Module 2

**Cognitive Computing**

The essence of cognitive computing is the acquisition and analysis of the right amount of information in context with the problem being addressed.

A cognitive system must be aware of the context that supports the data to deliver value. When that data is acquired, curated, and analysed, the cognitive system must identify and remember patterns and associations in the data.

This iterative process enables the system to learn and deepen its scope so that understanding of the data improves over time.

One of the most important practical characteristics of a cognitive system is the capability to provide the knowledge seeker with a series of alternative answers along with an explanation of the rationale or evidence supporting each answer.

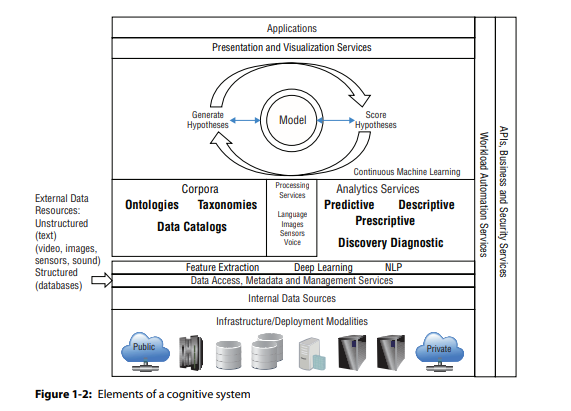
A cognitive computing system consists of tools and techniques, including Big Data and analytics, machine learning, Internet of Things (IoT), Natural Language Processing (NLP), causal induction, probabilistic reasoning, and data visualization

Cognitive systems have the capability to learn, remember, analyze, and resolve in a manner that is contextually relevant to the organization or to the individual user

**Design Principles of Cognitive Systems**

The initial model is developed by the designers of the system, but the cognitive system will update the model and use the model to answer questions or provide insights.

The corpus is the body of knowledge that machine learning algorithms use to continuously update that model based on its experience, which may include user feedback



A corpus is a machine‐readable representation of the complete record of a particular domain or topic. Experts in a variety of fields use a corpus or corpora for tasks such as linguistic analysis to study writing styles or even to determine authenticity of a particular work.

Deciding what to leave out is as important as what to include.

In a cognitive computing application, the corpus or corpora represent the body of knowledge the system can use to answer questions, discover new patterns or relationships, and deliver new insights

Before the system is launched, however, a base corpus must be created and the data ingested. The contents of this base corpus constrain the types of problems that can be solved, and the organization of data within the corpus has a significant impact on the efficiency of the system. Therefore, you need a good understanding of the domain area for your cognitive system before determining the required data sources

. The corpus needs to include the right mix of relevant data resources that can enable the cognitive system to deliver accurate responses in the expected timeframe. When developing a cognitive system, it’s a good idea to err on the side of gathering more data or knowledge because you never know when the discovery of an unexpected association will lead to important new knowledge

Given the importance placed on having the right mix of data sources, a number of questions have to be addressed early in the design phase for a cognitive computing system:

■ Which internal and external data sources are needed for the specific domain areas and problems to be solved? Will external data sources be ingested in whole or in part?

■ How can you optimize the organization of data for efficient search and analysis?

■ How can you integrate data across multiple corpora?

■ How can you ensure that the corpus is expanded to fill in knowledge gaps in your base corpus? How can you determine which data sources need to be updated and at what frequency?

During the design phase of a cognitive system, a key consideration is whether to construct a taxonomy or ontology if none already exist for the domain. Having such a structure may simplify the operation of the system and make it more efficient.

However, if the designers are responsible for ensuring that a taxonomy or ontology is complete and up to date, it may be more effective to have the system continuously evaluate relationships between domain elements rather than have the designers build that into a hard‐coded structure.

The choice of data structures can greatly impact the performance of the system on repetitive tasks such as knowledge retrieval for generating and scoring hypotheses. It is therefore advisable to model or simulate typical workloads during the design phase before committing to specific structures

**Corpus Management Regulatory and Security Considerations**

Data sources and the movement of that data are increasingly becoming heavily regulated, particularly for personally identifiable information. Some general issues of data policies for protection, security, and compliance are common to all applications, but cognitive computing applications learn and derive new data or knowledge that may also be subject to a growing body of state, federal, and international legislation

**Bringing Data into the Cognitive System**

Unlike many traditional systems, the data that is ingested into the corpus is not static. You need to build a base of knowledge that adequately defines your domain space. You begin populating this knowledge base with data you expect to be important. As you develop the model in the cognitive system, you refine the corpus. Therefore, you will continuously add to the data sources, transform those data sources, and refine and cleanse those sources based on the model development and continuous learning.

