Train Robot to Climb Stairs: Get Dimension of Staircase

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Project Proposal Report

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Department of Software Engineering

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DECLARATION

I declare that this is my 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
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The above candidate is carrying out research for the undergraduate dissertation under my supervision.

Signature of the Supervisor: Date:

ABSTRACT

Nowadays, robots are using in many industries. Such as vehicle fittings, agricultural tasks, food manufacturing events, rescuing programs, and waiter in hotels. As a result, that, the robots need to walk everywhere. Sometimes they have to climb stairs and happen to move on an obstacle environment. Many researchers have done research on this topic, and they have implemented different approaches to train the robots to climb stairs. Here the selected robot is a humanoid robot. It has two hands and two legs and a head and body. Recently some companies around the world have developed many kinds of humanoid robots. As previously mentioned, “Surena”, “Nao”, “Kime”, “Pepper”, “T-HR3” could indicate as examples of humanoid robots. This proposal is concerned with how to take the stair dimensions. this is the main part of this research because all these calculations depend on the dimensions. The need to take the dimensions of the stairs is that when considering the stairs, they have their own height, width, and range. It is therefore imperative to calculate the dimensions of each staircase separately.

***Keywords*: robot, staircase, dimensions**

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1. INTRODUCTION

1.1. Background

Time is a very important source who lives a complex lifestyle. So the people focus their attention to do activities within less time. With new technologies, most systems and applications become automated. Robots take the most significant role in this scenario. These days, robots are primarily considered for human-like operations. In this situation, a robot must be able to operate in real-world situations and navigate reliably in complicated residential contexts in order to perform high-level activities like delivery or home assistance. Multi-level environments with many floors connected by staircases are included. Self-climbing with humanoid robots is difficult due to the fact that humanoids frequently execute motion commands inaccurately. This could be owing to the fact that human hydroids only have a rough chromatographic estimation, causing them to slip on the ground and create joint stiffness due to friction. Furthermore, the sound is naturally affected by their small and light sensor observations. All of this can lead to erroneous posture assessments. However, in order to climb a trustworthy staircase, the robot needs a highly accurate stair posture assessment. Otherwise, it may slip from the stairwell's edge after taking a step forward or uphill [1]. In these a priori unknown and changing conditions, they are supposed to function totally or partially independently. As a result, the robots must be outfitted with appropriate sensors. The most detailed information about the surroundings is provided by visual sensors. Cost considerations must also be taken into account in order to allow for the widespread distribution of bipedal robots for general services in the future.

In contrast to wheel-based robots, sensor data fusion and image processing have just recently become important for bipedal robots. This complicates the use of large laser scanners or vision modules. Additionally, for undistorted picture processing, it may be required to compensate for the complex biped motion.

1.2. Literature Survey

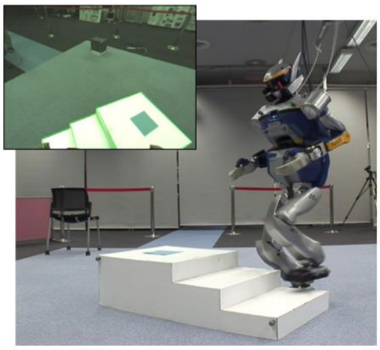


Figure 1 HRP-2 humanoid robot [2]

In [2], This research used programmable graphics hardware to speed the online operation of a robust model-based three-dimensional tracking system during the movement of a humanoid robot. The tracker recovers the complete six degrees of freedom of visible objects in relation to the robot. They used a cascade of fragment programs, as presented in figure 2, written in NVIDIA's Cg language and working on picture data stored as textures in GPU memory to execute their technique. They were able to improve our tracker's resilience to considerable camera movement and camera shake that is common during humanoid navigation by utilizing the GPU's computing capacity for perception. This has coupled their method with a footstep planner and a controller that can modify the height of swing leg trajectories adaptively. An HRP-2 humanoid robot (figure 1 shows) was able to effectively localize, approach, and ascend stairs, as well as avoid obstacles while walking, according to the integrated perception-planning-action system that resulted.

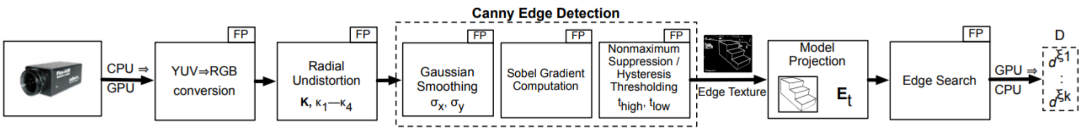


Figure 2 Image processing, model projection, and edge search are defined by a GPU fragment program cascade. [2]

The bipedal robot BARt-UH is used in this research to identify stair dimensions utilizing a linear laser [3]. The essential data is retrieved from the line laser projection onto the staircase. Three algorithms have been developed to do this, and a comparative analysis has been conducted. A line laser is projected onto the steps., in Figure 3, is used to determine stair dimensions. The following processes are required to obtain these laser contours.

