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Development of a precision agriculture downloadable content for the farming simulator game

Book or Report Section

Accepted Version

Pavlenko, T., Argyropoulos, D., Arnoult, M., Engel, T., Gadanakis, Y. ORCID: https://orcid.org/0000-0001-7441-970X, Griepentrog, H.W., Kambuta, J., Latherow, T., Murdoch, A., Tranter, R. ORCID: https://orcid.org/0000-0003-0702-6505 and Paraforos, D.S. (2023) Development of a precision agriculture downloadable content for the farming simulator game. In: Stafford, J. V. (ed.) Precision agriculture '23. Wageningen Academic Publishers, pp. 797-804. ISBN 9789086863938 doi: https://doi.org/10.3920/978-90-8686-947-3_100 Available at https://centaur.reading.ac.uk/112636/

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To link to this article DOI: http://dx.doi.org/10.3920/978-90-8686-947-3_100

Publisher: Wageningen Academic Publishers

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Gamification for communicating the advantages of Precision Farming: The Farming Simulator case

Pavlenko T.[1], Argyropoulos D.[2], Arnoult M.[3], Engel T.[4], Gadanakis Y.[3], Griepentrog H.W.[1], Kambuta J.[5], Latherow T.[3], Murdoch A.[3], Tranter R.[3], Paraforos D.S.[6,1]

[1]*Institute of Agricultural Engineering, University of Hohenheim, Garbernstr. 9, 70599, Stuttgart, Germany*
[2]*School of Biosystems and Food Engineering, University College Dublin, Belfield, Dublin 4, Ireland*
[3]*School of Agriculture, Policy and Development, University of Reading, Whiteknights PO Box 237, RG6 6EU Reading, UK*
[4]*European Technology Innovation Center, John Deere GmbH & Co. KG, Straßburger Allee 3, 67657 Kaiserslautern, Germany*
[5]*Department of Land Management and Systems, Faculty of Agribusiness and Commerce, Poplars Building 007, PO Box 85084, Lincoln University, Lincoln 7647, Christchurch, New Zealand*
[6]*Department of Agricultural Engineering, Hochschule Geisenheim University, Von-Lade-Str.1, 65366, Geisenheim, Germany*
d.paraforos@uni-hohenheim.de

Abstract

Precision Farming (PF) offers solutions enabling informed decision-making on farms and contributes to agricultural sustainability. However, despite the evidence-based benefits of PF, the adoption of different related technologies at the farm level is slow. One of the approaches for increased awareness and delivering knowledge about the advantages of PF is education among different groups of stakeholders. To address this issue, a study in the scope of an EIT-Food-funded project was aimed at integrating the main principles of PF into an existing game. The PF module can be considered a novel and innovative way to communicate the benefits of PF and encourage stakeholders to adopt its principles.

Keywords: serious games, adoption, gamification, variable rate, site-specific

Introduction

The application of precision farming (PF) technologies gives access to a large amount of data that can be used for making informed decisions on farms (Paustian and Theuvsen, 2017). These technologies have the potential to reduce costs, increase yields, and profit, as well as improve soil, water, and air quality (Kolady et al., 2020). There are different rates for the adoption of farm-level crop PF technologies. For some of them, the uptake is considered slow. For example, at the regional level, the adoption of variable-rate technologies (VRT) rarely exceeds 20 % (Lowenberg-DeBoer and Erickson, 2019).
In recent years, more attention has been given to convincing people to adopt technologies through playing serious games. A game itself includes a story, art, and software that are brought together into a finished product. A serious game goes beyond these three components, and also includes pedagogy, e.g. educational or instructive activities that bring knowledge or skills. This makes the game serious. But first comes an entertainment

component, and pedagogy is subordinated to the story (Zyda, 2005). Playing serious games should increase players' motivation and active engagement (Robinson et al., 2021).

Several studies present how serious games have been used in agriculture. The main focus of the Horizon 2020 project "GATES" was to create a serious game-based training platform to deliver training to the actors in the agricultural value chain on the application of smart farming technologies (GATES, 2019). A farming simulator application that was developed by Kovács et al. (2017), aimed at the introduction of agriculture to students and young generations. Nuritha et al. (2018) described the gamification of the social agriculture application for increasing end-user engagement. Tangworakitthaworn et al. (2020) described two serious games that enhanced learning for education in agricultural engineering to promote nature conservation and contribute to the environmental mindset of children and younger people. Orduña Alegría et al. (2020) stated that serious games can support the better exploration of diverse real-world scenarios related to climatic changes by contributing to the emergence of different behaviour theories.

