Vitis, the robot at the service of the vineyard

Chavant Arthur, Demoron Tanguy

***Abstract*— This article presents VITIS, an autonomous robot intended for the maintenance of the soil of the vines. This robot equipped with four driving wheels is intended to pass between the rows of vines in order to weed thanks to tools which will be equipped on the tool holder of the robot. Finally, this one is also equipped with a camera to recognize diseased vine leaves.**

***Index Terms* — Autonomous robot, Vineyard maintenance, Soil maintenance, Winegrowers, Robotics technology.**

Figure 0.0 - First version of Vitis

I. INTRODUCTION

WITH an average of 50h per hectare per year, soil maintenance is a tedious work and requires a lot of time for winegrowers. Our idea is to create an autonomous robot in order to help winegrowers in this task. Soil maintenance is important in a vineyard because the health and fertility of the soil directly affects the growth and productivity of the grapevines. Vines require specific soil conditions, such as proper drainage and adequate nutrients, to thrive. Maintaining the soil through practices such as tilling, fertilization, and irrigation helps to ensure that the vines have the necessary resources to produce high-quality grapes. Additionally, maintaining the soil can also help to prevent erosion, conserve water, and promote biodiversity in the vineyard ecosystem.

There are a few examples of wine robots that are currently available for purchase:

- Naio Technologies: The company sells several robots for vineyard maintenance, including a robot that can be used for thinning, and a robot that can be used for mowing [1].

Figure 1.0 – Oz Robot from ®Naio

- Abundant Robotics: This company designs and sells a robotic apple harvester that uses machine vision and machine learning algorithms to identify and pick ripe apples [2].

It's worth noting that these robots tend to be expensive and not yet widely adopted by the industry, they are usually intended for large scale vineyards and research institutions. Also, these technologies are still evolving, so it's worth doing more research to see which specific features and capabilities are offered by each robot, and how well they can perform in different vineyard environments.

In this article, we present in detail the different components of our autonomous vineyard robot, designed specifically for the tasks of weeding and recognition of diseased vine leaves. Our goal is to provide an in-depth understanding of how this innovative robot is made, as well as how it works and its capabilities. By taking a close look at every part of the robot, we hope to offer a comprehensive overview of the technology used and its potential in the wine industry.

II. TRANSFORMATION OF AN IDEA INTO A MODEL

A. *The sketch*

This robot was born from an idea, which we have fleshed out by learnings about the robots that already exist. This work gives us a first sketch of what our robot will look like. To make this model there are three main steps, the frame, the wheels and the tools carrier.

B. *Robot body*

To begin, we modelled on fusion 360 the different part of the sketch of the robot body then we cut it in wood with the

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laser printer and put them together in order to have the frame.

An assembled frame allows us to have removable robot and make changes in the future.

For more aesthetics, we know how to make part of the plexiglass chassis in order to offer better visibility of the interior of the robot.

C. Be able to move

Then we need to mechanise this frame. We decided to put four motorized wheels to have a robot adapted to the soil of the vineyard. The engines are put under the frame to raise the frame.

With a weight estimate of the robot we decided to choose four gear motors with a power of 15W and a torque of 1.6 Nm in order to drive on a 20° slope at 4km/h which allows it to adapt to all types of vineyards [3].

The last step was to install the sensors and the Arduino Mega board on the frame to begin code testing.

D. Vine yard maintenance

Our tool holder is located at the back of the robot, and it features a hydraulic cylinder that allows for smooth rotation. With this capability, the robot can decide whether to insert the tool into the soil for vineyard maintenance or keep it raised to turn for example.

This technology offers significant benefits. When it's time to cultivate the soil around the vines, the tool holder can be lowered, allowing the tool to penetrate the ground for activities like hoeing or mechanical weeding. On the other hand, for tasks such as pruning or targeted spraying that require working at higher levels, the tool holder can be raised to keep the tool away from the ground.

By incorporating this tool holder into our vineyard robot, we enable greater flexibility and efficiency in vineyard maintenance. The robot can adapt quickly to different tasks, reducing the need for specialized equipment or additional manual labour. The smooth rotation provided by the hydraulic cylinder ensures precise movements without risking damage to the vines.

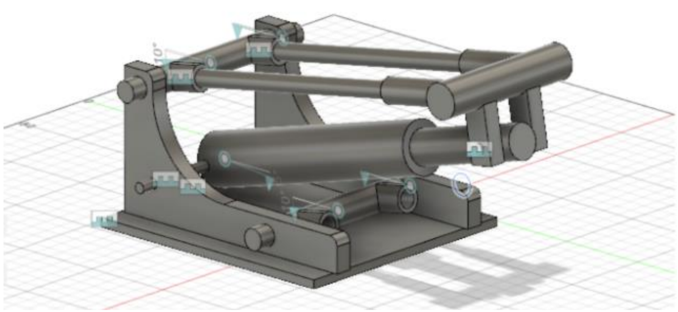


Figure 2.0 - Toolholder Modeling on Fusion 360

Figure 2.1 - Toolholder construction with 3d printer

III. MAKE THE MODEL AUTONOMOUS

A. Moving the Robot

To move in space the robot must be able to move forward, backward and turn. As there is no steering on the wheels, the robot uses the direction of the wheels to turn. For example, to turn left, the two right wheels turn forward and the two left wheels turn backward.

