

A Survey on Recent advances in Social Robotics

Ankur Pandey¹, Rupali Nikhare²P.G. Student, Department of Information Technology (AI&R), Pillai College of Engineering, New Panvel, Mumbai,
Maharashtra, India¹Assistant Professor, Department of Computer Engineering, Pillai College of Engineering, New Panvel, Mumbai,
Maharashtra, India²

ABSTRACT: A social robot is an autonomous robot with the ability to interact with humans or other autonomous physical beings under social context and reflect social cues. This paper reviews "social robots" as a research that evolved from robotics in order to develop robots that can interact with humans in an intelligent and social manner. We begin by discussing the background on evolution of social robots and defining social robots. Understanding context and defining importance of context awareness also plays a significant role in study of social robots. The various design challenges that requires attention and can affect robot's functionality and behaviour is included in this research. A comprehensive study of recent literature on social robotics is explored and is part of this work. Later we covered various applications where social robots can impact human lives in a positive manner.

KEYWORDS: social robots, context aware robots, human robot interaction, robot survey.

I. INTRODUCTION

The word robot initially appeared in a play called Rossum's Universal Robots written by Czech writer Karel Capek in the year 1921. The term 'robotics' also started appearing in short stories written by Isaac Asimov in 1940. Earlier people started development of very basic machines which used to perform simple tasks and with the advances in science and technology these machines started emerging into more complex and power structures which can indulge in heavy duty tasks. In order to automate the processes involved in manufacturing sector, first robotic company called Unimation was founded by Devol and Engelberger. As the industrial revolution came into existence the role of humans for repetitive industrial work saw a new replacement in form of robots. General Motors were the first to use robots in their assembly lines. The name of that robot was Unimate. Since researchers have been studying robots from a long time, various definitions have evolved overtime. The Robot Institute of America (RIA) defines the robot as a reprogrammable, multifunctional manipulator designed to move parts, tools, or specialized devices through various programmed motions for the performance of a variety of tasks [6, 10].

The science of robotics has fascinated researchers and scientists from all around the world. Since robotics is an interdisciplinary field so in order to understand the principles and mechanics that apply to robotics, a multidimensional view of various subjects is required. In order to understand social robots, we need to differentiate it from industrial, service-based and other derived types. Study of social robots requires understanding from the field of engineering, sociology, anthropomorphism in context of social robots [5], developmental psychology, artificial intelligence etc. Understanding human behaviour and creating an artificial life that mimics it are two different aspects. In order to sustain in real world environments these robots are required to perform complex tasks that can change with respect to time. Developing robots for assistance in day to day life needs tremendous focus on human robot interaction (HRI) and understanding the associated complexities.

As the study of artificial life evolved, researchers began to apply principles like stigmergy which is inspired by insect societies working in co-ordination with each other which results in creation of complex physical structures and

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

behavioural patterns [3]. Initially this influence from the biological world further led to a series of experiments to imitate animal beings for example Sony's Aibo, a 'robotic-dog' and a very good example of animatronics. Then there is Furby by Tiger Electronics which is an electronic toy having ability to communicate with pre-programmed vocabulary. Leonardo is a social robot that tries to mimic human expressions, track and interact with predefined objects developed by MIT [6]. Fig 1. shows these robots that are inspired from animal behaviours and accepted as toys and research tool to better understand human-robot interaction.



Fig 1. Robots in the form of pets

Defining Social Robots

Research in the field of social robotics started with the inspiration to mimic insects and animals and understanding their behaviour like working in swarm, flock of birds and it gradually moved to understand human perspective towards social existence. In order to create robots capable of human interaction in natural way, defining social robot is of prime importance. Various researchers have tried to define social robots in terms of functionality and behavioural aspects.

