Metrological evaluation and testing of robots in international competitions

Deliverable title	D5.2: ACRE Dry-run Field Evaluation Campaign
Deliverable lead	INRAE
Related task(s)	T5.2 ACRE Dry-run Field Evaluation Campaign
Author(s)	Daniel Boffety (INRAE)
Dissemination Level	public
Related work package	WP5 : Agri-food
Submission date	January, 2021
Grant Agreement #	871252
Start date of project	1st January, 2020
Duration	36 months
Abstract	ACRE (Agri-food Competition for Robot Evaluation) : Dry-run Field evaluation report

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 871252

Versioning and Contribution History

Version	Date	Modified by	Modification reasons
V0	January 2021	Daniel Boffety	
V1	February 2021	Daniel Boffety	After review (AK LNE)
V2	March 2021	Daniel Boffety	After review (VB LNE) and (MM POLIMI)

Versioning and Contribution History of the template

Version	Date	Modified by	Modification reasons
V0	June 2020	Virginie Barbosa	First version of template
V1	July 2020	Virginie Barbosa	Add of a second table for versioning of the template Minor modification of the top area of the template

List of Abbreviations and Acronyms

Abbreviation/Acronym	Meaning
ACRE	Agri-food Competition for Robot Evaluation
FBM	Functionality BenchMark
TBM	Task BenchMark

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 871252

Table of Contents

Deleted

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 871252

Executive summary

ACRE (*Agri-food Competition for Robot Evaluation*) is one of the robot competitions designed and organised by the METRICS project. ACRE brings the idea of *benchmarking competition* to the applications of robotics in agriculture. Among these, ACRE devotes particular attention to autonomous weeding: in fact, by providing an alternative to the massive use of chemical products, weeding robots have the potential to bring environmental, societal, and economic benefit to Europe and worldwide in general.
The initial goal of the dry-run campaign was to validate the evaluation plan and produce datasets for the upcoming cascade campaigns. It has been co-located in space and time with one of the field events of ROSE challenge, taking place at INRAE's facility in Montoldre (France). Such co-location was expected to help bootstrap ACRE by possibly involving already established ROSE teams and ensure the availability of datasets by leveraging ROSE teams' existing robots to collect them.
The ACRE field dry run has been co-located with the "second complete assessment" event of the pre-existing ROSE Challenge. Indeed, during a meeting with of ROSE Challenge participants that took place on June 17th 2020 it was decided that the ROSE second complete assessment will take place in October 2020 (between weeks 42 and 43, i.e., between 12th October and 23rd October). Consequently, and taking into account the ongoing Covid-19 health crisis, the ACRE dry-run field campaign has been moved accordingly.
The dry-run ACRE campaign had multiple objectives, i.e.: testing the environment, setup and execution of the benchmarks, identifying possible issues; collecting data to be used for subsequent activities of ACRE (such as cascade campaigns); establishing contacts with stakeholders to raise interest towards ACRE, promote the competition to possible participants, and collect feedback on the ACRE benchmarks and methodology.

1 Introduction

The goal of this deliverable is to provide an approach about the ACRE dry-run field evaluation campaign given the sanitary circumstances encountered. The unfortunate situation in Europe caused by the ongoing pandemic and the consequent emergency regulations had an impact on the METRICS activities and timeline of the ACRE competitions. In particular, the first event, the ACRE dry-run field campaign associated with ROSE second evaluation campaign, which had to take place in June 2020, has been postponed in October 2020 from 12 to 23 October. In this situation, for this ACRE dry run event, only three Functionality Benchmark (FBM) and one Task Benchmark (TBM) were considered, about FBMs, i/ The Plant discrimination FBM, ii/ the Weed destruction FBM, iii/The Field navigation FBM and for TBM, the intra-row weeding TBM in parallel with the ROSE challenge second evaluation campaign.

From respectively the two first FBMs (i/ and ii/) and the only TBM the main goal was to approach the method to obtain a dataset for the dry-run cascade campaign. The combinations of crops and weeds encountered of ROSE challenge, an association of the two crops, maize and bean, with the four types of weeds, ryegrass, mustard, matricaria and lamb's quarter (chenopodium album), were considered.

