A Robotic Assistance System for Bedridden to Reduce the Burden of Nursing Care

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Abstract— [1] **Bedridden patient is the one who confined to bed by sickness or old age. Caring for a person confined to bed is no easy task. Almost 4% of every 2.5 million elder people are bedridden. It is stated that 54 % of manual labors were need to taken care of bedridden patients through out the world. The exciting systems available for shifting bedridden patients is not effective. Without manual helpers there is no excisting system available for shifting bedridden patients. This design focuses on the action performed by the robotic system which will helps the patient to lift their body weights from their sitting position through a simple control like a joystick or swicthes. This process is achieved by the help of the pneumatic cylinders which is controlled by the air flows from the air compressor through the solenoid valves. The pneumatic cylinders can be operated in both ways to pull the patients in forward direction from bed to the robotic system and pull the patients in backward direction to reach the wheel chair with the help of switches.**

Keywords— Bedridden, Translocate, Robotic system, Pneumatic cylinders

I. INTRODUCTION

The bedridden patient faces various problems which include depression, nervousness, poor hygiene and bed sore. The researchers concluded that bed ridden patients have high rate of medical complications and there is a need for formal training for care givers [1]. For these patients, standing has many beneficial effects, both physiological and psychological in nature [4. Trying to restore the lost locomotion functions after SCI is a challenging task. Accurate models and model parameters may be needed in order to achieve adequate performance of rehabilitative devices or methods. Furthermore, feedback control usually requires accurate, reliable and calibrated sensors. When coping with such a delicate task as unsupported standing of a bedridden person, where the body is inherently unstable, system parameters are changing (primarily due to muscle fatigue) and the achievable stability margins of the closed-loop system are very narrow, we would like to use adaptive control and on-line identification of the changing parameters of the system, in order to achieve robust stability. As a consequence in present FES aided standing, paraplegics maintain an upright posture by means of usually substantial arm support, thus acting as an adaptive controller themselves. In the most usual FES-assisted posture, the knee joints are locked by the open-loop FES of knee extensor muscles, the hips are hyperextended (C posture) while the ankles are free to move. Improved standing balance can be achieved by adding the stimulation of hip extensors and abductors [1]. Due to fatigue of electrically activated knee extensors, a patient can usually only stand in the manner for a few minutes. Physically, standing may prevent joint contractures by interrupting the chronic sitting posture and may diminish osteoporosis. The upright posture may also improve functioning of the internal organs and aid in bowel and ladder function [2]. In addition, a standing posture may provide a platform for accomplishing everyday activities. For example if a patient would be able to reach some objects while standing that could not be reached from the confines of a wheelchair. Estimates the effort of ankle joint muscles via observation of the ground reaction force position, relative to ankle joint axis, resulting in robust standing [2].

Functional Electrical Stimulation:

Functional electrical stimulation (FES) is a rehabilitation technology which uses low-level electrical currents applied to the neuromuscular system. FES does not only provide support to the paralyzed person, but also active restoration of limb movement. In bedridden gait, assisted either by passive mechanical bracing or by FES, the equilibrium has to be provided by the use of crutches. It is unlikely that the balance problems will be solved in the near future. Restored walking in completely paralysed persons can be treated four-legged locomotion. Several methods for describing four-point gait have been developed [7, 8]. The simplest is the support formula specifying the number of feet on the ground at each stage of the stride. Muybridge, who captured the gait of human subjects and animals using still cameras triggered in sequence [2]**,** defined the footfall formula indicating which feet are on the ground at each stage. Gait diagrams can be also used displaying how long a given foot is on the ground **[8].** Another approach to the representation of four-point gait patterns is provided by relative phases **[4, 8].** Here, zero relative phases are assigned to the reference leg. The walking pattern is then described by three time delays expressed relative to the reference leg, representing the foot contacts with the ground in the other three legs. The states of a four-point walking pattern can be defined by the number of contacts with the ground. In this way we are dealing with four-point, three-point, and two-point stance phases.

