Four Wheeler Robot Construction using 3D Printing Technology

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Abstract—3D printing technology have been developing rapidly in the last 30 years, and indicate great potential for future development. It has already traversed through many disciplines such as medical science, architecture and even robotics. Integration of 3D printing into robotics is relatively new considering the recent popularity of 3D printing. This paper briefly discusses the construction steps of a four wheeler robot which is controlled wirelessly using smartphones.

Keywords-*3D printing; android controlled robot*

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I. INTRODUCTION

3D printing is a form of “additive” manufacturing in which a three-dimensional solid object is ‘printed’ (built) by adding layer after layer of a particular material. In terms of manufacturing technology, 3D printing is an additive manufacturing process during which the mass change of the part is positive ($\Delta M > 0$). In cases where $\Delta M = 0$ and $\Delta M < 0$ the processes are called equivalent manufacturing and subtractive manufacturing, respectively. [1] Although this manufacturing process has been existent for more than 30 years now, it became widespread and gained popularity of recent due to expiration of patents.

There are several stages of printing an object using a 3D printer. The first stage involves creating a digital model of the object we intend to print. This can be done by using Computer Aided Design (CAD) software. In CAD systems we can model any object using the tools provided there, they can be existing objects of the real world or non-existent objects. We can also create models of real-world existing objects using 3D scanners.

In the second stage we use ‘slicer’ software to process the model into printable layers. This sliced model is finally fed into the 3D printer which actually prints the object, making this the last stage of printing. Printing involves a different printer software which controls the axis movements of the printer. There are many software packages that does both slicing and printing on the same software package making it user friendly by minimizing details.

3D printing technology can be divided into four non-proprietary methods-Stereolithography (SLA), Selective Laser Sintering (SLS), Fused Deposition Modeling (FDM), and Direct Laser Deposition (DLD)-and four other proprietary methods-three Dimensional Printing (3DP), Polyjet Matrix Printing, Electronic Beam Melting (EBM), and Laminated Object Manufacturing (LOM). [2,3] Fused Deposition Modeling technique is used in this work.

In FDM method, the print material, usually a thermo- or duro-plastic, is heated and extruded through a small nozzle which moves along the X, Y and Z axes. The material is deposited in layers on the print bed. [4] As one layer cools it provides the base for the subsequent layer and this process continues until the printing of the whole object is complete. The material that we used in this work is ABS (Acrylonitrile Butadiene Styrene).

II. DESIGN

The design process of this robot is sub-divided into three stages. In the first stage we design the chassis (frame) of the robot. Second stage design involves the internal circuitry design and consequently the third stage design is the app design which will control the robot. The stages are discussed as follows.

A. Chassis

There are a number of commercial and open-source CAD systems available for 3D modeling. In this work we have used the Autodesk 123D Design due to its abundant availability of functions and very easy usability. [5] The chassis consists of the front and back wheels, the base and the top cover.

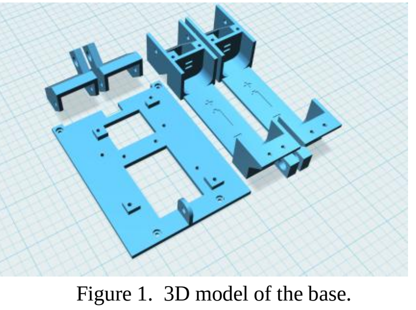

Figure 1. 3D model of the base.

