Information – Search for a unified definition & theory

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Abstract: *The fundamental institution about what is information and how to measure it remains a central issue of investigation in the current age of information. Different definitions in different contexts are found in literature. Some of these are Shannon's concept of uncertainty measuring information relevant to communication engineering[1], Information as a thing or commodity in context of information services[2], and Information as a fundamental unit of universe as postulated by Tom Stonier [3].A unified scientific meaning and understanding of "information" is still a subject of investigation. D. F. Fluckiger's research[4] on finding a unified concept of information is a sincere attempt to address the issue. In the paper, we attempt to address the issue in a unified identity. Our approach is to analyze the existing definition and theories of information, and a make a critical review on each of them. Depending on the reviews we attempt to integrate and unify the theory.*

Key words: *Information, Unified theory, Context specific,*

1. Introduction

In literature several definitions are found. Toni Carbo Bearman described information as the lifeblood of society. Without uninterrupted supply of information, today's society cannot run without disruption in business, industry, education, research, communication, entertainment and other activities. He graphically described this affair as "… how we make financial transactions, control the supply and movement of good and services, educate people, communicate information entertain …. Work or shop from home; communicate from virtually anywhere to virtually anywhere ……consult medical experts, sharing patient information, from remote areas….the list goes on".

Fritz Machlup defined information as an intangible thing, "involving either the telling of something or that which was being told." Michael Buckland described information as tangible thing, "as opposed to knowledge which is inherently intangible." Buckland pointed out that "in order to communicate knowledge it must be expressed or represented in some physical way as a signal, text or communication. Any such expression would, therefore, constitute information-as-thing!"

From the perception of the economic dimension of information, the notion of information as a resource has been accepted in several works. Information as a resource has diverse application in different fields of management and communication etc. Horton saw information as a resource "akin to oil and other raw materials." There are several critics to this definition of information. Among the critics, Michel Menou argued that the claim of information as a resource "needs to be supported by more than anecdotal evidence and a limited body of empirical research. …information is seldom identified to the level of specificity required to demonstrate its impact on any given situation or problem; while continuing controversies over the size and composition of the information economy, merely reflect, at least to some extent, discrepancy between the present level of understanding of micro level realities and their macro level representation." But "the

notion of information as resource is by now well-established in fact, most evidently in recognition of the related concept of a marketplace of ideas, as reflected in the profusion of national and international laws and policies relating to trade in information and its associated goods and services."

From uses point of view, "the notion of information as commodity has gained considerable currency in the past decade, with commodity in this case, comprising all manner of information services, and including trans border data flows. The concept of information as commodity is wider than that of information as resource, as it incorporates the exchanges of information among people and related activities, as well as its use."

Historically, one of the most durable definitions of information is the mathematical theory of communication developed by C. Shannon in 1948. Information refers to uncertainty of the occurrence of any message. More the probability of occurrence of an event or a message, the less is the amount of information, the event or the message carries, and vice-versa. Shannon, often know as father of the information theory defined information as the "reduction of uncertainty." His definition of information is for information or communication processes. In information theory and coding of communication engineering; information refers to uncertainty to the occurrence of any message [3-5]. The information(I) associated with a message that has the probability of occurrence as p is:

$$I = \log(1/p) \quad \text{……..(1)}$$

The unit of “I” is different for different base of log as shown in table(I). If an information refers to a set of messages m_i (i = 1 to n) with probability of occurrence p_i (i=1 to n), the average information, known as the entropy (H) the set carries is :

$$H = \sum_{i=1}^{n} p_i \log(1/p_i) \quad \text{……..(2)}$$

The entropy is a measure of uncertainty of the occurrence of the set.

The definition of Information as stated above for purely communication engineering point of view may fit to networking or compunication engineering or computer engineering.

For age of knowledge, information is best defined as [6]:

Raw Data when Processed = Information
Information - Noise (unwanted information, misinformation etc) = Intelligence
Intelligence + Experience = knowledge
Knowledge + Judgement = Wisdom
} …(3)

Bob Debold [7] defined knowledge as “Data and Information wrapped in application and experience.” He related data, information, knowledge and wisdom as below (fig 1):