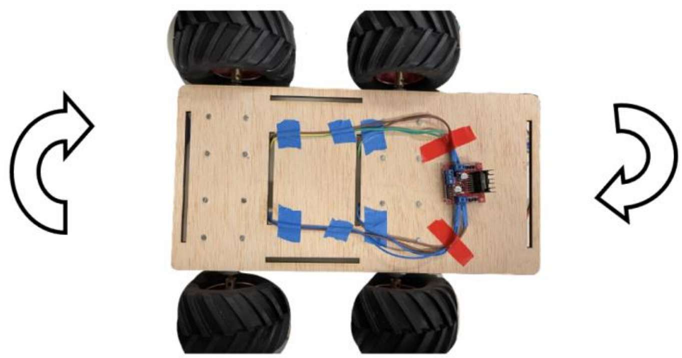


Figure 3.0 - Movements of Vitis

The advantage of this approach is that the robot does not need any space to make a complete turn, which is very important as there is not always room at the end of the vineyard row [4]. To manage the direction of the motors and ensure that they rotate simultaneously, an H-bridge must be used to control the polarity at the terminals of a dipole.

Note that it is necessary to pay attention to the saturation of the component and choose a bridge adapted to the four motors.

B. Autonomous movement

For the moment the robot uses two types of sensors, ultrasonic and infrared (figure 3.1).

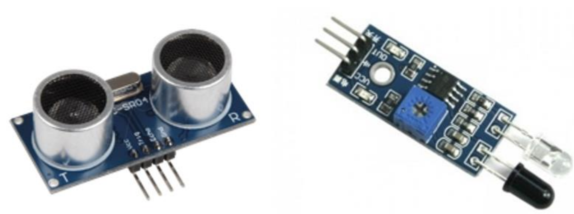


Figure 3.1 - Picture of an ultrasonic sensor and an infrared sensor

These sensors have different properties and are not used in the same way [5]. For example, the infrared sensors are placed on the sides and signal the robot to turn or not. They are easy to use because they return a Boolean signal, and they are set in advance according to the triggering distance. The ultrasonic sensor is at the front of the robot and stops the robot in case of obstacles.

It also allows the robot to slow down before the obstacle as it sends the distance in front of it to less than 20 centimeters.

C. Manual control

The gear lever, a notable inclusion, provides you with unparalleled control over the robot's movement speed. Whether you're navigating through tight and delicate spaces that require a slower pace or traversing open areas with swift precision, the gear lever allows you to fine-tune the robot's speed to match the task at hand. This newfound flexibility enhances your ability to navigate various environments and execute tasks with utmost accuracy.

In addition, the tool carrier button introduces a new level of convenience and efficiency to your robot's capabilities. With a simple press, you can activate or deactivate the tool carrier mechanism, giving you direct control over attaching and detaching tools or equipment. This seamless tool manipulation feature allows you to adapt the robot's functionalities on the fly, easily transitioning between different tasks and optimizing your workflow in a matter of seconds.

To further enhance versatility, the mode selection button enables you to effortlessly switch between manual and auto modes. In manual mode, you have full control over the robot's movements using the Bluetooth remote control. This mode is ideal for scenarios that require real-time decision-making or precise navigation to specific locations. On the other hand, the auto mode leverages the intelligence of the Arduino Mega board's four brains, empowering the robot to autonomously execute predefined tasks without constant input from the remote control. This mode is particularly useful for tasks that are repetitive or require longer durations, allowing you to focus on other aspects of your work while the robot operates autonomously.

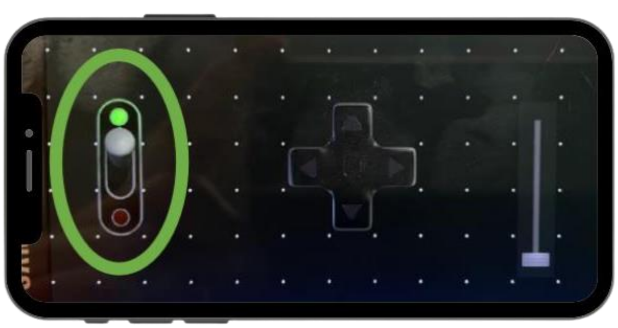


Figure 3.2 – Bluetooth remote control on Smartphone

IV. ELECTRIC ROBOT

Our robot runs on electricity, which makes it eco-friendly and cost-effective. It has an electric motor that delivers powerful and efficient performance while reducing harmful emissions.

