performance evaluation of autonomous weeding robots
Goal: encourage the development of autonomous innovative solutions for **intra-row weed control** in **field crops** with wide spacing and **vegetable crops** in order to reduce by 50% the use of **phytosanitary products**, and thus contribute to the achievement of the objectives of the Ecophyto II plan.
<table>
<thead>
<tr>
<th>Participants</th>
<th>Operational organizer (trust third party)</th>
<th>Funding body</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Challenge participants</strong></td>
<td><strong>Operational organizer (trust third party)</strong></td>
<td><strong>Funding body</strong></td>
</tr>
<tr>
<td><strong>Develop solutions</strong></td>
<td><strong>Contribute to the definition of the scientific and technological objectives of the challenge</strong></td>
<td><strong>Contribute to the definition of the scientific and technological objectives of the challenge</strong></td>
</tr>
<tr>
<td><strong>Finance the challenge</strong></td>
<td><strong>Organizes and leads the challenge</strong></td>
<td><strong>Finance the challenge</strong></td>
</tr>
<tr>
<td><strong>Contribute to the definition of the scientific and technological objectives of the challenge</strong></td>
<td><strong>Leads the definition of competition objectives and ensures that they are measurable</strong></td>
<td><strong>Contribute to the definition of the scientific and technological objectives of the challenge</strong></td>
</tr>
<tr>
<td><strong>Organizes and leads the challenge</strong></td>
<td><strong>Ensures fair treatment of participants</strong></td>
<td><strong>Contribute to the definition of the scientific and technological objectives of the challenge</strong></td>
</tr>
<tr>
<td><strong>Statue on the objectives of the challenge</strong></td>
<td></td>
<td><strong>Contribute to the definition of the scientific and technological objectives of the challenge</strong></td>
</tr>
</tbody>
</table>
The macro planning of the challenge
Operational organization of the ROSE challenge

- Four evaluation campaigns
- Six meetings in the experimental field
- An area of four hectares dedicated to experiments
AgroTechnoPôle site: Irstea Montoldre
Plot challenge ROSE

Fields meetings
Three key steps to evaluate

Detection
- Detect and identify plants

Decision
- Decide on the action to be taken

Action
- Carry out the weeding action
Types of crops planted:
- large crop with wide spacing: maize (row spacing 75 to 80 cm, foot spacing 14 cm)
- field vegetable crops: beans (row spacing 15 to 30 cm, foot spacing 3 to 8 cm)

Types of weeds planted:
spread out (horizontal):
- Model weeds: mustard
- Natural weeds: matricaria

with upright (vertical):
- Model weeds: ray grass
- Natural weeds: goosefoot
Détection

Prototype presented by BIPBIP in September 2019

Prototype presented by Weedelec in September 2019

Prototype presented by Pead in September 2019

Prototype presented by ROSEAU in September 2019

Detection evaluation
<table>
<thead>
<tr>
<th>Participant</th>
<th>Camera</th>
<th>Light</th>
<th>Resolution</th>
<th>Surface</th>
<th>d</th>
<th>θ</th>
<th>α</th>
<th>β</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RGB</td>
<td>Artificial (DEL)</td>
<td>5 Megapixels (5 pixels/mm)</td>
<td>45cm*55cm</td>
<td>40cm</td>
<td>0°</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Visible + hyperspectral (Carbon Bee)</td>
<td>Natural</td>
<td></td>
<td>50 cm</td>
<td>60°</td>
<td>0°</td>
<td>0°</td>
<td>0°</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>RGB + Infrared</td>
<td>Natural</td>
<td>1024*768 pixels</td>
<td>2m*1.3 m</td>
<td>1.3 m</td>
<td>0°</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>RGB</td>
<td>Natural (night excluded)</td>
<td>5 Megapixels (1.5mm/pixel)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>25°</td>
</tr>
</tbody>
</table>

Definition of the evaluation task

Provision of services of the data and test environments

→ References

→ Hypothesis

Metrics comparative between hypothesis and references

Error analysis and performance estimation

Four technologies for one evaluation
Acquisition of images by the 4 evaluated robots

