International Journal of Recent Trends in Engineering & Research
ISSN (ONLINE) : 2455 – 1457
IMPACT FACTOR : 4.101

LIMB EMPLOYING TRANS-MECHANISM

Kunal Yogeshkumar Parikh[1], Hiren Dave[2], Vishal Purohit[3], Hemal Dave[4], Milan Patel[5]
[1, 2]Sr. R & D Engineer, Department of R & D, Hermes Technologies, Gandhinagar, Gujarat, India
[3, 4, 5]UG students, Department of Biomedical Engineering, L. D. College of Engineering, Ahmedabad, Gujarat, India

Abstract: This paper talks about a newly developed paradigm for rehabilitation of paraplegics named L.E.T-walk. It's abbreviated as Limb Employing Trans-mechanism walk which provides resemblance of an artificial lower pelvis segment till the foot plate, with impedance controlled joints like knee and ankle, which will restrict the movement in either direction with a precise and well-programmed treadmill walk approach. It is so designed in its mechanical ways that it can be easily translated into a wheelchair mode whenever the user feels. Enhanced mechanical strategy distanced it from immense electrical malware expenses. For the easy control, we used an embedded system as a medium for communication, which holds all the notifications on the display, the command control for flexibility and user-friendly interactions. The possibilities to using the paradigm improved the GAIT cycle also reduced the distance and height barriers due to the plasticity of impaired limbs.The goal of this prototype is to perform specific defined movements by the means of drives incorporated in according places that provoke motor plasticity to the patient andthus help in motor recovery and reducesfunctional deficits.

Keywords: Rehabilitation; Paraplegia; Lower-Limb Exoskeleton; Powered Lower Limbs

I. INTRODUCTION

Traditional exoskeletons are often stubborn and less comfortable which result in less convincing and the total purpose of what they are designed for remains un-served. Additionally their attachments and fixations are tedious at times hence it remains a huge loop between consumer satisfaction and their recovery. All these factors stimulate innovation inthe domain of rehabilitation in such way it becomesmoreaffordable and available for more patients and for a longerperiod of time, which is the base concern of L.E.T-walk team Passive assist devices like crutches; orthosis, although are less complex and inexpensive, cannot provide energy to the impaired limbs, hence are confined compared to active devices and are out of the scope of this work.

Robotics had played a sumptuous role in each commodity where human interaction is either tedious or meaningless. When it comes to the rehabilitation it has found its place in the form of exoskeleton. An exoskeleton is worn like attire and if designed impedance free, it soon becomes part of a body. Robotics has found its potential advantage when it comes to a person with lower limb disorders over conventional techniques for the following reasons: 1) it bypasses the neural activity needed for limb employment; 2) it provides well calculated and calibrated outcomes for precise recovery, which conventional paradigm often fails to deliver; 3) high mechanical investment made it less complicated, both in the terms of maintainability and durability.

II. RELATED WORK DEATILS

This century has witnessed a tremendous rise in the sector of health care and medicine due to invasion of technology. Although many of rehabilitation robotics are being developed or are in a stage to create history, but the basic principle remains unchanged. Each system mentioned in Table 1 lags is designed as per task specific which at times raise the demand for something more to the existing consumer. The cost for distribution remains omnipresent factor, which often give the people give a good reason to crawl and face problems despite purchasing it.

SYSTEMS	PRINCIPLE OF WORKING	DEMERITS AND OBVIOUS PROBLEMS
Treadmill GAIT Trainers,	Three therapistsassist the legs and hip of the patient walking on atreadmill while part of the patient's body weight is supportedby an overhead harness.	Lags freedom of movement, confined to one place. Lack of flexibility i.e always the same challenge
Foot-Plate-Based GAIT Trainers,	the feet of the patient are positioned on separate foot plates,whose movements are controlled by the robotic system tosimulate different GAIT patterns	Confined to foot Require Time Investment
OvergroundGAIT Trainers,	They allow patients move under theirown control rather than moving them through predetermined movement patterns	They work on a feedback criteria which sometimes poses to erroneous output
Stationary GAIT Trainers,	A stationary trainingSystemwhich allows to carry out fitness exercises with active Participation of the paralyzed limbs.	Confined to particular domain. i.e area bound

Table 1: Existing paradigm for rehabilitation v/s LET

Our research work is to come over from the above demerits. The complete details of hardware and software parts of our project are given below.

