

Wearable Exoskeleton Assisted Rehabilitation in Multiple Sclerosis by using Adaptive Control Methods

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Abstract: A walking model with humanoid robot RH-2 can perform distinctive assignments in a joint effort by using PID controller different values of human in working environments is presented in this paper. Human-robot coordinated effort has a regular edge work as for human-robot association. In human-robot, we are using the linear control system to single inverted pendulum. In humanoid stride is frequently displayed with different forms of the modified pendulum, for example, 2D and 3D linear reversed pendulums. A human-robot is using the direct control system to using trial and error method using with PID controller and without PID controller in different values. By using humanoid-robot RH-2, the walking control was tested successfully. Contextual analysis is exhibited all together human-robot test platform humanoid-robot RH-2. This paper depicts the nonlinear hearty reference show versatile impedance controller for a functioning trans femoral prosthetic leg for amputees. We utilize a Sliding mode control [SMC] term to consider the questionable parameters of the framework and a strong control term so the framework directions merge to a sliding mode limit layer display heartiness to varieties of ground reaction force [GRF]. The underlying model is a pneumatically activated controlled fastened gadget, which is expected to fill in as a lab proving ground for a resulting self-fuelled rendition. We use particle swarm optimization [PSO] to upgrade the plan parameters of the controller and the adjustment law. The amputee subject with direct control of knee torque utilizing surface electromyogram [EMG] estimations of muscles in the remaining thigh. Hip vertical uprooting and thigh point movement profiles are connected to a trans femoral prosthesis joined to the robot. This methodology permits to constantly switch and interject among impedance and permission control. An improvement issue is defined and fathomed to adjust impedance decrease against clamour enhancement in picking the channel addition and transmission capacity. Procedures for control of controller conduct are introduced which result in a bound together way to deal with the kinematic ally obliged movement. We accomplish great following of joint removals and speeds for both ostensible and irritated estimations of the framework parameters.

Keywords: Collaboration of Humanoid-Robot, Linear Control Function, Nonlinear Controller, Robot Manipulator, Sliding Mode Control.

I. INTRODUCTION

Generally, mechanical autonomy has seemingly created a bigger quantity of curiosities than some other industry. We have visible ridiculously futile manifestations, as an instance, Harvard's origami-collapsing robot and dasher's sand workmanship robot. However, at this point, the sphere has natured the breezes appear to transport a greater software manner. The robot cannot exclusively be beneficial but moreover lifesaving. Apply autonomy has made energizing headways in social coverage innovation in a previous couple of years and the potential for medicinal robots seems boundless. Here are five automatic creations that hold the maximum assure for the prescription. A humanoid robotic is a robotic with its body shape labored to look like the human body. The shape might be for useful functions, as an instance, cooperating with human gadgets and situations, for exploratory purposes, as an instance, the investigation of others purposes. When all is said in carried out humanoid robots have a center, head, hands, and two legs, however, some styles of humanoid robots may additionally show just piece of the frame. Some humanoid robots likewise have makes a beeline for imitating human facial highlights, for example, eyes and mouths. Androids are humanoid robots worked to stylishly look like human beings. Pen biological structures of robot traits from phase degree client objects to instructive apparatuses to slicing aspect gadgets supplying complicated abilities illuminating troublesome problems.

A four-wheel pressure seed seeking out the robot has created and the mission of the seed expelling the system is to evacuate or obliterate the seed. This is an extremely good form of robotic implemented for reducing up of wood, tending wooden and gathering mash and hardwood in backwoods. The robot is applied in-legal guidelines to cut the grass. A social robot is a self-ruling robotic that collaborates and speaks with humans or one-of-a-kind unbiased physical professionals by following social conduct and standards joined to its task. Like specific robots, social robots are physically epitomized. Some manufactured social operators are structured with a screen to talk to the pinnacle or face to gradually communicate with employment. In those cases, the popularity of a social robot is based upon the type of the body. In the occasion that the body has some bodily engines and sensory capacities, at that factor, the framework can be

viewed as a robotic. Be that as it is able to, it's far the larger robots which are getting a chief growth in past due with a progression of creative sensors promising for greater granules faculties for a scope of massive scale envisioned bots, which for this reason will improve this handiness highly. The marketplace for regularly current robots is vital, specifically as advances in both AI(man-made recognition) and robotization all clearing new achievable consequences constantly.

