CHAPTER 1

MAN AND THE MACHINE

1. INTRODUCTION

The present thesis describes the research regarding finding solutions to disambiguation of linguistic ambiguity at the word level in the environment of context of machine translation. A comparison between how human beings as opposed to machines handle linguistic ambiguity could possibly be made and it would be illuminating. I start with comparative study of capabilities and limitations of man and the machine. Such a comparative study can be done only after understanding in detail how the machine works in the light of the theory of artificial intelligence.

A detailed study of how machines work encompasses issues like comparison between human beings and machines (section 2) in terms of their strengths (section 2.1) and weaknesses (section 2.2), comparison between natural languages and artificial languages (section 3) and artificial intelligence (section 4). The theory of Artificial Intelligence (AI) discusses definition of AI (section 4.1), genesis of AI (section 4.2), subfields of AI (section 4.3), AI and the cognitive process (section 4.4), and progress & future of AI (section 4.5).

Several attempts have been made to define human beings in relation to the animal kingdom treating mankind as a special sort of creation. Works of fiction like Hans Christian Andersen’s ‘The Nightingale’ and Mary Shelley’s ‘Frankenstein’ illustrate vividly the range of human curiosity concerning the creation of life from inanimate material. In Dorothy’s Tiktok, clothes seem to be the defining quality of a human, differentiating it from both a machine (Tin Man) and an animal.

With invention of machines the question arose whether animals are merely a variant of the machine. Still it points out where animals fall short of human hood. The issue is human beings’ dual nature i.e. human beings’ animal nature (Michel de Montaigne et al in the sense that human is not superior) and human beings’ mechanical nature (Rene Descartes’s proposition).

Human mechanical nature is discussed in terms of the relation between the internal working of human beings and clocks, with their intricate, precise, and more or less unfailing machinery, symbolizing the new age of scientific method and industrial discipline (Newton).

The next question that is usually asked is whether human skill is capable to make a machine like a man. In other words, discourses on this topic are underlined by the thinking whether human beings can create a machine, the automata that
can compete human beings’ identity, sexuality (the basis of creation), and the power of domination.

Human beings have the ambition to equate themselves with the nature’s power. This ambition motivates human beings to keep on trying to produce/manufacture a man-like machine, a thinking machine, a creative machine which would embody artificial intelligence. Nowadays ‘machines’ have taken very advanced forms of ‘machines’, and it is used interchangeably with ‘computers’. On 16 February 2008, Helen Briggs, a science reporter, BBC News\(^2\), reported that a leading US inventor has predicted that Machines will achieve human-level (artificial) intelligence including our emotional intelligence by 2029. It is interesting to note at this point that Allen Turing\(^3,4\) had already forecast that this would happen by the year 2000.

Despite years of research into artificial intelligence, the goal of building machines that can think about ordinary things the way any average person can think is still beyond reach. Now machines can design airplane engines, diagnose medical symptoms, analyze and repair problems in space craft, plan the best route for your rental car, and transcribe speech into text like an expert. But still machine cannot describe a typical photograph or recognize objects the way a three year old child can. It cannot understand sentences or draw the simplest conclusions about ordinary life. It is so as machines lack common sense that human beings claim to have.

Commonsense thinking is certainly more complex than many of the intellectual accomplishments that attract attention and respect, because the mental skills we call expertise often engage large amounts of knowledge but usually employ only a few types of representation. In contrast, common sense involves many kinds of representation and thus requires a larger range of different skills\(^5\). ‘Commonsense Knowledge’ and ‘the capacity for commonsense reasoning’ are the two facets of the problem of giving commonsense to computers. Common sense subsumes the thinking process.

The thinking process is supported by various types of knowledge and ways to represent knowledge. To make a machine behave like a thinking human being, we need to represent common sense knowledge either in the form of rules (of cause & effect) or in the form of descriptions of situations (in sequences).

The first step towards building a thinking machine consists of obtaining an understanding of similarities and differences between human beings and machines, as well as to know the strengths and the weaknesses of human beings and computers.

