

**REALITY, ANALOG AND DIGITAL IN THE THEORY OF KNOWLEDGE:
IS REALITY DIGITAL OR ANALOG?**

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ABSTRACT

The essay presents an analytical viewpoint of the relationships among the concepts of reality, analog, continuum, digital and discrete. We then answer the question: Is reality digital or analog? The spaces of ontology and epistemology are considered where the concept of reality is divided into ontological and epistemic realities. The epistemic reality is constructed on the basis of either methodological discreteness or methodological continuum. It is a model representation of the ontological reality in a continuum and represents *what there is*. The epistemic reality is either digital or analog. The digital and discrete representations are argued to emerge from the formalists and the *logistics* on the basis of dualism and the classical paradigm of thought with its logic and mathematics. The continuum and analog representations are argued to emerge from the intuitionists on the basis of duality and fuzzy paradigm of thought with its logic and mathematics. The epistemic reality exists as a digital-analog duality or a discrete-continuum duality. The choice of representations depends on whether one assumes exact information structure or defective information structure. Viewed in a set-theoretic structure, digital-discrete representations and the resulting knowledge structure are subsets of the analog-continuum representations and the resulting knowledge structure. The digital-discrete representations are approximations of the analog-continuum representations which are the enveloping of discrete-digital points in the process of knowing the elements in the ontological reality. The answer to the question: *Is reality*

digital or analog? is provided. The ontological reality is analog in the ontological space. The epistemic reality can be either analog or digital or both. In the epistemological space, the analog is related to continuum and inexactness and digital is related to discreteness and exactness. They are methodologically connected to fuzzy and classical paradigms with their laws of thought in knowing the ontological elements respectively.

The answer to the question: Is reality digital or analog? begins with an analytical toolbox of the *theory of the knowledge square* which has a number of relational building blocks of ontology and epistemology to the path of knowing.

1 THE ONTOLOGY

The first building block centers on *what there is* whose cognition is the *ontology*. The elements of *what there is* are represented as *ontological elements*. They are made up of objects, processes and states that are under continual internal transformations. The conceptual place is the *ontological space*. The collection of these elements for knowing is the *potential set*. The identities of all these elements in the ontological space are defined by *ontological characteristic sets* independent of and unknown to cognitive agents.

Each ontological element is defined by a unique set of ontological characteristics at any natural transformation period. The unique sets allow continuous multiple give-and-take relations among the ontological elements. These relationships are present whether the elements are aware of or not and allow groupings to be formed called *ontological categories*. The ontological space is continuous in the sense of the characteristic information signals that are propelled by energy for uninterrupted internal communications and transformations. This is the principle of *ontological continuum* where relationships and *categorial conversions* of ontological elements are continuous in all *ontological times*. The ontological categories obey universal laws of *categorial conversions* on the basis of information, energy and decision-choice actions by the ontological elements under the continuum. The information flows from the ontological characteristics is the *ontological information*. The system of continual transformations of ontological characteristics is the *ontological decision-choice system*. The transformation process is called the *ontological categorial conversion*. The interplays of information and energy that provide forces for categorial conversions are the *ontological moments* that operate in continua on the basis of *ontological time and space*. The ontological time and space are expressed in the *quality-quantity-time space*.

The quality-quantity-time space may be split into three spaces of 1) quality-quantity space, 2) quality-time space and 3) quantity-time space which encompasses space-time phenomenon in knowing. The quality-time space allows qualitative motion, holding quantity constant. The quantity-time space allows quantitative motion, holding quality constant. The quality-quantity space allows for the simultaneity of qualitative-quantitative motions that create simultaneous transformations. The complete ontological space is continuous and infinitely closed under infinite transformations that justify the phrase: the only thing that is permanent is change and transformations. Since the

ontological space is viewed as infinitely closed under continuum, it cannot expand. The view that the universe is expanding must also admit that the concept of the universe cannot be the universe since an expansion admits the existence of an empty space which is not accounted for in our concept of the infinite universe whether this infinity is seen as a simple infinity or supper infinity by a human conception. The universe is analog and the collection of the ontological elements constitutes the *ontological reality*