1) Capture a differential picture using two successive images, with the laser turned on in the first image and off in the second.

2) In the single support phase, a threshold operation is used to produce binary images.

3) Filter for dilution the next step is to locate comparable corner locations in each image. The distances between these locations are computed using a stereo triangulation technique, and the stairs' distinguishing characteristics, such as the distance to the stairs, the step height, and the step width, are calculated.

Other object identification issues may be simply adapted using the Hough transformation. The other two algorithms are heuristic techniques that are tailored to the task at hand. Their outcomes are quite comparable, and the algorithms are highly resilient against uncertainty since they may incorporate a lot of information about the predicted prediction.

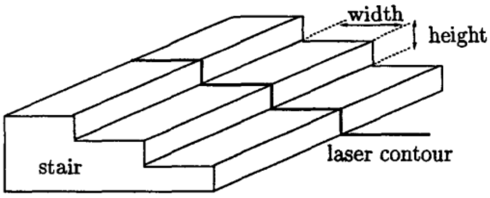
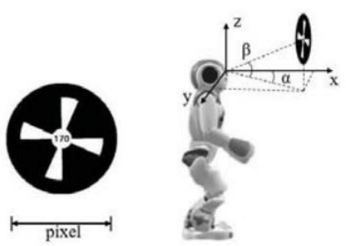


Figure 3 Laser line projection on the staircase [3]

In [6], For humanoid robots climbing stairs, this research demonstrates a target location and gait planning technique. The humanoid robot's target location allows it to precisely detect the stair position, and the gait planning algorithm allows it to ascend the stairs. The humanoid robot Nao can now climb a staircase with 2.928 cm steps due to this research. To calculate the dimensions of the staircase, create a relationship between Nao and the target place. Naomark is a peculiar sign consisting of a black circle and a white fan with a number in the middle, as shown in Figure 4 . Figure 4 shows the coordinate system. Following the relationship in Figure 5, the value of Ls may be computed using a neural network after measuring the distance d between the Nao robot and the Naomark.



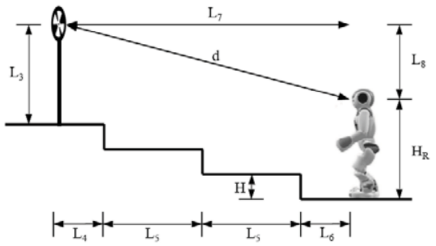


Figure 4 Naomark [6] *Figure 5 The positional relationship between stair and Nao [6]*

In [8], This research presents developing a new rescue mobile robot, the theoretical study and implementation of autonomous staircase recognition and stair climbing algorithms. Seniority is the basis of this system. The major objectives are to locate the staircase during navigation and to develop an autonomous stair climbing algorithm that is quick, safe, and smooth. It's necessary to look for a certain number of levels. A human operator is capable of driving silver upstairs (see figure 6). The experimental platform in this case is Silver. During stair climbing, the robot is guided by a fuzzy controller. The range data from two laser range finders that scan the surroundings horizontally and vertically is processed to generate controller inputs.

Figure 6 the passive robotic arm of Silver, the research's experimental platform, is equipped with two laser range finders. [8].

On the robotic arm, two Hokuyo URG-04LX LRF are attached, as shown in Figure 1. These sensors have a 1mm resolution and a 5mm tolerance and can measure distances up to 4 meters. They give 769 distance data at a sampling rate of 10Hz from a 270-degree sweep angle. The front-facing LRF (VLRF) scans vertically, whereas the back-facing LRF (HLRF) scans horizontally.

1.3. Research Gap

Many types of research have been done to obtain dimensions used by sensors or vision. In the low light situations how to perform this system, the proposed methodology by other researchers has not been discussed that. Other than that, we proposed system, that can identify all stairs in the staircase have the same dimensions or not before the climbing stairs. This part has not discus by other researchers. They try to do this; they assume all stairs are the same or obtain dimensions from time to time.

Referring to [2], this research is real-time 3D monitoring for humanoid locomotives and stairs with a GPU acceleration system. This is a vision-based system. And this is a robust model-based three-dimensional tracking system that was accelerated using programmable graphics hardware to work online at frame-rate during humanoid robot movement. They used a cascade of fragment programs written in NVIDIA's Cg language and working on picture data stored as textures in GPU memory to accomplish their technique. but this system does real-time data gathering and calculating the dimensions. And also this does not identify all stairs have the same dimensions.