HARDWARE DETAILS:

PIC Development Board: This is used to control and give command to the motor to run as per requirement. PIC18F4550 Microcontroller is used as heart of the system. This microcontroller is used for interfacing other device like Keypad, DC Motor, LED, LCD etc.

Primary chasy: High Grade polymeric plastic and ultra lightaluminium, which are specially designed to serve for the purpose of reducing the dead weight of the system itself. Plastic is used for engulfing the limbs and aluminium for transferring the body weight of whatsoever forces towards the ground.

Screw Motors: Specially designed this motors were fastened with PWM coding in MP lab and on the shaft, a purposely designed screw with specific size via lathe and milling of high enduring steel rod of about 20 mm thick diameter.

Ball Bearing: They are being incorporated at all the existing joint for compliance free locomotion and nullifying the frictional errors and functional noises.

Dual-Axis Mechanism: This is inspired from the gyroscopic dual axis mechanism for enabling the limb ankle and knee motion, in which one free axis is welded with a nut screwed in Screw motor to seek command in mechanical means with motor revolution and the other, is to be attached for holding the limb.

Wheels: They for the obvious reason for the transformation from an exoskeleton to a manual/electric wheel chair.

SOFTWARE DETAILS:

MPLAB X IDE: It is a software program that runs on to develop applications for Microchip microcontrollers and digital signal controllers. It is called an Integrated Development Environment (IDE), because it provides a single integrated "environment" to develop code for embedded microcontrollers.

EVALUATION OF PERFORMANCE: As per design described, LET-Walk is an exoskeleton, which is used to improve GAIT analysis deliver precise stance and stride phase. LET-Walk has a central concern with Rehabilitation of lower limb for paraplegia that will make user self-assisted.

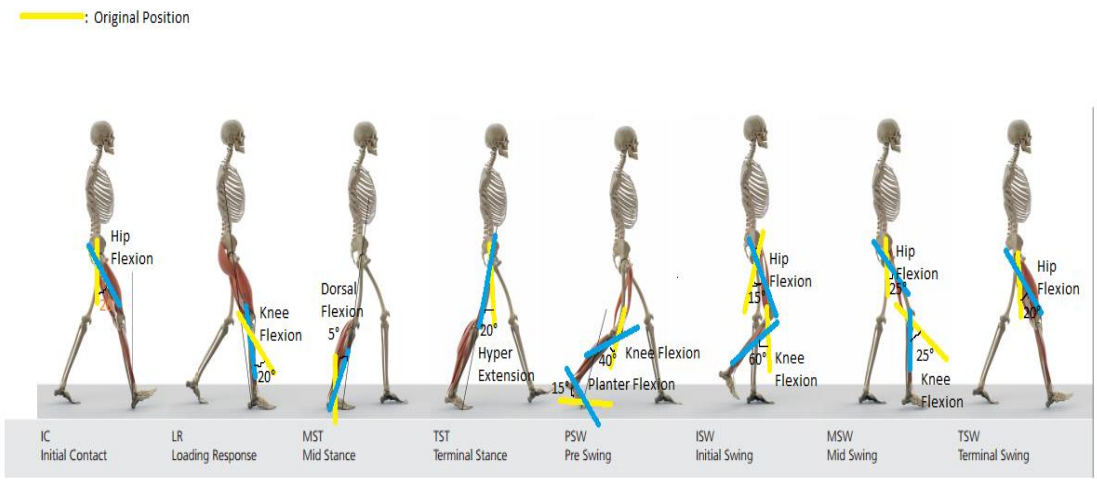

Figure 1: Natural GAIT cycle and related shifts (in degree)

In our design, we made a basic model of the lower-limb exoskeleton which is used by paraplegic patients for locomotion. In the traditional method, the patient used to wear the harness in their amputated leg for attaining stabilization while walking which is only used for patient's movements with a rigid harness, without bothering about GAIT cycle. Initially, they used to walk, but not by giving any movements in their joints like knee and ankle. Hence to overcome this problem and to execute patient's walk according to GAIT cycle, the concept of LET-Walk emerged.

