Design and Development of Unmanned Chemical Spraying Rover for Agriculture Application

M. Karthik, Nikhil Singh, Eshan Sinha, Bharani S. Anand, Gowreesh S. S.

Abstract*: There is an increase in usage of Unmanned Ground Vehicle (UGV) in the field of agriculture, specifically for the purpose of spraying fertilizers and pesticides. However despite existing technologies, no such platform has been created so far which aims to provide rover chemical spraying that can be used in a high risk areas at a low cost for extended periods of time. The principal objective of the present work is to Design and Develop a Unmanned Chemical Spraying Rover, to be able to overcome any kind of obstacle on the agricultural field, and a simple yet indigenous low cost mechanism for precise spraying agricultural enhancers such as fertilizers, pesticides, and insecticides. These primary objectives must be realized in a platform costing lower than similar alternatives in the market. The user can achieve controllable motion and variable flow of the enhancer by a suitable tethered, ground based remote control interface. Objective of the present work also aims to develop a multi-purpose rover machine, which can be used in tortuous terrain, crops and plantations of diverged heights. The Rover is maneuvered with the help of six geared motors each attached to one wheel. The rover's movement will be controlled using Bluetooth remote control, where the transmitter will be a smart phone.

***Keywords*: Bluetooth Controlled Rover, Fertilizer Spraying Rover, Geared and Servo Motor, Mini-Hydraulic Pump, Rocker Bogie Mechanism, Solid works.**

I. INTRODUCTION

Pesticides have numerous advantageous effects. These include protection of crops, preservation of agricultural commodities, wood products and vector-borne diseases. Unmanned Chemical Spraying Rover is designed such a way that it can carry 1.5 litres of pesticides in a closed chamber. With the help of mini-pump pesticides are sprayed precisely from the nozzle at the target. This will reduce the amount of pesticides required to control the harmful effect of pests. Unmanned Chemical Spraying Rover will automate slow, repetitive and dull tasks for farmers, allowing them to focus more on improving overall production yields.

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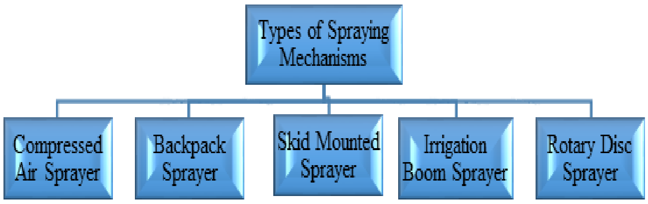

Fig 1. Types of Spraying Mechanisms used in Agriculture

Fig 2. Unmanned Chemical Spraying Rover

The literature study carried out shows that there is an increase in usage of Unmanned Ground Vehicle in the field of agriculture, specifically for the purpose of spraying fertilizers and pesticides. However, no such platform has been created so far which aims to provide rover chemical spraying and can be used in a high risk areas at a low cost for extended periods of time, despite existing technologies.[4]

II. OBJECTIVES

Since the rover available in the market currently are limited by their high initial cost, an alternative low cost means for agriculture application is necessary [2].
With the view of the above scenario, the current work focuses on the design and development of a rover spraying platform powered by six motorized wheels[5]. Remote operation of the rover platform is achieved by the user through a suitable interface. Hence, our specific objectives are as follows:

- To achieve all terrain controllable vehicle for agriculture purposes.
- To develop a chemical spraying platform powered by mini- pump.
- To develop a cost effective rover in the market.

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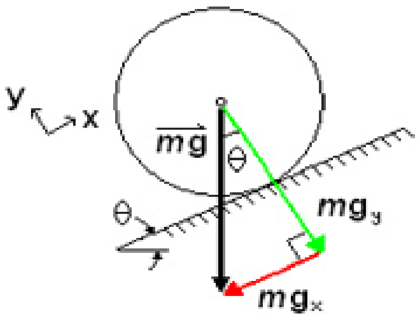
III. METHODOLOGY

A. Motor Calculation



$$mg_x = mg*\sin(\theta)$$
$$mg_y = mg*\cos(\theta)$$

Balancing the forces in the x-directions

$\sum F_x = ma = f - mg_x$

Inserting the torque equation in above Eq.

