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Geometrical Patterns Underlying Human Intelligence: Implications in Information Retrieval

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Bruneau, A.-Ph.: **Geometrical patterns underlying human intelligence: Implications in information retrieval.**
Knowl.Org. 21(1994)No.3, p.132-139 21 refs.
The author argues that there are underlying structures to the mind which may be described as a form of visual intelligence. This idea favors artificial intelligence research directed in studies of geometrical patterns to cognition. He hypothesizes that such patterns may be compared with geographical maps as well as topological or spatial entities present in most written languages, but especially spatially based scripts such as Chinese. A philosophical approach is employed to discuss these issues, most notably the German philosophy of Gestalt and an epistemological critique of the foundations of knowledge. He concludes such entities may provide the basis for a solid model of intelligence based on formalized, geometricized formal patterns and that this model may be used effectively in a connectionist environment. (Author)

Indeed, if we look at it formally — i.e., only considering in what way it exists, not what there is in it — even a silly fancy such as may pass through a man's head is higher than any product of nature; for such a fancy must at least be characterized by intellectual being and by freedom. In respect of its content, on the other hand, the sun, for instance, appears to us to be an absolutely necessary factor in the universe, while a blundering notion passes away as accidental and transcient; but yet, in its own being, a natural existence such as the sun is indifferent, is not free or self-conscious, while if we consider it in its necessary connection with other things we are not regarding it by itself or for its own sake, and therefore, not as beautiful.

G.W.F. Hegel
Introduction to the lecture on Aesthetics

1. Introduction

Humans have always held a great place for what can be seen. Expressions as widely different as rupestrian frescos of wild bison, Michelangelo's painting of the Sixtine Chapel, and sophisticated computer imagery illustrate what may be at the core of our species — a deeply felt sense of our own surroundings. What is the power of this "phenomenon"? Why is it humans seem to perceive shape, form, color, hue, depth and a whole variety of other "visual" stimuli so well — and why is it we have such difficulty in modelling them for information retrieval (IR)? The answer, of course, is complex since it entails the most intrinsic qualities we possess as human beings. Arguably, it is a problem Artificial Intelligence (AI) must also deal with because its purpose (to simulate the human mind) requires knowledge of deeper cognitive structures. Such are the issues which will arise in this paper. First, I will hypothesize that "visual intelligence" is a distinct form of cognition, and summize that this "geometrization"[1] is the basic tool we use to relate to our environment. Second, I shall show that the connectionist model is ideally suited to handle such an analog. Third, I shall illustrate that this model of perception has an IR potential precisely because it defines patterns in the mind. Thus geometrically patterned heuristics for machine perception should provide solutions to current problems in AI. But why employ a "sight" paradigm? The metaphor of a "visual pattern" is appropriate, because non-sighted individuals proficiently relate form and thus meaning through tactile or haptic perception. The question of symmetry of these two types of perceptual patterns is very similar to the one explored here. In essence, the senses do not determine the outcome of intelligence, they more aptly show the road to take. As quoted by the now famous work of William Chase & Herbert Simon on chess masters, vision may refer more aptly to one of many avenues of the "mind's eye". The "prime director" unquestionably remains the structures within the mind.

2. How may these patterns be useful?

The hypothesis that "geometrical patterns" underlay human intelligence certainly has bearing on any theory of machine intelligence. If visual patterns are the starting point of a human being's interaction with the outside world, the relationship must be instrumental to its own enhancement, namely what we call: higher-level or productive intelligences. This is similar in conception to geographical information systems (G.I.S.) which build and store analogs in vector format along superimposed dimensions. In effect we may speak of a three-dimensional data space. As well, maps go further than mere presentation when they illustrate in concrete terms very complex and abstract relationships in the physical world. What is true of maps may also be true of other "topological representations", i.e., they carry meaning by strict virtue of their "dimensionality" or "spatial relations". Indeed, it can be argued that it is in great part this dimension which provides meaning in other forms of "visual communication" (such as written languages, paintings, sculptures, films, multi-

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media, etc...). "Meaning" requires abstraction and this cannot be realized until "dimensional shapes" have been introduced in our own mind. In the end, to form "complex reasoning" individuals must respond to their own underlying "structures of mind."

