Design of a Robotic Humanoid using Autodesk Inventor

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Abstract: The use of Autodesk inventor as an open source platform for humanoid robot design and simulation is pursued in this work which also describes the design of the physical structure of a robotic humanoid. The mechanical design is completed using Autodesk inventor. The robot was designed in modules before the modules wereassembled to form a humanoid. The designed humanoid was then imported into MATLAB and simulated. The result shows that humanoid can be designed in Autodesk inventor and simulated in MATLAB. This enables researchers to carry out their researches on thehumanoid robot successfully in the absence of hardware support. The Autodesk inventor Simulation platform is simple, easy to operate and is in 3D simulation.
Keywords: Humanoid Robot, Constraints, and Simulation Platform*(Autodesk inventor).*

1. Introduction

Among various forms of robots, humanoid robotis the most integrated, complicated structure and the most similar to a class of humans, so it is suitable towork with humans in living and working environment. The robotic humanoid can be used to replace humans, to work in theenvironment that is known or unknown, harmful or dangerous. Therefore, the humanoid robot has great advantages and a wide range of applications.However, due to the high cost of making humanoid robot prototype, we should analyze the humanoid robot through simulation beforemaking the prototype. And on the basis of successful simulation, the actual prototype can be made.Therefore, the design of a humanoid robot in a simulation platform is necessary to enable the researchers tostudy the kinematics, dynamics and control method on the simulation platform, and then test at the prototype, to avoid damaging the prototype. At present, humanoid robot simulation is obtained through ADAMS or robot toolbox. However, bothtechniques are not applied universally due to the complex process of making the humanoid robot model.

This paper utilizes the use of Autocad desk inventor and MATLAB/Sim Mechanics as platform to design a humanoid robot.

Many researchers have designed humanoid on different CAD tool or platform: Tikhanoff *et al.* (2008)[6]proposed a new simulator for iCub humanoid robot, Giorgio *et al.* (2010) [3] proposed an iCub simulator to support collaborative research in cognitive development through autonomous exploration and social interaction, while Hirohisa (2015) [4]created a humanoid robot platform where some tasks can be performed by the robot. Tasks such as: maintenance of industrial plant, tele-operation of industrial vehicle, cooperative tasks with human, guarding of an office and care of patients in bed. Fumio (2002) [2]introduces an open HRP platform for humanoid simulation for both software and hardware. Oussama *et al.* (2008)[5] used Asimo platform to propose unified fashion of the whole body of humanoid robot to solve the problem of multi-point multi-link contacts, constraints and obstacles using extensive robot dynamic simulation conducted in SAI.Alberto *et al.* (2011) [1] developed an upgrade service for the design of the iCub humanoid robot to improve the mechanical and sensing performance. Most of the platforms are property of that country; like iCub simulator is used in France, HRP belongs to Japan, NAO and Asimo are both robotic humanoid simulators used in France and Japan. But Autodesk inventor has no owner; it is an open source simulator that can be used by any one from any country.

2. Humanoid Robot Model and Platform

The humanoid design is done using Autodesk Inventor CAD tool [7]. The robotic humanoid should be able to make same movements as a human. In other to let the robotic humanoid move like a human, the robotic humanoid should have the same degree of freedom (DOFs) like human. This robotic humanoid has 23-DOFs as shown in Table 1. The neck has two DOFs; there are two DOFs' at the shoulder, one at the elbow and three at the wrist. The effect of two DOFs at the wrist is negligible and can be adopted by the other two joints. Therefore, the wrist joint will only have one DOF which gives full control over the orientation of the gripper. The waist is assigned one DOF, two for the hips, one for the knee and one for the ankle.Therefore the designed robotic humanoid simulation in this research has 23-DOFs. Figure 1 shows the length of each link of the humanoid; all measurements are in mm. The degrees of freedom of each joint are shown in Table 1.
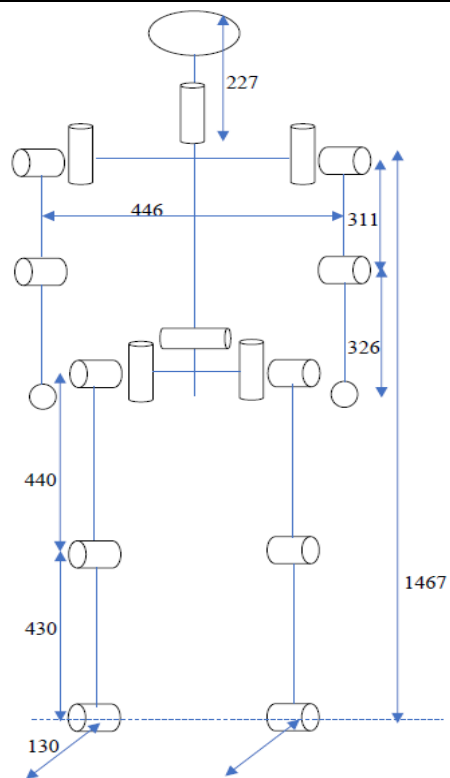
Table 1: Degrees of Freedom of Humanoid Robot

