A Cognitive Architecture for Self Learning in Humanoid Robots

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Summary
Cognitive is the mental process of knowing, including characteristics such as perception, awareness, judgment, and reasoning. Today humanoid robots need to become self-learner like humans, in this way they can be able to experience different things and learn from their experience, relating to, being, or involving conscious intellectual capable of being reduced to empirical factual knowledge. Considering the advantages of humanoid robots, in this study we propose a novel framework called Cognitive Architecture for Self Learning in Humanoid Robots (CASLHR). It combines the active memory, action schematical engine and sensor listener layers which try to produce human-like intelligence by analyzing the internal processes and the architecture of the human brain. The proposed CASLHR architecture may result in robust, safe, reliable, and flexible machines that can substitute humans in multiple tasks. This architecture is illustrated through case studies about fire-fighting task in the building and communication with the real-world. It can feel and perceive similar to a human being and will be able to learn from its experience and simultaneously updates its actions based on the success rate of its attempts to achieve a goal.

Keywords:
Cognitive architecture, Humanoid robots, Active memory, Action schematical engine, Sensor listener

1. Introduction

Humanoid robotics is a challenging and emerging research field. It has received powerful attention in many applications and continue to play an important role in the field robotics of the 21st century. Humanoid robotics applications are engaged in some common problems likes the understanding of human-like processing information and the primary mechanisms of the human brain are to deal with real world. The idea is similar to the robots which are flexible and adaptable as humans and performing more tasks with better precision than before. The physical appearance is also like the human body as well as the resemble human in their communicating, actions and reasoning about the real world [1–4]. The development of such robots needs integrating and coordinating research efforts in the vast range of disciplines such as artificial intelligence, control theory, learning theory, human machine interaction, computational and psychological perception and computational neuroscience [5–10].

Humanoid robots are employing by the human for assistance because of some case they can be avoided to do unsafe and unhealthy works. Humanoid robots are expected to provide in assisting human activities due to his friendly and flexible appearance [11]. However, we find significantly less advance in their control mechanisms. Mostly, these robots of routine codes have a fixed set that controlling behaviors in the inflexible reaction according to their surroundings. Their learning systems are not based on psychological findings, so it is hard for the human to interpreting the resulting knowledge that is obtained. Cognitive architectures can appear as a promising solution of this problem. They have software systems that set goals for overall intelligence and provide support for modeling human cognition [12]. These architectures provide rich cognitive capabilities that can certainly useful for humanoid robots.

Cognitive systems predict the future events by selecting actions and later learn from what happens, when they do act and after that they modify consequent expectations. In this process, they change actions how the world is perceived and which actions are possible regarding observations. However, latency inherent in neural processing has great ability to sense data and allow effective actions in natural systems [13]. Although, previously the cognition was utilized in different aspects as symbol processing unit of the brain which concern with rational planning and reasoning. Now of these early approaches is changing and view a strong relationship between the perception, action, and cognition [14, 15]. Humanoids will be given the ability to develop and learn in response to the input they receive.

The development of emotional connection of human to a robot is quite difficult and considers the effects of how systematically giving intentions, personality, and knowledge to the robot over a continued time period. Many of the software are developed for humanoid robot control under Open Source paradigm, its mean numerous developers will be able to modify these robots. Worldwide, there are a number of humanoid robots that have been recently develop such as the iCub [16], OpenCog [17], NimbRo-OP [18] are the open source framework having

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ability to interact with the environment and ensure the accomplishment of a particular task. They use their stored memory, already defined patterns, receive or get some things from the environment which is not enough for a humanoid robot to work efficiently and accurately. These architectures have the lack of learning ability, they take actions with respect to the pre-defined instructions given to them but they are unable to learn from their previous actions and modify these actions for future use. Much progress has been done in developing a robot that is capable of performing human-like behavior but still has some deficiencies that need to overcome for making a robot to perform same as a real world.

In this context, this research is trying to introduce a new architecture that has cognitive ability for self-learning in an interactive manner. A new proposed Cognitive Architecture of Self-Learning in Humanoid Robots (CASLHR) having three different layers: 1) Active memory 2) Action schematical engine 3) Sensor listener. CASLHR robots can be able to assist in the continuous validation and adaptation in real-world tasks as it will demonstrate the attributes very closer to a human behavior. In addition to this proposed structure, the sensory modules will enable evaluation and experimentation of sensing abilities, and highlight their importance in the generation of cognitive capabilities. This paper illustrates the consequences for the phylogenetic pattern, enactive method to cognition, the significance of humanoid embodiment, create perception and perform the valid action, reduce the empirical factual knowledge by the experience it gets from the environment and their cognitive issues are determined based on user experience. The result shows that the proposed architecture performs better than the existing humanoid robots architecture.

