A Review of Status, Challenges and Safety Issues in Human-Robot Interaction

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Abstract— Human Robot Interaction (HRI) is currently a very extensive a diverse research and design activity. The current status of human robot interaction has been review as key current research challenges for the human factors. Human robot interaction has been applied in various robots tasks including space, undersea, military, agriculture, education, piloting etc. Safety is an important consideration in human robot interaction. The accidents caused by robots can be grouped into three main categories: Engineering errors, human mistakes and poor environments conditions. This paper discuss about various status, challenges and safety issues in human robot interaction.

Keywords—Robot, Human Interaction, Supervisory Control, Tele operators, Tele robot, Humanoid Robots.

1 Introduction

Human robot interaction (HRI) is an active field of integrating and embedding with different techniques in artificial intelligence. This literature is expanding rapidly hundreds of publications throughout each year where it is mostly in the technical discipline of mechanical and electrical engineering computer and control science in Artificial intelligence (AI). While human-automation interaction, for example in space and piloting an aircraft has long been a major active issue in human factors. Robots can do powerful move and very rapid fire movements through by large operational space were the hazard and threats might arise from unintended contact between these robots and humans. Now-a-days a human work in close cooperation with robots more than ever. When it comes to human safety, accident prevention can always be improved. There are been many accidents caused by the human robot interaction in the past. Hence, that the potential danger has been increased. The purpose of this survey is to review possible status, challenges and safety issues in Human robot interaction.

2 Human Robot Interaction Can Be Divided Into Four Major Areas

1. Human supervisory control of robots performance of routine tasks. This might be include the handling of parts on manufacturing

Assembly lines and accessing and delivering of packages, components, mail, and medicines in warehouse, offices, and hospitals. Such type of machines are called as tele-robots, were they are capable of carrying out a limit series of actions automatically, based on the computer program, or communicating such information back to a human operator who updates its computer instructions as required.

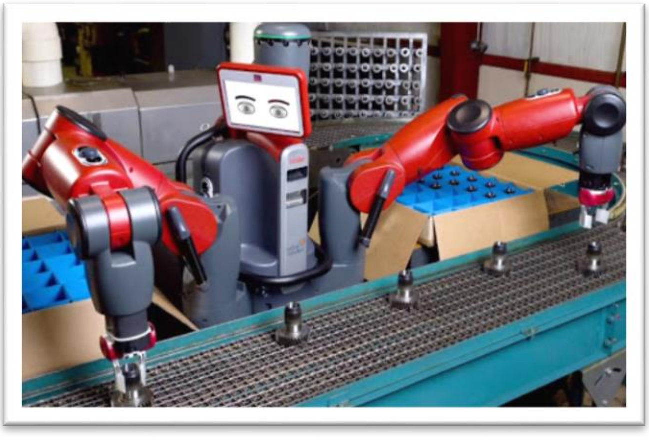
2. Remote control of space, airborne, terrestrial, and undersea vehicles for non-routine tasks in hazardous or inaccessible environments. Such machines are called tele-operators if they perform manipulation and mobility tasks in the remote physical environment in correspondence to continuous control movements by the remote human. If a computer is intermittently reprogrammed by a human supervisor to execute pieces of the overall task, such a machine is a tele-robot.

3. Automated vehicles as in which human is a passenger where a robot might need to operate the vehicle in automated highway and rail vehicles and commercial aircraft.
4. Human robot social interaction, including robot devices to provide the entertainment, teaching, comfort, and assistance for children and elderly, autistic and handicapped persons.

2.1 Human Supervisory Control of Robots for Routine Industrial Tasks

There is a huge type of artificial intelligence robot where they doing assembly line tasks: picking and placing, painting, welding and so on. To the extent that human operators required for the functions of the supervisory control (planning, teaching, monitoring of
Fig2.1: Baxterassembly line robot

Automatic control, making repairs, and learning from experience), such machines are tele-robot. The Baxter



assembly line robot is a marketed product by Rethink Robotics in Boston. It is a widely discussed robot designed to be safe to operate in close proximity with the

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people because it is been mechanically complaint, much like the human body. An interesting innovation in the Baxter robot is that displaying the set of eyes not for the robot to see but rather for it communicate to the human operator a scene of what the programmer to move its hand part of teaching the manipulation tasks or working it in close proximity to the people.

Current human robot interaction challenges for routine tasks extend well beyond the factory assembly line for fetching and delivery of parts and packages (e.g., as used by Amazon warehouse), mail pickup and delivery in office buildings, fetching and delivery of medicines supplies in hospitals, floor cleaning, and automated agricultural tasks. Safety (collision avoidance) is a major issue. The human factors research needs are in planning, teaching, display, control, and supervisor monitoring of automatic action.