3. Review of the literature

David Woodward (1) examined this "phenomenon" and coined the expression geography's "inner worlds". He discussed the idea that content could not be defined independently of the meaning attached to it by users. Visvalingam (2), on the other hand, determined that maps were generalizations, and that they involved processes, such as selection, classification, displacement, symbolization and graphic exaggeration. For him, cartographers communicated their knowledge in order to reach individual idiosyncrasies. C. Grant Head (3) went even further when he described the map as a "natural language", and theorized that like the process of reading a text, they required the existence of structures in the reader's mind that were, at the very least equally as important as the marks on paper. Buttenfield and Mackaness (4) compared the high volume of spatial data to medical scanned imagery, super computer digital arrays and architectural and engineering CAD diagrams. Hodgson and Plews (1989) examined spatial phenomena in terms of clusters that were to be found in feature space. They specified that correlation of the clusters could be performed visually. Finally, Larkin and Simon (5) distinguished between "sentential" and "diagrammatic" representations, and specified that diagrams and the human visual system provided at essentially zero-cost all perceptual inferences. To them the advantages of diagrams were "computational".

4. The link to connectionism

Connectionism has offered some solution to the engineering problem of such an "overall-scheme-of-reference"[2]. It resulted from biological studies on patterns of the brain. If these offered symmetry, it was theorized a computer architecture could be modelled to simulate the same kind of processing! Connectionism thus combined the ideas of cognitive science, psychology, neurophysiology and psycho-physics, and its inception in the field of AI proved hospitable to validation. It notably emphasized the lack of parallel ability in most "computer architectures". Thus it was and remains an essentialist notion that considers a computer will benefit from a design closely modelled on the assembly of neurons in the brain. The processing would thus involve a number of nodes and connections where coded signals could travel in "parallel" ways, providing more efficient input & output of digital signals. In theory, this conception is supposed to be ideal for problems that tend to be naturally structured in parallel ways such as pattern recognition, robotics, language translation, handling of remote sensing data and of course AI. In stricter terms, there is argument to be made for IR limitations as being a question of "hardware" and not "software". Proponents of connectionism have included Tienson (12) who cited it's goal to understand how we think, in terms of simplified models of artificially isolated parts or vague "desideratum" that may solve problems in the same way we solve problems. Metzler (15) thought the model had to be applied to a number of computational properties, and the implementation of a symbolic architecture was necessary before justifying changes from a software-oriented approach to a computer architecture approach to processing. Bechtel (13) offered a description of connectionism as a model and illustrated its basic components. Proponents of parallel-distributed processing (PDP) such as Rasmussen (18), emphasized the concurrent manipulation of data elements belonging to one or more processes as a means of solving particular problems and thus confirmed the connectionist vision, and McClelland, Rumelhart & Hinton (14) viewed a parallel architecture in terms of peculiarities of the human brain, i.e., where people are smarter than today's computers because the brain employs a basic computational architecture that is more suited to deal with natural processing tasks. The question left unanswered of course, was the nature of this "computational architecture". Treisman (21) emphasized the dichotomy between serial and spatially parallel phenomena, and suggested that several different representations could be set up preattentively. Dhar and Pople (20) examined the role of a representational framework in terms of how "expert" knowledge could be represented. They assigned essential importance to the "frame" idea, as a means for the mind to obtain, interpret and assimilate data.

5. The semiology of cartographic representations

Maps may be called a "physical stratum" par-excellence for representing reality because they combine the ideal of abstraction and that of conventional reality. The only difference between them and reality is one of scale between a micro structure and a macro structure. In a sense, maps may be seen as a classic solution to a number of IR problems, for the concept is almost as ancient as human beings. It can be argued, that "to be human is to have a plan" (i.e., a physical scale representation in one's mind). Thus the fact that we choose to "geometricize" our habitual structures should not be surprising. In maps, this has been done as a creative extension from a limited domain for centuries. These original maps were designed as tools for the affirmation of knowledge. Our current computerized society (i.e., the extent to which our data universe of gigabytes, terabytes or octobytes is being manipulated in algorithmic fashion) may learn from such an endeavour. Even more so, since in effect, the geometrization of our base data elements is already at hand. Computer data include a number of topological qualities, starting with the bytes which have two values, therefore two dimensions, and vectored data which have three. And even though computer architectures are designed to handle large amounts of data, today even these architectures may be called "inefficient" in handling the memory requirements for both data and applications. Map storage may offer powerful theoretic solutions to such IR

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problems! As "visual" representations, they possess certain qualities which differentiate them from simpler rules of logic. They are indeed "expressions" for conveying extremely complex "physical-spatial" relationships. Woodward said of cartographers that they paid great attention to users frames of reference:

Cartographers have noted many times that a map or picture is not a representation of reality but a representation of ideas, usually highly conventionalized, about that reality. The measured representation to scale that has been traditionally expected of maps reflects only one of a number of different ideas about reality. (...) map makers also recognize that there are intangible or immaterial qualities of reality that should be mapped cognitively or affectively. (1)

Visvalingam on the other hand expressed the "generalization" inherent in maps. He saw in them powerful tools for providing meticulous metrical and topological information. For him, maps could convey directly or implicitly information on location, direction, distance, height or magnitude, density, gradient, shape, composition, pattern, connectivity, contiguity, juxtaposition, hierarchy and spatial association. For him: "Unlike photographs, they are abstract models of reality and involve transformations of various kinds" (2). The complexity of information when one "reads" a map, was thus not to be taken lightly. C. Grant Head borrowed a similar premise in his work on "natural languages" in maps. He cited the importance of "visual variables":

If map 'symbols' are the smallest unit that carry meaning and are constructed from visual variables (defining characteristics) then map 'symbols' are equivalent to morphemes, and visual variables to distinctive features (...). The equivalent of words is the combination of meaningful symbols into geographic features, i.e., a crossroads village, or a hill (3).

His ideas illustrated the power of images in pre-perceptual memory and also provided a taxonomy of the levels of memory: from the pre-perceptual store (PPS), to the short-term memory (STM) and long-term memory (LTM). This classification had originated in the studies of Freud and Piaget, but were applied with success in cartography. Head thus imagined a "pre-attentive store" for visual information where all characteristics of the stimulus that are psychologically processed by the eye would be held "independent of attention (...) averaging for the visual PPS about 200 or 250 milliseconds" (3, p.2). According to Head, such neuron-like organization inside the brain helped us appreciate "fine details" as well as entire "physical constructs". Buttenfield and Mackaness exposed a similar process: "Visual perception appear to proceed from a global analysis to more and more finally grained analysis (...), and the information processing system of human beings is particularly sensitive to interpretations and subtleties that can be expressed iconically" (4). Thus, visual processing was seen as playing a significant part in cognitive perception. In effect they exposed the "synoptic" value of visual variables. They further said: "Representations may be rendered symbolically, graphically, or iconically and are most often differentiated from other forms of expression (textual, verbal or formulaic) by virtue of their synoptic format and with qualities traditionally described by the term 'Gestalt'" (4, p.432). Such representations were conceived as vehicles for information processing. What Hodgson & Plews alluded to remote sensing, thus relates to other "visual variables" because, if clusters on a map can be correlated visually and "cognitively" processed, this is a form of "visual processing".

6. Pictures and words

If features on maps can be processed efficiently, what about other "diagrammatic" representations? What Jill H. Larkin & Herbert A. Simon described as a "diagram worth 10,000 words" is entirely relevant to visual representations. Many scientists and mathematicians mention that they think in terms of "pictures or images". One famous example is Albert Einstein. His apparent "visual" explanation for the theory of relativity is case and point[3]. The point is that there are qualitative differences in the way diagrammatic and sentential representations provide meaning. Yet, both may travel to the same junction of object and thought. Paradoxically, the first is a much more primary expression than the second. For words, formulas, or numbers as well as pictures are always dimensional first. Larkin and Simon expressed a difference between words and pictures in these terms: "The fundamental difference between our diagrammatic and sentential representations is that the diagrammatic representation preserves explicitly the information about the topological and geometric relations among the components of the problem, while the sentential representation does not"(5). Strictly speaking if images have an underlying "structure" all their own, it may be that the mind has assigned one which plays an incremental role in perceptual advances. It can be argued that from this increment results "inference" (i.e., the very creative leap from fact to more complex reasoning). Thus it is a logical assumption to conclude these structures could be used as efficient "vehicles" for IR. As well, their "computational value" might provide some explanation for the evocative power of things visual. Larkin & Simon expressed the situation in these terms: "The advantages of diagrams, in our view, are computational (...) because the indexing of this information can support extremely useful and efficient computational processes" (5, p.99). As we shall see, connectionism has devised such an overall engineering effort to solve problems of data size and signal propagation. As such, connectionism may offer solutions to the lack of theoretical framework in this area.

