Cognitive computing is emerging from the shadows and rapidly impacting our professional and personal lives, illuminating a future where humans and machines will coexist to enable businesses to make faster and more informed decisions, improve operational performance and enhance organizational productivity.
EXECUTIVE SUMMARY

The pursuit of artificial intelligence (AI) has led to many technological developments that are accelerating as digital becomes the de facto way for businesses and individuals to interact and transact with one another. One AI-related area that promises to take the modern digital economy to the next level is the field of cognitive computing. Cognitive computing technologies can comprehend enormous amounts of data, apply reason, extract insights and continuously learn while interacting with people and fellow machines. They offer society an unparalleled opportunity to make smarter and more informed decisions.

These technologies are helping replicate human capabilities across the spectrum of sensory perception, deduction, reasoning, learning and knowledge. At a sensory perception layer, technologies such as computer vision and speech processing are providing better and faster insight into information contained in audio, video and still images, and helping to deliver superior user experiences. At a decision-making layer, technologies such as machine learning and deep learning are helping systems interpret information and arrive at effective, informed decisions. And at a processing layer, knowledge representation technologies such as dynamic ontologies, graph databases, etc. are helping intelligent systems reach wide and deep in search of connections.
In addition, high performance computing (HPC) technologies, such as parallel processing, in-memory computing, etc. are making searches and deductions faster and near-instantaneous. Together, these technologies are automating and accelerating the processing of complex datasets that have historically required repetitive human-cognition.

These developments are not going unnoticed. Forward-looking enterprises are finding ways to leverage these advancements for competitive advantage in the growing digital economy. For instance, banking and financial services companies are using cognitive computing to automate business processes, end-to-end. In healthcare, cognitive applications are helping doctors screen and diagnose patients faster, while allowing companies to broaden their reach across large and dispersed populations. Insurance companies are exploring the utility of chatbots and smart advisors to provide the right suggestions to their customers. Such applications are cascading across industries and disrupting traditional ways of doing business.

It is time for enterprises to seriously evaluate various adoption avenues of cognitive computing technologies, if they are not doing so already. They need to balance investment, risk and exploratory goals to identify appropriate technologies. This white paper explores a number of use cases, technologies that are already making or poised to make an impact, and a point of view on how enterprises should prepare to make this vital evolutionary leap.
Cognitive computing is already augmenting and accelerating human capabilities by mimicking how humans learn, think and adapt. When perfected, these technologies will replicate the human capabilities of sensory perception, deduction, learning, thinking and decision-making. The ability to harness vast amounts of computing power will take this paradigm beyond human replication both in terms of speed and ability to distinguish patterns and provide potential solutions that individuals may not be equipped to perceive. The jump in machine capacity not only promises to augment human potential but will spark and increase individual creativity and create new waves of innovation. Figure 1 identifies the broad ecosystem and illuminates three key converging areas of capability:

- **Sensory perception**, where machines are enabled to simulate human senses of sight, hearing, smell, touch and taste. Of these senses, the most developed in terms of machine simulation are visual and auditory perception.

- **Deduction, reasoning and learning**, where machines simulate human thinking to make decisions. Machine learning, deep learning and neural networks are the most prominent among these technology paradigms and are already being deployed as systems of intelligence to derive meaning from information and apply judgment.

- **Data processing**, where huge data sets are processed to facilitate accelerated business decisions and provide smarter suggestions. Hyperscale computing, knowledge representation and ontologies, high-performance search and natural language processing (NLP) are the leading technologies here and provide the required processing power to ensure systems of engagement work in real time.

### The Blending Layers of Cognitive Computing

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Figure 1
The jump in machine capacity not only promises to augment human potential but will spark and increase individual creativity and create new waves of innovation.

REPLICATING HUMAN SENSORY CAPABILITY

When it comes to programming machines to replicate human sensory perception, visual and auditory perception are fairly well evolved. Additionally, advancements in the fields of haptics that simulates the sense of touch, machine olfaction that simulates the sense of smell and gustatory technology that simulates the sense of taste are expected to take virtual experiences to the next level. For now, cognitive computing technologies are helping organizations to make meaning of visual and auditory inputs that can be applied in practice.

Making Meaning from Visual Inputs

Advancements in computer vision, image analytics, optical character recognition (OCR), pattern recognition, video analytics, etc. are helping organizations to make sense of visual inputs. The practicality of such technology is increasing every day with the advent of technologies that capture images and video, including drones, satellites, thermal cameras, medical equipment, etc., which are providing access to a variety of visual data sets that were previously not available. They enable not only process optimization like faster document handling and data entry, but also are helping fight disabilities by making the process of screening medical images easier and more portable.

