ALGORITHMIC INNOVATION: AN INQUIRY INTO "AI"

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I. INTRODUCTION

The term "Artificial Intelligence" or "AI," is well-known, though sometimes subject to the remark that AI is "neither real nor intelligent." Artificial? Though it may be part of its name, AI identifies a real technology category that is undergoing active development and discussion in both industry and research laboratories. Intelligent? Well, that is a different issue that rests heavily on how that term is defined. This article will explore what so-called artificial intelligence is and how it may be distinguished from human or general intelligence. This distinction is important because it underlies a number of legal issues that need to be addressed concerning inanimate machines and digital workers. These include (a) standards of conduct; (b) legal transactions and ownership; (c) rights and expectations; and (d) the relationships between and among human and digital workers.

Human Intelligence

Intelligence of the human or general kind, according to *The New Shorter Oxford English Dictionary*, 1993 edition, Oxford University Press Inc., New York, is "the faculty of understanding . . . to grasp the meaning of a subject" or "the faculty of comprehending and reasoning . . . to learn or gain knowledge from information received" or to learn by inference; and the faculty of "judgment." To these may be added the faculties of reasoning, consciousness, self-awareness, etc., which enable some abilities characteristic of general intelligence to imagine, create, adapt, solve problems, invent, and use language. Intelligence is clearly a complex concept having many and varied facets of meaning.

So, what is "*artificial* intelligence," actually? This article suggests a more accurate and instructive or useful term: that the initials AI more accurately stand for "algorithmic innovation." In fact, the technical advances and innovations that are called "AI" owe their very existence to innovations in the development of algorithms to solve a variety of problems or control performance of many kinds of complex tasks by implementing ingenious processes.

Defining the Term "Algorithm"

An algorithm is "a procedure or set of rules for calculation or problem solving," according to *The New Shorter Oxford English Dictionary*, 1993 edition. Thus, an algorithm is a process, more specifically a sequence of steps or actions for performing a particularly defined task or function. In simplest terms, it is a process. Every step and operation carried out by the algorithm is defined. The sequence of steps may include tests, decision steps, branches or loops, to consider a variable quantity, require a calculation, or present a choice of options to the following step. Each of these is defined and built into the process. The ability of the process to alter its sequence is limited by the specific sequential activity programmed into it. An algorithm is only capable of carrying out a preconceived and pre-devised series of actions, functions, or procedures. It is not an intelligent process in the sense of thinking, reasoning, changing its sequence in response to new or unpredictable information or conditions on the fly without instructions for proceeding; in other words, the ability to flexibly adapt to the inputs and environment in which it operates. Even an algorithm that adapts in a prescribed way to a limited set of definable inputs or conditions is not intelligent; it is merely following instructions.

Algorithm – A Simple Example

By its nature, an algorithm is a preconceived process that is explicitly limited by its terms. One example of the problem-solving aspect of algorithms is facial recognition, a machine learning process currently in use to determine if an individual present at an entrance to a secure facility is authorized for admittance. In its simplest terms it can compare various defined details or characteristics of a new facial image to a database of facial images and their peculiar individual characteristics to identify the new image and perhaps identity information associated with the particular database image.

A More Complex Example

Another example is more complex – the use of a computing system to perform analytical processing upon a large data set to identify patterns in the data or predict trends in the data over time. Predictive analytics is a very useful tool in understanding complex data sets or in making decisions as part of a long-term strategy of a business that is contemplating changes, either to its operations or in trying to understand how conditions in its market may change. The analytics process still must define the data set(s), the conditions of analysis, the limits of the analysis, etc., so that it can return useful results responsive to the question posed to the process. Intelligence is certainly required to devise the process, but the process devised is not itself intelligent; it is only an artificial, carefully structured, complex algorithmic process that does the same thing that a human can do except enabling it to be done by a programmed machine in a vanishingly small fraction of the time it would take a human to access and analyze the same data using paper and pencil. The processes in such examples advance only as instructed by the algorithm without any volitional or undirected aspect to how the process proceeds. The processes also require access to applicable data sets for training and the algorithmic routines to extract and analyze their content in the context of the desired outcome.

Defining the Term "Innovation"

The second term in the AI phrase 'algorithmic innovation' also deserves consideration. An innovation is a new or clever solution to a problem, typically driven by the need to discover and develop a more efficient system, apparatus, or process.[1] Thus, if an algorithm is developed that successfully and more efficiently solves a problem, it may satisfy the definition of an algorithmic innovation. While this kind of "AI" is a specific solution to a defined problem that proceeds as an ordered sequence of steps directed to a specific, desired outcome or result, this example of "AI" still lacks the attributes of human intelligence, even though it may implement an innovation in solving the defined problem. In general, it does not "think" its way or reason through the process or have the capacity to adapt to parameters or data not within a defined set. It is not conscious or self-aware, nor can it exercise judgment.

Uses of Algorithmic Innovations – Machine Learning

For machine learning systems constructed of networks of simulated neurons (i.e., neural networks – electronic networks configured to mimic the functional operation of sensory processes) to perform so-called deep learning, algorithmic innovation is a more accurate term of art than artificial intelligence to denote the concept embodied in such technologies. Examples of such

[1] If an innovation satisfies the conditions set by the Patent Statute, Title 35 of the U. S. Code, the innovation may rise to the status of an "invention." The inventor of an invention may be awarded a grant of patent in exchange for disclosing the invention to the U. S. Patent & Trademark Office in a formal application for patent. A patent grants the inventor the right to exclude others from using the invention for a limited time unless authorized by the inventor.

networks designed to respond to specialized algorithms developed, organized, and executed by a programmed computing device to perform defined tasks such as (a) review massive amounts of data to enable the algorithmic process to "learn" according to an embedded functional process; (b) discern patterns in the data according to a preconceived objective, defined concept or related to a particular question; or (c) determine the identity of an unknown image. If such systems provide results that prove to be more efficient than preceding systems or methods, the system may be termed an innovation. For example, some proponents of the conventional artificial intelligence/machine learning concept advance so-called "connectionist networks" as a type of neural network according to a machine learning model that is replicable on a computer controlled by an algorithmic program, wherein knowledge resides in "weighted connections" between units called "simulated neurons." This model is based on a functional theory of the brain embodied in a "computational architecture." But what if the human brain is structured and functions according to a model other than a computational, i.e., a programmed digital architecture?

The application of algorithmic innovation or "AI" includes machine learning and deep learning (as in multi-layer neural networks). Some examples include voice or facial (or image) recognition, musical composition, automated vehicles, etc. Software-driven features in new cars act to warn drivers of potential hazards or activate vehicle systems to avoid such circumstances. Other algorithmic innovations include products and features connected with user's computers and smart phones such as Siri® (Apple Inc.), Alexa® (Amazon.com Inc.), and the myriad of applications ("apps"), including computer games, that let users engage interesting or entertaining and often helpful tasks. Further, some recent AI products include programs developed to facilitate the services of professionals in routine applications of medicine, law, accounting, and certain executive functions of business management.

In fact, most of the innovations, features, and uses of data – that ubiquitous stuff that fuels the digital world – is processed by the algorithmic innovations implemented in the software that configures and controls the operation of the processors in the user's computing devices and smart phones, vehicles and appliances. None of these are really intelligent; but they perform complex process tasks and were all created by general human intelligence and well-developed skills applied to finding imaginative solutions to new problems.

In sum, we have noted that the term artificial intelligence, more aptly algorithmic innovation, as a field of technological development that seeks to develop a non-human, inanimate device, system, or process that can mimic and successfully substitute for human activity or the capabilities of the human brain and mind that are understood to arise from human "intelligence." Human intelligence, by contrast is a cognitive, biological mechanism and process that exhibits consciousness and self-awareness, and that has the ability to imagine, create, adapt to new circumstances or information, to reason, to think, to invent and use language, to solve problems, exercise judgment, etc. The field of AI thus approaches its work by trying to design a mechanism, e.g., a computer, that uses these kinds of attributes to perform particular functions. Thus, the computer may be configured by specific algorithmic processes to mimic specific functions performed by the human brain and mind as it would use its attributes of human intelligence to perform or direct the task at hand.