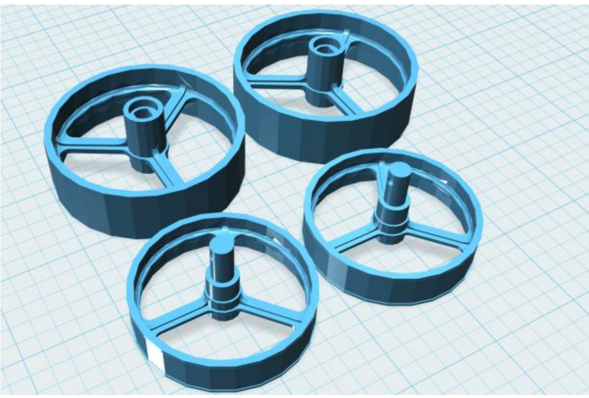

Figure 2. 3D model of the wheels

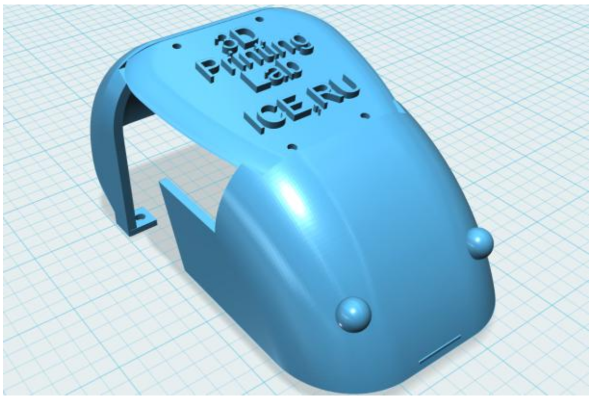

Figure 3. 3D Model of the top cover.

B. Electronic Components

Regarding the internal circuitry design, we used modular components rather than one custom PCB. The reason behind this is that this robot is still in a prototype phase and we intend to improve its features. We used the Arduino Uno as the central microcontroller loaded with the movement algorithm. Along with that we used a L293D IC for controlling the DC motors of the wheels. Another HC-05 Bluetooth module is used to interface with the controlling smartphone. The schematic diagram is as follows.

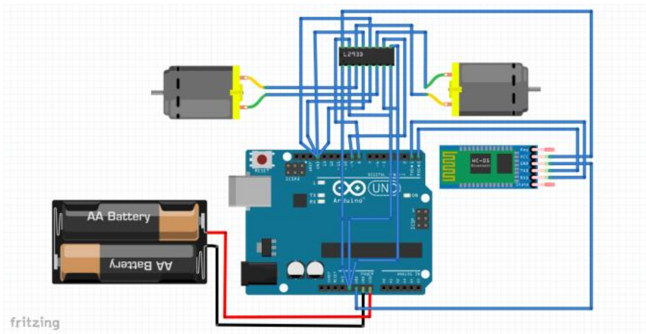

Figure 4. Schematic diagram of internal circuits.

C. Android App

To control the app remotely we designed an Android App using the Android Studio IDE. The UI of the app is very simple consisting of five control buttons. There's an additional selection button which takes the user to another activity for selecting the proper Bluetooth device to connect to. A graphical illustration is provided in Figure. 5.

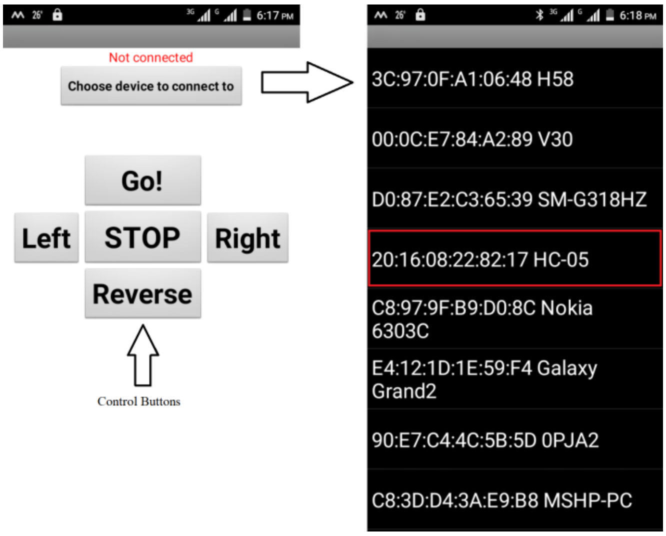

Figure 5. The UI of the android app.

