Book Review

Uncertainty and Information: Foundations of Generalized Information Theory. George J. Klir. Hoboken, NJ: Wiley, 2006. 499 pp. $94.95. (ISBN 0–471–74867–6)

This book studies *generalized information theory* (GIT), i.e., generalizations of two theories: possibility-based uncertainty theory and probability-based uncertainty theory. In the whole book, information has to be considered as the reduction of uncertainty, the latter to be defined.

Classical possibility-based uncertainty theory is the simpler and the older of the two theories. It measures how possible an event is (given a universe X and a subset $E \subset X$ being the set of all possibilities) if we are in a subset, $A \subset X$. One defines the function

$$r_E(x)\begin{cases} = 1 & \text{if} \quad x \in E \\ = 0 & \text{if} \quad x \notin E \end{cases} \tag{1}$$

(a more classical notation is $\chi_E(x)$, the characteristic function of E—also used in this book) and, for any subset $A \subset X$ one defines the possibility value $Pos_E(A)$ as follows

$$Pos_E(A) = \max_{x \in A} r_E(x), \tag{2}$$

hence defining the possibility function, Pos_E. In addition, a "necessity function" Nec_E is defined by

$$Nec_E(A) = 1 - Pos_E(\overline{A}) \tag{3}$$

where $\overline{A}$ is the complement of A in X (for the time being, all sets are ordinary sets, also called *crisp sets* as contrasted with so-called fuzzy sets, see below). Possibility-based uncertainty theory was developed by Hartley (1928), who found the amount of uncertainty associated with the (finite) set E is (essentially):

$$H(r_E) = \log_2 |E|, \tag{4}$$

where $|E|$ denotes the cardinality of E.

The function H is called the *Hartley measure* and one proves that this measure is unique (up to a multiplicative constant) based on the logical requirement that (with an abuse of notation: $H(r_E) = H(n)$ with $n = |E|$):

$$H(n.m) = H(n) + H(m) \tag{5}$$

It is well known that Equation 5, together with continuity of H, implies Equation 4 (up to a constant), cf. Roberts (1979), based on elementary observations of functions satisfying functional relations of the type 5 (see also, Egghe, 2005, Appendix I). It is surprising that in this text, this classical argument is not used or referenced and that a more intricate argument (of Rényi) is presented.

Less elementary is the theory of probability-based uncertainty. The notion of probability distribution function is well known: It is a function

$$p : X \to [0, 1] \tag{6}$$

on a general set X (taken here to be finite) with range the closed interval [0,1] such that

$$\sum_{x \in X} p(x) = 1 \tag{7}$$

From this, one defines a probability measure *Pro* as follows: for any $A \subset X$, define

$$Pro(A) = \sum_{x \in A} p(x) \tag{8}$$

It is clear that for any two disjoint subsets $A, B \subset X$, we have that

$$Pro(A \cup B) = Pro(A) + Pro(B) \tag{9}$$

a property called *additivity*.

Shannon (1948) developed probability-based uncertainty theory: In this case, the amount of uncertainty is measured as follows:

$$S(p) = -\sum_{x \in X} p(x) \log_2 p(x) \tag{10}$$

the so-called entropy of the system (a more common notation is $\overline{H}$ being the average of the point-wise information contents, $\log_2 p(x)$. Note that, when $|X| = n$ and when all probability values $p(x)$ are equal, hence

$$p = p(x) = \frac{1}{n} \tag{11}$$

for all $x \in X$, formula 10 reduces to

$$S = \log_2 n = -\log_2 p, \tag{12}$$

which is essentially the same as Equation 4, which is not surprising because probability aspects have been eliminated. The notion of entropy is the most important notion of information theory. It measures the (average) amount of information one has (i.e., reduction of uncertainty) when events appear, given the probability distribution p. There are numerous applications of this measure ranging from coding theory to automatic indexation to information retrieval and linguistics. Most importantly, formulae 10 and 12 form the basis for the notion of "bits," i.e., the number of zeroes and ones to binary represent the elements in a set of cardinality n (fixed or non-fixed length coding; see, e.g., the classical Heaps, 1978). In addition, the measure entropy is unique (up to a constant) based on the requirements that it is continuous and that the amount of information in two independent events is the sum of the amounts of information in the separate events (comparable with requirement, Equation 5).