Examining the various definitions provided in the literature, Breazeal [4] defines social robot as autonomous robots which can interact with people and understand their input from them using a social model. Duffy [5] proposes the definition of social robots as physical entity embodied in dynamic and complex social environment with the ability to behave in a way which favours its own goals and community at large. According to Hegel, Frank et al. [10] social robot is a robot with social interface where the 'social interface' consists of different design features which defines social qualities of robot from user perspective. Fig 2 shows that social robots requires a multidisciplinary approach from subject like sociology and engineering fields like electronics, mechanical, computer (software) etc.

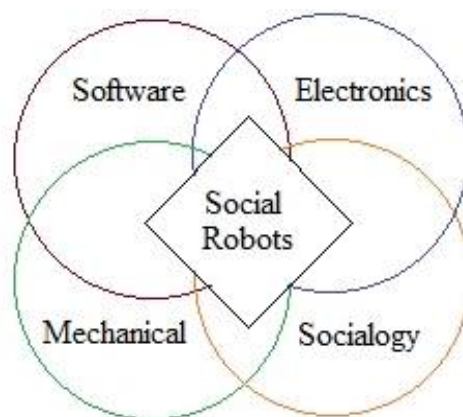


Fig 2. Social robots as a result of multidisciplinary research

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

In order to create robots that are more human like, intensive research is on the run. Appearance of robot plays a very vital role in social context which really impact the affinity towards social robot acceptance. Fig 3 describes the changes in the design of robotic faces from a mechanical to more realistic perspective.

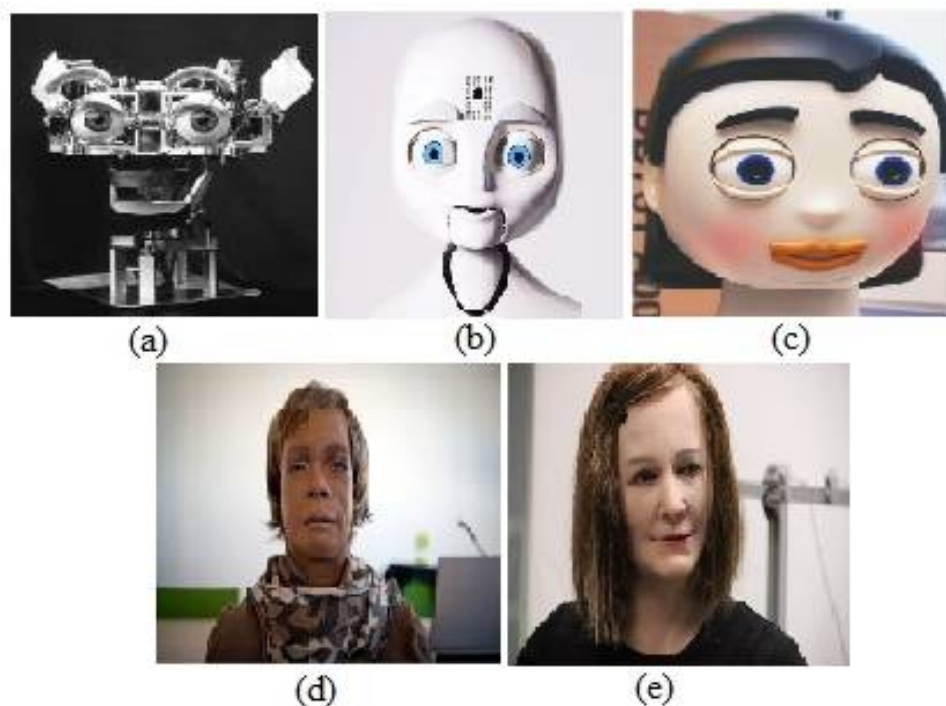


Fig 3. Changes in the design of robotic faces from mechanical to more realistic
(a) Kismet (b) Nexi (c) Flobi (d) Bina48 (e) Nadine

Context Awareness in Robotics

Defining context is significant for the robot's performance under different circumstances. Researchers have defined context and context awareness for many years but started applying it in the field of robotics lately. Independent of the area of application whether it is medical, security, entertainment, educational etc, it is important for robotic systems to have information about its surroundings to satisfy its functional and behavioural goals [19]. In order to acquire data from the surrounding, different sensors are used in robots. Breazeal et al. [1] emphasized the context awareness factor with the development of context based attention for social robot.

