RESEARCH METHODOLOGY: CA-2

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5 RESEARCH PAPER SUMMARIES

ON

ROBOTICS IN HEALTHCARE AND MEDICAL

1. Medical and HealthCare Robotics

This proposed paper talks about medical and healthcare robots that involve direct interaction with human users in the surgical theatre, the rehabilitation centre, and the family room. Telerobotics systems are being used to perform surgery, resulting in shorter recovery times and more reliable outcomes in some procedures. Socially assistive robotic (SAR) systems are being developed for in-clinic and in-home use in physical, cognitive, and social exercise coaching and monitoring. He application ar4as for medical and healthcare robots have been discussed, robotics systems are also successfully delivering physical and occupational therapy and replacing lost limb function. Robotic systems can also provide therapy oversight, coaching, and motivation that supplement human care with little or no supervision by human therapists and can continue long term therapy in the home after hospitalization. A robotic system is created that mimics the biology has been used as a way to study and test how the human body and brain functions. Societal Drivers have also been discussed in this paper for improved healthcare. Many methods have been adopted to train for medical procedures resulting in faster recovery time and improved worker productivity. Effective methods of training medical practitioners would lower the number of medical errors. These improvements will lower the cost.

This paper also talks about the motivation that resulted in the development of surgical robots. Surgical and Interventional Robotics

Current robots used in surgery are under the direct control of a surgeon, often in a teleoperation scenario in which a human operator manipulates a master input device, and patient-side robot follows the input. A complete surgical workstation contains both robotic devices and real-time imaging devices to visualize the operative field during the course of surgery. The next generation of surgical workstations will provide a wide variety of computer and physical enhancements, such as no-fly zones around delicate anatomical structures, seamless displays that place relevant data in surgeon’s field of view, and recognition of surgical motions and patient state to evaluate performance and predict outcomes.

Robotic Replacement of Diminished/Lost Function

Prosthesis is an artificial extension that replaces the functionality of a body part (typically lost by injury or congenital defect) by fusing mechanical devices with human muscle, skeleton, and nervous systems.

Robot-Assisted Recovery and Rehabilitation

This section talks about the patients suffering from neuromuscular diseases. This process uses the plasticity of the human neuromuscular system and helps them to relearn how to move. This process is time consuming and labor intensive but the benefits it provides in terms if patient health care costs and return to productive labor.

Behavioral Therapy

This section talks about SAR robotic field. SAR is a comparatively new field of robotics that focuses on developing robots aimed at addressing precisely this growing need. SAR is developing systems capable of assisting users through social rather than the physical interaction. Robots, then, can help to improve the function of a wide variety of people and can do so not just functionally but also socially, by embracing the emotional connection between the human and robot. Human–robot interaction (HRI) for SAR is a growing multifaceted research area at the intersection of engineering, health sciences, psychology, social science, and cognitive science.

Personalized Care for Special-Needs Populations

This section talks about the people with disabilities or disorders. Robotic technologies promise mobility aids that can provide adjustable levels of autonomy for the user, so one can choose how much control to give up, a key issue for users with disabilities. Intelligent wheelchairs, guide-canes, and interactive walkers are just a few illustrations of systems that have been developed and are, in a few cases, already commercially available.

Intuitive Physical HRI and Interfaces

This section involves physical interaction between patients and robots. The robot will need to provide useful feedbacks to the human operator, caregiver or a patient.

1. Healthcare Robot Systems for a Hospital Environment: CareBot and ReceptionBot

This proposed paper is divided into four sections namely

1. Introduction

Firstly this paper is talking about the various service robots that are being introduced into human lives and are helping us in many ways, such as assistants, guides, and companions. The various types of robots summarized are:

1. Cleaning robots: these are the most used robots in home environments.

Robot Name: Roomba.

1. For daily assistive system, Home automation robots which control home appliances as well as managing the home environment.

Robot Name: ApriAlpha, PaPeRo, and PBMoRo.

1. For all those people who feel lonely, Companion robots can help them throw away their loneliness, and animal type robots can provide “pet therapy”.

Robot Name: AIBO, and PAIRO.