After an introductory chapter 1, classical possibility-based uncertainty theory is discussed in chapter 2 and classical probability-based uncertainty theory is discussed in chapter 3.

The rest of the book is devoted to extensions of these theories. One can distinguish two different ways of doing this: first, by generalizing the notion of probability measure to monotone measures μ that are non-additive. Here monotone measures are measures satisfying the implication

$$A, B \subset X, A \subset B \Rightarrow \mu(A) \leq \mu(B), \tag{13}$$

which generalizes the additivity property. This occupies the attention in chapters 4, 5, and 6. A second way of extending these theories is by replacing ordinary sets by fuzzy sets (chapters 7 and 8).

In chapter 4, one studies monotone nonadditive measures such as Choquet capacities, i.e., monotone measures μ that satisfy

$$\mu\left(\bigcup_{j=1}^{k} A_j\right) \geq \sum_{\substack{K\subset\mathbb{N}_k \\ K\neq\phi}} (-1)^{|K|+1}\mu\left(\bigcap_{j\in K} A_j\right) \tag{14}$$

for all families of k subsets of the universe X (here $\mathbb{N}_k = \{1,\ldots,k\}$). Monotone nonadditive measures also appear in the theory of imprecise probabilities. A clear example (also given in chapter 4) is as follows. Suppose we have a universe $X \times Y$ being the Cartesian product of two sets $X = \{x_1, x_2\}$ and $Y = \{y_1, y_2\}$ (hence both are doubletons).

Assume that we know the marginal probabilities $p_X(x_1)$, $p_X(x_2) = 1 - p_X(x_1)$, $p_Y(y_1)$, $p_Y(y_2) = 1 - p_Y(y_1)$ and we want to use this information to determine the unknown joint probabilities, $p_{ij} = p(x_i, y_j)$ $(i, j = 1, 2)$. Note that one way of doing this is to define

$$p_{ij} = p_X(x_i)p_Y(y_j) \tag{15}$$

$(i, j = 1, 2)$; however, there is not evidence that this is always the case. The general solution of the above problem is by remarking that

$$\begin{array}{l} \text{(a) } p_{11} + p_{12} = p_X(x_1) \\ \text{(b) } p_{21} + p_{22} = 1 - p_X(x_1) = p_X(x_2) \\ \text{(c) } p_{11} + p_{21} = p_Y(y_1) \\ \text{(d) } p_{12} + p_{22} = 1 - p_Y(y_1) = p_Y(y_2) \end{array} \tag{16}$$

Note that $(d) = (a) + (b) - (c)$ and hence can be deleted. The other equations are linearly independent in the four variables, p_{11}, p_{12}, p_{21} and p_{22}, so one can be chosen as a free variable:

$$\begin{array}{l} p_{12} = p_X(x_1) - p_{11} \\ p_{21} = p_Y(y_1) - p_{11} \\ p_{22} = 1 - p_X(x_1) - p_Y(y_1) + p_{11} \end{array} \tag{17}$$

Of course, p_{11} is limited to

$$\max(0, p_X(x_1) + p_Y(y_1) - 1) \leq p_{11} \leq \min(p_X(x_1), p_Y(y_1)) \tag{18}$$

This yields a whole range of solutions, e.g., for the case $p_X(x_1) = 0.8$ and $p_Y(y_1) = 0.6$:

$$\begin{array}{l} p_{11} \in [0.4,0.6] \\ p_{12} = 0.8 - p_{11} \\ p_{21} = 0.6 - p_{11} \\ p_{22} = p_{11} - 0.4 \end{array} \tag{19}$$

So, we have a whole set of possible probability distributions, called a *credal set D*. Going back to the general notation X for the universe we can, for every $A \subset X$, define a lower probability function $\underline{\mu}(A)$ as the infimum over the credal set of the values $\sum_{x\in A} p(x)$ $(p \in D)$ and an upper probability function $\overline{\mu}(A)$ as the supremum of these same values. This yields monotone nonadditive measures for which there is a need for extension of the classical uncertainty theories. The general theory of imprecise probabilities (of which the above is an example) is further developed in chapter 4.