2. THE EPISTEMOLOGY

Given the existence of *what there is* outside the immediate knowability of *what there is* in the ontological space existing in a continuum, the question is how can the ontological elements be known by cognitive agents who are also part of the ontological elements? The cognitive framework for knowing is the *epistemology* with the *epistemological space* containing elements called the *epistemic elements* for possible knowledge. The epistemological space is composed of three sub-spaces of the *possibility* *the probability* and *the epistemic reality* that is different from the *ontological reality*. The first step in knowing is a process of cognitively moving some ontological elements, transforming them into epistemic elements and placing them in the *possibility space* that will contain the *possible epistemic elements*. The second step in the process of knowing is moving the possible epistemic elements and cognitively transforming them into *probable epistemic elements* and then placing them in the *probability space*. The last stage of the knowing process is where the probable epistemic elements are transformed into epistemic actual objects and placed in the *space of epistemic reality*. The four knowing blocks of the potential space, the possibility space, the probability space and the space of the epistemic reality define the concept of the *knowledge square* and the study of their connections and transformations constitutes the theory of the knowledge square which establishes a universal principle for the development of the theory of knowledge in both physical and non-physical systems. It is universal that applies to and unites all knowledge areas as a complete knowledge system [6].

In order to verify a claimed knowledge or a reality, the epistemological space must be an isomorphic construct of an aspect of the ontological space. Thus we have *epistemic elements*, like the ontological elements with *epistemic characteristics* where the epistemic elements are formed into *epistemic categories*. The epistemological space is a cognitive construct and hence it may be continuous or discrete in the sense that the characteristic information signals that are propelled by energy for communication and transformation may be viewed as represented in *intervals* or in *discrete points*. The epistemic space may follow the principle of either an *epistemic continuum* or an *epistemic discreteness* where the relationships and the *categorial conversions* of the epistemic elements follow a continuous process or discrete process under *epistemic times*. The epistemic categories obey universal laws of categorial conversions on the basis of information and the decision-choice actions on the part of decision-agents under either continuum or discreteness through the logical construction-reduction duality to obtain an epistemic reality as a human construct to be compared with some aspects of ontological reality.

Both constructionism and reductionism in the knowledge production require information from the ontological space through the sending-receiving processes from the ontological elements by the way of their characteristics. Every ontological element operates in the sending-receiving duality. The information that is received in the epistemological space from the ontological characteristics is the *epistemic information* which is subjective. The system of continuous or discrete transformations of the epistemic characteristics through the four spaces is the *epistemic decision-choice system* that follows a defined set of rules of reasoning different from the ontological decision-choice system. The transformation process is called the *epistemic categorial conversion*. The interplays of information and energy that provides forces for categorial conversions in the epistemological space is called the *epistemic moments* that operate in either a continuum or discrete basis depending on representation and laws of thought. The epistemological space is also quality-quantity-time space. However, whether one chooses to work with quality-time space or quantity-time space or quality-quantity space depends on the nature of continuum-discrete information representation that one selects. This selection will also dictate the nature of information representation, the paradigm of thought and the methodology of the knowledge production.

The process of knowing *what there is*, is an input-output duality where information is an objective input from the ontological elements through the *sending-receiving processes*. Such information is ontologically coded as objective information from the ontological characteristic sets in the sense of *what there is*. The sending process requires energy which is continuous. The cognitive agents receive this objective information as coded signals just as DNA that helps to identify the ontological elements and the category to which they belong. The coded information must be processed to reveal the identity of any element and its category by cognitive agents. The result of the information processing is a knowledge output that defines the input-output duality from the information-knowledge duality into the epistemic reality. The processing of information comes under nominalism, constructionism and reductionism. In nominalism, we have language for the initial decoding of the ontological information into epistemological information which must be processed into a claimed knowledge that will characterize the space of epistemic reality. Two important analytical questions emerge. Does nominalism involve analog or digital in representations where such representations assume the structure of formal and informal languages?