The rest of the paper is organized as follows: Section 2 describes some related work which includes the overview of the cognitive architecture and humanoid robots that were explored during the development of proposed architecture. Section 3 presents the proposed a cognitive architecture for self-learning in humanoid robots. Section 4 includes the results and discussion in which explain the case studies between the conventional robots and our proposed architecture of humanoid robot and section 5 describes the conclusion and future work of this research.

2. Related work

This section explains some basic concepts of cognitive architecture and humanoid robot models that are used in our proposed architecture.

2.1 Cognitive Architecture

The term cognition process and mental process are utilized for all the actions that human can do with their mind. These actions relating to the cognitive area includes thinking, awareness, perception, reasoning, self-examining, creativity, imagination, idea, decision making, memory, belief, desire, and emotion. Aristotle takes interest in the cognitive process in the inner working of the mind and its influence on human experience. The Greek philosopher found importance in the cognitive area that were based on experimental evidence, accurate information which was collected through complete observations and careful experimentations [13, 19]. From the past decades of the 20th and early 21st centuries, the cognitive science domain is emerging and developing various models regarding the description of mind and its related phenomena.

A cognitive architecture specifies the basic structure for an intelligent system and it includes those aspects of the cognitive system that shares the different theoretical assumptions over time. Mostly the origins of these ideas belong to the theories of human memory, skill acquisition, reasoning, and problem-solving. These architectures support the effective construction of knowledge-based systems that are developed with a software environment and programming languages [20]. They include:

- The short-term and long-term memories that store dynamic information including the performance approaches that use them and learning process that modify to more stable contents.
- The long-term memories access elements of cognitive architecture by comparing their patterns with the contents of short-term memory.
- The relevant long-term structures are retrieved from functional processes in which specific contents utilized for performing cognitive actions.
- The increment of learning directly depends on performance which involves the development of cognitive structure to long-term memories.

The key role of cognitive architecture seems from the central goal of the cognitive science and artificial intelligence that support the similar abilities as human [21]. Perception, memory, attention, planning and problem solving refers to the process of cognition. The human brain structure of information processing is mention in Figure 1.

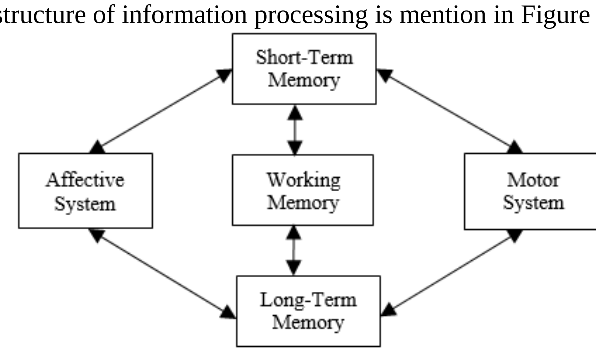

Fig. 1 Human brain structure of information processing

When a person observes something or information around it, then this observation move to short-term memory. In short-term memory, this information firstly interacts with the motor and effective system. Motor system sends the order to all body parts through peripheral nervous system and spinal cord, meanwhile the observed information is analyzed simultaneously by the working memory. If the important information is not saved in memory then it will save in long-term memory and it is memorized for long time period. Once the observed information is stored then next time the body shows some signals to review that action. The coordination and collaboration between these parts are concurrent to accomplish efficient work. The importance of working memory in the cognitive process has to maintain and update of information in mind [22]. Therefore, a rigorous representation of possible information connectivity with cognitive brain is to understand the interaction with surrounding world. In the context of human skills, the long-term memory of developing humanoid robots having the ability to perform in a complex environment and provide a flexible way during association with humans and objects.

2.2 Humanoid Robots

Humanoid robots can definitely useful from the strong cognitive capabilities of these architectures provided. It is considerable as a biological system which takes decisions and behaves in the environment, learns and adapts how to acts in the new situation and produce solutions on the basis of previous experience. The excellent feature of humanoid is the probability to interact, to demonstrate, to teach and to communicate with it. They can be utilized to predict the effects and plans about actions in order to achieve a desire goals [19]. Here we discuss some open source humanoid robots that having capability to interact with the environment.

