DESIGN AND FABRICATION OF COMPUTER CONTROLLED FOUR-WHEELED MOBILE PLATFORM

Gagan Saket, S. K. Dwivedy*, D. Chakraborty
Department of Mechanical Engineering,
Indian Institute of Technology, Guwhati-781039, India

ABSTRACT

Present work deals with design and fabrication of a mobile platform. The platform is mounted on four wheels. Two of these wheels are active which are independently driven by two stepper motors and steered by another stepper motor of higher torque capacity. Other two passive wheels are in the form of castor wheels and capable of turning through 360 degrees. This arrangement provides high mobility so that the robot can move in any direction without changing the orientation of the platform. Interface software connecting the platform to a computer through a parallel port has been developed. The high flexibility in maneuvering makes it highly applicable in important areas such as remote navigation, military applications.

INTRODUCTION

Extensive research has been carried out to develop mobile robots due to its wide applications in various important fields of applications. There are two basic types of mobile robots available viz. wheeled and legged. The wheeled mobile robot is more energy efficient, more continuous and smooth in movement and easy to control as compared to legged robots.

The simplest concept for wheeled mobile systems is a three-wheeled bogie where three points determine a plane making it possible to be placed on any surface. The advantages of a three-wheeled drive, combined with greater stability can be found in the Stanford Research Institute Robot Vehicle (SRIRV) [1]. Four-wheeled mobile robot, has found more popularity because of its extra stability. All wheeled vehicles require an even or close to even terrains to ply on. Wheels are not usually adequate for moving across uneven terrain. The well-known solution for such problem is Tank like drive. [1]. Gweon and Kem [2] designed and fabricated a hybrid wheeled mobile robot for a hostile environment. The robot has six-legged cylindrical configuration with each leg having a wheel at the bottom and the robot could move up the stair case, overcome obstacles, move along curvilinear path and rotate around its geometric center. Muller et al. [3] designed and fabricated a hydraulically driven autonomous combined legged and wheeled vehicle. The essential feature of this walking mechanism is the spatial leg mechanism with anthromorphic properties. This is realized using a spherical joint with three degrees at the hip, a revolute joint at the knee, and a pivotally suspended foot. Yamamoto and Yun [4] developed a control algorithm for the mobile platform. Seraji [5, 6] developed a simple on line coordinate control of mobile robot.

Literature review reveals that even though some works are available in the direction of design and fabrication of mobile robot, but this still remains an important area of research. Therefore, the present work aims at design and fabrication of a mobile robot having high maneuverability and fully computer controlled. The robot can change its direction without changing the orientation (i.e., the platform can move forward, backward, right, left, diagonally and can also rotate about the center of the platform) of the platform as shown in Figure1. In the following sections the design and the control of the platform has been discussed.

* Author for correspondence

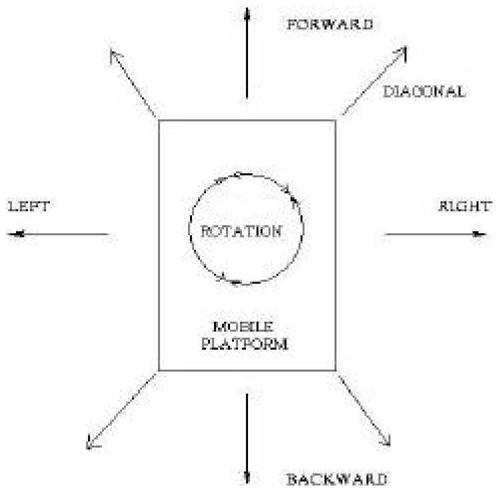

Figure1. Platform Motion

DESIGN OF THE PLATFORM:

Conceptual Design of the Platform:

The functional requirements of the platform are:

1. Should be able to change its direction without changing the orientation.
2. Should be capable of carrying a payload of at least 0.5 kg
3. Should have high maneuverability
4. Should be driven by belt
5. Should be light and small
6. Can be controlled through computer
7. Should be stable
8. Should be of low cost

Material Choice:

1. Mild steel has been used to fabricate the shafts, frames and pulleys used in belt drive.
2. Cast iron has been used for making bearing blocks and axle holder.