7. The idea of 'geometrical patterns'

What is "visual intelligence"? It is generally agreed that there are many expressions of human intelligence: spatial

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ability, kinesthetic ability, logical ability, musical ability, mathematical ability, etc. What apparently is not always justified, is that most of these evolve from a kind of "interface" or "interaction" with the environment. The problem is: the senses record certainly, but they do not provide "kinesthetic" reconstructions by themselves. Our different expressions are proof of that, because most of them develop afterthought. Thus the primary-motor would seem to require an internal structure. The reason for this precedence: if we cannot extract stimuli from the environment without some kind of extracting medium, we certainly cannot produce the effects without some kind of basic units. Early gestaltists saw the problem in a similar fashion:

When I look around an unfamiliar place or under limited conditions of visibility, I try to make sense of the things that I see, to recognize them; I hypothesize on their nature, checking such hypotheses by examining the characteristics of what is being observed; I predict behavior and adjust my original conjectures according to the results of these checks. (6)

This certainly describes the process of cognition, but as Kanizsa remarked, it gives evidence of some underlying principles, for the question remains how mere perceptual advances could be transformed into more complex forms of reasoning. For him, cognition consists of active construction by means of which sensory data are selected, analyzed and integrated with properties not directly noticeable but only hypothesized, deduced, or anticipated, according to available information and intellectual capacities. He thus developed a point of view entirely grounded in the mind. The philosophical argument had been echoed in other disciplines, no less empirically grounded than biology. Gardner commented on studies in neurobiology which suggested the presence of areas in the brain that corresponded, at least roughly, to certain forms of cognition. He remarked: "these same studies imply a neural organization that proves hospitable to the notion of different modes of information processing"(7). In this, the study on chess masters by Chase & Simon was particularly revealing. It cited amongst other things, the ability of these experts to perceive familiar patterns:

...wherever the information is stored — there is associated with it the internal name, structural information about the pattern that he can use to build an internal representation (a simulacrum in the mind's eye) and information about plausible good moves for some of the patterns. It is this organization of stored information that permits the master to come up with good moves almost instantaneously, seemingly by instinct and intuition. (8)

That this reveals a spatial intelligence is a matter of serious repercussion, for the implications and the exact nature of the patterns were not specified. In many ways, these patterns can be compared to images we see. For, literally and figuratively, visual images are not only what we see, they may involve what we have previously seen and recorded in latent memory. The best example of this is our use of metaphors in everyday language. Are metaphors "visual universals"? Certainly, human alphabets can be considered "pictorial representations"; and for most, it is only after the characters, lines or symbols have been conventionalized, that they become useful "heuristics" for expressing more complex relationships. For instance, Kuipers remarked about the English language: "...spatial metaphors are very common in our language for expressing many kinds of other relations: mental, social, musical, temporal, and so on. This suggests that spatial relations are useful in other domains"(9). As a vital lead, it would seem written languages are the ultimate spatial formalization. Other forms of "visual representation" include tonal qualities, various scripts, rules of logic, mathematical formulas, mark-up style, etc.. Indeed, most modes of expressions have developed "pictorial representations" as a means for regeneration and communication. For example, in written Chinese characters are the basic units that provide meaning. Yet, as Liwen Qiu pointed out: "Although a single character has a certain meaning, it is not a searchable term from the point of view of information retrieval"(10). Such deficiencies in current IR of "visual primitives" is an indication of the limits of current storage and retrieval systems. What can be termed the "gestaltness" of written Chinese certainly goes in the same direction as a theory on "visual frames", for if every stroke as a meaning except when in association, this process is strikingly similar to that of "complex reasoning". Written languages may thus be a good example of "visual icons" that provide a vehicle for efficient information processing and yet the theory for handling them seems misguided!

8. The parts versus the whole

In many ways what creates meaning may be "combination" and "correlation" of such simpler elements. This is partly what Gestalt philosophy was aiming at, in that for gestaltists it wasn't the individual bits and pieces of cognition which were important but the assembly of all units in one whole. The primary point is that if languages as well as other forms of symbolization form "icons" in dimensional space, this is "intelligence"! But the bigger question is why? It may be that sight involves more than just seeing! In many ways it may be called a form of "encryption" or "encodification" of simpler elements. This is why some kind of structure in the mind makes so much sense. Because, as human beings we have the ability to extract data from our environment but we also group them in terms of aggregate features. This requires a reassembling structure. From the assumption of such a structure, it is logical to assume neurons form the patterns. In a way this is what the gestalt ideas were paramount to in psychology, i.e., that perception resulted from association, and not from dissociation! The implications to the domain of AI should be equally formidable.