LET-Walk has equipped with 2 major concepts of completely different domains, Rehabilitation and Embedded System. Rehabilitation is a keyword of LET-Walk, which describes the basic applications of lower limbs amputees. Embedded system is the heart of LET-Walk, which we used for making this harness self-assisted. Here we are focusing on convert this harness into electrical harness by the means of embedded system. In the traditional method, all the joints are locked so a person can walk, without moving any joints of the leg but we usedmotor (screw) which is indirectly attached with their respective joints.

So, by using biomechanics techniques in LET-Walk one can achieve a natural GAIT Cycle, Also can know the perfect duration and angle of movements of each joint in each phase of GAIT Cycle. We found that normal walking required 4 major criteria:
(1) Equilibrium.
(2) Locomotion.
(3) Musculoskeletal Integrity.
(4) Neurological Control.

The initial phase is known as IC (Initial Contact). In this phase, heel comes in contact with the ground at the hip flexion of 20 degrees. By using hip hardware design for giving flexion, LET-walk is equipped with a handlebar for achieving required angle change keeping the stability in concern. We also took care that all other joints are at fix position and we can alter the position of joints only by screw motor.

LR (Loading Response) phase, knee and ankle have shock absorption and forward motion by heel rocker with 20-degree flexion in hip and knee and 10-degree planter flexion in the ankle joint. We have assembled an assembly that has been connected to ankle joint and hip (back side). From this, we can easily control knee joint by giving the revolution in screw motor of knee and ankle and get the desired pattern of GAIT Cycle.

MST (Mid Stance) phase controls to a motion of the tibia and shifting to the gravity centre. In this phase knee and ankle has flexion of 5 degrees. This phase in LET-Walk has a major function. Tibia bone is connected with a motor (which is not possible in human but here we only concentrate only in lower part of the body so we have to add tibia bone). This bone and centre of gravity can be controlled by tibia motor. Further, we get phase named TST (Terminal Stance)whichis used for controlled dorsal extension at the ankle joint with lifting the heel from the ground with hyperextension in the hip of 20 degrees and 10-degree dorsal flexion in the ankle joint. We controlled this both ankles by their respective motors that are controlled by embedded system.

PSW (Pre-Swing) phase has knee flexion of 40 degrees and planter flexion in ankle joint. This phase is forwarded by ISW (Initial Swing) that has min. 55° knee flexion for sufficient ground clearance. After that, MSW (Mid Swing) increasing hip flexion to 25° and dorsal extension of the ankle joint to neutral-zero-position. TSW (Terminal Swing) is the last stage of GAIT cycle. It has knee joint extension to neutral-flexion.

This all events occur in exoskeleton phase. When the patient cannot drive their joints due to pain in the joints at that time this whole exoskeleton converted into wheelchair mode. That can easily drag the patient. The whole movement of joints is controlled by their respective motors and drives.

IV. PROPOSED WORK

In the practical side of LET-Walk, we have to dominate all the phases with insignificant error by the means of LET-Walk and its sheer coding of motors and drives by Embedded System. Each and every angle is calibrated while providing the code for Screw motors revolution, of which some are interactive and some are simply irreplaceable. While constraining these motors, we are able to give a degree of freedom to human joints. So patient's can improve their GAIT cycle. Thus it fulfils its use as GAIT Trainer for giving assistance to the patients. When if the user is willing to switch mode from exoskeleton or he/she does not wish to move any longer or due to whatsoever circumstances at that time whole exoskeleton remodels achieving the maximum bending angle for knee motor into the wheelchair. So it can easily drag patient with castor wheels lying beneath.