In chapter 5, special theories of imprecise probabilities are presented. First, one extends possibility theory to graded possibilities (i.e., where the Pos measure can have values in [0,1] instead of {0,1}—somewhat comparable with the extension of crisp sets to fuzzy sets). Then, the monotone Sugeno λ-measures ${}^{\lambda}\mu$ are introduced and studied. These are characterized by the requirement for all $A, B \subset X$, such that $A \cap B = \phi$:

$${}^{\lambda}\mu(A \cup B) = {}^{\lambda}\mu(A) + {}^{\lambda}\mu(B) + \lambda\, {}^{\lambda}\mu(A)\, {}^{\lambda}\mu(B) \tag{20}$$

with $\lambda > -1$ (a parameter). Note the confusing notation (e.g., $\lambda\, {}^{\lambda}\mu$). Other monotone measures are the "belief measures" (*Bel*; being special Choquet capacities) and plausibility measures (Pl; being variants of Choquet capacities, called *alternating capacities*) are also studied in this chapter. The theory based on these dual pairs is called *Dempster-Shafer theory* (DST). To extend the uncertainty theories (as will be done in chapter 6) we also need the so-called Möbius representation m of Bel being

$$m(A) = \sum_{B\subset A} (-1)^{|A\setminus B|} Bel(B), \tag{21}$$

replacing the probability distribution on X (m now acts on $P(X)$, the set of all subsets of X). Finally, a set $A \subset X$, such that $m(A) > 0$, is called a *focal set* and F denotes the set of all focal sets induced by m (F is called *a body of evidence*).

In chapter 6, the generalized measures of uncertainty are presented. First, one gives the generalized Hartley measure for graded possibilities. For a possibility profile $r = (r_1, r_2, \ldots, r_n)$ (ordered decreasingly) and sets $A_i = \{x_1, \ldots, x_i\}$ $(i \in \{1, \ldots, n\})$, one defines the U-uncertainty as

$$\begin{aligned} U(r) &= \sum_{i=1}^{n} (r_i - r_{i+1})\log_2|A_i| \\ &= \sum_{i=2}^{n} (r_i - r_{i+1})\log_2 i \end{aligned} \tag{22}$$

The general Hartley measure in DST looks as:

$$GH(m) = \sum_{A\in F} m(A)\log_2 |A| \tag{23}$$

whereas generalized entropy in DST is given by the pair of measures

$$E(m) = -\sum_{A\in F} m(A)\log_2 Pl(A) \tag{24}$$

$$C(m) = -\sum_{A\in F} m(A)\log_2 Bel(A) \tag{25}$$

The author, however, recognizes that none of the above extensions of entropy are mathematically satisfactory because the subadditivity property of entropy is violated. The present reviewer is unable to comment further on the (lack of) quality of these measures. This reviewer, however, has the impression that, certainly from chapter 7 on, the book deteriorates into "unnecessary generalizations for generalization's sake." They do not have greater expressive power as claimed (admitted) in the Conclusion's section 10.4. Not only does one present (in chapters 7 and 8) fuzzy set theory involving very general definitions of complement, union, and intersections (assumably containing the "classical" Zadeh min–max definitions; it is not indicated whether the useful probabilistic sum and algebraic product operations are included as well). It also presents nonstandard fuzzy sets, e.g., where membership functions range in closed subintervals of [0,1] or even in fuzzy intervals of [0,1] (so-called fuzzy sets of type 2), or where membership functions are defined on fuzzy subsets of the universe X (so-called fuzzy sets of level 2); even higher types and levels are defined.