The iCub humanoid robot is specifically design to support the collaboration and coordination in cognitive architectures by autonomous exploration and socially interaction. The iCub fulfills the need for a robust humanoid robot that presents high capability perceptuo-motor with several degrees of freedom. It has the ability of cognition for learning and development and their software infrastructure motivates easily integration and reusability that encourages the resources sharing and collaboration. The software architecture of iCub robot is based on YARP which provides efficiency and control through an open-source framework which encourages distributed computation. The simulation and modeling provide the ability of prediction, the capacity of imagination and reconstruction [16]. The iCub uses a computational model of affordances. It involves the learning possibility of both the framework of dependencies between the different set of variables such as perception quality versus action and results, their links and use in deciding how to tackle the robots. It also constructs on computational model interaction and imitation between robots and human by analyzing the automatic development of models from experience, their improvement through feedback, synchronization, and timing [23–25].

The OpenCog is very flexible software development platform having strong and reliable integrative Artificial General Intelligence (AGI). The name OpenCog robot derived from “Open” mean open source and “Cog” mean cognition. The OpenCog Framework (OCF) libraries contain a cognitive process scheduler and a plugin structure which allow connection between perceptive, cognitive and control algorithms. The cognitive architecture involves the functional units and knowledge representation with a local AtomTable including knowledge and number of mind agent objects. A mind agent is an algorithm or collection of algorithms which accomplish a particular cognitive process on the Atom space functions. Atom representing the goals that stored in AtomTable, different tables show that which Atoms consist on top level goals. It is used to guide the allocation of attention and goal recycling process. OpenCog is generated using learning algorithm contains MOSES and PLN (Probabilistic logic networks). This humanoid robot should be capable of making an adaptable decision, having intelligence and has the ability to response like a human [17], [26, 27]. OpenCog respond on fixed and programmed knowledge and instructions but it is not able to make the variety of distinct decisions on critical situations. These algorithms are operating only to generate limited intelligence and behavior.

NimbRo-OP is an open source humanoid platform having the potential to communicate with more human-level environment. The software architecture of NimbRo-OP relay on Robot Operating System (ROS) middleware [28], [29]. The functionality of this software is the generation of behavior, perception, hardware abstraction and used to implement basic football sports skills. To develop a full-scale operation from image processing across trajectory planning up-to the dynamically full body motions generation, this robot is furnished with sufficient computing power and torque. NimbRo-OP architecture requires to be able to programmed with highly complicated agent behaviors [18]. This behavior refers to coordinating patterns and perceptual of any event. The behavior of NimbRo-OP is capable of searching the balls, move toward them when finding any perceived barrier, falling towards the target field and kick toward the goals. It also processes the signals of game controller during the match, which mean robot camera guiding the right direction during the game. NimbRo-OP architecture face difficulties to perceive in different situations like human behavior, a humanoid robot must play soccer same as the real human and perform actions according to the situation.

As above discussion about humanoid robots (iCub, OpenCog, NimbRo-OP), we find limited behavior in their software architectures. They show only specific or targeted behaviors in a critical situation. Humanoid robots must show real human-like behavior and having perfect intelligence, perception and cognitive process employ multiple behaviors according to the certain situation. Table 1 shows the comparison of above discussed humanoid robot architectures.

Table 1: Comparison of Humanoid Robot Architectures

Features	iCub	OpenCog	NimbRO
Software	YARP (Open source) as iCub middleware	AGI (Open source)	ROS (Open humanoid plateform) middleware
Memory	Episodic memory	Atom space	Nodes
Behavior	Specific human-like behavior	Pre-Planned learning behavior	Only used to implement basic soccer skills
Learning	Specific learning from targeted behavior	Deficiency in higher perception integration (Hebbian learning)	Less learning from environment
Decision making	All decisions based on pre-guided instructions	It has no ability to create different variety of decisions	All decisions depend on pre-defined guidelines

All robots work on limited task, they have less learning ability from environment and exhibit limited behaviors. They can perform limited decisions according to specific situation.

