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Human-Robot Interaction For Rehabilitation Robotics

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Abstract
Recent developments in robotics and artificial intelligence (AI) have raised interest in humanoid robots that mimic human characteristics and social robots designed for social interaction. Meanwhile, human-robot interaction (HRI) is emerging as a new field of study. The goals of this review study are to clarify the basic concepts of HRI and social robots, look into their current applications in the medical profession, and evaluate their potential for spinal care in the present and the future. Design, social sciences, robotics, artificial intelligence, and other disciplines are all combined in the interdisciplinary field of human-robot interaction (HRI) to create robots that can meaningfully engage with humans. Research on HRI is still ongoing in a variety of domains, including nursing and caregiving support, emotional and social support, cognitive and rehabilitation for the elderly, medical information and education, patient monitoring, and data collection, despite the fact that social robots have not yet been extensively employed in clinical settings. Research on spinal care is still in its early stages, but it is beginning to examine robotic assistance for rehabilitation activities, questionnaire-based evaluations for spine pain, and gait training aids. Future integration of social robots in spinal care will require a range of HRI research programs and proactive collaboration with spinal care specialists.
Keywords: *Human-robot interaction, Robotics, Social robot, Healthcare, Spinal care*

1. INTRODUCTION

Since the beginning of the Fourth Industrial Revolution, technologies like big data, the Internet of Things, and artificial intelligence (AI) have become essential components in a range of organizations [1]. Additionally, AI-powered robots are quickly emerging as crucial components that will influence this revolution's course. Presently, robots are not only employed in industrial environments but are also making significant contributions in healthcare, particularly through the use of surgical robots in real clinical settings [9]. Historically, industrial robots operated in isolated areas away from human workers for safety considerations. However, robotics advancements have led to the creation of robots that can work together and engage in social interactions, which has increased the significance of the field of research known as human-robot interaction (HRI) [2]. Even though physical HRI is still a relatively new concept in the medical field, it has already been included into the development of surgical robots. Social robots, such as those made for nursing and caregiving, have recently drawn more attention since they help patients and the elderly with their emotional and medical needs [3]. Mechanized machines were designed to increase profitability due to the rapid growth of technology and industry's efforts to increase production. Manufacturers of machining devices introduced numerically controlled (NC) machines, which allowed a variety of industrial firms to produce things of greater quality. This program produced the first generation of robots. A lot of people think that the industrial robot era started in the 1980s. Billions of dollars were provided by organizations all over the world to automate crucial processes in their mechanical production systems. The interest in robotization agreements led to an 80% increase in sales of modern robots over prior years[10]. Robots were employed in a number of modern segments to automate a variety of operations, including assembly, painting, binding, and transportation [13]. Significant developments like the web, Ethernet, Linux-based frameworks, and others emerged during these years, hastening the development of robots [4].

2. REVIEW OF LITERATURE

The vision-based approach has a lot of applications, but it has a lot of issues with machine and computer vision. Among the difficulties facing the speech-based system are the stochastic nature of human speech, the presence of noise, and the complex procedure of recognizing human speech and applying it for HRI. The behavior-based approach can be used to construct simple robots, however these robots can only be used for particular purposes. The multimodal method uses a range of tactics to handle each problem. To control and operate a robot, all of these technologies need an appropriate learning process. Robots need exact instructions when operating in a real-time environment. It uses human-computer interaction techniques to learn the task, control its behavior, and carry out the activity. Research on human-robot interaction has a lot of potential given the constraints of the previously stated disciplines. Most service robots [5] are designed to assist humans, particularly those with disabilities. They serve by performing a range of dirty, monotonous, distant, dangerous, and tedious jobs, like housework. Roomba is a brand of autonomous robotic vacuum cleaners. It can vacuum the floor while negotiating living spaces and common obstacles under normal operating conditions. Military robots, like BigDog [11], are autonomous or remotely operated devices designed especially for use in battle areas. They might be used to supply ammunition and supplies. The main advantage of using them is that it spares any family from weariness, eye closure, sickness, and—most importantly—the loss of a loved one [6]. The two kinds of robots—domestic and entertainment—are designed to entertain us and take care of the elderly. After a certain age, we need the support and company of our family and friends. Because life is moving so fast, we don't have time for our elderly. The care and support provided by these robots is really beneficial to them. A major milestone was contributed to the field of medical surgery by medical robotics. Robots are doing extremely precise and accurate procedures on people.

