

Applications of Intelligent Technologies for Efficient Businesses
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What Are Intelligent Technologies?

Intelligent Technologies are those that make a complex decision quicker and more accurate. Complex decisions are those in which many variables are involved or in which the relevant data is subjective or approximate in nature. Typically, these kinds of decisions involve substantial resources and usually occupy much of the analytic time of business decision maker. Complex decisions can be categorized as either tangible or intangible. Tangible decisions are such as those involving inventory levels, scheduling of materials deliveries, or routing shipments as in the trucking industry. Intangible decisions are such as that to select from among alternative acquisition candidates, picking the right common stock or selecting among candidates for a job promotion. In either category, Intelligent Technologies can be applied for the benefit of the business decision maker.

Complex Decisions Are Frequently Approximated

The decision process of most businesses is non-linear and fractured. In a simple organization a tight command structure may exist that permits the general manager to make all significant decisions. Other members of the organization carry out those decisions. A slightly more complex organization may employ a committee. In either case, implementation is slowed while information is disseminated and absorbed. Often, potentially critical information does not exist or exists in such volume and complexity that heuristics are employed to bring the process to a close. Rules-of-Thumb or intuition are commonly relied upon. The concept of "Shoot then Aim" has been around at least since the 1960's. In this scheme, the decision maker makes a decision then as time goes on "improves the aim" of the decision. Finally what is always the easiest is to make no decision at all. This usually comes in the form of allowing for all possibilities exemplified by "Keep Plenty of Inventory on Hand".

The Speed of The Decision Process is Valuable

In Ben Franklin's day communication occurred at "the speed of a horse". Most anyone could make decisions quickly compared to the infrastructure of the day. Supply systems were localized and the effect of bad or good decisions were not widely felt or known. In Andrew Carnegie's time, faster communication was available, but expensive. Lower transportation costs and the art of mass produced goods changed the impact of decisions. Industry ran boom & bust as inventories were out of sync with demand.

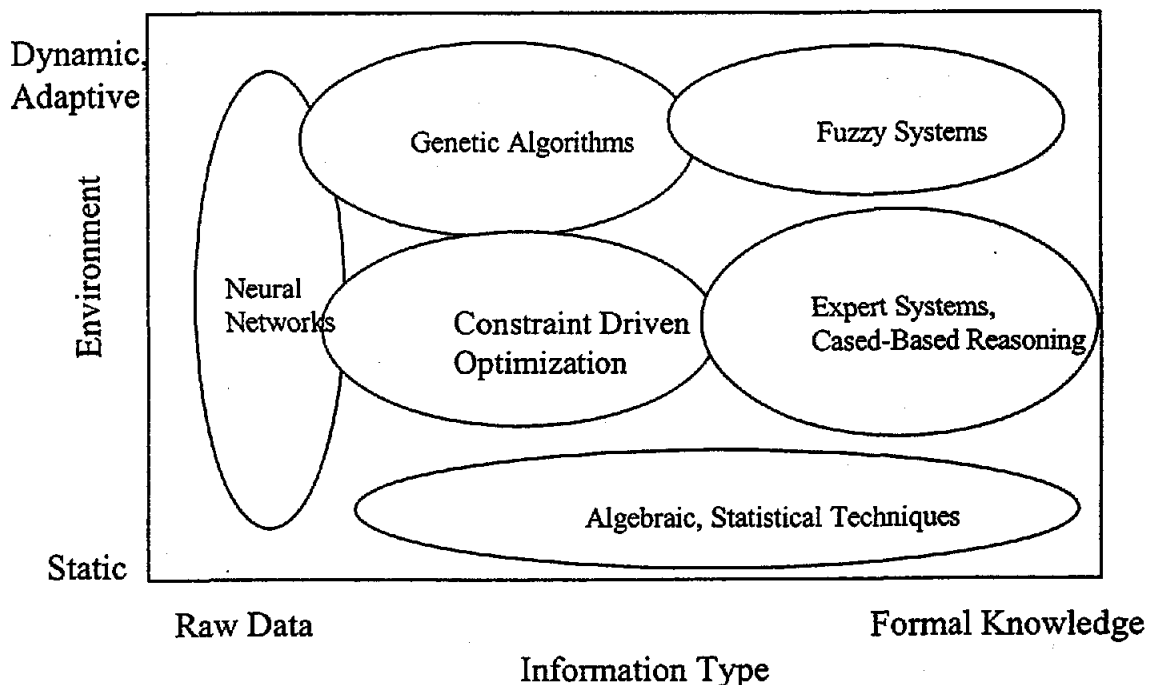
Communications were insufficient to keep the supply chain in synchronized. Today the issue is no longer the speed or cost of communication, but accuracy. Communication is sufficiently fast and transportation sufficiently cheap that the situation has changed from an information dearth to information over supply. We can all have access to “speed of light communication” but today, what information is important?

