Cognitive Systems Redefine Business Potential

Adaptive Intelligence Can Help To Optimize Decision-Making

White Paper

VENTANA RESEARCH

Aligning Business and IT To Improve Performance

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Establishment of Cognitive Systems

Cognitive computing is a new category of information technology that combines proven technologies with sophisticated analytical algorithms, natural-language- and machine-based learning and massive computer processing power to yield probabilistic responses to user questions. A cognitive system accesses information, both structured and unstructured, within an associated knowledge base to return responses that are not simply data but contextualized information that can inform users' actions and guide their decisions.

Cognitive systems have useful potential in many industries, and any organization that must process large volumes and various types of data likely will benefit from the ability to quickly generate actionable guidance. They can be used to develop information that helps businesses become more effective and competitive and helps decision-makers develop and reach conclusions more quickly with increased confidence.

The foundation of cognitive systems is a discipline known as cognitive science. Cognition is the sum of all the thinking processes that contribute to gaining knowledge that ultimately is used for problem-solving. This includes information acquired through sensations, awareness and judgment. In humans, cognition is a synergistic combination of sensation, perception, emotion, action and interaction. In computational systems these processes are modeled using hardware and software; machine-based cognition thus is a step toward imbuing an artificial system with attributes we typically consider human – the abilities to think and learn.

Cognitive systems are useful in any organization that must process large volumes and various types of data to generate actionable business intelligence.

Research in artificial intelligence (AI) over the past five decades provided the foundation for the development of cognitive systems. The prime tenet of AI holds that computers can be made to function like the human brain to the extent that, to cite an actual example, they can provide answers in real time to Alex Trebek's *Jeopardy!* trivia questions.

The development of cognitive systems is premised on the conviction that machines can be designed and built that can assemble evidence and develop logical hypotheses, thus improving people's ability to make well-informed decisions. These systems are able to learn – that is, to receive queries in natural language, form and evaluate hypotheses, return responses that are relevant, and in the process integrate new information and discover new patterns. They represent a step beyond currently available systems in that they can actively assist human users in decision-making rather than simply providing neutral input.

To develop such systems, scientists have engineered machine-based computational functions to mimic the human brain's learning and observation processes. Research on the physiology of the brain has been used to create machines capable of deriving meaning from vast amounts of data, whether numerical data in neat arrays or unstructured documents such as published news articles or financial reports.

Cognitive systems use recursive feedback cycles to improve the quality of their situation-specific guidance. In other words, the computer is programmed to continue learning as it receives and processes new data. The sophisticated learning algorithms deployed in a cognitive system enable the computer to process and respond to actual outcomes rather than relying solely on speculative forecasts or anticipated results.

The intention behind this design is to put large volumes and varieties of information into proper context while dealing with both information velocity and the uncertainty of the data from which it is derived; when this is accomplished, the system can more optimally support decisions. For example, a cognitive system could be tasked to identify from a pool of customer service responses what the current issues are with a specific product. Based on patterns of incidents, it could then return a list of issues, accompanied by confidence scores, that could be acted upon to avoid a future incident.

The sophisticated learning algorithms deployed in a cognitive system enable the computer to process and respond to actual outcomes.

Machine-based learning algorithms enable a cognitive system to generate findings that not only are relevant and useful but that improve with use and additional input. The result is a new form of adaptive intelligence that relies on continuous input and machine-based analysis to produce guidance that can assist people and organizations in more effective decision-making.

How They Developed

As research in these fields continued, business took note of developments, but several disparate factors had to mature and coalesce sufficiently for industry innovators to be willing to consider adopting cognitive systems outside the lab. These included:

- research in computer science, such as natural-language processing applied to text and machine learning as a statistical process based on unstructured data, that yields practical applications for business.
- advances in processing big data and statistical analytics of data and other forms of content, including developing new algorithms and software able to effectively and efficiently extract information from vast storehouses of data.
- evolution beyond traditional evidence-based expert systems.