2.2 Teleportation/Telerobotics in Hazardous or Inaccessible Environments

The era of robotics began with a human performance need by how to manipulate highly radioactive objects without exposing by human operator. At first the coupling between the human operator's master control and the slave arm hand was to be means of mechanical tapes but later this coupling employed electromechanical servomechanisms with force feedback.

Fig2.2. Master–slave manipulator

There are promising developments in using robotics avatars for surveillance, search and rescue for police work, border patrol, firefighting and rescue and military operations.

2.3 Automated Highway and Rail vehicles, Commercial Aircraft

The earlier **DARPA** (Defense Advance Research Project Agency) "Grand Challenge" contests of autonomous vehicles in 2004, 2005, and 2007 proved that the vehicle was guided by Artificial Intelligence (AI) were feasible. As well-known, recently Google has produced a self-driven car, demonstrated was successfully done on California freeways. However beyond by the feasibility demonstrations, it is hard to assume that a human driver will stay alert and to be ready to take over the control within a few seconds should be the automation fail.

Fig2.3. DARP robotics challenge in the public domain

In meanwhile many of the automobile manufacture have been developing the technology to be augment the human driver, such as radar augmented cruise control, run-off-the-road alarms, and vehicle-to -vehicle communication for preventing intersection collisions. According to the social aspects of driving in the traffic, as well as the degree to which cars can be safely automated, demands much future work in the automated robotic driver. In commercial aircraft telerobots in so far as the pilots mostly fly by exerting the supervisory control using flight man-augment system which is responsible for the control, guidance, and navigation. Thomas Sheridan of (MIT) has been pointed out all of the common aviation as skill, rule and knowledge behavior components.
Aircraft pitch, rolls, and the takeoff so far accomplished by the set of control by the subconscious human perceptual motor skills, for example steering a car on the road, following the set of traffic rules to stop at traffic lights, getting over proper lanes, and make correct turns in roads.

2.4 Human-Robot Social Interaction

Sophia is a social humanoid robot developed by Hon Kong based company Hanson Robotics. Sophia was activated on April 19, 2015.Sophia made her first public appearance at south by southwest festival (SXSW) in mid-march 2016 in Austin, Texas, United States. She is capable to display more than 62 facial expressions.

Fig 2.4.1 Sophia (First Humanoid Robot)

Sophia has been covered around the globe and has participated in such many high profiles interviews. In mean time while interviewers around the world have been interviewed and impress by the response of Sophia's to their questions. In October 2017 the robot became a citizen of Saudi Arabia, the first robot to receive a citizenship of any country. And in November 2017 Sophia was named for the United Nations Development Programmer's first ever innovation Champion, and the first non-human to be given any United Nations Title.

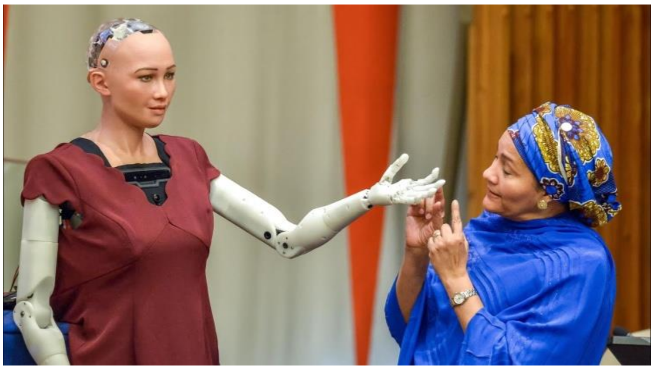

Fig 2.4.2 Human Robot Social Interaction

Cameras within Sophia's eyes combined with computer algorithms allow her to see. She can follow faces, sustain eye contact, and recognize individuals. She is able to process speech and have conversations using Alphabet's Google Chrome voice recognition technology and other tools. Around January 2018 Sophia was upgraded with functional legs and the ability to walk.

3 The Challenges And Benefits Of Robots Using Robots In Higher Education

Teaching instructing, programming a robot is a language problem were the set of diversity and burgeon aspects of human robot interaction reviewed to early stage suggest great opportunities for the human factors involvement in researching and designing the symbolic teaching. Robots offer an excellent tool for teaching engineering concepts that can be employed as teaching and demonstrating a variety of individual subjects, practical exercises, lab classes and project work. Besides learning about concepts of engineering, the students can be capable to develop their valuable skills such as creativity, teamwork, designing and problem solving.

