

ERGONOMIC INTERVENTION IN HUMAN-ROBOT DIALOGUE SYSTEM DESIGN: THE EMERGING TRENDS

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Abstract— Today, along with the human workers another breed of employees has come into being in the form of 'robots'. Such a scenario has appeared in both the sectors: manufacturing as well as the service sectors. On the other hand, the spirit of 'teamwork' is the demand of the modern day's work-environments. Thus, a very sound and healthy human-dialogue system design has become an essential characteristic of today's man-machine systems. These dimensions have led to the emergence of new challenges for the human factors engineers. Present paper puts forth some of the ergonomic issues which are coming up in the robotized work environments, particularly from human comfort and safety point of view.

Index Terms— Robotized work environment ; ergonomic design; human-robot dialogue system; communication system and human comfort and safety,

1 INTRODUCTION

The work scenario of the upcoming days is on the path of getting drastically revolutionized both in the manufacturing world as well as varieties of service sectors. Humans are getting more dependent on the machines and machines are competing with the human race in terms of different kinds of trades and skill-sets. Today, along with the human workers another breed of employees has come into being in the form of 'robots'. Initially, this reshaping of the work-environments remained confined only to the manufacturing shop floors. With the passage of time the trend has captured the service sectors too, so much so that today robots are already being used in such critical service areas also as, for example, operation-theatres where medical surgeons are employing robots to perform surgery in an environment of remote controls. Under these circumstances, a very sound and healthy human-dialogue system design has become an essential characteristic of today's man-machine systems. These dimensions have led to the emergence of new challenges for the human factors engineers. Present paper made an effort to explore the emerging research trends in the area of ergonomic design of the human-robot dialogue system (HRDS). The current findings pertaining to some of the ergonomic issues which are coming up in the robotized work environments, particularly from communication system and human comforts and safety point of views are discussed and based on the same, certain conclusions are drawn and, finally, scope for future researches are presented.

2 'HUMAN', 'ROBOT' & 'DIALOGUE' SYSTEMS:

Literally, by definition, the word 'human' implies "a man, woman, or child of the species *Homo sapiens*, distinguished from other animals by superior mental development, power of articulate speech, and upright stance"[1]. On the other hand, a "robot is a virtual or mechanical artificial agent. In practice, it is usually an electro-mechanical system which, by its appearance or movements, conveys a sense that it has intent or agency of its own. The word robot can refer to both physical robots and virtual software agents, but the latter are usually referred to as bots [2]." In general, it is agreed that robots are the machines which can move about, perform limbic motions mechanically, have sensors, manipulators and demonstrate artificial intelligence and a behavior that appears to be close to a

human being, .In the fiction-world, there was a time when the idea debated so often was: whether or not the humans would become the slaves of robots. In the real-life world till date this debate has still continued and a conclusive answer has been left to be provided only by the days to come. However, the real life picture has led to the realization of the 'team-work' in which robots are to be treated as a member of the team in which humans are also the participants. Thus, at the most one can say that humans are to be treated at par with robots.

So far as the word 'dialogue' is concerned, it originated from Old French *dialoge*, from Latin *dialogus*, and from Greek *dialogose* [3]. Literally, "dialogue is communication or discussion between people or groups of people such as governments or political parties"[3].With the advent of human-like entity called robot, a new dimension to the word dialogue has come into being and this has led to what is termed as "human robot dialogue (HRD) system". This recently evolved area of knowledge explores how the humans and robots interact or communicate with each other. In the design of the HRD system, the field of knowledge known as 'ergonomics' plays a very critical role. The application of ergonomics results in the 'ergonomic design of the HRD'.

3 ERGONOMICS & ERGONOMIC DESIGN OF HRD SYSTEM

Primarily, ergonomics, also called human factors engineering, is the study of the relationship between humans and machines when they interact with each other in a given work-environment.

Earlier researchers have been addressing the communication between humans and humans. Under these circumstances, ergonomists employed varieties of communication theories to understand and explain the dynamics of the human-robot communication system. With the robots appearing as partners

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1

of humans, the shop-floor work has already started exhibiting a work-culture in which humans are communicating with the machines called robots in a bidirectional pattern of the flow of information. This has revolutionized the field of communication between humans and robots, and old theories could no more be employed as a research tool.

