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Managing Technology »

Intelligent Systems and Applications in IT Management

Intelligent Systems?

Intelligent systems have been around since long, are applied in many domains, and typically fall under broader discipline of AI (artificial intelligence). AAAI.org[1] defines AI as *the scientific understanding of the mechanisms underlying thought and intelligent behaviour and their embodiment in machines.* Most of early applications of AI were based on technologies like expert systems. Expert systems represent and store expertise of domain experts in certain form, use and apply that expertise to solve a problem. AI especially in the context of business applications involves many techniques like artificial neural networks, fuzzy logic, genetic algorithms, case-based reasoning etc. Together these techniques address wide-variety of problems; they differ in the way they acquire, represent, store, retain, use, reuse and apply *knowledge* and solve problems. There are two basic forms of knowledge *explicit* and *tacit* as shown in table 1. The purpose of building intelligent systems using expert system and case-based reasoning technologies is to automate expertise to certain extent. Each technique requires knowledge to be represented in certain structured-form. However, techniques that are part of text mining and multi-media mining can deal with unstructured data and information sources.

The question is can machines be made intelligent using these two types of knowledge sources? Let us understand how human reasoning works. As illustrated in figure 2(a), whenever we encounter a problem or opportunity, we recall past experiences and see the possibility of reusing the most relevant experience(s) in the current problem context. As shown in figure 2(a), these experiences remain in tacit form. Can they be embodied into machine so that machine can reason the same way as we do? Let us look at three basic ways of doing it, may be asking questions:

1) Can these experiences be represented and stored in an explicit form so that machines understand them, *retrieve* the most similar experience(s) *matching* with current problem and *reuse* them to arrive at a solution to the problem as shown in figure 2(b)?
2) Can these experiences be represented and stored in an explicit form so that machines *learn* from these experiences with some machine learning technique, and use that *learning* to solve current problem as shown in figure 2(c)?
3) If experiences are not available in explicit form, can expertise of domain experts be extracted, represented and stored in a form machine can directly use and apply that expertise to solve current problem as shown in figure 2(d)?