Design Challenges in Social Robot

Design and development of social robots requires consideration of various factors so the robot can be adapted in the society. There is a concept of uncanny valley which is depicted in Fig 4. first described by researcher Mori that states the reaction of people for accepting various types of robots from industrial to humanoids [17]. In order to perform in all the possible scenarios, effective design of social robot should also consider people with human social disabilities like autism, schizophrenia and psychopathy [21]. End users perspective is essential in designing the social robot in order to meet real world requirements and such systems should be tested thoroughly in ecologically valid settings if it needs acceptance for long term in human societies [24].

International Journal of Innovative Research in Science, Engineering and Technology

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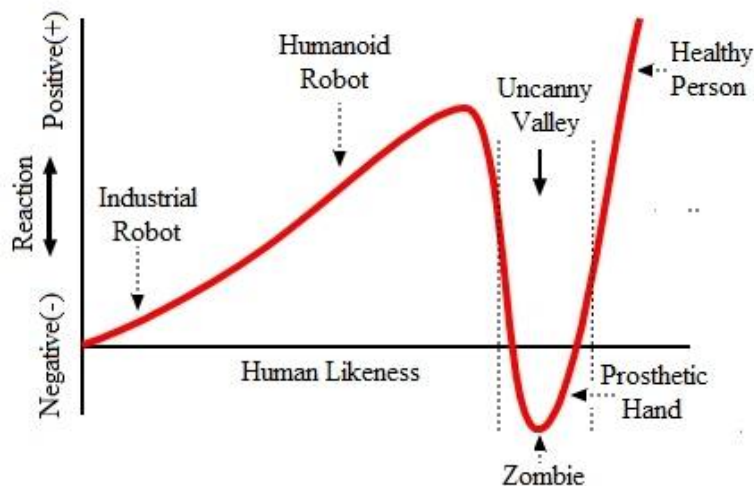


Fig 4. The Uncanny Valley(Mori)

II. RELATED WORK

In this section we cite the relevant past literature that describes the study, design and implementation of social robots using various techniques. Most of the researchers focused on complex design aspects and mechanical interaction. Multiple sensor system is rarely used in order to receive feedback from surrounding environment.

Kismet is a robot head made in the late 1990s at Massachusetts Institute of Technology by Dr. Cynthia Breazeal[1] as an experiment in affective computing, a machine that can recognize and simulate emotions. The name Kismet comes from a Turkish word meaning "fate" or sometimes "luck". The appearances of this robot were totally mechanical and have some efforts in aesthetics area. Authors designed and demonstrated visual attention system based on human eye gaze search behaviour like bottom-up and top-down behaviour. Their model is based upon Wolfie's model [Wolfie,1994] and created context dependent attention activation map by considering these three integrated perceptions: detecting the movements (using frame grabber to detect temporal differences in images), color detection (8 bit RGBY color channel), face detection (using ratio template algorithm to detect face front view). This map is used to direct eye movements and help the motivation and behaviour system of the robot. The motivation system deals with emotions and drives. The experiments conducted by them were on seeking people, interaction with people, avoid people, seek toy, avoid toy. When seek people behaviour was activated the robot spent 80% of its time looking at the face, 83% time while looking over toy face, overall time taken to look at faces was 5% in behavioural context and 24% when on avoid toy mode.[1]

