# E-Gaïa, the autonomous gardener

Brice Mabille and Jaime Alba Pastor

***Abstract*— This article shall walk you through the important steps of the project that we've completed so far, as well as how they were achieved. E-Gaïa is an autonomous robot intended for replanting arid and post fire areas.**

***Index Terms* — Assembly, autonomy, design, ecology, exploration, motion, revegetation, robot, rover**

## I. Introduction

FOR more than a decade, climate change has been a major issue which has greatly disrupted the world we live in. Aware of the risks nature is facing, our team decided to help preserve the wildlife at our own scale. For our third-year project, we chose to create the E-Gaïa robot which could plant in arid zones after a fire or in desertic areas.

Despite being an unconventional approach, an autonomous robot could assist in finding adequate locations, planting suitable seeds, and taking care of irrigation. We hope that this self-sufficient robot could help regenerating vegetation and by doing so, safeguarding the ecosystem.

## II. Mechanical structure

### A. *Mobility and suspension*

The mobility and suspension structure must enable the robot to overcome any kind of terrain it may find. There are lots of solutions such as the four-wheels used in the NASA's K-10 Rover Red [1] or the tank tracks used by the ECA Cameleon [2]. But we came up with the Rocker-bogie structure, developed in 1988 for the NASA's **Mars rover Sojourner** (Fig. 1) [3] and used in all the following rovers.

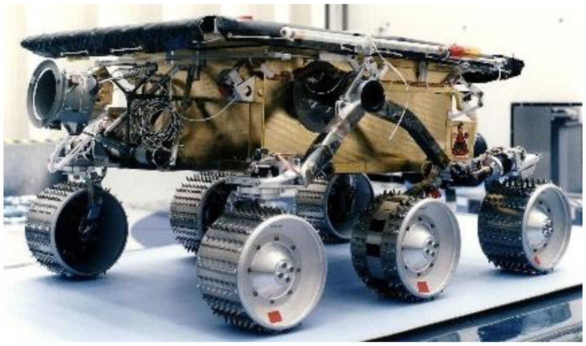

Fig. 1. NASA's Mars rover Sojourner using the first version of the rocker-bogie structure. The differential is located inside the chassis and is similar to the one found in a car. [3]

The "rocker" part of the suspension comes from the rocking aspect of the larger, body-mounted linkage on each side of the rover. A differential connects these rockers to one another and the vehicle chassis. The rockers will rotate in opposite directions relative to the chassis to ensure approximately equal wheel contact. The chassis maintains the average pitch angle of both rockers. A rocker has a drive wheel on one end and a bogie on the other.

The "bogie" element of the suspension refers to the smaller linkage that pivots to the rocker in the middle and has a drive wheel at each end.

The original differential employed was the one of a car [4], which is heavy and difficult to build. That is why we included the differential used in the **Perseverance rover** [5], which connects the rocker parts over the chassis.

Fig. 2. The Rocker-bogie structure of the E-Gaïa robot, equipped with the Perseverance's differential design.

The six-wheel configuration structure (Fig. 2) will provide full-time wheel contact when climbing steep features as well as excellent mass distribution, making it ideal for unknown and wild areas.

### B. *Drilling system*

For planting seeds, various technologies such as a tractor-like shovel or a small plough were considered. A drill, on the other hand, appears to be the most efficient way, being both swift and precise. But, because the reliability of this drilling mechanism is critical to the overall performance of the robot, it is still in the design phase.

The drill is powered by a high torque DC motor, allowing it to dig even in hard soil. Once the seed has been placed, the drill reverses direction to refill the hole by supplying an opposite

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current.

However, for the robot to move around freely, the drill must be able to return inside the frame. As a result, the drill has a vertical movement powered by a stepper motor. This motor will rotate a threaded tube linked to a helicoidal nut, translating it vertically (Fig. 3).

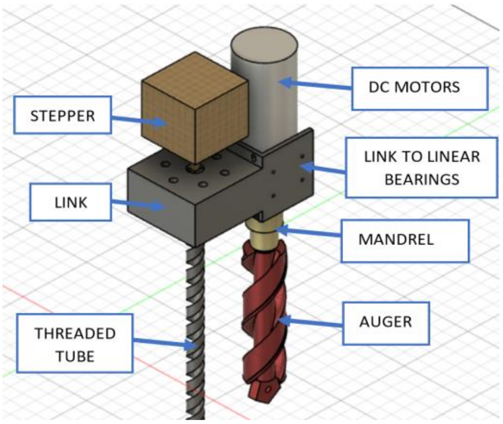


Fig. 3. 3D model of the drilling system equipped with vertical translation.

### C. Lidar guidance system

The robot should be aware of its surroundings in order to avoid obstacles. We considered three options: low-range ultrasound sensors, a camera, and the Lidar laser scanner. This last approach has the advantage of being very accurate and not requiring to compute the heavy images of a camera. This sensor determines how long it takes for light beams to hit an object and reflect back to the scanner. It also provides 360 degrees of vision when combined with a rotating structure [6].

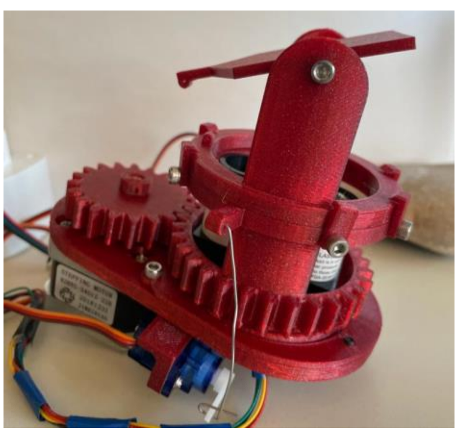

Fig. 4. 3D printed 360-scanner equipped with the Lidar sensor, a stepper motor and two servo motors

This arrangement (Fig 4) is made up of a stepper motor that rotates around the vertical axis. In addition, two servomotors control the angle of the mirror that reflects the laser.

## III. Programming structure

### A. Boards connectivity

The Arduino Uno R3 and the Jetson Nano will be used to control the robot's motions and actions. On the one hand, the Jetson Nano serves as the robot's brain, where data analysis and IA will later take place. The Arduino, on the other hand, controls the motors and other components that demand speedy responses.

These two boards are linked via serial connection to exchange data (USB port). However, because mapping the surroundings requires rapid communication, the Lidar is directly attached to the Jetson Nano rather than the Arduino.

### B. Driving's logical program

We developed the primary programming flowchart for autonomous driving. The idea is to guide the robot to a specified location. If that location is beyond the Lidar's range, we shall navigate using the GPS tracker by establishing intermediate locations. If it is within that range, the sensors controlled by the Arduino board will activate in the event that unexpected obstacles, such as walking people or larger events, occur.

## IV. Conclusion

During the first phase of the project, the suspension has consumed the most time. However, it is nearly finished, and once we begin coding, the program will be considerably easier to write since the suspension is mechanically regulated.

Furthermore, we have made some progress in the Lidar and drilling systems, which will allow us to catch up with schedule.

## Appendix

Our project is detailed on our GitHub repository:
https://github.com/jaimealbapastor/autonomous-gardener

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**Jaime ALBA PASTOR** completed an integrated preparation course in 2022 and is now enrolled in the Robotics and Autonomous Systems specialization at Polytech Nice Sophia. He is pursuing his passion while participating in fascinating projects whenever possible.

**Brice MABILLE** has completed a preparatory class for high schools and has incorporated the Robotics specialization from Polytech Nice-Sophia in 2022. He is developing his CAO passion through E-GAÏA, the autonomous gardener.