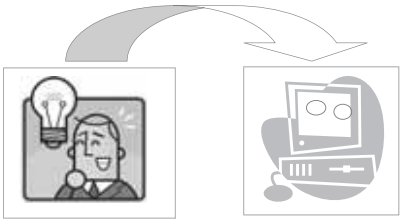

Fig. 1: Making machine intelligent by embodying intelligence

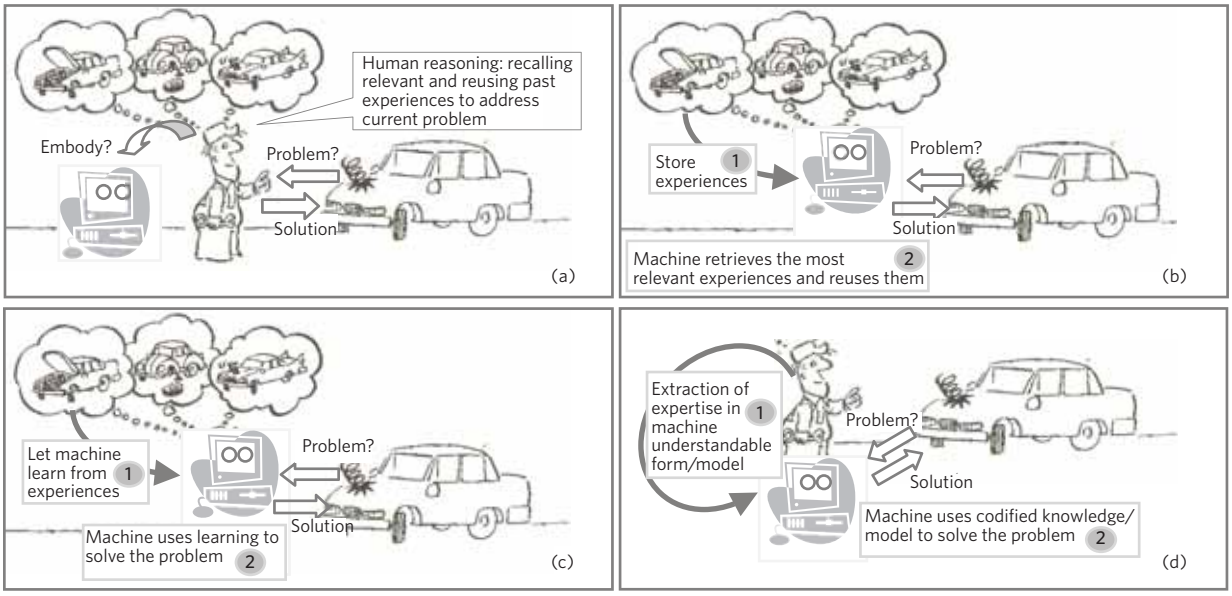

Fig. 2: Human reasoning and ways to make machine intelligence (basic figure modified from source[2])

Knowledge forms (experiences)	Description
Explicit	Expressed in some explicit or implicit form especially documented form (structured, semi-structured, unstructured): past solved problems, manuals, models, etc.
Tacit	Remains inside individual's brain

Table I: Basic knowledge types

These three examples illustrate the underlying principles of three kinds of intelligent techniques. The approach illustrated in figure 2(b) represents techniques like *case-based reasoning* (CBR) where a problem (new case) is solved by retrieving most relevant problems (matching cases) amongst the past solved ones (case base: past cases) and reusing their solutions in the current context; figure 2(c) represents the machine learning techniques like *artificial neural networks,* they learn from past examples; and use that learnt knowledge to solve given problem; and figure 2(d) represents technologies like *expert systems* where expert knowledge is *elicited* and presented in form like decision trees or IF condition(s) THEN action(s) rules called knowledge-base, this knowledge-base is used to solve new problem. Some intelligent techniques value-add or improve other techniques like fuzzy logic: instead of writing rules in expert systems in if-then-else form using simple comparison operators like less than, greater than (for example: *if CPU usage >=90%* and *Physical memory available <= 10%* then *send alert 'Do not start new application'*), they can be written as fuzzy rules (for example, *if CPU usage is very high* and *physical memory available is very low* then *send alert 'Do not start new application'*) called as fuzzy expert systems.

Experiences can vary depending upon the problem domain or problem itself. An experience can be: an evaluation of credit card application, an execution of a project, a failure of equipment, a fraudulent online transaction, an individual customer's buying and spending, a loyal customer profile, a churned customer profile etc. In an abstract sense, employee-, customer-, product- and service-profiles can also be called experiences. For example, a customer profile may represent what kind of customer he or she is, what he or she does or likes etc. More the experiences that are available and stored in structured and meaningful form, more useful they are when it comes to building intelligent systems. This is similar to the way humans understand some forms of knowledge (like videos) more quickly as compared to other forms (such as descriptive texts). However, most of the time this is not the situation, since experiences are available in unstructured form (e.g. IT support vendors maintain physical records of client complaint calls, engineers do not write the details of how they addressed the issue, and if they do, most of the time it is hand-written). The firms need to convert these physical records into databases and subsequently need to follow practice of capturing the details (from client support call till resolution) in electronic form in order to automate reuse using intelligent systems.