$ma = (T \div R) - (mg*\sin(\theta))$

$T = m*(a + g*\sin(\theta))*R$ … (Eq. 1)

Considering 45° inclination

Using Eq. 1 we have

$T = m*(a + g*\sin(\theta))*R$

$T = 3*(0.5+9.81*\sin(45°))*0.05$

$T = 1.1155$ Nm

Power, Current And Battery Backup Calculations

Power, $P = 2\pi NT \div 60$

$N = 30$ RPM (N = Speed of motor)

$\therefore$ $P = (2\pi*30*1.1155) \div 60$

$P = 3.50445$ Watts

Current, $I = P \div V$ ($P = V*I$)

$I = 3.50445 \div 12$ (Assuming V=12*V*)

$I = 0.29204$ A

Battery Backup,

Ampere Hour is specified by the builder,

i.e. R=2.5 Ah

$I_A = P_A \div V$ (P_A is actual power of the battery)

T_A = 24KgCm (Specified by the builder)

$T_A = 2.3544$ Nm

$P_A = (2\pi*30*2.3544) \div 60$

$P_A = 7.39656$ Watts

$I_A = 7.39656 \div 12$

$I_A = 0.61638$ A

Battery Backup, Time = $R \div I_A$

Time = $2.5 \div 0.61638$

Time = 4.056 Hrs

B. Calculation Summary

Table 1. Calculation Table

S. No	Angle of Inclination	Torque T (Nm)	Power P Watts (W)	Current I (A)
1	10°	0.3305	1.03823	0.08652
2	30°	0.8108	2.5472	0.21227
3	45°	1.1155	3.50445	0.29204
4	60°	1.3494	4.23926	0.35327
5	90°	1.5465	4.85847	0.40487

