Modeling and Control of Poppy Humanoid Robot

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I. Introduction

The Poppy robot, shown in Fig. 1, is a humanoid robot. Humanoid robots are created for many reasons such as exploration, search and rescue missions, and educational and research purposes. In this project, only the right leg of the Poppy robot is simulated and implemented on hardware. After this, position control is applied to the right leg. In our project, the hip of the leg is fixed to a fixed base, and the foot is the end effector. This project aims to apply the concepts learned in Robotics course to hardware. The right leg is shown in Fig. 2 and Fig. 3.

Fig. 1. Poppy Humanoid Robot

In this report, we present the hardware design and the reasons behind the design decisions. A preliminary circuit design for controlling the robot motion is also presented in section II. In section III The Simscape simulation results are presented and discussed.

II. Hardware Design

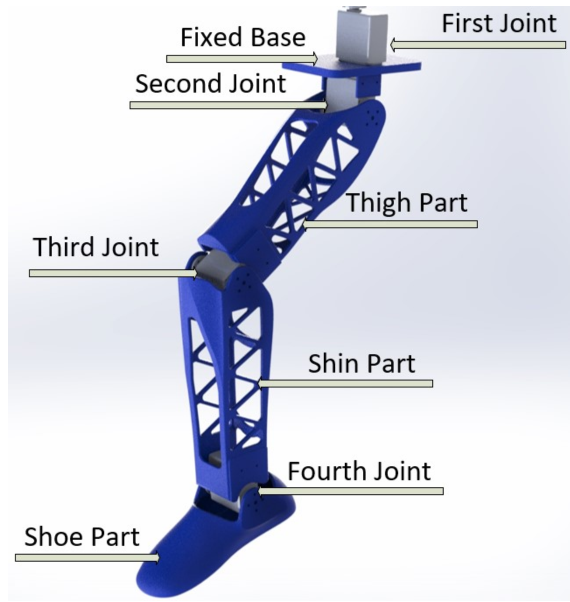

Fig. 2. Poppy Right Leg View 1

Fig. 3. Poppy Right Leg View 2

The assigned frames of Poppy's right leg are shown in Fig.4. The global and first frames are very close to each other so they are highlighted together.

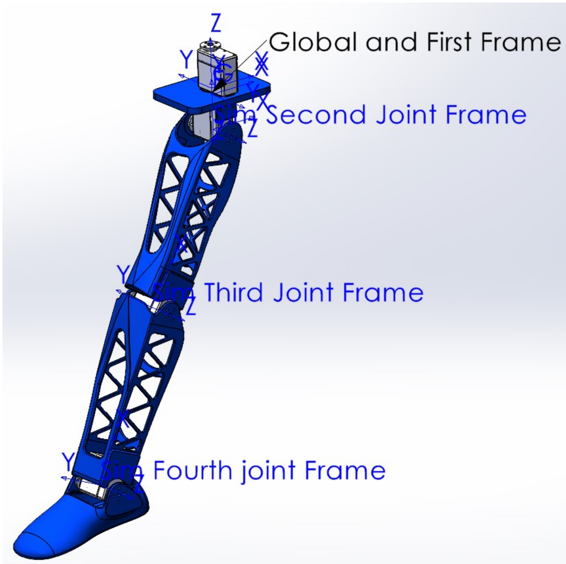

Fig. 4. Poppy Right Leg Frames

The motors of Poppy are dynamixel motors that are not available in the Egyptian market. So, the main changes in our design are based on the geometry of the newly used servo motors. The design of Poppy's leg has been modified by adjusting the motors housing including the bolts locations so that the new motors could fit properly in the design. The team has tried different ways to fit the new motors. However, scaling the parts by a factor was the smartest solution. The scaling feature in Solidworks software keeps the general shape of the whole part without changes. Scaling can be done either in all three axes or a single axis. Scaling was done only in the axis that the motor length doesn't fit as the uniform scaling increases the weight by a factor of 1.95. The simple foot part is scaled up by a factor of 1.25, the shin part is scaled up by a factor of 1.23 and the thigh part is scaled up by a factor of 1.11.

Fig. 5. The 3D Printed Shoe

A. Hardware Components

The right leg will be manufactured using 3D printing technology. Table I shows the components that will be used in the right leg along with their prices and their suppliers.