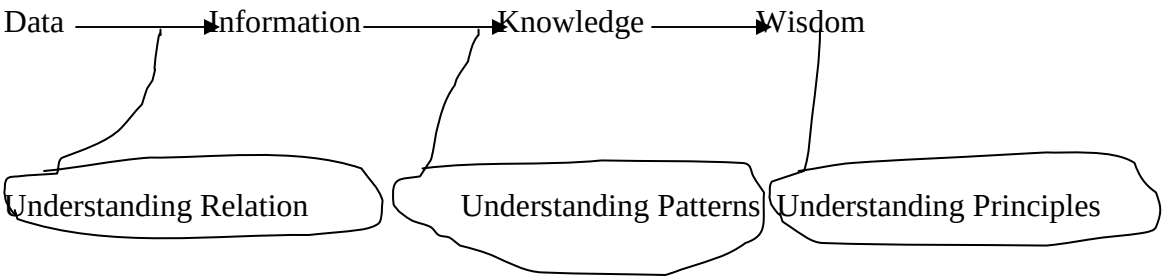

Fig (1): Relation of data with others

Recently Tom Stonier has speculated in his work "Information and Internal Structure of the Universe" that there is an analogy between mass/matter, energy/heat and information/order of an organization. It has been argued that information (I) resident in any organization is proportional to the order (O) of the organization:

$$I = C.O$$

where C is the constant of proportionality. If this relation exists there may be a possibility of interchangeability of information with energy (which otherwise speaking will establish a measurable and quantifiable relation between Industrial based society with Information based society). Tom Stonier established an exchange rate which is:

1 Joule per degree Kelvin = 10^{23} bits of information

Shannon information theory to that of Tom Stonier

In Shannon's information theory more entropy means more information. While the probabilistic second law thermodynamics, more entropy means more disorder. Does it mean that more information results in decrease in order? If "yes", how? The entropy of thermodynamics (the decrease in order) is a measure of how much a reaction is irreversible. The steam engine on its orderly works produces some waste heat energy. The waste heat of a steam engine that causes the hot atoms to randomly bouncing around is improbable to get back into orderly atoms. Once you get some information, you get so by consuming some energy either by computer processing or by network information downloading or other means of communications. These functions produce some waste heat that is not reversible. Thus durable definition entropy, a measure of information of Shannon perfectly matches with the entropy of the thermodynamics. Shannon's theory of information is a measure of uncertainty – the more you know, the less certain you are. How is it? The information, Shannon described is the information received by a receiver from an information source. As the information source has more uncertain messages, the receiver gets more information. Let us consider fig(2). Initially, "A" is an information source with two messages, X and Y of equi probable. "A" is the transmitter to "B". "B" is the information source to "C" and "D". B gets information $I = -P(x) \log P(x) - P(y) \log P(y)$ from "A". Thus "A" knows more. Now by the process, "A" becomes the information source of three messages, X, Y and Z with say equi probable. Aso "Bcan produce the current messages with more uncertainty for the receiver, C and D. Thus it is the reference that solves the puzzle.

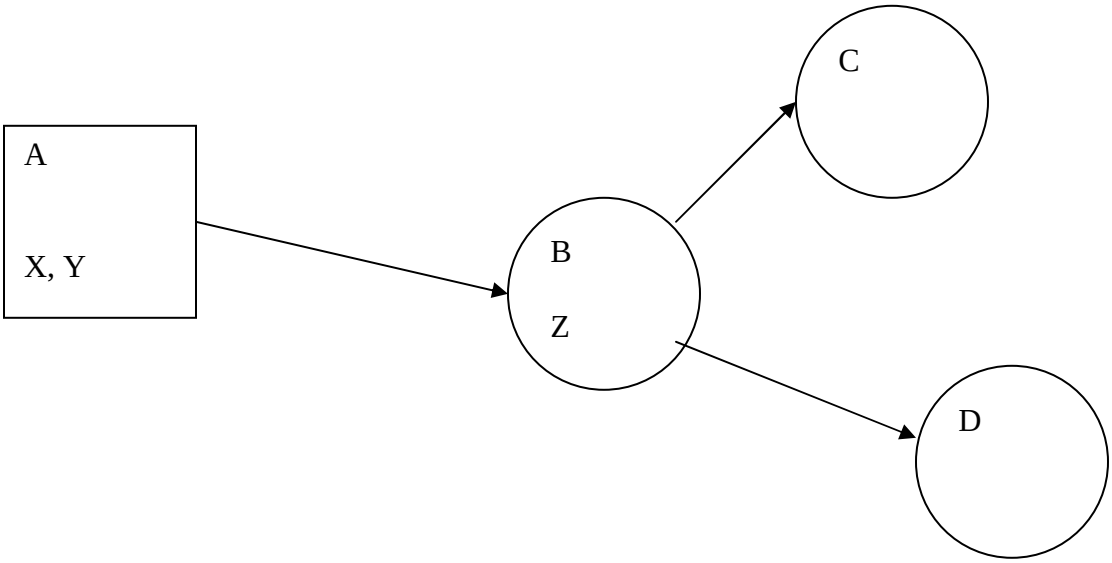

Fig 2. Illustration of disorder vs order nature of measurement of information

All the definitions are context and application specific. In some context some of them may be same and one, in other context they may differ considerably and may be contradictory to each other. D. F. Fluckiger's research on finding a unified concept of information is a sincere attempt to address the issue.

