Mechanical Design and Development of Agricultural Robot

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Abstract- **This paper presents a project developed at the Mailam Engineering college (Tamilnadu-India) aimed at designing, implementing, and testing an autonomous multipurpose vehicle with safe, efficient, and economic operation. This autonomous vehicle moves through the crop lines of a Agricultural land and performs tasks that are tedious and/or hazardous to the farmers. First, it has been equipped for spraying, but other configurations have also been designed, such as: a seeding ,plug platform to reach the top part of the plants to perform different tasks (pruning, harvesting, etc.), and a trailer to transport the fruits, plants, and crop waste.**

Keywords:* *autonomous vehicle, greenhouse, configurations

1. Introduction

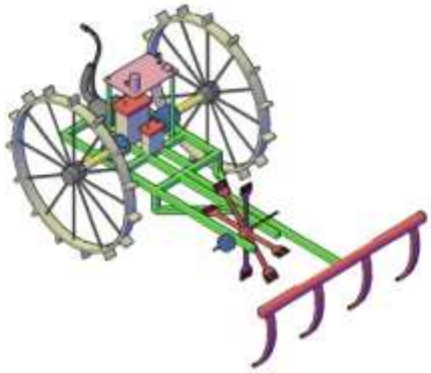
Agriculture is the backbone of Indian economy. But the state of agriculture is in its decreasing trend. This is due to lack of mechanization. Moreover there is a need for a combination of electrical and agricultural scientists working together for the development. This increases the per hectare productivity of the agricultural land. In the recent years, south-eastern Spanish has undergone an economic boom due mainly to the greenhouse cultivation. The climate of the area makes it ideal for this type of production system. In the province of Almería alone, the surface area covered by greenhouses is about 45,800 ha, with an annual production of 2.8 million metric tonnes (Cabrera & Uclés, 2011). More specifically, the scientific literature offers studies on the development of autonomous vehicles or robots built specifically for greenhouse tasks. Sandini et al. (1990) and Dario et al. (1994) developed the project Agrobot, which was a mobile platform with stereoscopic vision and a manipulator arm with a gripper/hand and six degrees freedom. Mandow et al. (1996) described an autonomous vehicle (Aurora) for spraying tasks. Subramanian et al. (2005) and Singh et al. (2005) described a mini-robot to perform spraying activities, for which navigation is controlled by algorithms based on fuzzy logic. Belforte et al. (2006) described an autonomous platform designed to evaluate the plant health. Kitamura and Oka (2005) developed a harvester robot for greenhouse sweet peppers. Another harvester robot was developed by Van Henten et al. (2002) to harvest cucumber. In general, the drawbacks of these autonomous robots are that they are not designed to work in soft soil with heavy loads and with different tools (multipurpose).

2. Material and Methods

The vehicle has been designed taking into account the following:

1. It must move in a soft soil and in an environment with many obstacles and tight spaces.
2. It must have enough capacity for optimal work performance.
3. It must perform different tasks within the greenhouse.

The CAD-CAE technology has been used in the mechanical design of the vehicle (Fig. 1). This technology provides a virtual prototyping to validate the design before its manufacture. This is done by creating geometric models of the components of the vehicle which are assembled virtually and tested with different mechanical motions. The software also helps optimize the arrangement of the components, the weight, and the aesthetic appearance of the vehicle. Once the virtual prototype was defined and analyzed, a physical prototype was built and tested.



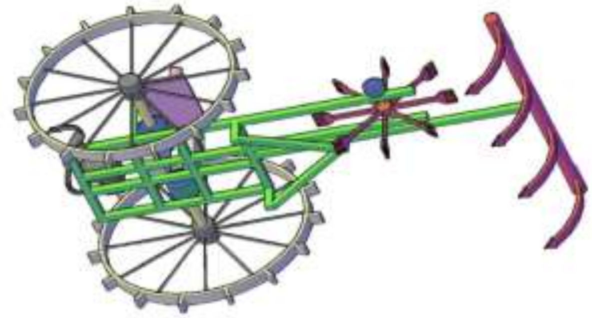


FIGURE 1. Mobile robot for agricultural

FIGURE 2. Exploding view of the components of the robot.

3. Results

3.1. Dimensions and frame

With the goal of satisfying the requirements listed above, a compact platform with two-wheel drive was developed (Fig. 2). The dimensions of the vehicle were fixed at 1 m wide, 1.75 m long and 0.53 m height above the ground. This ensures the movement through the crop rows, which in full development leave a free path of approximately 0.8 m, and guarantees the possibility of turning in the real terrain lanes, which are about 2 m wide.