An vital necessity in a giant lot of these programs is detecting weight, for a wide scope of motives and here past due advancements in weight sensors susceptible to alternate this region. The adaptable sensor's carbon nanotube composite coatings on a extensive scope of filaments comprise cotton, nylon, and fleece. Just as being incredibly adaptable. The masking can likewise quantify an extraordinarily wide scope of weight, from fingertip weight through to mechanical programs. The technique makes a nerve-like electrically conductive nanocomposite masking on fibre materials by electrophoretic testimony. A special universe structures it universes progressively the client global to cloud innovation, which can be related carefully to the calculation issue of mechanical autonomy. By utilising AI and AI devices within the cloud, limit and exhibitions can be scaled with the aid of stipulations, amplifying adequacy and furthermore increasing top capability to ranges ridiculous in even big project framework.

II. CONVENTIONAL CONTROL METHODS

A. Wearable Exoskeleton Assisted Rehabilitation in Multiple Sclerosis by using Conventional Control Methods

We hope to beat this delicacy during the time spent building up a running humanoid [1, 2]. Human-like walk and vitality utilization are two of the principal components to be considered while planning effective biped humanoid robots [3]. Most studies focus on biped walking. one of the essential upgrades to RH-2 as for its antecedent is the plan of the decrease leg. The decrease leg is important whilst coping with taking walks activities and power. Advantages of electrical cable mechanical technology may be in a complete duration simply if it goes akin to the human use with out supplanting him in paintings. The whole structure is going about as a modified the end mass of the pendulums gathered at the robot's cause of the centre of mass (COM). The manipulate design proposed has been taken attempted at utilising the model of RH-2. The human stroll is often displayed with special forms of the reversed pendulum, as an instance, 2D and 3D linear modified pendulums (LIP) [5-9]. Sensor aggregate demanding situations in sensor combination and information getting ready. Incorporate various detecting capabilities into little, low-manipulate, steady preparing subsystems. Here we gift a unique designing named F-IVT (Flywheel-Infinitely Variable Transmission) actuator that on a first dimension license to man-handle the traits of the decrease member development streamlining the running states of the electric engine and conquering the as of overdue referenced issues [10-12]. Managing present live line working

techniques and standard hotline hardware is every other technique for controlling the innovation.

This requires the established order of an electrical cable investigation robotic on the inspired line within 30 minutes of coming of the shape. Where g is denoted as gravitational acceleration, T – enter torque and Θ is function attitude, m-mass of the motor and l is duration of the link.

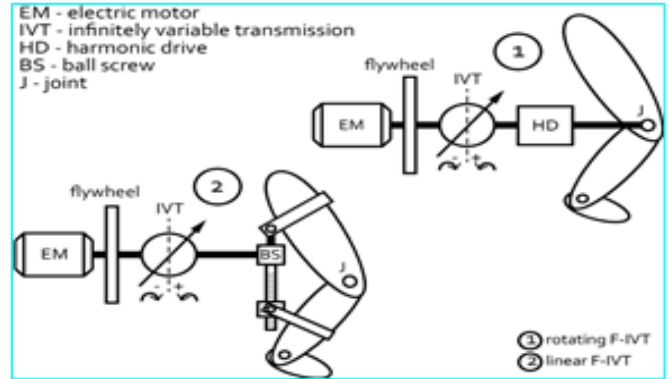


Fig1. Schematic diagram of the F-IVT architectures.