In the next section we'll consider some characteristics of general human intelligence that clarifies the distinction between its capacities and "artificial intelligence." This overview will conclude by examining some of the reasons this distinction matters.

II. CONSIDERATIONS OF GENERAL HUMAN INTELLIGENCE

Processing Information in the Human Brain

To set the stage for further discussion of AI as algorithmic innovation, consider one particular skill of human intelligence – the capacity to identify (or diagnose) and define an unfamiliar problem to be solved or question to answer. This skill further includes the capacity to review information or data that is relevant to the problem, both within one's own memory and from information about the problem and its environment. This ability proceeds from one's review of knowledge, experience, and perceived patterns of information to propose a solution to the problem, to develop the details of the solution proposed, to construct or describe the solution, and to test the solution, all without the constraints imposed in a formal algorithm. These skills suggest that the brain is organized to function much like the scientific method. The information content, from sensory inputs, both from observations via the extrinsic senses (sight, sound, touch, smell, taste) and from the intrinsic or cognitive senses of thought, imagination, and knowledge in one's memory, may be processed as patterns of information according to a model to be described. For example, a basic processing element may be called an "image pattern" – a mosaic of information from each of the extrinsic senses that conveys the brain's inherent sensory awareness, its knowledge, and its capacity to perceive patterns and relationships among these image patterns. Pursuit of this idea may reveal some things about how the brain works, a speculative discussion to be sure, but one that may raise questions for further study. Moreover, it may lead to the understanding needed for AI to approach the human capacities for intelligent activity.

In the foregoing, the word "image" is used here in the broad sense of a mosaic replica of the content of a visual scene, or of a sound, odor, taste, or touch sensation. This replica is understood herein as a metaphor applicable to all of the senses, both extrinsic (sensory) and intrinsic (cognitive). The image pattern metaphor introduced herein can also be thought of as a vehicle of memory processing that retains and conveys the sensed or cognitive information including the relationship among its elements. For example, the brain as a living, biological organ is constantly circulating the content of its existence as the blood circulation stimulates neuronal activity and communication within and among the various regions of the brain. It is thus no accident that extrinsic and intrinsic mosaic element patterns are also active, giving rise to awareness as consciousness, including imagination and thinking – or when its host body is asleep – as during dreaming.

Image Patterns

For example, consider the following sequence of processes, beginning with the perception of external (or internal) objects or sensations through the extrinsic sensory apparatus such as eyesight coupled to the human central nervous system. The output of the visual sense is formed as an image pattern on the retina and in the brain. It is postulated herein that the other extrinsic senses – sound, smell, touch, and taste – are similarly configured to produce patterns of the sensed information. These image patterns may be associated with other image patterns representing knowledge or thoughts, perhaps expressed as signs, gestures, sounds, symbols, etc. – all elements of language. The use of language enables further association with other image patterns, even to the extent of naming or classifying related patterns and their information content. These image patterns and content are retained in some form that facilitates, through means of access, near-instant recall.

Further, these image pattern elements may also function as the raw material of idea generation, ideas that are processes in the same way as original sensations and image patterns.

Awareness of these patterns and processes forms the stuff of consciousness, an ongoing activity of a human intelligence mechanism, i.e., general intelligence. Thus, the basic functional and structural elements of the human brain and mind in our model include the image patterns and the memory processes. To extend this idea one more step, the ingredients of consciousness and self-awareness include (a) image patterns, both extrinsic (sensory) and intrinsic (cognitive); (b) memory; and (c) memory access pathways facilitated by language as a principal catalyst of memory. Other such catalysts may include ideas, questions, etc. communicated verbally or textually by other persons. With this basic concept in hand, we can now consider human intelligence in more detail.

So where does this uniquely human intelligence come from? Let's digress a bit and explore a possible way that a human being's brain and mind develop to function in the image pattern model, and briefly consider computational and analog models of the operation of the human brain.

The Human Brain at Birth

For one concept that seems to contradict the computational model, consider a human infant at birth. Even though it has a brain, it initially lacks the capacity to act with intelligence, because it has not yet been exposed to any sort of stimulation except limited sensory input while still in the womb. Such stimulation may be in the form of extrinsic image pattern information sensed by the developing infant as variation in light or darkness, sounds, touch sensations, and perhaps tastes or even odors. These sensations occur in the form of rudimentary sensory image pattern fragments that the infant brain begins to process as responses to stimuli. Suppose, then, that beginning at birth, the infant experienced encounters with its environment through perceived sensations as they become functional – sight, sound, touch, smell, or taste. Over time, the infant brain acquires a knowledge base that begins to form the foundation of its mental and intellectual growth, including the association of elements of its knowledge with the sights of other persons, animals, and objects, the sounds of language, the sensations of contact with its body, the odors of food and the air, and the tastes of food and other objects it explores. The infant brain, equipped with this knowledge base, may then evolve the capacity to learn (as it absorbs information), and seek meaning in this content, perhaps according to an inherent curiosity that drives its interaction with its environment. Moreover, while motor skills and the accompanying development of the sense of touch are critical to the growth and functioning of the nervous system, the focus in this article is on the general intelligence of the human brain, and how algorithmic innovations are distinctly different from it.

Roles of Image Patterns and Consciousness

The above example of awakening sensory processes seems to be more consistent with an analog model based on image patterns formed in the developing brain of an infant in response to perceived sensory information that varies and is retained continuously over time. This unencoded, analog information may be more useful when, as an example, the perceived visual, auditory, or other extrinsic sensory images (i.e., sensation patterns) can be described or conveyed as time-variant signals rather than the discrete, encoded signals used in a computational (digital) architecture. Thus, we may tentatively term this ***image processing*** model as an analog model because it processes image patterns as the basic units of information input to the processing operations of the brain rather than executing digitally encoded, computational instructions of a programmed sequence to process digitally encoded representations of the images. As will be shown, this analog image processing model may also be helpful in developing an operational model for image patterns and consciousness (self-awareness) – two of the principle, unique, and defining properties of the human brain/mind.

Extending the example of a human brain at birth, one way to consider the attribute of consciousness may proceed as follows. Perhaps the human brain, not long after birth, begins to become aware of associations among what it senses, how the external world – especially other people – respond to it, and begins to learn the meaning of its interactions, both sensory and motor. As it develops awareness of itself and its surroundings, the phenomenon of consciousness and a sense of volition, the ability to direct itself or its own activity develops. The brain becomes structured for learning and interacting with its environment and its own thoughts through the normal activity of its growth from birth through childhood and maturation as an adult. The newborn infant’s environment contributes education along the way, both experiential and formal, especially including the development of motor skills and language skills. At some point the infant/child, as it develops this self-awareness, learns to direct its own behavior, originate its own thinking, reasoning, and problem-solving, etc., which are all aspects of what we call intelligence. Briefly stated, human intelligence is the capacity for original thought, untethered to a prescribed or predetermined process in response to its environment. These thought patterns are retained in the brain through the image pattern processes described above, forming part of the consciousness of the individual. However, the detailed concepts of the enabling mechanism(s) of human general intelligence are much more complex and deserve further consideration.

Digital (Computational) Versus Analog Models

In trying to understand the phenomenon of consciousness – of why the brain exhibits self-awareness of its own activity – the metaphor of a programmed binary processor is often considered as a way to construct a machine that might be capable of operating to produce the active sensation of itself as an entity having agency known as consciousness. Certainly, the computational agility of a binary computer underlies its extremely high speed, and the capacity to perform countless computations in arriving at an appropriate answer to a specific question using a specific algorithm dedicated to determining an answer to the question. Yet humans can often arrive at the same answer without being so particularly programmed or trained how to perform the task. The key in both cases is access to a knowledge base; the difference is in the means used to find the answer.

