Time Isomorphism

by Sven Nilsen, 2019

Assume that there is an initial condition `$S_0$` from which one can produce future states from by simulating it using a computer. In general, one can think about `$S_0$` as a function:

$$S_0 : \text{seconds} \to S$$

Where:

$$S_0(0) := S_0$$

The meaning of this is that `0` is the point in time where the simulation starts, relative to the simulation itself, where the only known information is the initial simulation. The simulation has a fixed point that maps back to itself. Using `0` in this context has an advantage that it represents the time relative to the simulation as an observer, such that there is no absolute time.

By treating this function as a black box, it is not possible to derive future states without simulation. In the context of observer selection effects, it is not possible to get the information an observer has at some later point in time, without "creating" the observer.

This property means that if `$S_0$` means some event in the past, for example a previous simulation for which all information is lost, and there is a recreation at a later point `$S_1$`, then there exists a function `$f_{01}$` such that:

$$\forall\ i, j\ \{\ (S_i = S_j) \Rightarrow f_{ij} : \{S := S_i\} \to \text{seconds} \to \text{seconds}\ \}$$

The first argument of type `S` is an observer which defines how time is measured. This parameter is only used to make time well-defined in theories such as General Relativity. When not specified, we assume that the first simulation is used to define how time is measured.

$$\forall\ x : \text{seconds}, i, j\ \{\ f_{ij}(x) := f_{ij}(S_i)(x)\ \}$$

When we have specified how time is measured, we get a function which maps moments of the first simulation into moments of the second simulation, using the time of the first simulation. For every moment in the first simulation, there is a moment in the second simulation that gives the precise same information. Yet, locally, time behaves the same for both simulations:

$$S_0 = S_1 \quad \Leftrightarrow \quad \forall\ x : \text{seconds}\ \{\ S_0(x) = S_1(x)\ \}$$

For example, if two people run 100m, `$S_0$` starting one second before the `$S_1$`, `$f_{01}$` is the following:

$$f_{01} := \backslash(x : \text{seconds}) = x + 1$$

This notion that two simulations of the same thing have a physical relationship that is independent of their local time, that maps to identical or similar states of each other, is called "time isomorphism".