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Images and Words: Fractals and Fuzzy Logic

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1. Introduction

Each of us has at some point been misunderstood. Three simple variables are involved: a) what we mean, b) the words we use for this and c) the objects, events or experiences in the physical or spiritual world to which they correspond (fig 1). In our minds there was a one-to-one correspondence between a, b and c. In the mind of the person who misunderstood us there was no such correspondence.

The correspondence that we assumed should exist between our meaning, our words and our objects, was not unlike the correspondence that Renaissance artists and scientists assumed between our perception, our (visual) images and the objects they represent, and built on a much older tradition which compared painting and *poetry (ut pictura poesis*). What was there, what we drew and what we saw were assumed to correspond.

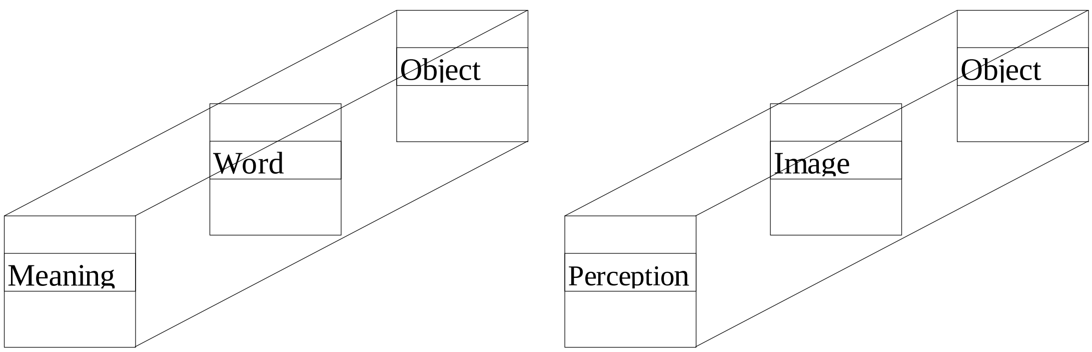

Fig. 1. Schema assuming a one-to-one relation between meaning, word and object or between perception, image and object.

These approaches to both words and images[1] were both guided by an underlying faith that under we could make these equations and that we would normally be understood. The faith relied on basic tools to certify that the process was correct, namely, logic in the case of words, and perspective in the case of images. Or so it seemed. In the course of the twentieth century, most of the assumptions underlying this optimism have been called into doubt. The extreme consequence of this approach would make non-correspondence and misunderstanding almost a matter of course rather than an accidental case. This paper explores these developments, suggests that the interim solutions are unsatisfactory and proposes a fresh approach.

2. Images and Fractals

In the case of images, we have become conscious that there is more to perspective than the basic inverse size/distance law, which states that the distance affects only the size of objects, such that if we double the distance an object is half as small, if we treble the distance, an object is one third as small, and so on. If an object has irregular contours, as we change the distance or the scale of an object, not only its size but also its shape changes. Mandelbrot cited as an example the coast of England. A small image of England, say five centimeters (at a scale of 1,000,000: 1), will have relatively few indentations along its coast line. A fifty centimeter image would have more. A five meter image would have many more and so on. The closer we approach the scale of 1:1, the more indentations there will be on the coastline. Hence scale affects not only the size, but also the shape and thus the relative length of the coastline.

Mandelbrot's example brought into focus a problem of which we have implicitly been aware for several centuries ever since the invention of the telescope and microscope. The familiar shape of an object in one scale becomes transformed as we move to a radically different scale. The surface of a table which appears completely flat and smooth to the naked eye, reveals itself as rolling plateaus at another scale and veritably mountainous at another scale.

Such examples led Mandelbrot to identify a larger problem. Organic forms in nature are predominantly irregular in shape. Our chief tool for dealing with nature is Euclidean geometry, which is regular in shape. The challenge, he argued, was to find a new geometry which could deal properly with nature's irregular forms. His proposed answer lay in fractals, which led him to entitle his book *The Fractal Geometry of Nature*.