Referring to [3], The goal of this research is to get stair measurements for path planning using the bipedal robot. This system obtaining the dimensions by using sensors. These use a state transition algorithm to plan the robot's path intelligently. To identify the dimensions of stairs, line lasers are also considered. Essential information is retrieved from the line laser projection onto the staircase. Three algorithms have been implemented to do this. These research main goals are the identification of stair features, for bipedal robot online route planning, such as the number of steps, step height, and step breadth.

Referring to [8], this research is by implementing image processing technologies to help a human robot climb the staircase. This system using by visions for obtaining the dimensions of the staircase. Controller inputs are obtained by analyzing range data from two LASER range finders, one horizontally and one vertically scanning the area. At the conclusion, the experimental results of the stair detection algorithm and the stair climbing controller are shown. This system the major objectives are to locate the staircase during navigation and to develop an autonomous stair climbing algorithm that is quick, safe, and smooth.

In we proposed system, People have a complex lifestyle so that if using robots, they must be able to accurately and quickly respond to human requests. Therefore, when climbing stairs, the dimensions of the stairs should be obtained very accurately and quickly under any environmental situation. In we proposed system we use vision and laser sensors to obtain the dimensions of the staircase. Using a laser sensor we gather all the distances of all the stair's front corners edge points. By using that distances, consider whether all the stairs have the same dimensions. If same, only we need to obtain dimensions of the first stair. And also using vision under any environmental situation and implementing image processing technologies we can obtain other dimensions of the stair. We believe that by implementing these changes to existing projects, we can obtain more accurate and very quickly dimensions of the staircase.

Research	Obtain dimensions for use by sensors	Obtain dimensions for use by Visions	Obtain dimensions for use by both (Hybrid)	Support for low light situation	Identify all steps have same dimensions
Autonomous Climbing of Spiral Staircases with Humanoids [1]	**Yes**	No	No	No	No
GPU-accelerated Real-Time 3D Tracking for Humanoid Locomotion and Stair Climbing[2]	No	**Yes**	No	No	No
Detection of stair dimensions for the path planning of a bipedal robot [3]	**Yes**	No	No	No	No
Stair climbing for humanoid robots using stereo vision[5]	No	**Yes**	No	No	No
Autonomous Staircase Detection and Stair Climbing for a Tracked Mobile Robot using Fuzzy Controller [8]	No	**Yes**	No	No	No
Proposed system	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**

Figure 7 Comparison of existing project

1.4. Research Problem

A robot must be able to operate in real-world situations and navigate reliably in complicated interior surroundings in order to perform high-level activities like delivery or home help. Multi-level settings with several floors connected by staircases are included. Climbing the automatic stairs with humanoid robots is a difficult undertaking, and humanists typically only carry out commands by accident. Because human hydroids have only a rough chromatographic estimate, they may slip on the ground and induce joint stiffness owing to friction. Furthermore, the sound is naturally affected by their small and light sensor observations. All of these can lead to erroneous posture assessments. To ascend a dependable complicated staircase, the robot, on the other hand, need a highly accurate posture assessment on the staircase. Otherwise, it may slip off the stairwell's edge after taking a step forward or uphill [1].

In previous researches, researchers have not been discussed how to obtain dimensions of stairs in low light situations. If using visions to obtain dimensions, we need to increase the brightness of vision.

The main problem is how we obtain the dimensions of the staircase while more accurately and faster. We are solving that problem by using, hybrid system. That is a combination of visions and sensors. In using the Vision sensor, I will capture a live image on the stair, and I using to calculate width and height by using a Convolutional

Neural Network. While that process, using a laser sensor we gather all the distances of all the stair's front corners edge points. By using that distances, find out if there is a pattern of the obtained distances by using python implementation methods. If it has a pattern, all the stairs have the same dimensions. Now we need to only obtain the dimensions in the first stair. We believe that in using that process we can obtain dimensions more accurately and very quickly.

2. OBJECTIVES

2.1. Main Objective

Get Dimensions of the staircase.

This is the main part of the robot to climb stairs system. Because all these calculations depend on these obtained dimensions. The need to obtain the dimensions of the stairs is that when considering the stairs, they have their own height, width, and range.
I plan to implement the proposed system more accurately and very quickly obtain the dimensions of the stair by integrating visions and sensors using convolutional neural network and python implementation methods. Following that way robots are able to accurately and quickly respond to human requests.