TABLE I
HARDWARE COMPONENTS AND PRICING

Component	Price	Supplier
PLA 1Kg Spool	400	A3D
3x RDS3120MG 180° 22kg Dual Ball Bearing Metal Gear Digital Servo	˜330x3	UGE
Servo Motor (10 kg.cm - Double Axis Metal Gear)	325	Future Electronics
SMPS Power supply 12V/15A	˜90	Amazon
4xDigital LED Voltmeter Display LM2596 DC to DC Buck Converter	˜80x4	Amazon
Arduino Uno R3	˜160	Amazon

B. Circuit Diagram

The circuit diagram showing the connections between the actuators, power supply, and the microcontroller is shown in Fig. 6. It was drawn using Fritzing.

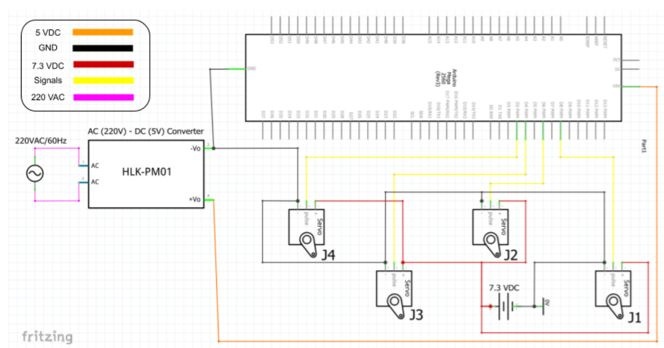

Fig. 6. Circuit design

III. SIMULATION RESULTS

The simulation is done on Simulink (Sim-Mechanics) by using the Simscape Multi-Body Link feature on Solidworks. Our part of the robot has four revolute joints. Three test cases were performed on the leg by plugging inputs coming from sin waves, sliders and signal builders to all the joints simultaneously. Figure 7 shows the simulation diagram of our system. One can find a combo box at the bottom of the diagram to select which input to give to the joints, sin waves, sliders or signal builders. In addition, there are four sliders above the combo box to change the angles that will be sent to the joints. There are two scope blocks to keep track of the angular positions and velocities of each joint. The mechanical limits of each joint has been considered in the simulation. The first joint has no limits while the other three have. The second joint is limited to move within the range between -90 degree and

90 degree. The third joint can move between 0 degree and 125 degree while the fourth joint can rotate from 55 degree to 135 degree. The rotation ranges have around 5 degrees of clearance for safety.

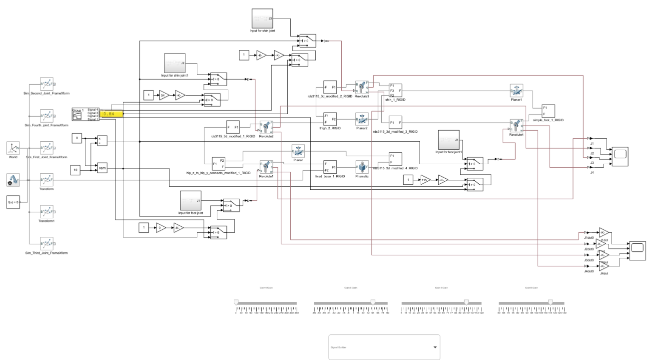

Fig. 7. The simulation diagram of the right leg on Simulink

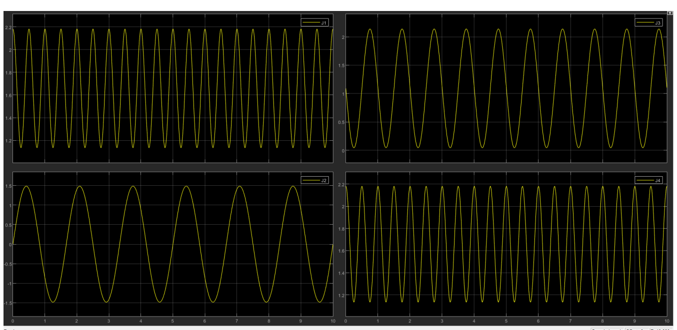

Fig. 8. Joint angles with a position sin wave input

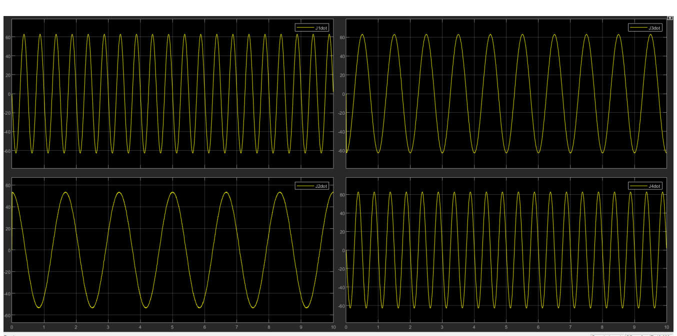

Fig. 9. Joint velocities with a position sin wave input

From figures 8 and 9, one can notice that the inputs have different frequencies. The values of the amplitude, frequency and shifting of each input considered the mechanical limits and the maximum speed of the motors which is around 80 rpm.