In addition to the declining costs of exponentially faster computer processors and data storage, advances in computing architectures – in particular, parallel computing, which is able to process vast arrays of data more accurately and rapidly – contributed significantly to progress in cognitive systems' development and their eventual launch into the enterprise.

In business as elsewhere, evaluating a body of information and using it to generate value – especially when it comes to decision-making – is critical. This is where cognitive systems can provide a distinct advantage. Using natural-language processing, an executive without advanced technical skills can pose a query about an important issue, whether it be about performance metrics in a fiscal year or daily operational reports. The system can then evaluate data, generate probabilistic hypotheses about outcomes, and issue recommendations accompanied by supporting context. Such guidance, supported by ongoing machine learning that can improve results and confidence rankings over time, can help an organization make better, more focused decisions.

A cognitive system can rapidly analyze large masses of data and come to insights not reachable by conventional analytics.

The cumulative effect of combining these concepts and technologies is a system that can rapidly analyze large masses of data, draw from its analysis conclusions that can guide users, and refine its criteria and responses based on an analysis of the type of results in which the user is interested. A cognitive system thus can arrive at insights not accessible using conventional analytics. Operating on big data and applying iterative capabilities, it can produce more useful actionable responses, based on a range of weighted evidence, than can systems relying on basic analytics and business rules.

This is not to suggest that cognitive systems operate in a separate specialized environment. On the contrary, they are most likely to be used to complement traditional programmatic applications and extend the value that can be derived from enterprise and social data, both structured and unstructured. We anticipate such systems will extend businesses' understanding of their competitive environments and add a forward-looking dimension to information-based decisions.

Why They Matter

Humans have limited capacities for absorbing information and methodically making decisions. The amount of unstructured data available on the Internet is exploding exponentially, and it is only one among many sources of relevant data. Soon, rather than terabytes of data, organizations will be storing one billion terabytes – a zettabyte – annually. A human simply cannot look at this much information and immediately detect actionable patterns, especially statistical anomalies or exceptions from institutional norms, much less extrapolate possible outcomes for the coming quarter or the next fiscal year.

A number of other factors impede accurate and reliable decision-making as well. Not the least among these are the human emotions that often color decision-making processes. How a human feels about one aspect that can shape a decision ultimately may influence that decision. But with the information acquired through a cognitive system's processing and analysis of large volumes of seemingly unrelated data, decision-makers can override inclinations colored by personal experience and remove emotional factors from decisions. For example, without objective information, an operations executive might fill a critical link in a supply chain based on personal attachment to a brand rather than by comparing suppliers based on fact-based data like reliability, resiliency and track record. By enhancing both information processing and objectivity, the technology acts as the ultimate professional assistant.

These technologies have evolved over decades, but only in recent years have they been combined to help people understand patterns, trends and issues hidden within their data.

By providing interconnected, instrumented intelligence – in reality, a set of networked data-gathering technologies – to augment human decision-making, these systems can add value for business and society. For example, customers often seek help in troubleshooting product malfunctions of various kinds through automated self-service. As their requests are in what in technology terms is known as "natural language" what they are describing or requesting often can be open many possible interpretations. Or a telecommunications service attempting to retain customers considering moving to another carrier must respond to a broad and changing variety of customer inputs (such as their current device, rate plan, demographic, location or history with the company) by selecting from many options the particular offer most likely to persuade the customer to remain or perhaps upgrade. In both instances, cognitive systems can move quickly through large amounts of data, filter it according to the conditions of each situation and return trustworthy recommendations.

Components of Cognitive Systems

Cognitive systems are built on a foundation of continuous learning and adaptive intelligence enabled by advanced information technologies. These are technologies that have matured over decades, but only in recent years have they been combined to help people understand patterns, trends and issues hidden within their data and identify actionable risks and opportunities.