III. PRINTING

We used UP Mini 3D Printer [6,7] for printing the chassis. The printer can be configured to use either PLA or ABS as the printing material. In this work we used ABS. The machine specifications are given below.

Print Technology: Fused Deposition Modeling (FDM)
Dimensions: 245 x 260 x 350 mm (W x D x H)
Weight: 5kg
Build Volume: 120 x 120 x 120 mm (W x D x H)
Layer Resolution: 0.25mm
Filament: ABS Plastic
Filament Color: White
Filament Diameter: 1.75mm
Nozzle Diameter: 0.4mm
Software: UP! V2.13
File Types: STL
Supports: Windows (XP, Vista, 7, 8, 10) 32/64 bit, MAC OSX 10.7 Beta

The consumed amount of print materials and the time required are provided in Table 1.

Part Name	Material Consumed (grams)	Time Required (Hours : Minutes)
Base	50.50	3:58
Wheels	36.40	2:55
Top Cover	58.60	4:09
Total	**145.50**	**11:02**

The images of the printed parts are provided in the figures 6 to 8.

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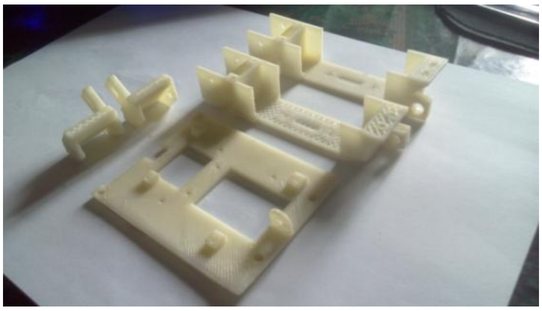

Figure 6. The base of the chassis.

Figure 7. The wheels of the robot.

Figure 8. The top cover of the robot.

IV. ASSEMBLY

We assembled the parts of the chassis together using screws and plastic ribbons and later installed the electronic parts into the chassis. The step by step assembly process are depicted in figures 9 to 13.

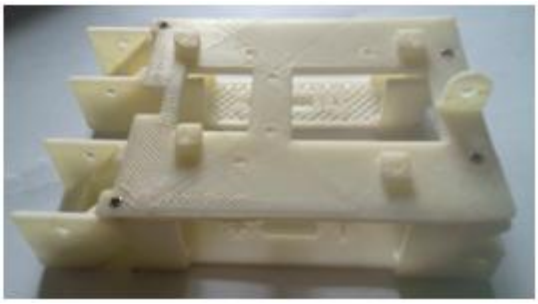

Figure 9. Assembling the base.

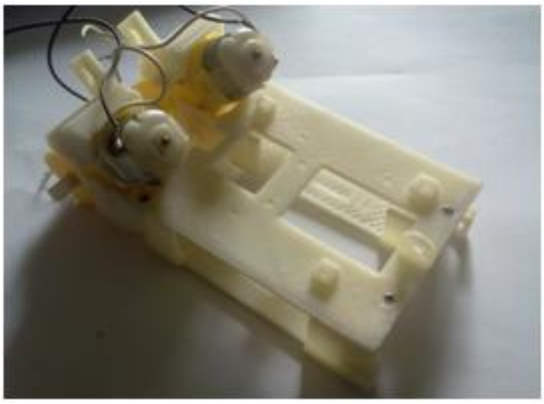

Figure 10. DC motor installation with the base.

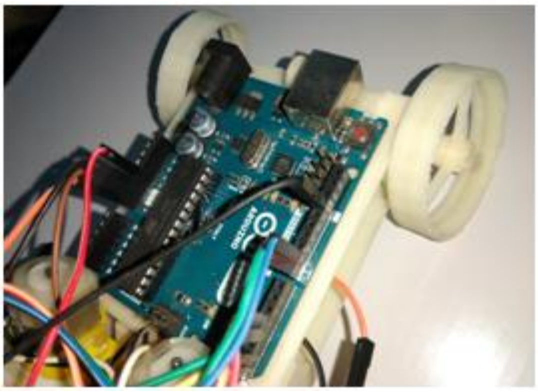

Figure 11. Installation of the Arduino and front wheels.