Chain	Joint	Degree of Freedom	Angle of Rotation
Head	Neck	2DOF × 1 = 2DOF	θ1 = −60 to + 60 θ2 = −30 to + 30
Arm	Shoulder	2DOF × 2 = 4DOF	θ1 = −45 to + 120 θ2 = +10 to + 90
	Elbow	1DOF × 2 = 2DOF	θ3 = 0 to + 135
Hand	Wrist	2DOF × 2 = 4DOF	θ4 = −45 to + 45 θ5 = −10 to + 45
	Finger	1DOF × 2 = 2DOF	θ6 = 0 to + 45 Linear motion
Trunk		1DOF × 1 = 1DOF	θ1 = +10 to + 60
Leg	Hip	2DOF × 2 = 4DOF	θ1 = −15 to + 90 θ2 = +10 to + 90
	Knee	1DOF × 2 = 2DOF	θ3 = 0 to + 135
	Ankle	1DOF × 2 = 2DOF	θ4 = −30 to + 20 Linear motion
Total		= 23DOF	

Figure 1: Measurements of the Humanoid Robot
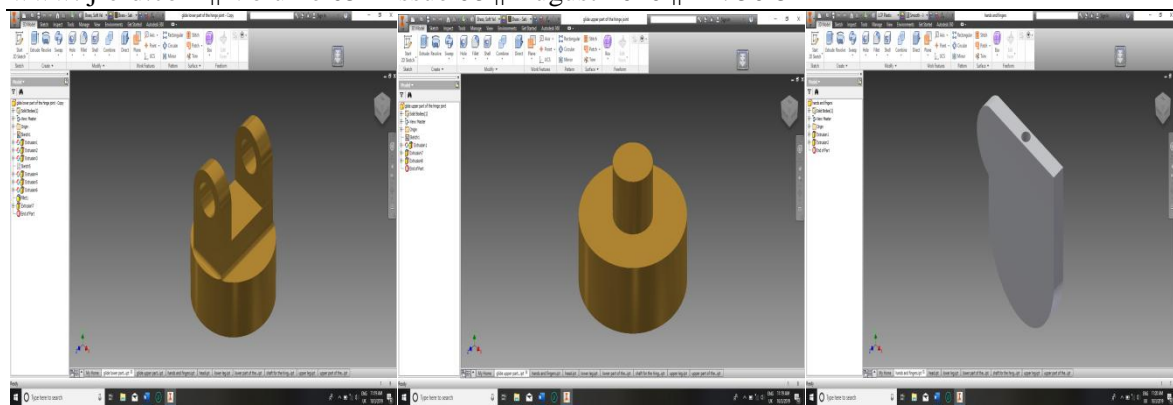
3.   Design of Robotic Humanoid Parts

