To understand *How the Mind arises from the Brain* it is necessary to start with simple first steps or “Building Blocks” then to gradually erect the total structure.

The first “step” is the field of <u>Artificial Intelligence</u> [AI]

The successes in that field do not constitute a form of intelligence. Rather, they are only a simulation of some of the intelligence-related actions of humans.

The study of AI is the study of how Universals can be represented in digital systems and how they can there be usefully manipulated.

ARTIFICIAL INTELLIGENCE
[BUT NOT YET A REASONING MIND]

SECTION 2

Representing and Perceiving Universals

Representing Universals

By the word *universal* is meant a class or category to which a particular specific example belongs [Aristotle's concept]. *Perception* is the process of properly correlating individual specific cases, examples, with universals. Perception particularly includes the proper identifying or recognizing of examples that have not previously been specifically experienced.

Humans perceive, recognize, a very large number of universals, of course. Some examples, in order to clarify the concept, are:

- recognition of the letter *E*, whether capital or lower case, hand written or mechanically produced, large or small, alone or among other symbols, even though the particular *E* being recognized may be different from any ever before seen;
- recognition of all beings that are human as human beings;
- recognition of all shirts.

The universal is the common characteristic of all elements of the group, that is *E*- ness, human-ness, shirt-ness in the above three examples.

Not only humans recognize universals; most animals do also, but the ability in non-humans is apparently more limited. Nevertheless, for example, a dog can recognize another dog as a dog even though the dog recognized was never before seen and is of a significantly different breed or appearance.

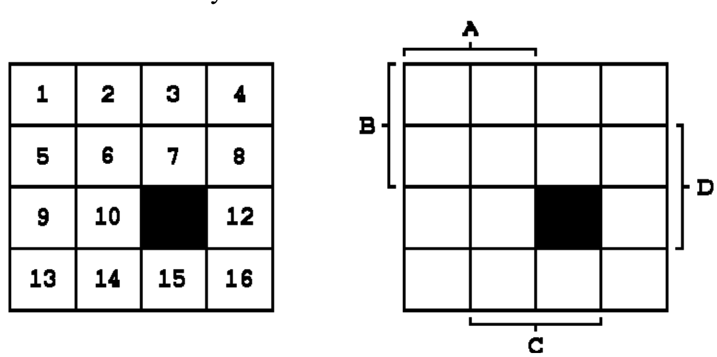
Recognition of universals is not always accurate even though the recognizer is competent. The sample may be a marginal case. For example, everyone is familiar with the problem of reading another person's handwriting, which involves properly recognizing various sample letters as samples of particular letters of the alphabet, which is a set of letter universals.

The process of perception involves an input, a data processor, and an output. For the present case the input is data from a sensory organ: eyes, ears, nose, etc. The processor is some mechanism that operates on the input data so as to correlate examples with universals. The output is data representing that correlation or identification. Of course a given input sample may be a sample of a number of different and perhaps unrelated universals. For example a particular letter *E* might belong to all of the following classes simultaneously: *E*, upper case, small, hand written, in ink, red, moving left to right across the field of vision, upside down, appearing progressively smaller, etc.

The process of recognizing universals is most easily understood by using the case of the sense of sight as the input. The procedures and conclusions apply equally to the other senses or to any coherent or systematic input system. For the purposes here, the sample is projected onto a screen (or the retina of the eye). The screen is not continuous, however. Rather, it is divided into an array of more or less uniformly spaced essentially identical sensors (the "rods and cones" of the retina). Each individual sensor can only register in an on-off manner (for the present); that is, if the part of the image projected onto the screen and falling on a particular sensor is light then the sensor is in the *on* state, if dark the sensor is *off*.

Thus the image projected onto the screen is represented on the screen as an array of black and white dots (*off* and *on* sensors) similar to a photograph in a newspaper as viewed with a magnifying glass.

