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**Objective:**
Make a cool robot using at least three sensors and the motors from the Lego Mindstorm kit.

**General Information:**
The robot that was designed had to meet the requirements specified in homework 0. Those requirements were that it had to walk on two legs, evade walls, sense a difference in light and create sound when it detects the specified light change. Initially, the design was that it could sense color and react to that change, but the kit provided did not have the color sensor which made it difficult to create a robot with that requirement. The design change that was done was to use the light sensor which we did have to mimic the color sensor. This was done by sensing the intensity of light.

**General Steps:**
1. Design a robot to suit the objective.
2. Build the robot.
3. Program the robot.
4. Test the robot.
5. Evaluate performance of the robot.
6. Alter the design if needed.

**Detailed Steps:**
A biped robot was designed in order to meet the objective. The robot was designed considering sensor placement and its center of mass. A sketch of the design idea is shown in Figure 1.

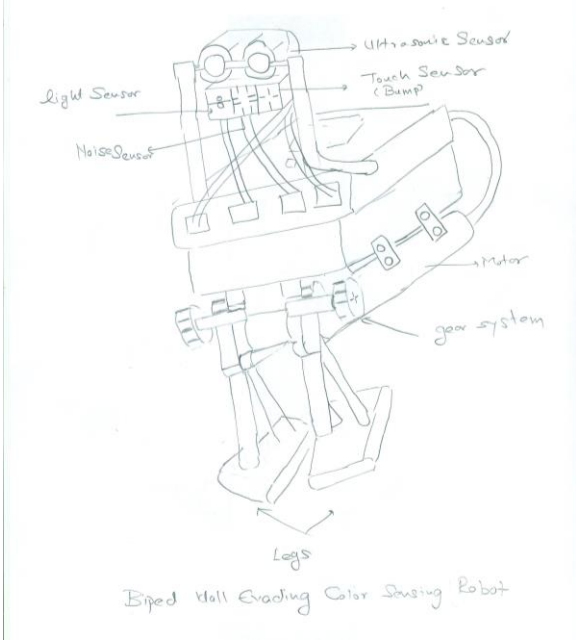


**Figure 1: Initial Design Sketch**

The robot was built using lego building blocks, one motor, a touch, light, sound, and ultrasonic sensors. This is shown in Figure 2.

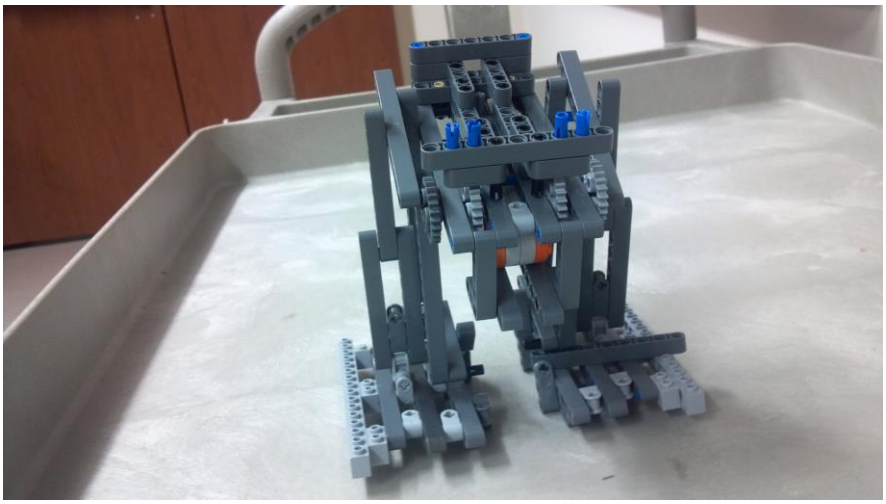

**Figure 2: First Built Robot Structure**

The robot was programmed according to the following algorithm.