Intelligent Technologies Can Improve Speed & Accuracy

In most processes, there is a tradeoff between speed and accuracy. However, intelligent technologies allow the time it takes to reach a target speed or accuracy to be highly compressed. That is, a target level of accuracy can be achieved in a few hours with intelligent technologies which might have taken days by an older method.

How much do we already know?

One of the keys to success with a decision situation is determining the type of information available and matching it with the appropriate technology as suggested in the figure below. The simplest case is that of a static environment and formal knowledge. These cases are generally quickly solved either graphically or with regression type tools. On the other hand, the most difficult and often impractical situations are cases where the environment is dynamic and there is substantial raw data to be dealt with. Many stock market situations fall within this sector.



Examples of Intelligent Technologies

Neural Networks are an attempt to operate a computer system on the neuron model of the brain. The brain is composed of 10^{10} neurons. A computer may be able to model 10^2 neurons. What is a parallel process in the brain must often be handled by computers as a serial process. So while the computer is faster than the brain at many processes, it may not be so for neural network processing. Neural networks learn by trial and error. 50,000+ trials are common in the search for the best solution. Essentially a proposed problem is setup in the Neural network typically with 20+ inputs and 1+ outputs. The network iterates and by a guided random search finds plausible correlations between inputs and output. This is extremely time consuming, but where there is no apparent model for connecting inputs to an output, the Neural network is an attractive starting point. Success stories are seldom published, but many people appear to make a living doing this work for Wall Street. However, no one has yet made the cover of Forbes for their neural technical savvy.

Genetic Algorithms are another 'model of nature'. Just as selective breeding of herds occurs in animal populations, genetic algorithms represent an attempt to do selective breeding of algorithms. Many possible algorithms are tried, the best are kept and then a new 'child' is bred from two existing pools of good algorithms (parents). This approach has applications in dynamic situations where the relative weighting of factors may be changing in ways that are not readily predictable by other methods.

Constraint Driven Optimization typically takes the form of a linear program or a system of equations which describe the situation and a separate objective equation. The system operates by maximizing or minimizing the objective. Clever solving strategies make this a very fast approach especially when dealing with whole numbers (i.e. gallons or pounds) where fractional solutions are satisfactory. These equations are slower when an integer solution (e.g. cases or shirts) is required. If a constraint system can be built, it is one of the better choices for driving to a fast solution. The downside is that it is very easy to develop a constraint system with thousands of simultaneous equations. It often takes someone with their head deep in the problem to keep these systems going.

Fuzzy Systems are based on the simple concept that there is a lot of gray between 'black' and 'white' or more states are needed in a system than 'on' and 'off'. The math behind fuzzy systems is straightforward, continuously varying, linear combinations of inputs to produce the output. The weighting of the inputs continuously varies depending on states of the problem. Fuzzy systems have grown in popularity as electronic feedback control systems. They replace otherwise impenetrable differential calculus with amazingly simple equations. For their simplicity, it is hard to follow exactly what is going on in the algorithm and are best demonstrated rather than analyzed.

Expert Systems or Case Based Reasoning were developed in the 70's and were one of the earlier forms of attempting to have a computer do real 'thinking'. A flurry of

activity in the early 80's resulted in few success stories. For most problems, an expert seldom has more than 10 rules (i.e. guiding principles or rules-of-thumb) he/she uses to derive the ultimate answer. The rules are easy enough to extract from the expert, but the core problem was that different experts tend to give slightly different answers. Thus, while it is feasible to model one expert, it was hard to get other experts to agree on the same solution. It was also hard for the computer to do the necessary hand-holding to convince the novice of the appropriateness of the solution. Expert systems have their best applications where there is a complex but precise solution e.g. building a parts list for a custom mini-computer. When the decision process is complex but the true answer has many possibilities e.g. geological models, it is unlikely an expert system will be successful.