To initially discuss the process an example using a relatively small array of sixteen sensors arranged in a square of four rows of four sensors each will be used as in Figure 2-1(a), below. It is necessary to be able to refer to each of the individual sensors (elements) of the array. This could be done by sequentially numbering them as in 2-1(a); however, it will be more useful to use the system of Figure 2-1(b), in which the array is divided in half four different ways.



(a) *(b)*

Figure 2-1

(The procedure being used is, of course, the digitizing of the image into binary elements and the description of the sensors and their binary states by means of Boolean Algebra variables and functions. In fact the eye, also, essentially digitizes the image on its retina and supplies signals that are essentially binary to the brain; however, the human processor is not quite Boolean. Boolean discussion will be used for the moment and the conversion to the biological mode of processing will then be presented. For those who are not familiar with these techniques the explanation is continued in simplified terminology.)

The half of the array of Figure 2-1(b) that is labeled "A" will be called *A*. The other half will be called *not A* and be marked with an underscore, i.e. written $\underline{A}$. We can then identify element number #11 of Figure 2-1(a), for example, in Figure 2-1(b) as being in

(2-1) $\underline{A}$ and $\underline{B}$ and C and D.

a description that fits no other element of the array.

This procedure makes use of Boolean Algebra, a mathematics of logic originally developed by the Englishman, George Boole, for the purpose of testing and interpreting the logical construct of verbal statements. Although it was developed well before even the notion of digital computers had occurred or could have occurred, Boolean logic is the underlying principle on which digital computers operate.

The letters *A, B, etc.*, are called *variables* meaning that they may vary in value. The allowed values in the present case are *1 = "true"* or *"yes" or "on"* and *0 = "false"* or *"no" or "off"*. Instead of writing "and" over and over as in equation *(2-1)* the notation

(2-2) $\underline{A}\underline{B}CD$ or, when needed for clarity $\underline{A}\cdot\underline{B}\cdot C\cdot D$

will be used and understood to mean the same as equation *(2-1)*. It is read as *"not A and not B and C and D"* and means the state in which *A is not true*, *B is not true*, *C is true* and *D is true*. It also means that portion of the array of Figure 2-1a which is *not in A*, *not in B* and is *in C* and is *in D*.

To refer to more than one element of the array at a time the connective read as "*or*" will be used, written as +. Thus to refer to the combination of the elements #10 and #11 of the four by four array of sixteen elements (per Figure 2-1a, above) the reference is

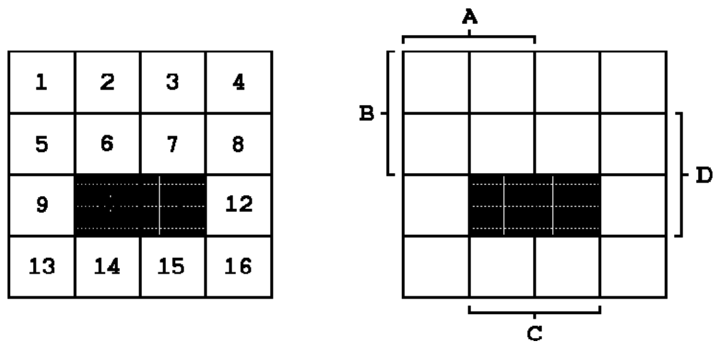
(2-3) $A\underline{B}CD + \underline{A}\underline{B}CD$

which is read as *"A and not B and C and D or not $\underline{A}$ and not $\underline{B}$ and C and D"*.

This reference can be stated more simply as

(2-4) $\underline{B}CD$

because if it is true for *A* and for $\underline{A}$ then it is independent of the value of *A*, whether it is *0* or *1*. That is, for the two elements, #10 and #11 of Figure 2-2a, below, as an area of the array, designation in terms of *A* is to no point. As Figure 2-2b shows, that area is correctly described as the area simultaneously in `not B and C and D` as equation *(2-4)* presents.



