Train Robot to Climb Stairs: Maintain Stability of Robot

21_22-J 34

Project Proposal Report

Balasooriya T.D – IT18212150

B.Sc. (Hons) Degree in Information Technology Specializing in Information Technology

Department of Information Technology

Sri Lanka Institute of Information Technology

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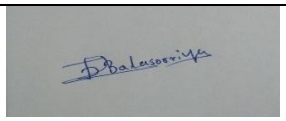
1.3 Declaration

We declare that this is our own work and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Name	Student Id	Signature
Balasooriya T.D	IT18212150	

The supervisor/s should certify the proposal report with the following declaration. The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

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Signature of the supervisor: Date

1.4 Abstract

As the improvement of the Technology human were introduced to machines which can help for their day-to-day life and after advancement of the technology human were build robots for experimental purposes or use of their work. So, there are various type of robots but among those types Humanoid robots are vey special because of they are building by analyzing and imitating human natural body language, movements, human motions etc.

For the human being, balancing the body while climbing the stairs is common and so routine that we are not almost aware of it. it is done by eyes, ears, legs, spine etc. altogether. For a humanoid robot with two legs this is a difficult task, a task that consumes considerable energy resources and computing power. Creating a balance system similar to human balance is a great advantage in robotics.

To implement such a system there is an upright pose controller to allow robot to walk stably by preventing tilting of the robot during walking on uneven floor.

In general, to for us to do that we need to calculate the global inclination of the floor is a key factor. It can be measured by A 2-axis accelerometer, and it is installed in the inertial sensor.

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1. Introduction

Maintaining the balance a robot is a big challenge and maintaining its stability is one of the final actions that a robot must consider. With the recent advancements of the humanoid robot, the interaction between humans and this type of robot has grown large and has aroused the interest of many researchers. Previous simulation projects were limited to upper body movements and the legs were ignored. Shortly thereafter, simulation was extended considering whole-body movements with the introduction of advanced motion sensors and the development of rapid human robots. Nowadays high levels of free humanoid robotics are available, and researchers are developing the interactive capabilities of these robots frequently to balance the robot while climbing stairs or carrying stuffs. Maintaining the robot's balance by imitating the human motion is an essential part of the research and can be illustrated in this research area.

There can be two types of humanoid robots, Torque based, and position based those two types. Torque based joint control robots are much complicated. So, I am discussing here about balance control of the robot while climbing the stairs. The main contribution of this project is to suggest a balanced strategy in performing simulations based on ankle joint correction. So, there the there is a important factor the center of mass. So, to do that we need to come up with a inverted pendulum model consider on the center of mass. And also we can use strategy that use ankle torque which is consider the GCoM by solving the support polygon.

To find the support polygon we can use a method to solve which leg holds the GCoM point at a time while climbing stairs. Below diagram is demonstrate basically how the detection procedure of support leg.