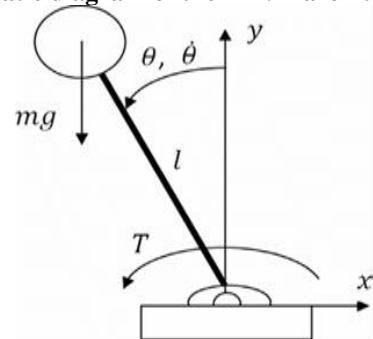


Fig2. Single Inverted Pendulum

This version isn't appropriately amazing to display the entire parts of the humanoid robot and to don't forget its nonlinearities. In any case, as can be checked in advancing staying in contact with, it gives thoughts-boggling results, even probable, as a first guess. There is leaping gravitational energy equal to mg, wherein g is the increasing tempo in mild of gravity. There is moreover a frictional power repudiating the advancement, which we perceive to be regarding the velocity of the tip with a disintegrating coefficient k. Utilizing Newton's second law of development, we can make the circumstance out of advancement the digressive manner as

$$ml \theta^{11} = -mg \sin \theta - k l \theta^1$$

Composing the situation of movement toward this route has the favorable role that the connection stress, that's the typical way, does not show up inside the circumstance. So as to collect a nation show for the pendulum, allow us to be given the state factors as $x_1 = \theta, x_2 = \theta^1$. Then, the state equations are defined as

$$x_1^1 = x_2$$

$$x_2^1 = -\frac{g}{l} \sin x_1 - \frac{k}{m} x_2$$

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From the physical portrayal of the pendulum obviously it has just two balance positions comparing to the balance focuses (0,0) and (π,0).

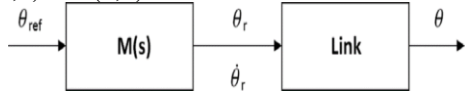


Fig3. Posture control system.

Substantially, the positions of pendulum are extraordinarily specific from every different. While the pendulum can in reality relaxation on the (0, 0) concord factor, it is probably not by way of any stretch of the imagination kept up on the (π, 0) point in light of the fact that subtly little inflammation from that parity will expel the pendulum. The modification between the two affability centers is in reliability residences. Another type of the pendulum conditions develops if we are able to apply a torque (T) to it. This torque is seen for our situation as a manipulate commitment to condition.

$$x_1^1 = x_2,$$

$$x_2^1 = -\frac{g}{l} \sin x_1 - \frac{k}{m} x_2 = \frac{1}{ml^2} T$$

B. COM control strategy using PID controller

The PID controller using K_p, K_i, K_d with and without controller the transfer function using various values to maximum, medium and minimum values of the with controller.

$$PID = k_p e(t) + k_i \int e(t) dt + k_d \frac{d}{dt} e(t)$$

The initial step is to get the exploratory exchange capacity of the lower leg actuator utilizing traditional PID strategies. For our situation, it is given by

$$M(s) = \frac{55.03S^2 + 5439S + 2.73 \cdot 10^6}{S^3 + 111.2S^2 + 5.14 \cdot 10^4 S + 2.73 \cdot 10^6}$$

As appeared via the suppositions conveyed over, the manipulate trouble in an open circle ought to be taken care of with the goal that the yield of the association follows the reference in figure3. Besides, in our scheme since the motor identified with the affiliation can seek after the reference with an insignificant slip-up. It suggests that the components of the affiliation are dropped on this system. Truly, we are trying to find the manage interest T that permits this fact. To accomplish this, the model arranging approach is utilized, in light of the records yield linearization of the shape. Conditions were given from the use of this system are introduced straightaway. Consider $y = x_1$, Thusly, the quick association between the data and yield of the structure is given by

$$y^{11} = -\frac{g}{l} \sin x_1 - \frac{k}{m} x_2 + \frac{1}{ml^2} u$$

With $u = T$ and $y = \Theta$. The purpose is to obtain the control law u so that y follows θ_{ref} as θ_r follows θ_{ref} , that is, a control law with the goal that the entire elements machines the model $M(s) = \frac{\theta}{\theta_{ref}}$ acquired already by exploratory PID. So as to do

as such, we characterize u as:

$$u = ml^2 \left[\left(\frac{g}{l} \sin x_1 - \frac{k}{m} x_2 \right) + v \right]$$

Thus that $y^{11} = v$ (from e. (7)).selecting as

$$V = \theta_r^1 + a(\theta_r - y)$$

It is obtained that

$$y^{11} = \theta_r^1 + a(\theta_r - y)$$

The assessment of 'a' is nominated by the trail-error process in order to obtain the minimum tracking error.