Making Meaning from Auditory Inputs

Speech processing, audio analysis, voice recognition, etc. are gaining momentum since they deliver superior and more human-like experiences to end users. We all enjoy smartphones nowadays, don’t we? The ability to process speech as audio files, analyze audio content to identify patterns and apply natural language processing have matured to a point where they enable users to interact with machines in a conversational mode. These are areas that we believe enterprises should examine in the near term. Beyond speech processing, analysis of sound patterns - in areas such as of medical diagnostics and machine diagnostics - is expected to help organizations make and apply meaning from such sonic inputs.

EMULATING THE POWER OF THE HUMAN BRAIN

When it comes to deduction, reasoning and learning systems, technologies such as machine learning, deep learning and neural networks are enabling new machines to simulate and augment human thinking at higher levels.

Machine Learning

Machine learning capabilities and techniques are helping applications identify patterns in large amounts of information, classify information, make predictions and detect anomalies. These techniques help organizations build systems that can process large amounts of data while applying human-like thinking to information, classify and correlate disparate pieces of information, make more
informed decisions and trigger actions in downstream activities. Such systems are also capable of learning over time without needing to be explicitly programmed to do so.

Deep Learning

As a branch of machine learning, deep learning attempts to model high level abstractions in data. Deep learning methods are based on learning representations of data. It applies multiple layers of processing units where each successive layer uses the output of the previous layer as input. Each layer corresponds to different layers of abstraction, forming a hierarchy of concepts. Deep learning solutions help create applications that can be trained both in a supervised and unsupervised manner. Numerous techniques such as neural networks are under development in the field of deep learning and are expected to soon be part of our daily life.

Neural Networks

Neural networks are among the most used deep learning methods to create learning and reasoning systems. The application of back propagation, as part of neural networks, helps to generate continuous improvement in deep learning algorithms and train multi-layered deep learning systems to enhance their knowledge bases. Neural networks are helping us solve complex problems that typically took skills acquired over many years of learning and human experience. These capabilities are expected to help organizations to analyze audio, video and images as well as any human expert would, only at exponentially faster speeds and at much greater levels of depth and quantity.

MATCHING THE SPEED OF THOUGHT

These aforementioned technological advancements will generate a huge amount of data, both structured and unstructured, and that data will be available for analysis. In addition to the challenges of effectively processing such large quantities of data, the success of cognitive computing applications will depend on how vast bodies of knowledge are represented, how effectively they are searched and how natural language is processed when a system is queried.

High Performance & Hyperscale Computing

In our efforts to match the speed of thought, techniques such as HPC and hyperscale computing are a necessity. Such technologies require systems of intelligence to have huge stores of embedded smarts to be responsive in near instantaneous ways. The effective use of computing infrastructure to rapidly process large data streams is what gives life and energy to cognitive computing. Beyond mere performance enhancement, HPC and hyperscale computing provide added scalability, the ability to process multiple parallel jobs and an ability to program at the network’s edge. Such systems are therefore critical to unlocking the innate capabilities of cognitive computing.

Knowledge Representations & Ontologies

What makes human thought special is the ability to draw connections through massive amounts of data, information, experiences and calculations. Making such deductions is often so abstract a
The success of cognitive computing applications will depend on how vast bodies of knowledge are represented, how effectively they are searched and how natural language is processed when a system is queried.

process that we call it instinct or even cultural capital. Such deductions are enabled by the way human knowledge has been collected over years of learning; reasoning and logic is hardwired into human DNA. Knowledge representations and ontologies are now under development to create a shared or common understanding of information structure, enable the reuse of domain knowledge in disparate situations, make implicit assumptions explicit, draw parallels and learn from nonrelated experiences. These capabilities will not only help to speed information search and retrieval but also support complex algorithms that cross-pollinate ideas across nonrelated domains.

Natural Language Processing

NLP is bringing about a change in the way machines understand human language, intent and sentiments behind words. As more machines start interacting with humans in various forms, particularly in functions such as customer service and support, enterprises will be able to tackle new classes of business problems with tighter collaboration between man and machine.

Ultimately, when it comes to conversational interfaces, multilingual translations and overall human interaction with machines, NLP is critical for enabling better understanding of context and sentiment, while making meaning.

EMERGING INDUSTRY USE CASES

Use cases where the aforementioned technologies are making an impact can be viewed through two perspectives. The first questions what technologies are being seriously explored by individual industries. The second perspective assesses the growing deployment of cognitive technologies across industries.