3. MATERIALS AND METHODS

A supervised machine learning method called random forest builds several decision trees. Numerous decision trees make up the forest, and the final choice in this case indicates that a classification problem is determined by the conclusions reached by the majority of the decision trees. According to Fatima and Pasha (2017), decision trees yield high variance and minimal bias. Lower bias indicates that the model can fit and accommodate the training data well, while high variance indicates that the test dataset performs poorly while the training data set performs well. While high variance is not a good thing, low bias is; this random forest adds some flexibility and turns the high variance element into a low variance. Since classification problems are difficult to solve with a single decision tree, the random forest is preferred over the decision tree. Since the random forest depends on numerous trees, some flexibility and unpredictability will be included [7].

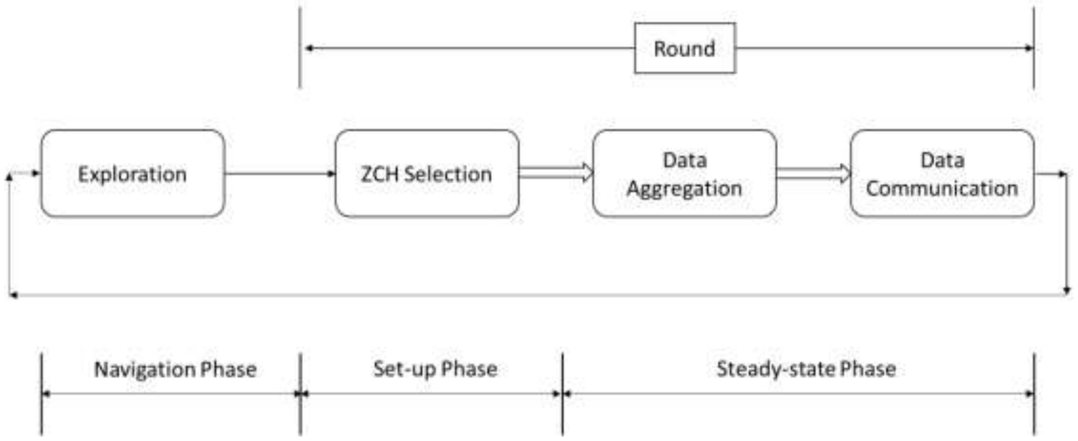

Figure 1: Process of exploration and communication

In RF, we randomly select a few row and column samples from the dataset. A high variance decision tree is constructed from the sample data as a result of the row and column sampling that we undertake. When more models and decision tree results are combined and the majority of votes are cast in a categorization, this large variance decreases. Bagging reduces variance as the number of models increases for a minor change in data since the high variance model indicates that if our model changes significantly, our aggregate value will not change much. When compared to earlier values, the impact of data changes on our aggregated value is still lower since we are growing the number of models (k number of models), which raises the K value [15].

In the case of Random Forest, the effect of changing data on all aggregated values decreases as the K value increases [12]. This decrease indicates that we are moving away from high variance models, which is why K is considered a hyperparameter since it decreases variance and all of these concepts overfit. K, row sample value, and column sample value are the most crucial hyperparameters to maximize random forest performance [8]. When dealing with huge datasets, the random forest model's performance and variance can be improved by fixing row and column sample values and marginally increasing the number of models, k. Our testing accuracy rises with increasing values of k; once the necessary increase is reached, it flattens off, indicating the model's best testing accuracy [14]. It indicates that k is a crucial hyperparameter for maximizing random forest performance.

4. RESULT AND DISCUSSION

In addition, the number of robots inspired by artificial intelligence increased. As businesses realized they needed to be institutionalized, they started to develop a standard set of electrical and digital/programming interfaces that would enable them to work together.

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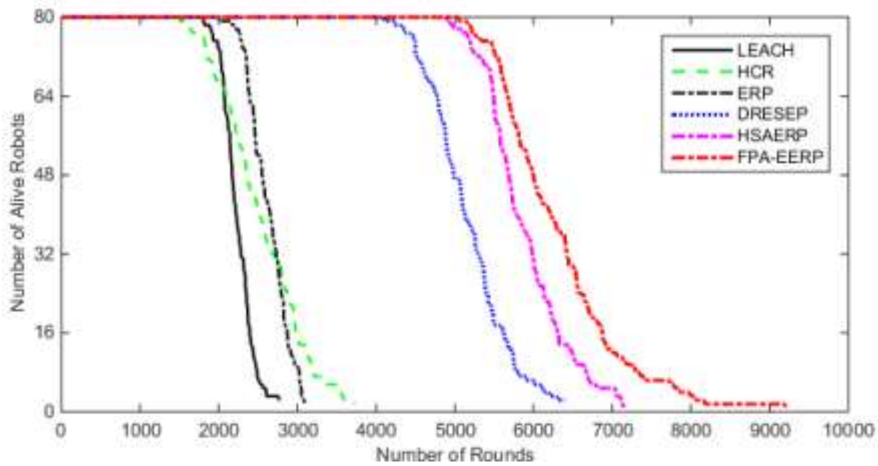

Figure 2: Comparison of no. of alive robots per round wrt different protocols

The interdisciplinary collaboration approach at HRI works as follows: Teams first work together to identify the robot's requirements based on its intended applications, which include helping with daily duties, offering companionship, and monitoring patients in medical settings. Engineers then design prototypes that satisfy these specifications.