**Algorithm:**

The procedure included designing a graphical program using LEGO Mindstorm NXT to meet the requirements. The program begins by pressing the touch sensor. On activation the robot moves in the forward direction. This motion continues until it approaches a wall within three inches. When the sensor detects the wall is less than or equal to 3 inches away, the output signal from the ultrasonic sensor tells the controller to move the robot in the backward direction. This backward motion continues till it detects a difference in light intensities. When it detects a bright intensity the robot calls out 'white' and waits till a darker intensity is detected. On detection of a darker intensity the robot calls out 'black'. After this detection it waits till it detects a brighter intensity once again. On this detection the robot calls out 'white' and it starts moving in the forward direction. Furthermore, when it hears a clap the robot stops motion and resumes motion on another clap. For this purpose the sound sensor was configured to detect intensities greater than 60 dB. On resuming motion, the robot continues to move in the forward direction and continues the sequential steps inside the loop which begins by moving the robot in the forward direction. Relevant delays are added in between various function blocks to enable smooth operation of the robot. These steps can be well illustrated by the program snapshot shown in Figure 3 below.

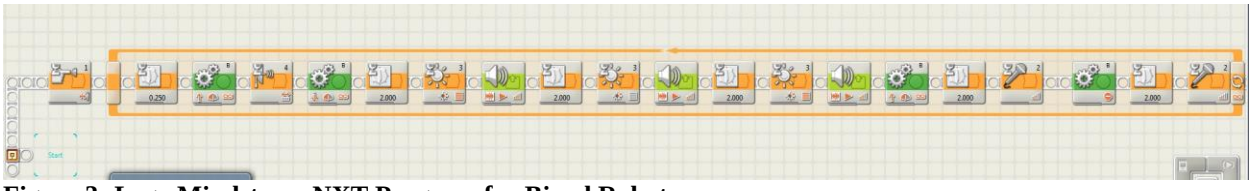

**Figure 3: Lego Mindstorm NXT Program for Biped Robot**

The robot was tested in order to evaluate if it meets the requirements. It was determined that the initial robot that was built would not function as desired. The structure designed for the legs would not support the load of the entire system. Although this design would not bear the load, the other design requirements were met; hence a need to reform the design.

**Revision:**
A new design was implemented with better load capacity and better distribution of the weight on the legs. The placement of the sensors was changed in order to counteract the weight of the controller. The size of the robot was also reduced in order to lower the center of gravity. The new design is shown in Figure 4.

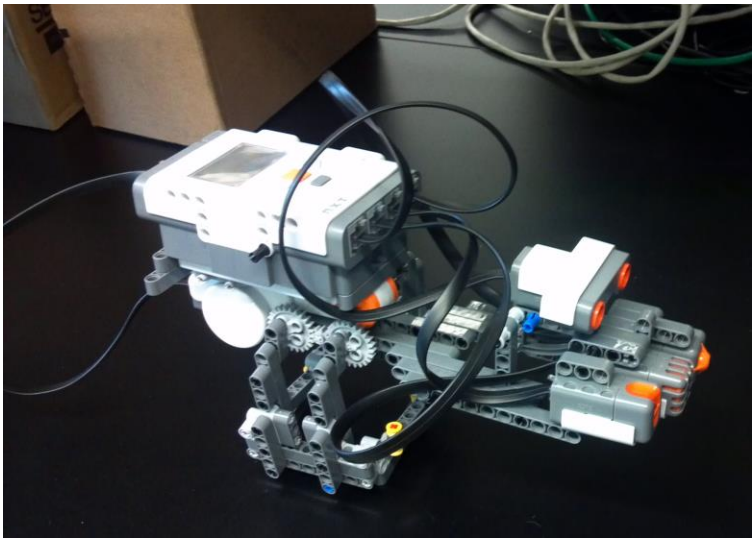

**Figure 4: Second Built Robot Structure**

Figure 5 shows a front view of the robot showing all of the sensors used.