In the new system where human-to-human communication system was replaced by human-to-robot communication system, several parameters got totally changed or modified. The 'modalities', also termed as 'channels of communication' like verbal communication, written messages and body-language communication etc. have emerged as the research topics in the HRD system. [4]. In this channel of communication, be it humans' or robots', there is always a fixed capacity, called 'channel capacity'. So long as the input information equals the output information, the communication systems remains 'noiseless'. When the output is lesser than the input, the channel capacity exceeds its limit and it is said to be a condition of 'overloading' in the communication system. An ergonomically designed HRD system targets at a noise-free dialogue system. In general, different constituents of a typical human-robot dialogue system may be : natural language system, speech recogniser system, text-to-speech system through the speech synthesiser, GUI system, dialogue manager, and the robot control and reporting system.

4 APPLICATIONS & IMPLICATIONS OF THE H-R-D SYSTEM DESIGN

The way a nation's economy is classified on the basis of two basic sectors, manufacturing and services, the robots are also categorized as industrial-robots and service-robots. Service robots employed in service sectors are also called 'social' robots [5]. Besides the robots employed on the shop floor, today, a large number of situations are being explored where humans might be replaced by robots in the very near future. In many developed nations researchers have already been successful on this front. For example in the field of medical sciences there have been many success stories, particularly, in the area of surgery where robots are being employed through remote controls by the surgeons in different OTs (Operation Theatres) of the world-class medical hospitals. Similarly, robots' applications are being explored for household services, handicapped people, elderly helps [6-9], shops, superstores, airports services etc. Another fast and widely upcoming and developing area of application is the child-robot interaction [10-11]. Varieties of toys and games are today being designed for different age-group children for their play, learning and education tomorrow's generation of these toys and games would be very much involving insect kind of robots and the users would be children. The success of robots' ever-expanding applications would be totally dependent on how efficiently the H-R-D systems are designed in future.

5 THE EMERGING TRENDS

As is well documented in literature, the man-to-man or hu-

man-to-human communication system has been widely studied by researchers in the past. With the advent of robots both in manufacturing as well as service sectors, a new breed of communication system has arrived in the form of human-robot communication system. Among the social robots, in particular, the research-trends are addressing the problems of communication with reference to the human-robot-dialogue system. In this context, the natural language processing would be exceedingly important as a research topic of the dialogue system. Recently, some new kinds of dialogue system are being evolved on the research front. One of them is termed as ARDS (Augmented Robot Dialogue System) which is characterized by the 'grammarless' natural language. Such a system aims at resolving 'some semantic reference problems', thereby effectuating improvement in the design of HRD system. Another trend has emerged in the form of 'proactive' kind of HRD system in which the dialogue system is so designed that the robot itself takes the initiative [12]. From the design and development point of view a 'prototype dialogue-based interactive system' has emerged. With the help of such a system a better HRD system can be designed. This is based on the dialogue patterns obtained through direct observation of human conversation [13].

6 CONCLUSION & SCOPE OF FUTURE RESEARCH

Today, along with the human workers another breed of employees has come into being in the form of 'robots'[14]. Initially, this reshaping of the work-environments remained confined only to the manufacturing shop floors. However, with the world getting more globalised and digitized, not only the manufacturing, but service scenario is also on the path of getting revolutionized through the ever expanding world of robotization. This has led to new horizons of knowledge under the nomenclature of 'human-robot-dialogue design'. This is based on various dimensions of perception, reasoning, and programming etc. Today, it is easy to observe that it would be exceedingly profitable to both the entities, humans and robots, if they work together as team members supporting each other's task as partners. This essentially would demand the involvement of the specialists belonging to the field of 'ergonomics' or 'human factors engineering' who have to shoulder the responsibility for the ergonomic design of the human-robot-dialogue (HRD) system. Ergonomics itself is a multidiscipline field in which researchers from different specialties like robotics, cognitive science, anthropometry, psychology, human-computer-interaction, natural language processing, artificial intelligence etc work together to evolve the optimum design of the HRD system. Besides the robots employed on the shop floor, today, a large number of situations are being explored where humans might be replaced by robots in the very near future. The emerging trends in the findings of the recently undertaken researches indicate various dimensions of HRD system as discussed earlier. Looking at the robot-users' population spread over the shop floor workers, medical practitioners, elderly people, the disadvantaged or handicapped persons suffering from memory disorders and attention deficit kind of

problems [15] and finally, the children pose a major challenge to the researchers of tomorrow, particularly from the viewpoints of spoken words (semantics), comprehension, intentional features, memory, channel capacity etc. as these parameters have a direct bearing on the quality and quantity of communication system associated with the HRD[16]. Eventually the final target for the future researchers would be to evolve a 'human-robot-dialogue' system that is almost identical to 'human-to-human dialogue' system.

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