Although chapter 8 gives fuzzy set interpretations of possibility theory and of probability theory one does not (apparently) present general fuzzified Hartley or Shannon measures. The fact that these theories are underdeveloped is also recognized in the concluding chapter 10.

The "methodological" chapter 9 is a mixture of philosophical and mathematical principles underlying uncertainty. The first two principles discuss the principle of "minimum" and "maximum" uncertainty. The latter one is mathematically formulated whereas the former one is not. Let us start with the latter one. As recognized in the book under review, this principle is better known as the *maximum entropy principle* (MEP) as it is also studied in Egghe and Lafouge (2006). The MEP can be formulated in a mathematically exact way as follows [as is also done

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in this book, but there is a confusion between the given effort constraints $(c_1, \ldots, c_n)$ and $(x_1, \ldots, x_n)$—we will use $(c_1, \ldots, c_n)$ here which is the same n-tuple as $(E_1, \ldots, E_n)$ in Egghe and Lafouge, 2006]: Maximize

$$S(p) = -\sum_{i=1}^{n} p_i \ln p_i \tag{26}$$

subject to the constraints

$$E = \sum_{i=1}^{n} p_i c_i \tag{27}$$

and $p_i \geq 0 \ \ (i = 1, \ldots, n)$ and

$$\sum_{i=1}^{n} p_i = 1 \tag{28}$$

(intuitively maximize the information content, e.g., of a text or speech, subject to a given effort value E, see Egghe and Lafouge, 2006). The method of the multiplicators of Lagrange correctly gives the solution (in the book under review and in Egghe and Lafouge, 2006): for $r = 1, \ldots, n$

$$p_r = c\rho^{-c_r} \tag{29}$$

with $c > 0$ and $\rho > 0$. Note that the method of the multiplicators of Lagrange only gives a necessary condition for MEP. In Egghe and Lafouge (2006), by giving an extra proof we show that condition 29 (i.e., with $\rho > 0$) is necessary and sufficient. This implies that a *principle of minimum uncertainty* (i.e., *a minimum entropy principle*) is nonexisting because this would imply the same necessary conditions! We recognize that, in the book under review, the latter principle has not been formulated in a mathematically exact way; however, making two sections (9.2 and 9.3) on these principles at least presupposes that they both exist in a mathematically similar formulation, which is not the case!

What is lacking here is the "old" principle of least effort (PLE), well known in linguistics (admittingly, less known in mathematics; see Egghe & Lafouge, 2006) and attributed to Zipf (1949/1965; but see also, Rousseau, 2002), which states that Equation 27 should be minimal, now subject to a constant value of Equations 26 and 28. In Egghe and Lafouge (2006) it is shown that this principle is equivalent with Equation 29, but for $\rho \geq 1$. This required a principle that is equivalent with Equation 29 for $0 < \rho < 1$. We found (Egghe & Lafouge, 2006) that the principle of most effort (PME; introduced there) is the "missing link": here we require Equation 27 to be maximal subject to a constant value of Equations 26 and 28. This principle is shown to be equivalent to Equation 29 for $0 < \rho \leq 1$ (and where PLE and PME coincide for $\rho = 1$, a degenerate case).

The last two principles in chapter 9 are also "very philosophical" and deal with the way we can go from one uncertainty theory to another. These principles do not belong to a mathematical theory and, as recognized in the book under review, are underdeveloped. We think we can leave it here in view of the pitfalls of the former (philosophical) "principle" of minimum uncertainty which is, mathematically, nonexisting and because of the underdeveloped state of many uncertainty theories (as recognized in this book). A general conclusion is that this book has the merit to discuss some acceptable extensions of uncertainty theories, e.g., to cases of non-additive probability measures and to cases of fuzzy sets, but that the book suffers from a nonappropriate mixture of mathematical principles and philosophical principles (often as a substitute for not yet understood or even non-existing mathematical principles).