Intelligent Systems in Managing IT

There are many activities that are part of managing information technology, which require substantial knowledge about various technologies and human expertise. For example, procuring software itself is one of the complex decision-making tasks. Typical questions that the decision maker may have in mind: (a) how can I get the software that takes care of all my functional and technical requirements?; (b) will it fit into, complement and be compatible with my existing IT setup or will I need to incur extra cost to procure additional required resources?; (c) what licensing policies does the vendor follow, what is the best that suits to my requirements?; (d) does the software and the vendor follow standard and best industry practices?; (e) is the vendor reputed?, does the vendor have enough capability?, will the vendor support me whenever my users face issues and need modifications?; (f) do I have required manpower to use the software or do I need to hire?, what kind of training and skill-sets will be required to use and manage the software?; (g) what is my TOC (total cost of ownership)?. Complexity in evaluation and selection process increases because of[3,4]:

- Large number of software products available in the market, continual advancements and improvements in information technology
- Existence of incompatibilities between various hardware and software systems
- Difficulty in assessing functional dissimilarities of various software packages
- Lack of technical knowledge and experience of software selection
- Changing user requirements of the software packages
- Existence of several constraints while choosing the best alternative
- Lack of structured description of features and user requirements of of the software package.

In general, major challenges involved in managing IT are: coping with rapid changes in technologies; procuring, supporting and managing many heterogeneous technologies and vendors; hiring and retaining IT skills; and ensuring compliance, security and ethical use of IT resources. Although IT management activities can be classified into several groups, based on similarity in tasks they are grouped into three broader groups to understand scope of intelligent techniques.

1. IT procurement
2. IT set-up/ infrastructure management
3. Managing IT expertise

IT Procurement

Intelligent techniques especially expert system and case-based reasoning have played major role facilitating software evaluation and selection tasks[5]. Use of a generic list (taxonomy) of software evaluation criteria along with its meaning and associated scales, measures (metrics), importance and priorities are essential for assessment of the software packages. Many a time except *functional* evaluation criteria, which vary from one functional area (e.g. accounting) to another (e.g. payroll), the other evaluation criteria such as *technical details* (like operating systems, hardware resources, standards used, input and output formats), *vendor details* (like reputation, availability of technical manpower, support and upgrade capabilities, feedback from existing clients), and *quality specific details* (like portability, maintainability, usability, reliability, efficiency), can be *standardized* (by creating feature vocabulary, using taxonomy or grouping various criteria,

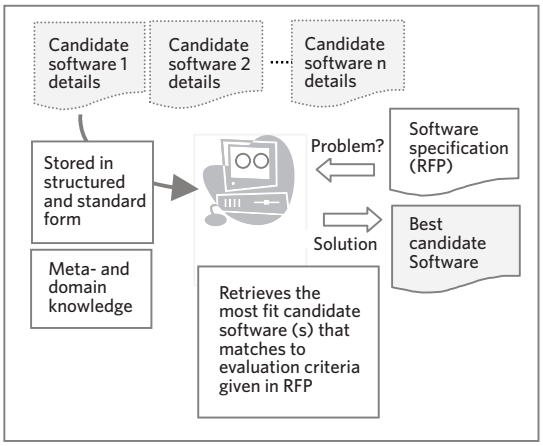

Fig. 3: Selection of software using CBR approach

using appropriate scales, measures, etc.). Based on requirement, the relevant evaluation criteria can be incorporated while preparing the standard RFP (request for proposal template), and vendors can be asked to provide the details in standard RFP template form.

Firms prepare and manage such RFP templates in spreadsheets/word processing formats, however, if they are made available online using web templates, the vendors can fill the relevant details more accurately within possible options available. Vendor responses (candidate softwares) become experiences (knowledge about individual software). Standard RFP specification can be intelligently matched against the candidate softwares and final scores can be arrived for each one using case-based reasoning approach and subsequently ranked. In case-based reasoning, domain knowledge plays very crucial role to retrieve most similar experiences by matching current problem with past experiences especially at feature level. For example, if software is portable (feature portability will have value 'yes') means it can work on many operating systems, etc. Figure 3 shows how case-based reasoning approach is used for software selection.