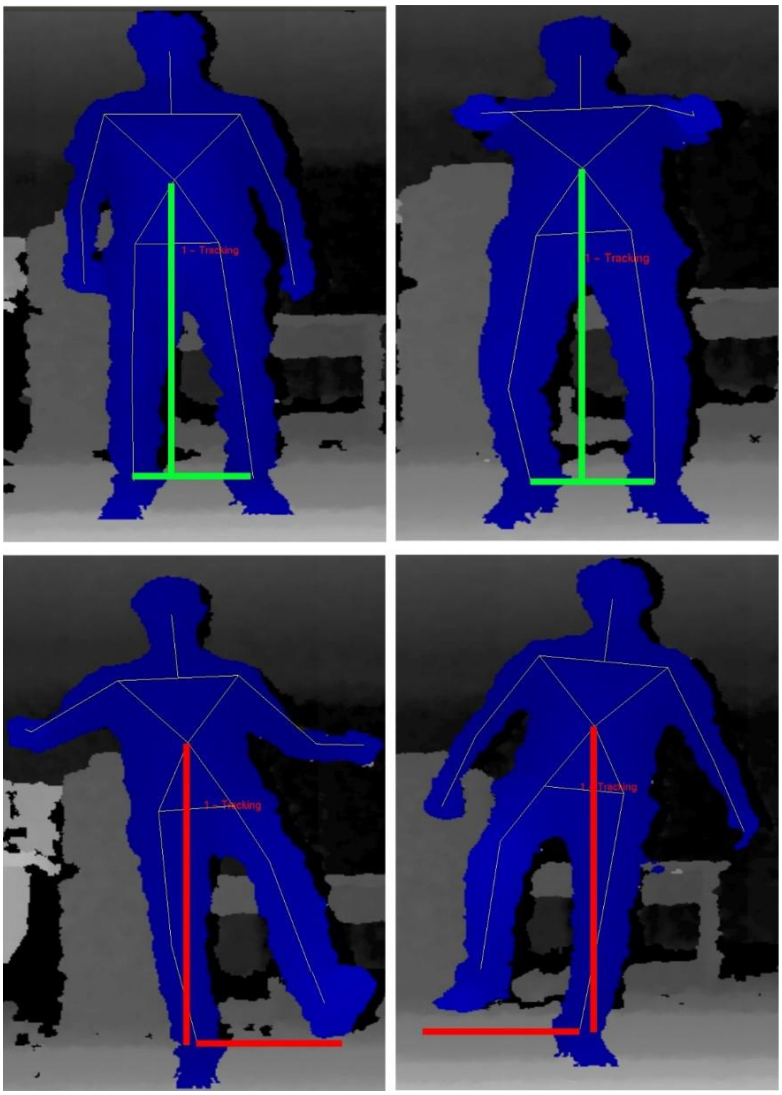

Figure 1-Support leg detection procedure image

Not only that, we need to implement a control design as well to activate our discussed strategies that I've mentioned. When this step is reached, double inverted pendulum models are there, representing the simple dynamic model of a human robot at each double as well as single support stage, respectively. In the presented model, the position of the ground projection CoM is controlled by the ankle joints. As mentioned above, a human robot is stable and limits the GCoM location within the supporting polygon. So, the centre of supporting polygon is assumed to be the necessary reference. In this project, a PID controller is designed to monitor the final reference. The following figure shows a diagram showing the structure of a activated PID controller.

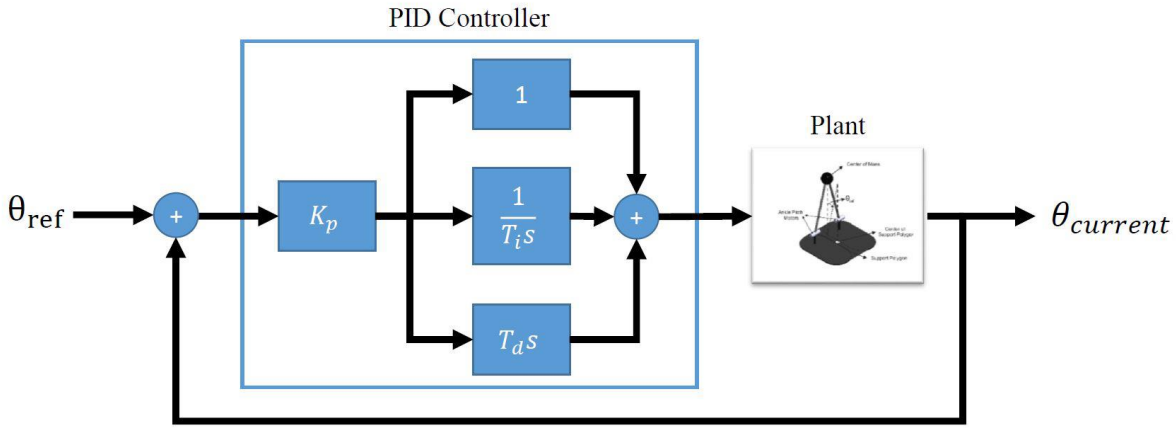

Figure 2 - PID Controller Diagram

2. Background and Literature Survey

Researchers have done different research about humanoid robot imitating human motion and maintain its stability when climb stairs. There are three parts to considering maintain balance of the robot. The first one is **Motion capture.** in motion capture basically captures robots process of record the movement of objects, **Kinematic Operation** does the robot move and most importantly the **Balance Control** will do a huge task for robot not falling during the movement and let it go smoothly on the ground as well as while climbing the staircase. Most of the research has done by implementing pendulum model and according to that control the balance by implementing a controller model as well.

3. Research Gap

Most researchers have been done lot of research about stability maintenance of a robot but most of them still struggle to find a robust stability system for humanoid robot. There are many movement characteristics to apply at a time and should also be very accurate to balance properly. General time of walking circle, foot status at each timing, walking speed, Leg joint angle pattern,

Pelvis movement, foot clearance during swing phase are some of major characteristics to consider. So, majorly I have found,

- Maintain stability while moving
- According to researchers, Robust stability system is challenging task
- Convert robot's movements according to human natural motion

as my research gaps. As I go through research papers I have come up with a chart which is related to my research area.