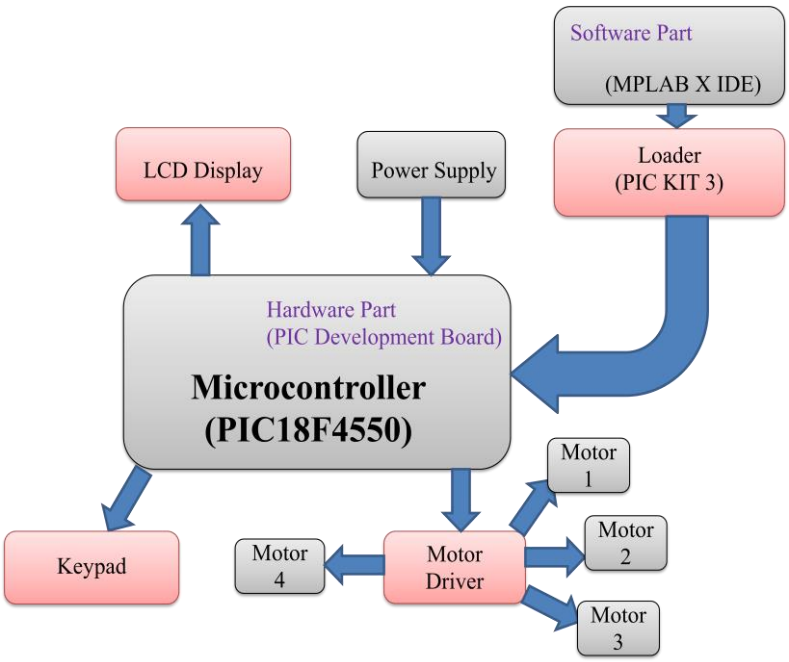

Figure 2: Block diagram of proposedsystem

MODES OF LET-WALK:

User can mainly give 2 different types of commands to LET-walk:
1. Exoskeleton Mode
2. Wheelchair mode

1. Exoskeleton mode: Command for exoskeleton mode can be given by hand mounted control panel. User can control exoskeleton suit from control panel. User can control speed of motors which will result in walking speed of suit. Another command is stair command, which will increase the size of steps which will help in climbing steps of stairs. Object detection or height detection will detect obstacle of difference in height and alert the user.Some natural forces like gravitational force does affect the work load on motor. Additional forces like frictional force, ground reaction force, backward force on motor due to weight of user etc. are accountable and faced in exoskeleton mode.