The technologies on which cognitive systems are built are varied and powerful. Machine learning systems can be set to automatically recognize complex patterns that can be used as a basis for intelligent decisions. Pattern-based analytics and procedures can be applied for data discovery. Distributed information processing is a hardware-related advancement that allows systems to process information in parallel and take full advantage of computational resources cost-effectively. Natural-language processing and unstructured content analysis, when combined with speech recognition technologies, allow systems to understand questions. Beyond this, natural-language processing can be used to produce well-informed responses that users can apply to their decision-making.

Machine learning systems can increase decision-makers' confidence by providing users with immediately understandable, situation-specific advice and guidance. Such a system does not render an explicit decision but returns weighted results or options that are relevance-based, scored using algorithms that behave predictably.

Results returned by a cognitive system are relevance-based, scored using algorithms that behave predictably.

Big-data technologies are contributing to a new generation of statistical analytics. With an exponential increase in available and affordable computing power, big-data analytics is no longer limited to a few very large organizations. New technologies such as the open source Hadoop provide organizations with the tools to analyze large data sets quickly and cost-effectively. Cognitive systems take these sorts of analytics one step further to generate business intelligence that enables users to gain depths of insight unavailable otherwise and act on them.

Machine learning systems can be applied to a wide array of enterprise issues that involve diagnosing challenges and identifying and evaluating possible actions to remediate or take advantage of the findings. Cognitive systems will play an increasingly central role in the creation and evaluation of statistical and predictive models that will yield insight as to what might occur and how to deal with it.

Algorithms and Cognitive Systems

The key to constructing a system that learns are the algorithms or computational procedures used in what is being called cognitive analytics. Generally one of two approaches provides the framework for a computer program: deterministic or probabilistic algorithms. Deterministic algorithms are predictable and predetermined, while probabilistic or non-deterministic algorithms don't always take the exact same path or approach to generating a solution. An advantage of using a probabilistic algorithm is that it can generate multiple possible outcomes. This, of course, is an advantage in business as it more often than not is beneficial to be able to see and evaluate options.

Within cognitive systems, the probabilistic recommendation process can start in an array of ways. A user might present a question to the system in natural language, much as one might query a colleague, with the system then parsing and evaluating the question and ultimately generating a hypothesis. But there need not have been an explicit query. The system could, for example, be configured to "push" to a financial trader a daily evidence-based list of buy, sell or hold suggestions derived not only using defined parameters but also from data gleaned from news sources. A cognitive system also can evaluate evidence that changes over time such as fluctuations in commodity pricing, extreme changes in weather or changes in the condition of a patient, and can search through knowledge bases such as medical literature to find relevant information; it then will return a range of probability-based recommendations or responses that address the conditions in question.

Queries need not be generated by people. A system can be configured to handle queries from one machine to another. Thus, one computer can prompt another to generate recommendations periodically to incorporate new data into decisions. A manufacturer, for example, could receive on a monthly basis information to use as input into decisions on production changes. In addition to being based on factors such as sales and inventory, this information could also be gathered from extended forecasts or extrapolated from news items discussing trends that might influence sales.

The system learns from the various outcomes, improving its recommendations over time.

This type of system learns from the various outcomes it generates, improving its recommendations over time. Such a system thus continually appreciates in value through the ongoing, recursive cycles of interaction and learning that enable it to return results of increasing utility and insight.

An Example: IBM Watson

IBM Watson is a prime example of a cognitive system. Named for IBM's founder, Thomas J. Watson, the system was built to demonstrate that a computing system could be developed that would respond to natural-language questions with the speed, accuracy and confidence of a human. Testing occurred in a very public forum – the television game show *Jeopardy!*. In a series of matches in February 2011, Watson defeated two of the show's most successful former champions.

Now this technology is being used in targeted pilot applications as the next step on the path to commercial applicability. In specific business contexts IBM Watson has been extended to include new capabilities useful to a range of workers and managers. Although some of these capabilities may be available individually in software elsewhere, Watson demonstrates the value of using them in combination. They include the abilities to understand and interpret natural human language; to work with vast amounts of unstructured data such as market or patient reports; to generate and evaluate hypotheses; to confidently weight responses; and to appreciate in value over time by continuing to interact with and learn from human users. The use all of these capabilities yields a greater-than-sum-of-all-parts level of performance that distinguishes it from other systems.