(a) *(b)*

Figure 2-2

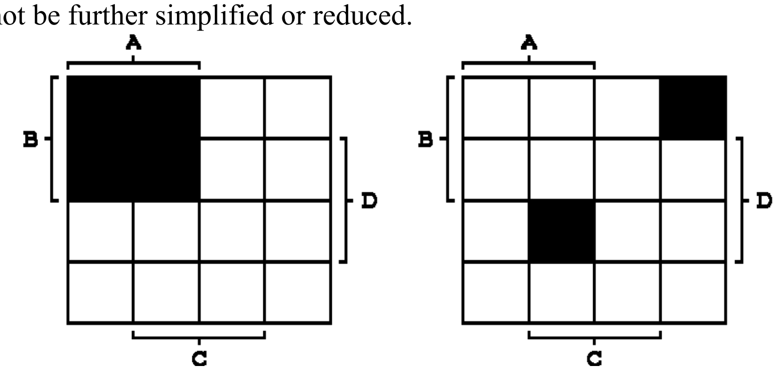
Other combinations of elements may yield similar such simplifications of the reference and still others may not. For example, the indicated set of four elements in Figure 2-3a, below, is

(2-5) $\mathrm{AB\underline{CD} + AB\underline{C}D + ABC\underline{D} + ABCD = AB}$

On the other hand, the two elements indicated in Figure 2-3b, below, are given by

(2-6) $\mathrm{\underline{A}BCD + A\underline{B}CD}$

which cannot be further simplified or reduced.



(a) (b)

Figure 2-3

PERCEIVING UNIVERSALS

Now let us consider the problem of recognizing (that is identifying the universal of) a simple cross, a horizontal line crossing a vertical line, in this system. More specifically, we wish to obtain a method for recognizing any such cross and only such crosses. Within the special case of the sixteen element array we wish to be able to properly assign any input, as it is projected onto the array, as a member or a non-member of the universal *cross*.

First we consider some examples of the specified input as in Figure 2-4, below.

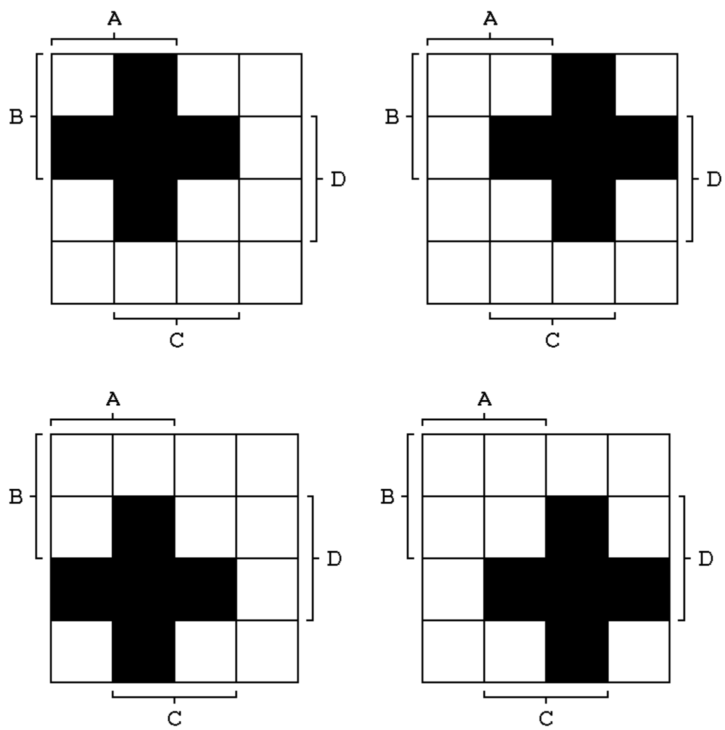


Figure 2-4

The elements making up each sample are as follows.