The humanoid was designed in parts or modules using the measurements of figure 1. Figure 2 shows humanoid parts designed using Autodesk inventor before assembling of the parts.
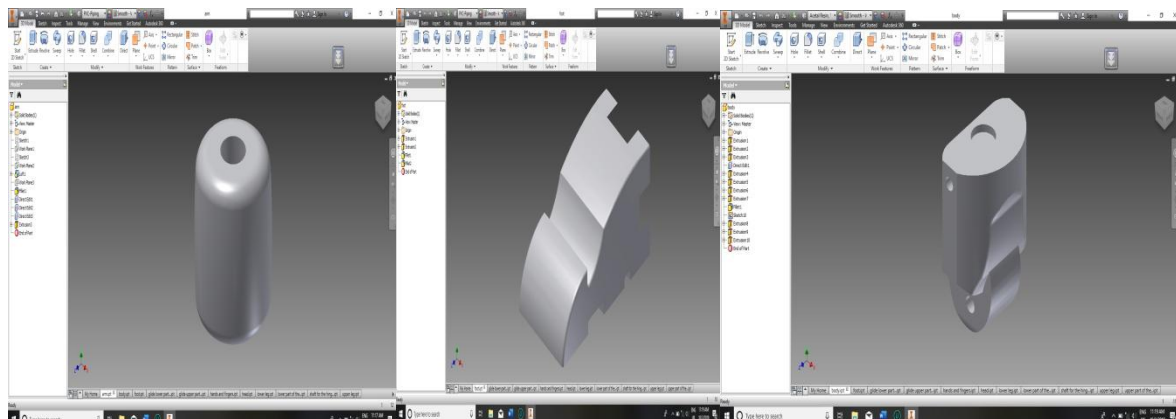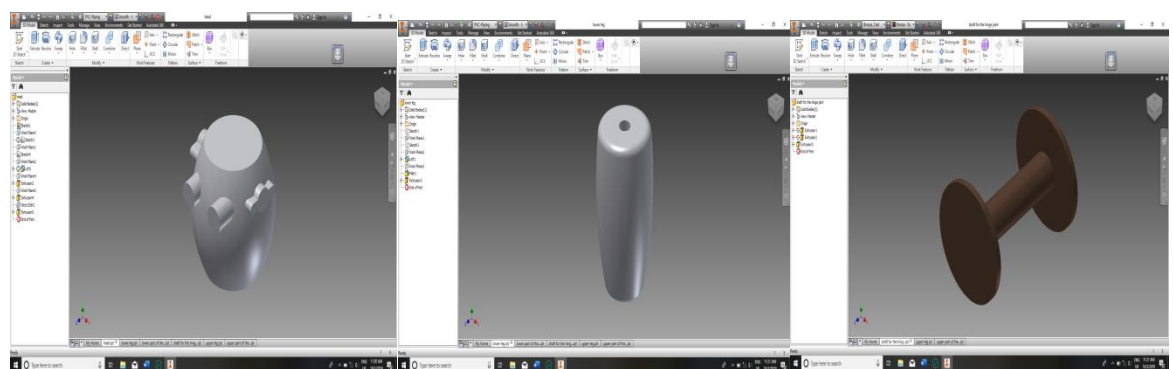
a. Humanoid Upper Arm   b.Humanoid Feet   c. Humanoid Torso
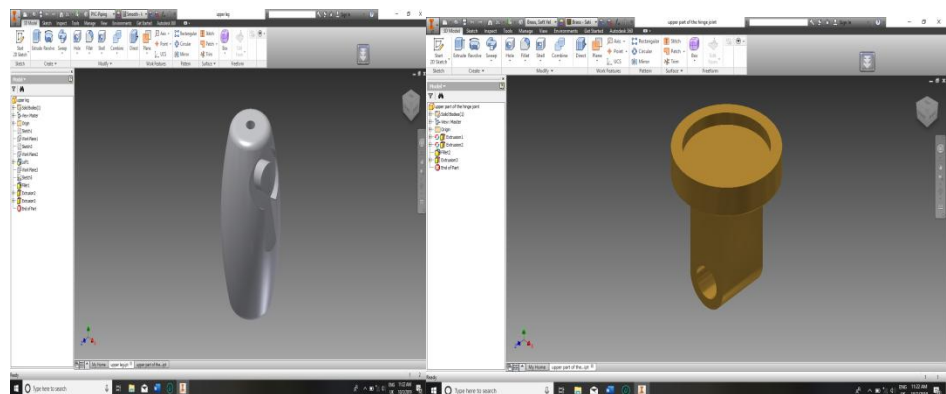
d. Humanoid Legs and Arms connector   e. Humanoid Hand connector   f. Humanoid Hand

