Internship proposal 2021 – Set up an open-source automated farming system

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Key words: *Bioregenerative Life Support System, Precision Agriculture, Robotics, Web-app, Linux, Arduino, Raspberry, Computer network, NTP, Shell, HTML, SCSS, Javascript, TypeScript, Ruby.*

1 Introduction

When space missions include humans, it is necessary to set up a life support system (LSS). Future space missions (e.g. colonization of Mars) are expected to involve longer distances and durations. For such missions, resupply from Earth is too expensive (or even impossible for a one-way trip) both in terms of energy and time, and it therefore becomes necessary to design bioregenerative LSS [3].

This is why the implementation of such systems is of interest to ESA: *"For more than 30 years, the European Space Agency (i.e. ESA) is active in the field of regenerative life support system. MELiSSA (Micro-Ecological Life Support System Alternative) is the European project of circular life support system. It was established to gain knowledge on regenerative system, aiming to the highest degree of autonomy and consequently to produce food, water and oxygen from mission wastes."*[1].

Growing plants in space, in addition to providing fresh food for astronauts, makes it possible to mitigate *"stress effects from long-duration space travel"* [6]. This is also a subject of interest since research does not exclude that it is possible to grow plants on the Moon and Mars [11]. For the European Space Agency (ESA), *"cultivating plants for food was a significant step in the history of mankind. Growing plants for food in space and on other planets will be necessary for exploration of our Universe"*[2].

[1] www.melissafoundation.org/

[2] https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Research/Plants

Figure 1: First space-grown salad eaten by astronauts in 2015 on the ISS.

Space food has always been brought from earth[3] but for more than twenty years some plant growth systems for space have been set up and tested in various conditions [13, 12, 2][4], for instance SVET (on Mir station, 1997) [5] and Lada (on the ISS, 2002) [1].

More recently, NASA set up the Vegetable Production System [7] (Veggie, 2014[5]) that produced the first space-grown salad eaten by the astronauts[6] (see Figure 1). In 2017, it was supplemented by the Advanced Plant Habitat (APH), that *"is the largest growth chamber aboard the orbiting laboratory. Roughly the size of a mini-fridge, the habitat is designed to test which growth conditions plants prefer in space and provides specimens a larger root and shoot area."*[7].

The european project EDEN ISS [14][8] has also studied, until 2019, systems architecture for cultivating plants in closed-loop systems for applications on earth and in space. This project led for instance to greenhouse design concept for the Moon and Mars [4]. Within the framework of the MELiSSA project, prototypes have recently been developed (e.g. for cultivation of tuberous plants [10] in the ESA Project "Precursor of Food Production Unit") and many research works have been carried out (e.g. on hydroponic systems [8] or potatoes in controlled environments [9]).

2 Automated farming systems

During most of the space missions, human time and attention are very precious. For instance, in the International Space Station (ISS), it is preferable not to assign additional tasks that are not related to ongoing experiments: *"At any given time on board the space station, a large array of different experiments are underway within a wide range of disciplines."*[9]. Plant cultivation would be a long and repetitive daily task that would increase too much

[3] https://airandspace.si.edu/exhibitions/apollo-to-the-moon/online/astronaut-life/food-in-space.cfm

[4] see also www.astrobotany.com.

[5] https://www.nasa.gov/content/growing-plants-in-space

[6] https://www.nasa.gov/mission_pages/station/research/news/meals_ready_to_eat

[7] https://www.nasa.gov/mission_pages/station/research/Giving_Roots_and_Shoots_Their_Space_APH