Unfortunately, Mandelbrot's answer did not solve the problem to which he had drawn attention. Fractals may have wonderful aesthetic aspects, but this fascination is intimately connected with their iterative nature whereby a pattern or image at a given scale recurs when one focusses into another scale. This is not what happens in nature. A surface which seems flat to the naked eye, under a microscope becomes hilly, then mountainous before dissolving into a series of forms and eventually into molecules and atoms. The simple iteration of fractal patterns does not capture the transformations of shape as we go through the different scales of nature. In short, if there is a non-correspondence between object, image, and concept, fractals cannot resolve the problem.

3. Words and Fuzzy Logic

There are unexpected parallels in terms of words and fuzzy logic. Until the twentieth century it was largely assumed that, like the connections between images, objects and percepts, there could be easy equations between objects words and meanings, the assumption being that logic provided the key to such links. However, philosophers from the time of Peirce onwards have been increasingly insistent that these links are by no means as obvious as we thought. The phrase "tall man" may seem obvious, but it will mean something very different to a pigmy and a Patagonian, let alone a child and an adult.

Just as fractals were intended to solve problems of correspondence in the case of images, fuzzy logic was introduced to solve problems of correspondence with words. This proposed solution has drawn great criticism from the champions of traditional logic on the grounds that one cannot reduce a fact to percentages. It makes no sense, they claim, to refer to a man as being 80% a man. One either is or one is not, they claim, and base their arguments on the law of non-contradiction. Hence the twentieth century has rightly drawn attention to major problems of mis-understanding in the realms of images and words, but the proposed solutions to these problems in terms of fractals and fuzzy logic do not resolve the issue.

4. Adjustable Perspective and Image Classification

In the case of visual images the principles of perspective work perfectly well as long as we do not radically change the scale. Images traced with ordinary sight are valid. Images traced with the use of an intervening microscope are equally valid. So what is needed is an adjusting perspective that takes into account different scales. Within each range of scales there will be no significant change in shape, the traditional inverse size distance laws will hold, and there will be a genuine correspondence between object, image and percept.

We need, of course, to be aware that there is no necessary one-to-one correspondence between an image and object. Some images are symbolic, some strive to express universal concepts and thus cannot reflect all the distinguishing characteristics of a particular object. So we need a classification of images into those intended to represent objects and methods of recording a digital equivalent of watermarks in order to assure that an image has not been adjusted or transformed.

5. Grammar and Cultural Words

A number of the debates between the champions of traditional logic and the exponents of fuzzy logic are resolved if we simply use grammar to make some basic distinctions.

Crisp	Fuzzy
noun (man)	adjective (tall)
	adverb (very)

pronoun (a, an)

Fig. 2. Crisp and fuzzy as a function of grammatical functions.

Supporters of traditional logic assume that one is discussing nouns. They are right to insist that a noun, once defined, either is or is not something. A man cannot be 72% or 83% a man, except loosely speaking. By contrast, proponents of fuzzy logic, typically refer to nouns with adjectives and/or adverbs, and they apply their fuzziness to the adjectival and adverbial part of their claim. They are not speaking about a person being 73% a man, but rather about his being 73% a "tall" man or 73% a "very tall" man. So the distinctions made between crisp and fuzzy terms lend themselves naturally to different grammatical functions. Nouns are crisp: adjectives, adverbs and indefinite pronouns are fuzzy.

It is instructive to note that those grammatical functions which are fuzzy are also much more subject to cultural differences than are those associated with crisp ones. For example, the the basic characteristics of the noun "man" are fairly constant around the world even though the term may vary somewhat from culture to culture in terms of the degree to which it evokes macho characteristics. By contrast, adjectives and adverbs vary enormously from culture to culture. In Nordic countries (such as Denmark, Frisia and Scotland) "not bad" is often a great complement and is effectively the equivalent of "excellent". Qualitative quantifiers such as "some", "quite a few", " a fair number", "many", "a lot" all depend on the speaker. Thanks in Scotland and a thousand thanks in Italy may mean the same thing.

What is required, therefore, is a basic vocabulary of elementary adjectives and adjectives, partly in combination with key nouns, for which individual users can adjust the parameters of personal meaning. The term "tall man" may be in the range of 6'- 7' 8" for a Texan and in the range of 4'5"-5' for a pigmy.