IT Infrastructure/Setup Management

Large firms have huge IT resources (large numbers of servers, desktops, storage devices, networks etc.) Various activities and performance need to be monitored on an on-going basis; and troubleshooting and finding root causes in case of failures; detecting abnormal behaviours, predicting and preventing downtimes; upon failure reduce time to repair or make systems up again; optimizing resources are some of the major tasks. Many systems and applications are configured to send alerts in case usage exceeds set thresholds, to create and keep logs. Intelligent techniques have been used to address first call resolution, self-service, technical help-desks and troubleshooting applications to improve the productivity and reduce the support cost[2,6]. They are also deployed to analyse various logs, alerts generated by the IT resources to detect anomalies or predict likely failures. Failure experiences can be stored in the form of 'what is failure' and 'what are the things that caused or lead to fail: e.g. logs of various events before failure'. These experiences can be reused to get early warning signals of likely failures and what are the preventive steps or measures to be followed to stop or prevent failures. Rule-based expert systems can be deployed by writing rules that interpret various logs, events and usage, and send alerts. Such intelligence can be embedded into IT resources themselves to help the systems to stop failures or recover/heal themselves upon failures (autonomic computing).

Intelligent systems have also been applied in securing IT systems such as neural network and rule-based expert system based intruder detection systems (IDS)[7].

Managing IT Expertise

Software project management, support and administration of various applications and systems require different kind of skills sets. In large size firms, pulling or hiring the right resource person is important based on the job profile. Same as that of software specification if the job profiles and employee skill-sets are specified in standard form using various criteria, matching job profiles with required job profile becomes easier. Right employee profile for right job improves productivity and employee satisfaction. Domain knowledge about various skill set is essential, for example, if a software engineer who has worked on C++ programming, can he or she work on project that involves C coding?

Many firms who are involved in IT services or have in-house software development have lot of expertise available. Many a time firms go through entire SDLC (software development life cycle), use various CASE (computer aided software engineering) tools and meticulously follow structured analysis, design and coding methodologies and approaches. UML (unified modelling language) facilitates tools, techniques and methodologies to develop software using object-oriented approach. Lot of software code is written in modular way, broken into reusable APIs (application programming interface), web services or in the form of libraries etc. Apart from software development, IT professionals possess knowledge about initiating and negotiating projects with clients, understanding requirements, executing projects and supporting projects, dealing with client team, best industry practices, etc. Intelligent techniques help to automate, retrieve and reuse such expertise required at various levels[8] e.g. (a) reuse of existing 'customer' class in the class diagram developed for one application in other application, (b) reuse of experiences of managing various ERP projects to estimate efforts required, do proper requirement analysis, and planning execution for new ERP projects, (c) reuse of API to develop a new application or as a part (composition) of new functionality. However, in order to develop intelligent systems to facilitate extensive reuse, experiences need to be properly structured and stored, for example, every API should have details like what input parameters it takes, purpose and data types of parameters, what it returns, programming language it is implemented, functionality of API, relationship with other APIs (whether it uses other APIs or part of other API etc.), detail categorization of API into using, etc.

Bottom Line

Intelligent systems have been around and increasingly found addressing serious business applications. Intelligent systems automate knowledge tasks, retain and reuse valuable expertise so surely would find utility in the firms in IT management. Some of these techniques are already part of knowledge management and business intelligence (especially predictive modelling) tools and technologies. More automation of various manual infrastructure operations, use of sensor technologies, complexity of managing so many technologies, availability of millions of logs/events in structured forms, and move towards reduction in TOC would get a push and make such systems applicable,

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feasible, effective and practical rather than remaining just academic research attempts or lab prototypes. Attempts are being made by the industry such as developing self-managing systems (autonomic computing).

However there are many challenges in general: there are lot of existing unstructured data, information and knowledge sources, a big task of converting these in structured form, capturing physical knowledge sources into electronic forms; complexity of modelling domain knowledge (like taxonomies, ontologies); defining and enforcing standards while creating and documenting experiences, adding meta-data to experiences; availability of expertise to model problems, develop and deploy intelligent systems; people willingness to share their experiences and so on.

With the advent of technologies like automated document classification, text and multimedia mining, NLP (natural language processing), ICR (intelligent character recognition), use of standards, CASE tools, some the challenges can be addressed to some extent.

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