The third FBM (iii/), the Field navigation FBM, was a specific experimentation about this METRICS ACRE dry-run evaluation and has been carried out on an independent plot of the INRAE experimental platform. This Field navigation FBM put in place with a maize experimental plot sown the 18th September with two maize sowing configurations had a first part with two areas of maize in straight

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 871252

row and a second part with two areas of maize with a curve row to create a row shift. Before and while the ROSE challenge evaluation period, the METRICS ACRE dry run with the field navigation evaluation has been presented and explained to the four ROSE teams to encourage their participations. In addition, an announcement of this dry-run event has been presented at the online ACRE METRICS workshop the October 17th from 10 a.m. to 12 a.m.. Another announcement about ACRE has been communicated at the online FIRA event with a short pitch of Pollimi the December 9th from 10:40 a.m. to 11 a.m. to inform all potential participant to be present at or to sponsor these ACRE events for the two future 2021 and 2022 years.

During the dry-run campaign, only one participant of ROSE challenge, the SITIA company partner of the ROSEAU team with its Trektor platform was kind enough to participate at this specific field navigation investigation at the end of the second ROSE evaluation week, the October 22th, 2020 afternoon.

2 Benchmarks approached in this dry-run field evaluation campaign

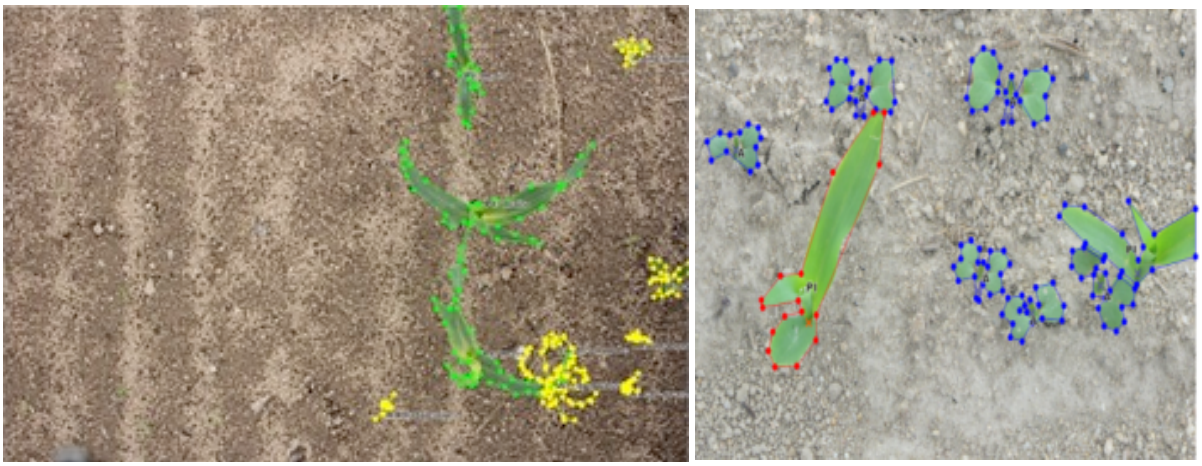
Plant discrimination FBM, Weed destruction FBM and Intra-row weeding TBM were approached by means of the second ROSE evaluation campaign. From these two FBMs and this TBM, the main goal was to check the feasibility of the evaluation plan and to obtain a dataset for the dry-run cascade campaign. All the combinations of crops and weeds encountered of ROSE challenge with the association of the two crops, maize and bean, and the four types of weeds, ryegrass, mustard, matricaria and lamb's quarter (chenopodium album) were considered.

2.1 Functionality benchmarks (FBM)

2.1.1 Plant discrimination

For this Plant discrimination FBM, the main goal was to differentiate crops from weeds on intra-row, an essential preliminary step for the autonomous weeding task. From each detection device used in the ROSE challenge, the images obtained allowed a classification of the crops and weeds present in intra-row. After human analysis, the plant classification produced by the Perception and Decision device of the robot can be compare with ground truth provided by qualified human as shown in the following Picture 1.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 871252



Picture 1: Plant discrimination with the detection task.
Crops annotations of the reference images.