The problem of relations among discrete, continuous, digital and analog reveals itself in terms of the problem of information representation and the problem of methods of information processing to create thought for knowledge acceptance. The problem of information representation in terms of logical and mathematical symbolism has been the first intense debate among the intuitionists and the *logistics* and formalists. The formalists and “logistics” emphasize discrete and hence digital in their work in the epistemological space where exactness is epistemologically claimed in discrete set representation of $\{0,1\}$ – truth system where an element belongs to or not [8][14][20][23]. They adhere to discrete systems such as integers which are then related to digital representation and discrete processes that lead to a search for discrete and digital mathematics and information processing where the quality phenomenon that generates vagueness is abstracted out [1][2][4][8][11][15]. The intuitionists emphasize continuum and hence analogue in their work in the epistemological space where inexactness is

epistemologically admitted in a continuous set representation of $[0,1]$ –truth system where an element belonging to a set has a qualification of a degree of belonging [1] [3][4] [10][12], [13]. They adhere to continuous systems such as intervals which are then related to analog representation and continuous processes that lead to a search for continuous and analog mathematics and information processing under the principle of continuum where quality that generate vagueness is integrated into the thinking process as it should be.

The second level of the debate is on the laws of thought. Here, the formalists find comfort in Aristotelian laws of thought where the law of identity of ontological elements is supported by the laws of excluded-middle and non-acceptance of contradiction in the knowledge-production process. Falsity is proven by contradiction and uncertainty is attributed to information limitation and characterized by quantity with *stochastic conditionality*. This is the *classical paradigm* of representation, information-processing and knowledge-production where the emphasis is on the digital. The stochastic conditionality and its measure relate to exact probabilistic reasoning in the probability space. The intuitionists find comfort in non-Aristotelian laws of thought where the law of identity of ontological elements is supported by the laws continuum and acceptance of contradiction in the knowledge-production process with *fuzzy conditionality*. Falsity is proven not by contradiction but by the size of the degree of contradiction operating on the basis of human decision-choice action and where uncertainty is attributed to both information limitation and its vagueness and characterized by quantity and quality with both stochastic and fuzzy conditionalities. This is the *fuzzy paradigm* of representation, information-processing and knowledge-production where the emphasis is on the analog. The fuzzy conditionality and its measure relate to the possibilistic reasoning in the possibility space and inexact probabilistic reasoning in the probability space. [2][6][10][20].

As discussed, continuum is the characteristic of the ontological space on the law of identity. This is the ontological reality which is established as the universal system that cognitive agents have no influence. It is *what there is*. The methodological continuum, leading to analog and methodological discreteness, leading to digital belong to cognition and the instruments of thought in order to connect the epistemological space of epistemic reality to the ontological space of ontological reality for knowing. The representation and the study of the ontological continuum and the relational chain of the ontological elements may be approached by the methods of either epistemic continuum or epistemic discreteness. Initially, informal languages began with analog in their qualitative and quantitative representations that are referred to as *linguistic variables* such as red, beautiful, nice and many others in the quality-time space. The linguistic variables such as big, small, tall, huge and others carry both quantitative and qualitative characteristics that are defined in the continuum in the quality-quantity-time space [34]. At the level of epistemology, continuum involves both quantity-quality duality that generates inexactness and inexact symbolism that encompasses approximation and inexact logic to obtain exact conclusion with *fuzzy conditionality* under *fuzzy rationality*.