1. Robots are also used for entertainment or guiding, such as a singer, actor, newscaster, receptionist and a playmate.

Robots are widely being used in healthcare facilities such as hospitals, most robots are used for delivering goods such as meals and linen. Some robots help people with physical aspects of healthcare, for example RIMAN help nurses or family members to lift patients safely.

In this paper, they have introduced new robot system for healthcare environments. The illustrated healthcare robot system consists of three main subsystems:

1. A receptionist robot system
2. A nurse assistant robot system
3. A medical server.
4. HealthCare Robot System
5. Overall Architecture

This section talks about the entire architecture of the healthcare robot system, which has three subsection: A receptionist robot system, A nurse assistant robot system, A medical server. ReceptionBot works at reception in a healthcare facility, and interacts with visitors based on a receptionist service engine and a definition of the workflow of the receptionist. CareBot works in the healthcare facility where patients are screened to gather personal information and health data such as vital signs. CareBot asks the patients to answer questions and helps them measure vital signs. RoboGen communicates with a ReceptionBot and CareBot in real-time. It is a secure server, and manages the patient’s information such as personal details, vital sign measurement results, medical history, and robot interaction records.

1. Robot Platforms

They use the iRobiQ as a ReceptionBot and Charlie as a CareBot in this paper.

This sections tells us the various platforms where IRobiQ and Charlie robots are been extensively used in our healthcare robotics research and are acceptable to people.

1. Medical Server: RoboGen

This section talks about the RoboGen medical server system. This robot is used for storing the patient’s medication data, storing health information including vital signs, measurements, and interaction records. This is built using the Microsoft ASP.NET and MVC framework and a Microsoft SQL server. Healthcare robots connect to RoboGen through web-services, and they communicate asynchronously.

1. The System Architecture of The HealthCare Robot System Focusing on the UoA Robotic Software Framework
2. UoA Robotic Software Framework

This section talks about the difficulties that are faced while integrating multiple software frameworks together; to overcome this problem we adapt our UoA Robotic Software Framework. This Framework consists of three layers:

1. Application layer
2. Robot manager layer
3. Components layer

The application layer, various applications are executed based on workflows. The application is able to interact with the robot manager using a predefined Application Program Interface (API) and a combination of Web Socket connections and JSON messages.

1. Robot Manager

This layer has 3 main roles:

1. Managing the status of each connected framework
2. Mapping the higher level API to the framework functions
3. Transferring the data from frameworks to frameworks.

The robot manager layer uses 2 main modules to perform these roles:

1. A robot manager core engine
2. Configuration data.

The robot manager core engine is responsible for managing the status of each connected framework.

The configuration data is responsible for mapping the API.

1. Sensor Manager

A sensor is used to sense something. In the healthcare environment the healthcare devices for measuring vital signs such as blood pressure, blood oxygen level, and pulse rate. These devices are different for different patients. To manage these complex conditions this section designed the sensor manager system. It consists of 2 subsystems:

1. A sensor manager core engine
2. Healthcare devices.

When a patient interacts with CareBot to measure vital signs using healthcare devices, CareBot sends requests to the sensor manager system using the predefined API, which is supported by the sensor manager system. Then, the sensor manager system checks available healthcare devices and assigns one of them to CareBot.

1. API Design for using SW Frameworks

This section uses existing framework systems such as ROS, OpenRTM, and RCOS. They designed an API for their framework to use the components of existing SW frameworks.

1. Experiments and Evaluations

This section gives a gist about the ReceptionBot and the CareBot developed and designed.

1) Confirming the operation of our designed robot system,

2) Evaluating the performance and efficiency of the proposed UoA Robotic Software Framework. ReceptionBot is waiting for a human at reception, and detects when the patient enters. If ReceptionBot finds a human face, it offers a greeting. If the human comes close to the ReceptionBot, it asks the purpose of visiting. The human can answer by pressing buttons on the screen or speaking to ReceptionBot. ReceptionBot checks whether the human is a pre-registered patient of the hospital, and registers them if not. Then, ReceptionBot assigns a room to the patient and tells the patient how to find the assigned room. At the same time, ReceptionBot sends a request to the CareBot to serve the assigned patient. When the patient arrives at the room, CareBot greets them, and starts the vital signs measuring process. CareBot informs the patient how to take measurements for the necessary vital signs. When the process is done, CareBot sends the measured data to RoboGen and guides the patient to the next stage.