2. HUMAN BEING AND COMPUTERS

Human brains and computers are complementary in their strengths and weaknesses.
2.1 HUMAN BEING’S STRENGTHS

Human Beings have the ability to approximate complex events in useful ways (using words, concepts). They can integrate information from many sources. They can make effective search of a large memory. They can integrate past experience with the present situation. There is a tight coupling of higher-level cognition with perception. Non-logical processes such as intuition are available for prediction and understanding.

2.2 HUMAN BEING’S WEAKNESSES

Human Beings have a high error rate, slow responses and great difficulties with logic and formal reasoning as compared to silicon time scales. A huge loss of details in memory storage is possible in case of human beings due to several reasons such as prejudicing. They are not transparent in the sense that they lack explanation for their actions.

Human beings and computers can be compared by studying the elements of the human cognition process and comparing it to the computer. Human beings possess a unique ability of cognition which facilitates spotting differences and observing visual patterns. Computers do not have cognitive abilities of the type that human beings possess yet computers can do calculations faster and more accurately. Computers are not creative as human beings but they are more precise than human beings. Both human beings and computers store data in invisible Data-Bases. Computers can make visual presentation of the data which can be seen on the computer screen. Internally, in computers, there are arrays of grid cells that comprise Vector Data (Patterns & Structures). The computer documents are instantly available and can be opened and processed with far greater freedom and flexibility in terms of exchanges of products and services than printed matter. The advantages of speed, visual impact, ease of use, convenience, and cost-effectiveness all come together at the time of the use of the computer.

We, human beings use some language while thinking consciously. This leads us to find the difference between a natural language and an artificial language.

3. NATURAL LANGUAGES AND ARTIFICIAL LANGUAGES

Natural languages refer to the languages used in the environment of human beings. Artificial languages refer to the languages used in the environment of machines. Artificial languages are used to instruct, to run the machine as per the need.

Human beings build commonsense overtly with the help of natural language and apply it through natural language only. A modern attempt to build a common sense database needs to start with a study of natural language and applying its techniques to develop artificial language. A precise (but may be difficult) artificial language which can state facts clearly and unambiguously can be developed.
The door to the task of developing such artificial language was opened when Richard Montague’s Universal Grammar refused to distinguish between artificial and natural languages with reference to formal ascription of meaning. Formal ascription of meaning has to be sharply distinguished from meaning conferred upon signs by using language.

Development of any artificial language asserts/presumes that meaning in pragmatic sense can be separated from its forms, that is, forms of linguistic units, say, words / lexemes etc. Computers do not understand the signs they are handling as in the way human beings do. Operation of a machine deals with formalization of natural language. For computers, syntactic tokens are produced by relating them to something that the tokens signify. Natural language can be interpreted / translated into artificial language through machine.

Whatever candidates for meanings are considered (individuals, sets, structures, functions from possible worlds, truth values); they are assigned to formulas of some given (object) language (within the meta-language). An isomorphism between syntactic structure and semantic structure is all that is needed to give meaning to the expressions of a language. The meanings can be ascribed to its formal constituents, observing the conventions of the syntax (and of the meta-language). It simply presupposes that meta-language is already available. The expressions of the (object) language can be mapped upon the semantic content of such meta-language. Every intelligible sense of ‘formal system’ implies that such a system has to be used by someone in order to have any connection with meaning. The sense of a formal system is all about context dependent interpretation.

Thus, meaning can be formalized using artificial languages like natural languages. The issue is how to achieve formalization of meaning using artificial languages.

There are two opposing ideologies / thoughts about man and machine. The conflict is between whether there are comparable similarities between man and machine; or whether they are completely different. The research in the field of developing man-like machine is known as Artificial Intelligence.

4. ARTIFICIAL INTELLIGENCE

Humanity is on the brink of advances that will see tiny robots implanted in people’s brains to make them more intelligent, said Ray Kurzwell. He added that machines were already doing hundreds of things humans used to do, at human levels of intelligence or better, in many different areas. (Mr. Ray Kurzwell is one of 18 influential thinkers chosen to identify the great technological challenges facing humanity in the 21st Century by the US National Academy of Engineering.)

The world may see a radical evolution of the human species with the merger of man and machine and rapid innovation in gene research and nanotechnology. The result will be a world where there is no distinction between the biological and
the mechanical, or between physical and virtual reality. All researches involved in building anything that resembles creation of the nature, come under AI, artificial intelligence.

