Design Validation and Analysis of A Humanoid Robot

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Abstract— *The paper is about the design validation and analysis of a humanoid robot. The robot made is of 34 inches (86.36 cm).The structural design of the humanoid is made on the basis of golden ratio and the results of the design is validated by an already existing humanoid NAO.*
Keywords— Humanoid Robot, humanoid NAO, robots.

I. INTRODUCTION

Humanoid robots have been an attractive research area for the last two decades. A main reason for this is that these robots are theoretically capable of performing similar tasks and acting in similar environments as the human. Even more, there are also tasks which are too complex to be performed by simple robots and too hazardous for human to undergo. Therefore humanoid robots provide a generic platform for researching and developing technologies on a wide range of areas. Some examples are bipedal walking, stereo vision, self-localization and human-robot interaction. Despite the long research on development of humanoid robots there is still a huge lack of functionality and performance, compared to an actual human.The applications of robots with human-like dimensions and motion capabilities, humanoid robots, are plentiful. Humanoid robots constitute both one of the largest potentials and one of the largest challenges in the fields of autonomous agents and intelligent robotic control. In a world where man is the standard for almost all interactions, humanoid robots have a very large potential acting in environments created for human beings.

At the time this paper is being written, the greatest challenge is the stabilization of bipedal walking. This is a key problem in development of humanoid robots. There are several examples of humanoid robots which can walk acceptably stable but require one order of magnitude more power compared to human walking. On the other hand, the new studies in passive dynamic walking introduce a class of bipedal walkers with the energy efficiency of a human.

In traditional robot control programming, an internal model of the system is derived and the inverse kinematics can thus be calculated. The trajectory for movement between given points in the working area of the robot is then calculated from the inverse kinematics. Conventional industrial robots are designed in such a way that a model can be easily derived, but for the development of so called bio-inspired robots, this is not a primary design principle. Thus, a model of the system is very hard to derive or to complex so that a model-based calculation of actuator commands requires to much time for reactive tasks. For a robot that is conceived to operate in an actual human living environment, it is impossible for the programmer to consider all eventualities in advance. The robot is therefore required to have an adaptation mechanism that is able to cope with unexpected situations.

II. DESIGN PARAMETERS

The design of the humanoid is based on the basic concept used for the human body. The human structural design is based on Golden Ratio. The golden ratio is otherwise called as the 'Divine Proportion' or 'phi' (φ) which represents a mathematical ratio with special properties and aesthetic significance. An enormous number of things in the universe are engineered around the ratio, ranging from the human body to the arc of the covenant to snail shells to the orbits of the planets. The divine ratio and golden rectangles appear throughout the ancient architecture and art. The golden ratio is believed to be the most aesthetically pleasing and harmonious means of design. Statistical analysis indicates that "the people involuntarily give preference to proportions that approximate to the Golden Section (Golden ratio)". The Fibonacci numbers are Nature's numbering system. They appear everywhere in Nature, from the leaf arrangement in plants, to the pattern of the florets of a flower, the bracts of a pinecone, or the scales of a pineapple. The Fibonacci numbers are therefore applicable to the growth of every living thing, including a single cell, a grain of wheat, a hive of bees, and even all of mankind. It plays a vital role in the arrangement of petals in flowers, structure of DNA and various proportions in human face, structure of sea shells etc.If we take the ratio of two successive numbers in Fibonacci's series, (1, 1, 2, 3, 5, 8, 13 . . .), we will find the following series of numbers: 1 1 =, 2 1 = 2 3 2 = 1.5, 5 3 = 1.666 . . ., 8 5 = 1.6, 13 8 = 1.625, 21 13 = 1.61538. ... It is easier to see what is happening if we plot the ratios on a graph.

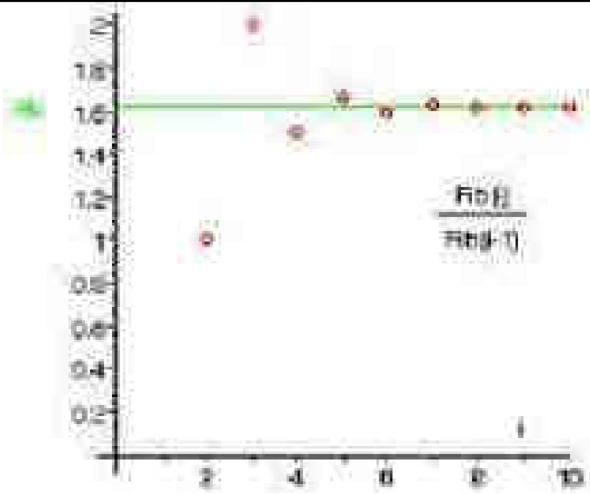

Fig.1: Picturization of convergence of Fibonacci Series

The ratio seems to be settling down to a particular value, which we call the golden ratio or the golden number. The golden ratio 1.618034 . . . is also called the golden section or the golden mean or just the golden number. It is often represented by a Greek letter Phi φ. The closely related value which we write as phi with a small "p" is just the decimal part of Phi, namely 0.618034.