In attempts to relate the epistemological space to the ontological space, should the developments of the tools of knowledge-search and understanding be inexact symbolism and reasoning or should they be exact symbolism and reasoning? These two paths of the development of the theory of knowledge presented an intense debate in the field of

mathematics and symbolic logic that have been mentioned previously. The current debate is shifted from between the formalist and the intuitionists to between the proponents of the classical paradigm with its exact symbolism, logic and mathematics and those of the fuzzy paradigm with inexact symbolism, fuzzy logic and mathematics. In terms of the activities in the epistemological space, all the paradigms accept the identity conditions of the ontological space and its elements. The points of disagreement are on the epistemological space which is of human creation. Such disagreements center on the nature of the information input that must be used in the creation of epistemic elements and the logic of epistemic processing to develop the epistemic reality. The advocates of the fuzzy paradigm or the position of the intuitionists claim that by human nature, his cognitive limitation, language limitations and inefficient observations, we receive a *defective information structure* which is composed of defectiveness due to qualitative vagueness that generates *fuzzy uncertainty*; and defectiveness due to quantitative incompleteness that generates *stochastic uncertainty*.

The representation of this defective information structure must take the form of inexact symbolism on continuum principle that allows the representation of *fuzzy-random variable* and *random-fuzzy variable* that are defined as fuzzy non-singleton sets with associated degrees of belonging. The reasoning must follow the *fuzzy laws of thought* and *soft-computing* in the *true-false duality* under the laws of continuum and acceptance of contradictions in thought through decision-choice actions with the fuzzy rationality and *flexible inexact determination*. The advocates of the classical paradigm or the formalists disregard quality and vagueness and hence do away with the *defective information structure* due to qualitative vagueness that generates fuzzy uncertainty. They concentrate on defective information structure due to quantitative incompleteness that generates *stochastic uncertainty*. The representation of this defective information structure takes the form of exact symbolism that allows *discrete* and *digital* representation of information with exact classical *non-random* and *random variables* that are defined as precise singleton sets. Here, the reasoning follows the classical laws of thought or exact reasoning in the *true-false dualism* under the laws of excluded middle and non-acceptance of contradictions in thought with rigid exact determinations under the *classical rationality*. Digital representation is exact and avoids the problem of quality. Analog representation is inexact and embraces the problem of quality.

As discussed, the following conclusions are drawn. A space-time continuum is a characteristic of the ontological space. It does not emerge from digital description. Digital description as an exact representation is a characteristic of the epistemological space. It is appropriate as *approximate representations* of points in the continuum. It follows the analytical representation of exact rigid determination on the rules of the classical paradigm. The logical continuum is an *enveloping of the discrete logical process* and so analog is an enveloping of the digital logical process which is a point-to-point characterization of the analog process. The concept of minimal length, time, energy, information and how could we observe them are epistemological questions and must be separated from the questions of ontological reality which must be distinguished from epistemic reality which is a cognitive model of the ontological reality. The right way that the fundamental discreteness must be seen is in terms of human limitations in attempts to know the ontological elements and processes in a continuum through observations, acquaintances, senses and reasoning.

The ontological space is infinitely infinite and is incapable of expansion. It is continuous and infinitely self-contained. There is no empty space to expand into in terms of space-time phenomenon. It is self-correcting and self-transforming through infinite categorial conversions in terms of quality-time phenomenon where every qualitative disposition has a corresponding quantitative disposition and vice versa. The epistemological space that is either discretely or continuously represented is finitely infinite and under a continual expansion depending on the activities and behavior of cognitive agents with the epistemic elements. The wrong way to look at the fundamental discreteness is to associate it with ontological activities that are independent of the general human thought system. The right way is to view discreteness as a methodological approach to overcome complexity and use the classical paradigm to understand the ontological continuum through the technique of sequential problem-solving where “x is x” and “10 is 10” which is an appropriate representation for the classical laws of thought with unconnected opposites and excluded middle.

