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Intelligent Robotics to Boost Collaboration Between People and Devices and Helping Robots to Adapt to Dynamic Situations and Communicate Naturally with People

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Abstract

Enhancement of collaboration with the aid of intelligent robotics and building efficient communication between people and devices presents a larger-scale advantage for practical application. The paper aims at exploring the capacity of intelligent robots to boost collaboration between people and devices and help robots to adapt to dynamic situations and communicate naturally with people. The paper adopts a deductive and qualitative methodology to conduct an empirical study on the topic. The paper elaborates on the use of 3D estimations and the usage of deep learning for pattern recognition to enhance natural communication between robots and humans. The challenges regarding coherence, swiftness and accuracy are also discussed, illustrating the necessity to build a deep neural network that can accommodate the features of intelligent robotics. Therefore, the possibility of enhancing collaboration through the establishment of response patterns that can create effective and communicative relationships between people and devices is present with the help of intelligent robotics.

Keywords

AI, collaboration, communication, deep learning, human-robot interactions, intelligent robotics.

INTRODUCTION

Intelligent robotics is used nowadays in various fields to enhance collaboration between multiple agents. Collaboration between people and devices is one of the major spheres of technological development. In recent years, reliance on devices has increased significantly, therefore demanding the development of robots with adaptability for dynamic situations. The relationship between a robot and the user is created based on effective communication. Intelligent robotics helps to develop a structure of communication where the patterns of understanding the question and answering questions are as natural as a human's response. Hence, the prospect of collaboration and communication is related to the development of intelligent robotics capable of boosting the present technology effectively.

The comprehensive abilities of intelligent robotics are used widely in various levels of management. For example, human resource management benefits significantly from the implementation of intelligent automation helping in management activities and decision-making processes [1]. Augmented reality and virtual reality are used to connect with people and provide sensory simulations. Human-robot collaboration is capable of monitoring various activities and providing a flexible and dynamic framework for diverse functionality. Enhancing collaboration between humans and devices is essential as the connectedness of everyday devices such as computers, tablets, mobile phones and so on creates the foundation for constant communication. IoT protocols are incorporated to access digital data and maintain privacy and security [2]. The most critical issue faced during human-machine collaboration is related to the inability to express and explain.

Human communication is based on both verbal and nonverbal gestures. The inability of devices to portray these natural gestures of communication limits their ability to the dynamic process of message transmission and reception. Distributed intelligence is considered to be an effective approach for optimising the ability to interact among smart devices which are interconnected with the IoT system [3]. The implementation of 5th generation communication networks (5G) is being designed for reliable and wireless connectivity, essentially revolutionising the interactions between people and devices. Intelligent robotics is considered to be an effective and sustainable solution for the current challenges and constraints faced by devices within a dynamic situation, designed to communicate naturally with its users. Structuring specific deep learning and machine learning algorithms for analysing the natural patterns of human interaction, a device can be created that uses diverse communicative functions such as the figure of speech, gestures and so on [4]. In this paper, the topic of utilising intelligent robotics for boosting collaboration between people and devices is explored along with studying the diverse and innovative ways in which this intelligent robotics can help the robot to adapt to dynamic situations and communicate naturally with people.

LITERATURE REVIEW

The capacity of intelligent robotics to boost human-machine collaboration

Intelligent robotics possess the high capacity of simultaneous functioning, creating a network through which each connected device can be supported. The rapid growth of interconnected smart devices in everyday life demonstrates the necessity of establishing a digital network through which human-robot communication can occur most naturally, in a dynamic environment. The growth of the industrial robots market globally indicates the acknowledgement of the diverse capacities of robotic technology. It is indicated that cylindrical robots have a growth rate of 11.99% followed by SCARA robots at 10.82%, cartesian robots at 10.28% and articulated robots at 9.86% annually [5]. Therefore, the scope for collaboration is enhanced by the growth of the industrial robotics market globally.