C. CAD Modeling and System Overview

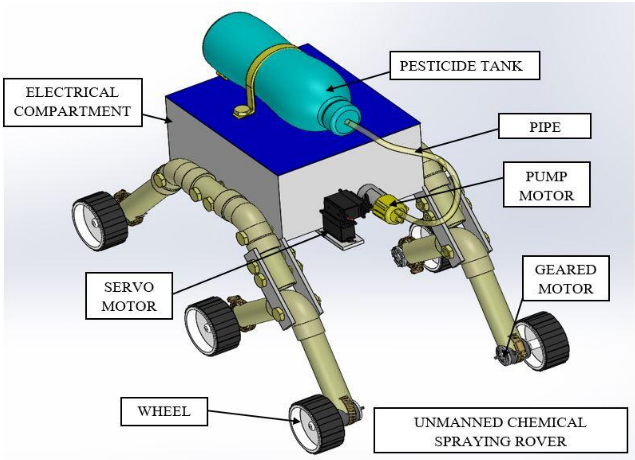


Fig 3. Isometric View of the Rover

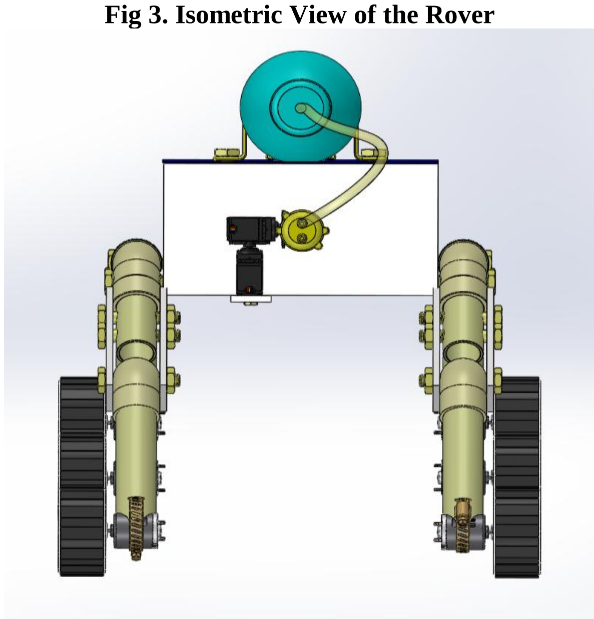


Fig 4. Front View of the Rover

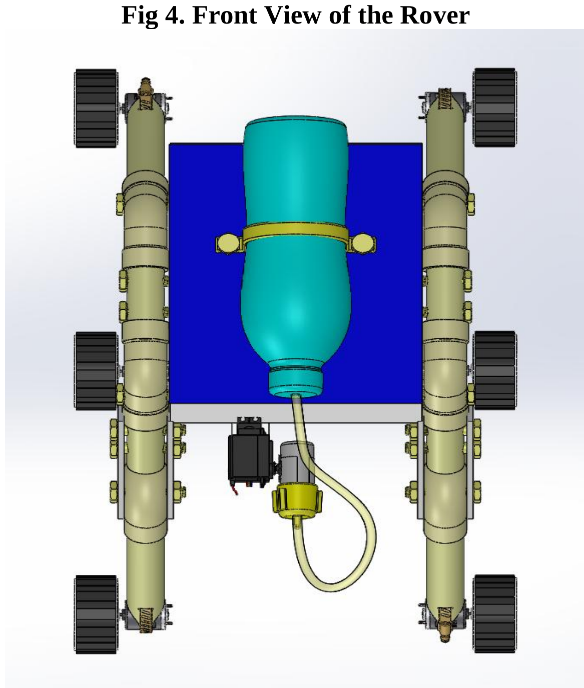


Fig 5. Top View of the Rover

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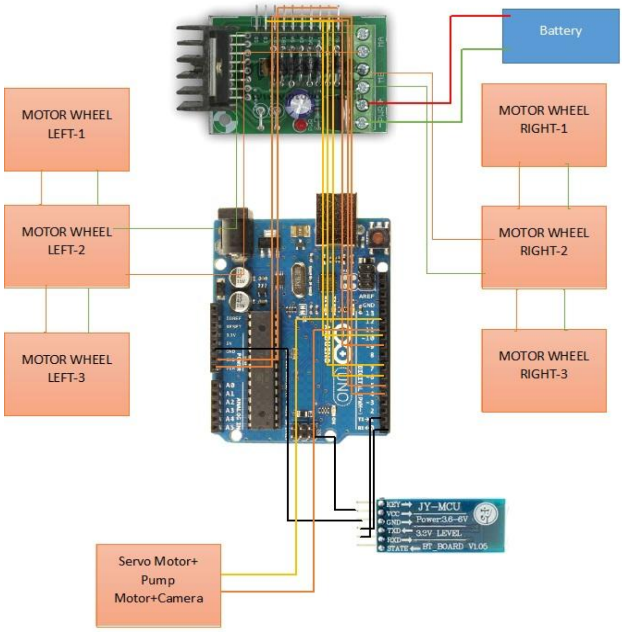

Fig 6. System Overview

From the proposed system overview given in Fig. 5, we can see that the Rover is controlled by a Smartphone running on an Android application. The Rover's control unit is developed using Arduino microcontroller. The Rover's control unit is equipped with two L298N motor driver, a camera, a Bluetooth receiver, two servo motor(for controlling the direction of spraying), one pump motor(to spray the pesticide),two 12V dry cell batteries and six 12V 30RPM DC motors. One of the L298N motor diver commands the movement and direction of the rover while the other motor driver controls the spraying of pesticide, while the Arduino solves the data collected large distance from the Bluetooth module send by the android phone application. The Android operating system has an application which makes use of the mobile's inbuilt orientation sensor to control the movement in four directions (forward, backward, left and right) as instructed by the user; the rotation of the rover in left of right direction is achieved by a mechanism known as "Steer By Drift Method", hence rotating the mobile phone in any particular directions results into the corresponding propulsion of the unmanned rover and there is also an option for only direction control by arrows on the android application. The directional control commands are communicated to the unmanned rover through the Bluetooth communication via Bluetooth module.