Consider for a moment a comparison between a computational (digital) model of a human brain versus an analog model, where the digital model is represented by binary-encoded information (whether alpha, numeric, or pictorial elements) and the analog model is characterized by the time-variant and dynamic, elemental content of the image pattern concept. Binary data is subject to – i.e., processed by – program manipulation, encoded in binary form in a digital computer processor. If even one bit of the binary code or the operative program is corrupted or missing, the encoded data is changed, yielding a representation substantially different from the raw or original object. In a binary system, such errors must be further processed by programmed error-correction codes.

In contrast, the mosaics of the image patterns are produced from the sensory apparatus – arrays of large numbers of spatially arranged elements that retain the character and intensity of the sensation to represent the original object. If a single one – or even several – of the sensory elements is missing or changed, the effect is vanishingly small, i.e., trivial, because the remainder of the image is largely intact. No further processing is required to make use of the image pattern. In essence, the brain may ignore the defect or fill in the space with the information of the positions adjoining the missing element.

Another important attribute of the human brain not found in a computational machine is that the brain can – and often does – originate a spontaneous thought that did not arise from any input. If such original thought, idea, or concept occurred in a computational machine, it may be evidence of a defect or "bug" in the machine or its programming.

Characterizing an Analog Model of the Brain

Accordingly, it is this writer's notion that the computational or digital metaphor of a programmed, binary encoded processor is substantially limiting. It restricts our thinking because it is necessarily limited to the specificity of its sequential, digital, programmed process activity. In contrast, the brain is a general purpose, biological organ that is unconstrained by an artificial rule or process. The brain is comprised of tens of billions of living cellular objects called neurons, the basic structural elements of the central nervous system, and other structures interconnected and configured to generate and respond to the interchange along the neuronal networks of electrical charges or electro-chemical ions associated with the sensory and interpretive activity that we perceive as thinking, consciousness, imagination, concepts of mind, of a soul, and so forth. It is also this writer's notion that consciousness may be closely related to memory and the awareness capacity of the brain to recall the memories that reside within it.

For more on this aspect of human intelligence, and a discussion of the structure and operation of the human brain, the additional material in the Appendix following page 15 of this essay may be helpful. For now, it is time to return to further consideration of algorithmic innovation as a more realistic and accurate substitute for the ubiquitous term "artificial intelligence."

III. ARTIFICIAL INTELLIGENCE OR "AI"

The term 'artificial' refers to a substitute for a real thing that it purports to replace or mimic; something contrived in form or function to substitute for the original. This may occur when the original is inoperative, not available, or has certain limitations of its own that can be overcome by the artificial entity or agent. An artificial entity or agent is not the same thing as the real or original entity it replaces. Like 'intelligence,' the term 'artificial' is a generalized term that can mean anything contrived or purpose-built. Thus, the words "artificial intelligence" construed together denote an algorithmic innovation that (a) embodies a capacity to substitute for a complex, arduous (as in hazardous or difficult), repetitive human task; and (b) does not possess or require the attributes of imagination, self-awareness, originality, reasoning, thinking, and other conscious behaviors that are characteristics of human intelligence.

We began this essay about artificial or machine intelligence with a proposal to re-name the concept known as "AI" as *algorithmic innovation* as a more precise term that more clearly distinguishes between so-called artificial intelligence and the capabilities of the human mind. We noted further that artificial intelligence lacks the distinguishing attributes associated with general human intelligence because it is not free to think or reason or modify its behavior or functions. Moreover, because it is not aware of itself, it cannot be conscious. If a fault is encountered during the process, it is unable to diagnose and solve the problem unless it is specifically programmed to respond to certain prescribed instructions by advancing along a different process path than the main program. Decades of work by a great many highly capable scientists, mathematicians, and others have failed to produce a machine or machine/algorithm combination that could be said to be intelligent as defined herein. That goal appears as elusive as it was 50 years ago.[2] Yet, examining the nature of algorithms is instructive to understand why their applications and innovations, while useful and often provide vastly improved process efficiencies, have yet to become indistinguishable from general human intelligence.

[2] Mitchell, Melanie, *Artificial Intelligence: A Guide for Thinking Humans*, Farrar, Straus and Giroux, New York, 2019, pp. 275 – 77.

IV. WHY THIS DISTINCTION MATTERS

In this essay it is argued that artificial intelligence is a misleading term. It is misleading because it obscures the fact that it is a technology more accurately termed an "algorithmic innovation" embodied in an inanimate device. It is also misleading because it does not exhibit the faculties or capacities of general human intelligence. The distinction is important because an inanimate device lacks agency and therefore cannot be held responsible or considered as a legal entity. This raises a number of questions – problems associated with recognizing inanimate algorithmic devices, processes, and systems as legitimate legal entities, personalities, or agents.

First, an inanimate, algorithmic entity should arguably be subject to a different legal <u>standard of conduct</u> than a human entity credited with conduct characterized by intelligence and volition, both uniquely human traits. Few would argue that it is important to recognize the nature of an actor in a legal matter. For example, how does a person or his/her property harmed by an inanimate machine (unlike machine tools operated or controlled by a human operator) recover damages from an inanimate actor that lacks general intelligence or sensibility, that cannot own property or enter into agreements, but may be capable of harm to persons?

But if actors and entities exist as inanimate algorithmic innovations, how do we devise a legal structure to govern their interactions, activity, and conduct reduced to objective criteria where intent, motivation, and other subjective elements do not apply? Thus, the use of the term artificial intelligence produced by algorithmic entities or agents injects an expectation of human attributes or traits, and therefore substantial legal ambiguity regarding risks and applicable standards of care, into the duties and culpability of inanimate machines. Such ambiguity can lead to difficulty in resolving legal issues as to their cause and effect.

For example, how should the law of tort be adapted or expanded to include harmful action by algorithmic machines? Is the 'reasonable person' standard of conduct for human beings transferable in any way to the conduct of an inanimate *machine* or robot? What would be the defining attributes of a 'reasonable algorithmic machine' or a 'reasonable robot' controlled by one or more algorithms? Does the term reasonable algorithmic machine or robot even make sense if such a machine or robot is not capable of reasoning? Does the burden of protecting users or the public rest with the legal system or with the inventors, engineers, manufacturers, sellers, owners, or users of algorithmic machines? These are questions to be resolved by development and issuance of new statutes, ordinances, or regulations. Initially, perhaps the creator or owner of an algorithmic machine is responsible and liable for harm just as the manufacturer may be liable for a defective product. Alternatively, would a user then be liable for the illegal use of a machine, instrument, or product?

Second, in other areas of the law questions arise as to the status of inanimate algorithmic agents in legal proceedings, transactions, and ownership. For example, can an inanimate agent be subject to the civil and criminal laws of a jurisdiction? Can an inanimate agent engage in a legal transaction? Do the regulations of government agencies apply to inanimate agents? Should the law of intellectual property be adapted or revised to include an algorithmic machine as an inventor, author, or owner? Such questions may become unwieldy or complex if such inanimate entities are assumed to be intelligent in the same way as humans, or assumed to possess the attributes of common sense, the ability to reason and understand statutory requirements or complex situations that require adherence to laws and regulations, and the ability to make judgments based on training, factual information, and evidence.

In another example, are inanimate algorithmic entities capable of creating original works or authorship or invention? Most statutory schemes presume authors and inventors are human persons, and that ownership rights of works of authorship and invention resides in human persons – the author or inventor – unless assigned or otherwise transferred to a legal entity such as a corporation or another person. In concrete terms, can an algorithmic process or inanimate machine create a work of authorship that qualifies as copyrightable subject matter? Can an algorithmic process or inanimate machine conceive an invention that can be the subject of an application for patent? Regarding this last question, the U. S. Patent and Trademark Office, as well as the patent offices of the European Union and the United Kingdom have held that the answer is no, because an inventor must be an individual person who can affirm under oath that he or she is the inventor of the subject matter of his or her application for patent. See The matter of Dr. Stephen Thaler, who asserted that his artificial intelligence "creativity machine" called DABUS invented the subject matter of an application for patent.[3]

Consistent with the theme of this article, the "AI" system invented by Stephen Thaler was necessarily configured (at least in part) to a specific purpose: to conceive (within a range of possibilities, perhaps even without defined boundaries) a description of a process, machine, manufacture, or composition of matter. Without Thaler's contribution to the design of his "creativity machine," such conception could not have occurred spontaneously. Therefore, DABUS is a tool for use by an inventor, but is not itself an inventor.