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9. The role of a connectionist architecture

What may be the role of such a geometry of the mind? Connectionism has gone a long way in answering this question. It developed a philosophy based on the position that computers would be more productive if they followed the most productive qualities found in human beings. What "phenomenology" expressed of the interdependence of units within a phenomenon as well as with other phenomena, could thus be modelled in one mechanical "experience". Connectionism employed a deductive approach to this end: i.e., an understanding of the generality of structure and function for a larger totality than what had been considered before! Michael Tye agreed that the role of connectionism was to develop "a much more general thesis about the mind"(11). A pragmatic reason for this was that biology did not know much about the processes involved in the brain, let alone how they generated thought. Certainly they had summized the existence of neurons, but little was known of the inner processes. As Tienson remarked: "Neurons operate in times measured in milliseconds at best, 106 approximately slower than the current generation of computers. The exact significance of this comparison is not clear, since we have no idea how cognitive functions might be implemented in the brain, although it seems certain that single neurons compute single functions"(12). This so-called "expertise" was perhaps sufficient reason to pursue the problem, since efforts in pattern recognition, speech recognition, recall and recognition theory, and spatial assembly had provided sufficient reason to think it could work. Yet, it was first deemed important to determine what all these processes have in common. For Bechtel: "categories have a prototype structure : some exemplars (ex. robin) are judged to be better examples of the category (ex. bird) than others (ex. duck). This (suggests) that categories are not characterized in terms of necessary and sufficient conditions"(13). PDP has also examined the notion of schemata, which fit very neatly into this sort of connectionist model. As well, schemata could theoretically be retrieved rather efficiently through a maze of connections. Rumelhart, Smolensky, McClelland and Hinton described the schemata in this fashion:

Schemata are not "things". There is no representational object which is a scheme. Rather schemata emerge at the moment they are needed from the interaction of large numbers of much simpler elements all working in concert with one another. Schemata are not explicit entities, but rather are implicit in our knowledge and are created by the very environment that they are trying to interpret — as it is interpreting them. (14)

Here, the workings of a potential connectionist architecture are confirmed — for not only can data be spread out through a maze of elements (nodes), but it can also be retrieved or emerge at the right moment. Stability of the system thus performed in accordance with thermodynamic principles: "units change their activations as a result of their inputs and thereby alter their outputs, until the system settles into a state of highest entropy" (13, p.18). The control of the flow could then be accounted through complex algorithms. Metzler described the flow of data units within the connections as: "numerical values from each unit to the ones it is connected to (...) not correspond(ing) to anything in the domain. Each unit has some form of summation function which determines how it should respond to the inputs it receives, and it responds by sending numerical values to its neighbors."(15) This process may be the key to connectionism because it allies computer conventions with what was well understood about the brain. Formal syntactic rules of representation could then be used while still respecting the free association of connections. Rumelhart, Smolensky, McClelland & Hinton also illustrated a similar conception that can be likened to a dialectical approach, because it regarded intelligence in its entirety, not from the point of vue of its complexity:

If the human information processing system carries out its computations by 'settling' into a solution rather than applying logical operations, why are humans so intelligent? (...) How can we do logic if our basic operations are not logical at all? We suspect the answer comes from our ability to create artifacts - that is, our ability to create physical representations that we can manipulate in simple ways to get answers to very difficult and abstract problems. The basic idea is that we succeed in solving logical problems not so much through the use of logic, but by making the problems we wish to solve conform to problems we are good at solving(14, p.44).

This is the crux of the problem. In many ways it is difficult to imagine something simple doing something so complex. But this interaction is in great measure, the same kind of interaction human beings seem to experience with their own environments. For example, we may see an apple, then the table it stands on, then the room, etc., but as well we will record a great variety of details within this view: from the color of the apple, to it's freshness, to the material of the table, whether the light shines on it or whether it is in shadows, etc. So, the difference between our macroscopic and microscopic appreciation of the environment does not come from a single element within it, it comes from a process that includes very large amounts of perceptual "advances" (i.e., the mind leaps forward and captures these representations which are thereafter stored and re-associated at will). In computer terms, perception may be compared to such processing of micro features. Why? In PDP at least, it is the assembly of micro features that are the most basic structures involved in processing. For Rumelhart:

When we speak of a distributed representation, we mean one in which the units represent small, feature like entities we call micro features. In this case it is the pattern as a whole that is the meaningful level of analysis. This should be contrasted to a one-unit-one-concept or localist representational system in which single units represent entire concepts or other large meaningful entities (16).