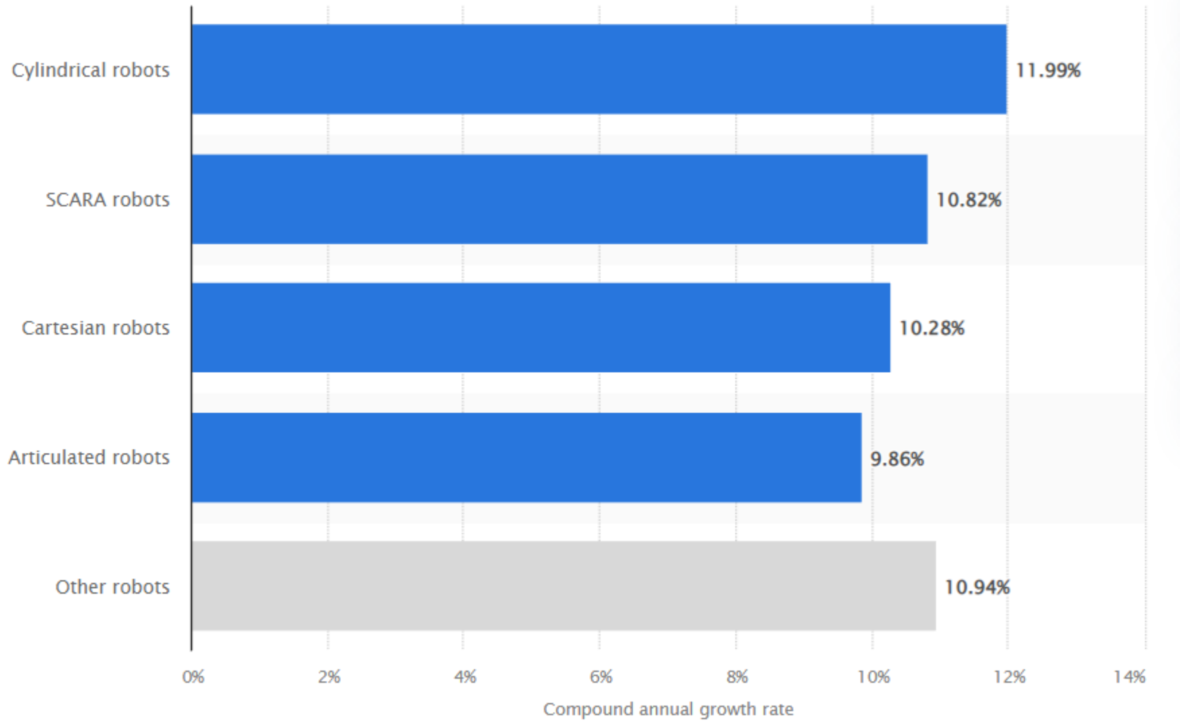

Figure 1: Annual growth rate of different types of industrial robotics globally [5]

Intelligent robotics are used in various sectors to create a network of smart devices facilitating diverse operations. Smart devices are used for communicating with users through various types of commands. Brain-computer interfaces (BCIs) are utilised for connecting intelligent devices such as robotic arms, wheelchairs and so on, benefiting disabled users [6]. Increasing collaboration between users and such devices in the medical sector helps to establish dynamic features. On the other hand, such devices, interconnected with an electroencephalography (EEG) signal pre-processing can help to process and clarify the data to ensure that the users, especially those who are disabled can control these devices through proper communication.

Smart devices used nowadays are incorporated with deep learning algorithms to extract the pattern of users and provide adequate features to fulfil the needs of the users. Human activity recognition (HAR) is gaining popularity due to the efficiency of embedded sensors that can provide an efficient platform for human-device interaction. A dense neural network model can be used which consists of four different hidden layers in order to classify the features of input into various categories [7]. 95.79% Accuracy in classification has been identified in the proposed model which indicates the capacity of the network for a sensor-based operation.