Third, in the business domain many white collar and skilled manual jobs are beginning to include tasks performed by digital workers, thus raising the issues of rights and expectations of digital workers as members of a work force. Digital workers utilize such tools – such as specifically configured algorithms – to perform certain repetitive, tedious, or potentially hazardous tasks by robots operating under the control of such algorithms. Further, the distinction between jobs performed by algorithmic innovations embodied in inanimate machines and jobs requiring human intelligence becomes important because not all jobs are readily automated. Thus, managers must be able to weigh the cost/productivity of such digital workers using these digital tools, inanimate entities controlled by algorithms, and the needs of a process for such human traits or attributes as reasoning, judgment, discretion, adaptability, etc. The distinctly human skills needed in certain tasks, such as problem solving and judgment, must be retained to ensure optimum productivity and quality of output.

Moreover, artificial intelligence is more likely to be accompanied by heightened expectations for the performance of the algorithms used to configure the machine or process. This may include the ability of the machine or process to mimic or exceed the capability of a human being in all or certain defined respects. Thus, in considering the use of inanimate, algorithmic entities to perform tasks without human intervention, these expectations should be evaluated to

[3] See www.uspto.gov > 16524350_22apr2020 DECISION ON PETITION, which denied petitioner's request to accept a Substitute Statement in lieu of a Declaration and Oath of inventorship stating DABUS as the inventor of U. S. Application Serial Number 16/524,350.

determine whether they may be unrealistic or unsuitable. The role of such a machine or process needs to be carefully considered and defined before its employment, including cognizance of the limitations of these entities and the risks that may be present in their use.

Fourth, the relationships between and among human and digital or algorithmic workers in the workplace must be considered because it determines the facilities required, the work environment, and the need for supervision, administration, and maintenance.

V. CLOSING THOUGHTS

Despite over a half-century of effort, the machine "intelligence" that emerges is inherently limited to specific, narrowly defined tasks. The products of these efforts generally do not exhibit the capabilities of human intelligence we have enumerated. Thus, to make this distinction, it is proposed that the initials AI represent a more precise and meaningful term: *Algorithmic Innovation*. Algorithmic Innovation defines the technology embodied in the various products developed to date that are configured to perform a wide variety of specific, well-defined human tasks. The contents of the programming incorporated into computer systems to perform such tasks essentially include one or more algorithms devised to carry out each assigned task, thereby utilizing the computational capacities of the digital computing systems or platforms.

Finally, the idea of distinguishing artificial intelligence and algorithmic innovation as in this essay is presented as a reasoned consideration for further investigation. Understanding that the initials "AI" should suggest the content of the technology it refers to rather than what the technology seeks to mimic thus opens discussion to the technical and consequential issues in a more concrete way. It is a curiosity-driven discussion to try to shed some light on what algorithmic innovation is, how it inherently differs from general human intelligence, and what adjustments or adaptations to our system of statutes, regulations, procedures, and case law are suggested by the emerging and sophisticated capabilities of machine learning.

Author's Note: The opinions expressed herein are solely the author's except as otherwise noted.

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APPENDIX

THE HUMAN BRAIN – AN INFORMAL INQUIRY

In this essay, we'll examine some aspects and characteristics of human intelligence, and explore in a high-level way one concept of how the brains of humans and other vertebrates, especially the human brain and mind, might work to enable these unique, defining characteristics. This review may help to understand why successful efforts to replicate the human brain and mind and its intelligence in a machine are still beyond the horizon.

I. SOME ATTRIBUTES OF HUMAN INTELLIGENCE

Few would disagree that the human brain is an extraordinary organ. Some of its amazing feats include (1) apparently unlimited storage capacity for memories – information, mental images, etc.; and (2) apparently near-instantaneous recall of those memories, information, and mental images with little effort or information identifying the subject matter or its location. An aspect of this may include an efficient recall process of a memory element initiated by awareness of a word about it or of a conscious input. Another example is the rapid response to auditory or visual perceptions – wherein a sensed "image" travels through the neural networks interconnecting the sensory organs with the brain. Further, (3) it is a characteristic of the human brain that it is aware of its existence and activity, including the ability to ponder its origins and other questions of the natural world; and (4) that it sometimes paradoxically operates according to relatively slow thinking processes that sort through the stored memories or new information in the context of a present question, circumstance, or sensation to arrive at a coherent thought or response. The human brain is, broadly speaking, a highly complex information processing system structured of biological elements, but one that is not thoroughly understood in its functional aspects.

Moreover, (5) the capacity for inventing and using spoken and written language, the medium of expressing information, for composing thoughts, etc., may be what chiefly differentiates the human brain from other mammalian brains. This capacity for conceiving and expressing ideas internally and independently of input signals from the five sensory organs includes ideas or thoughts that may be conscious or unconscious, verbal or nonverbal, or that may be and often are original or unrelated, directly or indirectly, to existing memory content or present discourse. Another important capacity is (6) the exercise of judgment based on standards of conduct in social, legal, ethical, or moral domains.

Questions about such mental capacities thus arise: why is this so? How did they develop? How do they work? What is the mechanism or process that enables consciousness? After some preliminary considerations to establish some definitions and context, the dominance of the visual sensory functions of the human nervous system suggests looking inside the visual sensory apparatus and the visual cortex for clues to the operation of these mechanisms.

II. MODELING THE BRAIN

In one conventional approach to modeling the human brain, mathematical or computational analogues are employed to construct models of the physical functions or operations of the naturally evolved biological structures. But such models are not the same as the brain itself, physically or functionally; they are only hypothetical representations – analogues – constructed to functionally mimic some behavior or activity of the brain. As analogues, they only represent a limited part of the full repertoire of the brain's capabilities.

A Useful Analytical rule

There is a doctrine of the U. S. Patent Law, called the Doctrine of Equivalents, that states "if it is not structured in the same way, and does not function in the same way, to produce the same result as the particular object, then it is not the same thing."[4] This doctrine, a part of the law for distinguishing an invention presumed to be an obvious variant, is applied during the examination of an application for a grant of patent on an invention in the U. S. Patent and Trademark Office by a patent examiner. Called "same way, function, result," this rule may suggest an insight applicable to modeling the structure and operation of the human brain. Thus, if a proposed structural analogue and its operation do not replicate features of the brain accurately – in the same way, providing the

[4] This Rule, from the U. S. Supreme Court case styled *Machine Company v. Murphy*, 97 U. S. 120 (1877), became part of the analysis set down in the seminal case on the law of non-obviousness of inventions in *Graver Tank Electric Mfg. Co. v. Linde Air Products Co.,* 339 U. S. 605 (1950).

same function to yield the same result – then it cannot be confidently assured that the proposed model, or explanation of its applicability, is a sufficient replication of the object brain.

Neurons – Structural elements of the Brain

The basic structural components of the brain and the central nervous system are the neurons – cells comprised of a soma or cell body (including the nucleus), an array of dendrites connected to the cell body, and an axon extending from the cell body. The dendrites usually function as input pathways for sensory information conveyed by neurotransmitter signals along and received from axons of other neurons of the central nervous system across the synapses that couple neurons into networks. The axon provides an output link to other neurons via the synapses, wherein the neurotransmitters cross an infinitesimal gap between axon and dendrites of successive neurons when the neurotransmitter signals exceed a threshold. A single neuron can be connected with a great many other neurons. The neurotransmitters are electro-chemical signals comprising electrical charges or chemical ions of varying amplitudes or other characteristics that convey the signal variations between neurons. Thus, the neurotransmitter signals convey information about a neuron cell's activity from neuron to neuron through the synaptic gateway of a network.