3. Cognitive Architecture of Self learning in Humanoid Robots

This section describes the proposed Cognitive Architecture of Self-Learning in Humanoid Robots (CASLHR) which has the capability to work human-like cognition, thinking and decision-making power, modify and respond actions based on previous experience. This proposed architecture consists of three main layers that explain the overall structure of self-learning process in humanoid robots. Firstly, the inner layer is the active memory which integrates entity, entity relationship, pattern, action, and goals which has capabilities of autonomous learning by interaction and actively explore the environment. Active memory is used to memorize the set of actions and take the right decision for actions in order to accomplish the desire goals. Secondly, the middle layer is action schematical engine that contains perception, feeling processor, execution manager, and the validator is utilize for input and output, it processes the information that is for performing the valid action to achieve the goal and the schematical engine on the basis of Mata data to perform or process the actions. Finally, the outer layer includes sensor listener that takes senses from the external environment and move it into the internal (middle, inner) layers for processing. Similarly, it conveys the processed output taken from internal layers to the external environment. CASLHR is design to produce intelligence like the human by evaluating the internal processes and the structure of the human brain. Here, we are trying to train the learning behavior of robots to imitate the human brains activities, understand the methods of planning, awareness, reasoning, Judgment and representing in traditional artificial intelligence and produce dynamic behavior of robot like real human in the environment.

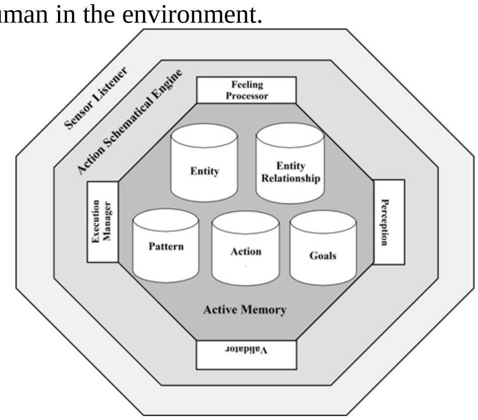

Fig. 2 Cognitive Architecture of Self Learning in Humanoid Robot

The complete architecture of the proposed model for humanoid robot is mentioned in Figure 2. More details of these layers are illustrated as follows:

3.1 Active Memory

An active memory appears as an inner layer of our proposed architecture and based on advance cognitive processing generally and particularly for learning. All information are generated and reused through contents in the system is facilitated by active memory, in which it can be permanently stored and retrieved similar to the human brain. In our proposed humanoid robot, active memory utilized as repositories for knowledge regarding the interaction with world and individual, about current series of activities. While the autonomous learning process improves this knowledge when the robot interacts with the environment and also improves their actions accordingly. Both learning and memory are the fundamental aspects of cognition, in which intelligent skills developed like planning, deliberative reasoning and self-regulation. CASLHR is capable to memorize the set of actions and social connection with the surroundings and used to predict the effects of actions and plans for achieving desire goals.

Hence, operations that modify the memory's content are the entity, entity relationship, pattern, actions and goals utilized in our proposed architecture. When the robot interacts with environment, it takes elements of perceptual memory that contain the recent partial view of the relevant real-world entities. Robot percept an instantaneous observation and according to these observe entities it makes the relationships between these entities. Only the required or useful actions with respective patterns keep in memory that exactly match to accomplish a desire goals, all other entities only valid for the specific moment over time. The recognition of any observe entities like face, gesture, voice, object and obstacle are types of percept that used to perform actions which basically fed into the active memory. In an active memory, every repository has individually relationship with the middle layer.

A. Entity: An entity exists that all the real-world objects observed by a robot consider as an entity. The object that exists also appears to indicate distinction from other entities or existences. The entity is utilized to identify elements, whether the existing objects or abstract ideas having complete name or not. Humanoid Robots will be save all these entities in their memory and utilized to perform and modify the actions.

B. Entity Relationship: An entity relationship repository defines a memory process systematically. Different entities are associated with each other by a relationship. The relationship is further categorized by means of cardinality and the type of the linkage between entities. The process is demonstrated as components (entities) which are linked with each other through relationships that expressing the dependencies and requirements between them. Entity relationship repository is used to figure out the entities, their attributes, and relationship among the entities.

C. Pattern*:* Pattern is basically the scheme that directs the robot about the directions and angle of movements of its parts as a whole. The active memory initially analyzes the entities and their relationships. Later, it observes the placement and pattern of all entities in its surroundings. Lastly, it plans a scheme of its movements, the angles on which it has to move its parts to complete a successful action. We can categorize pattern into two main parts:

a) Naive Pattern: Naive pattern basically refers to the first attempt of robot movement. When active memory receives the stimuli of any entities and their relationships for the first time it has no experience about whether it's proposed direction will succeed the goal or not. Active memory will set a pattern and if succeed it will learn this successful pattern for future use. If pattern doesn't make a successful attempt it will revise its pattern for an improved attempt. This mechanism will induce a learning behavior in active memory.

b) Learned Pattern: When active memory read similar entities and their relationships again, it has a learned pattern to execute that made its previous attempt successful. Active memory will constantly update its patterns and will only memorize those patterns that made its attempts successful.

