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Ambient Intelligence in Ubiquitous Robotics

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***Abstract*-Ubiquitous robot is also known as ubibot, a third generation of robotics, which can give us various services at any place as well as any time in a ubiquitous space through a network. The previously ubiquitous robotics architecture is unable to remove the conflicting behavior as well as unable to operate in uncertain and dynamic environment. In this paper, behavior-based control architecture of ubiquitous robot is discussed towards a series of action for a certain objective and to avoid the multiple objective conflicts. By using fuzzy-neural approach in the proposed architecture, ubibot is able to take decision in dynamic environment.**

***Keyword*- Ubibot, Ambient Intelligence, proportional–integral–derivative (PID), Radio frequency identification (RFID) tags.**

I. INTRODUCTION

The rapid development in robotics in twenty-first century made robotics application in the areas where it was not possible before [1]. Recently many researchers have tried to make not only human-like robot but also diverse robot systems that can achieve mission in fields like medicine [2], bio-engineering [3], nanotechnology [4] and military [5] etc by substituting human activity. Robot is an intelligent mechanical creature which can function autonomously. Today robots are moved from the structured environment to the unpredictable human environment [6]. Therefore, conventional controlled manipulator robots are replaced by the emerging Intelligent and Ubiquitous robots. The traditional linear and non-linear control method for robotic manipulator includes PIDs (proportional–integral–derivative) type control [7] which is unsuccessful to solve the industrial control problem due to four reasons:- First, PID can work only in well-defined environment to execute certain repetitive or fixed action but unable to handle unpredictable situation in a dynamic environment without human intervention [8]. Second, PID controller requires precise knowledge of dynamic model which is difficult in case of robot arm controlling in determining the actual parameters of robots [9]. Third, it is difficult to describe knowledge-base and information of robotic manipulator mathematically by PID conventional controller and fourth conventional controllers are system specific. Therefore, a key challenge in robotics is to control the robot to function autonomously in unstructured, dynamic and uncertain environment [10]. To overcome such problems, intelligent control systems are introduced. Intelligent control systems are derived from soft computing technique [11] which is capable of handling uncertain and changing environment. Soft computing is proposed by Dr.L.A.Zadeh to solve non-linear dynamic and mathematically unmodelled systems as well as to incorporate human knowledge such as recognition, understanding, learning, inference so that intelligent control system can be constructed [12].

Intelligent robot possesses specific assumptions such as sensing, perception, knowledge presentation, action planning and execution must be dealt autonomously. To overcome such limitation Ubiquitous robotics come, this is a crossroad between robotics and Ambient Intelligence. Ubiquitous computing developed the interest in ambient intelligence for smart space, as it is highly suitable in a network environment, where any kind of information can be accessed by whenever and wherever the users are. The robotics paradigm shift is motivated by ubiquitous computing. The basic concepts of ubiquitous computing include four main characteristics. First, every device should be networked. Second, user interfaces operate calmly and seamlessly. Third, computers can be accessible at anytime and at any place. Fourth, ubiquitous devices are able to provide suitable services according to the specific situation. Now a days the computer technology are moved from the mainframe era, where large computer system was shared by many users, through the personal computer era, where a human uses a computer as a stand-alone devices or networked system, in a work or home environment, to the ubiquitous computing era, where a human-being uses various networked computers simultaneously, so that environment becomes unobtrusively.

In a ubiquitous era, where all the devices such as electrical appliances are networked to each other and a robot will provide various services by any devices through any network, at anytime.

II. LITERATURE REVIEW

Kiyoshi Kogure has published the paper [13] "Toward Ubiquitous Intelligent Robotics". In this paper, he has described that ubiquitous robot is a kind of embodied intelligence that includes the sphere of people's activities and record, these activities for the people support. By using this concept, he has developed an intelligent environment for capturing experience and a wearable event recording system for a medical care.