The book has a relatively fair price, but it should only be recommended to researchers in this narrow field and certainly not to general researchers in information science (including informetrics researchers) as is the case for the *JASIST* readership.

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New Directions in Cognitive Information Retrieval. Edited by Amanda Spink and Charles Cole. Dordrecht, The Netherlands: Springer, 2006. 250 pp. $99.00. (ISBN: 1-4020-4013-X)

Since the early days of research in Information Retrieval (IR), researchers in the field have been trying to design the "perfect" IR system. In the conventional system-oriented view, a "perfect" system is defined as one that finds the best match between a user's stated request and documents from a collection. This view has proven to be very limiting. It has led many researchers to focus only on how to improve various aspects of document representations and the matching algorithms. As a result, the system-oriented approach to IR tends to disregard users' cognitive behaviors as well as the problem-solving context in which an IR process is being carried out. It has become evident that to succeed, IR researchers need to look beyond machine algorithms. A better IR system should do three things: (a) to be aware of the *topic*—the user's subject area of interest, (b) to consider the *task*—the job that the user is trying to complete, and (c) to incorporate *the context* defined by Mizzaro (1997) as "everything not pertaining to *topic* and *task*, but however affecting the way the search takes place and the evaluation of results" (p. 811). To address the problems associated with designing such a complex and interactive IR system, some IR researchers shifted their attention to the user's side of the retrieval process. This shift was inspired by the rising popularity of cognitive science in the late 1970s. Out of this era came the new cognitive-oriented direction in IR (Ingwersen, 1999).

The book *New Directions in Cognitive Information Retrieval* discusses recent changes in the field of Cognitive Information Retrieval (CIR) from the early 1990s to the present. Many researchers consider this time period to be the beginning of the holistic approach to CIR. According to this new, more expansive view, the task of IR is to understand the different cognitive structures from both the user's side and the

system's side of the retrieval process, their relationship to each other, and how understanding them can help to improve the performance of IR.

Although there are a number of prior works that deal with some aspects of the recent developments in CIR (e.g., Ingwersen & Jarvelin, 2005; Kuhlthau, 2004; Spink & Cole, 2005), this is the first book that has attempted to summarize the most fundamental concepts, processes, and techniques of this holistic approach to CIR. This book represents a truly international effort: The 18 contributors are from Australia, Canada, Denmark, Finland, the United Kingdom, and the United States. The book itself is divided into five sections and includes a preface, biographies of the authors, and an index. The number of chapters in each section ranges from one to four. Each chapter usually begins with a literature review of related work and ends with a projection of future research directions. A list of references concludes each chapter.

Due to the wide range of topics covered in the book, different readers might find certain chapters more relevant to their particular interest(s). Therefore, instead of touching on only a few selective chapters, this review will briefly consider the most important contributions of all chapters, followed by the general evaluation of the book's strongest and weakest aspect.

The Introduction in the first section establishes the purpose of the book: to provide an overview of the new directions in CIR research and highlight the interdisciplinary nature of the field. This section concisely outlines the book's structure and provides summaries to each chapter.

The second section, "CIR Concepts," lays out concepts that are fundamental to the field and are extensively used throughout the book. Specifically, it tries to reconceptualize the traditional, static, and often one-sided notions of *information need*, *document representation*, and *relevance*. First, Cole et al. describe the typical user-system interaction from the cognitive perspective as a series of interactive states. In particular, the authors focus their discussion on a *selection state* that is responsible for producing knowledge from evidence presented by a system. Second, Larsen and Ingwersen introduce the notion of *cognitive overlaps of various polyrepresentations*. According to them, to improve the performance of an interactive IR system, both the user's actual information need as well as documents in the collection should be represented from different perspectives. The resulting overlap of different representations then can be used by the system for retrieval purposes. Then, Ruthven proposes an alternative view on *relevance*. Current binary-based and topical views of relevance are ineffective at recognizing the dynamic nature of relevance. According to Ruthven, relevance should constantly change in accordance with changes in the situation and user's cognitive space. And finally, Ford introduces the concept of *knowledge need*. To satisfy knowledge need, users are engaged in *knowledge behavior*. In turn, knowledge behavior defines appropriate *information need*(*s*) and initiates *information behavior*.