In the current research, we like to address the issue in searching the followings fundamentals issues:
(i) Is information discovered or invented?
(ii) How is it discovered or invented?
(iii) How is it represented & why is it done so?
(iv) What is its significance?

2. Basic Ideas

In order to find answer to the issues raised, we consider
:
A. scientific sets of raw data received over a number of experiments as below:

Expt.: 1 { 1, 1, 1}
Expt.: 2 { 1, 2, 4}
Expt.: 3 { 1, 3, 9}
Expt.: 4 { 2, 1, 2}
Expt.: 5 {3, 1, 3}

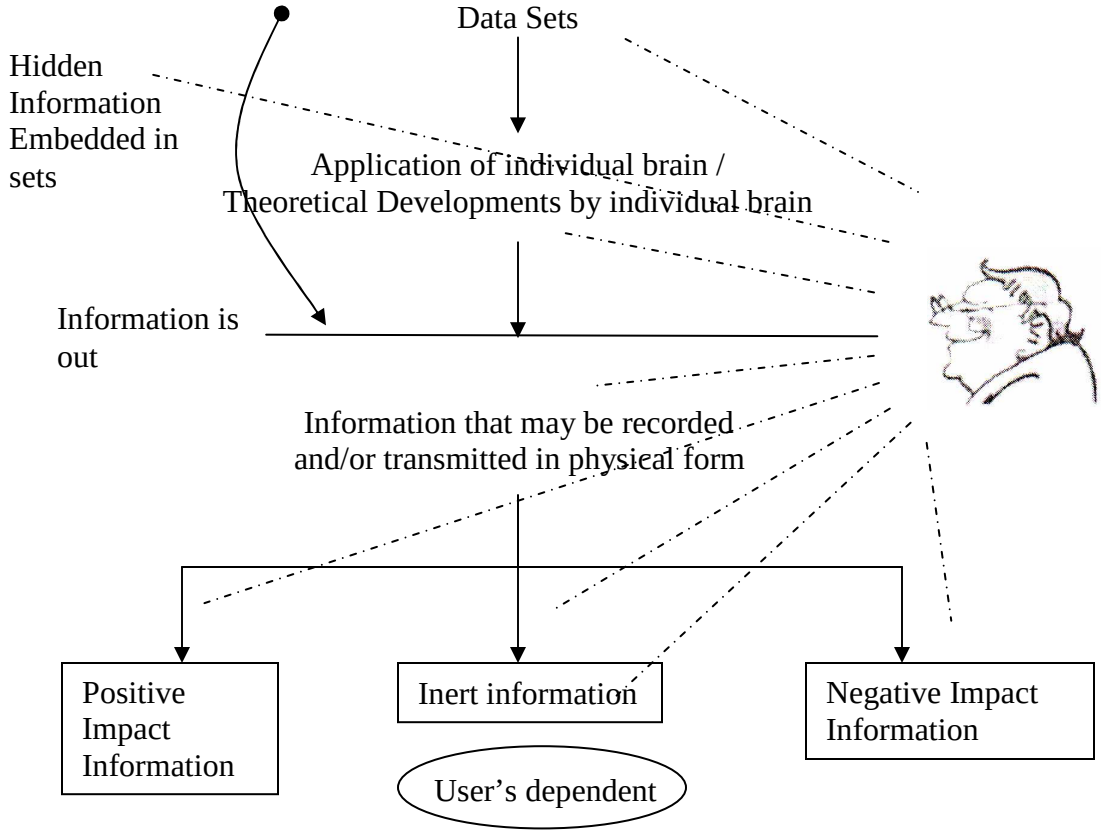

Fig. 3: Information discovering and conveying

An analyst applies his brain and establishes a relation among three elements of each set of experimental data as below:

$e(3)=e(1).\{e(2)\}^2$ ……. (4)

equ (4) provides a scientific information. [It is other way, $E=mc^2$]

This information the investigator passes on to others in form of publication.