4.1 DEFINITIONS OF ARTIFICIAL INTELLIGENCE

The term Artificial Intelligence was introduced in 1956 by the US computer engineer John McCarthy\(^1\). The standard connotation of the term is the design of hypothetical or actual computer programs or machines to do things normally done by minds, such as playing chess, thinking logically and writing poetry, composing music, or analyzing chemical substances. The challenging problems arise in the attempt to stimulate functions of intelligence that are largely unconscious, such as those involved in vision and language.

The confusion about the definition of Artificial intelligence (AI) arises from the ill-defined word intelligence. Though the followers of weak AI simply state that some "thinking –like” features are found in expert systems. But followers of strong AI makes the bold claim that computers can be made to think on a level (at least) equal to humans.

According to an interpretation made by followers of strong AI, (also called as hard AI) all thinking is computation, from which it follows that conscious thought can be explained in terms of computational principles, and that feelings of conscious awareness are evoked mere by certain computations carried out by the brain or by a computer. A debatable implication of this view is that a computer that can pass the Turing Test must be acknowledged to be conscious\(^12\).

The followers of Weak AI interpret artificial intelligence in slightly low tone. According to them conscious awareness is a property of certain brain processes, and whereas any physical behavior can, in principle at least, be simulated by a computer using purely computational procedures, computational simulation cannot in itself evoke conscious awareness\(^12\).

Now-a-days AI, Artificial Intelligence has shifted to Amplified Intelligence. The focus and theme of Amplified Intelligence research is human-centered computing which is about fitting technology to people instead of fitting people to technology. Amplified Intelligence, AI, technologies refer to building cognitive prostheses, computational systems that leverage and extend human intellectual capacities, just as eyeglasses are a kind of ocular prosthesis. Building cognitive prostheses is fundamentally different from AI’s traditional Turing Test ambitions. Cognitive prostheses don’t set out to imitate human abilities, but to enhance them. Current active research areas under the umbrella of AI, Artificial/Amplified Intelligence include adjustable autonomy, advanced interfaces and displays, biologically-inspired robotics, cognitive work analysis, communication and collaboration, computer-mediated learning systems, expertise studies, human strength and endurance amplifying devices, intelligent data understanding, knowledge modeling and sharing, knowledge representation, natural language processing, software agents and work practice simulation.
In fine, we can think of artificial intelligence as the field of study in which the possibility and practicality of developing intelligence outside human beings is experimented. It can partake the development of intelligent tools that can work independently or work as prosthesis for human beings.

4.2 GENESIS OF ARTIFICIAL INTELLIGENCE

AI comes into play due to the invention of various techniques, namely, Bayesian Classification / Networks, Neural Network, Search Engine and their combinations. Bayesian Network (also Belief Network) is a mechanism for representing probabilistic knowledge. Inference algorithms in Bayesian networks use the structure of the network to generate inferences efficiently compared to joint probability distributions over all the variables.

Neural Network (NN) is the mathematics-based network of programs that function in a manner similar to the manner in which human brains function. Neural Networks (NN) can learn. For example, NNs can approximate a given function. Neural Networks methods are used to provide non-linear operations on representations. Such operations deal with the relational links between input and output signals in non-linear fashion. Perceptron is an early example of a neural network; it is a pattern-recognition machine into which distinctive features of a target patterns are input with weights reflecting their relative importance.

Search Engines are designed for the finding of a path from a start state to a goal state, similar to planning, yet different.

A combination of techniques is also possible as in the case of the use of neural networks to guide search. Availability of 'Association Rules', facility of maps and scatter plot graphical display, use of decision trees etc. also facilitate AI.

The availability of computers may create many problems. We think that computers are better than human beings and start to rely too much on computers resulting in loss of certain skills. Information on the internet is only a primary source of information. Addiction to computers creates social problems also like societal disaffection and isolation.