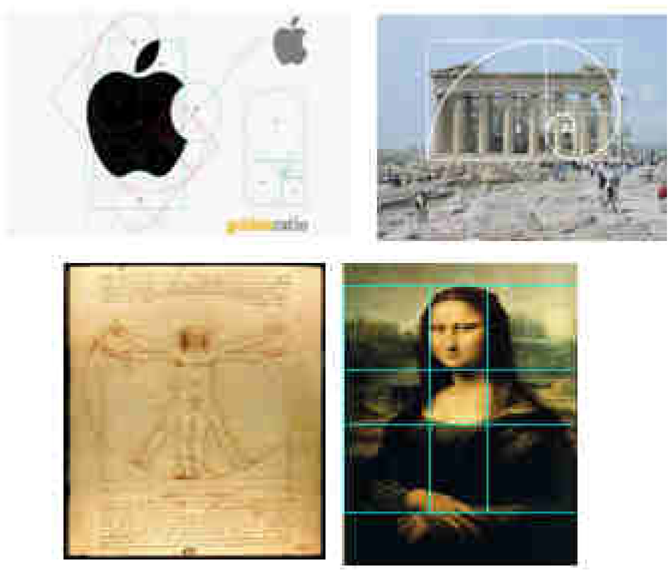

Fig.2: Application of Golden ratio in human body, architectural, apple logo and Monalisa.

Golden Ratio in Humanoid Structural design

The Golden ratio is used a key factor for the dimensions of the structure of the humanoid. Comparing the humanoid's dimensions to the original human body structure the golden ratio used in the humanoid are:

1. Ratio of the distance of the elbow from the wrist to the distance of wrist from the tip of the finger is a golden ratio.

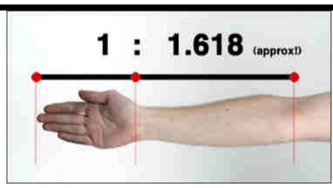

Fig.3: Golden ratio for human hand

2. Ratio of the distance of navel from the bottom most part of the body and top most part is the golden ratio.

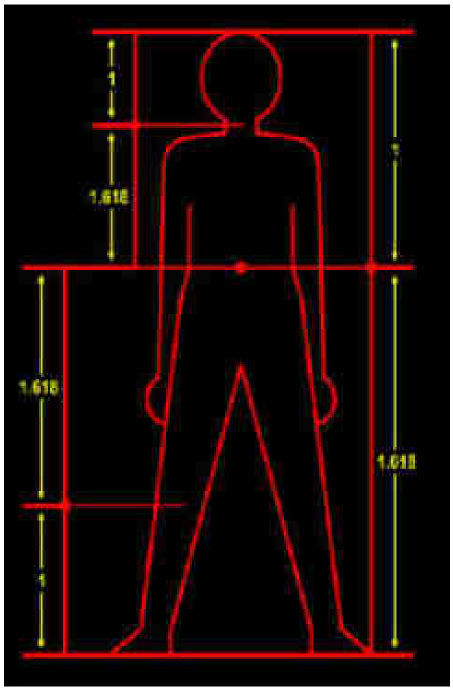

Fig.4: Golden ratio for human body

4.1.2 Balancing

The balancing of the weight is important in the dynamic conditions. After the static condition, during the locomotion of the humanoid there will be unbalance of the weight which needs to be balanced otherwise the robot may fall as the center of mass will shift to any out centered point. The mass distribution of the entire mass of the humanoid is made in the form of a triangular form.