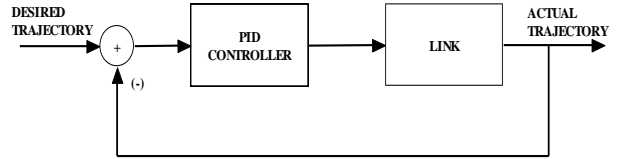


Fig4. Leg Simulink-Model with PID Controller

III. SLIDING MODE TECHNIQUE

A. Wearable Exoskeleton Assisted Rehabilitation in Multiple Sclerosis by Control of Sliding Mode Technique

Control engineering for human-robot co-hobby in community conditions has been introduced. The unique control circles, communitarian act ones, have been broke down and mimicked for the example of RH-2. Direct manage design for human-robot co-project in cooperative has been displayed. The specific PID controllers have been breaking down and leg reproducing for a humanoid robot. The stance power has been performed by means of making use of the model of the unmarried transformed pendulum and controlling the robotic's decrease leg. Further research will concentrate on to expand the nonlinearity and the clever primarily based controllers for the leg model. The SMC controller is able to operating in non-linear for manage of the robotic leg version with distinct traits. It has been confirmed that the SMC controller can efficaciously be advanced, that could provide performance quite near the predicted controller and much advanced to the conventional PID controller and PID controller underneath simultaneous torque disturbance of any random magnitudes.

B. SMC Controller

We completed reproductions with 1% to half of select up aggravation parameter deviations, and we noticed that following execution stayed genuine.

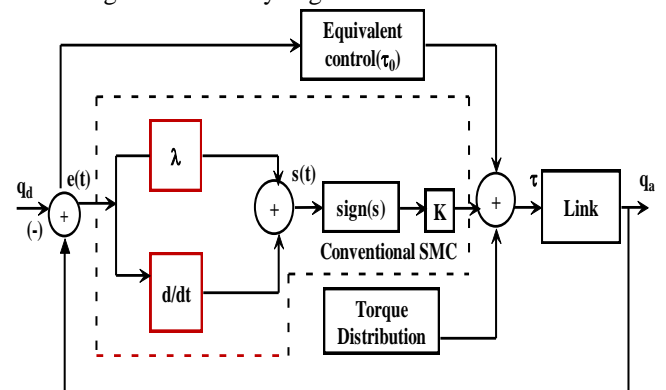


Fig5. Block diagram of the conventional sliding mode control.

It is visible from the duplicate effects that following of robot controller by using thinking about a sliding mode controller (SMC) manner offers the least goal work an incentive in the exam with PID. SMC gives least following mistake and notable aggravation dismissal contrasted with PID tuning parameters. The instructions stayed inside their restrict layers after the adjustment time body, which brought approximately super energy and following execution. The above shows the various controllers i.e., SMC and PID. It is observed that compared to PID, the SMC provides better trajectory performance. The disturbance rejection is good with SMC than PID.