D. Action*:* A combination of patterns will generate an action. The step by step movement of robot body to make a successful attempt will specify an overall action. However, it is not necessary that successful pattern may lead to successful action. Sometimes the movements and angles lead to correct movement but the robot performs this action at a wrong target. Hence, the pattern will succeed but the action will not be successful and it has to perform the action again. Thus, the action is also categorized into two main parts:

a) Naive Action: Naive action leads to the very first mobility (set of patterns) to fulfill a target. At this point, it has no experience of which action produce better result. If the action performed leads to a successful result it will memorize this set pattern and thus action, but if the action results in a wrong attempt it will revise its action to make a successful attempt.

b) Learned Action: Learned behavior is based on experience. In case of similar environment, entities and relationship the active memory will recall that learned behavior that has led to a successful accomplishment of target. Only successful actions will be memorized by the active memory for future use.

It determines the attempts of actions that can be addressed in a number of ways. The robots could perform the experiments on its own by selecting an action based on past experience. However, sometimes the robot has to learn repository which provides considerable assistance by demonstrating the appropriate action to attempt. The CASLHR robot has learning ability to focus on those potentially successful actions to perform valid task similar like the human intelligence.

E. Goals: The complete set of actions will leads towards the goal. The correct pattern may not ensure a correct action, but set of correct actions lead towards the successful achievement of the desired goal. When a goal is accomplished successfully, the robot will memorize the valid set of patterns and actions that make the achievements. After the achievement of goals in various times, robot will decide to modify their repository according to success of the goals. We emphasis on the role of goals regarding performance guidance, the robot computes goals according to plans and retrieves them when the working environment give signals that it can be achievable.

3.2 Action Schematical Engine

Outside the active memory core portion lies in our proposed architecture is the layer of action schematical engine. The description provided below that is split into two sections: The section 1 will explains the details of the components of action schematical engine layer and section 2 will elaborate the overall working of the action schematical engine layer.

3.2.1 Detail of Components of Action Schematical Engine Layer

Action schematical engine is used for input and output, it processes the information that is for performing the action to achieve goal, schematical engine on the basis of Mata data to perform some actions. While the robot becomes more complicated, it increases their repository of all possible actions. The process of action schematical engine layer is following:

A. Perception: When the robot gets input from sensor layer, it will move to the action schematical engine for further process. The robot figure out of its numerous perceptions that are related to learning the action. Perception process continuously engages with different jobs. Initially, the robot must need to know about where the things are and what objects having which properties are present before the movement of manipulator towards engagement. As robot's perception abilities expand, the searching capability becomes more enormous. Learning issues become more manageable if the robot could be restricted on those specific related perceptions.

B. Feeling processor: In CASLHR feelings arise in sequence or time fluctuating intensity same as human naturally occurring emotions and often extend the stimuli that produce them. It can figure out that the feelings using postural or facial, vocal and emotional expressions display a strong message that exchange between the individuals in the shared space. The feelings of the robot can be initialized very close to the human level which accomplish the organism to all multiple actions. This message is further transmit to circulate other processes which can support these multiple actions or update these actions properly. In CASLHR, the importance of feelings can be seen from the fact that these are used to coordinate the behavior response, shifting behavior hierarchies, promoting physiology support, control, interaction and establishing position related to other objects.

Feeling processor and perception are mutually work together, sometimes the robot observe the environment than first feels something and make perception based on the situation, in some cases the robot show feelings according to perception and perform actions. Our architecture of action schematical engine is utilized to the feeling processor and perception for a humanoid robot to perform a collabrative task where the robot must seek assistance to accomplish its desire goals. Robot feelings are effectively working with human interactions, it is important to considering internal significance of the feeling processor for the robot performance. So, that perceivable plans can prepare a set of signals for the robot human association.

C. Execution Manager: The execution manager performs as the central component of the decision maker that has ability to handle the complex environment in our robot architecture. This unit is basically responsible for determining the behavior of humanoid robot throughout the interaction with the world. In this regard, the execution manager seems to be input-output devices that contain information about the environment which received through perception and feeling processor. This module then takes actions in the form of speech and show the response or issue the control commands to validator unit after verification. Execution manager will formulate a scheme to perform actions for achieving goals and this scheme will further move to the validator for the final decision.

