A Model of Causal and Probabilistic Reasoning in Frame Semantics

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Abstract. Quantum mechanics admits a "linguistic interpretation" if one equates preliminary any quantum state of some whether quantum entity or word, i.e. a wave function interpretable as an element of the separable complex Hilbert space. All possible Feynman pathways can link to each other any two semantic units such as words or term in any theory. Then, the causal reasoning would correspond to the case of classical mechanics (a single trajectory, in which any next point is causally conditioned), and the probabilistic reasoning, to the case of quantum mechanics (many Feynman trajectories). Frame semantics turns out to be the natural counterpart of that linguistic interpretation of quantum mechanics.

Key words: frame, frame and reference frame, frame semantics, formal and mathematical semantics, entanglement, quantum information

The thesis of the talk is fourfold:

(1) Probabilistic reasoning can be seen as the interaction of at least two frames in a sense of frame semantics.

(2) Then causal reasoning can be interpreted as the particular case of zero interaction between the frames.

(3) In turn, this allows of the frames to be interpreted formally as correspondingly "reality" and the "image of reality", and language as an (even one-to-one) mapping between those two universal and formal frames of "reality" and its "image".

(4) Probabilistic reasoning can be further represented formally as the "entanglement" of two or more frames and thus in terms of quantum information.

A few terms need some specification, namely: "frame semantics", "frame" "formal semantics", "entanglement", "quantum information", and "quantum computer":

"Frame semantics" is meant in the sense of Charles J. Fillmore: "Frame semantics offers a particular way of looking at word meanings, as well as a way of characterizing principles for creating new words and phrases, for adding new meanings to words, and for assembling the meanings of elements in a text into the total meaning of the text" [1: 111].

"Frame": "The idea is that people have in memory an inventory of schemata for structuring, classifying and interpreting experiences, and that they have various ways of accessing these schemata and various procedures for performing operations on them" [2: 25]. "By the term 'frame' I have in mind any system of concepts related in such a way that to understand any one of them you have to understand the whole structure in which it fits ..." [1: 111]. The "frame" already linked to formal semantics is specified as a set of well-orderings referring to something as its "logic", in which any property, relation, part or feature of that something can be understood by somebody or by a group.

Consequently, that formal and semantic "frame" means the relation between the wholeness of that something and the "logic" of it as a collection of well-orderings.

“Formal semantics” is a term used both in logic and in linguistics but in partially different meanings. The common is the utilization of mathematical and logical models. However, the logical “formal semantics” addresses the natural entailment in language in terms of logical sequence while the linguistic “formal semantics” discusses rather the correspondence both of linguistic units and the wholeness of texts to reality in terms of mathematical mappings, set theory, and logic.

“Entanglement” is a term in quantum mechanics, meaning the information interaction between two or more quantum systems and thus being fundamental for the theory of quantum information. The formal and mathematical definition of “entanglement” as that Hilbert space, which cannot be factorized to any tensor product of the Hilbert spaces of subsystems, allows of the term to be generalized to any model utilizing Hilbert spaces. For the formal and semantic model used here is based on Hilbert space(s), the concept of entanglement is applicable. It is the mathematical base for the model of probabilistic reasoning.

“Quantum information” is a term initially coined by quantum mechanics to describe the base of a generalized kind of information underlying all quantum mechanics. Quantum information can be interpreted both as transfinite series of bits and as finite or infinite series of qubits. A bit is the elementary choice between two equally probable alternatives, and a qubit (i.e. quantum bit) can be interpreted as the elementary choice among an infinite set of alternatives though it is initially defined in quantum mechanics as the normed superposition of two orthogonal subspaces of Hilbert space. The quantity of information whether classical or quantum is the quantity of the corresponding elementary choices (whether bits or qubits) necessary for transforming a well-ordering to another (both, whether finite or transfinite). Thus quantum information can be interpreted as the quantity of elementary choices necessary to transform a frame into another and consequently the information of a probabilistic reasoning formalized as above.

“Quantum computer” [3, 4, 5] is a mathematical model involved by quantum mechanics to interpret its formalism as a generalized kind of calculation, processing quantum information. Thus all physical states and processes may be also seen as computational.

The argumentation for the thesis:

(1) Probabilistic reasoning can be understood as the appearance of a new frame by interaction of two or more initial frames for some essential part of each of them is shared by all. Thus the understanding of each of them separately generates immediately the understanding of the probabilistic reasoning as a new whole demonstrating therefore the appearance of a new frame, which is not the simple additivity of the sub-frames composing it. The set of well-orderings formalizing semantically a frame can be substituted by a point of Hilbert space, and interpreted as a wave function of a quantum system. Any possible frame is measurable as a single value of quantum information. Then the probabilistic reasoning will be interpretable as the entanglement of the quantum systems corresponding to each sub-frame composing it.

(2) Causal reasoning can be interpreted after that as a particular and borderline case of probabilistic reasoning, a “zero” probabilistic reasoning, or just the simple additivity of the sub-frames composing them. The corresponding “wave functions” are orthogonal to each other and there is no entanglement between them.

(3) Language is reduced to an infinite countable set (A) of its units of meaning, either words or propositions, or whatever others. It includes all possible meanings, which can be ever expressed in the

language rather than the existing till now, which would always a finite set. The external twin of reality is introduced by another set (B) such that its intersection with the above set of language to be empty. The union of them ($C=A\cup B$) exists always so that a one-to-one mapping ($f: C\leftrightarrow A$) should exist under the condition of the axiom of choice. The mapping (f) produces an image (B (f)) of the latter set (B) within the former set (A). That image (B (f)) serves as the other twin of reality to model the reality within the language as the exact causal reasoning of the reality out of language (modelled as the set B). In the model, the necessity and sufficient condition of that causal reasoning between reality both within and out of the language is just the axiom of choice: If the axiom of choice does not hold, the relation between the sets B (f) and B cannot be defined rigorously as an exact causal reasoning but rather as some simile and the vehicle between the two twins of reality can be only probabilistic reasoning.

(4) Probabilistic reasoning formalized as above is representable as the wave function of the frame compounded by two or more sub-frames, which interact between each other by means of the shared nonzero intersection. The quantity of quantum information of a probabilistic reasoning is different from that quantity of the corresponding causal reasoning. Thus the probabilistic reasoning demonstrates the entanglement of the composing sub-frames after they have been formalized as points in Hilbert space.

One can utilize the picture of the maximal frame, in which are chosen two positions as two points.

Furthermore, the proposition connects them by a single "classical trajectory" while, the metaphor does the same by all possible trajectories, each of which is differently probable. Any understanding chooses only one of them. The analogy to the Feynman interpretation of quantum mechanics [6, 7, and 8] is obvious. It addresses further the idea for the mathematical formalism of quantum mechanics to be only adapted to the relevant terms of frame semantics. Indeed any measurement in quantum mechanics corresponds to a given understanding of what the metaphor mean. The metaphor unlike any proposition does not predetermine how it should be understood, however it defines implicitly a "wave function" of all possible understandings as the set of pathways, in any of which it can be interpreted equally justifiably.

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