1. Development of a New Humanoid Robot WABIAN-2\*

This proposed paper is focused on a humanoid robot called WABIAN-2.

1. Introduction

This section talks about the increasing number of people with limb disabilities with a majority of people suffering from lower limb disabilities. Therefore the demands for establishing a human walking model that can be easily adapted to clinical medical treatments are increasing. Moreover, this model is required for facilitating the development of rehabilitation and medical welfare instruments such as walking machines for assistance or training. In this paper, a new humanoid robot—WABIAN-2— with two 7-DOF legs, a 2-DOF waist, a 2-DOF trunk, and two 7-DOF arms is proposed.

1. Design Concept

This section discusses about the human motion, humans body mechanisms mainly comprises bones, joints, muscles and tendons that actuate each part of the body. Replicating all the human body features in a robot is impossible therefore the primary goal should be considered as development of a robot that can imitate equivalent human motion. Humans can move any part of their body; the Japanese Association of Rehabilitation Medicine (JARM) and the Japanese Orthopedic Association (JOA) have established the basic rules of representation and measurement methods for the range of motion (ROM). The ROM is a useful guide in developing the humanoid robot.

1. Mechanisms

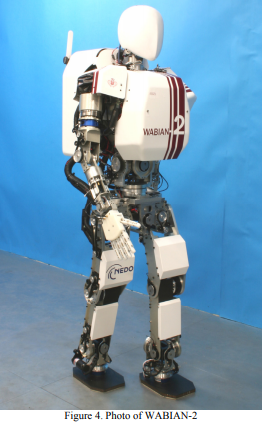
This section explains the entire structure and architecture of the WABIAN-2 robot. The framework is mainly fabricated from aluminum alloy for lightweight, high stiffness, and a wide movable range. The weight of WABIAN is around 64.5kg with batteries. The results were computed using Newton-Euler’s method and estimated using mass distribution. For the joints several specifications were established.

1. Waist and Trunk

The wait was made with a combination of a roll and a yaw joint and is attached in the middle between the hip joints. A 2-DOF trunk having a pitch and a roll is assembled over the waist. The robot stands and bends sideways at 30 degrees. These ranges correspond to the maximum moveable ranges in a human

1. Arms

The concept of arms was designed based on that the robot can hold the robot’s weight while it leans on a walk-assist machine. Since the robot can lean on a walk-assist machine most of the weight will be distributed on both its forearms.



1. Experiments
2. Walking Experiments

The effectiveness of the WABIN lies under the efficiency of the robots walking ability. Two waling styles were carried out on a horizontal platform:

1. **Conventional walking:** This has a constant waist height and bending knees at all times.
2. **Stretch walking:** This style is with human like knee joint pattern including stretch out knee phases.
3. Waling with a waling assist machine

In this experiment, the robot system under development without the neck and the hands actuator system, and the outer coverings, was used.

4. A Robot System for Medical Ultrasound

This paper has describes a robot system for medical ultrasound. A safe, light robot was designed to perform ultrasound examinations of the carotid artery. The robot was controlled in a motion/force mode that allows a seamless switch between rate and mode control. The system requirements are representative of the range of problems that need to be solved for effective collaboration between humans and machines, and can serve as a test-bed for control and interface research work. The robot-assisted ultrasound examination system would provide other benefits, such as the ability to collect and optimize 3-D ultrasound images, the ability to provide guidance to interventions (e.g. puncture) and register images. Teleradiology is another possibility although a number of methods for transmitting ultrasound images have been proposed.

1. Ultrasound robot design

This section states that the robot used for ultrasound probe positioning must be safe under any circumstances, including power failure, and should move fast enough to allow the ultrasound examination to take place at a pace close to that achieved by the unassisted sonographer.