IV. ARTIFICIAL INTELLIGENT CONTROL METHOD

A. Wearable Exoskeleton Assisted Rehabilitation in Multiple Sclerosis by Using an Artificial Intelligent Control Method

Control engineering for human-robot co-pastime in network conditions has been added. The unique control strategies have been used for the example of RH-2. Direct manage layout for human-robot co-project in cooperative has been displayed. The distinctive PID and neural based controllers were utilized for a humanoid robotic. The stance energy has been executed by using making use of the version of the unmarried converted pendulum and controlling the robot's decrease leg. The ANN controller with feed-ahead neural networks is able to running in real time for manage of the robotic leg version with different traits. It has been confirmed that the ANN controller can successfully be evolved, that could provide performance pretty near the expected controller and much superior to the traditional PID controller beneath simultaneous torque disturbance of any random magnitudes. Further studies will deal with to increase the nonlinearity and the sensible primarily based controllers for the leg model. The synthetic Neural community (ANN) making use of the one-of-a-kind unsettling influences varieties of essential rectangular errors (ISE). Artificial Neural network (ANN) utilize the increase and different unsettling affects to include few instances for digital diagrams (1% to 50%). Looking on the PIDNN for the distinctive additions utilizing the unsettling have an impact on has befell and outcomes are out for the misfortunes (1% to 50%). The addition misfortunes for the ANN and PIDNN are to shift the all-out variety of unsettling impacts to great reactions is ANN. The distinctions approximately diagrams were to better for PIDNN to ANN. The human walk is regularly displayed with distinct types of the reversed pendulum, for example, 2D and 3D linear modified pendulums (LIP) [6-10].

Sensor combination challenges in sensor combination and data preparing. Incorporate various detecting abilities into little, low-control, constant preparing subsystems. Here we present a novel designing named F-IVT (Flywheel-Infinitely Variable Transmission) actuator that on a first dimension license to man-handle the traits of the lower member advancement streamlining the working states of the electric engine and conquering the as of late referenced issues [11-12]. Managing existing live line working techniques and

standard hotline hardware is another method for controlling the innovation. This requires the establishment of an electrical cable investigation robot on the stimulated line within 30 minutes of coming of the structure. A few models can be utilized to obtain steadiness. A part of the ones depends upon the calculation of ZMP [13-14]. The digital granny walker spring damper constants tentatively fluctuated while bodily looking at their belongings [15-17]. Strolling become began within the only help degree. A slight push turned into linked to the robotic to force it forward. After the rush, no out of doors intercession became required. An management robot is which works semi or completely independently to perform administrations valuable to the prosperity of humans and hardware, barring fabricates activities. The Zero Momentum Point (ZMP) estimation is moreover imperative for the semi-on-line assessment of ZMP improvement [18-19]. On the off threat that ace's intentions are acknowledged in advance of time, a right example can be decided for legs and arms. The human-robot joint effort has a regular device as for human-robot commune. The humanoid stroll is frequently validated with distinct kinds of the rearranged pendulum, as an instance, 2D and 3-d directly disenchanting pendulums. The single rearranged pendulum connected to the robotic and the check display M(S) of lower leg actuator.

B. Artificial Neural Network (ANN) based PID Controller (PIDNN)

We achieved reproductions with zero% to 10% aggravation parameter deviations, and we noticed that following execution stayed precise. It is seen from the duplicate outcomes that following of robotic controller by thinking about an Artificial neural network (ANN) method gives the least target paintings an incentive in the examination with PIDNN. ANN gives least following mistake and splendid aggravation dismissal contrasted with PIDNN tuning parameters.

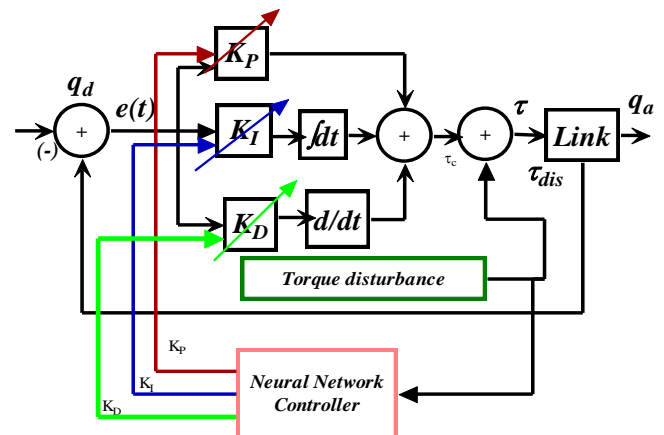


Fig6. Block diagram of the PID controller with artificial neural network (PIDNN).