The focus of the third section, "CIR Processes," is on the various CIR processes associated with Human Information Behavior (HIB), and how these processes may influence one's knowledge-seeking behavior. Among CIR processes discussed here are *multitasking, task process*, and *children's information seeking processes*. Previously, these activities have been studied only in part.

Spink and Cole open the section with a discussion of how multitasking may influence the retrieval process. They argue that users are naturally engaged in multitasking during their searching and seeking activities; however, in Saracevic's Startified model of IR interaction, multitasking has been relegated to only the searching part of the retrieval process (e.g., search techniques). To fully account for the multitasking aspects of information seeking as well, the authors link Popper's Problem Solving model and Kuhlthau's Information Search Process model to Saracevic's model.

Next, Vakkari and Järvelin attempt to infuse a *task* component into the Information Seeking & Retrieval (IS&R) methodology. Here, they provide a thorough analysis of the relationships between common independent and dependent variables in various studies of three areas: IR, interactive IR, and IS. The authors note and discuss the inherent limitations of existing IS&R studies. According to these two authors, one major limitation is that most previous studies did not include a *task* as an independent variable. As an alternative, they propose and describe in detail three task-based study designs targeted to reveal the relationship between performance and access variables.

Beheshti, Bowler, Large, and Nesset discuss designing an IR system for children. The authors relied on Kuhlthau's Information Search Process model and the results of some previous empirical studies to formulate an initial set of guidelines for a "search pal," a learning-based IR system for children. As part of their research, they also relied heavily on exploration of existing pedagogical agents that emphasize and facilitate knowledge building to reach their findings. They conclude that a "search pal" should be interactive, motivational, and friendly. It also should be able to help children to make sense out of an ever-growing amount of information on the Internet.

"CIR Techniques," the fourth section, concentrates on answering two very key questions: (A) how HIB can be captured and interpreted during user-system interaction and (b) how cognitive perspective on IR can be used to design more user-oriented interfaces for IR and/or more effective searching training.

In recent years, various techniques based on *Relevance Feedback* have shown very promising results. These techniques, often used for a query expansion or for adjusting term weights, basically rely on the user's evaluation of initially retrieved results; however, based on the results of previous user studies, Kelly concludes that these techniques are very rarely employed by users, possibly because they require a little bit of extra work from the users. As a solution, she suggests utilizing an unobtrusive method for collecting user's feedback, usually referred to as *Implicit Feedback*, and then examines different techniques to study this feedback. As a framework for her analysis, Kelly used the classification framework of behaviors for Implicit Feedback originally proposed by Oard and Kim (2001).

Hook and Börner analyze the "best practices" of Knowledge Domain Visualization (KDV) design. The authors argue that KDV is a powerful educational source to study "structure and scholarly domains." In interactive IR systems, KDVs can be used either in the front end (as a query formulation mechanism) or in the back end to visualize results; however, according to Hook and Börner, educators should use KDVs with caution due to their limitations. For example, KDVs may give a false feeling of strict boundaries in a domain or they may require a special cartographic literacy from students.

In the closing chapter of this section, Lucas and Topi propose a theoretical foundation for a new search-process model. The authors note that without proper search training, users will not be able to benefit from powerful features of modern IR systems; however, to provide effective training, educators first need to understand how the search process works. In their chapter, they propose and discuss their own search-process model to represent training needs. Their model relies heavily on the empirical studies that have analyzed user's common search errors and results from other training research in related fields. Because of its "straightforward process nature," the authors prefer their own model to "a large number of other models [that] have been developed to describe various aspects of the information seeking or searching process or behavior" (p. 218). When fully developed, their search process model can be used to design more effective search training programs.