Dr. Ken Ford (Director, Institute for the Interdisciplinary Study of Human & Machine Cognition (IHMC) University of West Florida) warned in one interview (by Astrobiology Magazine staff writer) that it is not just enough to make machines behave more like humans (the thought is similar to shastrawidyaa, in Indian tradition), but it is also necessary to improve humans working and playing in concert with their new and inevitably busy machine environments (the thought is similar to astrawidyaa in Indian tradition)
4.3 SUBFIELDS OF ARTIFICIAL INTELLIGENCE

There are four subfields of artificial intelligence, viz., Robotics, Computer Vision, Expert Systems and Natural Language Processing, NLP. (We are mainly largely concerned about NLP).

Robotics incorporates Robotic arms; it is fast and accurate but classified as ‘not intelligent’ as it is mechanical in nature. Moderately intelligent Computer Vision refers to devices with which they can see and do remote sensing. Such devices are trained to spot patterns. Expert systems are intended to act like human beings in infinite field such as automatic programming. Expert systems also deal with knowledge in a specified field, such as medical diagnosis. They are designed to offer advice or make decisions requiring a high level of expertise. They are featured as ‘not intelligent’ as knowledge put into is by human beings and not by themselves. Natural Language Processing (NLP) deals with understanding a statement by interpreting and responding to it. It is still under development as yet computers have no extended cognition regarding metaphors, images and paraphrases.

Thus, AI mainly concerns itself with Automatic Programming, Natural Language Processing (NLP), Knowledge Engineering / Knowledge Representation, Planning, Constraint Satisfaction, Machine Learning, Visual Pattern Recognition, Speech Recognition, State Space / Problem Space and the Combined Problems.

Automatic Programming refers to the task of describing what a program should do and the task of having the AI system that ‘write’ the program. The challenge of Automatic Programming is to build a system that implements the given specification and prove that the implementation matches the specification. It can do better than a team of programmers.

Natural Language Processing (NLP) refers to the processing and (perhaps) understanding human (natural) languages. It encompasses search-based / Neural Network-based / Statistical or Probabilistic NLP. Processing of a text in natural languages by computers includes evaluating, indexing, parsing, translating, correcting, and understanding the text. Natural languages can be processed by computers at different levels like, the character level, the word level, the sentence level and the message level. Entering text is NLP at character level. Word level NLP includes checking spellings, making word lists and concordances, indexing and counting word frequencies in terms of type-token. Sentence level NLP refers to parsing, checking grammar and style. Message level NLP means knowledge-presentation, question answering, search, machine translation, and generation of language. Tools for computing natural languages include Machine Readable dictionary (MRD) or thesaurus and large corpora (that can facilitate the use of its statistical properties).

Knowledge Engineering / Knowledge Representation refer to transforming what we know about a particular domain into a form in which a computer can understand it.
Planning in AI is concerned with systems that construct sequences of actions to achieve goals in real-world-like environments. Planning is making decisions for given set of actions, a goal state, and a present state, about the sequences of actions that must be taken so that the present state is turned into the goal state in real-world-like environments.

Machine Learning refers to the programs that learn from experience. It includes Reinforcement Learning and Neural Networks among many other fields.

Decision Tree Learning, Support Vector Machines, Memory-based Learning and Bayesian Learning are a few of Machine Learning methods. Similarity estimation among contexts (texts overlaps etc.) and among lexical items with respect to machine readable dictionaries (MRD) and Lexical Knowledge Bases (LKB) are useful in Machine Learning in the field of NLP. It can be achieved by combining pattern induction with probabilistic description of word semantic classes for Machine Learning.

Active machine learning refers to the use of annotated data to drive the sampling of further evidence from material which is not annotated.

In biology, learning to adapt to given demands corresponds to learning by an individual organism. However, in nature there is a different type of adaptation, which is achieved by evolution. We can use evolutionary mechanisms to create machine learning programs.

Constraint Satisfaction is solving problems, using a variety of techniques. Visual Pattern Recognition is the ability to reproduce the human sense of sight on a machine. Speech Recognition is conversion of speech into text.

State Space or Problem Space is the formulation of an AI problem into states and operators. There is usually a start state and a goal state. The problem space is searched to find a solution.

Thus, the field of AI includes the study and automation of intelligent behavior. Its success is proposed to be measured by applying Turing Test\textsuperscript{3, 4} or in a limited domain. AI study can be the study of human intelligence with computer as a tool\textsuperscript{17} or the study of machine intelligence as artificial intelligence. Such a study can be theoretical, empirical or applied.