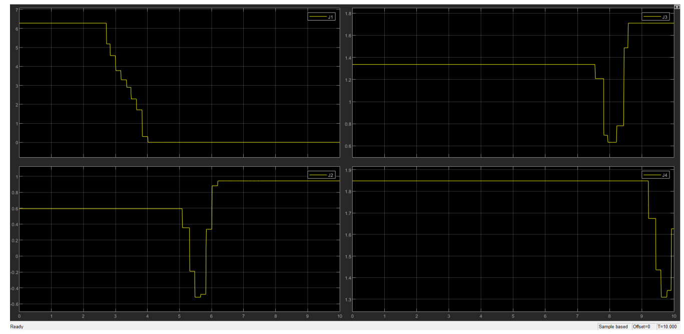

Fig. 10. Joint angles with slider input

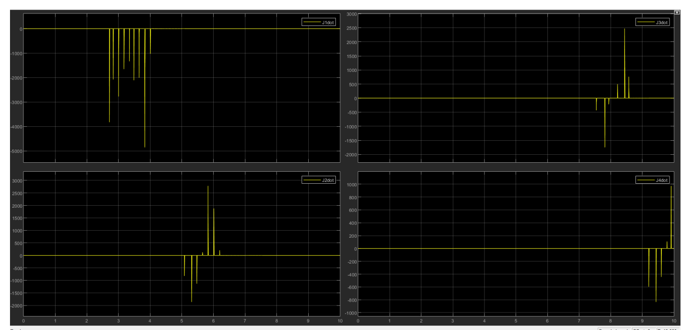

Fig. 11. Joint Velocities with slider input

In case of slider input, the mechanical limits were considered. However, one can see from figure 11 that the velocities of the joints have very high values because of the discontinuity resulting from the slider block in Simulink.

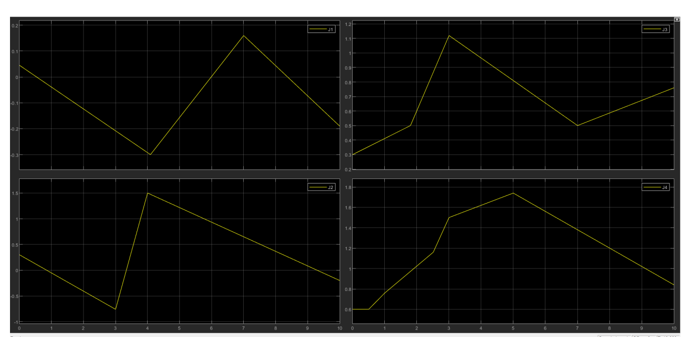

Fig. 12. Joint angles with a signal builder used as a position input

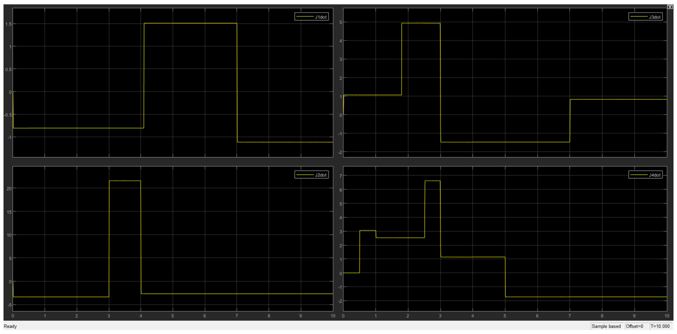

Fig. 13. Joint velocities with a signal builder used as a position input

Finally, signal builders were used considering the mechanical limits and top speed of the motor. One can notice from figure 13 that there were sudden changes of the velocities of the joints. This is because signal builders use straight lines to generate their signal which results in sudden changes of the slope of the straight lines forming the signal which will result in infinite acceleration, so this way cannot be used practically.