An algorithm based on an appraisal theory to control a Khepera robot

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Abstract

In the last few years, the emotion process was generally considered as a special mechanism for adaptation, because it is a specific case of a brain process in which a stimulus evaluation is linked with a behavioral reaction. It seems interesting to explicit this process in a formal definition to test a model. This paper focuses on the definition of a specific model of emotion (appraisal model) for a robot.

Introduction

Object of this paper is to formulate an algorithm to elicit and differentiate emotional reactions on a robot. This algorithm has been used in a previous research to adapat an autonomous robot (Khepera robot (Mondada, Franzi, & Ienne 1994)) in an unknown world, with strong modifications and stimuli. This algorithm is based on an appraisal theory, which is a special view of emotional activation. It suggests:

> ...that the nature of an emotional reaction is based on the individual's subjective appraisal or evalution of an antecedent situation or event. The evaluation is generally considered to rely on cognitive processing of environmental or proprioceptive stimuli (Scherer 1997, p.114)

There are several definitions of the appraisal process, but this paper is too short to discuss the difference between all definitions. For this algorithm we chose Scherer's definition(Scherer 1993; 1997) because he has postulated a restricted number of evaluations which can occur at different levels (Leventhal & Scherer 1987). In this model, there are five evaluations: novelty/suddenness, intrinsic pleasantness, goal conduciveness, coping potential and compatibility with standards.

This paper is divided in three parts. The first one is focused on the low level of this model (data, processes, input/output). The second one is focused on the high level of this model (goal, appraisal, emotion). The third part defines an alogorithm to learn with appraisal. Experimentation and results are not reported in this paper, but other papers and code sources (In C language with API for webots) are available at http://ea654.univ-lyon2.fr/perso/foliot/webots.html

Low level computational model

We attempted to design an overall architecture relying at most on local computation. We define all processes by a parallel computing.

Data

We defined a single way for data. We used a stack designed as following:

$$\text{Stack}_n[x, y, t] = \text{Weight}$$

(n stack number x, y places t number of time iterations *weight* value of element)

There are two kinds of stacks: a) short time stack: at each iteration the stack moves along iterations and data are destroyed b) long time stack: data are not kept. The number of stack represents a specific data (Sensory input, motor input, state ...).

Input/Output

This algorithm is designed to control a Khepera robot. Inputs are infra-red sensors allowing it to detect surrounding obstacles and a color camera (with a resolution of 160x120 pixels). Outputs are two independent motors driving the wheels.

Process

Each process is defined by a rule and an activation weight. When activation exceeds a threshold, the rule is executed. There are four parts in the rule.

Condition: tests a condition between stacks (If the condition is true, then the rest of the rule is executed. If there is no condition the rule is always true).

Execution: contains the operation that has to be done.

Allocation: puts in the stacks the operation results.

Activation: raises or decreases activation level of target processes.

Communication

In order to run this parallel algorithm on a traditional computer, we defined a special condition for communication. At each step, when a process is running, it is allowed to read the state of all stacks and other processes at the current and previous step and to change the stack and the activation only for the next step.

Algorithm of low level

```
For each step (t_n) do
  Send all sensory data in sensory-stack at t_n
  For each process
      read activation at t_n
      if(activation > threshold)
          read data from stack at t_n
          test condition
          if(condition = true)
                execute operation
                send data in stack at t_+1
                send activation a t_+1
  Read data for motor from motor-stack (t_n)
  Move short time stack
```

Hight level computational model

We think it is necessary to have a single way to represent and interpret all data. A body representation is a good way to do it, because body-patterns provide a first organization of data, such as left, right, front, near, far,... We tried to represent all data by a value on the body representation. We define: a) an input sensory body representation b) an output motor body representation c) an internal sensory representation d) an internal motor representation

Goal

A goal (such as avoiding obstacles, following a wall, pushing an object) is defined by an expected value in the internal body sensory representation and by an expected value in the internal motor representation (such as moving forward, going left, going right,...)

Appraisal

We used Scherer's theory, in which there are five appraisals, but we used only four appraisals:

Novelty: tests a difference between the current value of sensors and the previous value. If there is novelty, we keep in memory the stimulus which caused the novelty reaction

Displeasantness: if a pain stimulus is perceived (hit or warning for example). If there is no pain, then return pleasantness.

Hindrance: if there is a difference between the input sensory stack and the expected value

Coping: there are two sorts of coping: a) compares all possible motor directions with the sensory inputs b) computes how long a negative emotion appears. The longer it is, the more important the decreasing of the coping will be.

Emotions

Each appraisal check activates or inhibites different emotional processes. Each emotion processes tries to change the low goal. We defined five emotional targets : **Joy:** focuses on the current goal. **Fear:** tries to do a low goal on the over direction of novelty stimuli. **Anger:** tries to do all goals, excepted the goal causing the anger reaction. **Distress:** tries to do a random goal. **Sadness:** does nothing.

Learning

We used values returned by appraisal and emotion to learn. In this model, learning occurs each time the mean state contains a strong displeasure value. This produces a new pattern containing the newer stimulus as a sensory input. The process then waits to observe which goal is associated to this stimulus and checks whether this goal allows to come back to a normal state. If this normal state is reached within a small amount of time, the representation is associated to the pattern, otherwise, the pattern is destroyed.

Algorithm of learning

```
If(novelty > 0)
 Keep stimulus in memory stack
 If(stimulus == pleasantness)
  Destroy stimulus in memory stack
 Else
   If(stimulus == displeasantness)
       Wait and observe the reaction associated
                    with this stimulus by emotion
       If(reaction decreases displeasantness)
           Create an association between stimulus
                                and motor reaction
           If(Waiting is too long)
               Stop learning and destroy stimulus
```


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