AI is often compared to Cognitive Science. It involves application of theory / theories of Cognitive Science. In short, manlike machine’s functioning should map human beings’ cognitive process.

4.4 ARTIFICIAL INTELLIGENCE AND COGNITIVE PROCESS

The field of Cognitive Science includes the study of cognition, mental activity involving acquisition, storage transformation and use of knowledge. It is concerned
with the study of mental processes such as memory, language, thought and consciousness. Its success is measured in terms of explanatory power of a cognitive theory which includes psychological and neurological plausibility, computational and representational power, practical applicability to educate, design etc.

4.4.1 Cognitive Computation: Human and Machine

The human being’s brain power comprises the knowledge, skills, and personality quirks which make them human. Brains are made up of carbon compounds whereas digital computers are made from silicon. Digital computers are accurate (essentially no errors), fast (nanoseconds) and execute long chains of serial logical operations (billions). Somehow brains are inaccurate (low precision, noisy), slow (milliseconds, 106 times slower) and execute short chains of parallel non logical associative operations (perhaps 10 operations). But humans do better and faster than computers in many tasks such as speech recognition, object recognition, face recognition, motor control, most complex memory functions and information integration.

To do real cognitive computation we need to build brain-like computers! A brain-like computer means a computer that can function like a human brain.

To develop brain-like computers, brain-like architecture will be needed to run these applications efficiently. These attempts usually start with massively parallel arrays of neural computing elements. These elements are based to some degree on biological neurons. Biological neurons are extremely complex electrochemical structures. They are similar to the layered 2-D anatomy of mammalian cerebral cortex.

Hierarchical Temporal Memory (HTM) model simulates what would be commonly classified as intelligence. It captures the essential computation by constructing tree-like hierarchies.

4.4.2 The Computational Model of Cognition

Computational Model of Cognition refers to a computer program which implements a theory of aspects of cognition or to the representations and processes of some cognitive theory made precise by analogy with data structures and algorithms. Computational Modeling of human cognition is not programming but it is the theory of human cognition; at best such models may inspire the construction of a theory of Computational models of human cognition can be useful as research tools in cognitive science.

To construct such computational models, one first needs to define what the system is required to do and the constraints under which it is required to operate. One also needs to consider a condition/capability needed by a user to solve a problem or achieve an objective as well as the part of the world within which the problem exists.
4.4.2.1 The Function of Computational Models of Human Cognition

The Computational Model of Human Cognition simulates the Cognitive Process. It generates behavior by implementing a given theory. Theory necessarily explains the behavior and describes the Cognitive Process.

The function of such computational models can be sketched as shown in figure (1).

![Diagram of Computational Models](image)

Figure 1: The function of Computational Models

Computation of cognition can be achieved through the process of machine learning i.e., by adapting to given demands.

Any task related to computation involves programming languages. Computers require their own artificial languages in order to function.

4.4.2.2 Programming Languages for Computation

The most common programming languages for AI that are considered to be good seem to be Pearl, Lisp, Prolog, C, and recently Java. LISP, a high-level language, favors fast prototyping over fast execution for many years. LISP languages have features that are good for garbage collection, dynamic typing, and functions as data, uniform syntax, interactive environment and extensibility. PROLOG language is a fruit of realizing that a set of logical statements plus a tool to prove general theorem could make up a program. PROLOG language is used due to its features like garbage collection, dynamic typing, functions as data, uniform syntax, interactive environment, extensibility, plus, a built-in unifier, being good for problems in which logic is intimately involved, good for problems whose solutions have a succinct logical characterization. The major drawback of this language is that it is hard to learn. C language, the speed demon, is mostly used when speed of
execution of the simple program (e.g. neural networks) is important. JAVA language is a new comer yet to develop; it is specially featured for platform independence, garbage collection, portability or any application; it has a decent set of built in types. The major drawback of JAVA is that it is not as high-level as Lisp or Prolog and not as fast as C.

The thought of developing computational model of human cognition leads to the requirement of understanding cognition i.e., the process of thinking.