2.2. Specific Objectives

- **Stair's front corners edge points**
- **Get dimensions of stair**
- **Identify stairs have the same dimensions**

3. METHODOLOGY

Background and Literature survey were conducted to obtain the dimensions of the staircase area and to learn about similar implementations carried out by researchers throughout the world. As indicated in the research gap, certain areas have yet to be addressed, while others need to be improved. As a result, the criteria listed below were identified.

- The suggested model should be able to classify all stairs with the same dimensions.
- If not same stairs, identify dimensions of stairs should be real-time and fast.
- The suggested model should be able to classify the dimensions of the staircase in any environmental situation.
- Obtain the dimensions of the staircase should be quickly.
- Obtain the dimensions of the staircase should be more accurate.

3.1. System Diagrams

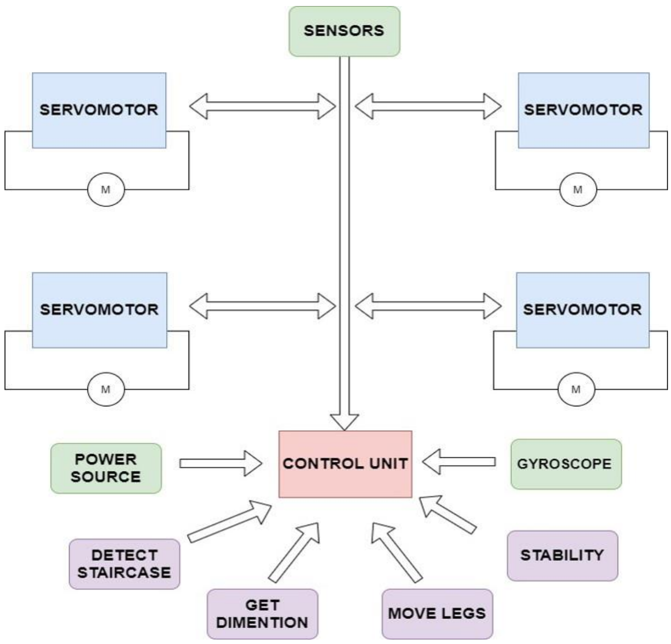


Figure 8 Overall System Diagram

Figure 8 shows the overall system diagram. Bottoms can see the main objectives in the purple color.

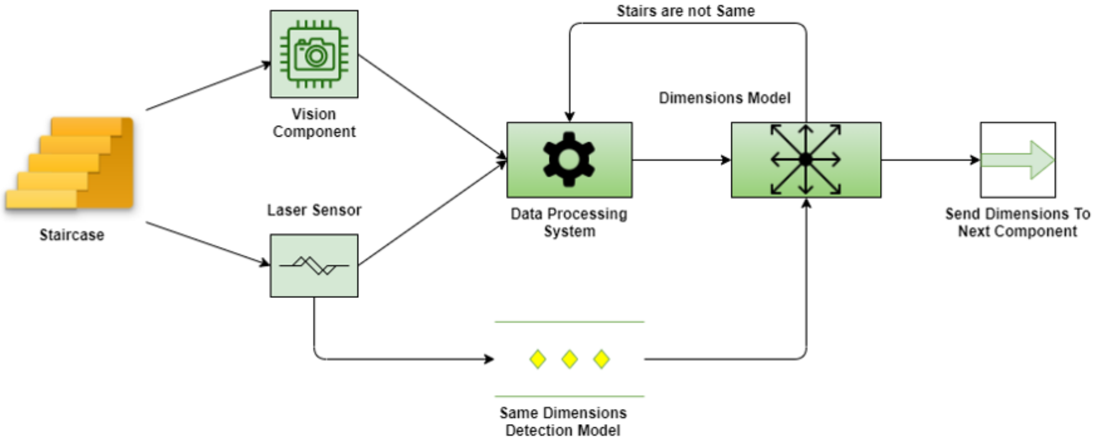


Figure 9 Individual System Diagram

In figure 9 shows get dimensions system diagrams. In the diagram, first shows the detected staircase object and the input takes by using vision components and a laser sensor. Like if in the low light situation, need to increase the brightness of the view. While that process, using a laser sensor we gather all the distances of all the stair's front corners edge points. By using that distances, this data will send to the data processing system and same dimensions detection model. In the same dimensions detection model component, consider whether all the stairs have the same dimensions. If it is not the same pattern, identify the stair that broke the pattern and sends those data to dimensions model. In data processing, calculates the dimensions in the first stair by using convolutional neural network & python algorithms. After that it will send dimensions model and it will check to have the pattern broken in stairs. If it has, send the dimensions up to that stair, and start the re-calculate the dimension from the pattern broken in the stair.

