A review on humanoid robotics in healthcare

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Abstract. Humanoid robots have evolved over the years and today it is in many different areas of applications, from homecare to social care and healthcare robotics. This paper deals with a brief overview of the current and potential applications of humanoid robotics in healthcare settings. We present a comprehensive contextualization of humanoid robots in healthcare by identifying and characterizing active research activities on humanoid robot that can work interactively and effectively with humans so as to fill some identified gaps in current healthcare deficiency.

1 Introduction

The use of robots for surgery has given rise to a large number of new methods which has led to the emergence of a wide variety of robots for use in the medical domain. [1] Points out numerous research areas in the application of robotics in healthcare settings. Such as robotic surgical Systems [2, 3], laparoscopy surgery and tele-rounding robots [4], robot-assisted rehabilitation [5-7], caregiver and patient's assistants [8-10], robotic applications in dentistry, bio-prosthetic [11]. The list continues as the technology advances and even more applications of robot in healthcare could be envisaged.

Humanoid robots that could be used to remotely carry out tasks are also very important. Such robots are endowed with human capabilities to assist caregivers and patients particularly in contaminated environments. These remotely operated robots are to possess certain characteristics for human robot interaction. However, tele-operated semi-autonomous robots can be used to perform assisted healthcare tasks during outbreaks which would reduce the time personnel need to spend in dangerous contaminated areas while putting on their personal protective equipment in high temperature and humid conditions particularly in the West African region. Furthermore [12] highlighted some healthcare robots that have been developed for similar fields of application [13, 12]. The robot Cody is able to wash human limbs autonomously and an evaluation of the patient's system showed that acceptance strongly depends on the interpretation of robot intention [14]. Other robots serve as rehabilitation [15], the nurse assisting lifting of patients [16] or even blood sampling [17].

While research on humanoid robots for general or supportive patients care particularly for disease containment has hit the ground running in other developed countries due to the recent outbreak of Ebola virus disease that shook the world it is also important for those affected directly to find a solution to their problem. We propose a broad overview of some of the current and potential applications of robotics in health care settings and we carefully selected some robots for patients care.

2 Literature Review

Table 1. Summary of different application of robot for general and supportive care [13].

Author	Robot	Description
[18]	ARMAR III	Developed to support tasks in 'human-centered' environments to include households. Upper torso is humanoid in design. Designed to interact with humans and manipulate objects in the environment.
[19]	Care-O-Bot 3	Mobile robot assistant designed to help humans in everyday environments. Includes an arm and gripper for manipulation of objects, a tray for carrying and transferring objects, and a flexible torso enabling butler-like gestures such as bowing and nodding.
[20]	Cody	Robot assistant developed to help caregivers with patient hygiene, specifically bed baths. Uses a compliant arm and gentle force to perform 'wiping motions' similar to those used during bed baths.
[21]	PR2	Mobile humanoid robot design to support tasks in human environments. Capable

		of manipulating objects and performing tasks such as setting a table and emptying a dishwasher.
[9]	RIBA	High load capacity robot designed to lift and transfer patients.
[22]	RIBA	Designed in appearance similar to a giant teddy bear. Carries patients in 'human-type' arms. Equipped with tactile sensors to detect patient's contact position, allowing motion adjustment to be made accordingly.
[16]	Robotic Nursing Assistant	Designed to help caregivers with physically demanding tasks such as lifting and transferring patients. Upper torso is humanoid in design.
[23]	Hair-Washing Robot	Robot assistant designed to help caregivers wash patient's hair.
[24]	ASIMO	Human-size humanoid robot. Capabilities include walking, running, and climbing stairs, carrying objects, opening doors, and pushing carts.
[25]	ROSE	Tele-operated robot for home care applications. Capable of performing tasks such as grabbing and placing objects, opening doors, and cleaning.

3 Characteristics of Humanoid robot

3.1 Vision system

Visual perception is fundamental to most robotics systems working in human environments, it is also essential to a wide variety of tasks such as manipulation, tracking, human–robot interaction [26]. [27] Developed a simple and affordable vision-based robotic system for the identification of the Euclidean position of red spheres that emulate ripe tomatoes. This is done by using a RGB-D sensor in a fixed position, together with a 5 DOF manipulator. Robotics should follow the condition and perceive the surroundings to achieve the goal. Due to perception, robots check their state of joints by using encoders or sensors. Robots developed nowadays are covered with force-sensitive skins. Many humanoid robots use senses like laser rangefinders or ultrasonic distance sensors. They also use cameras, to enable them to focus their attention towards specific objects and screens to interpret the images.