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Gilbert Harman alluded to similar structures in chess players:

To understand what a king in chess is, you have to understand the role of the king in relation to the roles of the other pieces in chess - pawn, queen, rook, knight and bishop. Similarly, to understand how beliefs function, you have to understand how beliefs function in relation to desires, intention, perception, emotion, and inference, given that a creature acts in ways that promise to achieve its goals given its beliefs. (17)

We could also describe a map in the same way, i.e., an assigned value of individual bits and pieces within a greater whole or in association with other structures all intermingled and interrelated with each other on many dimensional planes. The fact this may be the way humans think does not make the task of engineering it any easier. For in computer terms, connectionism poses difficult problems, not least of which is the current computer design (except for Cray's). The role of "weightings" on the individual connections and other factors such as : "(the) properties of the individual units such as their thresholds of activation and summation functions" (15, p.261) also come into play in such an architecture. Rumelhart compared the connectionist model's system of constraints to language processing. He saw the role of syntax in language in a connectionist fashion: "syntax constrains the assignment of meaning. Without the syntactic rules of English to guide us, we cannot correctly understand..."(19). For example, if one says : "I saw the grand canyon flying to New York!", others may be hard-pressed to understand what the speaker is saying. The point is: "..the syntactic structure (...) is determined in part by the semantic relations that the constituents of the sentence might plausibly bear on one another. Thus, the influences appear to run both ways, from the syntax to the semantics and from the semantics to the syntax" (19,p.6-7). Why is this important in a connectionist model? It seems clear that the basic idea of association of sense-making units is what provides meaning. If this is so in everyday language, chances are a computer modeled according to these patterns will also process in an equally efficient manner. Standard situations could then be stored as original "scripts" or "schematas" and efficiently processed and retrieved. It is also clear that a connectionist architecture has the potential to handle data in this, their original primal way. What McClelland, Rumelhart and Hinton theorized about the role of "primary frames" is thus entirely relevant to the connectionist model. For in microscopic terms: "...none of the letters, considered separately, can be identified unambiguously, but (...) the possibilities that the visual information leaves open for each, so constrain the possible identities of the others that we are capable of identifying all of them" (19, p.7-8). The principle of brain structure would therefore seem to be compatible to an IR environment where one need only require partial information to recapture the whole! This final example shows that processing of information in geometrical fashion has the potential for being a very productive form of computer processing, perhaps in the same fashion as "mental pictures" schematized as mental patterns may form a background to more complex forms of reasoning. The connectionist model certainly offers a choice vehicle for a theory of the mind based on visual representations!

10. Information retrieval implications : artificial intelligence in design

What are the implications of such a "scheme"? It is clear that it can serve as a vehicle for understanding intelligence at its most primary level. Whether the schemes exist or not is not at issue; the issue is the organization may be evocative of a broader reality. This is the implication of any rule-of-thumb, in that it helps to understand very complex and composite realities. But the next question is: how will these exemplars perform? This is important because, if intelligence can be formalized in any way, the model requires beyond-doubt accuracy. Therefore, we must describe how we think "intelligence" should perform! Gardner defined human intelligence in this manner:

To my mind, a human intellectual competence must entail a set of skills of problem solving - enabling the individual to resolve genuine problems or difficulties that he or she encounters and, when appropriate, to create an effective product - and must also entail the potential for finding or creating problems - thereby laying the groundwork for the acquisition of new knowledge. (7, p.60-61)

Intrinsically, if our aim is to develop artificially intelligent machines we must know how "expert" knowledge is going to be represented, because "the representational framework adopted can play an important role in how subsequent data are obtained, interpreted, and assimilated into the framework"(20). The problem with mathematical formulae or statistical methods is that they often reduce to the extreme and may thus stultify a composite reality. This is of some importance in models of intelligence, for if human beings can learn and adapt, so must our model. In problem resolution or problem-solving, Dhar & Pople (citing Doyle) established the basic difference between reasoned assumptions and probabilistic ones:

...conditionals of a problem situation (defaults or exceptions to general propositions) are recognized explicitly instead of being "homogenized" into certainty scores as in the probabilistic approach. For example, a rule that takes explicit cognizance of exceptions and/or defaults might be : IF there is an increase in throughput, THEN increase direct labour UNLESS you off load part of the manufacturing process to another facility, or UNLESS...(20, p.543)

As they argue, numerical "judgments of certainty" often hide more specific information not yet made explicit by the expert informant. Rumelhart, Smolensky, McClelland &