The Steering and the Driving Mechanism:

The schematic diagram of the steering and the driving mechanism is shown in Figure2. The dotted lines represent the belts in the belt drive. This arrangement is mounted on the active wheel assembly. The steering motor is used to control the direction of the two driven wheels simultaneously. The driving motors along with the belt drive and the axle rotates as a unit when rotated by the steering motor. Thus the relative position between them does not changes. The two driving motors drive the platform. The platform moves along the current direction of the wheels. Based on the assumption that friction coefficient between the wheels and the road surface is 0.5 in sliding and 0.07 in rolling the steering torque required has been calculated and accordingly a stepper motor of capacity 300N-mm has been selected. Similarly the driving torque required for the driving wheels are calculated and two stepper motors of capacity 300N-m have been selected which would suffice the requirement.

Detailed Design of the Platform:

Detailed design of the mobile robot has been carried out based on the functional requirements, material limitations and machining limitations. The final assembled platform is shown in Figure 3 without wheels and without motors. All the components have been analyzed to guard them against all possible modes of structural failure and accordingly the dimensions are decided.

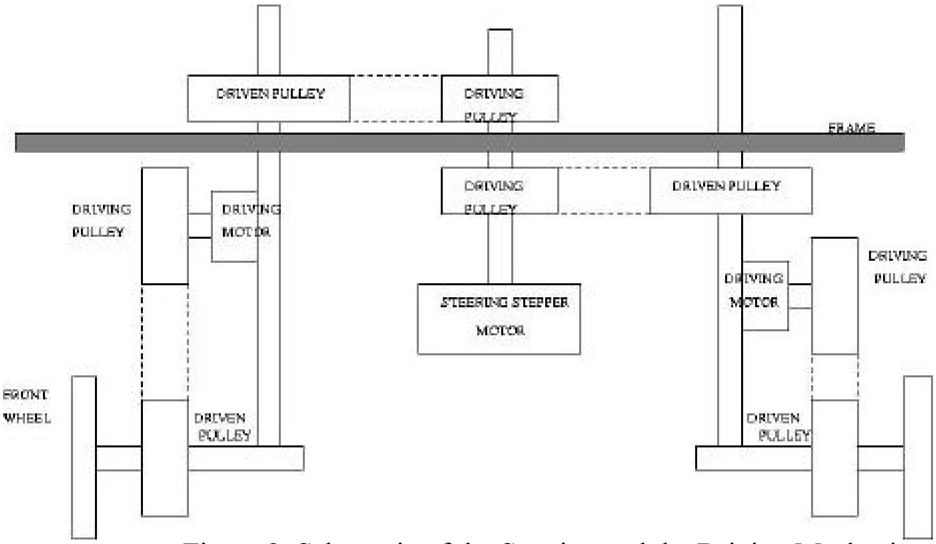

Figure 2. Schematic of the Steering and the Driving Mechanism

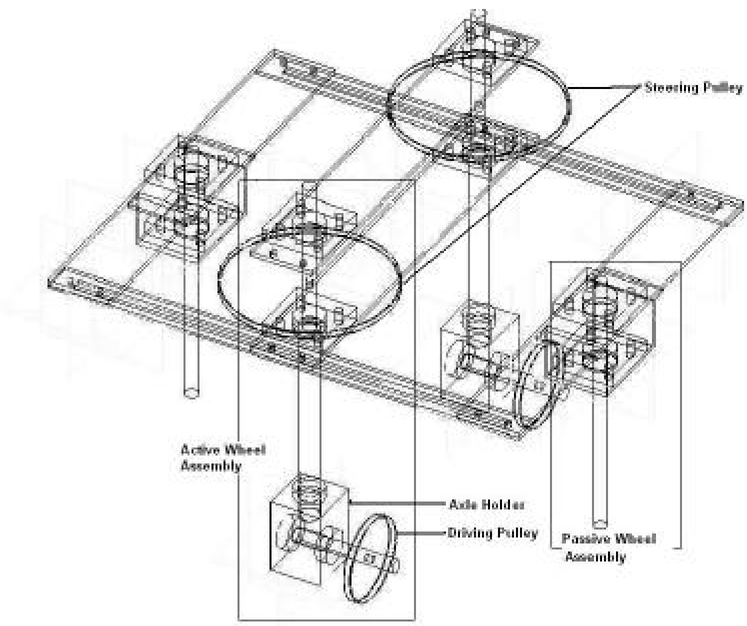

Figure3. The complete structure of the platform.

Active wheel arrangement:

Figure 4 shows the active wheel arrangement. The platform consists of two active wheels, which drive and steer the platform. This assembly is mounted with the steering and driving mechanism (shown in Figure2). Two separate driving motors attached on the vertical shaft independently drive the two wheels. The steering motor mounted on a separate frame synchronously controls the two vertical shafts that mount the driving mechanism. This arrangement eliminates the conventional common shaft between the wheels making it possible for the two active wheels two turn through 360 degree.

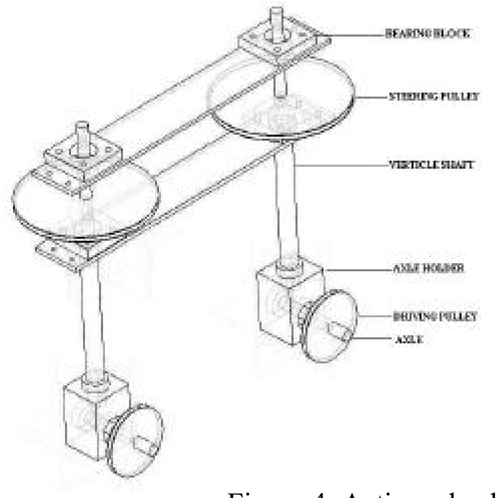

Figure 4. Active wheel arrangement.

Passive wheel arrangement:

Figure 5 shows the arrangement of passive wheels. The arrangement is called passive because there is no active mechanism that controls these wheels. This arrangement is mounted on shaft supported by bearings and attached to it at its end is ball castor wheels. The passive wheels automatically align themselves with the active wheels.

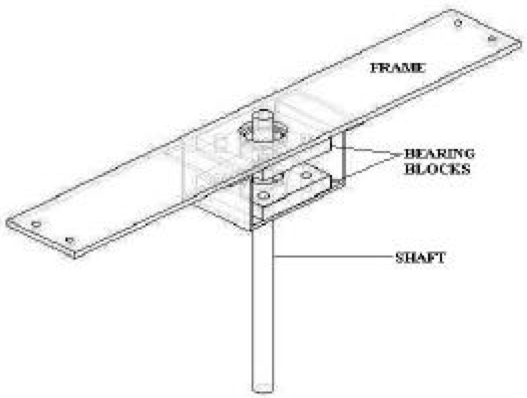

Figure5. Passive wheel arrangement.

Axle Holder:

Since the two active wheels are independently connected to the two driving motors, it was necessary to have an arrangement to hold them separately. This was made possible by designing an axle holder. This is fixed on the driven shaft by means of screw so as to prevent any relative motion between them and the driven shaft. The axle holder along with the attachments is shown in Figure 6.

Other Accessories

The frames were made using mild steel. The side frames have 8mm wide slot along the length of the frame to provide finer adjustment of the center distance in the belt drive. The pulleys have been fitted using screws that fit into a hole in the shaft at the proper location. This was necessary as the pulleys were too small to accommodate a keyway for a keyed connection.

Bearing blocks have been used to fit the bearings at every support of the shaft and the axle. The pulleys and the bearing blocks are shown in Figure7.