6. Universal Concepts and the Classification of Individual Words

A second domain broached by the exponents of fuzzy logic entails classification in terms of relations between terms. A generic term such as bird is chosen and the question is asked to what extent examples such as sparrow, eagle, chicken, turkey or dodo are considered typical (or prototypes to use the jargon of fuzzy language). From a subjective standpoint this may be both challenging and interesting. From a practical viewpoint, however, this is an example of trying to re-invent the wheel since librarians and scholars have already spent millions of hours creating classification systems and taxonomies of knowledge which organize knowledge in terms of genus and species.

Closely related are the efforts made by proponents of fuzzy logic to determine whether a term is basic (e.g. chair), whether it has superordinate or broader terms (e.g. furniture)

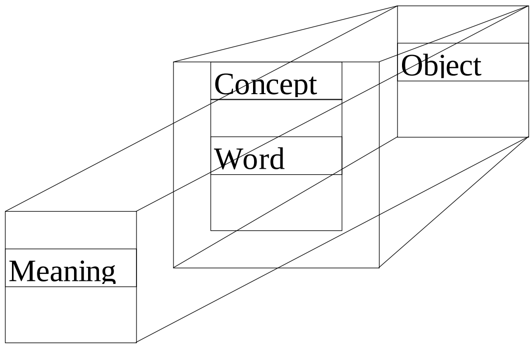

Fig. 3. Visual schema of how a correspondence between object, word and meaning can lead to broader concept. This in turn can generate related vocabulary.

and subordinate or narrower terms (e.g. lounge chair). This again is something that librarians have tackled. What is needed, therefore, is a cross-referencing between classes, definitions, explanations, titles, abstracts and contents as in the SUMS approach. Hence whenever one links an object with a word one can choose to go to a broader concept as a means of contextualizing the term and discovering related vocabulary (cf. fig. 3).

To take a simple example, let us say that the initial word is hawk. If the user asks for narrower terms they are given examples such as chicken hawk and sparrow hawk. If they ask for broader terms they are taken into birds of prey and find eagles, buzzards etc. In principle this is the kind of activity that is usually associated with expert systems. What is different in this case is that the results are not generated by complex examples of artificial intelligence or neural networks but rather on the basis of existing classification systems.

As a next step one would wish to add a temporal dimension to these classifications. We know that the major classification systems be they of libraries (Congress, Dewey etc.) or specialized topics (botany, periodic table in chemistry, etc) have their own histories. Plants as organized by Aristotle were very differently arranged than by Linnaeus or by botanists today. The terms linked with the word "flower" have expanded enormously over the centuries.

Given developments in object-oriented programming one would wish to develop objects with these characteristics which change over time and in different cultures. Hence the term "flower" would have characteristics which adapted automatically depending on the time and place. The largest and smallest examples of an object would automatically be included to define the parameters thereof. Hence if we chose pumpkin we would be given not only the size of a typical pumpkin (e.g. 8 inches in diameter weighing five pounds) but also the smallest and largest known pumpkins.

7. Conclusions

Clear communication requires correspondence. In the case of images this entails correspondence between object, representation and percept. In the case of words this entails correspondence between object, word and meaning. The proponents of fractals and fuzzy logic have made us aware of conditions under which this correpondence does not onbtain. However, as we have shown, their solutions are not satisfactory. Instead we need adjustable perspective and cultural filters in order to restore to images and words the kind of correspondence necessary for understanding to be the norm.

In a world where object-oriented programming is becoming ever more significant, we need a richer approach to objects that defines in addition to their substance (who, what?), and their place (where?), their temporal co-ordinates (when?), their construction (how?) and their underlying purpose, cause or reasons (why?). Moreover, these must be co-ordinated such that we can trace the ways in which answers to these questions may shift as we change the co-ordinates of time and space. Paper has different meanings in thirteenth century Beijing than it does in seventeenth century Paris or twentieth century New York. New breakthroughs in knowledge require much more than simply making everything available electronically. They require a whole new approach to classification of and access to knowledge as we have known it in the past.

Perspective Unit, McLuhan Program, Toronto 24 October 1995

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[1] Just how far one could take this analogy between words and images has long been a matter of debate. Some have argued that words and images can both be viewed as languages, each having their own "grammars". Russian artists and linguists played a key role in this view, which was subsequently championed by American philosophers such as Goodman. Others, such as Gombrich, have claimed that there are fundamental differences between verbal language which emphasizes universals and visual images which favour individuals.