The guidelines stayed internal their restrict layers after the adjustment time frame, which introduced about exceptional energy and following execution. In designing of ANN

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controller, the information sets want for training the neural networks had been generated by using trial blunders estimation. The variety of torque disturbance within the system has been chosen as zero to ten percentage. Where K_{PNN} , K_{INN} and K_{DNN} are gain values of PIDNN controller is defined in fig6. For each robot leg model, the best-trained network has been retained as the controller and it has been permanently saved as a MATLAB file called as the net. Finally, the performance of the PID and NNPID controllers are compared in terms of the time domain specifications i.e., trajectory tracking and disturbance rejection.

Table 1. PID parameters with ANN for various disturbances

S. No	%dis	K_p	K_i	K_d	Error
1	0.01	115.5	248	103.4	0.000701
2	0.02	114.6	247.1	102.9	0.000709
3	0.03	112.9	245.7	102.2	0.000722
4	0.04	110.2	243.2	100.9	0.000746
5	0.05	105.7	239.1	98.82	0.000788

V. RESULTS

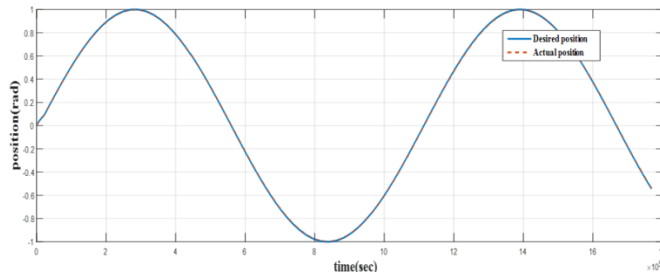


Fig7. Simulation response (with PIDNN controller with 1% disturbance).

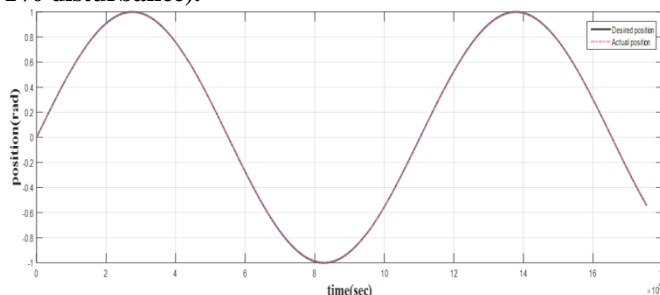


Fig8. Simulation response (with PIDNN controller with 2% disturbance).

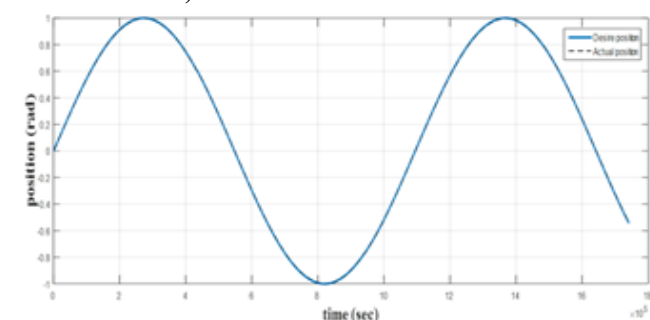


Fig9. Simulation response (with PIDNN controller with 3% disturbance).

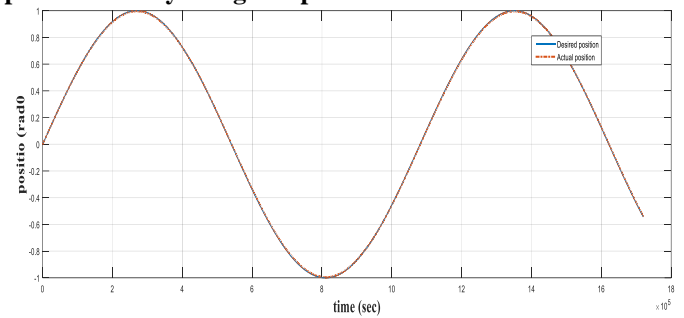


Fig10. Simulation response (with PIDNN controller with 4% disturbance).