Watson and similar systems promise to show their value in data-intensive industries that require analysis of huge volumes of structured and unstructured data; that could derive direct benefit (such as competitive edge, risk assessment or saving money or resources) from the speed and accuracy of a response to a question or input provided to a cognitive system; that see an advantage in systematically learning with every outcome or action, becoming smarter with each iteration; or that have critical questions requiring decision support with prioritized recommendations and evidence.

Examples of Cognitive Systems

Groundbreaking examples are being implemented in several industries. The strongest initial applications of cognitive systems are emerging in financial services and healthcare. Both sectors accumulate enormous amounts of data of widely varying types, be it commodity market updates or hospital patients' vital signs or admission records.

Financial Services

Computational resources have long been used in financial services to "crunch" numbers. Computing today has moved far beyond its original use for automated calculation; although computers typically do not make actual management decisions without human intervention, they can add significant value by providing information extracted from huge volumes of data that professionals and consumers alike can use in decision-making.

Such technology is being applied to assist financial services representatives with information they can use to provide clients with recommendations.

Such technology could be applied, for example, to assist financial services sales representatives. They do so by making available information the sales reps can use to provide clients with product selection, product use or other recommendations based on real-time financial and economic information as well as data relevant to the individual client. In retail banking, this might include presenting an array of alternative services to customers or assisting in narrowing the choices financial planners can present to customers about, say, selecting retirement investments.

Institutional banking professionals could also use cognitive systems' analytical capabilities in a number of ways – to assist in assessing risk for lending, for example, or in reaching other types of business-critical hypotheses that could lead to a timely decision. Here again, the results are based on extracting and developing information from a vast repository of historical information as well as the most current available data.

Healthcare

Healthcare is a multifaceted, diverse industry with numerous challenges, professional concerns and expectations, as well as stringent regulatory demands (in particular the Health Insurance Portability and Accountability Act of 1996 [HIPAA], which ensures the privacy and security of patient information). All of these factors impact the design of any technology constructed to address a challenging array of tasks ranging from clinical research to workforce scheduling.

A healthcare provider and research facility, for example, is working with an international technology systems provider to develop a cognitive system able to evaluate options for cancer diagnosis and treatment. The system will work with clinical information, patient data and huge volumes of published research and literature to help physicians and allied professionals improve the quality of patient care. It will search the body of available oncology information to find information pertinent to an individual patient's case. The system enables healthcare professionals to develop a specific diagnosis and sharpens their ability to individualize subsequent treatment plans for each patient based on the best information available.

Another potential benefit of such a system is that diagnostic tests and various other clinical information – both structured and unstructured data and reports or narratives – could be linked to a patient's electronic medical record to make it possible for attending physicians to access those records in order to evaluate options, such as possible drug therapies. The patient and the physician both would be able to use the system's output as a basis for informed decisions they may need to make during the course of a treatment regimen.

Value and Benefits of Cognitive Systems

One unique value of cognitive systems is that they provide to the user not only recommendations but also information that supports those recommendations. Each recommendation is scored based on relevance; the human using the system evaluates the information presented and ultimately decides whether to use some, all or even none of that intelligence. The systems also make data fully transparent so users can examine the sources of recommendations if they wish. While users are not obligated to use and act on the intelligence generated by a cognitive system, they can incorporate the results into the decision-making process, balancing and/or augmenting their own existing knowledge and expertise.

Cognitive systems can benefit organizations and their decision-makers in myriad ways. They can be used to provide situational intelligence to answer a question based on history as well as current information or conditions. They can enable individuals to take informed actions and make timely decisions, and also can provide guidance on possible future actions or make it possible to develop informed, proactive business strategies in a timely fashion. Cognitive systems have the added benefit of giving users an accurate range of responses to a specific question without allowing the results to be colored by human factors.

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