The prospect of collaboration is enhanced by creating an interconnected network that is controlled by the analysis of communicative patterns. Deep-learning algorithms are used for extracting the data related to communicative patterns that are incorporated in the development of specific systems with the capacity for natural interactions. Necessary coding based on the language used by human beings is incorporated into the system. Therefore, enhancing the understandability and dynamicity of smart devices helps to create a space for collaboration.

Challenges of enhancing dynamic collaboration

Multiple challenges are faced when creating dynamic collaboration and communication between people and robots. Human-machine interaction can be confusing for the user as the spectrum of commands and responses are not organic. In essence, the communication between people and devices is limited to the ability of the specific device to understand the commands of the user and provide coherent responses. Electromyography (EMG) is used widely as a pattern for task recognition using deep learning methods that can help in movement classification, estimation of force and prediction of joint angle [8]. On the other hand, robustness and multimodal sensing are incorporated to mitigate the challenges regarding disturbances of the EMG-based algorithm for human-machine interaction. Hence, stability of responses can be achieved without which the challenges of interactions persist.

Human-machine interaction can have communication delays, uncertainties, and nonlinearities that reduce the efficiency of communication between the device and the user. A bilateral teleportation technology is used with a stable and adaptive system of fuzzy backstepping control design that can mitigate the issues of communication [9]. The uncertainties of responses and disruption of communicative flow can decrease the efficiency level of smart devices. The users are also faced with a delay in operations, requiring five commands repeatedly in order to make the device understand. On the other hand, the system of communication that is essentially dependent on the input-output architecture of the system often faces issues due to a lack of understanding and concern with voice commands. Voice commands are highly challenging for smart devices to perform due to the excessive sound transmission of the external world. Therefore, considering the role of intelligent robotics, using AI to understand the patterns of commands and communications used by people, to perform the task competently.

METHODOLOGY

The methodological structure for the paper is established to ensure that data collection and data analysis processes are scientific and evidence-based. The philosophy of pragmatism is applied to the research to ensure that practical knowledge is being analysed to indicate the cause and effect of each variable related to intelligent robotics and its capacity for delivering enhanced collaboration between people and devices. On the other hand, this particular research philosophy is also associated with the development of a research work that is rooted in the analysis of evidence which has aided the researcher in acknowledging the present usage of intelligent robotics for human-machine interactions.

An empirical study design is adopted along with a deductive approach to explore the gathered from various secondary resources effectively. The deductive approach has aided the researcher to develop new theories and hypotheses based on existing theories and information, ensuring that reliable findings are presented. It has also contributed to the analysis of empirical data, contributing to the development of a paper that not only addresses the present capacity of intelligent robotics but also discusses the ongoing technological advancements towards the future growth of communication between people and devices. Therefore, the methodology for the paper helps the researcher to demonstrate a structured analysis of diverse secondary resources.

Secondary resources are gathered from an extensive internet search in various electronic databases, such as Google Scholar, ProQuest, IEEE and so on. An inclusion-exclusion criterion is also adopted based on a purposive sampling technique. The inclusion-exclusion criteria are as follows:

- Peer-reviewed article journals
- Publications made in the last 5 years
- Publications made in the English language
- Resources available for free and in full-text pdf format
- Resources containing specific and relevant keywords (intelligent robotics, human-machine interactions, communication, collaboration and so on)

The analysis of data is conducted by using a thematic analysis strategy through which different aspects and dimensions related to the topic are discussed separately. The thematic analysis has helped the researcher to follow a structural review of various secondary resources that emphasises the interconnectedness of smart devices and how intelligent robotics can be used to verify natural communication. The validity and reliability of the paper are further maintained by ensuring that the consistency and accuracy of the results are projected clearly in the paper.

