The Information Principle ☆

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ABSTRACT

The conventional wisdom is that the concept of information is closely related to the concept of probability. In Shannon's information theory, information is equated to a reduction in entropy—a probabilistic concept. In this paper, a different view of information is put on the table. Information is equated to restriction. More concretely, a restriction is a limitation on the values which a variable can take. The concept of a restriction is more general than the concept of a constraint and the concept of a probability distribution. There are three principal kinds of restrictions: possibilistic, probabilistic and bimodal. A bimodal restriction is a combination of possibilistic and probabilistic restrictions.

Underlying the restriction-centered approach to information is what may be called the Information Principle. Briefly stated, the Information Principle has three parts. (a) Information = restriction. (b) There are three principal types of information: possibilistic information, probabilistic information and bimodal information. Bimodal information is a combination of possibilistic information and probabilistic information. (c) Possibilistic information and probabilistic information are underivable (orthogonal), in the sense that neither is derivable from the other.

Information is all around us. And yet, there is widespread unawareness of the existence of the Information Principle. In particular, what is not recognized is that possibilistic information and probabilistic information are underivable (orthogonal). An important empirical observation is that propositions in a natural language are carriers of predominantly fuzzy possibilistic information (FPI) and fuzzy bimodal information (FBI). Existing systems of reasoning and computation—other than fuzzy logic—do not have the capability to reason and compute with fuzzy bimodal information.

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1. Introduction

Our age is the age of information. Information is all around us. And yet, there is widespread unawareness of what may be called the Information Principle. Briefly stated, the Information Principle has three parts. (a) Information = restriction. (b) There are three principal types of information: possibilistic information, probabilistic information and bimodal information. Bimodal information is a combination of possibilistic information and probabilistic information [13,15]. (c) Possibilistic information and probabilistic information are underivable (orthogonal), in the sense that neither is derivable from the other. Fig. 1. Equating information to restriction is unconventional. Conventionally, in Shannon's

information theory, information is related to uncertainty through the concept of entropy [6]. There is no semantics. Attempts to introduce semantics into information theory have met with limited success. Equating information to restriction opens the door to introduction of semantics into information theory. Restriction, possibilistic information and probabilistic information are infrequently used terms. What do they mean? An answer to this question is described in the following.

2. The concept of a restriction

The concept of a restriction has a position of centrality in fuzzy logic [10,18]. Informally, a restriction, $R(X)$, on a variable, X, is a limitation on the values which X can take. Fig. 2. Typically, a restriction is described in a natural language. Example. Assume that I ask: How long will it take me to drive from Berkeley to SF Airport? I get various answers: about an hour, between 45 min and 90 min, usually about one hour, usually about an hour and a half during rush hour, etc. Each of these answers is a restriction on the values which the variable X, travel time from Berkeley to SF Airport, can take. The concept of a restriction is more general than the concept of a constraint and the concept of a probability distribution. A probability distribution is a restriction, but generally it is not viewed as a constraint. The canonical form of a restriction is expressed as

$$R(X) : X \text{ is} r\ R,$$

where X is the restricted variable, R is the restricting relation, and r is an indexical variable which defines the way in which R restricts X. X may be an n-ary variable. R may be an n-ary relation. Note. In the sequel, the term restriction is sometimes applied to R.

There are many kinds of restrictions. A restriction is singular if R is a singleton. Example. $X = 5$. A restriction is nonsingular if R is not a singleton. Nonsingularity implies uncertainty. Generally, information is conveyed by nonsingular restrictions. A restriction is precisiated if X, R and r are mathematically well-defined. A restriction is direct if the restricted variable is X. A restriction is indirect if the restricted variable is of the form $f(X)$. Example.

$$R(p) : \int_a^b \mu(u)p(u)\ \mathrm{d}u \text{ is likely}$$

is an indirect restriction on p, with likely playing the role of a fuzzy probability.

The principal kinds of restrictions are: possibilistic restrictions, probabilistic restrictions and bimodal restrictions.

Definition (*Possibilistic restriction (r = blank)*). A possibilistic restriction is expressed as

$$R(X) : X \text{ is } A.$$

where A is a fuzzy set in U, with a specified membership function, μ_A.

Example.

$$\underset{\text{restricted variable}}{X} \quad \text{is} \quad \underset{\text{restricting relation (fuzzy set)}}{\text{small,}}$$

where X is the restricted variable, small is the restricting relation (fuzzy set), and r = blank. The fuzzy set small plays the role of the possibility distribution of X.
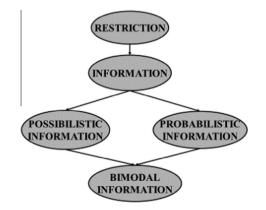

Fig. 1. The Information Principle.