**Leveraging Internal and External Data Sources**

Most organizations already manage huge volumes of structured data from their transactional systems and business applications, and unstructured data such as text contained in forms or notes and possibly images from documents or corporate video sources

Just as an individual learns to identify the right external sources to support decision making—from newspapers to network news to social media on the Internet—a cognitive computing system generally needs to access a variety of frequently updated sources to keep current about the domain in which it operates

**Data Access and Feature Extraction Services**

The feature extraction layer has to complete two tasks. First, it has to identify relevant data that needs to be analyzed. The second task is to abstract data as required to support machine learning.

Any data that is considered unstructured—from video and images to natural language text—must be processed in this layer to find the underlying structure. Feature extraction and deep learning refer to a collection of techniques—primarily statistical algorithms—used to transform data into representations that capture the essential properties in a more abstract form that can be processed by a machine learning algorithm

Although these layers appear as a straightforward process of importing and refining data, it should be noted that external sources may be added or removed based on their value in hypothesis generation and scoring over time. For example, a medical diagnosis system may add a new external source of case files or delete a journal if it is found to provide unreliable evidence. For cognitive systems that provide evidence to support hypotheses in regulated industries, the data access layer processes or the corpora management services should maintain a log or other state data so that an auditor can determine what was “known” at any point in time

**Analytics Services**

Analytics refers to a collection of techniques used to find and report on essential characteristics or relationships within a data set. In general, the use of an analytic technique provides insights about the data to guide some action or decision. A number of packaged algorithms such regression analysis are widely used within solutions. Within a cognitive system, a wide range of standard analytics components are available for descriptive, predictive, and prescriptive tasks within statistical software packages or in commercial component libraries.

**Machine Learning**

Continuous learning without reprogramming is at the heart of all cognitive computing solutions. Although the techniques used to acquire, manage, and learn from data vary greatly, at their core most systems apply algorithms developed by researchers in the field of machine learning.

A typical machine‐learning algorithm looks for patterns in data and then takes or recommends some action based on what it finds. A pattern may represent a similar structure (for example, elements of a picture that indicate a face), similar values (a cluster of values similar to those found in another data set) or proximity (how “close” the abstract representation of one item is to another).

Cognitive computing systems use machine‐learning algorithms based on inferential statistics to detect or discover patterns that guide their behavior.

**Supervised Learning**

Supervised learning refers to an approach that teaches the system to detect or match patterns in data based on examples it encounters during training with. The training data should include examples of the types of patterns or question‐answer pairs the system will have to process.

Learning by example, or modeling, is a powerful teaching technique that can be used for training systems to solve complex problems. After the system is operational, a supervised learning system also uses its own experience to improve its performance on pattern matching tasks.

**Reinforcement Learning**

Reinforcement learning is a special case of supervised learning in which the cognitive computing system receives feedback on its performance to guide it to a goal or good outcome. Unlike other supervised learning approaches, however, with reinforcement learning, the system is not explicitly trained with sample data. In reinforcement learning, the system learns to take next actions based on trial and error. Some typical applications of reinforcement learning include robotics and game playing. The machine learning algorithms assess the goodness or effectiveness of policies or actions, and reward the most effective actions. A sequence of successful decisions results in reinforcement, which helps the system generate a policy that best matches the problem being addressed.

For example, reinforcement would be used in robotics or a self‐driving car. The learning algorithm must discover an association between the reward and a sequence of events leading up to the reward

**Unsupervised Learning**

An unsupervised learning system can identify new patterns, instead of trying to match a set of patterns it encountered during training. Unlike supervised learning, unsupervised learning is based solely on experience with the data rather than on training with sample data

Unsupervised learning is the best approach for a cognitive computing system when an expert or user cannot give examples of typical relationships or question‐answer pairs as guides to train the system

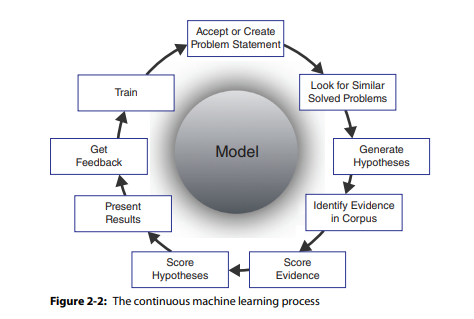
Unsupervised learning is also appropriate when new patterns emerge faster than humans can recognize them so that regular training is impossible. For example, a cognitive computing system to evaluate network threats must recognize anomalies that may indicate an attack or vulnerability that has never been seen before. By comparing the current state of the network with historical data, an unsupervised learning system can look for changes or a state it has never seen before and flag that as suspect activity. If the activity is benign, the system can learn from that experience not to flag that state if it sees it again in the future.

unsupervised learning you begin with a massive amount of data, and without preconceived notions about the patterns, relationships, or associations that may be found.