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Hinton hinted a similar process in their example of the multiplication of large numbers (i.e., 343x822): "Each cycle of (the) operation involves first creating a representation through manipulation of the environment, then a processing of this (actual physical) representation by means of our well-tuned perceptual apparatus leading to a further modification of this representation" (14, p.45). The fact that they mention the creation of a representation may be the key to the broader problem, because even here, a sort of heuristic "step-ladder" was used: "By multiplication, we reduce very abstract conceptual problems to a series of operations that are very concrete and at which we become very good" (14, p.45). Thus the operation would simply seem to be the reversed process of human perception. This may be why the idea of "visual intelligence" is so attractive. By thinking out our visual stimuli we abstract the notions which thereafter can be used proficiently even with mixed signals (or distortion) emanating from the environment. Treisman similarly suggested: "parallel pop-out may be diagnostic of the presence of a unique feature which is analyzed in early vision"(21). For her, feature maps generated in early vision and could "pop-out" as soon as a target produced activity in a separate feature maps. This helped her hypothesize a sort of "representational space". What are the implications of Treisman's ideas? Simply put, if we can perceptually classify microfeatures spatially, then there is precedent to classify text or phrases spatially, three-dimensionally and topographically. Why? Because in essence the basic-level "prototypes" are very similar. The preceeding arguments should have made this quite clear. Even so, we may justify the process in terms of Treisman's 5 central qualities of objects: 1) they can be recognized "rapidly", 2) when viewed from "novel orientations", 3) under moderate levels of "visual noise", 4) when they are "partially occluded" and 5) when they are "new exemplars" of a category. Thus IR will certainly progress when it finds answers to this trail of evidence. It is a prerequisite Metzler saw as essential in any future "intelligent" system, for as well as efficiently processing any amount of data, a proper system will require "compositional" and "combinatorial abilities":

...an intelligent system must respond appropriately or coherently to its environment, and that implies that somehow it stores representations of the relevant aspects of its environment upon which its actions are conditioned. A critical characteristic of this compositionality is that it is unlimited. We are capable of taking a finite number of cognitive entities and creating an infinite number of combinations of those entities (15, p.266).

What Metzler had applied to representations certainly also applies to AI, in that the patterns are uniquely designed to handle "knowledge operations". For Metzler connectionist systems greatest advantage is that they handle "back propagation" algorithms. Such techniques are considered paramount for learning machines, for if backtracking is not involved the system will simply not be able to learn. In a broader sense similar factors are involved in human decisions when ideas flow in different directions, some are abandoned and others are processed efficiently at once. If computers are going to simulate such free-flow of ideas, they will have to simulate a similarly expansive and incursive structure.

11. Conclusion

Geometrical patterns may form human being's most primary mode of interaction with the environment. Humans are therefore not that different from other animals, but they differ in one substantial way: they can abstract simple notions and carry them to extreme lengths based on the original "building blocks". This power of abstraction is tremendous and one could think it may have evolved by itself — but the evidence is overwhelming in saying that humans are after all not so far from animals in the way that they perceive and assemble these primary units. The evidence presented in this paper should at least have illustrated that in the human mind, complex reasoning at its most constituent is a by-product of the simplest elements. Therefore, vision (or touch or hearing) as our unquestionably versatile natures should show us do not work alone, they work in tandem with preceding elements. Therefore, artificially intelligent systems will not evolve by themselves, they will evolve from a similar understanding of these modest but so considerable units that define us as human beings. It is hoped that this paper will have provided a glimpse into their dialectical appeal.

Acknowledgement

The author wishes to thank Dr. J.A. Large, Dr. John Leide and Marcos Silva of McGill's GSLIS for their help, suggestions and criticism in preparing this paper and Chantal Métivier of the National Library of Canada for her stylistic recommendations.

Notes

1 In the context of this paper this expression will refer to the organization of elements in spatial, topological or dimensional terms.