These interconnected structures of neurons together form parts of the system or network of the central nervous system. Also connected to the axons are another, very numerous kind of neuron, called the supporting "glia" cells. There are two types of glia cells, astrocytes and oligodendrocytes. The astrocytes support the many functions carried on during the activity of the central nervous system. The oligodendrocytes are specialized cells that function primarily to ensure the production and growth of the myelin insulating sheath of the axons.[5]

Brain Functions

The brain is comprised of many tens of billions of neurons classified in various types related to their location and organized in a variety of discrete, functional configurations through perhaps a hundred trillion interconnections. These interconnections enable the storage of

[5] See, e.g., *The Life and Death of a Neuron*, part of a Brain Basics series, NIH Publication No. 02-3440d, September 2002, 10 pages. Prepared by the Office of Communications and Public Liaison of the National Institute of Neurological Disorders and Stroke, National Institute of Health, Bethesda, MD 20892. Available at www.ninds.nih.gov.

information – the memory system of the brain. The central nervous system, of which the brain is an integral part, processes and communicates sensory and motor signals from neuron-to-neuron, coordinating the physiological processes of the human body, both physical and mental. The brain has the capacity to remember information received by its extrinsic and intrinsic senses and generated by its cognitive faculties. The brain is also the locus of conscious and unconscious activity such as thinking, reasoning, judgment, problem solving, imagining, creating and so on – activities that generally originate in the brain independent of the sensory and motor activity carried on in the central nervous system.

Communication in the Brain

Most models of the brain are built on computational algorithmic processes that configure and control digital computer structures. Such algorithmically configured systems are typically devised to produce the same or a similar result of some defined capacity or activity of the brain even though these models may not be structurally or functionally analogous or may not operate in the same way. This is because the brain, likely not a machine that operates according to binary encoded data, more likely operates according to some other kind of process or system of processes.

The motion of electric charge in the form of chemical ions along the neuronal pathways of the nervous system forms an electric current. This current is a substantially *continuous* (i.e., non-digital) phenomenon. Further, such motion of electric charge more closely resembles an *analog* signal that may vary in intensity or amplitude, frequency or duration, etc. These characteristics or parameters of an analog signal differentiates it from the digital – binary encoded – signals of programmed digital computers, where the programming employs algorithmic, binary-encoded processes to configure and control the arithmetic operations of the computer upon the binary-encoded data. In contrast, the information communication within the brain appears to more closely resemble processing of analog information that is comprised of the direct parametric outputs of the sensory receptors and other receptors of conscious and unconscious brain activity. It is just the exchange of information via these receptor outputs with the connected and neighboring neurons that transfer the output sensory information to other parts of the brain, which respond in appropriate ways to these parametric values and retain, or not retain them, depending on the volitional (or other modes) of inputs that may be applied by the “owner” of the brain.

Extrinsic Sensory Receptors

The brain and central nervous system of all animals includes connections to sensory receptors – organs that are structured to respond or be receptive to external elements or conditions of the environment. In humans, and most other animals, there are receptor organs located in distinct parts of the body for sight, sound, smell, taste, and touch. It is hypothesized here that these receptors, the portals through which the brain obtains information about the environment outside the body of the organism, are structured and formatted to produce *image patterns* of information (described later) about conditions external to the organism to enable it to carry on its existence, and to function within its environment as it encounters the many and variable conditions in the environment.

In the foregoing, the word "image" is used here in the broad sense of a mosaic replica of the content of a visual scene, or of a sound, odor, taste, or touch sensation. This replica is understood herein as a metaphor applicable to all of the senses, both *extrinsic* (sensory) and intrinsic (cognitive). The image pattern metaphor introduced herein can also be thought of as a vehicle of memory processing that retains and conveys the sensed or cognitive information including the relationship among its elements. For example, the brain as a living, biological organ is constantly circulating the content of its existence as the blood circulation stimulates neuronal activity and communication within and among the various regions of the brain. It is thus no accident that extrinsic and intrinsic mosaic element patterns are also active, giving rise to awareness as consciousness, including imagination and thinking – or when its host body is asleep – as during dreaming.

Intrinsic Sensory Functions

There are other sensory-like features that operate within the organism to provide functional information in the form of pain, hunger, temperature, fear, and danger for example. These sensations act to inform the organism about the importance of extrinsic sensations. These functional sensations, processed within the brain, either voluntarily or involuntarily, may be expressed in the activity and behavior of the organism. Intrinsic (cognitive) sensations may also be formed and interpreted in a manner similar to the image patterns produced by the five extrinsic senses discussed above. Moreover, such image patterns, when originating from within the brain/mind of an individual as conscious or subconscious thoughts, ideas, imagination, knowledge or learned information, etc., independently of the functional stimuli and sensory information external to the brain, may be a defining attribute of human intelligence, along with the ability to use *language* to interpret and express them.

Development of Language and Memory

Consideration of the ability to use language raises the question: how did language arise as a distinctively human trait? In one hypothesis, the human (and mammalian) brain evolved from and in concert with an essentially visual system – the eyesight with its retina, optic nerve formed of neurons, and a visual cortex formed of specialized neurons and pathways – together structured to form, recognize, and remember visual images of the surroundings and objects in the environment as image patterns. The aggregation of image patterns retained by each individual become the knowledge of the individual. New image patterns may be added to that knowledge base, while repeated reception of image pattern information reinforces the strength or possibly the importance of the image pattern content. Such repetition and strengthening thereby tends to favor the repeated pattern and its recall, which exemplifies, and may embody, the action of memory.

Pattern recognition of content becomes an inherent operative function of the brain. Since the brain, a dynamic, living biological system is always active, processing image pattern information moment by moment, such content is likely circulating more or less continuously. Thus, the brain is equipped to readily notice when an image pattern traveling along neural pathways in the brain is new or familiar. This suggests the presence of a memory function in the brain is configured to notice similarities and differences in image patterns. Perhaps this conscious awareness of recognized patterns (as in exceeding a threshold) is an act of recall of the content of image patterns from extrinsic (sensory) or intrinsic (cognitive) sources. But questions remain. For example, how does an organism distinguish awareness, as in its automatic response to a sensory stimulus, from consciousness of the content of the stimulus image?

Perhaps at some point in evolutionary time, early hominids began to represent objects – and image patterns – by hand or vocal signals or by pictographic symbols, scratched in the soil or marked on a rock surface. From that beginning, a rudimentary language evolved as a communication medium among individuals, perhaps about sources of food, location of predators or other dangers, or to express relationships, etc. Pictographic symbols became expressed in groups such as words, and the ways those pictographs, symbols, or words were used – the development of grammar and syntax – began to facilitate communication. Means to record the words would thus become the precursor to written language.

The Role of Language

In fact, based on the above hypotheses, it is proposed here that language is an enabling *catalyst of memory*, of remembering content processed and retained as image patterns of all the types identified previously. The invention of language, the process invented by humans to describe objects, persons, the environment, ways to obtain food, build shelter, provide clothing, and to describe their thoughts, to communicate with other beings, to record important information, etc., may have originated with sounds or gestures, with vocalizations, or making marks. The development and use of language may be a remarkable extension of the abilities of all animals, to one degree or another, to use some form of language as an important way in which they interact with other members of their species and their environment. Thus, a reasonable postulate is that language, because it is so closely associated with every activity of humans and the processing of experience taking place in their brains/minds, is a natural and essential catalyst of remembering the content of the brain/mind's conscious and subconscious activity.