4.4.2.3 Thinking and Knowledge

We, humans, usually think before reacting to the real world. We also think for self satisfaction and for many other reasons. Thinking machines, we dream for, are certainly expected to think none other than to help us to solve problems. There are problems of commonsense as well as some hard and poorly defined problems.

Reaction, representation, attention, decision, meta-decision, embodiment, intention, imagining, planning, reasoning, recollection, identity, reflection, moral reflection, self-reflection, self-imaging, social reflection, self-awareness are some of the tools to organize and use for solving some hard and often poorly defined problems.

Knowledge of ontology, knowledge of cause/effect relation, knowledge of like/dislike information, spatial knowledge, knowledge of use, knowledge of the relation between concrete situations and concrete episodes and the knowledge of visual events are applied to solve different types of common sense problems.

When we think we include thinking of a past situation, action in anticipation, imagination about how things might have been done, prior event that caused past situation/thinking and purpose in doing/thinking.

While thinking, we require different type of knowledge such as knowledge about ways to use other kinds of knowledge, knowledge about reasoning by applying rule-based and analogy-based methods, knowledge about different ways to manage and to co-ordinate multiple types of the thinking process and common sense to reason on great scale and in diverse ways.

Common sense relates with knowledge about many, different areas such as physical knowledge of how objects behave, social knowledge of how people interact, sensory knowledge of how things look and taste, psychological knowledge about the way people think, and more. Furthermore, each of these different facets of life requires its own specialized methods of reasoning about them. It is about how to make systems that are abundant with many types of knowledge and many ways of thinking about different things. One can claim that knowledge management is the key to success in developing man like machine.

We have seen above that the human being’s brain power comprises the knowledge, skills and personality quirks which make them human. While
constructing any brain like machine the very first problem encountered is regarding human knowledge, its nature, its discovery, its acquiring & its formalization (turning it into information through the process of learning), its representation & its retrieval (also known as information retrieval IR) or its extraction (also known as information extraction IE) and its sharing. Other issues related to human skills and personality quirks are far away.

4.4.2.3.1 Knowledge Discovery in Humans & Computers

Anything that is known is knowledge. Knowledge is different from a belief or opinion. A belief, a conviction, faith, or confidence in something or someone is something which is stronger than a baseless opinion but not as strong as an item of knowledge. Opinion is a proposition that is accepted as true without compelling grounds, therefore falling short of being a belief and far short of constituting knowledge. The three major classes of knowledge are declarative knowledge (knowing that), procedural knowledge (knowing how), and acquaintanceship knowledge (knowing people, places, and things).

In humans, sensory perception leads to cognitive data; such data is necessarily imbued with meaning. Accumulation of data leads to knowledge by links. Knowledge acquired through learning turns into information.

In computers large and diverse data are collected via direct perception or via sensing devices and stored on physical medium, i.e. libraries using an index to catalog; it is uniform compared to real world libraries. In new method of relational database, data is stored on a system of relations and organized by entities, attributes and relations between entities. Computers receive the information and do fast data collection in digital form. Data ranges from local to global scale. Computers can store everything that is machine readable; it is an ever increasing data store. In case of computers one can easily edit the internal data view to change the external data view.

Data thus collected serves as the mine for knowledge Discovery in Databases. It is also known as Data Mining. It is defined as the nontrivial extraction of implicit, previously unknown, and potentially useful information from data28. Through interactive learning process, machine needs to be able to adapt to new data and learn new techniques where AI comes into play.

Knowledge Discovery in Databases (KDD) is a chronological procedure which includes selecting and compiling the data-set, cleaning the data including recoding element in a consistent form, and dealing with missing and erroneous elements analyzing the data to find patterns and associations, interpreting and evaluating the derived information, and verifying the derived information through subsequent methodologies. It applies statistical techniques and visualization techniques to discover and present knowledge in a form which is easily comprehensible to humans.
Theories are formulated through filtering raw data and selecting relevant data, ignoring rest to identify selected data. Then search is done for patterns. The data is analyzed to find patterns and associations by interpreting and evaluating the derived information and verifying the derived information through subsequent methodologies. Relationships are formulated that leads to knowledge. Computers are expected to be able to adapt to new data and learn new techniques through interactive learning process.

One can conclude that storing data, filtering data to search patterns followed by establishing relations among them, all require proper representation of data and the knowledge thereof.