2.1.2 Weed destruction

For Weed destruction FBM, the main goal is to destroy the weeds in intra-row without damaging the crops. For this evaluation, several prepared plots containing crops and weeds have been marked in the rows by visual markers, blue visual marker for the crop and yellow visual markers for the weeds (as shown in the following Picture 2). The evaluation consists of a comparison of the state of the intra row area in the plot before and after the weeding. With the visual markers, this evaluation is independent from other functionalities. To assess the effectiveness of the weed destruction and the impact on the surrounding crops, the observation of the plot is not performed just immediately after the robot path execution, but after some time, from one to several days, depending on the weeding technique used and the current weather conditions.

Picture 2: Weeding action task: color-coded markers indicate weeds
to be weeded (yellow) and crops to be preserved (blue)

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 871252

2.1.3 Field navigation

2.1.3.1 Environment

For this dry-run field navigation evaluation, a specific environment has been prepared in parallel of the ROSE challenge on the INRAE site of Montoldre in France by INRAE team. Four small experimental plots of 2 meters wide by 46,5 meters long have been prepared and sown with two rows of maize crop, the inter row spacing was 75 cm and the maize plant spacing on the sowing line was 14 cm. Two maize plots were with two maize straight lines and two other were with a curve part in the middle to create a row shift (offset). At each end of the plot, a free grassy area allowed to realise the half turn. The meteorological conditions in October limited the maize growth at only two or three small yellow leaves for an approximate size between five to six centimetres. The figure 1 below shows the field navigation evaluation set up.

