exploitation of the topological map. It is planned to combine drives modeling self-preservation, curiosity and fatigue for this.

4 Summary and Outlook

The concept of an emotion based control architecture for autonomous robots is presented. This architecture consists of 3 main parts: Behavior, Emotion, and Cognition. The great advantage of the introduced architecture is that it can be used in completely different systems, as described in section 3. In the future the proposed architecture had to be improved with the help of psychologists, sociologist, and biologists. In addition the parts that had not been implemented and tested till now have to be realized on robots. And finally the whole system has to be tested on different robots.

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