ESMERA AGRICULTURE CHALLENGES

Agriculture presents many challenges for robots and yet the potential rewards are also high. Key amongst the challenges is the identification of target plants and determining their status when natural variability may be high; Dealing with fragile materials; Working outdoors in differing weather and light conditions; working in open areas that potentially allow access to members of the general public as well as farmworkers. Traditional approaches to automation have relied on the tractor as a central resource, with increasingly sophisticated tools deployed from, and powered by, the tractor unit. However, for many applications tractors are not an appropriate solution, either being too big or causing too much soil compaction. Robotic systems with a smaller footprint and lower ground pressure could open up many areas of agriculture that have to date required large quantities of labour to undertake the tasks or which have been undertaken in a very ineffective manner. Further, by targeting down to the individual plant, benefits such as increased yield, less pollution from herbicides and pesticides, and lower operating costs can result.

ESMERA has identified several industrial challenges and classified the needs for further technical advances in 1 main challenge. Under each Agriculture challenge, ESMERA propose two options of industrial challenges that can be solved, option a) ESMERA proposed challenge and option b) Open challenge

Agriculture Challenge 1: Targeted treatment / manipulation of plants with access restrictions.

Targeted treatment/manipulation of plants with access restrictions is one of the problems that can be solved by robotics. As defined in the Robotics 2020 Multi-Annual Roadmap, the key abilities that are paramount for this challenge are:

- **Motion ability:** The robot must be capable of traversing an open field with potentially rough terrain (and in the case of the vineyard steep slopes) while maintaining its location relative to farm facilities and individual plants. It must also be capable of accurately locating itself even in similar local environments.
- **Perception ability:** Plants have natural variation. The robot must be able to distinguish target plants from other features in the environment. Potentially the robot should also have the ability to assess the condition of the plant, i.e. ready for picking in the case of flowers or in need of treatment in the case of vineyards.
- **Dependability:** The system will need to work in adverse, outdoor conditions for long periods of time achieving rates at least equivalent to a human worker.
- **Interaction ability:** The robot will have to be able to be easily tasked and re-tasked by an operator in terms of areas of work and types of flower to be picked or types of disease to asses. Importantly the robot will be working in areas that are impossible to completely fence off and so must interact with both human workers and members of the general public in a predictable and safe manner.
- **Decisional autonomy:** The robot will have to operate autonomously for significant periods of time during a working day. Arguably the robot will have to exhibit Decisional Autonomy at, at least, Level 6 as defined by the Multi-Annual Roadmap, i.e. Task Autonomy.
- **Manipulation ability:** Whether picking flowers or deploying a spray system such that maximum coverage is achieved with minimal wastage, the robot will have to exhibit a high level of dexterity and manipulation planning.

It is expecting from the system to fulfil the following metrics:

- **Efficiency:** Accessing plants in an outdoor environment while causing minimal damage to either the plants themselves or the soil structure, i.e. having a low ground pressure.
- **Reliability:** Identification of individual plants, amongst fields of similar plants together with an assessment of the condition of the plant, and carrying out appropriate operations on individual plants, e.g. picking operations or application of treatments for pests or diseases without causing collateral damage.
- **Safety:** Working in a safe manner, cognizant of the potential proximity of farmworkers or members of the general public.
- **Data storage ability:** Recording and maintaining records of the work carried out together with specific geolocation data.

Under the above challenge, ESMERA project proposes two options. The proposer must address at least one of these challenges although addressing more than one or highlighting where elements of the proposed system could be used for the benefit of more than one system would be beneficial.

A) ESMERA proposed challenges: this challenge is extracted from two industrial use cases which are:

AGRICULTURE CHALLENGE 1.A1 (A1.A1)

Picking herbal flowers. Picking flowers for use in herbal medicine is currently a very labour-intensive process. Human pickers also potentially cause damage to the plants and / or the ground during the process which can limit further production of flowers. A robot system for herbal flower picking must have:

- Relatively small physical size and weight to access compact fields of flowers.
- Determine its position relative to the crop and key farm facilities.
- The ability to determine if a flower is close to the optimum size and state for picking in all light conditions (note that due to the nature of the process working during or just after rain is not permitted).
- Be capable of being adapted to work with different flower types.
- The ability to pick the flower causing minimal damage to the flower or its parent plant.
- Transfer the flowers to a suitable collection bin.
- Work at a similar pace to human pickers.
- The robot must record the yield and quality of the harvest relative to the location of the picking operations.
- Transport the picked flowers to a designated collection point and transfer said flowers (or exchange a collection bin)
- Operate safely in the presence of human workers or members of the general public.
- Be capable of sustained operations during the picking season. Note that this will mean energy sources are not depleted in the

Figure 1: Picking flowers

middle of a field. Energy usage must be predicted and sufficient resource preserved to enable a return to a recharging / refueling point.

Proposals addressing this challenge should ensure on their own the availability of a replication/testing environment/field for their experiments. In case outdoor fields will be used, proper timing will need to be planned for crops to be available in the duration of the project.

AGRICULTURE CHALLENGE 1.A2 (A1.A2)

Treatment application in steep slope vineyards: Steep slope vineyards account for 10% - 12% of European viticulture land area and produce some of the highest value wines. Row sizes are quite narrow, typically 90cms – 150cms. Currently, where possible, treatments are applied from a small tractor-based system that uses an air-blast system. Losses are high and ground compaction is a problem.

What is required is a smaller robot-based system that can access these steep slope vineyards and selectively apply pesticides / fungicides to individual plants. Such a system would need to:

- Access all areas of a steep slope vineyard autonomously and in all ground conditions, e.g. dry, muddy, etc.
- Optionally, assess the condition of individual vines to assess whether treatment is required.
- Apply treatments to individual plants efficiently and effectively (whether to all vines or only selected ones) achieving spraying losses of 20% or less.
- Be capable of either auto-refilling treatments or notifying an operator when a refill is required.
- Monitor its own energy usage and allow sufficient margin to transfer to facilities where refueling / recharging can take place, i.e. it must not get stranded in the field.
- Be capable of operating for 4-6 hours in any working day.
- Work at a similar rate, or greater, as a person using a manual sprayer.
- Operate safely in the presence of workers, members of the general public, potential obstacles and steep inclines.
- Keep detailed records of treatment rates applied down to individual plant level.

Proposals addressing this challenge should ensure on their own the availability of a replication/testing

Figure 2: Current spraying in steep slope vineyards

environment/field for their experiments. In case outdoor fields will be used, proper timing will need to be planned for crops to be available in the duration of the project.
This challenge is provided by the company ADVID.

B) Open challenge (AGRICULTURE CHALLENGE 1.B (A1.B))

Any other proposal for similar technologies is eligible for funding, provided that a thorough explanation of the industrial needs is presented. The proposals will also have to clearly identify the state of the art in commercially available solutions and highlight the differences/advances over it. More specific each proposal in order to be in line with the ESMERA requirements has to provide:

- Clear indication of the company, institution or other that are in need of the proposed solution (no funding is allocated to challenge providers)
- Description of the problem that the company or companies need to be solved.
- Proof that currently there is no comparable solution (concept or approach, performance, cost…) in the market.