FINDINGS AND DISCUSSION

Using intelligent robotics to establish collaborative people-device interactions

The use of intelligent robotics and the management of devices to enhance interactive collaborations between people and humans are achieved. Intelligent robotics are designed with AI, deep learning, machine learning, IoT, AR/VR and other such system components that essentially ensure that when interacting with a person, the output of information is accurate, swift and understandable. Positioning intelligent robotics for controlling other smart devices further ensures that communication is effective and engaging to provide the users with a feeling of human-to-human interactions. A teaching-learning-collaboration (TLC) is used to help robots learn from various human demonstrations that are related to language-based instructions [10]. Experimentation on articulating the practice, received from human demonstrations by the robots, holds an advantage in updating the knowledge regarding tasks and integrating optimisation strategies for reinforcing the algorithms for learning with maximum entropy reinforcement inversion. The traditional framework for collaborative robotics is being shifted to enforce dynamicity and adaptability based on real-time and practical information.

Space for cyber-physical interactions in the present day is dependent upon the use of mobile devices that are integrated into Internet-of-Things (IoT) and cyber-physical systems (CPSs). Achieving collaborative interaction between the robotic world and the human world parallelly can be critical, especially with the emergence of new cyberspaces every day. It is stated that a novel structure for cyber-physical-social systems (CPSS) can be used for the management of systems and operations, including efficient designing of architecture, applications, analysis of case studies and network enhancement structures [11]. Establishing an efficient interface for human-machine communication Based on sensors and actuators is presented in various technological frameworks. Sensors are a potent source of information that provides positive signals required to operate robotic actuators [12]. Designing a new generation of robotics that can enhance collaboration with intelligent and sophisticated learning techniques and an algorithm for controlling the deployment of tasks can be highly effective. Therefore, the accomplishment of an effective design for physical human-robot collaboration can facilitate solutions for the present problems.

Automation in robotics technology has flourished based on a structure that can provide easy and robust operational capacity for human-machine interaction. In essence, the prominent areas of robotics are related to automation emerging as different types of revolutionary technologies that can assist other devices with a balanced approach [13]. Enhancing the scope of collaboration between people and devices with the help of intelligent robotics not only paves the way for an efficient and interconnected system of smart devices but also facilitates the structuring of a wider network that can be updated with real-time information based on human activities. The capacity of these robotics can be utilised to decrease the scope of error and achieve collaborative goals based on robust data analysis and presentation.

Enhancing the cognitive abilities of robotics is also related to the enhancement of capacity. Multi-purpose devices such as smart watches, armbands and chest straps are experimented with by incorporating a sophisticated interaction protocol for the detection of accuracy and cognitive effort [14]. Variability of data based on sensors is used by intelligent robotics to make adequate classifications between the patterns of interactions and enable various devices within its network to provide efficient outcomes.

Designing response patterns for dynamic communication between people and devices

Designing adequate patterns of response for natural and dynamic communication between people and devices are also faced with various challenges regarding the lack of proper understanding and real-time information. A system for maturity level-based classification is used to design responses for robotics with efficient responses [15]. A convolutional neural network (CNN) with the same classification system can be introduced for training and creating augmented databases. Enhancement of responsive articulation among the robotics working in tomato harvesting shows results for the successful incorporation of this system that not only provides interactive enhancements but also ensures accuracy in making predictions. Therefore, based on a more efficient model for accurate predictions, the crucial challenges related to communicative inefficiencies can be mitigated and people-device interaction can be optimised significantly.

On the other hand, a soft sensor system for the detection of a "polymeric mechanical actuator" can be used for composing linear responses within the system. "Ionic polymer-metal composites (IPMCs)" based actuators are used for establishing a model of "nonlinear finite-impulse response (NFIR)", which is driven by data, providing efficient responses within a controlled environment [16]. The principles of non-linear and linear models can be applied to creating a neural network that helps in demonstrating a deep learning algorithm for providing accurate responses. A seamless structure for communication can be facilitated with the design of response patterns used by the majority of people. However, it must also be stated that the incorporation of response patterns based on sensor-related data and real-time human demonstrations requires a robust capacity for data analytics. Therefore, collaborative patterns using artificial intelligence for demonstrating sophisticated human-machine interaction are based on both designing and evaluating the robotic system.