Fig 3.1: Teaching Robot

While using within the Mo-Rob (Modular Educational Robotic Toolbox) project, we focused on these set of issues and how to be integrated them into a framework for the educational robotics. The main objective of this challenges is to associate with the using of robots in higher education initially we used LEGO and ERI platforms for introductory undergraduate teaching. It is proved the success of these potential project based and experimental classes. However shortcomings of the platforms became the platform that has been evaluated in the number of student projects and shown to be effective.

4 Safety Issues In Human Robot Interaction

Robots could do many powerful move and rapid movements through by large scale of operational space. Hazards and threats are able to arise from unintended contact between these robots and humans. The out coming moves of robots and robots arms are difficult to predict where due to changing operational requirements. Operators can be able to require working in close distance to the robot system while the machines are being powered. While the operating spaces of two or more robots could be overlap were it can represent a major threat for human worker from multiple sources. In modern time humans work in closer cooperation with robots more than ever. In the resulting situations contact could be unavoidable between robots and humans. In similar instance it is actually desired however every contact creates the potential for an accident. Once the hazards are known the issue could be eliminate or it may reduce through by design, safeguarding, control and other methods. When it comes to human safety accident prevention could be improved. There are many accidents caused by robots in the past. In these early days the number of robots surrounding to the human greatly increased. So, that the potential danger from robots is greater than ever. This purpose safety is an important consideration in human robot interaction (HII).

5 hazards Overview

In order to improve the safety in human robot interaction (HII) needed to determine where the bigger danger could lies through, who is the most endangered person to interaction to the robot, which could the consequences for potential injuries, which factor could have the greatest impact on safety.

5.1 Sources of Injuries

The cause of accidents caused by robots that can be divided into three main categories: Engineering errors, Human mistakes and Poor environmental conditions. Engineering errors are might include errors in robot mechanics (faulty electronics, loose connections across parts). Accident caused by these errors cannot be predicted even by the most attentive human operator. On the other hand, human accidents, which are more controllable, happen due to various factors, such as inattention, fatigue, inobservance of the guarding procedures, inadequate training programs or incorrect procedures for initial robot start-up.

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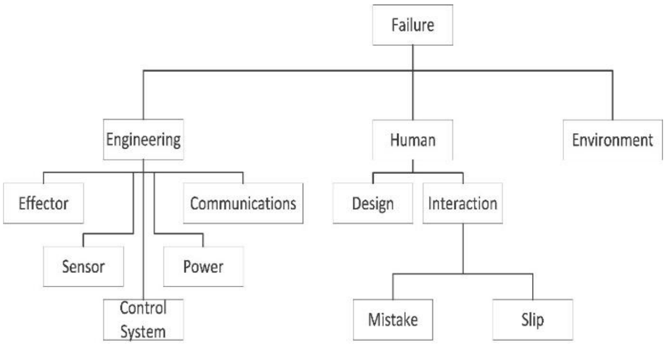

Fig 5.1: Taxonomy of Failure

The source of this state of environmental factors refers to extreme temperature, poor sensing in lightning conditions or difficult weather, all which can lead to in correct response by a robot. Fig 6: Shows depicts the classification of accident sources mentioned above.

5.2 Endangered Personnel

The person who operates the robot is the most risk person. A survey report based on caused effect analysis of 32 accidents is prevented in. It resulted shows the robot operators were subject to injuries in 72% of the reported accidents. Maintenance worker accounted 19% of accidents, whereas programmers were least prone to accidents 9% of cases.

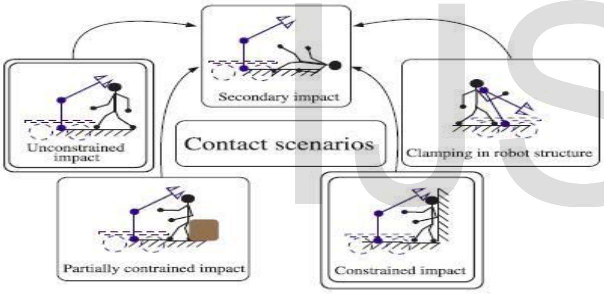

Fig 5.2: Classification of undesired contact scenarios between human and robot

This directly corresponds to the amount of time a person spends in the proximity of a robot. Maintenance workers are usually better trained to

Handle such uncertainty. In many situations however they called when it is already known that the robot is not functioning properly. These injuries are generally due to human mistakes, such as when another maintenance worker activities a robot system to test it while the first worker is still in robot cell. The robot programmers have exceptional knowledge of robot operation, so their injuries often fall into two categories. Most frequently, their injuries are due to unexpected bugs in the software. Less commonly, injuries can occur during the learning procedure. However, they can teach and test robots at lower operating speeds and hence reduce the likelihood of injury.