D. CAD Modeling and System Overview

Arduino is nothing but a board based on microcontroller, which gets its source of power from the assistance of a battery or a DC adapter. Arduino has been developed as an environment which is open sourced, which gives opportunity to beginners and also a platform to establish their electronics and coding skills as there are a lot of both online and offline content for Arduino in terms of supports like add-on kit, the project codes, forums and tutorials. Different versions of Arduino boards are accessible and larger boards can give more memory and also with various other controller and which will come with significantly higher amounts of inputs and outputs. The Arduino, whose architecture is built on the AT mega 328 platform and can have energy source either from the USB or its independent DC port. There are diverse characteristics of this board are:

1. Digital I/O pins: These are numbers 0-13 on the Arduino board and is used to take input and output based on the software flashed and returns a 0 or 1 that is low or high signals
2. Analog Input signal: These are numbered (A0- to A5) and are used to scan for analog signals from the sensors.
3. AT mega 328: Arduino are built on the ATMEL's AT mega 328microcontroller. Which is a8bit microcontroller and has the following set of characters:

- Flash memory of 32 kb ISP (Instructions per Second) with read-while-write capabilities.
- EEPROM of 1024 Byte and 32 Pin count.
- Number of General use I/O lines- 23.
- Number of Ext. and Int. Interrupts- 24.
- USART Serial Interface Device.
- 1.8-5.5Vof Operation Range.

E. Application

1. The android application that is used for controlling this Robot is "Bluetooth RC" and is available on Google play Store.
2. The application is connected to hc-05 Bluetooth module in the car and controlled either by the directional keys or by the gyroscope of the mobile.

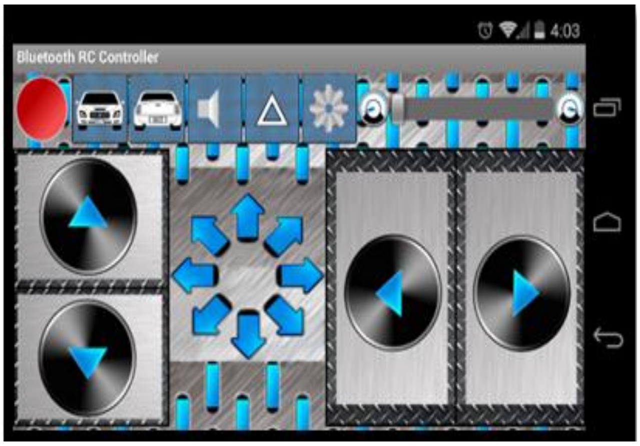

Fig 7. Application in Directional Keys

Fig 8. Application using Gyroscope of Mobile

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IV. PROTOTYPE RESULTS

A scaled down prototype of the final model is achieved. The pesticide spraying mechanism in agriculture field as been tested.

Fig 9a. Actual Picture of Rover (Isometric View)

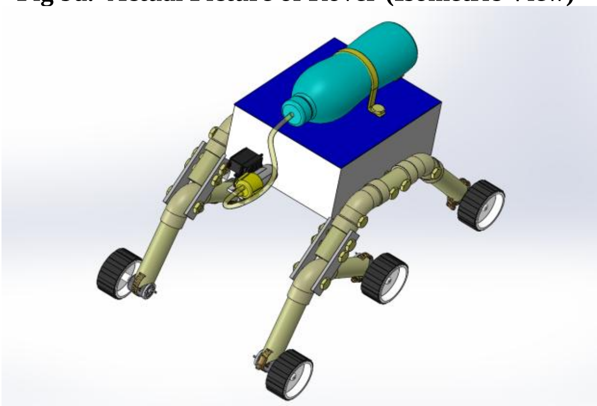

Fig 9b. CAD Model of Rover (Isometric View)

Fig 9c. Actual Picture of Rover (Side View)

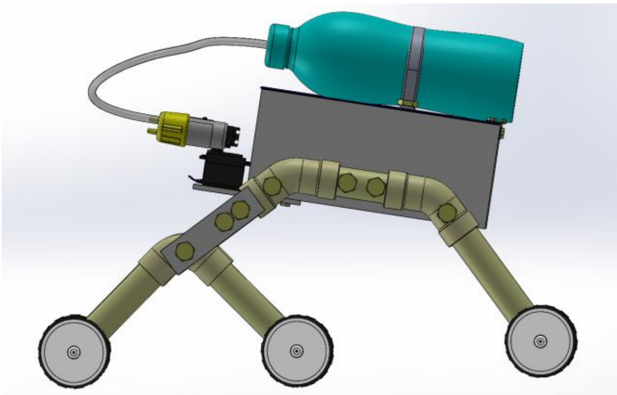

Fig 9d. CAD Model of Rover (Side View)

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