1. Control

This section talks about the controlling of the robot while examining. During the ultrasound examination, the operator controls the ultrasound machine as usual, but moves a hand-controller joystick instead of the ultrasound probe. Some of the control modes are:

1. Master-slave mode without force feedback
2. Master-slave mode with force feedback
3. Shared operator/ robot controller mode
4. Shared operator/ robot controller/image processor control.
5. Visual servoing and feature tracking

In this section, a number of motion tracking algorithms have been implemented to evaluate the feasibility of ultrasound image servoing. Two feature based methods were also implemented:

1. Start algorithm and
2. Discrete snakes

The star algorithm uses an edge-detection filter to detect. The discrete snake method, which was proposed to extract boundaries from ultrasound images, is also modified for our purposes. This method minimizes an energy function between a closed curve and points detected via the star algorithm.

This paper also focuses on the various challenges:

1. Human-dependent specifications

This challenge encountered is the dependency of specifications on people. Studies of human capabilities and actions require appropriate instrumentation and studies with several too many subjects.

1. Design for safety

The ultrasound robot design illustrates the difficulty of designing mechanisms that can be safely manipulated by people at reasonable speeds and accelerations.

1. Controller design and tuning

Reliable parameter adaptation/learning schemes are necessary to allow multiple users without designer intervention.

1. Ergonomic interfaces

Multiple control modes as encountered in this system for ultrasound will be more and more common. They require the fusion of multiple channels of sensory data to present to the operator, and the interpretation of possible conflicting commands from the operator in order to produce a desirable outcome.

1. Effectiveness

The benefits of such a system still requires human factors studies, and these have to be fairly extensive in the area of medical devices.

5. Medical robotics for minimally invasive soft tissue surgery

This paper discusses about the trends and developments in medical robotics for minimally invasive tissue surgery. The systems that are discussed in this paper are classified according to the following surgical specialties:

1. Neurosurgery
2. Eye surgery
3. Ear, nose and throat (ENT) surgery
4. Thoracic and cardiac surgery
5. Gastrointestinal and colorectal surgery
6. Urologic surgery

Earlier robotic surgery applications tended to focus on orthopedics, since it is easier to deal with bone which does not change shape when cut or pressed. Recent studies are focusing on the difficult task of soft tissue surgery.

The field of surgical robots has reached a level of maturity in which cost-effective systems are now being developed that provides a clear clinical benefit. This implies that more recent robots tend to be smaller, lower-cost systems which have a specific application, rather than devices that are designed for a more general purpose.

Soft tissue tends to move Name unpredictably when pressed or cut, therefore the majority of robots are telemanipulators in which the location of tissue is visually tracked by the surgeon. Thus the surgeon at the master closes the control loop visually to position the slave robot appropriately. The addition of hectic systems ensures that forces are constrained to avoid damage to tissue.

Surgeon interaction can be minimized by using simple sensing to adapt automatically to periodic motions, such as those caused by the patient breathing or by heartbeat. The development of improved sensing systems has helped to provide the clinician with further feedback, permitting smart-tool interactions, thereby ensuring greater accuracy and patient safety.

While some robot systems have used predetermined models of tool–patient interactions in order to attempt to adapt autonomously to changes in the tissue condition, the majority use some sort of real time imaging with surgeon intervention to cope with such changes.

Thus, the integration of real-time imaging into robotic systems has become of considerable importance. Ultrasound has proved a cost effective adjunct to robotic surgery and image quality has improved considerably in recent years.

Although more relevant to imaging bone, CT-based robotic procedures are also having an impact on soft tissue. However, it is in the use of MR-compatible robot systems for real-time soft tissue surgery that extensive research and development has been undertaken. While there has been considerable innovation in robot technology, it has been the integration into a total system, developed for use in the demanding environment of the operating room, which has seen the greatest impact on patient outcomes. In order to achieve this integration, the more successful robotic surgery groups have formed close relationships with clinicians as well as imaging and computer science groups.

It is the formation of these interdisciplinary collaborations, in which surgical requirements have a leading part, which has had a considerable impact on patient outcomes. Future soft tissue robotic surgery will be better integrated, less invasive, and with demonstrable improvements in surgery that lead to better outcomes for both surgeon and patient.