One-point stance phase was in general also possible. However, standing on only one foot would result in possible hazardous situations in completely paralyzed patient's walking and is impossible for walking machines. However, a major issue in any application based on functional electrical stimulation is the fatiguing of stimulated muscles. Rapid muscle fatigue during standing can result in loss of balance, leading to new traumas. During stiffness-supported standing, the subject controls muscle fatigue by using the upper trunk for balance, therefore reducing its functionality [14]. In order to reduce the burden of fatigue, an artificial control system needs to be designed in such a way as to allow sustained functionality of the upper trunk and minimize fatiguing by its own rules. The greatest source of ankle muscle fatigue is compensation of the gravity-generated torque around the ankle joints. In order to minimize this torque, the vertical projection of the total body’s centre of mass needs to be located within close proximity of the ankle joint axis. Another major contribution to muscle fatigue is the control of body sway in an anterior/posterior direction and the associated torque required to sustain vertical body equilibrium [9].

Understanding the unimpaired subject’s control over constrained balancing provides useful information for further improving the quality of the proposed control strategy. Analysis of unimpaired subject stance indicates a combined ankle–hip strategy as the most used sequence of responses to anterior–posterior disturbances [9]. The subject around the ankles prior to the disturbance also affects the overall postural strategy for disturbance rejection [10]. Subjects use a different postural strategy when perturbed while leaning near their forward or backward limits of stability. An important feature of postural dynamics is the effect of the forward lean, which results in a significant increase in the tonic component of ankle torque. Postural stability is improved here by simplifying the response to the perturbation [11], because the risk of falling backward is reduced by increasing the stability margin between the centre of gravity and the posterior limits of the base of support. The postural ankle dynamics can be based on a single muscle group—ankle plantar flexors. Two different strategies for disturbance rejection were explained. We investigated the capability of the closed-loop model to reject disturbances, imposed at the ankle joint (in anterior and posterior directions) for various stiffness levels and neural system delays in the presence of biomechanical constraints. By limiting permissible excursions of the centre of pressure, we found out that the length of the foot is the most important constraint, while the strength of the trunk muscles is not of major importance for successful balancing. Double inverted pendulum structure: feet—support surface; lower extremities—first segment; trunk, head, and arms—second segment.

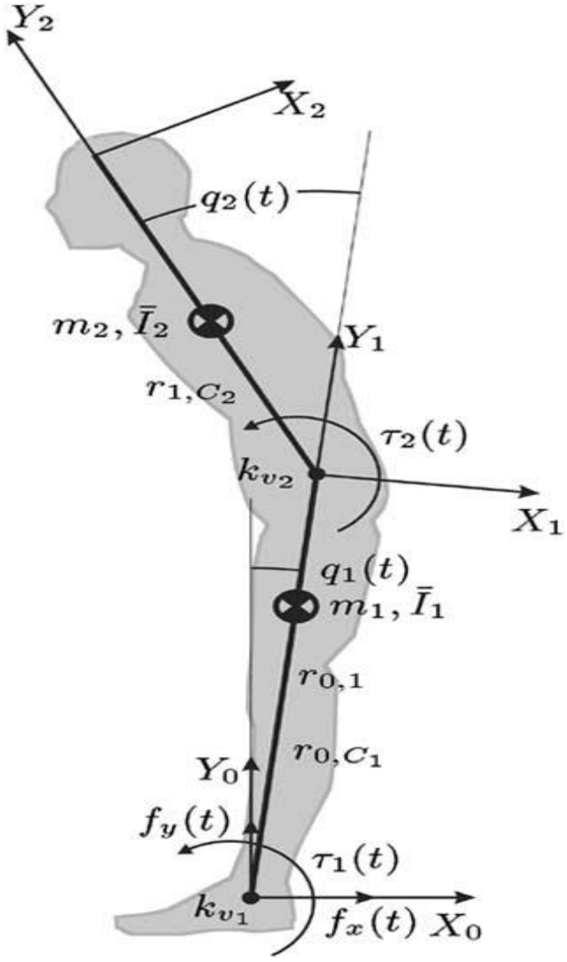

Fig.1. Standing position [1]

Centres of masses of both segments and their distances from joints r and r are shown. The lower body link length is noted with r_{0,C_1} and r_{1,C_2} q (t) and q (t) are the ankle and trunk joint angles, respectively. r_1 and r_2 are the net torques produced by FES of muscles in the ankle joint and by voluntary activation in the trunk. m are the masses of both links and I_1 , I_2 are the moments of inertia around the mass centres of each link. K_{v1} and k_{v2} are coefficients of viscous friction for ankle and trunk joints, respectively [3, 4].