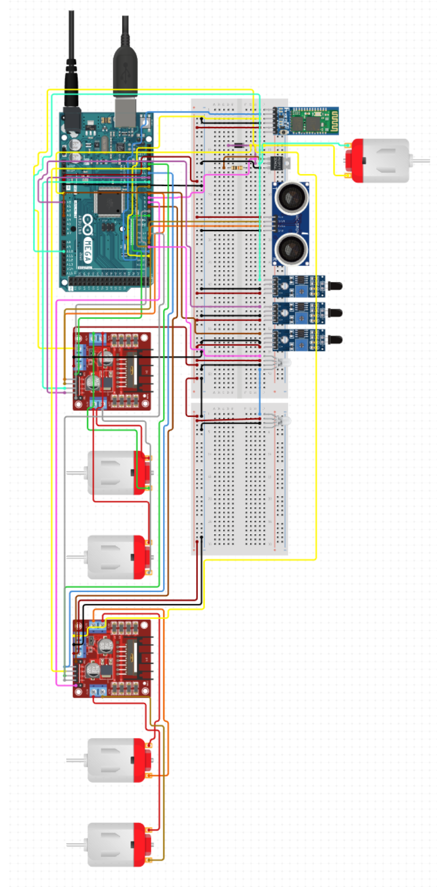


Figure 4.0 – Electric diagram

What's more, the robot is designed to be easily repairable. Its simple disassembly allows for hassle-free replacement of electronic parts. This means that if a component gets damaged, it can be quickly and easily swapped out, minimizing any downtime and keeping repair costs low.

In addition to its ease of repair, another advantage of our robot is the ready availability of its components in the market. Whether you need to replace a motor, sensor, or any other electronic part, finding the necessary components is hassle-free. This accessibility ensures that repairs can be carried out swiftly, without delays or difficulties in sourcing the required parts.

Furthermore, the robot's electrical system is designed with simplicity in mind. The electrical circuit diagram is straightforward and easy to understand, enabling technicians to diagnose and troubleshoot any issues efficiently. This simplicity not only facilitates repairs but also allows for easier customization and modifications, making it convenient for users to adapt the robot to their specific needs and preferences.

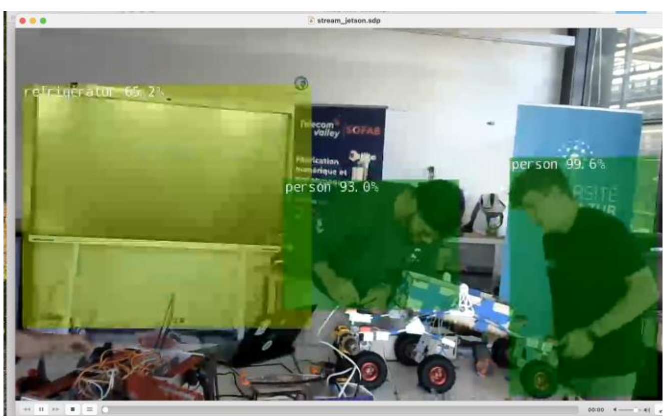
V. Disease Recognition

Vineyards face numerous challenges, and one of the most critical is the presence of diseases that can wreak havoc on crops. The key to mitigating the impact of these diseases lies in early detection and prompt action. However, traditional manual scouting methods are time-consuming, prone to human error, and often fail to cover large vineyard areas effectively.

Figure 5.0 – Nvidia Jetson Nano

But fear not, for we have a groundbreaking solution that combines advanced technology and artificial intelligence to revolutionize vineyard health monitoring. Our camera system, powered by an NVIDIA jetson nano, brings together the best of AI and computer vision to detect and prevent diseases in vineyards with unprecedented accuracy.

Our camera captures images. These images are then processed in real-time using the power of the NVIDIA, enabling swift analysis of vast amounts of visual data. Our python algorithm detects over 80 different objects and we will in the future make it detect diseases on vineyard leaves.



VI. Conclusion

In conclusion, our autonomous viticultural robot dedicated to weeding and recognizing diseased vine leaves highlights promising technological advances in the field of precision agriculture. By understanding the different parts that make up this innovative robot, we were able to appreciate its potential to improve the efficiency, productivity and sustainability of the wine industry.

Figure 6.0 – Final Version of Vitis

The robot's propulsion system, with its specially designed motors and wheels, allows safe autonomous navigation in the vineyards. On-board sensors provide real-time perception of the environment, allowing the robot to avoid obstacles. The robot's tool holder system, offers a precise and effective solution for eliminating weeds without harming the surrounding vines.

The diseased vine leaf recognition system, based on computer vision, makes it possible to identify and accurately diagnose signs of disease. However, despite the progress made, it is important to point out that the technology of the autonomous vineyard robot still requires continuous improvements. Further research should be conducted to optimize performance, reduce costs and adapt the robot to different types of vineyards and climatic conditions.

References

[1] Naïo Technologies, a French start-up company from specializing in agricultural robotics. Available : naio-technologies.com

[2] Abundant platform combines computer vision and machine learning to delivery high-quality produce. Available : linkedin.com/company/abundant-robots

[3] A website to adapt the engines to our needs. Available : community.robotshop.com/blog/show/drive-motor-sizing-tool.

[4] An article that presents the existing robots and how to be inspired by their solutions. Available: vignevin-occitanie.com/fiches-pratiques/la-robotique-en-viticulture/

[5] University course on sensors. Available : electronique-mixte.fr/wp-content/uploads/2018/10/Capteur-ultrasonique.pdf

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