2 Simile for the German expression of "gestalt".

3 The visual expression: "Imagine a large mass, A, travelling in a straight line through space. The direction of travel is North from South. The mass is surrounded by a huge glass sphere etched with circles parallel to each other and perpendicular to the line of travel, like a giant Christmas tree ornament. There exists a second mass, B, in contact with the glass sphere at one of the etched circles. B's contact with the sphere is at some point below the largest circle which is the middle circle. Both mass A and B are travelling in the same direction. As A and B continue their motion, B will be continually displaced along the etched circle which is the point of contact with the sphere. Since B is continually displaced, it is actually tracing a spiral path through space-time being the North-bound movement. Yet this path when viewed from someone on Mass A from inside the glass sphere, appears to be a circle, not a spiral." Cf. Gardner, (7, p.172-173).

https://doi.org/10.5771/0943-7444-1994-3-132 - am 13.01.2026, 03:00:46. https://www.inlibra.com/de/agb - Open Access -

References

(1) Abler, R. F., Marcus, M. G., Olson, J. M. (Eds.): Geography's inner worlds: pervasive themes in contemporary American geography. New Brunswick, NJ: Rutgers U.Press 1992. 412p. (p.51-52)

(2) Visvalingam, M.: Trends and concerns in digital cartography, Comput.-Aided Design 22(1990)No.3, p.115-, 127 refs.

(3) Head, C. G.: The map as natural language: a paradigm for understanding, Cartographica, 20(1983)No.4, p.8-9, 108 refs.

(4) Buttenfield, B.P., Mackaness, W.A.: Visualization, In: Geographical Information Systems: principles and applications. New York, NY: Longman 1991. p.428, 2v.

(5) Larkin, J.H., Simon, H.A.: Why a diagram is (sometimes) worth ten thousand words. Cognit. Sci. 11(1987) p.66, 21 refs.

(6) Kanizsa, G.: Organization in vision: essays on Gestalt perception. New York, NY: Praeger 1979. 267p. (p.1)

(7) Gardner, H.: Frames of mind: the theory of multiple intelligences. New York, NY: Basic Books 1983. 440p. (p.59)

(8) Chase, W.G., Simon, H. A.: The mind's eye in chess, In: Visual information processing: Proc. 8th Annual Carnegie Symposium on Cognition, Pittsburgh, PA, May 19, 1972. New York, NY: Academic Press 1973. 555p. (p.217)

(9) Kuipers, B.: Modelling spatial knowledge. Cognit.Sci. 2(1978)No.2, p.152, 20 refs.

(10) Qiu, Liwen: Applicability of string indexing to the Chinese language with special reference to NEPHIS. Int.Class. 16(1989)No.2, p.89, 3 refs.

(11) Tye, M.: Representations in pictorialism and connectionism. South.J.Phil. 26(1987)Suppl., p.163. 32 refs.

(12) Tienson, J. L.: An introduction to connectionism. South.J.Phil. 26(1987)Suppl., p.2, 35 refs.

(13) Bechtel, W.: Connectionism and the philosophy of mind: an overview. South.J.Phil. 26(1987)Suppl., p.28. 52 refs.

(14) Rumelhart, D.E., Smolensky, P., McClelland, J.L., Hinton, G.E.: Schemata and sequential thought processes in PDP models. In: Parallel distributed processing: explorations in the microstructure of cognition. Vol. 2: Psychological and biological models. Cambridge, MA: MIT 1986. p.20, 2v.

(15) Metzler, D. P.: Connectionist and symbolic information processing: a critical analysis and suggested research agenda for connectionism from the symbolic perspective, In: ASIS '90: Information in the year 2000: From research to applications: Proc. 53rd Annual Meeting Amer. Soc. Inform. Sci., Toronto, 4-8 Nov. 1990. Medford, NJ: Learned Inform. 1990. 27(1990) p.262

(16) Rumelhart, D.E.: The architecture of mind: a connectionist approach. In: Foundations of cognitive science. Cambridge, MA: MIT Press 1989. 888p (p.135-36)

(17) Harman, G.: Some philosophical issues in cognitive science: qualia, intentionality and the mind-body problem. In: Foundations of cognitive science. Cambridge, MA: MIT Press, 1989. 888p. (p.833)

(18) Rasmussen, E.M.: Introduction: parallel processing and information retrieval. Info.Proc.Mangt., 27(1991)No.4, p.255, 51 refs..

(19) McClelland, J.L., Rumelhart, Hinton, G.E.: The appeal of parallel distributed processing. In: Parallel distributed processing: explorations in the microstructure of cognition. Vol. 1: Foundations. Cambridge, MA: MIT Press 1986. p.6-7, 2v.

(20) Dhar, V., Pople, H. E.: Rule-based versus structure-based models for explaining and generating expert behaviour. Comm. ACM 30(1987)No.6, p.542, 23 refs.

(21) Treisman, A.: Preattentive processing in vision. In: Computational processes in human vision: An interdisciplinary perspective. Norwood, NJ: Ablex 1988. 489p. (p.436)

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