**Hypotheses Generation and Scoring**

A hypothesis in science is a testable assertion based on evidence that explains some observed phenomenon or relationship between elements within a domain. The key concept here is that a hypothesis has some supporting evidence or knowledge that makes it a plausible explanation for a causal relationship.

This is conceptually similar to a hypothesis in logic, generally stated as “if P then Q”, where “P” is the hypothesis and “Q” is the conclusion.



**Hypothesis Generation**

In a typical cognitive computing system, there are two key ways a hypothesis may be generated.

1. The first is in response to an explicit question from the user, such as “What might cause my fever of 102 and sore throat?”

In this scenario, the cognitive computing application must look for plausible explanations. It could, for example, start by presenting all the possible conditions in which you might expect to see these symptoms. (Each condition would be a candidate hypothesis explaining the symptoms.) Alternatively, it may recognize that there are too many answers to be useful and request more information from the user to refine the set of likely causes. This approach to hypothesis generation is frequently used when the goal is to detect a relationship between cause and effect in a domain in which there is a known set of causes and a known set of effects, but there are so many combinations that the mapping of all causes to all effects is an intractable problem for humans to solve.

**Typically, this type of cognitive computing system will be trained with an extensive set of question/answer pairs.**

1. The second type of hypothesis generation does not depend on a user asking a specific question. Instead, the system constantly looks for anomalous data patterns that may indicate threats or opportunities. Detecting a new pattern creates a hypothesis based on the nature of the data. For example, if the system is monitoring network sensors to detect threats, a new pattern may create a hypothesis that this pattern is a threat, and the system must either find evidence to support or refute that hypothesis.

**Hypothesis Scoring**

Hypothesis scoring is a process in which the representation of the hypothesis is compared with data in the corpus to see what evidence exists to support the hypothesis, and what may actually refute it (or rule it out as a valid possible explanation). In fact, scoring or evaluating a hypothesis is a process of applying statistical methods to the hypothesis‐evidence pairs to assign a confidence level to the hypothesis. The actual weights that are assigned to each piece of supporting evidence can be adjusted based on experience with the system and feedback during training and during the operational phase. If none of the hypotheses score above a predetermined threshold, the system may ask for more evidence (a new diagnostic blood test, for example) if that information could change the confidence in the hypothesis.

**Presentation and Visualization Services**

. The general advantage for visualization tools is their capability to graphically depict relationships between data elements in ways that focus attention on trends and abstraction rather than forcing the user to find these patterns in the raw data.

As a cognitive computing system cycles through the hypothesis generation and scoring cycle, it may produce new answers or candidate answers for a user. In some situations, the user may need to provide additional information. How the system presents these findings or questions will have a big impact on the usability of the system in two ways. First, when presenting data supporting a hypothesis such as a medical diagnosis or recommended vacation plan, the system should present the finding in a way that conveys the most meaning with the least effort on the part of the user and support the finding with relevant evidence. Second, when the system requires additional details to improve its confidence in one or more hypotheses, the user must present that data in a concise and unambiguous way

**Infrastructure**

The two major design considerations for cognitive computing infrastructure decisions are:

1. Distributed Data Management—
2. Parallelism—

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**What is ontology in simple words?**

**The simplistic ontology definition is the branch of philosophy that studies existence. The word ontology comes from the stem of the Greek word on or ontos, meaning "being." So, ontology studies and attempts to understand the very nature of existence, reality, being, and becoming.**

**Taxonomy is a science that deals with naming, describing and classification of all living organisms including plants.**

**The Role of NLP in a Cognitive System**

NLP is a set of techniques that extract meaning from text. These techniques determine the meaning of a word, phrase, sentence, or document by recognizing the grammatical rules—the predictable patterns within a language. They rely, as people do, on dictionaries, repeated patterns of co‐occurring words, and other contextual clues to determine what the meaning might be. NLP applies the same known rules and patterns to make inferences about meaning in a text document.