(2-7) (a) $ABC\underline{D} + AB\underline{C}D + ABCD + \underline{A}BCD + A\underline{B}CD$

(b) $\underline{A}BC\underline{D} + ABCD + \underline{A}BCD + \underline{A}B\underline{C}D + \underline{AB}CD$

(c) $ABCD + A\underline{BC}D + A\underline{B}CD + \underline{AB}CD + A\underline{B}C\underline{D}$

(d) $\underline{A}BCD + A\underline{B}CD + \underline{AB}CD + \underline{ABC}D + \underline{AB}C\underline{D}$

These can be simplified by expression in terms of two-element areas as

(2-8) (a) $ABC + ABD + ACD + BCD$

(b) $\underline{A}BC + \underline{A}BD + \underline{A}CD + BCD$

(c) $A\underline{B}C + A\underline{B}D + ACD + \underline{B}CD$

(d) $\underline{AB}C + \underline{AB}D + \underline{A}CD + \underline{B}CD$

(That these expressions include the central element of the cross four times instead of once is mere redundancy and does not affect the accuracy or effect of the expression.)

The commutative principal of mathematics applies to this mathematics; that is, the order of stating variables has no effect on the result. For example

$\underline{A}BC + A\underline{B}C = A\underline{B}C + \underline{A}BC = B\underline{A}C + CA\underline{B}$

Likewise, the associative mathematical principal also applies; that is, factoring and the related grouping of variables has no effect on the result. For example

$$A\underline{B}C + AB\underline{C} = A\cdot[\underline{B}C + B\underline{C}]$$

Making use of those principals equation *(2-8)* can be expressed as

(2-9) $AB[C + D] + CD[A + B]$

or as

$AC[B + D] + BD[A + C]$

or as

$AD[B + C] + BC[A + D]$

Each of equation *(2-8(b)*, *(c)* and *(d)* can be similarly expressed. All of the resulting formulations have the same general form:

(2-10) $\text{cross} = V_1\cdot V_2\cdot[V_3 + V_4] + V_3\cdot V_4\cdot[V_1 + V_2]$

where V_i, i = 1, 2, 3, or 4, is a Boolean variable like A, B, etc.

That is, the cross in the four by four element array being treated, is apparently characterized by an identification in terms of the four Boolean variables as the *and-ing* of any two variables with the *or* of the other two, that whole then *or-ed* with the *and-ing* of the other two variables with the *or* of the first two, any or all of the variables being natural or *not-ed* consistently.

Examination of the four by four array being used demonstrates the validity of the following identity

(2-11) $A + B = \text{NOT}[\underline{A}\cdot\underline{B}] = [\underline{\underline{A}\cdot\underline{B}}]$

with the use of which equation *(2-10)* can be rewritten as

(2-12) $\text{CROSS} = V_1\cdot V_2\cdot\text{NOT}[\underline{V_3}\cdot\underline{V_4}] + V_3\cdot V_4\cdot\text{NOT}[\underline{V_1}\cdot\underline{V_2}]$

Either of the two logically equivalent formulations, equation *(2-10)* or *(2-12)*, is the extraction of the indicated universal, *cross-ness* from the samples with which the analysis began. Either formulation is, therefore, the means to the perception of that universal in the sample array being studied.

So far in this analysis four sample crosses as in Figure 2-4 have been examined. In the simple four by four array being studied there are a total of ten possible symmetrical crosses. The other six are displayed in Figure 2-5 below and on the following page.