The digital representation of ontological continuum is an analytical convenience that allows the extensive development of the classical mathematics to be used to derive exact propositions that may be poor systems’ representations . The ontological universe is a creation outside the human direct experience but incorporates humans as ontological elements. The epistemological space is a creation of cognitive process within the ontological space in human attempt to know and understand ontological elements that surround him. Time, energy, liquid and information flows are ontologically continuous. These flows can be represented and studied with digital process as approximation between intervals with continuously connected points in the epistemic space. Importantly, a minute, an hour, a day, a month and a year are human calibrations to understand complexities of flows. Similarly, a unit volume, a unit length, unit energy and many others must be viewed in the same epistemic structure and must be related to the consumption-production duality and the phenomenon of exchange. The discreteness and digital are purely epistemic methods which allow the construction of epistemic reality but not the ontological reality.

The question of comparability of ontological space and epistemic method of fundamental discreteness is epistemologically irrelevant since the epistemological process may be viewed as residing in the discrete-continuum or digital-analog duality. In continuum, we find discreteness and vice versa and in analog we find digital and vice versa in the epistemological space. From the view point of the classical paradigm, that has taken hold of our knowledge-production process, the only way to represent, describe, modeling and theorizing about the ontological continuum is through the methods of discreteness and digital. In this way, the world scientific picture, as it cognitively evolves in stages is presented as digital and then claimed to be exact without human intervention. This scientific picture as obtained with methods of discreteness and digital is simply a subset of that which could be obtained with either the methods of continuum or analog or both.

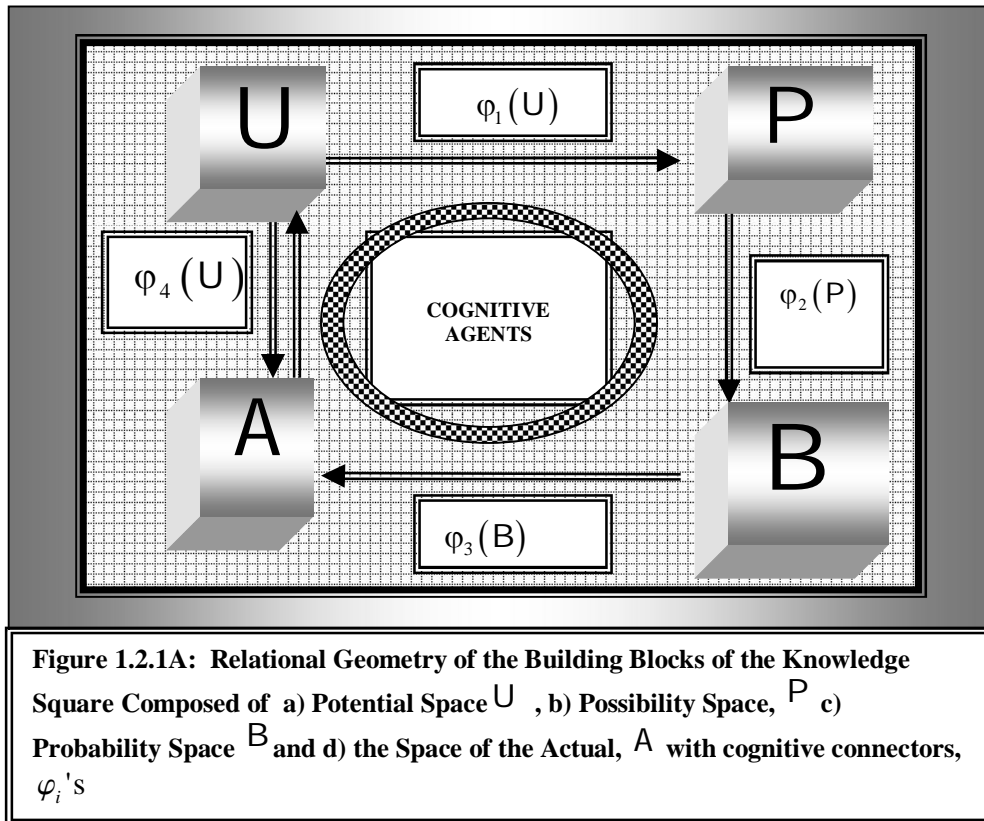
The question as to whether reality must be purely analog may be answered by distinguishing the *ontological reality* from the *epistemic reality*. The ontological reality exists in an ontological continuum and is simply *what there is*. It exists in opposites, polarity, duality and unity in continual transformations through self-adjustments, self-correction and self-integrating. Example is life-death duality that involves all

