Record: an integrated framework to build, evaluate and simulate

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RECORD: an integrated framework to build, evaluate and simulate cropping systems

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Introduction

The rapid change in the agricultural industry driven by continuously arising challenges requires the development of new methods of production in order to guarantee sustainable agriculture. In silico approaches, based on the study of a wide range of possible systems through modelling and simulation, offer the possibility of identifying more quickly new systems to tackle current social, political and environmental concerns (Bergez et al., 2010).

However, building, testing, evaluating, using models (i.e. simulating different scenarios of management, pedo-climate situation, and constraints) is far from being a straightforward task. Numerous models already exist dealing with plenty of questions regarding the agrosystem functioning. Nowadays one of the main issues is more how to couple them and how to use them at different spatial and temporal scales rather than developing new ones from scratch. Integrated assessment (Rotmans, 2009) is today key word of research projects. To help the French researcher community working on cropping systems development, the French National Research on Agronomy (INRA) set up a 4-year project to develop an integrated modelling framework to gather, link and provide models and companions tools to answer new society questions regarding agriculture.

The aim of this paper is to present the framework through some examples of uses. After a brief presentation of the specifications (functional and non functional) and of the chosen computing framework, we will provide different examples to enhance the strength of the approach and how new questioning may be tackled by using the RECORD environment.

Specifications

Functional specifications were drawn during a two-day meeting in January 2007 (Bergez et al., 2007). About 50 French researchers working on cropping systems and using models to understand, analyse and develop cropping systems joined this meeting. Ideally, the computing framework should enable (short list):

- to develop new models as modular components, to re-use and combine them in order to represent cropping systems at different time and spatial integration steps;
- to allow the modelling and simulation of farmer's decision making process;
- to link with statistical packages to perform model calibration or in silico experiment analyses;
- to link with economics and optimization software and risk analysis;
- to link with databases and GIS;
- to include random weather generators to work on climate change and uncertainty

Based on these functional specifications, non functional specifications were developed (Chabrier and Raynal, 2007). Without getting in large details, software architecture, running platform, performances, programming languages, graphic user interfaces ... were analysed.

Computing choices

After having analysed or tested different existing platform (CAPSIS, ModCom, Diese, Ptolemy II), or graphical modelling packages such as ModelMaker, Stella, Simile, the VLE core environment was chosen .VLE is based on the DEVS discrete event formalism of the Modeling and Simulation theory (Zeigler et al., 2000) and is a common framework (formal and operational) for the specification of dynamical systems. DEVS defines an atomic model as a set of input and output ports and a set of state transition functions. Every atomic model can be coupled with one or several other atomic models to build a coupled model. The set of atomic and coupled models and their connections forms the structure of the model. The VLE Virtual Laboratory Environment (Quesnel et al., 2009) is an original framework that can be used to model, simulate, analysis or visualize dynamics of complex systems. It is a free and open source software developed in C++. VLE is able to integrate specific models developed in most popular programming languages into one single multi-model. One can also create a model from scratch using the GUI and linking different submodels with ports.

Examples

In order to give a flavour of the possibilities of the RECORD platform, we enumerate some examples of models currently developed by INRA agronomists:

- Providing essential cropping systems models, by encapsulating existing ones or by coding them directly into the platform: The STICS models (Brisson et al., 1998) which is a largely used cropping systems model in France has been integrated by encapsulation and made available for research on cropping systems; As for the SUNFLO model, it was coded within the RECORD environment to allow working on sunflower genetics;
- Linking decision and biophysical models to mimic action of farmers: the MO_USTICS project links the STICS model to the generic decision model MODERATO (Bergez et al., 2001) in order to develop alternative crop management systems; a phD work is also aimed at developing a generic atomic decision model for RECORD.
- Dynamically creating new entities: a crop acreage phD work allowed to develop dynamic link with GIS database and to create at run time new plots with specified crop and crop management on it;
- Integrating pest in cropping systems management: A phD is currently working on modelling the effects of spatially distributed cropping systems on the epidemics of potato late blight and on the durability of cultivar resistances (Aubertot et al, 2010); the WHEATPEST project (Soudais et al., 2010) enables quantifying individual and combined yield losses caused by a variety of pests on wheat(diseases, weeds and insects);
- Searching innovative cropping systems: optimisation algorithm such as P2P specifically developed to search optimal crop management systems have been integrated in RECORD; The MicMac design project aimed at integrating different models and approach to develop innovative cropping systems.
- Linking with statistical packages: extension allowing link to and from the statistical package R has been developed allowing model calibration, sensitivity analysis …

Conclusions

The building phase of the RECORD modelling framework is now over. Different research projects use the framework as a tool or even as an approach to reach their objectives. As developed models may be made available as package to the community, it is expected an exponential development use of the framework. Search, wait and see.

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