Language, Brain Activity, and Recall

So how might this postulate, that language is the means by which the human brain/mind – or the brain of other animals – facilitates the processing of image patterns, be utilized in remembering image pattern content? As mentioned previously, sensory image patterns corresponding to external stimuli may typically be accompanied by associated language statements or thoughts as internally generated image patterns. If this is true, then the close association of these related image patterns because of related content among them may tend to reinforce each other, even traveling along the same neuronal pathways. This reinforcement or strengthening could be a way of refreshing the memory of the content, thereby facilitating its recall, or facilitating the priority of one memory over another. This effect may occur by noting – as in comparing – similar patterns of neuronal activity that may reinforce or enhance but also facilitate recall. The latest (in time) image pattern, of whatever type or form, thus may function like a catalyst – a mnemonic device of content which, when the comparison is noticed, brings "forward" into consciousness the earlier image pattern representing the recalled or remembered content that is then "retrieved" from memory, perhaps in more detail. Such recall may begin by merely thinking of the content as an image pattern (initially with minimal detail, but detail subject to enhancement upon further attention to it), whose relationship to the content sought provides the key to accessing the image pattern containing the desired content – the memory of the content.

Remembering Content

One of the mechanisms used by humans to remember content is to record the content as spoken, pictorial, or written language in images, in books, collections, or recordings, or in the form of visual art or compositions of artistic performances such as music and dance. These mechanisms, including language, are all inventions of the human brain/mind. They are external mechanisms for preserving the information about human activities, both intellectual and physical. They provide the means to extend the enjoyment or utility of the content to others or for later use, or to preserve it long past the lifetime of the authors or inventors. But what is the mechanism used by the human brain/mind to record and preserve content for later use? We will consider this subject further below as we examine the utility of ***language as a catalyst of memory*****.**

Effects of Lost Extrinsic and Intrinsic Senses

One important effect of the five extrinsic senses, when one of them becomes inoperative, is that the loss of a sensory output acts to disable the organism to some degree. Loss or impairment of sight results in blindness. Loss of hearing results in deafness. Loss of the sense of smell (anosmia) or taste (ageusia) results in loss of important information about the environment or the food available to the organism. Loss of the sense of touch (hypoesthesia) may result in the inability to determine whether the organism is injured or is in a circumstance where injury is imminent. Thus, the extrinsic senses form the essential interface system between the organism and its environment that enables the central nervous system and the brain to respond appropriately to the conditions of its existence.

The loss of intrinsic senses may be the effect we perceive as loss of memory – the inability to recall content known to exist in the brain. A simple answer might be that such loss is evidence of an interruption in a neural pathway, a death of neurons, a malfunction in the portion of the brain that retained the content, or alteration of the image pattern itself. Answers to these questions await further research into brain function.

C. A THEORY OF BRAIN FUNCTION

Processing Sensory Information as Image Patterns

We return now to the concept of an image pattern, considered here as a fundamental property of the central nervous system that enables one concept of the operation of the brain. We know that the sensory organs are comprised of a great many specialized receptor cells, typically but not always, organized in one region of the body. These receptor cells are configured to respond to specific external stimuli by conducting "outputs" of neurotransmitters along connected nerve pathways to the region of the brain that processes the composite sensation representing the perceived information. The composite sensation from each array of receptors – for vision, sound, smell, taste, and touch – may correspond to a composite pattern of impulses or information elements that represents the external stimuli. The pattern, embodying the composite set of information elements, provides an image – a replication – of the external stimuli. The external stimuli thus produce an ***image pattern***, a composite mental image of the assembled information elements, in the form of a *mosaic* of information, which is retained or recorded in the brain. We'll begin this study by considering the operation of one of the extrinsic senses.

A Visual Image Pattern

The idea of an image pattern or mosaic is suggested by the retina of the eye which resembles a light-sensitive screen composed of an array of receptor cells, rods and cones, that respond to light emitted by or reflected from an object. The lens of the eye focuses an image of the object on the retina. Each one of the array of rods and cones in the retina responds to a minute portion of the image.[6] The composite response of the retina provides a pattern that replicates the

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[6] More on the basic structure of the eye can be found in the course text "Vision and Psychophysics," by Ethan D. Montag, an instructor at the Center for Imaging Science, Rochester Institute of Technology, Rochester, New York 14623. Chapter 9 of Part One, "Photoreceptors," begins with "Rods & Cones," (Part 1 of Ch. 9). This text may be found at: www.cis.rit.edu/people/faculty/montag/vandplite/pages/chap9.

image, hence, an *image pattern.* Image patterns are dynamic, and not static, because their patterns vary with time; that is, the patterns and content images are continually changing.

The Image Pattern Concept

The term mental image suggests the idea that the image produced by the extrinsic sensory organs resides in the brain as an image pattern, conveying information about the content of an external stimulus. This concept may also suggest how it might relate to the way such mental images are processed in the brain. This concept, while applicable to all of the five senses, is closely analogous to the sense of vision. This may explain why the sense of vision appears to be a dominant one in the interaction of the human with the external world or environment, and the fact that so much of our memory processing is carried on in visual terms as visual image patterns. Memories may be stored as image patterns (i.e., mental images). Thus, image patterns may represent visual, auditory, olfactory, gustatory, and haptic sensations and provide a convenient way to trace the operations carried on within the brain (and mind).

Remembering an Image Pattern

The sensations that the brain receives as images may be retained in the brain for processing or storage (i.e., remembering) that type of information. Note that the term "image" is used in a broad sense. If an image pattern is reinforced in some way such as by repetition or coincidence the image pattern is more likely to be remembered or recalled. If an image pattern is not reinforced or "refreshed," then it may decay and likely be forgotten. In the process of remembering an image pattern, it may be associated with identifying information such as a thought or name or idea perceived along with the sensation giving rise to the image pattern. It is noted that an image pattern may be a scene (like a photo), or text (as a printed passage, or a verbalized statement, or an imagined phrase or word). An image pattern may also be an auditory fragment (like a melody or spoken word), a sound (like thunder or a dog barking); an odor (like a fish or gasoline); a taste (like a sweet, sour, or salty food); or a felt touch (like a handshake, catching a ball, or a hot or cold object). In one example, the concept of an image pattern or its mosaic metaphor seems quite consistent with the well-known trait of some individuals who possess a "photographic memory."

Intrinsic Image Patterns

Another kind of image pattern may arise as a thought originating within the brain not directly caused, related, or associated with an image pattern corresponding to one of the five extrinsic senses. For example, an idea – a conscious thought – that may be defined, described or expressed as a text phrase or some other perceptual form may be retained or recorded as a non-sensory image pattern. Or a non-textual or nonverbal concept may become conscious; further thought adds details that better define the concept thereby producing a clearer image pattern. That concept may then become associated with a textual image pattern or other form of image pattern as it is stored in memory or is considered in some conscious context. All of these image patterns are formed as arrays or mosaics of information elements that correspond to the aggregated pattern of neuro-transmitted signals, whether they originate from sensory organs or from within the brain.

Image Patterns as a Basic Unit of Memory

Thus, the concept of an image pattern may be understood in one model as a key element of the process by which information is processed in the brain. An image pattern is analogous to an assembly of information elements formed as a replica of the pattern of a plurality of neuronal responses that occur in the sensory structures of the brain and also in the internal, cognitive operations that originate independently of the sensory structures. In the functional region of the brain corresponding to each particular sensory category, the replica – a temporary image pattern that integrates the assembly of information – may be subject to enhancement or decay if it is not refreshed by additional sensory inputs or conscious reinforcement that may occur as the image pattern is processed in the brain.

Processing Image Patterns

The image pattern, though considered thus far as a discrete unit of memory, may in fact be part of an aggregation of elemental image patterns, associated by some common link (such as another image pattern the mind originates in association) connected to the aggregation. It appears reasonable to postulate that the concept of image patterns may unify the encoding of sensory, mental, and perhaps other types of images having informational content. What is not yet well-understood is the functional processing of information carried out in the brain and whether an encoding scheme is active in the brain to form, address, and identify image patterns and if so, how it works. What is known, however, is that defined regions in the brain are associated with specific functions, sensory, motor, thinking, feeling (emotion), etc.