4.4.2.3.2 Knowledge Representation

The encoding and storage of knowledge in computational models of human cognition is known as Knowledge Representation. It is a major branch of artificial intelligence and is also studied in cognitive psychology, logic for computer science, and linguistics. The representation of informal and intuitive human knowledge is one of its major unsolved problems.

A body of formally represented knowledge is based on a conceptualization\textsuperscript{29}. A conceptualization is an abstract, simplified view of the world that we wish to represent for some purpose. It involves the objects, concepts, and other entities that are presumed to exist in some area of interest and the relationships that hold those entities. Every knowledge base and knowledge-based system, or knowledge-level agent is committed to some conceptualization, explicitly or implicitly.

An explicit specification of a conceptualization is done under ontology. Philosophically, ontology is a systematic account of Existence. For knowledge-based systems, what exists is exactly that which can be represented. When the knowledge of a domain is represented in a declarative formalism, the set of objects that can be represented is called the universe of discourse. This set of objects, and the describable relationships among them, are reflected in the representational vocabulary with which a knowledge-based program represents knowledge.

For knowledge representation, a frame structure is used. It is a knowledge structure of an everyday aspect of the world, say, a house in the real world. It contains fixed structural information, such as, all houses are assumed to have walls, a roof, and various other fixed attributes. It also contains slots capable of accepting one of two or more values representing variable information, such as, a house may be built from brick, concrete, or wood and it may or may not have a garden, a garage, a swimming pool, and so on. The American cognitive scientist Marvin (Lee) Minsky formulated this ‘frame structure’\textsuperscript{30}.

In knowledge representation, one has to face the problem (known as Frame Problem) of specifying formally what is left unchanged when an action is performed. For example while moving a block, its color remains unchanged, and in a formal representation of the action this needs to be made explicit, because some actions
do have side-effects of changing color as in the experiment of getting white color out of seven-color-wheel. This problem is often solved with the help of some form of non-monotonic reasoning, especially default reasoning.

Fuzzy-Logic is influential in the field of knowledge representation. It is a form of logic based on fuzzy-set-theory in which propositions have continuously graded truth values ranging from 0 to 1, rather than being either false (0) or true (1) as in conventional Boolean logic.

In practice, several tools and mechanisms are used for knowledge representation and acquisition such as WordNet, FrameNet, Open Mind, LifeNet, ShapeNet & ConceptNet and Experiential Knowledge Acquisition mechanism, Terascale Knowledge Acquisition mechanism etc.

The project of Open Mind Common Sense (OMCS) maintains a web site to acquire a variety of commonsense knowledge from the general public. LifeNet, the probabilistic graphical model (400,000 links) focusing on commonsense knowledge is expected to provide a substrate for commonsense reasoning about a person’s context, by providing an ontology and knowledge base focused on a person’s context such as where they are, what they are doing what they just did and what they might do next. ShapeNet is a database of 50,000 objects’ shapes that are linked to the concept nodes in ConceptNet which is meant to use commonsense knowledge in vision tasks. ConceptNet is a freely downloadable large-scale semantic network (over 1.6 million links) relating a wide variety of ordinary objects, events, places, actions, and goals by 20 different link types, mined from the OMCS corpus. It comes with a part-of-speech tagger and chunker, and a spreading activation inference engine.

Experiential Knowledge Acquisition mechanism refers to the algorithms which are developed for extending and evaluating commonsense knowledge bases using location and other sensory data about people’s real-world experience. Tools are being developed to sense a person’s context using noisy speech data.

Terascale Knowledge Acquisition refers to developing the web mining frameworks to acquire large quantities of commonsense and other types of knowledge from the web.

Knowledge thus represented can be shared by programs and computers; may be to reuse it. Knowledge sharing is also seen as knowledge communication. In other words, we can say that knowledge should be represented in such a way that it can be shared.

4.4.2.3.3 Sharing of Knowledge

Knowledge-based systems are based on heterogeneous hardware platforms, programming languages, and network protocols which require interoperability and operate on and communicate using statements in a formal knowledge representation.
To support the sharing and reuse of formally represented knowledge among AI systems, it is useful to define the common vocabulary in which shared knowledge is represented. A specification of a representational vocabulary, called ontology, is used for a shared domain of discourse, i.e. definitions of classes, relations, functions, and other objects.