Research	Implement a walking pattern	Detect human motion	Converted human motion to mechanical property	Maintain stability while moving
Walking pattern generation in sagittal plane possessing characteristics of human normal walking[1]	Yes	Yes	No	No
A Guide for Human Walking Model and Control - Insights from Mechanical Property Analysis of Human Walking[2]	Yes	Yes	No	No
Whole-body imitation of human motions with a Nao humanoid[3]	Yes	No	No	Yes
Balance Strategy for Human Imitation by a NAO Humanoid Robot[4]	No	No	No	Yes
A control method for transfemoral prosthetic knees in level walking and stair ascending based on thigh angular motion[5]	No	No	No	No
Stair Climbing Stabilization of the HRP-4 Humanoid Robot using Whole-body Admittance Control[6]	No	No	Yes	Yes
Proposed system	Yes	Yes	Yes	Yes

Table 1 – Research gap with research papers

4. Research Problem

In My main part is to control stability while moving and climb the staircase.

As my research questions In there,

- When it walks and climb stairs control it's stability is the main part
- How to detect human motion
- Implement a generate walking pattern
- How to convert human motion to mechanical property
- How to maintain stability while moving

My first thing is to extract features from human walking. So, here I consider about walking circle, step length, Heel clearance foot position majorly. And consider on implement a walking pattern generator and calculate, then use motion sensors to get robot current values in order to balance it. As well as it should be work in ground walking and also climbing staircase.

5. Main Objectives

As my main objectives I have two things to consider on my research area. Which is,

- Maintain stability while moving
- Define a model for human walking pattern

In here I am going to implement a way for generate walking pattern and by using inverted pendulum model which is based on center of mass I am create the human walking model. So next, I am going to maintain stability while robot walking. In order to do that I need to have controller which is known as PID controller. It is considered about robot's current data and using that data kinematic operation would be controlled.

6. Specific Objectives

As my Specific Objectives I have break down my main objective into smaller parts because it easier to do my implement part very clearly. So that,

- Detect supportive leg
- Implement a controller design
- Analyze mechanical properties of human walking
- Create the human walking model
- Get feedback of walking and optimize the movement

Are my specific objectives. In here, To find out support leg, I need to look at the two indexes which is Bent of the body center and Height of swing foot. So, Identifying single support phase bent of the latter index is on consider as support leg. As well as the other index is height of the foot which is rolling from floor. Then the next thing is to Implement a controller design which is consider on Foot orientation, Leg length, Speed, and foot position from our walking pattern generator produced. That is the major thing to do when breakdown the main objective.

7. Methodology

Initially I have to find out how to extract human motion from human walking so that I used walking pattern generator to consider on human characteristics (Walking Circle, Step length, Heel clearance, foot position)

And I had used here position-based approach. So, I have Implement a walking pattern generator and I have given here an actual human data about walking and balancing body then when robot start to walk there have a feed back controller and it will compare existing data in the generator and robot's current data. So, after that if the current data is not in the possible range balance controller will balance robot's movement after kinematic operation has done

As well as when in the climbing staircase robot have to move upward it's leg than usual range it will detect by the feed back controller and control the upper body to bend forward and I am going to use knee ankle strategy in order to implement this climbing staircases in my proposed system.

I have provided a system diagram below here to get how it works.

