CHAPTER 2

INTELLIGENT SYSTEM APPROACHES

The purpose of this chapter is to express the context of the research by giving a brief description of the concepts used in the research work.

Computational intelligence is a well defined set of computational methodologies and approaches to address complex problems of the real world applications. It is used when traditional methodologies and approaches are not effective or feasible. It basically includes fuzzy logic systems, neural networks and evolutionary computation. Computational intelligence techniques are usually bottom-up, where order and structure emerges from an unstructured concept.

Affective computing is the study and development of systems and devices that can recognize, interpret, process and simulate human effects. Affect in standard linguistics is used as a synonym for feeling and includes moods and attitudes. There are several affective lexical resources like General Inquirer, SentiWordNet, Words (ANEW), WordNetAffect. WordNet developed by George Miller in 1995 determines semantic relations between words and is an extended dictionary specifying word relations such as similarity, part-of relations, hierarchy or manner. WordNet-Affect developed by Strapparava & Valitutti in 2004 is an affective lexical repository of words referring to emotional states. It extends WordNet by assigning a variety of affect labels to a subset of
synsets representing affective concepts in WordNet (emotional synsets). It also has an additional hierarchy of affective domain labels.

2.1 INTELLIGENT AGENTS

An agent also known as software agent perceives its environment through sensors and acts upon that environment through effectors [32]. An ideal rational agent should execute actions so as to maximize its performance measure based on the integral knowledge it has. Events are things that happen, including the actions of agents. In principle, every kind of behavior and internal process of an agent can make use of the emotional state. The agent function for an artificial agent will be implemented by an agent program. The agent function is an abstract mathematical description; the agent program is a concrete implementation, running on the agent architecture. An agent’s behavior is described by the agent function that maps any given percept sequence to an action. The scope of agents is given in Fig 2.1.

Fig 2.1: Context of Agent
Intelligent agent as depicted in Fig 2.2 is a system that interacts with its environment in flexible, goal-oriented ways, recognizing important states of the environment and acting to achieve necessary results. Agents are constructed by considering a suitable architecture (computing device) and developing efficient agent programs (functions which implement the mappings from percepts to actions). The agent program is designed using Artificial Intelligence techniques.

![Intelligent Agent](Fig 2.2: Intelligent Agent)

### 2.2 SOFT COMPUTING

Soft computing is an emerging and promising trend and is a synergistic combination of three computing paradigms: neural networks, fuzzy logic and probabilistic reasoning which include genetic algorithms, chaos theory, belief nets and learning theory as shown in Fig 2.3; each contributes usually at different functional levels providing a hybrid system. It provides a flexible framework to construct computationally intelligent systems [37]. Soft computing shows promise in dealing with
the inherent complexity of modeling human behavior. All the techniques of soft computing are interrelated and are used in appropriate combinations to build systems. The components are complementary, offering features to solve complex problems.

![Diagram of Techniques of Soft Computing]

It is different from the conventional computing paradigm (hard computing) as it is tolerant of uncertainty, imprecision, and incomplete truth and has the ability to adapt to unknown and highly dynamic environments to improve performance. Hard Computing deals with precise models which generate accurate solutions whereas Soft Computing deals with approximate models. This is clear from Fig 2.4. Human mind is the role model for soft computing and the goal of soft computing is to emulate the human mind to a feasible extent.
2.3 NEURO-FUZZY SYSTEMS

Artificial Intelligence techniques such as neural networks and fuzzy models have been studied and analyzed in the past few years in the hope of achieving human like performance in the fields of engineering. A neural network is a well-organized information processing system which resembles in characteristics to a biological neuron [31]. Artificial neural networks as shown in Fig 2.5 have a large number of highly interconnected processing elements called nodes or neurons, which operate in a parallel fashion and are configured as regular architectures. Every neuron is connected with the other neuron through a connection link. The link is related with weights that contain information about the input signal. The collective behavior of artificial neural networks is characterized by their inherent ability to learn, recall and generalize training patterns or data which is similar to that of a human brain.
Fuzzy system is a system whose variables range over states that are fuzzy sets [35]. For every variable, the fuzzy sets are defined on some pertinent universal set, which is an interval of real numbers. Fuzzy set is a set without a crisp boundary and is characterized by membership functions. Fuzzy logic is a prevailing problem-solving methodology with a multitude of applications in control systems and information processing. The fuzzy inference system as depicted in Fig 2.6 is a computing framework based on the concepts of fuzzy set theory and fuzzy reasoning. It comprises of three conceptual components: a rule base which contains a selection of fuzzy rules; a database defining the membership functions used in fuzzy rules and a reasoning mechanism, which performs the inference procedure upon the rules and given facts, to derive a reasonable output or conclusion.
A neuro-fuzzy system is basically a fuzzy system that employs a learning algorithm derived from neural network theory to determine its parameters (fuzzy sets and fuzzy rules) by processing data samples [37]. The neuro-fuzzy system as in Fig 2.7 consists of the components of a conventional fuzzy system with the exception that computations at each stage is performed by a layer of hidden neurons and the neural network’s learning capacity enhances the system knowledge. This approach is becoming one of the major areas of interest because it has the benefits of neural networks as well as of fuzzy logic systems. In addition it removes the individual disadvantages of the systems by combining them on the common features.

The common features of neural networks and fuzzy logic are distributed representation of knowledge, model-free estimation, ability to
handle data with uncertainty and imprecision etc. It integrates the advantages of fuzzy systems which deal with unequivocal knowledge that can be explained and understood and neural networks which deal with implicit knowledge that can be acquired by learning. Neural network provides a good way to adjust the knowledge of the expert (AI system) and automatically generate additional fuzzy rules and membership functions to meet certain specifications. It helps in reducing design time and development costs. Fuzzy Logic enhances the generalization capability of a neural network system by providing more reliable output when extrapolation is needed beyond the limits of the training data.

Rule 1: If $x$ is $A_1$ and $y$ is $B_1$ then $f_1$
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Fig 2.7: Neuro-Fuzzy System

2.4 EMOTION-ORIENTED COMPUTING

Emotion is the language of a person’s internal state of being, normally associated to their internal (physical) and external (social) sensory
Emotions are complex multifaceted phenomena and involve experience, feelings, physiology, behavior, cognition, perception, and conceptualization. According to the OCC (Ortony, Clore and Collins) model, emotions come from the appraisal of three different aspects of the world: the consequences of events, the actions of agents and the perception of an object. Research in the domain of emotion has found that intelligence and emotion are interconnected. Emotional information can be encoded lexically, syntactically and morphologically in the words of a sentence.

Emotional agent has an emotional state which gets altered by stimulus from environment or internal elements. An emotional agent can be implemented using a pertinent computational approach. The ability to recognize emotion is one of the significant features of emotional intelligence, an aspect of human intelligence which has been argued to be even more important than mathematical and verbal intelligences. Machine intelligence needs to include emotional intelligence. Emotion interacts with thinking in ways that are not explicit but important for intelligent functioning as shown in Fig 2.8. Machines would never need all of the emotional skills that humans need; however, there is substantial evidence that machines will require at least some of these skills to appear intelligent in interacting with people.
The human thinking and reasoning process has three offshoots to it i.e., rational, emotional and reactive which interact with each other to enable to smooth functioning of the mental faculties. Depending on the inputs from the environment the appropriate output is generated based on this interaction. Hence consideration of emotional aspect is important in designing computer based systems whose reasoning should be analogous to human reasoning processes.