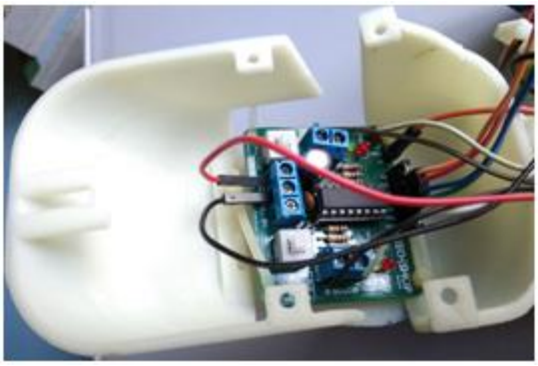

Figure 12. Placement of the motor driver under the top cover.

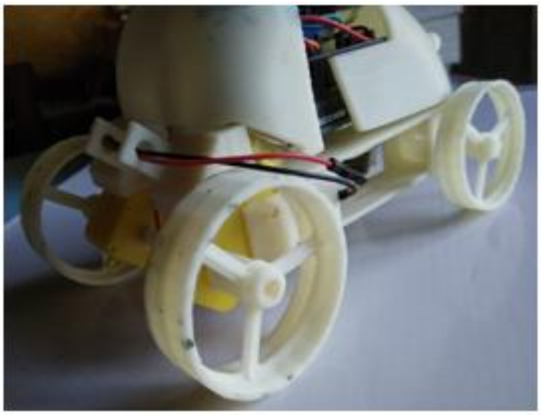

Figure 13. Placement of the back wheels.

V. TROUBLESHOOTING

Due to the print material of the robot being ABS Plastic, the robot could not gain sufficient friction needed in order to move around in smooth surfaces. So to provide the required friction we used cut pieces of thin rubber and attached them to the back wheels. Figures 14 and 15 show the adjustment to the robot and the final version of the robot respectively.

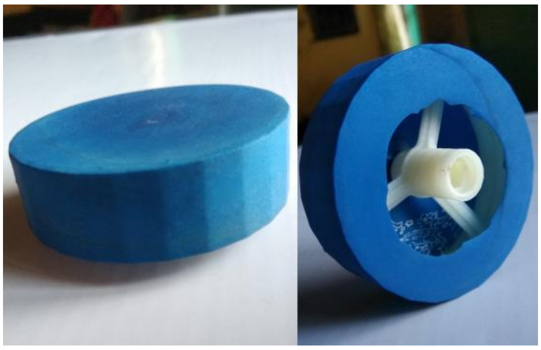

Figure 14. Attaching thin rubber on the back wheels

Figure 15. The four wheeler robot

VI. RESULTS AND DISCUSSION

We used two 3.7V 3260mAh Li-ion batteries in serial to provide power to the Arduino and the motor drivers. The batteries and the Bluetooth module are placed beneath the chassis. We test drove the robot and it can be operated within a 15 meter radius from the controlling smartphone for a continuous 45 minutes.

Most of the components were bought from the local market and some of them were bought from online stores. The total cost of the robot was around 27USD including the price of the printing materials. The amount is higher than expected, the reason being that we used a modular approach to our construction. We used separate modules for each and every electronic part of the robot. If we reduce the modules to one single PCB we can reduce the cost to 19USD.

In both cases the cost of the body (frame) itself is 7USD which is again high considering that ABS is relatively cheap. But 3D printing is still a very recent technology in our country hence we don’t have any local market making exporting from outside our only option. Considering the international market price of ABS filaments, the cost of the frame would be reduced to 4USD. Thus making the total cost of the car around 16USD.

With slight modifications we can use this robot as a surveying machine in hazardous situations. Its manufacturing cost is low and does not require any special remote controller, can be operated via smartphones which makes it suitable and provides easy usability for such situations.

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