D. Validator: The working of the validator is to re-confirming of the actions, it is superior task what he can finally do. The output of execution manager includes the sequence of actions because every unit represents distinct environment intention that contains one accurate action for each unit. These actions contain control and interactive responses of the humanoid robot. If the robot executes correct action then it will get positive feedback to enhance the reward function and it learns from these right execution commands for better future selection. Considering the set of all possible achievements can play a vital role in providing vigorous action selection. If the validator didn't accept the strategies then it will send back to the execution manager for improving actions. In this case, the execution manager is more cautious and motivated to investigate multiple queries before performing the action for validation. Moreover, validator includes a set of query actions in the sort of verification questions like the human brain, which can be ejaculate in some situations that mandate additional information.

3.2.2 Working of Action Schematical Engine

This layer will be activated in the middle layer of the working procedure. It will activate after the active memory has completed its working. However, it also depends on the type of approach used that could be top down and bottom up. The working of this layer is divided into two main steps:

A. Feeling Processor & Perception: This phase is basically a two-way process. Either robot will feel anything first and will make a perception about the surrounding, entities and its prospect goal, or it may develop a perception first and afterward show its feelings. Any stimuli from the external environment will trigger the feeling processor and perception. The resultant of the feeling and perception will be shown in form of gestures on the facial part of the robot.

B. Execution Manager & Validation: Based on the feelings and perception concluded in the first step the execution manager will formulate a strategy to perform an action for the achievement of a goal. The formulated strategy will be forwarded to validation unit. If the strategy formulated passes the execution check it will be implemented, but if the validation check fails the strategy will be sent back to execution manager for updating. The strategy will not implement until it passed from validation module.

3.3 Sensor Listener

This outer layer of the model basically works as an input and output layer. This layer takes senses from the external environment and moves it into the internal layers for processing. Similarly, it conveys the processed output that taken from internal layers to the external environment. Sensors are fixed for the purpose of extracting appropriate views of the module of engagement. Sensor layer is to control the incoming and outgoing actions based on its cognitive approach. It also takes information from internal layers to perform set of actions in the form of communication and interaction with surroundings and get feedback for further processing. The sensor listener allows to coordinate with the movement of hands and eyes for manipulating and grasping the objects. Additionally, the approach to the sensory modules of the humanoid robot will enable the testing and evaluation of sensing abilities and reveal their significant role during the development of cognitive abilities.

The overall summary of our proposed architecture is said to be a complete framework of cognitive architecture of humanoid robots. It consists of strong memory similar like the human memory and has better ability to face challenges when interacting with the environment. Our proposed humanoid robot having powerful capabilities of learning from experience, it modifies actions and performs more valid actions as well as stores these actions in memory. If the same situation happened in future than it reminds past actions and has thinking abilities to plan new strategies for make right decision to perform actions. The actions performed by our CASLHR architecture of each module relates to the cognition. The cognitive abilities of humanoid robot include thinking, creativity, imagination, awareness, perception, feelings, behaviors, self-examining, decision making, desires, reasoning, and ideas. The cognition and artificial intelligence ability make its architecture similar to the human brain.

4. Results and Discussion

Our proposed CASLHR architecture is evaluated as the cognitive abilities of self-learning in the humanoid robot. In this section, we discuss the two case studies and apply these case studies into conventional robots and proposed architecture. Firstly, we consider the fire fighter robots [30] and the CASLHR architecture is demonstrated on it. Secondly, the robot communicates with the people and share his experience related to extinguish the fire in the building. More details of these case studies are illustrated as follows:

4.1 A Case Study of Fire Fighter Robot

This case study is split into smaller tasks and each task is implemented in the most efficient manner such as self-autonomous working of the robot, navigation of the robot in every room step by step, finds the fire in a specific room, approaches the fire from a specific distance, extinguishes it and finally return to the front of the building. It works with different sensors during its functioning. The robot required the sensor to properly navigate by the floor plan without touching any surrounding objects. A sensor used to locate the flame, so that it can be extinguished. Firstly, we apply this case study into the conventional robots and after we apply with our proposed architecture.

A. iCub: When the robot gets commands by sensing the tone of fire alarm and extinguishes the fire, it will detect these signals through agents and store these signals into the episodic memory. It will verify that these signals already exist in memory or not, if robot find out these pre-guided signals then it will perform its effective state and pass these signals to the selection of actions that navigation of robot in the building and search the already programmed location and extinguish the fire effected area.

