Chapter 4
Agents in Quantum and Neural Uncertainty

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ABSTRACT

This chapter models quantum and neural uncertainty using a concept of the Agent–based Uncertainty Theory (AUT). The AUT is based on complex fusion of crisp (non-fuzzy) conflicting judgments of agents. It provides a uniform representation and an operational empirical interpretation for several uncertainty theories such as rough set theory, fuzzy sets theory, evidence theory, and probability theory. The AUT models conflicting evaluations that are fused in the same evaluation context. This agent approach gives also a novel definition of the quantum uncertainty and quantum computations for quantum gates that are realized by unitary transformations of the state. In the AUT approach, unitary matrices are interpreted as logic operations in logic computations. We show that by using permutation operators any type of complex classical logic expression can be generated. With the quantum gate, we introduce classical logic into the quantum domain. This chapter connects the intrinsic irrationality of the quantum system and the non-classical quantum logic with the agents. We argue that AUT can help to find meaning for quantum superposition of non-consistent states. Next, this chapter shows that the neural fusion at the synapse can be modeled by the AUT in the same fashion. The neuron is modeled as an operator that transforms classical logic expressions into many-valued logic expressions. The motivation for such neural network is to provide high flexibility and logic adaptation of the brain model.

INTRODUCTION

We model quantum and neural uncertainty using the Agent–based Uncertainty Theory (AUT) that uses complex fusion of crisp conflicting judgments of agents. AUT represents and interprets uniformly several uncertainty theories such as rough set theory, fuzzy sets theory, evidence theory, and probability theory. AUT exploits the fact that agents as independent entities can give
conflicting evaluations of the same attribute. It models conflicting evaluations that are fused in the same evaluation context. If only one evaluation is allowed for each statement in each context (world) as in the modal logic then there is no logical uncertainty. The situation that the AUT models is inconsistent (fuzzy) and is very far from the situation that modeled by the traditional logic that assumes consistency. We argue that the AUT by incorporating such inconsistent statements is able to model different types of conflicts and their fusion known in many-valued logics, fuzzy logic, probability theory and other theories.

This chapter shows how the agent approach can be used to give a novel definition of the quantum uncertainty and quantum computations for quantum gates that are realized by unitary transformations of the state. In the AUT approach, unitary matrices are interpreted as logic operations in logic computations. It is shown, that by using permutation operators that are unitary matrixes any type of complex classical logic expression can be generated. The classical logic has well-known difficulties in quantum mechanics. Now with the quantum gate we introduce classical logic into the quantum domain. We connect the intrinsic irrationality of the quantum system and the non-classical quantum logic with the agents. We argue that Agent-based uncertainty theory (AUT) can help to find meaning for quantum superposition of non-consistent states for which one particle can be at the different points in the same time or the same particle can have spin up and down in the same time.

Next, this chapter shows that the neural fusion at the synapse can be modeled by the AUT. Agents in the neural network are represented by logic input values in the neuron itself. In the ordinary neural networks any neuron is a processor that models a Boolean function. We change the point of view and consider a neuron as an operator that transforms classical logic expressions into many-valued logic expressions or in other words, changes crisp sets into fuzzy sets. This neural network consists of neurons at two layers. At the first one, neurons or agents implement the classical logic operations. At the second layer neurons or nagents (neuron agents) compute the same logic expression with different results. These are many-valued neurons that fuse results provided by different agents at the first layer. They fuse conflicting or inconsistent situations. The network is based on use of the logic of the uncertainty instead of the classical logic. The motivation for such neural network is to provide high flexibility and logic adaptation of the brain model. In this brain model, communication among agents is specified by the fusion process in the neural elaboration.

The probability calculus does not incorporate explicitly the concepts of irrationality or logic conflict of agent’s state. It misses structural information at the level of individual objects, but preserves global information at the level of a set of objects. Given a dice the probability theory studies frequencies of the different faces $E=\{e\}$ as independent (elementary) events. This set of elementary events $E$ has no structure. It is only required that elements of $E$ are mutually exclusive and complete, that is no other alternative is possible. The order of its elements is irrelevant to probabilities of each element of $E$. No irrationality or conflict is allowed in this definition relative to mutual exclusion. The classical probability calculus does not provide a mechanism for modelling uncertainty when agents communicate (collaborates or conflict). Recent work by Halpern (2005) is an important attempt to fill this gap.

This chapter is organized as follows: Sections 2 and 3 provide a summary of the AUT starting from concepts and definitions. Section 4 presents links between quantum mechanics and first order conflicts in the AUT. Section 5 discusses the neural images of the AUT. Section 6 concludes this chapter.
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