Industry-Specific Scenarios

• **Banking, financial services and insurance companies** deal with an enormous amount of transactional data, contend with a large amount of back-office processing requirements and need to scale up efficiency in advising their customers. Automated systems that monitor, track and report suspicious activities to detect, predict and avoid fraud are improving with the application of machine learning. At a consumer level, robo-advisors have appeared that help customers make decisions based on their behavioral patterns by leveraging their Code Halos to personalize banking offerings. In the back office, cognitive technologies are automating document processing, contract management and other processes where a large amount of human manual effort is being accelerated with robotic process automation supervised by humans.
• In healthcare, medical image analysis and processing is poised to increase the portability of screening and diagnosis. For instance, specialized screening for conditions such as diabetic retinopathy traditionally was limited in availability due to the need for specialized equipment and numerous specialists—thus precluding many patients from being screened preventatively. However, the ability of deep learning systems and neural networks, which learn from previous human diagnosed images, is helping create systems of intelligence that can analyze medical images, predict the risk and existence of such conditions, and recommend either immediate human intervention or offer a reassurance of normality. This would help providers reach larger at-risk populations, many of whom would probably not screen themselves unless the problem was severe.

• Travel and hospitality companies are building applications that reduce the time-intensive process of surfing multiple websites, aggregators and customer review sites when consumers research and plan trips. These applications use machine learning applied on consumer behavior statistics to personalize travel deals and promotions and deliver it to the traveler via social media or e-mail. Chatbots that collect information and provide suggestions are also on the rise.

• Retailers thrive on personalization. Cognitive computing apps can act as a personal shopper answering frequently asked questions, providing suggestions about products, tapping into the engagement on social networks and making recommendations based on the shopper’s previous purchases, interests and needs.

• Manufacturers depend on the accuracy of supply and demand predictions. Cognitive computing can help sift through large amounts of data and provide the right information to disparate teams across finance, operations and the supply chain to facilitate better collaboration based on shared goals and assumptions. Machine learning is already helping optimize production capacity, supply chain management and pricing. Moreover, the ability to analyze images of facilities over time can help improve physical plant security; it can also help identify issues such as leakages and enable better utilization of inventory space and movement.

These are just some examples. Very soon we expect practically every industry to leverage the broad spectrum of cognitive technologies within their workflows to ensure high efficiency, better user experiences and agility.

Technology Driven Scenarios

• OCR for automated data extraction: OCR technology has been applied across the spectrum of industries specifically to extract information in images and optimize document management
processes. For instance, it has been nearly perfected for processing printed checks, and is fairly accurate for handwritten checks as well, although it occasionally requires manual confirmation. The technology is also now being applied to process insurance forms, mortgage documents and general health forms, where scanned images and photographs of such forms are being used to digitally send information.

- **Chatbots, robots and intelligent virtual assistants**: Call them what you may, these technologies represent the latest El Dorado of the AI world. Whether they are text-based or voice-enabled, these virtual personalities are becoming mainstream. From general purpose assistants like Siri, Google Assistant, Cortana or Amazon Echo, to specialized assistants that are trained in specific fields, bots are improving customer experiences across industries and building efficiencies at scale. Smart agents can be deployed for utilities and servicing; when coupled with augmented reality and the Internet of Things, they can both enhance the maintenance of domestic appliances and make high-value public infrastructure such as grids easier to run, more efficient and better monitored.

- **Video analytics**: This technology analyzes streaming video feeds from cameras to provide real-time analysis about user-predefined behaviors of people, vehicles or objects. It can help identify perimeter or tripwire breaches, abandoned objects, removed objects, vehicles moving in unexpected directions and more. In addition, a key differentiator from other analytics offerings is that intelligent video analytics indexes alerts, along with other activities, across cameras and sensors. For example, a whole set of attributes can be indexed covering each and every event. As such, the technology is finding multiple applications in advertising where emotion analytics can be used to evaluate messaging, logistics where self-driving automobiles are being explored and physical security where long-running footage can be easily scanned.

- **Image analytics**: This technology includes medical image processing in healthcare but extends far beyond that. It is also used in applying high-spatial-resolution imagery of terrain to analyze water, crops, build-up, forestry, contextual information, elevation detail and spectral indices, as well as helping conduct surveys for insurance purposes or for environmental needs. Analyzing real-time satellite or drone imagery with structures such as roads, driveways and sidewalks can automatically create and update layers in geographical information systems. We already discussed specific applications in image analytics – i.e., OCR.

The examples above are just a sampling. Many other technology-driven use cases are evolving to include speech-enabled applications, biometric security, motion analysis and event detection, multi-modal communication, conversation analysis, etc.

**THE ROAD AHEAD FOR ENTERPRISES: A HEURISTIC APPROACH**

Given this deluge of developments, enterprises need to carefully sort and examine how and where to adapt and adopt cognitive computing technologies based on their maturity (see Figure 2, next page). We recommend a four-step heuristic approach that will help enterprises not only see immediate ROI but also prepare the business to transform for a completely disrupted future landscape. Here is our approach:
- **Step One: Categorize the technology landscape across a maturity continuum.** Enterprises should look at the broad swath of technologies and categorize technologies across a maturity continuum. The closest for adoption are those that are highly mature, while those that are in experimental stages are at the far end of the spectrum.

