Material vs. Information Causation — An Ontological Clarification for the Information Society

Andrew U. Frank, Vienna, Austria

The web is an immense collection of human knowledge of the world. Humans use this information and cause changes in the world. A separation of reality from the information realm leads to understanding causation as a process starting with decisions in the information realm and the transformation of the decision to material activities that (often amplified by technical systems) change reality. This information causation seems to be the prototypical meaning of causation and material causation as described by the physical "laws of nature" a figure of speech (metaphor), convenient for human thinking.

Introduction

Aristotle constructed science on the observation that "to know is to know the cause", but it seems that the concept of causation itself is confused and the noun 'cause' and the verb 'to cause' are used in different contexts with very different meaning. Sentences like

1. The heat from the fire caused the water to boil.

2. The pictures he saw on the web caused him to return home.

describe causal relations. It is apparent that the two example sentences describe two radically different situations. A contemporary encyclopedia lists more than a dozen different kinds of causality (Wikipedia 2007). The common definition for causality describes it as the relation between cause and effect, where the effect is the direct consequence of the cause. It has been recently observed that a better understanding of causation is crucial to advance science (R. Poli, Mitteleuropa Foundation, Bolzano). In this contribution I differentiate between two different kinds of causation, which I will call *material* and *information causation* and which can be further subdivided; for example, information causation can be split into a subjective and a social causation, but this shall not be explored here further. The sentence (1) above is an example for material causation and sentence (2) for information causation. The two different types of causation occur in different realms, namely the material reality and the information realm. The information realm includes among other things the Web, which makes this clarification of great practical importance.

Any proposal to split the reality we experience in different realms must provide a description of the processes linking the entities in one realm with those in the other. An analysis of the processes that link reality to the information realm contributes to the applicability of ontology to information systems and therefore to the information society. Ontology has become not only one of the most popular buzzwords in Information Technology literature, but it contributes substantially to understand questions of semantics on the web (the "web 2.0" or "semantic web" hype) and the limitations of human knowledge—an eminently philosophical question. The difficulties with the logical analysis of causation stems not only from the attempt to capture two crucially different processes in one logical structure, but also that causation in the sense of a human agent causing some change is a process that links the information realm with the reality realm and can only be analyzed, if these two realms are properly separated and connected.

The two example sentences indicate two sources for the concept of causation: material (physical) causation, as described by so-called "laws of nature" and causation involving information processing and human decisions. I will analyze the two in turn and then connect the second to the first by processes linking reality to the information realm. My approach is realistic (with an idealist touch) and could be related to the difference between the early Wittgenstein (Wittgenstein 1960) and his later writings (Wittgenstein 1963).

The next section introduces a very narrowly defined material realm and discusses the meaning of "laws of nature" and causation in this context. Section 3 and 4 show how agents construct information from observations of reality and change reality through their activity. Section 5 shows how (human) agent optimizes information processing by constructing objects and actions. I conclude with the observation that the common sense meaning of causation is closer to the meaning of information causation, where an agent through an action causes change; material causation appears as metaphorical transfer of this concept (Lakoff 1987) and reminds of animation of nature with agents.

Material Causation

An extensive philosophical literature to causation exists, from Aristotle onwards—not even a summary review can be given or shall be attempted in the limited space for this contribution.

Natural laws (laws of physics) are often stated as rules implying causation, but other formulation for natural laws are possible and widely used (e.g., Partial Differential Equations PDE). Natural "laws" in classical, macroscopic physics connect states of the material world such that changes at one place or time have effect at other places or times; e.g., pouring water in one end of a U-tube "causes" the water level in the other end to rise. The processes can be modeled as strictly local PDEs, which are convenient for computational models but not adequate for the reasoning style of the human brain. A description of material causation, as e.g. PDE, contains no notion of object, event, or action; it uses only properties observable at points. The human interpretation of causes and effects is more a simplified, aggregated description of physical *processes* that make changes at one place propagate to other places and result in changes there. It conceptualizes physical forces, e.g., heat in (1) as agents that act and cause events (water boiling).