Industrial robots are also analysed within their spectrum of intelligent robotics for collaborative enhancement of human-robot interactions. A deep learning approach for establishing a collision detection framework (CollisionNet) is proposed to create a signal for robot collision to recognise various occurrences of collision [17]. As a data-driven approach unifying the features of extraction of high dimensional signals and the processes of decision-making, the proposed framework is capable of eliminating the lengthy and heuristic nature of the traditional process. High-performance ability is associated with this type of network that can help in detecting the anomalies of responses. On the other hand, it is for the regulator that the Geneva Emotion Wheel (GEW) can be used for measuring the emotional level of interactions that helps robots to express their responses efficiently [18]. GEW Is considered to be beneficial based on its ability to reduce labels and cover states of no emotions as well as provide ease of administration. Analysing the responses based on an emotional parameter can help devices to interact with human beings on a more personal level which reasons the satisfaction level of the users.

The utilisation of intelligent robotics for enhancing the adaptability of devices

Using intelligent robotics for enhancing the adaptability of devices is considered to be a growing topic of research in recent days. The Internet of Things (IoT) is used for establishing a platform for connecting various devices and enhancing the ability to communicate and transfer data with the use of standardised protocols such as TCP/IP [19]. Robots used in different fields of healthcare, military, agriculture and industry can be benefited from the enhancement of adaptability as these devices are improved using cloud computing, machine learning, IoT and AI-based technology. Multi-Role Robotic Systems are also designed to provide enhanced adaptability for robotics. Therefore, the tasks conducted by devices connected to intelligent robotics can be used for automated operations in the aforementioned segments. Especially for industrial inventory management, the use of intelligent robotics can be highly beneficial.

Cloud computing has significantly impacted the development of intelligent robotics. Industry 4.0 emphasises the utilisation of intelligent manufacturing for services and products. Artificial intelligence, cloud computing and the internet of things (IoT) are regarded as the pillars for creating a smart factory. A cloud-assisted smart factory (CaSF) with a four-tier vertical integration is considered to be optimal for the performance enhancement of robotics on an industrial level [20]. The development of intelligent robotics for creating collaboration between the factory workers and the device used within the factory establishes a foundation for advanced adaptability. In other words, it can be stated that smart devices interconnected with an integrated network help to facilitate adaptability within a dynamic situation in which the user can use specific features for accurate communication.

Simulation-based designs for enhancing adaptability are also adopted by researchers, training robotics to rely on evidence-based information analysis for decision-making and communication. For example, the challenges of recognising dynamic hand gestures are aimed at being resolved with the implementation of 3D hand pose estimation along with deep neural networks and data fusion [21]. The swiftness of 3D estimation modelling helps to enhance the dynamic reception of information with high levels of accuracy. Furthermore, a 3DCNN + ConvLSTM framework is also used to develop a data identification and classification structure providing 92.4% accuracy of the proposed 3D model. Therefore, a data-driven framework for gesture recognition for advanced human-robot interactions indicates the accuracy and reliability of a simulated system.

Scope for intelligent robotics to enhance response capacity between people and devices

Reliance on real-life simulation of data for improving transparency of communication enhances the scope for intelligent robotics to provide a higher capacity of response for human-machine interaction. Physical human-robot interaction (pHRi) is used for characterising the dynamic movements of humans that are integrated into the robotic motions [22]. A multiaxial force sensor is used for creating a feedback loop based on natural force and robotic motion. In essence, the algorithms used for creating this natural force feedback with the use of the human hand can develop an accurate system that is also adjustable to dynamic situations. Therefore, the system can be regarded as a model for analysis and experimentation for intelligent robotics.