The frame provides support to the batteries and all elements of the steering and traction system. As shown in Fig. 2, the platform has a rail on each side; the rails serve to attach the different tools designed for spray tasks, lifting platform, etc.. Note that through this straightforward mechanism many tools can be easily used, multiplying the applicability of the original vehicle. It also has two lateral shields (Fig. 2 (2)) made of steel plates to protect the batteries (Fig. 2 (2)). The steering system and the propulsion system complete the vehicle. As the travel speed of the robot is low, a suspension system is not necessary. For autonomous operation, a set of sensors: cameras, laser sensors and incremental encoders have been installed. These sensors are used for the navigation system, which controls the movement inside the greenhouse. Finally, navigation-control strategies were implemented in order to steer the vehicle. This paper describes only the mechanical design of the mobile robot.

3.2. Steering system

It consists of 2 drive wheels mounted on a common axis, and each wheel can independently being driven either forward or backward. While we can vary the velocity of each wheel, for the robot to perform rolling motion, the robot must rotate about a point that lies along their common left and right wheel axis. The point that the robot rotates about is known as the ICC - *Instantaneous Center of Curvature*

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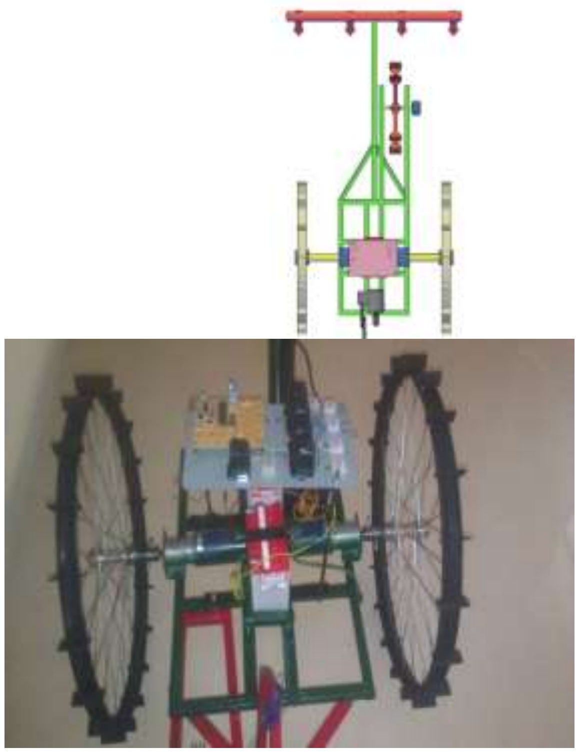

FIGURE3. Differential Drive steering axle

Each axle is attached to the vehicle frame with a slew bearing that is driven by a DC electric motor (Fig. 3). The slew bearing has 300 mm pitch diameter, 120 teeth and module of 2.5 (model VE030A00, La Leonessa S.P.A, Carpenedolo, Brescia, Italy). The DC electric motor has 350 W (Edon motors S.L, Vallirana, Barcelona, Spain). To transfer the motor power to the slew bearing, an 18-tooth gear and module 2.5 is used.

3.3. Propulsion system

The propulsion system needs to be easy to control, to supply, and to install. Therefore, for the propulsion system of the robot, two drive axles driven by DC electric motors of 24 V and 900 W are used (Fig. 4). These are located in the differential of each axle. Two traction batteries of 12V and 170 Ah supply power of the mobile robot.

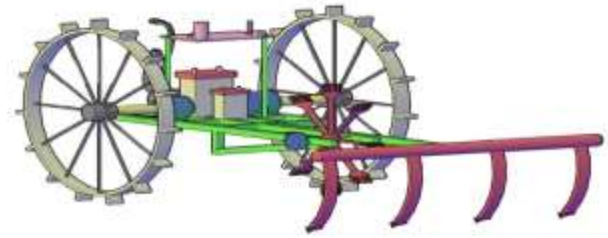

FIGURE 4. Drive axle

3.4. Tools for agricultural tasks

As mentioned above, the goal of this work is to design a multi-purpose vehicle for work inside greenhouses. Two tools were designed for the vehicle: a spraying system (Fig. 5) as made up of a platform of 1.75 x 0.71 m, two scissors arms which connect the platform to the base, and a hydraulic cylinder which extends the scissors arms.

FIGURE 5. The mobile robot with a spraying system

3.5. Advantages

1.It is a fully automated technology.
2.No need of large area for cultivation.
3.Easy to develop the enriched product.
4.Though we are monitoring, data of the plant is stored in the microcontroller which is used for future analysis.

4. Conclusions

Electric mobile robot has been designed and developed for agricultural tasks in crops, using CAD-CAE software. This small-sized vehicle can move with great maneuverability in an area with many obstacles, tight spaces, and can work with different tools to performer several tasks like spraying, pruning, etc..

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