The observations that we would to make are:

a) information in equation (4) established by the investigator was duly there in nature. It was only the brain of investigator that processed the experimental data to DISCOVER it. Thus information is NOT INVENTED.
b) it is DISCOVERED by intelligent process, may be in this example by experimental data sets. But it may be theoretical development by human ever increasing & fertilized brain as was done by Einstein.
c) information is represented in form of investigator's intelligent form and in some physical terms (like in communicating languages on papers, signals in communication channel). It is done so for his own record and to transmit the same to other users.
d) information may have three forms of significance : i) positive significance. For example good scientists & engineers may use equ (4) for nuclear power plant, ii) negative significance. Bad people (like bad politicians & rulers) may use it for nuclear bomb, and (iii) no significance like farmers may have no interest in equ(4).

The whole of observations is portrayed in fig (3).

B. Sorts information.

Data sets of one-day cricket of Saurav and Sahawag of India are as below:

Sourav : { Match:279, Run: 10,123, Av: 40.65, WK: 93, Av.: 37.31, Catch: 96 }

Sahawag: { Match: 153, Run: 4608, Av.: 32.45 Wk: 69, Av.: 39.89, Catch: 64 }

Analyst applies his brain and finds the following information:

In all fields of runs, wicket, and catch in one-day cricket;

Sourav is a better player than Sahawag

The observations (a-c) as made in A are duly applicable to B. In reference to observation (d); the positive, the negative and the inert application of information (2) may be respectively applicable to Sri Buddhadev Bhattacharjee, Chappel and a non-cricket loving fellow.

The above situation may more meaningfully be looked as:

A data set in a file on a disk of a computer is (first of all) nothing else than a sequence electrical charges - and for itself it doesn't contain information. It becomes information, if:

- someone observes the scenario and makes his reflections on information sources (like Shannon did), or
- someone retrieves the data set and reads its content represented with characters on a screen, a sheet of paper, ...

The gained information may have (as you observe correctly) different impact within the memory of the individual:

- 'Positive impact information' - this is the simplest case: The individual didn't know before the content of the data set.
  Effect: He knows more after the information process → his 'knowledge' increases.
- 'Inert information': The individual gets information he already knows→ nothing new!
  Effect: He gets a confirmation that what he already knows is also memorized in the data set → his 'knowledge' usually increases by this simple realization.
- 'Negative impact information': The individual gets information that is divergent to what he already knows.
  Effect: at least two possibilities:

- He learns that the information of the data set is wrong and he gets e.g. the impression that the content of the database must be updated.
- He learns that there are other opinions on what he already 'knows' and that he probably must take care for 'updating' his own knowledge.

In any of these cases the individual increases his own knowledge (information) on the regarded situation of data retrieval. The only case where he doesn't increase his knowledge is if he ignores the corresponding results. A decrease of knowledge is not possible.

Analysis

The examples (A & B) sighted above highlights different features of analyzing information. Amount of information in any thing or experiment or data set depends on variance of the same. For example if in example (A) elements of data increases from 3 to 4 to 5 …….., the finding correct relation among the element as information increases. This is because number of relations would have been more. More relations provide more information. Thus VARIANCE increases, probability happening a correct relation decreases to the observer. For example when set has a two data that may be linear quadratic relation, we have two option:

a.data12+ b. data2=0

or a.data1+b.data22=0

But with three data, we have 3! possibilities. This means that Information has a measurement related to some probability of happening, occurrence, findings etc., like that one established by Shannon. But still some questions are unanswered. First even if information measurement is done by probability of happening why it should be:

$$I_{Known} = -\sum p_i \log p_i \qquad \text{\_\_\_\_\_(5)}$$

and not

$$I_{Unknown} = -\sum (1 - p_i) \log(1 - p_i) \qquad \text{\_\_\_\_\_(6)}$$

as because information is not what we know (p_i) but what we do not know ($1-p_i$) .

Secondly, whether it is process, or thing or anything; information is already resident in data set, natural or artificial. As such information creation is proportional to the level of intelligence (i) of processor.

3. Conclusion

Our search and analysis reveal that information resident in universe is constant. It is there in the data set. It is obtained by the application of intelligence application of processor/human beings, and it is applied negatively, positively or inertly by human behavior. Information is relative in terms of processor's intelligence)level of processing) and level of applications. It is relatively and hardly is measurable by some absolute

measurement like that of Shannon. There remains lots of research for investigation inthis area. But information may be generated or lost by action of incidents. An accident occurs. This action creates some information. A species die permanently in universe. This creates loss of some information.

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