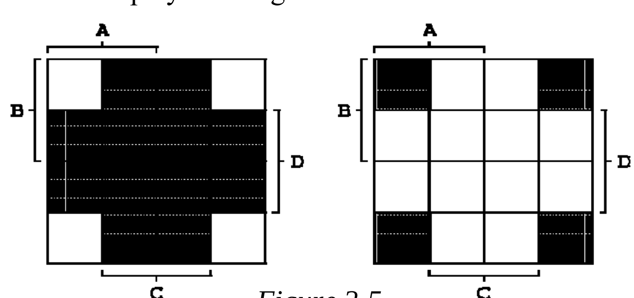


Figure 2-5

Figure 2-5 continued

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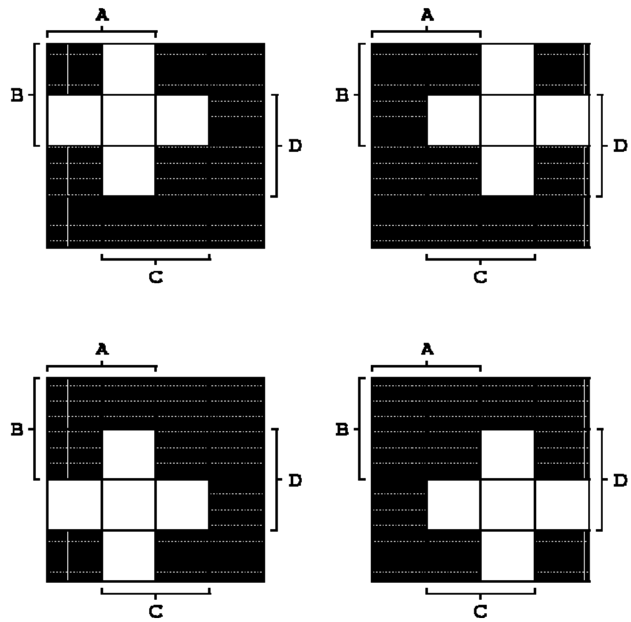

Referring to Figure 2-6, below, Some asymmetrical crosses would also be identified by the formulation. For each symmetrical cross consisting of five elements there are three ways that it can be asymmetrical: horizontally i.e. lengthening the horizontal part by one additional box, or vertically i.e. lengthening the vertical part by one additional box, or both.

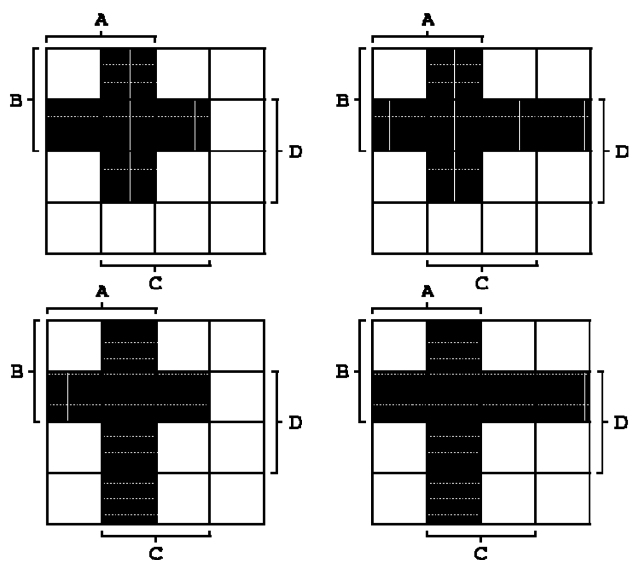

Figure 2-6

Figure 2-6

Thus each cross can appear in four forms. The total number of possible crosses, symmetrical and asymmetrical is that four times the eight possible symmetrical five-element crosses, equals *32*. That plus the two larger crosses equals a total of *34*.

The total number of different patterns that can be displayed on this sample sixteen element array is

$$2^{16} = 65,536$$

The logical formulation just developed detects the *34* cases having the universal *cross-ness* in common out of the *65,536* total cases.

At this point the example of the four by four array of sixteen elements can be abandoned in favor of the general case of a practical, human perception system. The purpose of the example was to illustrate in a general sense that:

1. A sensory input can be analyzed;
2. A limited number of input samples can be sufficient to reasonably well establish a formulation for a universal;
3. That can be done by digitizing the data into binary representation, and
4. The formulation of the universal can be of a kind corresponding to well known digital logic arrangements as used in digital computers and some automatic control systems. However, digital computers are not intelligent.

> To validly deal with the real problem of
> *How the Mind Arises from the Brain*
> it is now necessary to address a more realistic system, the human visual system.

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