The fifth section, "Conclusions," has only one chapter in which the editors Spink and Cole put together different opinions expressed in the book's previous chapters and focus their discussion on the future of CIR. They organize the new directions effectively by placing them into four groups: Integration with Human Information Behavior (chapters 6, 7, &11), Cognitive Studies (chapters 2, 3, 5, &10), Social and Organizational Studies (chapters 2, 7, & 8), and Relevance and Evaluation Studies (chapters 4 & 9).

New Directions in Cognitive Information Retrieval is an extremely valuable and timely compilation of essays. It is well organized and written in very accessible language. More importantly, the book meets the goal set forth in the Introduction. Currently, the field of CIR as a whole is in transition, moving from the user-only approach to a more

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holistic approach to IR. To fully understand these changes, an overview of recent developments in the field will prove to be both practical and useful for anyone interested in the field of CIR. For example, there has been significant progress in CIR's theoretical framework. Some new theories include the introduction of models such as *Selection State-Information Channel Model* by Cole, Beheshti, Leide, and Large, a *Global Model of Polyrepresentions* by Larsen and Ingwersen, and a *Multitasking and Coordinating Model for Human Information Behavior* by Spink and Cole. Now that these recent developments are on the table, researchers within the CIR community have a common ground for future discussions of where the whole field is going.

In addition to the advantages already mentioned, various chapters of the book clearly lay out distinctions between two historically different research camps in IR—system-oriented and user-oriented—and how these differences can be overcome through a holistic approach to CIR. The most relevant example of what this book is trying to achieve can be found in chapter 5, "New Cognitive Directions" by Ford. The chapter provides a detailed overview of the current research in IR and IS. An "evidence map" produced as a result of this extensive analysis can be used to find a middle ground between the two approaches.

However, there are a couple problems with this book. First, the Introduction does not offer a clear explanation as to why certain chapters were included and how all the chapters are connected to each other. Furthermore, for people new to the field, the Introduction would have been a good place to describe the origins of CIR and the historical developments of the field. The missing background information would have been a great help in conceptualizing CIR within the broader discipline of IR and for differentiating research in CIR from research in overlapping disciplines such as IS or IR in Context. Another minor problem with the book is its index. There is strong evidence that the index was built automatically, without proper human oversight. For example, we can find index terms that are irrelevant to CIR, such as "Bush, George W." and "Kerry, John." Although these terms are used in an example in one of the chapters, they are not directly related to the content of the book. Another example of a poorly chosen index term is the term "United states" extracted from the biography section of the book. It was the only term of its type included; yet, no other country names from this section appeared in the index. But probably the most damaging aspect of automatic indexing is that there are no subtopic categories indicating the context in which index terms are used in the text. Therefore, for common words such as "user" and "information," we end up with a list of over 100 references.

Despite the minor drawbacks described, the book is a great source for researchers in the IR&S fields in general and in the CIR field in particular. Furthermore, different chapters of this book also might be of interest to members from other communities. For instance, librarians responsible for library instruction might find the chapter on search training by Lucas and Topi helpful in their work. Cognitive psychologists would probably be intrigued by Spink and Cole's view on multitasking. IR interface designers will likely find the chapter on KDV by Hook and Börner very beneficial. And students taking IR-related courses might find the thorough literature reviews by Ruthven and Kelly particularly useful when beginning their own research.

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This work is concerned with the information revolution and the information society, with some specific reference to developments in the Republic of Ireland. We have choices, both individually and collectively, with regard to the development of technologies, and our capacity to exercise choice can be enhanced by an increased understanding of information developments. Established understandings of the information revolution and the information society are inherited and expounded, rather than transformed. The modern information revolution has been subject to a variety of characterizations, but there is little disagreement that economic, social, political, and cultural changes are taking place, and that "the starting point for such change must be the computer revolution and digitalised information" (p. 186). The information society concept is also endorsed.