Hypothesis: outputs from detection systems

Comparison
1. Mapping
2. Calculation of the error rate

References: manual annotations

Objective: determine the position of weeds and/or plants of interest on the images
Metric

Evaluation via the EGER metric:

\[ EGER = \frac{\sum_{k=1}^{N} C_k + FA_k + O_k}{\sum_{k=1}^{N} NR_k} \]

- \( C_k \): costs of confusion on the image \( k \)
- \( FA_k \): false alarm costs on the image \( k \)
- \( O_k \): costs of forgetting on the image \( k \)
- \( NR_k \): number of plants detected in the reference (weeds and plants of interest)
Development and use of the DIANNE software
**Next steps:**

- January 2020: presentation of the results of the first campaign
- Presentation of the results of the first campaign
- Availability of the four annotated databases during 2020 (250 images with minimum annotations per technology).
- New evaluation in June 2020

Possibility to use the parcels for image acquisition on request from IRSTEA Montoldre

To follow the progress of the challenge: [http://challenge-rose.fr/](http://challenge-rose.fr/)
Thank you for your attention
<table>
<thead>
<tr>
<th>Influencing factors</th>
<th>Controllability</th>
<th>Robustness test</th>
<th>Measurements made</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weather (rain, wind,...)</td>
<td>No</td>
<td>No</td>
<td>Daily measurements by weather station</td>
</tr>
<tr>
<td>Brightness</td>
<td>No</td>
<td>- During the image-based detection task</td>
<td>Measurements by luxmeters when participants pass through</td>
</tr>
<tr>
<td>Soil moisture content, temperature, useful water reserve</td>
<td>No</td>
<td>No</td>
<td>Daily measurements by ground probes</td>
</tr>
<tr>
<td>Clay rate measurement</td>
<td>Yes (constant)</td>
<td>No</td>
<td>Measurement before the first meeting</td>
</tr>
<tr>
<td>Technical itinerary</td>
<td>Yes (constant)</td>
<td>No</td>
<td>Described before the start of the campaigns</td>
</tr>
<tr>
<td>Crop density and distribution</td>
<td>Yes</td>
<td>- During the field detection task</td>
<td>Taking pictures before each meeting</td>
</tr>
<tr>
<td>Stage of plant development</td>
<td>No</td>
<td>- When detecting on the image database</td>
<td>Daily image capture</td>
</tr>
</tbody>
</table>

Global influencing factors
<table>
<thead>
<tr>
<th>Title</th>
<th>Project acronym</th>
<th>Coordinating body</th>
<th>Academic partners</th>
<th>Technical and economic partners</th>
</tr>
</thead>
</table>
| Bloc-outil et Imagerie de Précision pour le Binage Intra-rang Précoce | BIPBIP | Laboratoire de l’Intégration du Matériau au Système (IMS, UMR5218 CNRS, university of Bordeaux, Bordeaux INP) Team MOTIVE | • Bordeaux Sciences Agro  
• Bordeaux INP  
• CNRS  
• Université de Bordeaux (IMS, Labri équipe Rhoban) | • Les Fermes Larrère  
• Elatec  
• CTIFL |
| Perception Et binage autonome des cultures en Agriculture Durable | PEAD | Research institut Xlim (UMR CNRS 7252, multi-sites Limoges, Poitiers, Brive, Angoulême) Team REMIX | • CNRS  
• Université de Limoges (Xlim) | • CARBON BEE  
• SABI AGRI |
| RObotics SEnorimotor loops to weed AUtonomously | ROSEAU | SITIA (Engineering company) | • INRA (UMR Agroécologie)  
• IRSEEM | Les chambres régionales d’Agriculture de Pays de la Loire et de Bretagne |
| Robot de désherbage localisé par procédé électrique haute tension combiné avec une gestion prédictive par vision hyper-spectrale et post-évaluation par drone | WeedElec | UMR Itap Information, Technologies, Analyse environnementale, Procédés agricoles (Irstea, Montpellier SupAgro) Teams COMIC and PEPS | | • Irstea  
• CIRAD (AMAP, UR AIDA )  
• INRIA ( ZENITH, LIRMM)  
• INRA (UMR EMMAH/UAPV) |

Participating consortia to the ROSE challenge