4. PROJECT REQUIREMENTS

4.1. Functional Requirement

- Get vision based data.
- Get sensors based data.
- Calculate Dimensions of staircase.
- Identify same stairs or not.
- Send results to other components.

4.2. Non-Functional Requirement

- Speed
- Accuracy
- Light weight
- Maintainability

5. Work Breakdown Chart

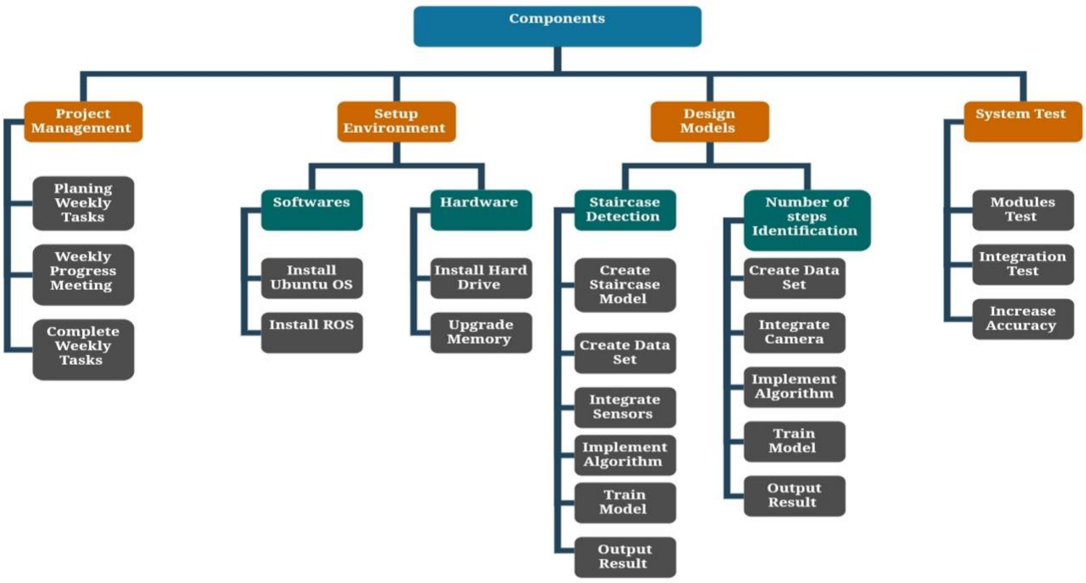


Figure 10 Work Breakdown Chart

6. Grant Chart

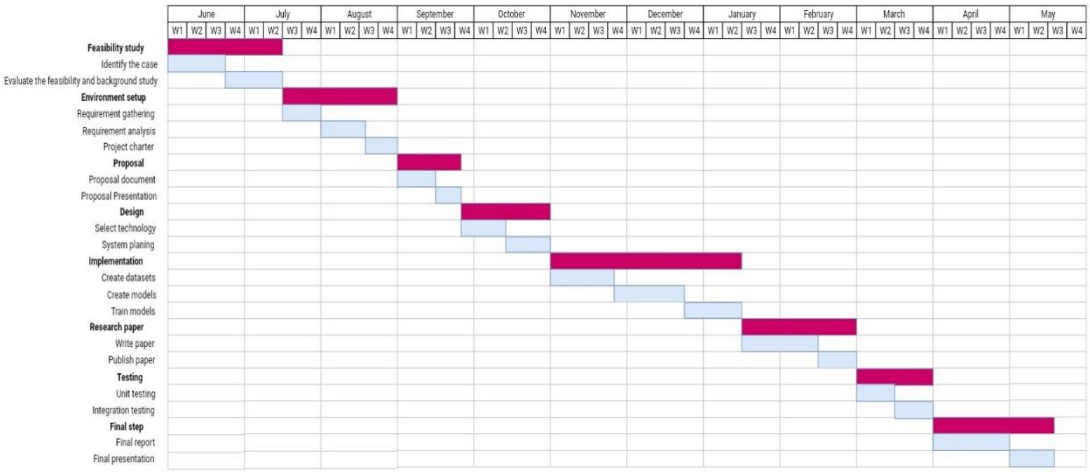


Figure 11 Grant Chart

7. BUDGET AND BUDGET JUSTIFICATION

Component	Amount (USD)	Amount (LKR)
Framework and libraries	00	00
Internet Charges.	30.00	6000.00
Total	**30.00**	**6000.00**

Table 1 Budget and budget justification

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