

Towards a knowledge-based DIGItal Twin for a tOMato production system – DIGITOM

Doctoral position at IRHS, Angers, France

The Institute for Horticulture and Seed Research – IRHS (UMR1345) is seeking a Ph. D. student within the frame of a research project on ontology-based multiscaled modelling of tomato, financed by Institut Agro Rennes-Angers (1.10.2024 – 30.9.2027) and starting on October 2024.

Context and background

In the context of challenges such as climate change, scarcity of workforce, pressure from new pests and diseases, regulations concerning the use of pesticides, production of horticultural crops has become a difficult endeavour. There is a real need to develop new production systems, that overcome these problems. At the same time, enormous progress has been made recently at the frontiers of information science, artificial intelligence and sensor technology. 3D plant models representing plant architectural and physiological development in space and over time at different resolutions (scales) are now available, putting the creation of a horticultural digital twin within reach. Such a digital twin (i.e. a multi-scaled model able to update its parameters automatically) would be a powerful tool enabling us to rapidly optimize existing, and to propose novel, production systems *in silico*.

A digital twin consists in multiscale models with a multitude of parameters. The matter is how best to interconnect these models, and to reason simplifications at the scale of the digital twin. We therefore need to automatize the exploration of these different scales. This can be achieved thanks to a formal representation of the multi-dimensional landscape of scales and parameters through an ontology. The aim of this thesis is to navigate the ontology to determine what is relevant by comparing simulated with real data. The challenge is to carry out such a comparison by developing a method for automatically moving from one scale to another, without losing essential information.

What you will do

- Characterizing the multidimensional landscape of scales and parameters: Inventory of photosynthesis and biomass production models (especially for tomato), characterize the key parameters to create an ontology describing the parameter landscape of each model.

- Building the integration system: Define how to transfer data between ecophysiological models and scales, and represent them in the ontology for the tomato crop case. Exploit the information to describe how to use the output of one model in another.
- Greenhouse trials: Define how to measure the environment and the plants at the desired level of detail for the model(s) under consideration, based on the results of the system (output from point 2).
- Refining the integration system: Compare the experimental results with the integration system to improve the representation. A second set of experimental data may be used to validate the corrections made. Data analysis, parameterization, calibration and validation of the model

Generally, you will conduct a bibliographical comparison and an analysis of the code of various models, then propose a (re)coding of the models (Functional-Structural Plant Model, Process-Based Model, or 3D model of the greenhouse) based on an ontology to be created. This work will be followed by a sensitivity analysis, optimization studies, simulation of scenarios and validation using the platforms GroIMP and R. Validation will be provided by experiments planned on a greenhouse located on the campus.

Where you will work

Established on January 1, 2012, the Institute of Research in Horticulture and Seeds (IRHS) (<https://irhs.angers-nantes.hub.inrae.fr/>) reunites in Angers the main regional actors of the research in Plant Sciences. IRHS is a Joint Research Unit (UMR 1345) under the supervision of INRAE, the Institut Agro Rennes-Angers and the University of Angers. With currently more than 250 staff, including 183 on permanent positions, it integrates expertise in genetics, genomics and epigenomics, physiology and ecophysiology, biochemistry, plant pathology, microbiology, modeling, bioinformatics, biostatistics and biophysics for the quality and health of horticultural species and seed production.

The research team ImHorPhen (Imaging for Horticulture and Phenotyping) within IRHS is responsible for the development of the PHENOTIC plant phenotyping platform (<https://phenotic.hub.inrae.fr/>), in particular through automatic acquisition and processing systems capable of monitoring plant growth in controlled conditions at different development stages (seeds, seedlings, adult plant). ImHorPhen develops and implements methods for novel high-throughput phenotyping workflows, image analysis, machine learning, and modelling, and has recently devoted significant attention to the acquisition and processing of bioclimatic data using sensor networks, in order to achieve automatic, real-time updating of models. On the other hand, the team has acquired expertise in creating images of virtual plants which serve as training data sets for artificial neural networks in the field of deep learning.

Your profile

You should have sound skills in at least two of the following domains: bioinformatics, data sciences, computer science or plant sciences. You must be at ease with programming (knowledge of the JAVA language would be a plus) and should have a strong interest in agronomy (or plant science) and be ready to carry out experiments in interaction with agronomists. Applications with both data science and plant sciences degree will be appreciated. Your ability to communicate in English both orally and in writing is essential. (Basic) knowledge of the French language (resp., willingness to learn it) will be a strong asset, as you will have to communicate with technical staff.

Practical information

Remuneration: gross monthly salary of approximately 2100 €

Duration of project: 36 months

Deadline: May 17, 2024

If you are interested in this offer, please send your CV and a letter of motivation per email to:

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and to

Dr. Julie Bourbeillon
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Candidates will be shortlisted for an interview by the graduate school (ED VAAME). The application procedure is largely in French, but we are available to provide help if you need.

All information regarding the application process is located here: <https://theses.doctorat-bretagne.fr/vaame/campagne-2024>

The actual position is listed in the “Environnement Physique de la plante Horticole (EPHOr)” or the “Institut de Recherche en Horticulture et Semences (IRHS)” sections.