Brain Activity

First some initial postulates. A healthy brain is always active. It does not "go dormant," though it may slow down its activity, yet never cease activity except at death. The brain's activity level is most likely proportional to the level of sensory perception of either extrinsic or intrinsic image pattern information. The human brain's activity can – and often is – organized to a conscious purpose, as in learning, recalling, creating, problem solving, imagining, etc.

Second, the brain is configured to notice when one image pattern, newly formed or newly in circulation, is similar in some respects to a previous image pattern and responds by noticing the similarity and forming an association. This recognition of similarity may be facilitated by language because groups of ordered symbols may be expressed or formed as image patterns that participate in the recognition – the awareness of the similarities among image patterns – thus acting as a catalyst of memory. Language thus appears to function as an operative communication and processing mechanism for processing the content in the form of image patterns. Further, perhaps sequences of image patterns are not stored in entirety but retained in truncated or abbreviated form (such as by dropping redundant content to conserve neuronal space) such that the brain (a) can fill in the details, and (b) add or reconstruct successive related image patterns.

Third, although these image patterns are subject to reduction of resolution over time, by abbreviation, decay, lack of reinforcement, or inattention, *what if* . . . the brain uses image patterns as "addresses" whereby a thought formed as an *intrinsic* image pattern is matched – i.e., circulated in a search for a match as an inherent function of the brain's memory operation – with other image patterns residing in the brain having related or similar content? Such a process would enable the recall of the matched image pattern having the related or similar content. Perhaps this is one way the brain locates, connects, and recalls through the use of image patterns as the basic unit of address, both extrinsic and intrinsic. For example, a thought, expressed via language (intrinsic) becomes an address for related or similar patterns, even a particular one by expressing a specific thought about the content of the sought pattern in memory. In this way language may act as a catalyst for memory because it facilitates the recall process in the brain.

Fourth, in another interesting example, dreaming may be evidence of the brain's activity, usually but not always while its host is asleep, though often the images perceived or revealed to the host's awareness appear random or unorganized; or sometimes formed of disparate or unrelated "memories" – image patterns formed at other times in other circumstances or contexts. Some would say that in dreaming, the brain is merely making up a narrative.

III. CONSCIOUSNESS – ANOTHER FUNDAMENTAL PROPERTY

Turning now to conscious thoughts, and unconscious or subconscious thoughts, the question arises how such thoughts might originate as image patterns. In one model, consider a new-born infant, born with a brain that we'll assume has a minimal amount of information stored in its "memory," sort of a "clean slate." This assumption is subject to inaccuracy because the infant, at some point in its development while in the womb, may have perceived some extrinsic image pattern information variation in light or darkness, sounds, touch sensations, and perhaps odors or even tastes, in the form of rudimentary sensory image pattern fragments that its brain begins to process as stimulus/response activity. Such sensing, processing, and retaining of these rudimentary fragments may be the precursors of the learning processes that are carried out by the infant brain as it develops. Upon birth, the exposure to the external world brings forth an avalanche of sensation, stimulating the brain's growth, as new neural pathways are formed to accommodate the brain's activity. The rapid increase in sensory stimulation may even contribute to beginning to acquire some sense of language that it will later use to relate to the world outside of itself. The neurological motor pathways become active as the infant expresses its needs through its gestures and the responses to them, generating additional sensory image patterns and pathways as it processes feedback from the external world. Perhaps even rudimentary, non-coherent (in terms of language) intrinsic thoughts originate in the infant brain as it develops.

Self-Awareness

Thus, not long after birth, the human brain begins to notice (become aware of) associations among what it senses, how the external world – especially other people – respond to it, and begins to learn the meaning of its interactions, both sensory and motor. As it develops awareness of itself and its surroundings, the phenomenon of consciousness and a sense of volition, the ability to direct itself or its own activity develops. Over time, the brain becomes structured for learning and interacting with its environment and its own thoughts through the normal activity of its growth from birth through childhood and maturation as an adult. The environment contributes education along the way, both experiential and formal. At some point the infant/child, as it develops this self-awareness, learns to direct its own behavior, originate its own thinking, reasoning, and problem-solving, etc., which are aspects of what we call intelligence. Briefly stated, intelligence is the capacity for original thought, untethered to a prescribed process (or unprescribed by a predetermined process). These thought patterns may remain in the brain through the image pattern processes described above, forming part of the knowledge and consciousness of the individual. The concept of intelligence, however, is much more complex and deserves further consideration.

Attributes of Intelligence

Why, for example, does intelligence defy attempts to define it? Perhaps it is because it is not understood how it occurs, is revealed or produced, leaving us to resort to describing its characteristics, attributes, or the effects of its activity. For example, we consider intelligence of an individual in terms of cognition, reasoning, thinking, consciousness and self-awareness; or a social intelligence based on articulate communication, the use of language according to rules of use (grammar, syntax, tense, structure), etc. Thus, perhaps the simplest thing we can say is the intelligence is the capacity for original ideas or thoughts, untethered to a prescribed or predetermined process. Perhaps it is the capacity for unstructured reasoning, thinking, or imagining of concepts, ideas, or thoughts. Perhaps it is the capacity to rapidly relate to disparate content in new ways to solve a problem or respond to an immediate situation. Or, perhaps, it is all of, or a combination of, these traits.

Thus, the term "intelligence" can be defined in many ways, often depending on the context in which the term is being considered. It is not difficult to recall a set of common aspects such as the ability to create new ideas, concepts, or thoughts; to have judgment or common sense; to have the ability to adapt to new circumstances or information 'on the fly,' so to speak; to think and reason or purposely consider new facts; or to solve problems without constraint by preconceived rules (except in rare circumstances as defined by the problem at hand). Considering its many and varied aspects, intelligence is an amorphous, generalized, and dynamic set of attributes that takes on meaning in specific contexts.

The Effect of Intelligence

But one over-arching attribute is that intelligence is aware of itself; it is conscious of itself and of its activity, and in its conscious awareness of an idea or train of thought. It is also characteristic of intelligence that a thought or thoughts may give rise to related ideas, thoughts, or questions that in turn lead to other thoughts. Or, a train of thought may be interrupted or distracted by an unrelated thought or idea, wherein the brain's focus is diverted to an alternate, unprescribed path. Original ideas may emerge into conscious awareness, related or unrelated to a current state or focus. Or, when pursuing an idea or question, any of these aspects of thinking or reasoning may become part of the conscious activity. Another attribute of the brain's activity is that on occasion it may operate without the conscious awareness of the individual wherein the activity of the brain occurs sub-consciously or unconsciously, as in dreams, for example. But that is an aspect of consciousness to be examined in other articles.

IV. CONSIDERING A NON-COMPUTATIONAL MODEL OF THE BRAIN

The image pattern concept that stores information as extrinsic or intrinsic image patterns lends itself well to a non-computational model of the biological brain of humans and animals. We begin by postulating first that intelligence is consciousness directed to a purpose or question. Second, consciousness is awareness of information in image pattern form. Further, intrinsic (cognitive) image patterns are expressed in the same elements as extrinsic (sensory) image patterns, i.e., mosaics of visual, auditory, olfactory, gustatory, or haptic (touch) sensations received by the brain and assembled in an image pattern. For example, thoughts expressed in language may be "sensed" as visual or auditory image patterns. Further, those image patterns may be augmented by image patterns of smells, tastes, or touch (haptic) sensations.

Carrying this concept further, we can postulate that thoughts, ideas, etc. are formed of sequences of image patterns as in a video sequence; and thinking or imagination may be considered as directed awareness by sifting, riffling, or scanning through sequences of successive image patterns, searching for particular or related image patterns of extrinsic or intrinsic information or memories. Such riffling or scanning, which is similar to riffling through a deck of playing cards or the pages of a book, thus enables recall from memory the image patterns – whether concisely or loosely defined – that correspond to the desired purpose or question.

