Chapter 3
Social Active Inference

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ABSTRACT

The free energy principle and its corollary, active inference, were introduced by Karl Friston as an explanation embodied perception and action in neuroscience, and since, it has been used to address many other issues in different fields mainly related to cognitive science like learning, optimal decision, or interpersonal inference. Negotiation is a process where each negotiator has conflicting motivation is aiming to maximize his utility and where agreement is reached when the opposing interests are balanced. The purpose of this chapter is to illustrate how the free energy principle might be used through active inference in modeling a negotiation process based on an example of real life. The work is an attempt to bring together a dynamic logic framework with appropriate operators to consider motivation among agents on one hand and the active inference framework on the other hand.

INTRODUCTION

Early analysis has been conducted to compare autopoiesis to the free energy principle (FEP) and active inference (Friston, Kilner, & Harrison, 2006; Friston, 2010) with respect to self-organization, self-preservation and operational closure (Kirchhoff, 2016; Sajid, Ball, & Friston, 2019) based mainly on the fact that living systems take care to maintain their organization in the face of environmental perturbations. As a matter of fact, active inference is a self-organizing process of action policy selection. FEP and its corollary active inference were introduced by Karl Friston as an explanation for embodied perception and action in neuroscience and since then it has been used to address many other issues in different fields mainly related to cognitive science like learning, optimal decision or interpersonal inference. Negotiation is a process where each negotiator with conflicting motivation is aiming to maximize his utility and where agreement is reached when the opposing interests are balanced. The purpose of this chapter is to illustrate how the free energy principle might be used through active inference (McGregor, Baltieri, & Buckley, 2015) in modeling a negotiation process based on a real-life example. Our work is an attempt to bring together a dynamic logic framework with appropriate operators to consider motivation among agents on one hand and the active inference framework on the other hand. Among these operators: K

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(Knowledge), B (Belief), [a]f (after the action a has been performed, the formula f is true), A (Ability) and D (Desire). Their semantics are based on Kripke structures (Cohen, & Levesque, 1990).

FEP is based on the idea that for an adaptive agent to survive over a long period it must occupy only a limited repertoire of states among all the states it could possibly occupy. This kind of disorder reducing or entropy exporting can be formalized with active inference which seeks to minimize an information-theoretic quantity known as surprise. For tractability reasons, this minimization is made possible by the optimization of a bounding quantity called free energy.

This chapter is organized as follows. Section 1 presents an overview of FEP and active inference under their discretized formulation. A first example is given in the following section to analyze the expected free energy expression and to illustrate basic computations of its value. Section three introduces the KARO logic augmented with some constructs to express preference and emotion. In section 4, a second example is given, based on a real-life scenario to discuss how both active inference and KARO logic articulate in the scenario steps.

BACKGROUND

In this chapter, active inference is considered in the context of cognitive agents and cognitivism. A cognitive agent is an agent that not only can learn about itself and about the environment it is interacting with but also imagine how the world would look like under different courses of actions and decide which action should be taken. Among these agents, rational agents are those which have preferences for advantageous outcomes. Cognitivism is a theoretical framework for understanding the way the mind perceives, acquires, remembers, processes, stores information and solves problems (Stavredes, 2011). Cognitivism is very present in artificial intelligence and, in particular, in learning theories and machine learning. Active inference explains how the agent decides which action to take by considering the course of actions that fulfills its prior beliefs about preferred observations. At the heart of this process, generative models play a central role. A generative model is an internal probabilistic representation of the agent's beliefs on how hidden states of the environment relate to observations and how they transit to each other. Based on the generative model and the target priors, purposeful behavior emerges from variational free energy minimization which ensures that the agent avoids surprising states. As a matter of fact, active inference is a self-organizing process of action policy selection explained in terms of minimizing the free energy expected under a course of action. This is because under some ergodic assumptions, the long-term average of surprise is entropy and for a system or an agent to survive they must actively attempt to minimize their own entropy (Friston, Kilner, & Harrison, 2006; Millidge, 2019).

In modal logic, an agent is characterized by mental features, such as knowledge, belief, obligation, and commitment. These are represented by modal operators, the meanings of which are in general given by the possible world semantics. It is assumed that at the implementation level an agent is represented by a program together with its generative model. Modal logic provides declarative specifications of what the

agent program should compute, whereas the programming language provides operational specifications of how to execute an agent program. Only the declarative specifications are considered here within KARO framework with respect to active inference. KARO is a logical framework for modeling rational agents by defining how beliefs, actions, information and intention of agents are related.

There have been a number of applications of active inference in various domain as listed in (Parr & Friston, 2018). For example, in electrophysiological responses for simulating neuronal processing with

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