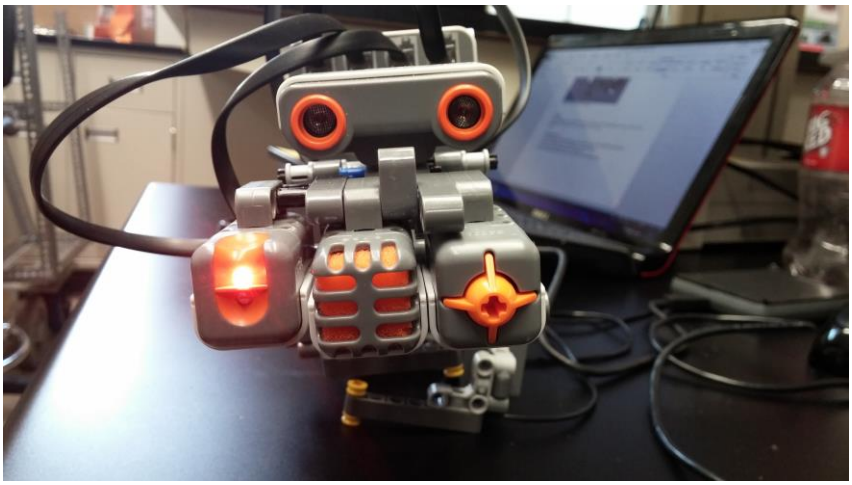

**Figure 5: Second Robot Sensors**

Figure 6 shows the gear arrangements for the robot.

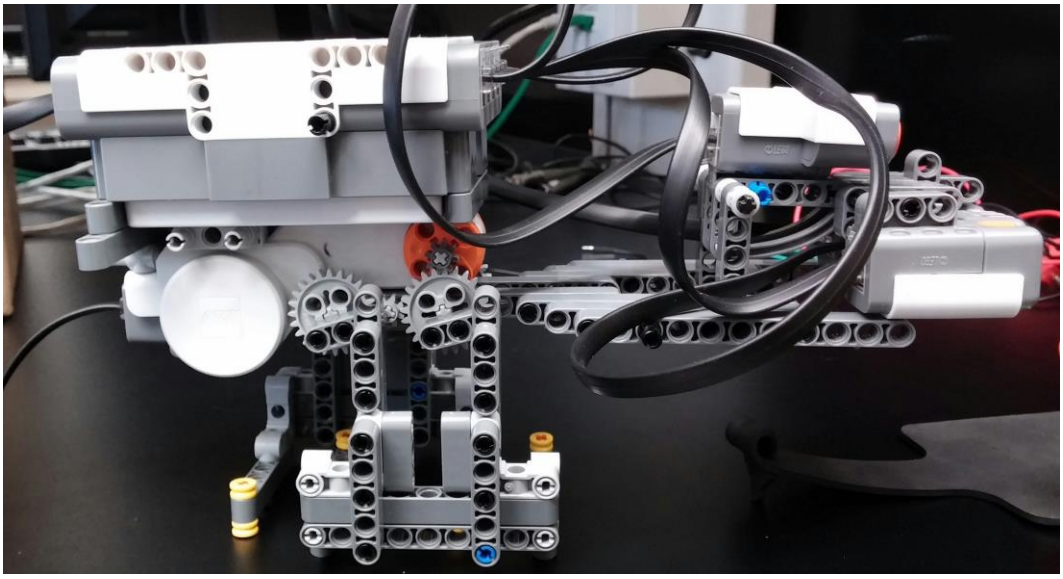

**Figure 6: Gear and Leg Assembly for the Robot**

**Results:**
The new design was tested to meet the requirements & it did satisfy all of them. This can be illustrated by a demonstration video uploaded on YouTube.
Link: https://www.youtube.com/watch?v=VnZFHjIgS6Q&feature=youtu.be

**Learned concepts:**
1. Hands building & graphical programming experience with LEGO MINDSTROM NXT 1.
2. Interfacing various sensors & controlling event based outcomes.
3. Gear placement, design & function for a biped robot.
4. Role of weight distribution & center of gravity for a biped robot system.

**References:**
http://robotics.benedettelli.com/
https://www.youtube.com/watch?v=CAHYjNOBs8k