In relation to Ireland, the question of the impact information and communication technologies (ICTs) will have on the dispersed Irish population is raised, along with other issues. Will ICTs enable bypassing of the clientelist politics that has been strong in Ireland (pp. 10–11) (and was inherited by parts of the United States)? Difficulties of citizens in understanding electronic information, arising from initially retaining established arrangement and content, intelligible primarily to government officials, are noted (p. 131), opening up a distinction between technological and semantic issues, which could have been more fully exploited.

Issues which have relevance to Ireland, but which are also significant for other nation states, are raised. Electronic communication across political boundaries calls established understandings of national sovereignty into question. With regard to controlling objectionable publications, such as child pornography, restriction at source is highly likely to be ineffective, and control has to be exercised at the point of reception (pp. 100–106). Increasing economic and political interdependence reduced the sovereignty of states before the information revolution; more could have been made of the temporal sequence, and possible direction of causality, from changes in economic and political relations to the diffusion of technologies, rather than the familiar, and slightly contradictory, statement that "economic globalization . . . has followed from information technology" (p. 145).

The interconnection between technology and society is treated, and a causal relation from technology to society is often assumed. For instance, vernacular bibles are regarded as having been enabled by the reduced costs of printing compared to handwriting (p. 23), rather than understanding the diffusion of printing technology as a product of the Puritan stress upon individual conscience and belief. The adoption of a telegraphic style is ascribed to the desire to avoid labor in encoding rather than to the costs of channel capacity, significant under 19th century conditions. The divide of technical and mathematical from human and social understandings is partially reproduced, and the significance of the computer as a universal information machine is not fully conveyed.

The richest insights emerge when the discussion is informed by anthropological sources, corresponding to the author's disciplinary

background. It is noted that, "human communities dependent on oral language have tended to be relatively small in size" (p. 18), although a causal relation from technology (the technology of speech) to society is still implied. That most information, with the exception of sacred knowledge, was equally distributed in early nonstate societies is observed (p. 76). A view of human development, associated with Lewis Morgan, where each stage is identified by its characteristic technology, is introduced (p. 65). Some of the data described seems anthropologically explicable: the constant and effortless shifting of teenage users of new technologies in the United States from one mode of communication to another (p. 156) could be compared to the possibly of oral speech being written, and writing read as speech, with the advent of written literacy. The deepest anthropological theme, that changes in human being are produced by human activity — that man makes himself — is not made explicit, although it has particular relevance to Ireland, with its recent transition from an agricultural to an information economy, with a diminished industrial stage. Earlier, but as late as Caesar's time, the Irish were living in group marriage, and the gens persisted: "in the [eighteen] thirties the great majority of the inhabitants of County Monaghan still had only four family names, that is, they were descended from four gentes or clans" (Engels, 2001, pp. 194–195).

The information society concept inevitably forms a major part of the intellectual context for the work, although as much reference is made to the information revolution. The concept is adequately represented, but some concern must be expressed about its diminished analytic value, particularly its discriminatory power. The concept has been valuable in drawing attention to a set of increasingly well-recognized developments, but differentiations within the concept, for instance with regard to the relation between human mental labor and information technology, have occurred through themes introduced from other discourses rather than directly from the dynamics of the concept itself. It is asserted that "the Internet is only a technology; people still have free choice" (p. 48), but the possibility that humanly created dynamics can be as powerful as natural dynamics, particularly for the individual, is not introduced: an individual cannot choose to be a scrivener, or copier of legal documents, on the 19th century model, after the information revolution. Intimations of further insight are raised when allusion is made to the prospect in the 1970s of computers doing tasks that had previously been done by human labor or that had not been possible at all (p. 51).

In conclusion, the strength of the work lies in the adequacy of its representation of established understandings of information developments and the specificity of its reference to Ireland. The challenge, as continually and finally raised, is "to understand the changes taking place and decide what the future structure of society should be like. With that knowledge, it is possible to intervene and so exercise control over technology, rather than walking backwards into the future" (p. 192). Addressing this challenge may require movement beyond established knowledge.

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