- **Step Two: Identify immediate opportunities for adoption.** Take a look at immediate opportunities that can showcase ROI and help free up resources and funding for longer-term projects such as robotic process automation and infrastructure automation. Apply mature technologies to these opportunities so that the success rate is high and realization of value is fast.

- **Step Three: Pilot and prototype emerging areas.** Using a combination of mature and evolving technologies, identify use cases to deploy as pilots for business transformation. Prime among these are the development and deployment of virtual assistants - using deep learning for creating learning systems that can scale. The focus here is to ensure that as the enterprise transforms, the medium-term disruptions are managed effectively.

- **Step Four: Assess moonshot projects.** Think radically and identify disruptive technologies; the truly disruptive ones are those that are on a three-year trajectory and should involve research exploration, and adoption of technologies that are just emerging from academic research. While mature technologies can provide a strong foundation to these moonshot projects, what will make these successful is the application by design of embryonic technologies that have not yet fully bloomed.

**Getting Real**

As we move further into the digital era, three key imperatives rise to the surface: the ability to deliver superior experiences, the ability to derive insights for decision-making and the ability to optimize costs and productivity. Across these three imperatives, cognitive computing applications augment human capabilities for automation, enable creative and innovative vehicles for delivering experiences, and build applications that learn, deduce, reason and become more efficient over time. They will be designed to decode information from a wide variety of information sources and form factors, process and analyze such information, learn from limited information and adapt to contexts over time.

**Assessing Technology Maturity**

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Figure 2
In short, we are looking at a future where systems and applications will accelerate our intelligence, innovation and creativity by freeing up a large amount of our cognitive load. Enterprise adoption of cognitive technologies can accelerate the growth of your organization's business value and also its business benefit for the future.

**FOOTNOTES**

1. [http://whatis.techtarget.com/definition/haptics](http://whatis.techtarget.com/definition/haptics)
   [http://www.huffingtonpost.in/entry/virtual-dining-project-nourished_us_571fa82ee4b0a5ebde38f198](http://www.huffingtonpost.in/entry/virtual-dining-project-nourished_us_571fa82ee4b0a5ebde38f198)

2. [https://www.technologyreview.com/s/513696/deep-learning/](https://www.technologyreview.com/s/513696/deep-learning/)


   [https://www.cognizant.com/industries-resources/insurance/analytics_insurance_health_fraud_detection.pdf](https://www.cognizant.com/industries-resources/insurance/analytics_insurance_health_fraud_detection.pdf)
ABOUT THE AUTHORS

Srinivas TK
Associate Director, Global Technology Office
Srinivas.TK@cognizant.com

Srinivas TK (TK) is an Associate Director at Cognizant’s Global Technology Office (GTO) and is responsible for thought leadership dissemination, market messaging and managing GTO’s technology alliances. He is a deep generalist with 16-plus years of cross-functional experience in the IT services industry and has played a multitude of roles across consulting, delivery, business development, marketing and alliance management. He received a post-graduate degree in business management from T.A. Pai Management Institute, Manipal. TK can be reached at Srinivas.TK@cognizant.com | LinkedIn: www.linkedin.com/in/srinivastk.

Ramakrishnan Viswanathan
Manager, Business Development, Cognitive Computing & Data Science Lab
Ramakrishnan.Viswanathan3@cognizant.com

Ramakrishnan Viswanathan is a Manager of Business Development within Cognizant’s Cognitive Computing & Data Science Lab (CDS). He has over 12 years of experience in pre-sales, strategic partnership, business development and business analysis for Cognizant’s strategic engagements, as well as its Application Value Management Practice and Global Technology Office. Ram has an executive program in sales and marketing (EPSM) degree from Indian Institute of Management, Calcutta. He can be reached at Ramakrishnan.Viswanathan3@cognizant.com | LinkedIn: www.linkedin.com/in/ramakrishnanviswanathan.
ABOUT COGNIZANT

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World Headquarters
500 Frank W. Burr Blvd.
Teaneck, NJ 07666 USA
Phone: +1 201 801 0233
Fax: +1 201 801 0243
Toll Free: +1 888 937 3277

European Headquarters
1 Kingdom Street
Paddington Central
London W2 6BD England
Phone: +44 (0) 20 7297 7600
Fax: +44 (0) 20 7121 0102

India Operations Headquarters
#5/535 Old Mahabalipuram Road
Okkiyam Pettai, Thoraipakkam
Chennai, 600 096 India
Phone: +91 (0) 44 4209 6000
Fax: +91 (0) 44 4209 6060