5.3 Classification of Injuries

Injuries can be classified according to their type between the pinch (56%) and impact (44%) injuries. Pinch injuries occur that when a robot traps a worker between itself and an object where the main impact injury occurs when the robot and the worker collide. The consequences are able to classified as minor with no lost work time injuries and fatal injuries which could base on results were the pinch injuries seems to be of more serious nature then the impact on accidents.

6 Industrial Robots

Industrial robots were introduced in order to replace human workers performing dangerous, difficult, dull, monotonous and dirty tasks. In the past, these dangerous workplaces caused human workers injury and disease. Some health hazards that affect human workers in workspaces are toxic fumes, heat, radiation, noise, physical injuries and so on. In automated production systems, robots are deployed in large numbers for assembly, handling, welding and coating tasks. Robots thereby not only improve safety, but also productivity in heavy industry. However, as described in the previous section, robots can also represent a hazard for the people surrounding them. This section emphasizes accidents caused by robots in industry and gives an overview of safety measures proposed by current standards. Danger to the human workers can further be reduced by proper installation of a robot system. By building high floor surfaces for covering the cables, the likelihood of tripping and falling over them is minimized. Restricted and operating spaces shall be established and clearly marked, as well as traffic routes (e.g., pedestrian aisles, visitor routes, etc.). Access and safe pathway to support services (electricity, gas, and water), control systems, service and cleaning shall be provided. Special attention needs to be devoted to the recovery from a failure. Loss of power or variations in power shall not result in a hazard. Re initiation of power must not lead to any motion, as defined in upon recovery, robot operation shall be reinitiated manually. Start and restart of the robot system shall be simple operations, and shall require relevant safety and protective measures to be functional. Location of actuating controls shall be chosen carefully, so as to prevent unintended operation. Status of actuating controls shall be clearly indicated (e.g., power on, fault detected, etc.). In many cases, collaboration between worker and robot is required. Therefore, it is not always possible to shut the robot off. A good solution is to equip the robot with force torque sensor along with a force torque control techniques, as described in.

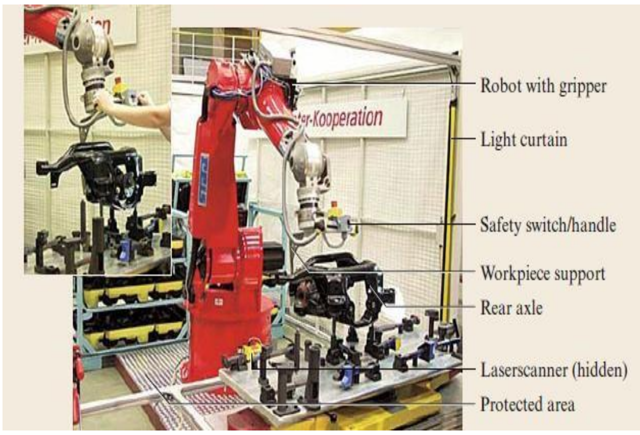

Fig 6.1: Human-robot-cooperation for handling tasks.

Inside a regular robot cell which is secured by light curtains, the robot handles gear boxes at regular speed in fully automated mode. Upon a human approaching the light curtain, the robot goes in the reduced-speed mode. The worker grasps the safety switch which activates the force-torque sensor. The worker guides the robot almost effortlessly by its handle.

7 Conclusion

Research and design in (HRI) demands much greater participation by the human factors community than has occurred in the past, except forsome contexts, such as commercial aviation and military systems, where human factors professionals have long participated. Current technology for "self-driving" cars and drones poses huge challenges for safety and acceptability. Robots are slowly and increasingly pervading in many segments of human lives. They are becoming part of our living environment. While useful, robots also represent a potential hazard. They can move their arms or bodies forcefully and very rapidly and often manipulate dangerous and sharp tools. This represents a threat to all living agents that are surrounding robots. If humans are present in the robots proximity, the situation gets even more dangerous. To address the numerous challenges enumerated before requires i) the design of new sensing technology and of fast sensor fusion algorithms to track multiple moving targets in real time, ii) to achieve robust detection of human motion in order to build good predictive systems, iii) to ensure robust detection of contact between robots and surrounding living agents in multiple points, and iv)to develop fast responsive controllers that can re plan trajectories in complex, cluttered environment in real time.

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