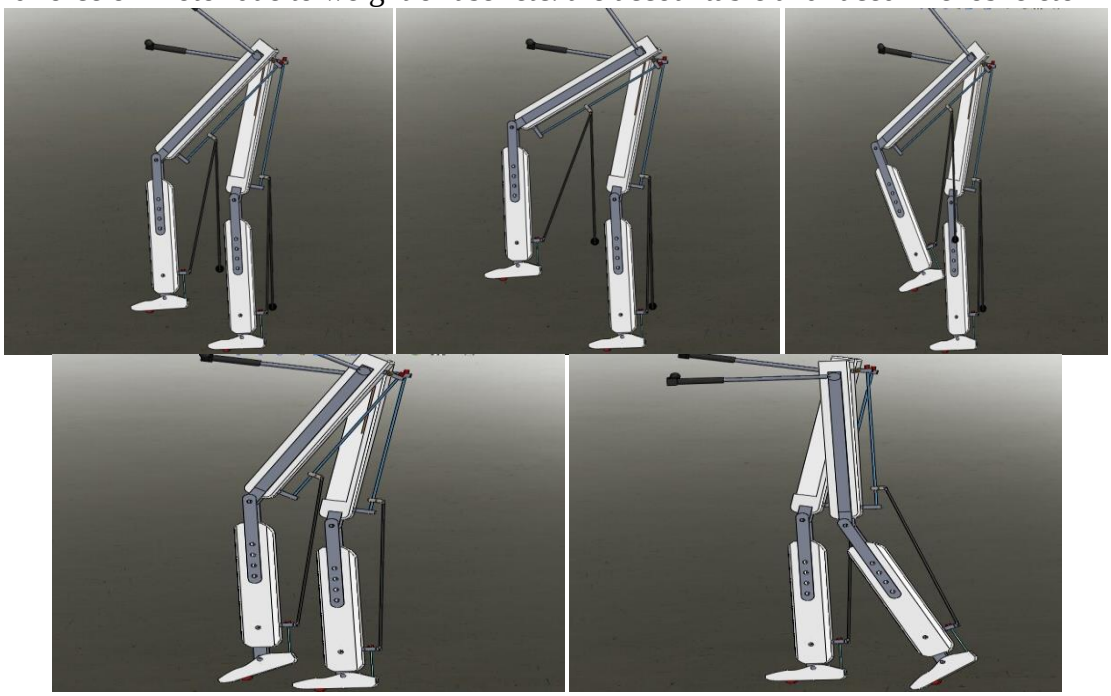

Figure 3: Various phases of GAIT Cycle by LET

Paraplegic person can walk without help of another person just with little support of crutches. Using the stair mode user can climb up and down on stairs.Currently existing exoskeleton suits need external supports via crutches or other person. Also they can't be transformed into wheelchair for rest of user.

2. Wheelchair mode: Due to more workout or exercise while walking using LET-walk in exoskeleton mode if user needs some rest he/she can turn the wheelchair mode on. It will convert into a wheelchair and there will be no need for support and user can rest on wheelchair and change the place by dragging.In wheelchair mode user can give some commands like move forward, move backward, turn left or right, Speed increase/decrease, obstacle detection etc.Some forces like gravitational force, frictional force with due to shaft of motors and wheels and surface friction force due to contact of wheels with surface.

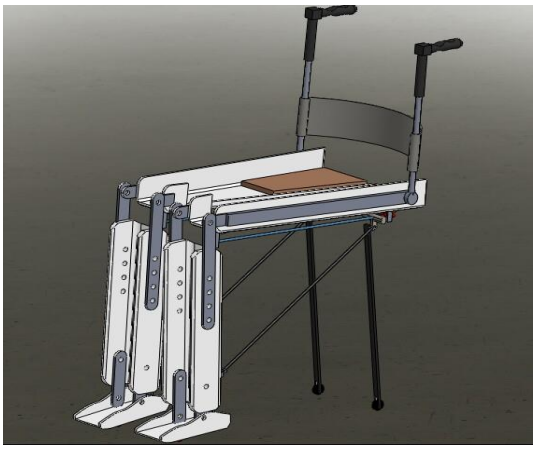

Figure 4: Wheelchair Mode of LET

Challenges are stable transformation of exoskeleton mode to wheelchair mode which should run smoothly. Another challenge is comfortable and durable structure which is comfortable even on uneven surfaces.An ultrasound sensor is installed which will calculate the height of the stairs and then perform motion during stair climbing mode.

V. CONCLUSION

L.E.T is really motivated by the certain incidencesand experiences to be nullified, incidents like impaired person facing height and distance barrier. It was purposely crafted for the gratitude of those helpless people, who wants to achieve no less than a normal human being.LET is a challenge to existing Rehabilitation paradigms to be available at this cost, yet being this flexible and robust simultaneously.Regardless of it, we respect the existing commodities for giving us the loop holes and feel them with success named Limb Employing Trans-mechanism.

REFERENCES

[1] M.A. Mazidi, R. McKinley and D. Causey, PIC Microcontroller and Embedded Systems: Using Assemble and C for PIC, ISBN: 0-13-600902-6, 2008
[2] PIC18F2455/2550/4455/4550 Data Sheet from Microchip Technology Inc, DS39632C, 2006
[3] MPLAB® ICD 3 In-Circuit Debugger User's Guide For MPLAB X IDE from Microchip Technology Inc, DS52081A, 2012
[4] PICkit™ 3 Programmer/Debugger User's Guide from Microchip Technology Inc, DS51795A, 2009
[5] Effects of training with the Re-Walk exoskeleton on quality of life in incomplete spinal cord injury: a single case study, Spinal Cord Series and Cases (2016) 3
[6] Force Sustainment: Rehabilitation, Regeneration and Prosthetics for Re-Integration to Duty. (pp. 6-1 – 6-14). Meeting Proceedings STO-MP-HFM-228, Paper 6. Neuilly-sur-Seine, France: Apr 2013