B. OpenCog: When the robot finds the instructions about firefighting mode, it store these signals into the memory namely atom space. These atom spaces are connected with each other and interacting with mind agent. Mind agent executes some cognitive actions because it is unable to do the variety of decisions due to its less intelligence and also it is not able to learn the new behaviors. It performed actions by mind agents that extinguishes the fire in the building.

C. NimbRo: When this robot gets commands to extinguishes the fire effected area, it is unable to perform these actions because it is specifically programmed to play the football game. To perform these actions, it needs to be programmed how to sense the fire affected area and perform certain actions.

D. Proposed CASLHR: When CASLHR robot get instructions for firefighting then first of all it will sense the flame in the fire effected area through sensor listener layer and send these instructions to inner layers to perform the following steps in each layer:

a) Active Memory: An active memory includes some operations that the robot is initially contain a set of actions to achieve ultimate goals and store these actions into the memory for future use same as human intelligence.

- Entity: In firefighting situation, the entities include as follows: building, offices, stairs, furniture, people, fire hose, pump, water, gas and chemical.
- Entity Relationship: Entity relationship includes the following set of relations: the building has relation with offices and stairs, office furniture is placed that is used by people, other things in offices that have direct or indirect relation with offices, people and building, firefighting pump with the chemical or water.
- Pattern: The robot start moving after detecting the tone using tone decoder that is produced by a fire alarm when sensing the fire. The movement of the robot all over the building is achieved through information providing by sensor, find the targeted area of fire through a sensor which detects the density of temperature in several parts of the floor.
- Actions: Fire fighter robot performs various actions: automatically start on fire alarm, move towards target by detecting alarm, spray chemical or water on target area to control the fire.
- Goals: Ultimate goal of fire fighter robot is to find the fire flames and perform necessary actions to overcome it for the safety of humans, materials and environment from danger.

b) Action schematical engine: Now we discuss how action schematical engine work with fire fighter robot which describe in three steps.

Step 1:

- Feeling Processor: Feeling processor takes signal from tone detector and automatically starts the robot. Actually, it gives the sense to the humanoid robot what he will do after listening that tone and change his behavior for particular action.
- Perception: Now he makes sense that there is a fire in the building.
- Execution Manager: Directs him for the movement.
- Validator: Validator validates the execution manager action and robot started his movement when the validator send signal to the sensor listener.

Step 2:

- Feeling Processor: Feeling processor detects the temperature density with the help of sensor.
- Perception: Robot make the perception that still target is not achieved.
- Execution Manager: It gives the directions to keep moving until reached at the target.
- Validator: Validator validates the execution manager action and robot continue its movement when the validator guide the sensor listener to proceed this action.

Step 3:

- Feeling processor: Flame sensor continues to detect the temperature density.
- Perception: At maximum temperature (particular level of temperature set by us) robot makes the perception that he has to be reached at targeted area.
- Execution manager: Stop the robot and make the decision to throw the chemical or water.
- Validator: Validator validates the execution manager action and robot throws the chemical or water when the validator sends the command to the sensor listener.

c) Sensor Listener: Finally, the sensor listener layer gets commands from validators and send these action’s signal to the sensor listener to perform these action. This layer is utilized as to sense the set of commands and after process from inner layers to get a set of valid actions for performing specific task such as listen the fire alarm, robot start its movement, continue movement until the specified level of temperature density, continue to throw the chemical or water on the fire affected area until it sense all the fire should be controlled.

4.2 A Case Study of Robot communication with real world

When the robot meets with the environment, talking to the people about how he can gain experience during extinguishing the flame in the building. Similarly, we apply this case study into the conventional robots and after we apply with our proposed architecture.

A. iCub: When the iCub robot gets instructions from the environment to share experience how you achieve your target to extinguishes the fire, it will sense these instructions through the agent and save into the episodic memory. It will examine that these instructions already happened or not, if the robot observes these pre-programmed instructions then it will accomplish its effective state process and pass these instructions to perform actions that share major steps how effectively overcome the fire in the building, how to sense the flame effected area.

B. OpenCog: When the OpenCog robot receives set of directions from the human about sharing experience during firefighting in the building, then it save these set of directions into the memory. OpenCog memory is called atom spaces which are linked with each other. It ensures the set of directions are already store in atom space or not and after it interact with the mind agent. The mind agent performs special cognitive process due to its low intelligence level. Mind agent executes the set of actions that share some experience how he saves the building from the major problem and throws the chemical on the flames.