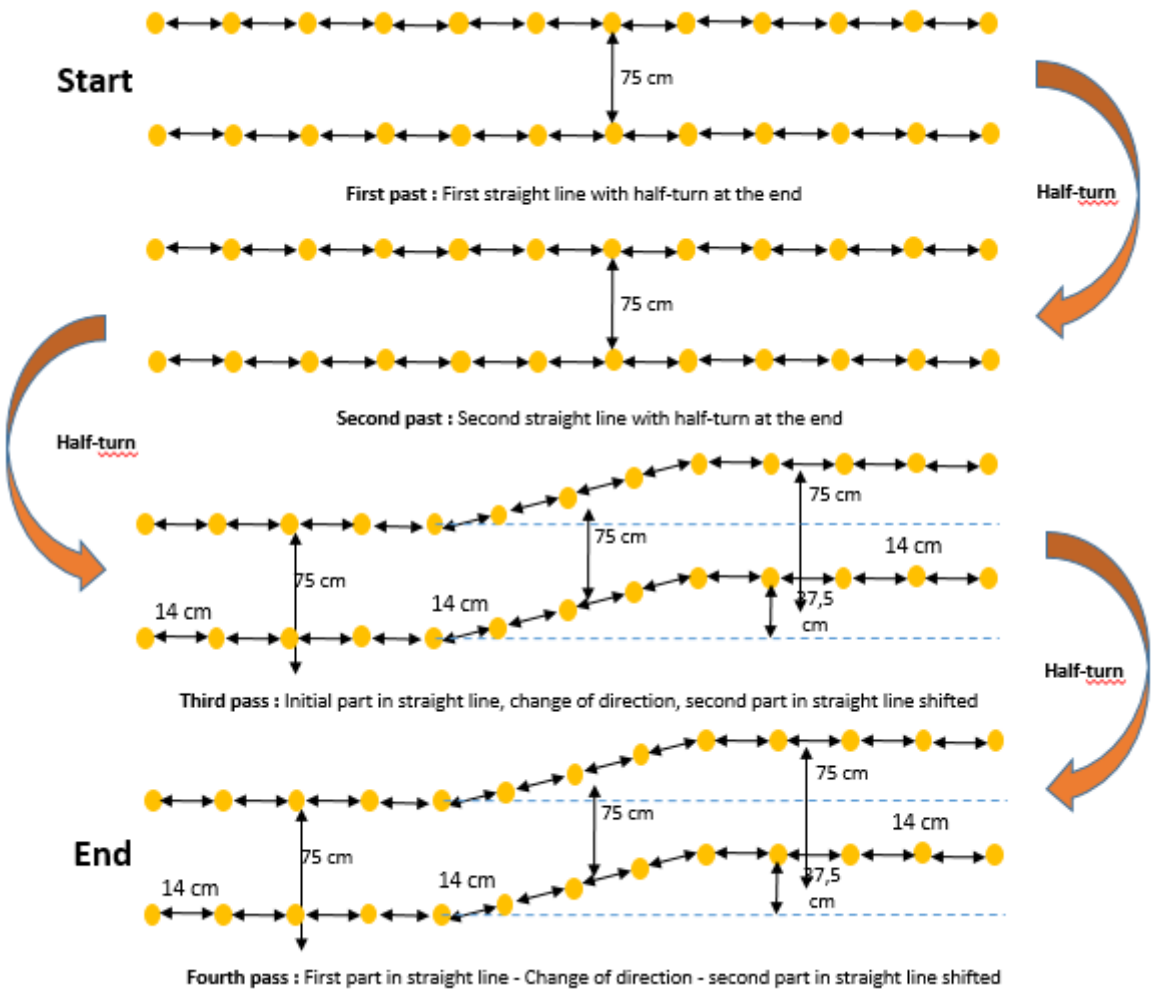


Figure 1: Field navigation evaluation set up with four maize plots.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 871252

2.1.3.2 Investigations

Only one participant of ROSE challenge wanted and participated at these investigations proposed about the METRICS ACRE field navigation evaluation, the SITIA Company. SITIA, a partner of the ROSEAU team in the ROSE challenge, participated with its Trektor platform (as shown in the following Picture 3). This specific field navigation investigation took place at the end of the second evaluation week of ROSE challenge, the October 22th, 2020 afternoon. Before this investigation operation, a SITIA operator recorded several waypoints between the maize rows on each plot with a portable RTK GPS to prepare and to configure the future Trektor trajectories on the experimental field. For the two first plots the maize rows were straight and for the two following plots the maize rows were straight in a first 10 meters part, then there was a change of direction to create a shift, and finally a second straight part until the end.

The Trektor robot platform, placed manually in front of the first straight row at the start point as shown in the figure above, followed the maize rows until the end using the GPS points stored in memory. For this experimentation, the Trektor speed chosen was low and all trajectories realised ended without damaging the crop. At each end of maize plot, the SITIA operator controlled each half turn manually. A video recording of the Trektor trajectory has been done (see METRICS/ACRE Website). The time and the speed could be extract in relation with each distance covered.

Picture 3: Field navigation experimentation with SITIA Trektor (a pass in straight line, a half turn controlled manually and a pass on curve line after half turn)

2.2 Task benchmarks (TBM)

2.2.1 Intra-row weeding

The goal of this task is to perform fully autonomous intra-row weeding of a row without help of visual marker, the weeds located among the crop plants of a row must be eliminated without damaging the crop. The intra-row weeding task is a global evaluation regarding the autonomous weeding of the row from one or more types of weeds. There are no markers on the plants and the navigation is required to be fully autonomous. For the evaluation, the number of weeds destroyed and crops plants uprooted during the intervention of the weeding system have been assessed. Both crop plants and weeds are precisely counted before the execution of the task (as shown in the following Picture 3). To assess the

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 871252

effectiveness of the weed destruction and the impact on the surrounding crops, the observation of the plot is not performed just immediately after the benchmark. Instead, robot performance is assessed according to the results of one or more delayed observations of weeds, which may show regrowth and crops, which may suffer from not immediately obvious damage but after one or several days depending of the weeding technique used and the current weather conditions.

Picture 4: Intra-row weeding and damaging crop plants assessment.
On identified assessment area, counting of crop plants and weeds before and after the weeding action

METRICS Internet Access :www.metricsproject.eu/agri-food

NOTE: COVID-19

The unfortunate situation in Europe caused by the ongoing pandemic and the consequent emergency regulations had an impact on the activities and timeline of the ACRE competition. In particular, the first field event, the dry run field campaign associated with the ROSE second evaluation event who had to take place in June 2020, have been planned in October 2020, from 12th to 23th. This is a less good period for the plant growth to get the right stage of crops and weeds. As well, the confinement period already passed impacted all robotics teams with a delay for all robotic developments. Some robotics solutions are not finished, not complete or not tested and of course not operational for the field campaign.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 871252