g. Humanoid Head   h. Humanoid Limb   i. Humanoid Joint connector

j. Humanoid Lower Limb and Arm   k. Humanoid Neck

Figure 2: Body Parts of the Designed Humanoid in Autodesk Inventor

After the building of body parts of figure 2, figure 3 was obtained during assembly in Autodesk inventor.Using the constrain tool of the Autodeskinventor; the humanoid was assembled to have same degree of freedom as in Table 1.Figure 3 was simulated using the Autodesk inventor constraints. The humanoid was able to walk with the torso being static while the legs swing. Figure 4 shows the Sim Mechanic [8] model of the designedAutodesk inventor model converted to Simulink [8] model using simlink.r2016a.win64 add on [9] and figure 5shows the MATLAB display of the designed humanoid. A controller can be built in MATLAB [8]to simulate the designed humanoid.
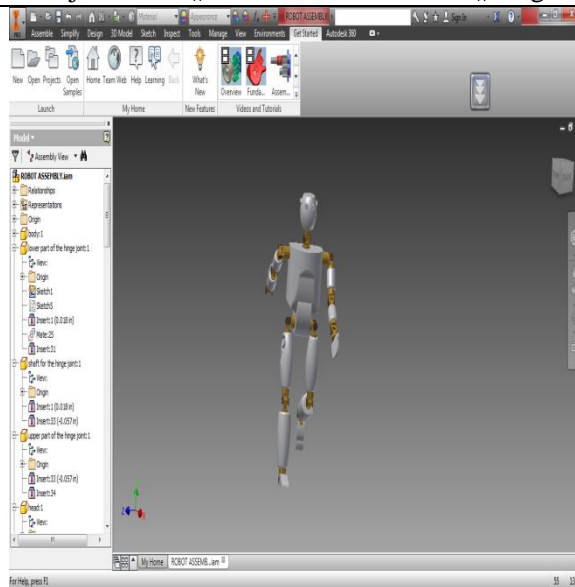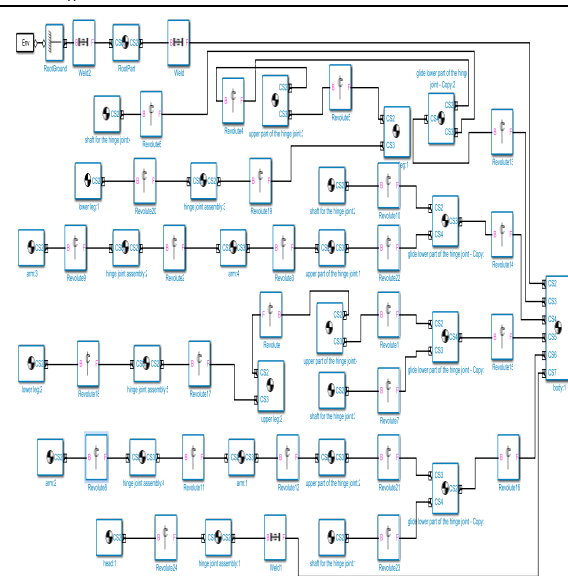
Figure 3: Humanoid Design using Autodesk Inventor

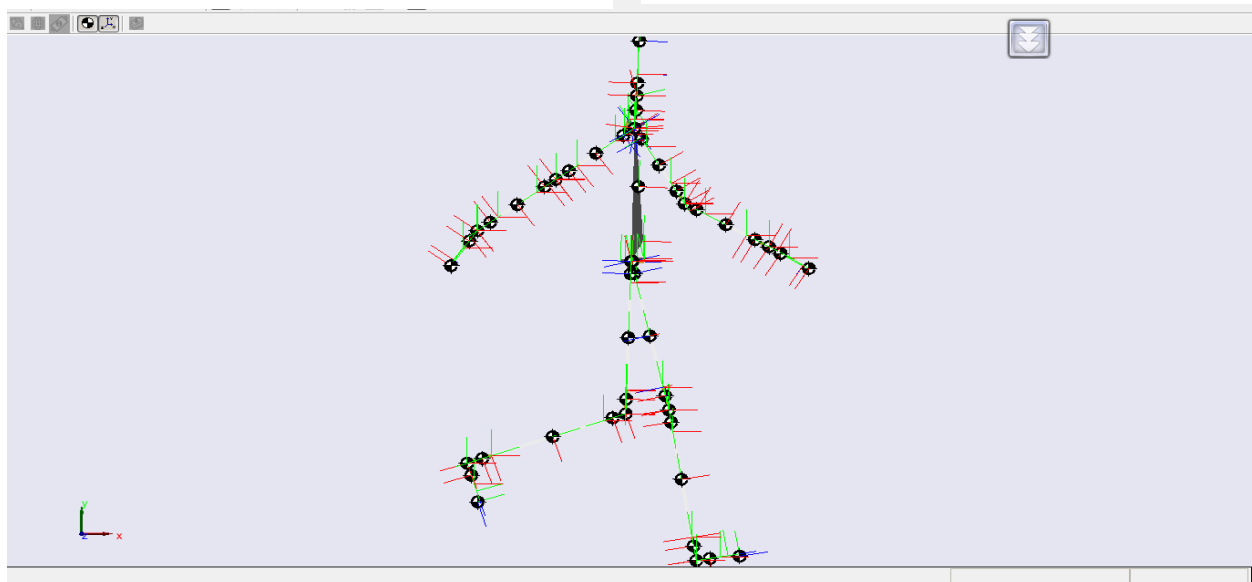Figure 4: Humanoid Design converted from Autodesk Inventor to Simulink

Figure 5: Autodesk Inventor Simulink model of the Humanoid Robot

4. Conclusion

There has been a significant research interest in the area of humanoid motion planning, control and applications and the use of any open source platform to achieve these goals. This research made use of Autodesk inventor to design a robotic humanoid and import the deigned humanoid into MATLAB/Simscape where controllers can be design and ran with the humanoid design. The design humanoid was simulated and it was running in MATLAB.

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