Case Based Reasoning adds a twist to expert reasoning in that as cases are played out their success or failure results are fed back to the core of the system and next time the system is a bit smarter. All the buy-in problems described with expert systems also apply to case based reasoning.

There is Plenty of Technology, So What Works?

Determination and a good nose for the problem works. The secret is to look at more data than is practical for the human expert. While the human decision maker will use a lot of simplifying assumptions and rules-of-thumb, intelligent technologies can often look at the detailed underlying data to produce a more accurate answer.

Technology is not the question. Hardware or SAS modules are not that expensive either. The expensive part is development time. Agreement on the correct solution is mandatory.

Check-off for Interesting Problems

The following are some key issues which an 'expert' would cover to determine whether there is a feasible problem for intelligent technologies.

- Is it a high value problem? Is the solution valuable enough to justify a development effort lasting many months?
- Can experts agree on the characteristics of a correct answer? If there is no agreement, the project can never be finished.
- Is the decision needed much faster or more accurately than current 'rules of thumb' can provide? A decision on one item of inventory is easy. 10,000 items of inventory becomes overwhelming.
- Is there a top manager committed to the problem? Solutions involving Intelligent Technologies always require high level commitment to succeed.
- Can the commercial (production) solution be solved in a short enough processing time that the answer is relevant? The iterative solutions e.g. neural networks,

genetic algorithms can be very time consuming. Large constraint systems can also be very slow.

The Tie to Data Mining

These techniques are a natural for data mining and of course data mining is a natural for SAS (A data mining module is being tested). Data mining is the mathematical parallel to a literature search. If a person knows what they are looking for, specific key words etc., then the search can go very quickly. However, if one is looking for anomalous phrases or "non-standard usage", then the search becomes much more difficult. Such a search will turn up Huckleberry Finn's Qulocalisms along with the unintentional non-standard usage. How to train the system to ignore all the Huck Finn's of the world is the time consuming problem.

Success Stories Remain Localized

Some believe Neural Networks to be a mainstay of Wall Street. From Texas it is hard to assess this activity. A magazine titled "Intelligent Technologies in Finance" never made it past a few issues. None of the articles in the magazine's short life were from true finance people. What success stories exist are not widely published. The owner of a 20-30 person neural software company seems to stay fully occupied with stock market related jobs.

One person reports of using neural networks to identify a new rate classification system for auto insurance purposes. He had to go back and redo the problem with non-linear regression before the state insurance board would accept his solution. Although the regression model could not be made as favorable to his company as the neural network model, the neural network approach was essential to the ultimate regression solution.

One interesting tidbit was the story of where an oil company notice a customer using several different credit cards to make 50 cent gasoline purchases at the gas pump in a row. It turns out that the most likely person to do this is someone using stolen cards and is checking to see which cards are still good. This is a wonderful application, but was the thief discovered through data mining or by the thief not fitting any case in a case based reasoning system or was a constraint exceed in a constraint based system? The authors vote for one of the non data mining scenarios.

The authors' best success story was in the use of constrained systems to optimally distribute sized clothing merchandise to stores based on size sales history and current inventory. The customer originally thought it to be a neural network problem. However, in discussions with users it became apparent that there was sufficient expert knowledge that a neural network would not be needed.

In Summary

Given enough time any complex decision can be made. The future belongs not to those with the right answer but to those with the quickest and most correct answer. Intelligent technologies allow more accurate and faster answers but obtaining these answers is not easy.

Data for most organizations is quickly becoming overwhelming. Given the increasing power of cheap computers solutions can be formulated. Potential problems will continue to expand. Technology is now cheap enough to track individual grocery items having an average value of little more than one dollar. Technology to collect the data is no longer the limiting factor. Developing an efficient analysis system and obtaining agreement on what is the correct solution are the tests for the future. Ultimately the successful systems will allow the managers to be more efficient. After all, that is what most business is about.