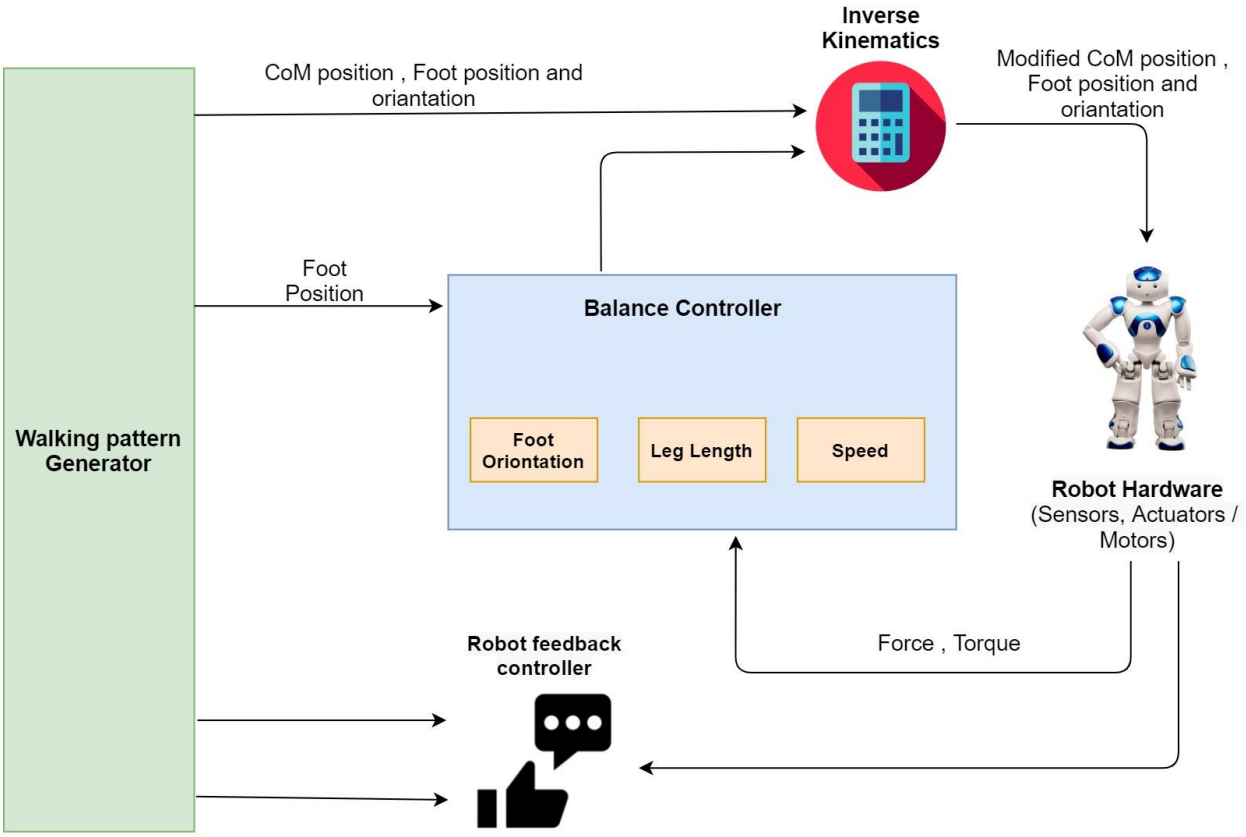

Figure 3 – System Diagram

8. Budget and Budget Justification

Component	Amount (USD)	Amount (LKR)
Frameworks and libraries	**Free (0$)**	**0 LKR**
Internet Package	**30$**	**6000 LKR**
Total	**30$**	**6000 LKR**

Table 2 – Budget Details

9. Reference List

Reference Number	Reference
1	S. Lee, J. Lee, D. G. Lee and Y. Oh, "Walking pattern generation in sagittal plane possessing characteristics of human normal walking," 2016 IEEE International Conference on Mechatronics and Automation, 2016, pp. 1066-1072, doi: 10.1109/ICMA.2016.7558710.
2	G. Chen, B. Hou, S. Guo and J. Wang, "A Guide for Human Walking Model and Control — Insights from Mechanical Property Analysis of Human Walking," 2020 Chinese Control And Decision Conference (CCDC), 2020, pp. 4785-4790, doi: 10.1109/CCDC49329.2020.9164160.
3	J. Koenemann and M. Bennewitz, "Whole-body imitation of human motions with a Nao humanoid," 2012 7th ACM/IEEE International Conference on Human-Robot Interaction (HRI), 2012, pp. 425-425, doi: 10.1145/2157689.2157830
4	P. Shahverdi, M. J. Ansari and M. T. Masouleh, "Balance Strategy for Human Imitation by a NAO Humanoid Robot," 2017 5th RSI International Conference on Robotics and Mechatronics (ICRoM), 2017, pp. 138-143, doi: 10.1109/ICRoM.2017.8466225.
5	K. Inoue, A. Pripunnochai and T. Wada, "A control method for transfemoral prosthetic knees in level walking and stair ascending based on thigh angular motion," 2016 38th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), 2016, pp. 4638-4641, doi: 10.1109/EMBC.2016.7591761.
6	S. Caron, A. Kheddar and O. Tempier, "Stair Climbing Stabilization of the HRP-4 Humanoid Robot using Whole-body Admittance Control," *2019 International Conference on Robotics and Automation (ICRA)*, 2019, pp. 277-283, doi: 10.1109/ICRA.2019.8794348.

Table 3 – References list