In an effort to explore human response to a socially competent embodied agent, Scheeff, Mark, et al. built a life-like tele-operated robot 60cm long, 50cm high and 35cm wide. It uses motion, gesture and sound to interact with people close to its vicinity using motor driven wheels. It moves its head in a yes or no motion and express 9 different emotional states with eyebrow movement and by voice. The control of gaze direction (pitch and yaw for head), platform movement, sound output and emotional state can be controlled by a video game controller which is in the hands of the remote operator. This robot is designed on Pentium 200 MHz processor using motor control cards, batteries, sensors. The software consist of 2 components: layered motion synthesis engine developed using Perlin's Improv System (Perlin and Goldberg 1996) and audio engine. [2]

The authors Terrence W. Fong, Illah Nourbakhsh and Kerstin Dautenhahn [3] have reviewed many socially interactive robots. The various social aspects of human-robot interaction are discussed. From the context of defining social robots, various design strategies and methods and core system components, this paper provides a detailed overview.

KASPAR, the minimally-expressive humanoid robot designed as a therapeutic toy for children with autism. KASPAR has been designed by Dautenhahn, Kerstin et al. by the University of Hertfordshire's Adaptive Systems

International Journal of Innovative Research in Science, Engineering and Technology

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Research Group. It is remote controlled with different movements of the head/neck, different facial expressions, variety of arm gestures. It can perform task with object like drumming, imitation. It has 3D special dimension of interaction but the child must be positioned in front of the robot for interaction. The nature of interaction is free but guided by experimenter. [11]

Simon, a turn taking interactive robot was designed by considering factors like syntax, semantics, paralinguistic, eye gaze, and body language using C6 software system, Microsoft speech API on Windows 7 with predefined grammar. It was designed especially for turn taking interaction and handling time outs, cue management and handle timing of continuous feedback to the human about its internal machine state.[16]

Michael Ferguson et al. designed a social robotic platform named 'Nelson' for educational and research purpose. The robot consist of a social face, arms for representing gestures, advance sensor system etc. The complete robot is controlled by sending serial commands using a computer.[17]

BINA48 (Breakthrough Intelligence via Neural Architecture 48) has variously been called a sentiment robot, an android, gynoid, a social robot, a cybernetic companion, and "a robot with a face that moves, eyes that see, ears that hear and a digital mind that enables conversation". It is basically a thinking and conscious being.[23]

Nexi, robot learning from free-form human generated feedback without guidance or evaluative feedback. A framework for learning from human feedback TAMER is used to apply on physically embodied robot. It can go to left right and straight direction and the behaviours taught consist of; go to, keep conversational distance, look away, toy tantrum (not moving forward), magnetic control (repel from the object) and time consumed in training are 38.5, 11.4, 7.9, 6.9, 16.4 minutes.[25]

Nadine is a realistic female humanoid social robot designed by the Institute for Media Innovation department of Nanyang Technological University and modelled on its director Professor Nadia Magnenat Thalmann.[20]

III. METHODOLOGY

In this section we discuss various factors which are required in building and what factors are need to be considered in an interactive robot.

Design Approaches

Human are expert in interaction with others and if technology follows human expectations then interaction will be more enjoyable and competent. As robots are being structured with faces, speech recognition, lip reading skills, face emotion detection makes robot and human interaction like human-virtual human interaction.

From design point of view, interactive robots are built in two ways: biologically inspired and functionally designed. Biologically inspired means internal simulation or mimic the social intelligence found in living being. Function designed means to construct robot that appears social intelligent outside without basic in science in the internal design.

Robots have limited perceptual, cognitive and behaviour abilities as compared to humans. So in the future there may be difference in social communication between human and robot. But with artificial intelligence, it is possible that robots may become highly sophisticated in complicated social area like infant care taking relation, elderly care taking relations, personal tuition teacher, etc.

The differences in design technique mean that the evaluation and success criteria are different for different robots. And it is difficult to compare socially interactive robots outside their target environmental use.