Material Realm vs. Information Realm

I separate from the material realm of existence-per-se (Husserl 1900/01; Heidegger 1927; reprint 1993) the realm of information, which I structure in ontological tiers (Frank 2003). In a first tier I concentrate on observations and activities to change physical (point) properties of the material

world. The material world has observable properties at every point in space at the present time. Observations represent the state of some observable properties at this point and time, as *information* (Figure 1). (These point observations give the state of one property at one point and are more basic than the aggregated observation of objects and actions of the phenomenologist (Bergson 1896; reprint 1999)). The observation represented as information endures in time and preserves values for observed states that are not directly observable any more. In general, the model of reality is assumed a true representation of reality and its limitations are seen non-consequential.

The collected observations form a first approximation of an image or model of reality. If one assumes a one-to-one relationship (isomorphism) between material and information realm, no differentiation between the two are necessary (Mac Lane 1998; Lawvere et al. 2005). This assumption of an isomorphism seems to be the source for the often observed tendency in ontological studies to *equating* things existing in the material world and human talk or thinking about it.

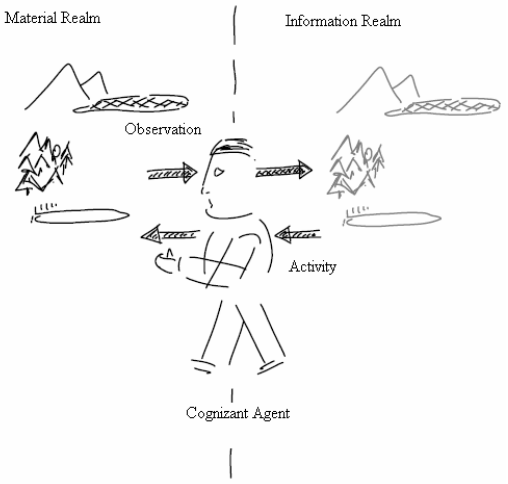

Figure 1: Cognizant Agents form an image of the material reality

Even a cursory glance convinces that collected information can not be in general isomorphic to the material world: precision of observation is limited, amount of detail must be reduced, etc. A list of ontological commitments to imperfection in the information realm as an image of the reality has been published elsewhere (Frank 2007c). The impossibility to have perfect information has lead human thinking to find methods that are efficient and effective with imperfect information.

Processes Link Reality and Information Realm

Three processes are necessary; two connect between reality and information realm and one runs inside the information realm (Figure 2):

- *Observations*: Observations transfer information about reality into the information realm. The imperfections in the different sub processes from observation to encoding characterizes the different types of imperfections of the information collected (for more details (Frank 2007c; Frank 2007a)).

- *Decisions*: The cognitive process in cognitive agents—primarily humans—use is the information they have obtained to arrive at decisions. The decision process is only partially conscious and accessible to introspection (Roth 1994). The process how decisions are reached can—sometimes—be reconstructed with logical or even quantitative models; but not always. Sometimes we construct rationalizations with defendable arguments, which are not the true justification for actions we execute.

- *Activities*: Cognizant agents do not only form an image of reality through observation, they can act on reality and change it through their activity because agents are part of the material world and the same physical laws apply to bones, muscles, and energy in their bodies.

The semantics of observation and activities are grounded as the loop starting with observation of reality is closed by the agent observing the effects of his activities (closed loop semantics for observations and actions). This gives a closed loop connecting observation as the sensation from sensors with actions as the proprio-sensoric information of activities (Frank 2000). This gives semantic grounding to the agents internal code for observations and activities with respect to reality; which reminds of Wittgenstein's concept of defining (grounding) words by how they are used.

Processes in the Information Realm

Humans and many animals reduce the complexity of the observations from the world by forming objects. The mental construction of objects is typically not a conscious process and the conceptualization of the world as a collection of objects so cognitively salient that many ontologies assume that objects are objective features. Such an assumption of "objective" object formation ignores the substantive differences between agents in forming and delimiting objects. Everyday objects or animals are not problematic, but geographic features, e.g., what are the boundaries of a mountain? (Smith et al. 2000) or socially constructed objects (Searle 1995), are not part of material reality.