Paolo Dario has published the paper [14], "EU Views and Strategy for the Future of Advanced Robotics". He has suggested the global communication network will increasingly integrated with robotics and mechatronics technologies and establish a new paradigm which is defined as "Ubiquitous Robotics", which is well accepted notion of the web as infrastructural communication network serving the global community as well as the single individual. This new concept will provide "augmentation" to individual users and to communities in a broad sense and in different situations.

Hideki Hashimoto has published the paper [15], "Intelligent Interactive Spaces Integration of IT and Robotics", he described the intelligent space (ispace), integrated with enhanced information technology and advanced robotics. The core of the intelligent space is an ubiquitous distributed sensory networks, integrated with human living environment that can track multiple human and other objects inside the space. Mobile robots are operating in human living environment, with the support to the human such as guiding. The ispace contain artificial space memory for interaction between ispace and human applying mobile robots as well as other intelligent device node. The spatial memory is an

information organizing and classification technology, using the concept of gesture recognition, for context-aware information exchange between ispace and the human.

Bong Keun Kim has published the paper [16], "Ubiquitous Localization and Mapping for robots with Ambient Intelligence". In this paper, a novel approach of knowledge management for space /location perceiving capacity of robot is discussed. In this regard first, the ubiquitous function services for smart object, smart logic and smart discovery services are proposed in order to distribute knowledge flexibly and reliably to the changing environment. Afterwards, physical and virtual spaces are merged by RFID tags. Through this, it is shown that ambient intelligence is realized and the space localization and mapping problem of robot can be solved more easily.

Donatella Guarino has published the paper [17], "Monitoring the state of a Ubiquitous Robotic System: A Fuzzy Logic Approach". In this paper, he has suggested that inclusion of robotic device in Ambient Intelligence System is known as Ubiquitous Robotics. He has discussed the problem that how we can provide a comfortable, natural interface between the everyday user and a complex system which is consists of a large multitude of highly heterogeneous devices. The important aspect of this problem is to monitor the state of the ubiquitous system by the user's system. The solution for this is expression-based semantic to represent heterogeneous devices and a common uniform point to aggregate the information point to aggregate the information from all devices into a summary status presented to the use. For this author use fuzzy logic and propose a specific type of ubiquitous robotic system called Ecology of Physically Embedded Intelligent System or PEIS-Ecology.

Yongning Li has published the paper [18], "Semantic Location –aware model for Ubiquitous Computing". Author presented a semantic location-aware model that the ability to integrate heterogeneous location-aware system into ubiquitous computing environment and also has the capability of sharing knowledge, reasoning and adjusting the usage policies of services dynamically through a unified semantic location manner.

Sonia Mentoza has published the paper [19], "Area-based Collaborative Ubiquitous work into organizational environments". In this paper Author suggested the SEDINU (SErvice Discovery for Nomadic Users) system that facilitates the interaction with specific contexts i.e. user's role, location and goal. He define a web-based for support ubiquitous environment, in which users can interact and collaborate, while moving within a quite large organization that include several departments or admistrative services. The SEDINU system aims to provide nomadic users with collaborative sessions, for access services and program special tasks.

III. TYPES OF UBIQUITOUS ROBOT

A. Sobot

Sobot stands for software robot, it has the ability to move within the environment and connect to other system without any time and with no geographical limitation. Sobot has three main features such as self-learning, context-aware intelligence, calm and seamless interaction.

B. Embot

Embot stands as embedded robot; it is planted in the environment or in Mobot. Embot with various sensors are able to detect the location of the user or a Mobot and able to authenticate them. An embot include all the objects which are networked, sensing functionality and can be equipped with microprocessor. Embot contain three main characteristics such as calm sensing, information processing and communication.

C. Mobot

Mobot also called as Mobile robot. Mobot has the mobility feature as well as the capacity to provide general services in corporation with Sobot and neighboring Embots. Mobots has the characteristics of manipulating the implementation of arms and mobility which is common in wheel and biped robot.