3.2 Manipulation tasks

Humans have the ability to move their hands almost 30 DOF [28]. Some of the humanoid robots that were built cannot hold the unknown objects from the environment like humans. The reason behind this is lack of learning ability to perceive and sense the new objects. Improvements were needed so that they could hold the things and sense them by touching [28]. Also learning from demonstration can be used to train soft robotic hands to perform dexterous manipulation tasks. The ReMeDi robot led to the design of a light cable-driven manipulator [29] which then advanced to the construction of a large SCARA type manipulator with 6 DOF which is used for palpation [12].

3.3 Sensing behavior

There are different types of sensors used in humanoid robots. But [28] focused on specific on sensors used to grasp the objects means arm's sensors. Sometimes arms are small so according to them, sensors must be small according to the joints. For loop gesture of hand, there should be a measurement of every joint. [28] Highlighted that from the many approaches that were used for this [30] gave concept of using plastic potentiometer at ever finger's joints. Another technique by [31] gave that linear potentiometers at wrist joint to calculate the angles of joints. But this idea was flopped due to lack of precision cause of friction of tendons. Most useful idea was given by [32].

3.4 Mobile Platform

Humanoid robots have to be flexible enough for easy maneuvering. While fixed robots will always find a place in manufacturing, humanoid robots with mobile base promises additional flexibility to end-user in new applications. These applications include caregiver and patients assistance, medical and surgical uses as well as security. [12] Propose two types of motion for the mobile base, the short distance motion which cater for the robots positioning next to the patient to obtain an appropriate position area for the robot arm and a long distance motion which involves movement between the robot parking lot and the examination room.

4 Applications of Humanoid Robotics in Healthcare

4.1 Tele-Healthcare

A Tele-operated Service Robot is a robot that is controlled by a human being from a distance and performs tasks typically in uncontrolled environments [25]. Tele-operation enables an operator, to act remotely as if the operator was on the spot, by for instance copying the manipulations of the operator at a distance. An example is the Da Vinci Robot used for medical surgery [25].

The use of tele-operated humanoid robots in healthcare represents an exciting opportunity to help doctors, nurses and patients to ease the high risk of

infectious disease transfer [33]. [34] Investigated the use of teleoperated robots to allow healthcare workers to perform some of their duties at a safe distance from the infected patients. The result suggest that patients will trust the robot less when the operation is unseen than when the operation is visible. More investigation needs to be carried out to know the extent of the effect. However, the design of the Tele-operated Service Robot [25] can be adapted for the development of a healthcare robot for the general task of supportive patients care.

4.2 Humanoid Robot for Pain Relief

Humanoid robots are used to implement techno-psychological distraction for children in order to reduce their pain as a result of stress and anxiety during a medical procedure. Studies carried out by [35-37] all point to the fact that children are more likely to smile when encountering medical procedures with a robot. The aim is to turn children's attention away from the pain of the needle toward an amusing activity. [38, 37]. States the principles of attentional capacity theory, that the distraction stimulus must be stronger than the pain stimulus to gain the child's attention. Although, music and cartoons have shown effectiveness in reducing pain and anxiety among children undergoing a variety of medical procedures [39, 40, 36]. It would appear that these distractions are not always strong enough to turn children's attention away from the pain. It is now believed that multisensory strategies, which combine visual, auditory, and tactile senses, may have a greater impact on pain than single-sensory strategies [39, 36]. Given the mixed results mentioned above, it stands to reason that stronger and more engaging forms of distraction, which invite the child to engage in an activity, may be necessary for medical procedures.

In addition to other interventions, we suggests that techno-psychological distraction for children for management of pediatric pain be considered. When programmed with humanistic characteristics and to execute psychological strategies, a humanoid robot shows promise of reducing procedural pain and distress in children [37],

4.3 Humanoid Robot for Aging Population

In a society where there is a rise in the disabled and aging population, there is a strong demand for robotics to tackle problems that arise from their inabilities to relate effectively with their environment. Robots for executing patient-transfer tasks are needed in nursing care facilities and hospitals, [9] developed a new prototype robot named RIBA with human-type arms which was designed to perform heavy physical tasks requiring human contact, the robot was able to transfer a human from a bed to a wheelchair and back. The caregiver can intuitively give instructions to RIBA through tactile sensors using a newly proposed method named tactile guidance. RIBA was developed to cope the difficulties encountered previously by RI-MAN [41, 42].

5 Conclusion

More interest are now being directed towords robotics in healthcare because of the successes robots can bring as it has been in other domain. Still, we have not seemed to have been able to appreciably utilize this technology in developing countries for effective healthcare delivery. Healthcare needs a pathfinder solution in which the investment and risk of robotics applications are small. However, There are a number of exciting advances in robotics in recent years, which points to a fruitful future. Humanoid robotics in healthcare settings is rapidly evolving. We examined the state-of-the-art of the emerging field of the current and potential applications of robotics in healthcare.

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