Common Design problems

Any robot system must solve common design problems like planning, decision making, navigation, sensing the environment, mobility and manipulation actions, human-robot interaction through interface and control architecture. A socially interactive robot must perceive and interpret human activity and behaviour so interactive robots must also address these problems. In human oriented perception, a robot must perceive and interpret human activity and behaviour like gestures, human activity human cues, etc. In natural human and robot interaction, both should communicate as peers who know each other well and have believe behaviour with social expectations. In readable social cues, robot should send signals to human to give back its internal feedback allow human to interact face to face manner. Facial emotional expression, body language and vocal sound and pitch are included as well. In real time

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performance, robots must operate at human rates. So robot needs to perform a competent behaviour by listening, processing, making decision, giving output in proper form like speaking or movement.

Body of robot

The body of the interactive robot consist of hardware parts according to the performance and the environment it is working into. An interactive robot can have a physical body or only display interface. If a robot has physical body then some robots can be more embodied than the others like Aibo(Sony) has approximately 20 actuators (mouth, head, ears, tails and legs, sensors like touch, sound, vision and distance) and Khepera (k-Team) has only two actuators and proximity sensors. Researchers till now have not explicitly focused on design atleast not in traditional industrial design sense.

Artificial Emotions

Emotions play an important role in human behaviour, communication, interaction and to make proper relationship with others. Numerous architectures have been proposed on artificial emotions. Some robots are capable of displaying emotions in very limited way like actuated lips, flashing lights, moving eyes, etc. For example Kismet has eye brows, eyeballs, eye lids, mouth with two lips and tilting neck which are controllable.

Speech for robot

A robot can interact with humans through speech as output. The speech processing has various parameters and currently work is still going on in order to make machine generated output speech sound much similar to human voice.

Personality of robot

Personality is describes in five traits: extroversion which means sociable, outgoing and confidence; agreeableness which means friendliness; conscientiousness means helpful and hard-working; neuroticism which means emotional stability and adjusted; openness which means intelligent, imaginative and flexibility. If a robot has compelling personality then people would be more willing to interact with robots and establish a relationship.

Perception of robot

A robot must mimic the behaviour of humans like human eye movements, facial expressions, body movement, etc. For that to achieve the visual motor control system must be very precise and clear. Perception include active sensors like ultrasonic sonar, etc., person tracking, speech and gesture recognition, gaze tracking. There are several questions like how a robot will know when and what to initiate a communication, how to observe action into behaviour, how robot will evaluate its behaviour, correct errors and when robot has achieved its actual goal. Initiation is used for leaning motor skills from observation.

IV. APPLICATIONS

Robots with different degree of freedom is been used by various industries. Some of the applications are: support elderly and disabled people, home assisting, cleaning, and arranging objects in order, fetching objects in real life environment like car driver, masseur, tattoo maker. They can also be social life supporter, guidance, suggestion givers. Applications in education sector include personal home tutor, school teacher for clearing doubts, feedback taker from the students. It can be a personal friend who acts and behaves like human, and can be our best friend in near future.

V. CONCLUSION

As we look into the future, with the fast pace ongoing research in science and technology, social robots will play a vital role in enhancing research towards artificial life. Systematic help from engineers, sociologists, psychologist working in co-ordination with each other will take the research in social robots by leaps and bounds. Social robots will assist in health care, rehabilitation, and therapy. Social robots will work in close proximity to humans, serving as tour guides, office assistants, and household staff. Social robots will engage us, entertain us, and enlighten us. In order to

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

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make social robots that masses can adopt, user perspective will play a very crucial role. Context awareness in robotics will help the robot to understand its surrounding better and adopt the changes in its behaviour and functionality accordingly. This will further aid in designing more intelligent and robust social robots that can sustain in a variety of environments.

VI. ACKNOWLEDGEMENT

I am using this opportunity to express my gratitude to thank all the people who contributed in some way to the work described in this paper. My deepest thanks to my project guide for giving timely inputs and giving me intellectual freedom of work. I express my thanks to the head of Information technology department and to the principal of Pillai College of Engineering, New Panvel for extending his support.

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