The stick pictures of two paraplegic patients are shown in Figure **2.** Their standing postures showed the feature of the C-posture in which the body centre of mass is behind of the hip joint. The hip hyperextension coped with foot joint dorsiflexion in their standing postures. Distribution of hip joint angle and angular velocity is denoted by the thin lines shown in Figure 3. The thick ellipsoids denote 95% confidential limit and black circles denote averages of them. Although the hip joints were swayed, the subjects could keep the standing posture. Their hip joints were not supported by any external mechanism, nevertheless 95% confidence ellipsoids denoting the magnitude of sway are small and the averages of the velocity are approximately 0 rad/s[10]. These results suggest that the C-posture can be a stable attractor and the swayed range of a hip joint is in the basin of attractor [6].

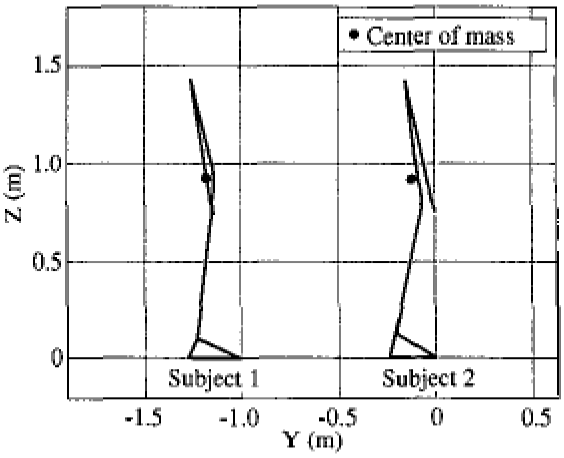

Fig 2: Standing postures [1,2]

The foot joint angle should he adjusted so that the following two conditions of stability are satisfied: (1) the equilibrium between gravity moment and resistive moment in hip joints must the stable. (2) The margin between the centre of pressure and the boundary points of foot support area must he sufficiently large. Although measured postures and simulated postures showed the feature of the C-posture, some differences of the hip joint angle were found. The differences might be related to individual hip joint resistive characteristics [6]

II. METHODOLOGY

To set a new platform for bed ridden person to bring some functions and freedom. This system allows them to remain standing position in a complete vertical way, so it will enables the user to move into a sitting or standing position without leaving too much pressure by incorporation of robotic system.

As referred in the figure x, y and z represent the direction of the system. The system comprises of stand like structure which connect to a rotating bottom. When the belt connected to the strand, it pulls the patient according to the input given. When the cylinder gets operated in a forward direction the patient will tend to stand erect in a vertical position. When the cylinder gets operated in a backward direction the system leaves the patients from vertical position so that they can able to sit properly. By this simple step the patient can able to sit and stand without any problem and as referred it’s a hand free system there is no need of any other help and no pressure is applied to the arms.

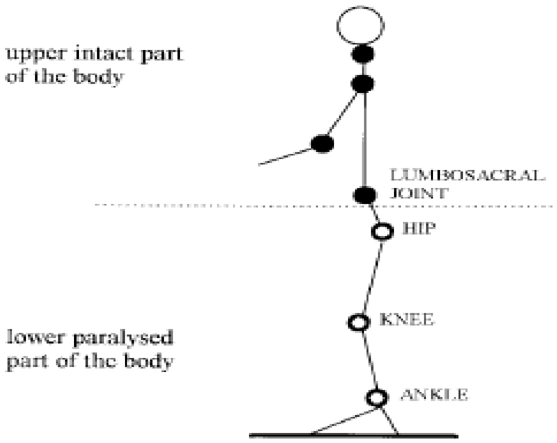

Fig 3: paralyzed ankle joints [1]

The system incorporates the devices which is described below and shown in the circuit diagram fig5.