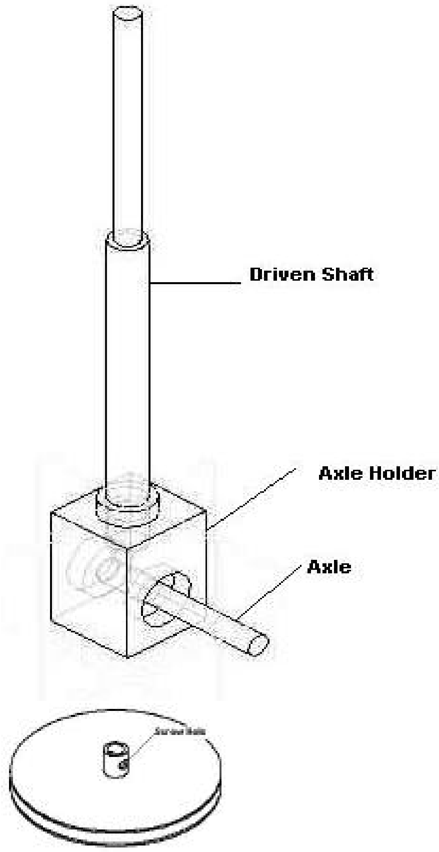

Figure 6. Axle holder arrangement.

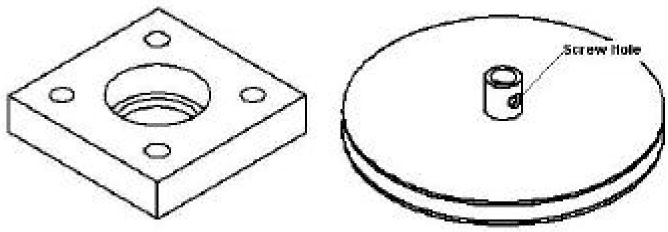

Figure7. The Bearing Block and the Pulley.

Platform Specification:

The various specifications of the platform are:

1. Platform length : 470 mm
2. Platform width : 400 mm
3. Platform height : 355 mm
4. Payload carrying capacity : 0.5 Kg
5. Weight of the platform : 7.5 Kg
6. Stepper motor specifications:
    a. Type: Hybrid-Variable Reluctance.

b. Holding torque : 400 N-mm
c. Detent torque : 40 N-mm
d. Step angle : 1.8 degrees

Figures 8(a) and 8(b) show the photograph of the fabricated mobile platform and the complete assembly of the platform along with computer control interface respectively.

Figure 8(a) Final fabricated platform

Figure 8(b) Computer controlled platform

Control of the platform

Figure 9 shows the display of the interface program. The program made in Visual Basic, uses the parallel port to connect the platform to the computer. The Program is capable of identifying the port address all by itself. The program uses the first 4 data pins of the parallel port to control the steering motor. The next 4 data pins are used to control the driving motors. The program gives four controls to guide the platform Forward, Backward, Left and Right. This can be done in steps or continuously by keeping the control buttons pressed. The forward and the backward controls are used to control the driving motors, and the left-right controls are used to steer the platform by controlling the steering motors. The program stores all the recent motions performed by the platform and can be recalled to repeat the sequence of motion. The program also has the provision of speed control. It has two modes of operation for the stepper motor:

1. **The Normal mode:** The motor is operated in the wave mode i.e. exiting only one phase at a time. This gives low torque but high speed.
2. **The High Torque mode:** The motor is run in full step mode by exciting two phases simultaneously. This gives almost double the torque of that given in normal mode but low speed.

Figure 9. The interface program.

CONCLUSION

In the present work, a computer controlled mobile platform capable of exhibiting high mobility has been designed and fabricated. An interface program has also been made that connects the platform to the computer through parallel port. The platform is capable of moving forward, backward, right, left, diagonally and can also rotate about the center of the platform. Due to this omni directional movement this platform will find extensive application where mobile robots are used.

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