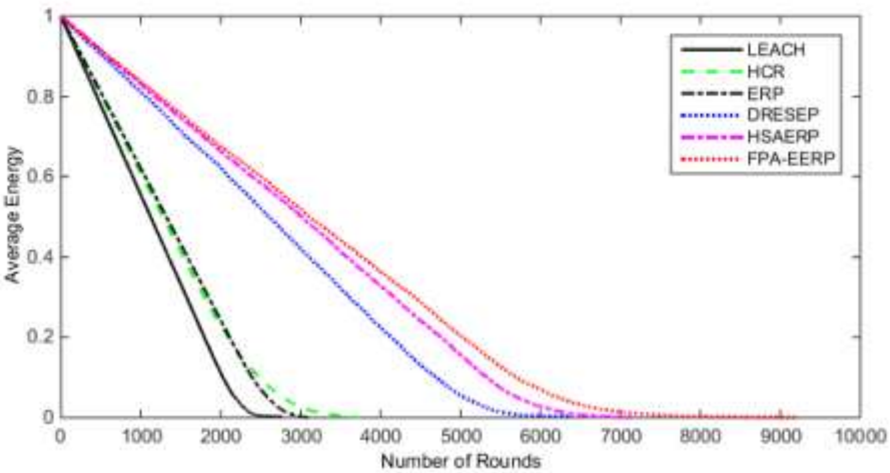

Figure 3: Comparison of average energy per round wrt different protocols

The prototypes are then tested on actual people by psychologists or medical professionals to observe interactions and gather data on the robot's effectiveness and user happiness [8].

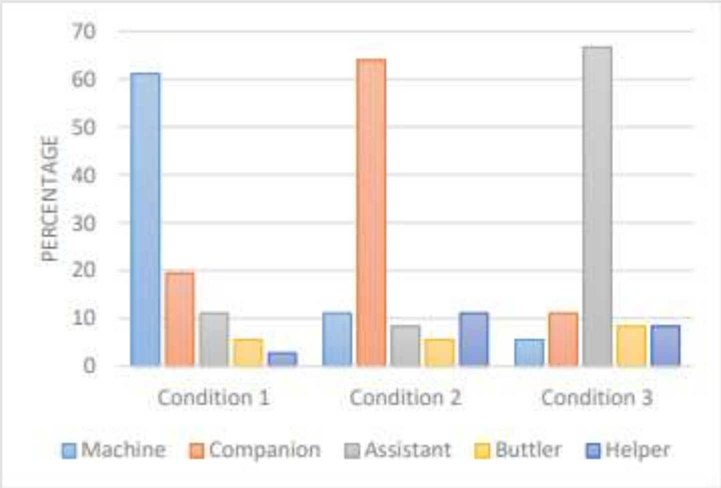

Figure 4: Perceived robot role in different behaviour conditions

The robot's functionality and design are then iteratively improved by engineers and designers based on feedback from testing, with psychologists or medical experts providing insights into how modifications might impact human engagement and emotional responses. Following design completion, the robot is eventually deployed in real-world scenarios, where ongoing assessment facilitates the collection of performance data throughout time and its impacts, guiding future advancements. The PARO therapeutic robot is a noteworthy example of interdisciplinary teamwork in healthcare.

5. CONCLUSION

Human-Robot Interaction (HRI) and social robots are introduced in this review paper, which highlights the growing importance of HRI, particularly in the context of spinal care both now and in the future. Our suggested Query and Rough Set based methodologies have been used to quantify and acquire the human assessment of the suspect. A decision tree classifier, the foundation of the suggested query-based method, assigns the given individual to one of the "n" available classes. Every class has a certain probability attached to it. When using a rough set-based technique, a set of reduct sets is determined. Each reduct set's decision table, which categorizes the test vector, has been calculated. Based on the test vector's membership in these classes, the database's results are retrieved. Robotics technology continues to generate new execution capabilities and use cases because to specialized improvements made possible by advances in AI/ML and computing capacity. Despite the widely accepted adage that "equipment is hard," interest in the applied autonomy space continues to grow. The billion-dollar sub-verticals of robotics technology, such as contemporary service robots with machine vision and many more, are attracting a lot of investment.

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