- *Object formation*: Agent reasoning is simplified by identifying uniform regions in space as objects and uniform regions in space-time process space as action. The level of detail at which objects are formed and classified depends on the current goal of the agent (Frank 2007b).

- *Agents construct models of reality*: Agents form not only factual models of reality as they observe it, but construct future models of the possible and impossible world and plan for actions that they could execute to attain an apparently attractive future world state ("goal"). Agents use predictive rules to assess the outcome of plans of actions to decide if they want to execute the plan.

- *Agent decisions are imperfect*: The agent's knowledge of the current state of reality as well as the rules an agent uses to predict the outcome of his actions are imperfect (satisficing in the sense of Simon (Simon 1997)). Therefore, the results of actions are not always the expected ones.

- *Actions*: Agents execute the plans they have decided on; decisions lead to activities, which translate the information realm processes into material processes.

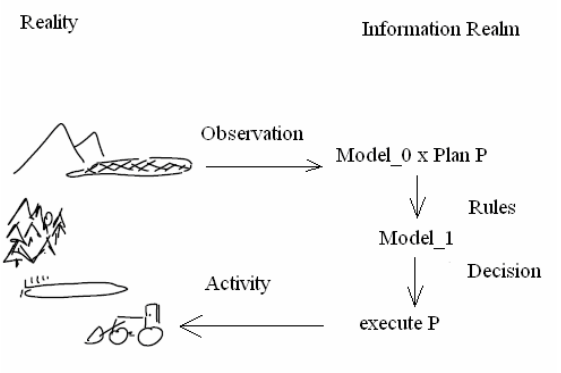

Figure 2: The processes involved in information causation

Neurophysiologic studies have shown that the information in the information realm is attached to matter and cognitive actions and decisions are chemical-electrical processes in the neural tissue. Biological agents contain complex systems that translate between decisions in the information realm, which are minuscule material changes to muscle actions that are macroscopic, material actions. The gap between the information realm processes and the material activity (Searle 2004) is closed by

1. the fact that the information processing in the agent is also a material process (neurobiological agent, electronically in a computerized agent), and

2. assuming that agents have goals (for example a goal to survive), which make them produce plans.

Conclusion

The two initial example sentences stand prototypically for two different ideas of causation:

- material effects causing changes in the material world and

- decisions in the information realm causing changes in the material world through activities of agents.

Observations and activities link the material world to the information world where cognizant agents construct imperfect models of their material environment and actions decided on. Information causation links back from the information realm to the material world.

The prototypical meaning of causation appears closer to the second example sentence: decisions of persons—based on information obtained directly and indirectly from their environment *cause* through their actions changes in reality.

Physical causation appears similar to information causation only if objects and actions are constructed—not presented in the sufficient description of physical laws by partial differential equations. To view physical causation as caused by an implied agent "nature" (respective parts like gravity, heat, electricity) may be a remnant of animism.

The difficulty with the logical analysis of causation is explained by observing that causation (as defined above) links the information realm back to the reality realm (Figure 3). Physical actions are fully within the reality realm and decisions fully within the information realm, an agent causing a material change is a process linking the two realms. The analysis of this process was hindered for centuries because it links the microscopic neural activities with the macroscopic material changes. Observation of neural activities and insight into activation chains is a recent addition to science and it was not possible to give a coherent account of causality unless the relation between reality and information realm is clarified, for which neural sciences have laid the foundations.

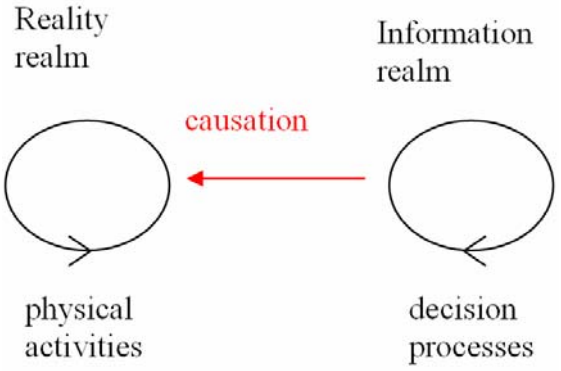

Figure 3: Causation links separated processes in material reality and information realm

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Email: frank@geoinfo.tuwien.ac.at