

Reality will ultimately be analog and digital

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Abstract

In order to explore analog or digital reality, we first define Reality with a postulate: Reality is that on which everybody can agree. Statements about Reality must potentially be accessible to everyone on earth. In our macroscopic experience, we describe physical reality analogically and digitally. Therefore ultimate Reality will be both analog and digital.

Essay

Is reality analog or digital ? Posed in these terms the question bears the imprint of modernity. Throughout history, philosophers of science often examined dual aspects of nature. Is nature continuous or discrete ? Are the fundamental entities making up reality waves or particles ? Should we describe the physics of the universe in terms of qualities or quantities, with figures or with numbers ?

The analog/digital duality appeared quite recently in the history of science as a byproduct of the electric respectively electronic processing of information. The sequence “analog” before “digital” has its historical meaning: the electric analog processing of signals chronologically preceded the electronic digital treatment of signals. Electric signals take a continuous range of values which can be translated in a similar form by analog devices, while electronic signals can take advantage of stepwise digitized variations. Before the discovery of the electron and the transistor, the world was described analogically, literally flowing from ($=\alpha\nu\alpha$) similarities between words ($=\lambda\omicron\gamma\omicron\varsigma$). After the digital revolution, the world is digitized, made countable with the help of our fingers, digits. So historically, the question is settled: reality which seemed analog to the preceding generations evolves more and more towards a digital world.

Furthermore with the extending possibilities of computers to simulate reality and recreate virtual worlds, the question grows out as a serious challenge. Could the reality of something as complex as Life ever be described in terms of digital processes ? Some 10 years ago, the question “Is Life Analog or Digital ?” was posed in an Edge discussion [1]. Against the stream in favor of a digital world, Freeman Dyson recalled the Richards – Pour El theorem,

which states that an analog calculation is more powerful than its digital counterpart. With a continuous function one can fit continuous behavior of natural systems to exact precision, leaving no holes between successive values as would do a discrete digitized function. So should we describe reality analogically or digitally ?

First let us investigate what's exactly *Reality*.

In common sense, Reality is that which exists effectively. However, is there anything in our world that can claim to have the status of existing effectively ? This question has occupied generations of scientists and philosophers, without definite answer. So, in order to deal with the essay question, I need to "postulate a truth" about what's existing effectively. This truth about Reality will have no absolute value of truth, but it will help me to start deductions about Reality.

I postulate Reality to be that on which all people can agree. With this postulate, Reality will have a universal character. Surely, this won't give an exclusive answer whether Reality is analog or digital. There will always be people who prefer analogous and others who prefer digital descriptions of Reality. An exclusive answer (analog XOR digital) of the essay question is therefore impossible. With respect to Reality, the qualities analog and digital are suggestive. We must investigate a deeper level of Reality to reach something on which everybody can agree: physical reality. Physical reality must be potentially and reproducibly accessible through experiment to any human inhabitant of earth. If it is not, the corresponding statement about reality is biased.

For example, let's take an object of everyday life: a stone. A stone is real, if anyone can potentially take that stone, throw it, drop it, feel its weight... That's physical reality, something on which everybody can agree. One can quantify that reality. One pebble and another pebble will add to a quantity of two pebbles. The reality of pebbles can thus be quantified in discrete amounts. Two pebbles dropped at the same moment will have the same continuously accelerating speed. The reality of the motion of pebbles can thus also be described with the help of a continuous function. Reality of pebbles is digital and analog.

As a side note, some aspects of reality need to be defined more precisely before one can talk about their reality. For example, my feelings are suggestive. As long as I haven't characterized them in words, numbers or figures understandable by everyone, I can't put them to the test of reality. They may represent mere illusions (one could say "mere feelings"). But

if I succeed in characterizing my feelings in such a way that anybody on earth can agree about them, I'm authorized to poll their reality. For instance, I may qualify and quantify my feelings with respect to their consequences on my body and characterize some aspects of their reality.

Bit by bit, one can thus investigate deeper aspects of physical reality and end up with a universal agreement about the fundamentals of Nature. Some aspects of physics haven't reached the stadium of universal agreement yet. This is the case for processes at the cosmological scale or at the atomic and nuclear scale, because the rules governing their behavior are not directly part of our everyday experience. We haven't yet managed to describe all their reality with concepts or words on which everybody can agree. It is the physicist's job to enlarge the scope of universal agreement about physical reality.

The only way to achieve a description of reality on which everybody can agree is then to use words, pictures and concepts of everyday life. Anytime we use abstract concepts or anytime we write mathematical formulas, we should do our best to relate them to objects and behavior on which everybody can agree. Otherwise there is big chance we are either arguing about words or building on unreal hypotheses that may take us very far into dead-ends.

For the objects inaccessible to direct perception, for example the objects of the submicroscopic realm, we are like blind. We can only perceive them with tools that upsize their interactions with our senses. For example, if we want to detect infinitesimal small quantities of light, we need to send the light on a detector's surface that's electrically very sensitive. A little light can then create a tiny electric current which in turn will cause a cascade of current amplifications until the current is large enough to be perceived by anyone. In this way we have put fundamental quantum behavior at hand for everyone. Anyone on earth can have a feeling of the electric current. The current is physically real, so the small amount of light that is at its origin is physically real.

The trouble now is: how do we interpret the interaction between light and electric current and subsequently between the electric current and our skin or the screen of an oscilloscope? Is the induced current really a consequence of the small amount of light we have projected on the detector? And in which way? Are small quantities of light analog or digital? Do we have a continuous flux of light-wave or a discrete amount of light-particles? And is the electric current a continuous flow of electric-wave or a discrete amount of electric-particles. Beneath the range of some micrometers, there's a whole realm where our senses are indirectly

stimulated and we are ignorant about the fine structure of reality. Only hypotheses and deductive thinking on notions that are related to our everyday experience can help us farther.

We are like a blind man who uses a stick to extend its perception of the surrounding world. Ideally, a stick is a one-dimensional continuum, but the interactions with the other objects can be either discrete or continuous. The blind man's stick can either hit an obstacle on the road, or gently and continuously glide on a smooth floor. In both cases, the environment he explores is real. Real in the sense that anybody can agree about the interactions between the stick and its environment. Any person can reproduce the same movements with the stick in the same environmental setup and come to similar conclusions about Reality. The invisible reality of the blind man has continuous and discrete aspects, depending on the way he uses the stick.

Because we describe our macroscopic world analogically as well as digitally, there's no reason that we will do differently for the submicroscopic world. In our macroscopic world, we have objects with continuous motions, characteristic lengths, discrete interactions. In the quantum world, it's exactly the same: we talk about discrete particles having a continuously evolving Hamiltonian (in the Heisenberg picture) or a continuously evolving state vector (in the Schrödinger picture), because we know about continuously evolving functions or vectors in the macroscopic world. We will describe anything happening in the submicroscopic world with concepts derived from our macroscopic experience, analogically *and* digitally. Only then can we come to universal agreement about its reality.

Ultimately the understandable reality will be analog *and* digital.

Reference

[1] *Is Life Analog or Digital?* Question for the Edge discussion group from Freeman Dyson, Edge 82, March 13, 2001