Thus, recall is a sifting or scanning process performed by the brain – which is always active – searching in a directed way for matches or congruence of subject matter that together may satisfy the initial purpose or answer the question posed at the outset. In this process the image patterns may be sorted into categories, complex or simple that together maybe arranged or assembled into the thought, idea, or concept. If the sifting is undirected – as simply the result of the brain's activity (as in dreaming, for example) – unexpected, sometimes original image patterns may emerge into awareness.

In this model the "deck" of image patterns may be large or small or contain many or few patterns in a group. The content of the deck or group may be organized differently or may be modified by applying other ideas to further define the task in the context of the original purpose or question. On other occasions the purpose or question used to define and initiate the search may be revised or redefined based on the outcome of the recall process.

In a continually active brain, image patterns may circulate in response to the environment – external or internal – being experienced by the organism containing the brain. The image patterns contain the raw information in the form of extrinsic (sensory) or intrinsic (cognitive) data arranged in the natural mosaics produced by the sensations of the sensory apparatus or the thoughts that arise from the operation of the conscious imagination in the brain of the organism.

When a purpose or a question is posed or imagined by the brain the riffling process begins, searching to intercept and gather pertinent or relevant information to form a response or answer. In this native, prototypical model, the raw information is not encoded, either by analog (continuous) or digital (discontinuous) coding schemes. Accordingly, the brain does not operate by processes of computation on the raw image pattern information. It processes the information as it exists in its original form. This is why the oft-proposed computational or mechanistic models of the brain are likely misplaced; that is, such models are mimics of certain limited, narrowly defined processes that occur naturally in the brain but are incapable of consciousness, self-awareness, thinking, imagination, etc. that characterize the essential attributes of the brain.

Self-awareness, an aspect of consciousness, is just the conscious knowledge that the brain has of its own activity as it perceives and identifies the information content of the image patterns it uses to produce, or that give rise to thoughts, ideas, answers, decisions, etc. that are all part of the daily existence of the organism.

V. ARTIFICIAL INTELLIGENCE

Meanwhile, equipped with this brief idea of some aspects of what general human intelligence is, and how it arises in the brain, the term "artificial" is used to differentiate human-engineered, inanimate surrogates for the real attribute of general human intelligence. Further, the term "algorithmic innovation" more accurately embodies the content of and defines the term euphemistically called "AI" – the so-called "artificial intelligence." The idea of distinguishing artificial intelligence and its more accurate realization "algorithmic innovation" in this way is presented as a reasoned consideration for further investigation.

Considering models of the human brain, we are conditioned by science and technology to think of the activities of nature in analog or digital terms as the exclusive keys to modeling the mechanisms observed in nature. But are the mechanisms and operations of the human brain accurately modeled or characterized in such metaphorical or computational terms? Suppose the processes of a biological organ such as the brain, with its capacity for consciousness, self-awareness and imaginative thought, proceeds through operations that are not wholly continuous or wholly discreet (binary)? Perhaps both analog and digital modes are utilized or even necessary to fully explain these processes. Perhaps some other operative model enables the capacities of these intangible and unique characteristics.

For example, consider the concept of an "information hub" that disseminates certain associated meaning or subject matter, whether or not it distributes disinformation or contains erroneous ideas or facts?[7] These information hubs by definition tend to draw attention to themselves and their literal content or associated meaning embodied in the name of the hub, usually a person or a publication. But such terms, as in the actions of leaders, other celebrities, or other media often mislead and divert attention from the truth of the subject matter that bears the name as addressed in their communication. So it is with the term artificial intelligence, because it is an ambiguous term.

Returning to the question of possible models of the human brain, a mechanical system is inactive until turned on and provided inputs – information, conditions, programs, etc. In contrast, a biological system is always active because it is alive, subject to the continuous physiological processes that occur within the organism as long as it is alive, sustained by the energy taken in and converted to useful form by its utilization of the caloric energy in food and its internal circulatory processes.

Perhaps the brain also functions as a system of continuous circulatory processes whereby, in response to the availability of life-sustaining energy, the information being processed in the brain by communication, circulation, or processing of image patterns proceeds according to the functional needs of the brain? So the question is, how and by what agency do these circulatory patterns operate? How do they accomplish memory, consciousness, self-awareness, imagination, etc.? Such questions await further exploration.

V. CLOSING THOUGHTS. . .

Certainly, this essay raises more questions . . . but questions are a way of expressing our curiosity, which often leads to understanding and progress. So, the difficulty in devising a suitable model to accommodate algorithmic innovations arises in efforts to understand the means – the mechanisms or processes of consciousness and the intelligent product of the activity of the human brain and mind. To pose one example, we know that humans observe the world they encounter, retain information about the encounter, perhaps questioning certain aspects of it and their

[7] The idea of an "information hub" is proposed in a new book entitled "*Doom*," by Niall Ferguson, an English historian and author, where individuals such as political leaders or social or cultural leaders define networks of connectivity that produce or dissemble information – accurate or not – within and beyond their networks.

observations in the form of what, where, how, and why queries. We have explored the possibility that the information may take the form of image patterns – patterns of content about objects or activity or ideas that may be processed for retention or conscious consideration. The accumulation of retained information may occur in categories of repeated encounters or experiences. Consideration by questioning or by reflection may reveal relationships and conclusions in the form of knowledge, knowledge that can be useful to the individual upon recall and application to new circumstances. It is an example of the capacity for cognition that we can imagine without knowing how it comes about; hence, the underlying question: What is the means – the mechanism(s) or process(es) – of consciousness? Until science has answered these questions, it is suggested that the term "artificial intelligence" be set aside pending the emergence of a human-engineered inanimate machine that truly exhibits the attributes and properties of general human intelligence.

Returning once more to the concept of image patterns, we noted that image patterns may be remembered in some form, perhaps a process that may include translation into textual or some other symbolic form that includes some form of routing or indexing or context association, such as through language or connection, to enable recall. Consciousness may be the awareness that we can recall a memorized image pattern or information element simply by naming or describing it, or, more basic, just the image of it, as in the term 'imagination,' with which it shares the same Latin root, connoting formation of a mental image or concept. Just that act of imagining – apparently instantaneous to humans in their (relatively slow) sense of the passage of time – brings forth the memory or at least a fragment of it. So how does the brain do this? It is an extraordinary ability, that the mere thought or suggestion, whether expressed as an image pattern or in symbolic language, is sufficient to access a memory in the brain! Because a language statement or image is thus so often the trigger of recall from memory, this suggests the postulate we discussed previously: that *language is a catalyst of memory*. The memory recalled may be a single image or it may be a sequence of images. It may be static or dynamic, as in a sequence of image patterns. So, the question becomes, what sort of processing, in what sort of structural arrangement enables this ability? How does that old memory become instantly recalled merely upon perceiving, in the present, a portion of the content of that long-ago remembered image, or something similar that reminds us of that content?

A tentative hypothesis emerging from this investigation, which is only an initial inquiry, appears to show that the brain is always active. It is considered as a functional biological organ, not a programmed, computational machine. It is an organ that appears in some respects to operate like an analog system. Its activity includes processing of image patterns, both extrinsic (sensory) and intrinsic (cognitive), that are continually being generated or originated and circulated. These mosaic-like elements are subject to fading, maintenance, or enhancement; to dormancy, linking, or combining; or to erasure, storage, or recall; to identify a few categories of process activity. These activities may be facilitated by language, perhaps functioning as a catalyst to the various activities. These catalytic elements may be structured to function in the manner of image pattern elements. However, the mechanisms of these activities are not understood beyond the hypothetical processes identified in the foregoing. Certainly, this hypothesis raises many questions . . . ; questions for investigations and other essays that lead to greater understanding of the human brain and its extraordinary capabilities.

Author's Note: The opinions expressed herein are solely the author's except as otherwise noted.

FOR FURTHER READING:

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