On the other hand, satisfaction and comfort levels among humans are to be analysed while designing a network for physical collaboration. The establishment of a framework based on a distributed network for quick training and filtration of design is beneficial for real-time and resource-limited applications [23]. The level of manipulability during human-robot interaction testing enhances the scope of developing a structure that can contribute to establishing a framework using artificial intelligence and augmented or virtual reality. Furthermore, it is stated that facial expressions using empathy for robotic interactions are beneficial for social interactions [24]. In essence, controlling the thoughts and feelings as expressed through the facial expression of the robots can help to create a sustainable relationship with the user. These social robots are used for various purposes. The system is also integrated with the ability to sense the emotional state of the user in order to produce accurate emotional responses. The scope of enhancing facial and verbal expression for the robotic devices enhances collaborative efficiency. Therefore, the sophistication of 3D simulation and emotional protocols are beneficial for developing dynamic response capacity.

DISCUSSION

Based on the above secondary resource analysis it can be stated that the use of intelligent robotics for enhancing the collaboration between people and devices as well as helping robots to enhance their adaptability in dynamic situations regarding communication can be achieved with the implementation of various AI-based technology, CNN and sensor-based models. Intelligent robotics are designed with AI, deep learning, machine-learning, IoT, AR/VR and other such system components. Enhancement of accuracy and understandability is demonstrated by the implementation of robotics technology. For example, the Internet of Things (IoT) is used for establishing a platform for connecting various devices and enhancing the ability to communicate and transfer data with the use of standardised protocols such as TCP/IP. Therefore, the development of a strong and efficient network can establish interconnectedness, creating a network for smart devices used daily by people.

On the other hand, robots are used in diverse fields as well such as social services, industry, military, agriculture, healthcare and so on, indicating the scope for technological advancement required for collaborative robotics. The inability to answer users' commands with efficiency and accuracy can be challenging due to the lack of adequate simulation-based design. Dynamic gestures are also considered to be one of the most challenging aspects related to collaborative communication. Models based on 3D motion estimations and simulations are considered to ensure that the accuracy and reliability of responses are received. Sensor-based data analysis to create patterns of responses and consider emotional protocols further assists in enhancing adaptability and dynamicity in human-robot interactions. Use of deep-learning algorithms may also be used to demonstrate these patterns in sequential actions. Therefore, intelligent robots hold the capacity to enhance collaboration between people and devices, enabling higher levels of adaptability while communicating with humans.

CONCLUSION

Intelligent robotics helps in building a network within which different types of smart objectives can be operated. The prospect of collaboration and communication in a dynamic condition is also facilitated by sophisticated robotic technology which includes AI, AR/VR, cloud computing, deep learning, machine learning, IoT and so on. Intelligent robotics possess a high capacity for simultaneous functioning, creating a network through which each connected device can be supported. The rapid growth of interconnected smart devices in everyday life demonstrates the necessity of establishing a digital network through which human-robot communication can occur most naturally, in a dynamic environment.

However, Multiple challenges are faced when creating dynamic collaboration and communication between people and robots. Human-machine interaction can be confusing for the user as the spectrum of commands and responses are not organic. Robustness and multimodal sensing are incorporated to mitigate the challenges regarding disturbances of the EMG-based algorithm for human-machine interaction. Hence, stability of responses can be achieved without which the challenges of interactions persist. The use of intelligent robotics helps in facilitating a system that can mitigate the challenges of accuracy, data identification, coherence and swiftness.

Different types of network architecture such as deep neural networks as well as sensor-based data analysis for creating response patterns are suggested to establish a response system that can be adaptable and dynamic. Industrial robotics is further developed based on 3D estimations and 3G network structuring that increases human-machine interaction. Enhancement of accuracy and understandability is demonstrated by the implementation of robotics technology. For example, the Internet of Things (IoT) is used for establishing a platform for connecting various devices and enhancing the ability to communicate and transfer data with the use of standardised protocols such as TCP/IP. Therefore, the possibility of enhancing collaboration through the establishment of response patterns that can create effective and communicative relationships between people and devices is present with the help of intelligent robotics. The rapid development of artificial intelligence assists in the creation of a system which helps to facilitate communication that is both natural and empathetic based on real-time human interaction.

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