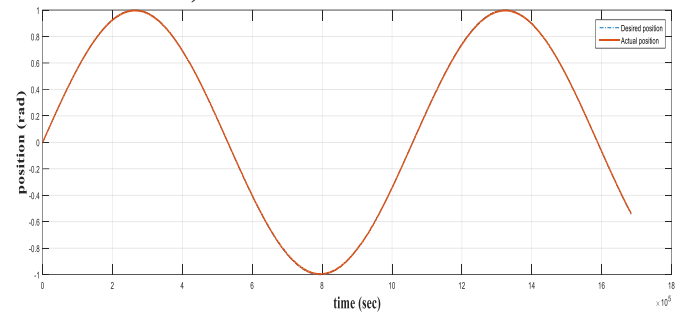


Fig11. Simulation response (with PIDNN controller with 5% disturbance).

VI. CONCLUSION

Control engineering for human-robot co-activity in community situations has been introduced. The distinctive control methods have been used for the instance of RH-2. Direct control design for human-robot co-task in cooperative has been displayed. The distinctive PID and neural based controllers have been utilized for a humanoid robot. The stance strength has been accomplished by utilizing the model of the single transformed pendulum and controlling the robot's lower leg. The ANN controller with feed-forward neural networks is capable of working in real time for control of the robot leg model with different characteristics. It has been demonstrated that the ANN controller can successfully be developed, which can give performance quite close to the estimated controller and much superior to the conventional PID controller under simultaneous torque disturbance of any random magnitudes. Further research will concentrate on to develop the nonlinearity and the intelligent based controllers for the leg model.

VII. REFERENCES

- [1] R.P Kumar, J.W. Yoon and G.S. Kim, "Simple dynamic walking model with Toed feet", Proceedings of IEEE RAS International conference on humanoid robot, Korea, 2008, PP.245-250.
- [2] C.A Monje, P. Pierro and C. Balaguer. "A new approach on human-robot collaboration with humanoid robot RH-2", Robotica, 2011, Volume 29, pp.949-950, DOI: 017/ s02635 74 71100018X.
- [3] S. A Green, M. Billing Hurst, X. Chen and J.G. Chase, "Human robot collaboration a literature review on augmented reality approach in design", Int. J. Adv. Robot. Systems, Volume 5, no.1, 2088, pp. 1-18.
- [4] S. Kajita, T. Nagasaki, K. Yokoi, K. Kaneko and K. tanie, "Running Pattern Generation for a Humanoid Robot",

Proceedings of IEEE International Conference on Robotics and Automation, EEUU, Washington DC, (2002) pp. 2755-2761.

[5] T. Sugahara and Y. Nakamura, "Variable Impudent Inverted Pendulum Model Control for a Seamless Contact Phase Transition on Humanoid Robot", Proceedings of IEEE International Conference on Humanoid Robots (Humanoids 2003), Germany (2003).

[6] S. Kajita and K. Tani, "Simplest of Dynamic Biped Locomotion on Rugged Terrain", Proceedings of IEEE International Conference on Robotics and Automation (ICRA) (1991) pp. 1405-1411.

[7] T. Komura, H. leung, S. Kudoh and J. Kuffner, "A Feedback Controller for Biped Humanoids that Can Counteract Large Perturbations During Gait", Proceedings of IEEE International Conference on Robotics and Automation (ICRA), Barcelona, Spain, (2005) pp.2001-2007.

[8] Y. Yamamoto, H. Eda and X. Yun, "Coordinated Task Execution of a Human and a Mobile Manipulator," Proceedings of IEEE International Conference on Robotics and Automation, Vol. 2 (1996), PP. 1006-1011.

[9] T. Komura, A. Nagano, H. Leung and Y. Shinagawa, "Simulating Pathological Gait using the enhanced Linear inverted pendulum model", IEEE Trans.Biomed.Eng.52(90), 1502-1513 (2005).

[10] Roberta Alo, Francesco Bottiglione and Giacomo, "Kinematic Energy Recovery in Human Joints: The Flywheel-Infinitely Variable Transmission Actuator", Springer International Publishing AG 2017 J. Gonazalez-varags et al. (eds.), Wearable Robotics: Challenges and Trends, Bio system & Bio robotics 16, DOI 10.1007/978-3-319-46532-67.