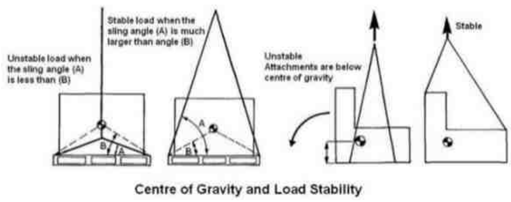

Fig.5: Center of gravity and load stability

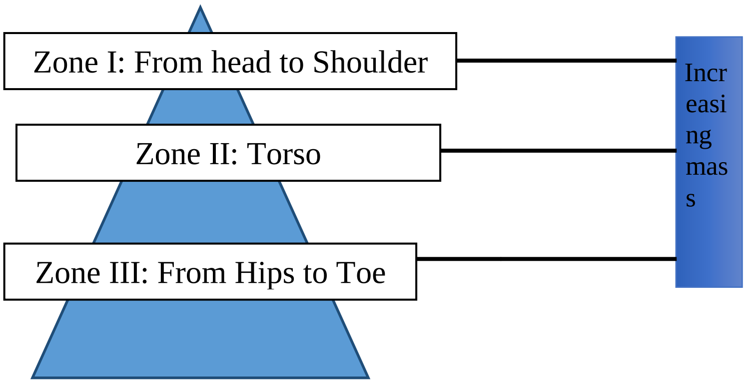

Fig.6: Weight Distribution of the humanoid

The main reason of selecting the weight distribution in a triangular shape is that the center of gravity is the lowest in comparison to all the other shapes.

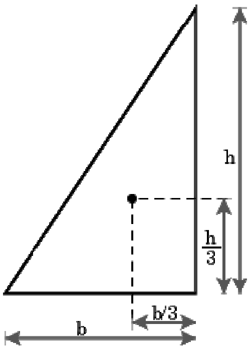

Fig.7: Center of gravity and load stability

The fact that we as humans are bipeds and locomote over the ground with one foot in contact (walking), no feet in contact (running), or both feet in contact (standing) creates a major challenge to our balance control system. Because two-thirds of our body mass is located two-thirds of body height above the ground we are an inherently unstable system unless a control system is continuously acting. The purpose of this review is to introduce the reader to the basic anatomy, mechanics, and neuromuscular control that is seen in the current literature related to balance control.

III. FINAL DESIGN AND VALIDATION

The final design of the humanoid considering the golden ratio parameters are as shown in the figure.

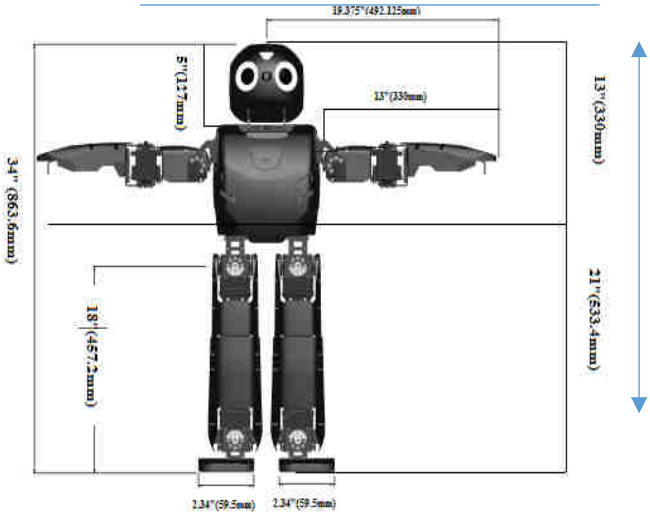

Fig.8: Design of our Humanoid

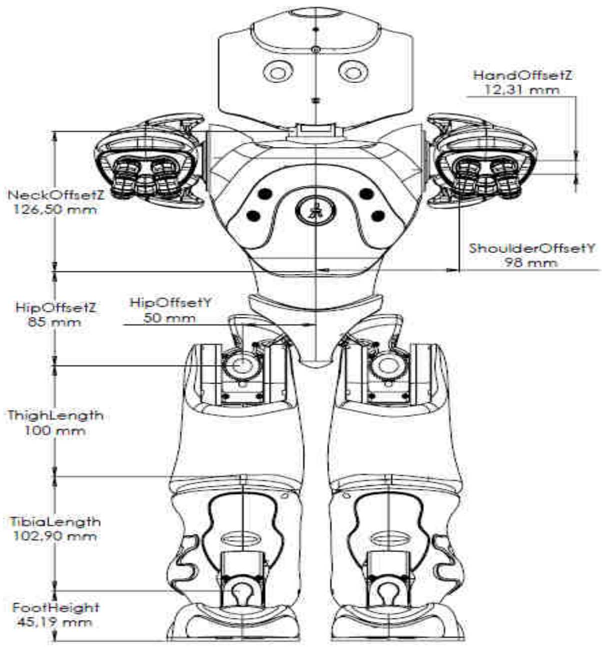

Fig.9:Design of NAO

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