IV. PROPOSED ARCHITECTURE OF UBIQUITOUS ROBOT

Sensors are used for perceiving and assessing the environment and collect the stimulus information about the environment. Behavior selector is used to choose a proper behavior based on stimulus information sense by the sensor. Based on that behavior or condition on which robot has to react is selected by fuzzy logic. By using fuzzy logic, we can derive the event-condition-action rules. For example:-

When 'Tony' comes into the room,
If there is no one, then turn on the air conditioner.

By selecting the appropriate rules and removing the conflicting situation afterward we apply the learning mechanism such as Neural Network in this. Consider the adjusting weighting parameter between condition and action, if ubibot does a proper behavior for a given command, then the weight between the condition and behavior is strengthened, otherwise weakened.

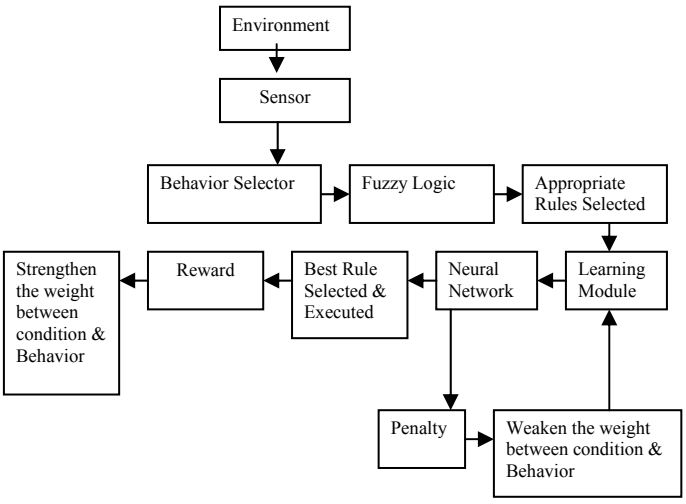

Fig.1 Architecture of Ubiquitous Robotic

The updation rule is as follows:-

$W_{ij}(t+1) = W_{ij}(t) + \rho$ ……. reward

$W_{ij}(t+1) = W_{ij}(t) - \rho$……penalty

Where Wij is a weight between the i^{th} condition and j^{th} action or behavior subset. ρ is a constant for giving the reward or penalty to the rule. This architecture is helpful in behavior control, remove conflicting behaviors of ubibot and help them to operate in dynamic environment by soft computing approach.

V. COMPARISON OF UBIQUITOUS ROBOT WITH TRADITIONAL AND INTELLIGENT SYSTEM ROBOT

The table shown shows that how ubiquitous robot is superior to intelligent system and PD/PID type robots.

Table 1 Comparison of Ubiquitous Robot with Intelligent Robot and Traditional Robot

Characteristic	PD/PID type robot	Intelligent system robot	Ubiquitous robot
Mathematical equation	Not solved	Solved	Solved
Dynamic environment	Not suitable	Suitable	Suitable
Calm and seamless network	No	No	Yes
Many network computer support simultaneously	No	No	Yes
Self-learning	No	Yes	Yes
Context-aware intelligence	No	No	Yes
Recognition feature	No	Yes	Yes

Ubiquitous Robot contain Context-aware intelligence and Recognition feature as well as also handle many computer simultaneously and it can make the network calm and seamless.

VI. CONCLUSION

A significant amount of work has been done in the field of ubiquitous robotics, Ubibot provide various services by any devices through any network, at any place and anytime in a ubiquitous space. From the past decades, with the aim of overcoming the limitation of robotic platform as well as providing a suitable and realistic way of deploying the robot in real world environment for that ubiquitous robotics paradigm comes. But the main task of behavior coordination is still a bigger problem in the field of robot navigation. For future work we will implement this architecture for controlling the robot navigation in path planning and obstacle avoidance problem and provide the more specific task coordination mechanism.

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