C. NimbRo: When the NimbRo robot gets commands from human to explain how he successfully extinguished the flame, it is unable to execute any actions regarding firefighting task in the building because it specially programmed for the football game. NimbRo robot needs to be programmed for performing firefighting task then it will able to share experience.

D. Proposed CASLHR: When CASLHR robot meets with the people and the sensor get set of instructions regarding how he gain experience during the fire extinguish. Robot shares the how fast he sense the location of fire area, how efficiently and effectively control the flame in the building, how many abstacle faces on the way to extinguished the fire. So, the robot analyzed the working pattern of human-like intelligence and it depicts a clear example of experience based learning. At first attempt, the robot was naive to set of patterns and actions about the office building, whether it will achieve the goal or not. Robot arbitrarily selects the amount of chemical to be thrown on the fire and the distance on which it has to set its position to fire the chemical. The patterns and actions set initially were constantly revised to make a successful attempt. After finalizing the feeling and perception of the robot, it finally makes the strategy to throw the chemical on the particular fire area. This strategy will be implemented by sensor listener after validation otherwise it will be sent back to execution manager for alteration in their decision. In the second experience, a learned behavior of humanoid robot was observed. Thus, the previous experience of the robot makes the actions more better in order to achieve goals. The strategy of the robot was verified by the validator and thus the robot tries to improve its action and behavior constantly providing a similarity to a human-like behavior. It senses the fire in the environment and responds it accordingly. Every time experience makes the overall output as a successful attempt.

The results of above discussed cases studies that apply on conventional robots and proposed CASLHR architecture are explained in Table 3. The results indicate that the conventional robots have less ability of learning and perform actions based on given pre-programmed instructions. They utilized stored memory to receive some instructions from real-world that is not sufficient for a humanoid robot to work more accurately, effectively and efficiently. To overcome the deficiencies of conventional robots, our proposed CASLHR architecture has the capability to perform much better way similar like human cognition.

Table 3: Results of case studies between conventional robots and proposed CASLHR architecture

Humanoid Robot	**iCub**	**OpenCog**	**NimbRo**	**Proposed CASLHR**
Observe Instructions	Observe information using iCub Interface	DeSTIN scalable deep learning architecture is utilized for encoding low level procedure to high level procedure	The visual perception is provided by ROS software framework	It will sense the information through sensor listener. It is basically used for input and output to the environment
Information Processing	YARP libraries are adopted for information processing	Information is processed by mind agents	Nodes are employed for information process and connecting together	Active memory and action schematical engine are employed for information processing
Information Storage	It stores the information in episodic memory	Atom space is used to store information	Robot uses the RBDL library for information storage	Information is store in different repositories of active memory
Case A	It will extinguish the flame in the fire effected area by sensing the pre-programmed signals	It will extinguish the fire in the building by receiving pre-planned instructions	Its functionality is limited to soccer skills, so it is unable to perform firefighting task	It will extinguish the fire in the building, utilizing the valid set of actions to throw chemical or water as well as store all valid actions into the memory
Case B	It will share only major steps of experience about how he overcome the flame in the building	It will use atom space to share some experience how it will save the building from major problem	Its capability is restricted on soccer skills, so unable to get any experience of firefighting task	First time robot will share experience to secure the building by employing valid actions that verify by validator and store these actions in memory for future use. After that it’s learned behavior utilizing more valid actions based on previous experience and new situation

5. Conclusion and Future work

The emerging trend of robotics is opening new horizons in the field of automation and information technology. In this paper, we are presenting a new approach to automate a robot that will be a very close match to human behaviour. Every action involves a prediction and each action will alter the perceptual world to some extent. Equivalently, every span of perceptions is basically connected or associated with an action. Compared with conventional humanoid robots, our approach significantly improves the learning behaviour from experience and provides more valid decisions according to the situation. CASLHR humanoid robot will exhibit its features almost similar to a human being. To develop feelings and perception and to show a learned behaviour after validating actions are the key characteristics of this robot architecture. The unique feature of this architecture is that it constantly learns from its experience. It polishes its successful experiences and modifies in the case of unsuccessful attempts. Thus, it gives rise to an innovative approach to experience based learning. This research can be further analysed in the future by validation checks in the action schematical engine that can be updated to a broader scope, so the strategies of the robot may be precisely validated and implemented more specifically for the successful accomplishment of goals. Furthermore, up gradations in sensory layers can be made, so that robot may be able to receive stimuli from maximum types of stimulus or sources that provide more fluent sequence of actions in the context of learning from the environment.

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