Intelligent Information Systems

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INTRODUCTION (INFORMATION SYSTEM TYPES & FUNCTIONS)

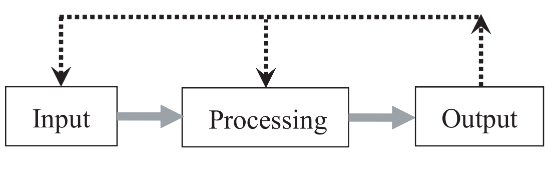
Information Systems (IS), not surprisingly, process information (data + meaning) on behalf of and for the benefit of human users. Information Systems comprise the basic building blocks shown in Figure 1, and as such can be likened to the familiar Von Neumann computer architecture model that has dominated computing since the mid 20th Century. In practice, IS encompass not just computer system hardware (including networking) and software (including DataBases), but also the *people* within an organization (Stair & Reynolds, 1999).

Information Systems are ubiquitous in today's world–the so-called "Digital Age"–and are tailor-made to suit the needs of many different industries. The following are some representative application domains:

- Management Information Systems (MIS)
- Business IS
- Transaction processing systems (& by extension, eCommerce)
- Marketing/Sales/Inventory IS (especially via the Internet)
- Postal/courier/transport/fleet/logistics IS
- Geographical Information System (GIS)/Global Positioning Satellite (GPS) systems
- Health/Medical/Nursing IS

The roles performed by IS have changed over the past few decades. More specifically, whereas IS focussed on data processing during the 1950s and 1960s, management reporting in the 1960s and 1970s, decision support during the 1970s and 1980s, strategies and end user support during the 1980s and 1990s, these days (the early years of the 21st Century) they focus more on global Internetworking (O'Brien, 1997). Accordingly, we nowadays find extensive use of IS in e-business, decision support, and business integration (Malaga, 2005). Let us take a closer look at one of these–Decision Support Systems. A DSS consists of (i) a (Graphical) User Interface, (ii) a Model Management System, and (iii) a Data Management System (comprising not only Data/Knowledge Bases but also Data Warehouses, as well as perhaps incorporating some Data Mining functionality). The DSS GUI typically displays output by way of text, graphs, charts and the like, enabling users to visualize recommendations/advice produced by the DSS. The Model Management System enables users to conduct simulations, perform sensitivity analysis, explore "what-if" scenarios (in a more extensive manner than what we are familiar with in spreadsheets), and so forth.

Figure 1. Generic information system



BACKGROUND

Whenever we encounter "intelligence" in relation to IS, it is usually in the context of (i) the decision making process itself, (ii) intelligent organizations, (iii) software agents, or (iv) the incorporation of Artificial Intelligence (AI) techniques.

For instance, Filos (2006) characterizes a "smart/intelligent" organization as being networked in the following three dimensions: (a) Information & Communications Technology (ICT), (b) organizational, and (c) *knowledge* (it is interesting to note the link here between (c) and the discussion which follows in this article). Furthermore, in the "Digital Age," the latter necessarily incorporates uncertainty and unpredictability. In this regard, Kelly and Allison (1999) demonstrate how the following concepts from Complexity Theory can be applied to improve business:

1. Nonlinear dynamics
2. Open systems
3. Feedback loops
4. Fractal structures
5. Evolutionary theory
6. Group self-organization

Filos (2006) further observes that rather than attempt to control their environments, organizations in the Digital Age will *adapt* to them (lest if they don't, they run the risk of stifling creativity, imagination, and innovation). Again, this notion of "adaptability" will resurface in our impending discussion of "intelligence."

According to Simon and Newell (1961), the human decision-making process comprises three phases, namely: (i) "intelligence," (ii) design, and (iii) choice. The use of the term "intelligence" here has a different meaning from that used in this article. More specifically, it is used by Simon and Newell in the sense of backgrounding a specific topic, as one performs in undertaking a literature review prior to commencing a new research project; in other words, to learn what has gone before (in order to "stand on the shoulders of giants," to paraphrase Einstein), and to avoid "re-inventing the wheel."

"Intelligence" can take yet another meaning within the context of IS, more specifically in relation to system security. Intelligence gathering is a prime concern of the latter, with various IS developed to support these endeavours. There are inherent dangers in such systems however, as flagged by the American Civil Liberties Union (http://www.aclu.org) in relation to the use of biometrics generally, and more especially to the 2008 RFID legislation; stated simply, whereas RFID is capable of providing audit trails, their indiscriminate use *could* encroach on ones privacy). The interests of "Big Brother" (i.e., Government) need to be balanced against citizens' rights in this regard, especially because identity theft has become such a major concern since the turn of the century. Space does not allow us to pursue these issues further, as this really warrants another article (book?) entirely.

INTELLIGENT INFORMATION SYSTEMS

Before we proceed further with our discussion of Intelligent IS, we need to define what *we* mean by the term "intelligence." We can regard "information" as being data + meaning. By extension, we can characterize "knowledge" as information + experience. Defining "intelligence," however, is a rather more challenging task. In the AI world, intelligence is generally viewed as encompassing:

- Awareness of (knowledge about and the ability to interact with) the surrounding environment, and
- An ability to learn from experience and adapt accordingly.

The first of these criteria presupposes an efficient method of encoding, storing and retrieving knowledge. Several different methods exist for doing so, including if…then (or fuzzy) production rules, frames (schema), semantic networks, propositional/predicate logic, or Artificial Neural Networks. The second criteria raises the issue of "learning" from experience, incorporating such knowledge into a "Knowledge Base" (KB), and consulting this knowledge (wisdom?) when encountering new situations and circumstances, whether consciously or unconsciously (i.e., relying not just on reasoning but also on intuition). It also implies some pattern recognition ability, in order to extrapolate from known situations, to apply heuristics (rules-of-thumb), and to build upon existing knowledge.

The claim that IBM's Deep Blue is intelligent because it defeated a human (World) Chess Champion is somewhat missing the point. The ability of the former to look a long way ahead with sequences of next moves–up to 100 billion–is indicative of little more than a brute force approach, after all (i.e., *un*intelligent).

In this article, we will restrict our focus to natural/biological systems that appear to exhibit "intelligence" (irregardless of our specific definition of the latter term). Our premise is that by mimicking (or alternatively taking inspiration from) nature, we stand to develop systems which *naturally* exhibit intelligence." Table 1 compares and contrasts the attributes of such biologically-inspired ("soft computing") approaches with that of logic and reasoning–the underpinning of conventional (algorithmic-based) computing.

REPRESENTATIVE INTELLIGENT SYSTEMS

After briefly describing the underlying principles of each approach, we proceed to cite representative examples where researchers have applied "intelligent" techniques to solve real-world problems. We restrict ourselves to six biologically

Table 1. Classical vs. soft computing

Classical computing	Soft computing
2-valued (Boolean/crisp) logic	many-valued (Fuzzy) logic
precise	approximate
deterministic	stochastic (i.e., incorporates some randomness/unpredictability)
exact/precise data	ambiguous/approximate/inconsistent data
sequential processing	parallel processing

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