In the ontology, definitions associate the names of entities in the universe of discourse (e.g. classes, relations, functions, or other objects) with human-readable text describing what the names are meant to denote, and formal axioms that constrain the interpretation and well-formed use of these terms.

There are conventions at three levels regarding knowledge-level communication, viz., representation-language format, agent communication protocol, and specification of the content of shared knowledge. Ontologies can be used for conventions of content-specific specifications\textsuperscript{40}.

So far we have seen a snapshot of AI. There were promises to keep and dreams to fulfill. Some are kept, some are fulfilled. Certainly we are passing the path towards the goal. There are yet many things to achieve. It is the right time to see the progress in AI and future in AI.

4.5 PROGRESS AND FUTURE OF ARTIFICIAL INTELLIGENCE

Alan Turing\textsuperscript{3,4}, one of the founders of computer science, claimed that by the year 2000, computers would be able to pass the Turing test (game of imagination) at a reasonably sophisticated level, so that the average interrogator would not be able to identify the computer correctly more than 70 per cent of the time after a five minute conversation\textsuperscript{3,4}. AI hasn’t quite lived up to Turing’s claims.

As on today, computers are only good at one specific field as they do not have imagination and extended cognition, they cannot understand metaphors and images. The progress in the field of AI is marked by deployed speech dialog systems by firms like IBM, Dragon and Lernout & Hauspie, applications of expert systems or case-based reasoning for a computerized Leukemia diagnosis system which check for blood disorders (better than human experts), machine translation for ‘Environment in Canada’ (a software developed in the 1970s translated weather forecasts between English and French), ‘Deep Blue\textsuperscript{41}’, the first computer to beat human chess ‘Grandmaster’ and fuzzy controllers in dishwashers, etc.

A point to note is that as soon as an AI technique truly succeeds, many treat it to be something else than AI. For example, when Deep Blue defeated Kasparov, there were many who said Deep Blue does not illustrate AI application, since after all it was just a ‘brute force parallel MiniMax search’!

The challenges facing humanity include exploring natural frontiers, making solar energy affordable, providing energy from fusion, developing carbon sequestration, managing the nitrogen cycle, providing access to clean water,
preventing nuclear terror, securing cyberspace, enhancing virtual reality, improving urban infrastructure, advancing health informatics, engineering better medicines, advancing personalized learning etc. To overcome these challenges human beings seek advancing research in AI.

We can expect that Artificial Intelligence would exceed human intelligence for several reasons. Firstly, machines can share knowledge and communicate with one another far more efficiently than human beings can. As human beings, we do not have the means to exchange the vast patterns of inter neuronal connections and neurotransmitter-concentration levels that comprise our learning, knowledge, and skills, other than through slow, language-based communication. Secondly, humanity’s intellectual skills have developed in ways that have been evolutionarily encouraged in natural environments. Those skills, which are primarily based on our abilities to recognize and extract meaning from patterns, enable us to be highly proficient in certain tasks such as distinguishing faces, identifying objects, and recognizing language sound. Unfortunately our brains are less well-suited for dealing with a type of complexity of patterns, such as those that exist in financial, scientific, or product data. The application of computer-based techniques will allow us to fully master pattern-recognition paradigms. Finally, as human knowledge migrates to the Web, machines will demonstrate increased proficiency in reading, understanding, and synthesizing all human-machine information. Human beings are constrained in their creations by what they can imagine.

One can predict that the creative and constructive applications of contemporary & future technologies will dominate. Human existence on this planet will be irreversibly altered with computer power in order to think, to reason, to communicate, and to create in ways we can scarcely even contemplate today.

CONCLUDING COMMENTS

So far we have seen the theory and practice and techniques in the field of computers in the light of AI Theory.

Computers are developed on the model of the human cognitive process. So we need to describe any task on the basis of and in the fashion in which we think, but, in a transparent way.

While working in the field of NLP, one has to apply the same techniques of computation. The way a linguist should write the grammar of any natural language needs to be logical in a way that the computer can follow to achieve the end goal. How it can be done will be seen in forthcoming chapters.