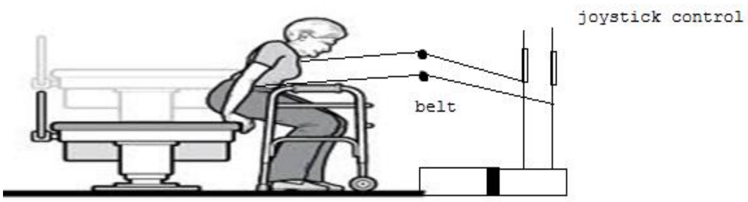

Fig 4: Experimental setup

This circuit is designed to run a motor from the same power source as your microcontroller. It doesn’t require any integrated circuits and uses a commonly available component.

Control circuit for cylinders and air compressor:

Electronic circuit for Trans locating system. This system has four switches. First two buttons for air compressor on and off. And other two for controlling solenoid valve which determines the direction of the pneumatic cylinders. Air compressor is set to be on, then the air flows through the solenoid valve. So when the third and fourth buttons are pressed the valve gets opened and the cylinder gets operated in forward and backward directions accordingly to the program.

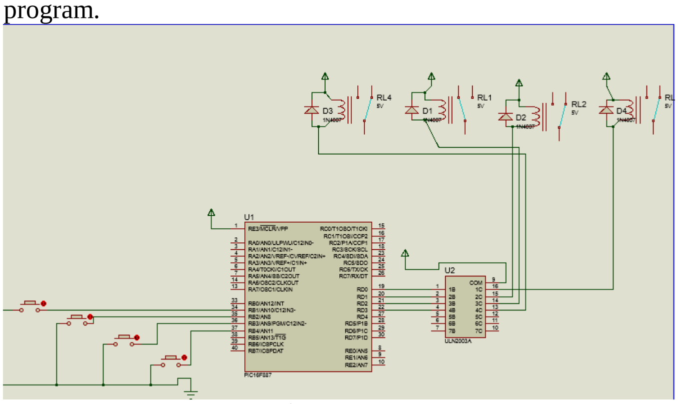

Fig 5: control circuit for air compressor and cylinders.

Calculation for measuring pressure and weight:
Minimum pressure to make cylinder work: 20 Psi
Maximum pressure for 10 bars cylinder: 150 Psi
Piston area=63 mm diameter=31.5mm=0.0315m radius
Area=pi*r*r=3.141592*0.0315*0.0315=0.00311 sq.m
I bar=100000 Pascal’s; 1 Psi=6894.76 Pascal’s
Force in newton’s= area* pressure= 0.00311* 200000=622 N
Force in kilogram= 622/9.81=63.40 kg

A system for Trans locating patients from bed to wheel chairs this system is made with adjustable columns, which is suitable for various heights of the patients. The rotating floor is used to get the desired direction of the wheelchairs. The knee cap is for providing additional support.

III. RESULTS AND DISCUSSIONS

The result that indicates a dc motor rotates in both clockwise and anti-clock wise direction according to the pin value. As the cylinders will operate in opposite direction the system will bring the patient to stand and sit. This system will help the bedridden patient to move freely without any physical strength. This method will be carried out by means of any control like joystick or switches so that the patient can easily operate the system. So this method has several advantages over the other methods. The shifting mechanism is done with the help of a belt that will be wrapped around the hip region and it is connected to the system, so when the cylinders moves in forward direction to lift the patient to stand and to sit the cylinders will moves in backward direction.
Advantages- it’s an inexpensive system

IV. CONCLUSION

This control strategy for unsupported standing for bed ridden patients was proposed. The approach integrates the sitting and standing position without leaving too much pressure to the arms. This simple device works in a manner that provides arm-free standing.

V. FUTURE WORK

In future study we propose to produce a system which will translocate patients from bed to wheelchair. This method has several advantages over other methods because the patients can able to sit and stand on their own without any other help. This will increase the confident level of the patient in many ways.

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