transformation of existence. The transformation of life to death is an ontological process in continuum. The epistemic reality is cognitive creation through a methodology and paradigm of thought with its laws of thought. It may exist in either an epistemological discreteness or digital process. It may also exist as an epistemological continuum or analog process. The epistemic discreteness is human deficient attempt to knowing and understanding the ontological continuum in simplicity. The epistemological continuum is human attempt to knowing and understanding ontological continuum in complexity. The complexity, synergetics and energetics exist in digital-analog, discrete-continuous and reality-potential dualities as integrated systems whose paradigm of thought must be the fuzzy paradigm to deal with linguistic vagueness, ambiguities in reasoning and conclusions.

Every symbol and meaning can be represented as a set that shows the degree to which the symbol belongs to the set. Let such a set be \mathbb{X} with a generic element, $x \in \mathbb{X}$. The degree to which $x \in \mathbb{X}$ is represented by a membership characteristic function of the form $\mu_{\mathbb{X}}(x) \in [0,1]$. Thus $\mathbb{X} = \{(x, \mu_{\mathbb{X}}(x)) \mid x \in \mathbb{X}, \mu_{\mathbb{X}}(x) \in [0,1]\}$ is an analog with a distant representation. Digital representation implies that $\mu_{\mathbb{X}}(x) = 1$ or 0 for exactness. An analog representation implies that $\mu_{\mathbb{X}}(x) \in [0,1]$ for inexactness which is a fuzzy covering of the digital representation where $\{0,1\} \subset [0,1]$. The digital is simple and more preferred information representation and processing because of exactness and the extensive development of, and general familiarity with the classical mathematics and logic. It, however, loses substantial degree of relevance in representation as the system's complexity increases. The analog is complex and less preferred information representation and processing because of inexactness and the relatively less known and the lower development of the fuzzy mathematics and logic. The inexactness is, however, compensated by increasing degrees of relevance in representation as the system's complexity increases. The work on analog system will reveal new scientific world pictures that are not contained in the digital system which is an approximation of some set elements in the analog system. Digital epistemic reality is a subset of analog epistemic reality which may or may not have correspondence with ontological reality.

NOTES

The Knowledge Square: The ontological space is the potential space as the collection of the elements of *what there is*. The epistemological space is composed of the spaces of the possibility; probability and epistemic actual. They are analytically connected by cognition.



The Classical Laws of Thought: *all propositions are either true or false but not both.*

1) The law of identity (what there is, is what there is); 2) The law of non-acceptance of contradiction (nothing can exist and not exist), 3) The law of excluded middle (everything is or is not)

The Fuzzy Laws of thought: *All propositions contain true and false characteristics in varying proportions where the acceptance of all true propositions and all false propositions is by decision-choice actions operating on a defined rationality.*

1) The law of identity (what there is, is what there is); 2) The law of acceptance of contradiction (every truth has a false counterpart and ever false has truth counterpart thus exists in contradiction), 3) The law of continuum (everything is and is not).

The Principle of Enveloping and Approximation: Every discrete (digit) has a continuum (analog) enveloping and ever continuum (analog) has discrete (digital) approximations in the epistemological space. Methodologically, therefore, the epistemic reality may be digital or analog or both. The digital has the strength of epistemic

exactness. Its weakness is simplicity and high uncertainty. The analog has the strength of epistemic complexity. Its weakness is inexactness and low uncertainty. The epistemic reality is a model of ontological reality.

The Duality and Dualism: Duality involves the principle of opposites with continuum in a unit interval $[0,1]$ for all representations and reasoning. : Dualism involves the principle of opposites with excluded middle in the discrete form $\{0,1\}$ points for all representations and reasoning where $\{0,1\} \subset [0,1]$. Dualism is a subset of duality.

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