[8] https://eden-iss.net/

[9] www.nasa.gov/mission_pages/station/research/experiments_category

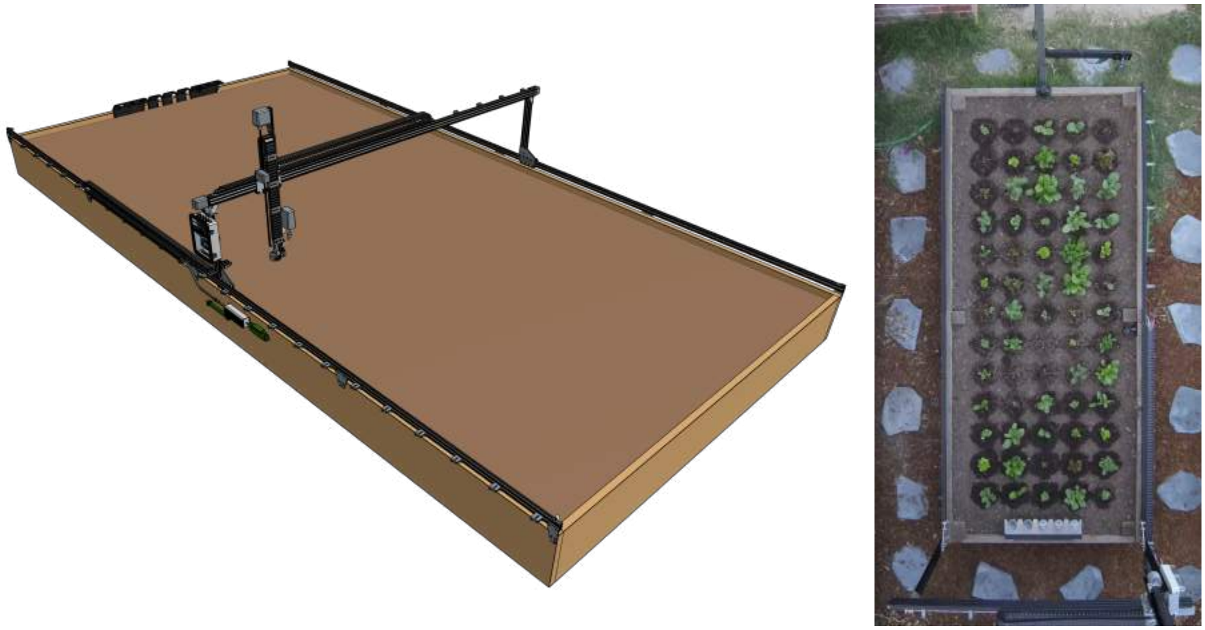

Figure 2: Farmbot Genesis XL robotic system.

the workload of the human team involved. It is therefore interesting to study systems for growing plants with automated monitoring and interventions.

In order to conduct further research on bioregenerative life support systems, the Department of Aerospace Vehicles Design and Control at ISAE-SUPAERO is now equipped with a Farmbot Genesis XL (`https://farm.bot/`, see Figure 2), an open source Cartesian coordinate robot farming machine. The research work that will be carried out with the help of this robot fits into the framework of the ALICE (AI for Life In spaCE) project. The goal of this project is to pave the way towards autonomous plant growing system capable of analyzing and reacting to the growing process in order to quickly obtain healthy plants while optimally use space and resources (nutrient, water, etc.).

The purpose of this internship is to assemble the Farmbot Genesis XL robot , control it, and set up the data collection. It will be carried out in the following stages:

- Carry out an inventory of the Farmbot's parts (see `https://genesis.farm.bot/v1.5/FarmBot-Genesis-V1.5`).
- Identify the location of the water and electricity supply, *i.e.* the final location of the farmbot.
- Considering the identified constraints, propose a way to make the web-app self-hosted (see `https://software.farm.bot/v12/FarmBot-Software`).
- List the lacking parts (planter bed, electric adapters, cables, garden hose, WiFi repeater, Raspberry Pi, etc.).
- Host the Farmbot web-app and create a local network to which the Farmbot and users can connect (see `https://developer.farm.bot/v12/Documentation`).
- Follow the necessary training to use the Fablab (InnovSpace) tools to assemble the Farmbot.

- Build and install the Farmbot in its assigned location.
- Propose and implement a data collection system.
- Propose and set up a system for deploying cultivation strategies.
- Formalize the cultivation problem and propose data-based strategy optimizations.

Good knowledge of computer development and familiarity with the following tools will be highly appreciated: Linux, Arduino, Raspberry, Computer network, NTP, Shell, HTML, SCSS, Javascript, TypeScript, Ruby.

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