

# INTO-CPS – Development of Agricultural Robots

## **The Agricultural Case Study**

Within the last decades an increased focus in the agricultural industry is aimed towards higher level of automation ultimately with autonomously driving field robots. An important factor for any development of a new product is the time to market, though testing and validation takes time and typically requires the production of a number of costly prototypes. Therefore, reducing the time to market and the capability of visualising concepts and preliminary results to potential collaborators and customers are crucial when developing and launching new products.

The INTO-CPS project has supported the development of the agricultural field robot 'Robotti' to evolve from a concept machine for research purposes through a prototype to a finished product ready for sale in 2018. Using the modelling and simulation tools of the INTO-CPS tool chain, multiple simulations have been conducted as a part of the development and provided valuable information about the robotic system.

Through the INTO-CPS project, several important advantages of model-based engineering have become clear. Especially the fact that it becomes possible to increase the amount of R&D possible independently of having access to the physical machine itself, a test location, suitable weather conditions etc. A good example is how the model-based approach has provided the capabilities to develop the high-level control algorithms in parallel with the manufacturing of the physical prototypes. This allows for developing and optimizing the design of a given prototype virtually rather than spending days fine tuning control in the field.

## **The role of INTO-CPS**

The close collaboration with the technology providing partners in the project ensured that the relevant research results could be adapted directly into the development of the agricultural robots. An example of this is the Design Space Exploration (DSE) feature, which is available on top of the Co-simulation Orchestration Engine inside the INTO-CPS tool suite. This feature has been applied to investigate the optimal parameters for the controller in order to increase the performance on the robot. The DSE technique allows for performing numerous virtual tests exploring the candidate design space in an easy manner, which has shown to be a very valuable capability.

The model-based approach has been applied in the development of an additional application (in addition to Robotti). During 2017 we wished to examine the reusability of the models developed and thus added an additional case study for the autonomously steering an industrial-size lawn mower. Due to the fact that the model architecture was already established it was possible to reuse and modify the existing models to simulate the lawn mower in similar fashion as for Robotti. This was a part the development of an autonomous lawn mower. This product was initialized, developed, tested and finalized entirely during the last year of the INTO-CPS project. In addition, it turned out to be possible to combine the new models with the 3D animation FMU on top of the Unity platform in only 6 hours enabling visualisation in 3D for example experiencing how it is to sit on top of the mower in a virtual setting! The experiences here clearly demonstrated to us that it is important for us to use this technology in the future and thus the CEO of Agrolntelli is acting as the chairman of the INTO-CPS Association taking the technology further after the completion of the INTO-CPS project.

## **Impact**

Model-based visualisation has contributed both in the R&D and in internal and external communication. This was demonstrated in 2016, where Agrolntelli were able to show an interactive simulation of Robotti at

the agricultural expo Agromek. A stand was made focused on Robotti where the robot could be steered from a tablet and the corresponding motion visualized in a 3D environment on a monitor. This was not only a visual attraction, but also a key feature when telling the story about Robotti to future collaborators and potential customers. Robotti was rated as a pioneering new innovation and won the Agromek Award in 2016<sup>1</sup> at the Agromek show in Herning, Denmark.



*Figure 1: The autonomous Robotti robot in the field*

More information:

- <http://www.agrointelli.com/>
- [www.into-cps.org](http://www.into-cps.org)

Movies:

- [https://www.youtube.com/watch?time\\_continue=1&v=OLAwr54UubY](https://www.youtube.com/watch?time_continue=1&v=OLAwr54UubY)
- <https://www.youtube.com/watch?v=GUFQOSbXehs>
- <https://www.youtube.com/watch?v=A95YGKpMTuM&t=13s>
- <https://www.youtube.com/watch?v=sb3vGZtXIOk>

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<sup>1</sup> <https://www.agromek.com/press/agromek-press-releases/agromek-award-for-robotti?PID=38864&M=NewsV2&Action=1>