1. **The Importance of Context**

Translating unstructured content from a corpus of information into a meaningful knowledge base is the task of NLP. Linguistic analysis breaks down the text to provide meaning. The text has to be transformed so that the user can ask questions and get meaningful answers from the knowledge base. . With NLP it is possible to interpret data and the relationships between words. It is important to determine what information to keep and how to look for patterns in the structure of that information to distill meaning and context. This context is critical to assessing the true meaning of text‐based data. Patterns and relationships between words and phrases in the text need to be identified to begin to understand the meaning and actual intent of communications

An NLP builds layers of contextual understanding by first looking to the left and right of that word to identify verb phrases, nouns, and other parts of speech. To build up the layers of understanding, the NLP can extract elements of meaning that can answer questions such as:

■ Is there a date? When was the text generated?

■ Who is speaking?

■ Are there pronouns in the text? To whom or what do they refer?

■ Are there references to other documents in the text?

■ Is there important information in a previous paragraph?

■ Are there references to time and place?

■ Who or what is acting, and who/what is being acted upon?

What are the relationships of the entities (people, places, and things) to each other (usually indicated by verbs)? It is important to distinguish the actor and recipient of transitive verbs. (For example, who is doing the hitting and who is getting hit.

1. **Connecting Words for Meaning**

To understand language we have to understand the context of how words are used in individual sentences and what sentences and meanings come before and after those sentences. We are required to parse meaning so that understanding is clear

1. **Understanding Linguistics**

NLP is an interdisciplinary field that applies statistical and rules‐based modeling of natural languages to automate the capability to interpret the meaning of language. Therefore, the focus is on determining the underlying grammatical and semantic patterns that occur within a language or a sublanguage (related to a specific field or market). For instance, different expert domains such as medicine or laws use common words in specialized ways. Therefore, the context of a word is determined by knowing not just its meaning within a sentence, but sometimes by understanding whether it is being used within a particular domain. For example, in the travel industry the word “fall” refers to a season of the year. In a medical context it refers to a patient falling.

1. **Language Identification and Tokenization**

In any analysis of incoming text, the first process is to identify which language the text is written in and then to separate the string of characters into words (tokenization ). Many languages do not separate words with spaces, so this initial step is necessary.

1. **Phonology**

Phonology is the study of the physical sounds of a language and how those sounds are uttered in a particular language. This area is important for speech recognition and speech synthesis but is not important for interpreting written text

1. **Morphology**

Morphology refers to the structure of a word. Morphology gives us the stem of a word and its additional elements of meaning. Is it singular or plural? Are the verbs first person, future tense, or conditional? This requires that words be partitioned into segments known as morphemes that help bring understanding to the meaning of terms. This is especially important in cognitive computing, since human language rather than computing language is the technique for determining answers to questions. Elements in this context are identified and arranged into classes. There are elements including prefixes, suffixes, infixes, and circumfixes.

**Lexical Analysis**

Lexical analysis within the context of language processing is a technique that connects each word with its corresponding dictionary meaning.

The process of analyzing a stream of characters from a natural language requires a sequence of tokens (a string of text, categorized according to the rules as a symbol such as a number or comma.

The analyzer (sometimes called a lexer ) categorizes the characters according to the type of character string. When this categorization is done, the lexer is combined with a parser that analyzes the syntax of the language so that the overall meaning can be understood.

The lexical syntax is usually a regular language whose alphabet consists of the individual characters of the source code text. The phrase syntax is usually a context‐free language whose alphabet consists of the tokens produced by the lexer. Lexical analysis is useful in predicting the function of grammatical words that initially could not be identified. . For example, there might be a word like “run” that has multiple meanings and can be a verb or a noun.

**Syntax and Syntactic Analysis**

Syntax applies to the rules and techniques that govern the sentence structure in languages. The capability to process the syntax and semantics of natural language is critical to a cognitive system because it is important to deduct inferences about what language means based on the topic it is being applied to. Therefore, although words may have a general meaning when used in conversation or written documents, the meaning may be entirely different when used in context of a specific industry. For example, the word “tissue” has different definitions and understanding based on the context of its use

**Discourse Analysis**

One of the most difficult aspects of NLP is to have a model that brings together individual data in a corpus or other information source so that there is coherency. It is not enough to simply ingest vast amounts of data from important information sources if the meaning, structure, and intention cannot be understood.