This paper aims to describe the development process of the second version of the PF DLC (downloadable content) as a part of the GIANTS Farming Simulator game (GIANTS Software GmbH, Zurich, Switzerland). The main objective of the study is to disseminate knowledge about the benefits of PF among different groups of stakeholders and to contribute to increasing their interest in PF technologies. The novelty lies in the use of a widely accepted game related to farming to reach a larger audience.

Materials and Methods

The Game

Farming Simulator is a game, in which a player takes a role of a modern farmer to develop and run a farm. The game offers three diverse American and European environments. In this study, Farming Simulator 22 was used. This version of the game has a wide range of farming operations including farm management, agricultural systems (such as animal husbandry, cropping, and horticulture), and forestry. It has a choice of over 400 machines and tools represented by more than 100 real agricultural brands. In addition, this version also provides seasonal cycles (GIANTS, 2022).

First DLC and implemented PF features

The outcomes of the first part of this research (Pavlenko et al., 2021) resulted in the introduction of eight PF features in the DLC and their implementation in version 19 of the Farming Simulator game. The list of PF features consisted of: (1) automatic steering with an RTK GNSS receiver; (2) the introduction of soil heterogeneity based on different soil texture classes and different pH levels; (3) the different soil texture classes that correspond to a different level of yield potential; (4) soil sampling and soil properties based on laboratory analysis; (5) site-specific variable-rate lime spreading; (6) site-specific variable-rate nitrogen (N) fertilizer spreading with two different options (organic fertilizer and dry and liquid mineral N fertilizer); (7) yield logging on the combine harvester for grain crops and creation of yield maps; and (8) farm economic analysis.

Questionnaires on PF features ranking

To get feedback from students studying agriculture and related sciences, four universities from four countries were involved: The University of Hohenheim (Germany), The

University of Reading (UK), University College Dublin (Ireland), and Lincoln University (New Zealand). In total 95 undergraduate and postgraduate students received a questionnaire with the task to rank PF features based on their importance. The number of students varied per country: Ireland (9), Germany (27), New Zealand (45), UK (12). The questionnaires were provided to the students either by email as a Word or Excel form or as a link to Google forms. In both cases, the questions were the same. Collection of the students' feedback about PF features was done regardless of the fact of whether they had played the game or not. The students were provided with a list of features and were asked to rank them by assigning a rank from '1' to '5', with '5' having the highest priority. The list had 26 PF features in total.

The same questionnaire that was given to students, was disseminated to representatives of the scientific community as a Google form. It was done by: i) providing the link to the audience during the presentation of the paper (Pavlenko et al., 2021) at the ECPA 2021; ii) including the link to the survey in the ECPA newsletter that was disseminated via email; iii) individual email contacts; iv) link dissemination by the universities' networks. The questionnaires were anonymous. No personal data was collected from the audience and appropriate ethical clearance procedures were followed.

Student workshops and feedback related to both DLCs

After the release of each DLC, a number of workshops were organised in the universities involved. In this case, the workshops aimed to get feedback from the students about their impressions on both versions of the developed PF DLC. In total 135 undergraduate and postgraduate students received a questionnaire with questions such as "What was it like to play the game with the PF DLC?" and "How likely are you to adopt PF on a farm?". The number of students varied per country: Ireland (10), Germany (20), New Zealand (88), UK (16).

Discussions

The study was accompanied by regular virtual meetings of the partners of the consortium. During these meetings, different PF features and their integration into the game were thoroughly discussed. The criteria for the selection of the features included feedback from the agronomy and crop science specialists, inputs from the agricultural engineers, discussions on the importance of the PF features as well as the technical possibilities to develop and implement them in the game itself (provided by GIANTS Software).

Results and Discussion

Feedback on PF features

Figure 1 illustrates the results of the ranking of PF features by students and scientists. In total, 73 replies were obtained from the scientific community, and 95 replies were obtained from university students. Based on the survey results, the PF features, the importance of which scientists and students ranked with the smallest difference in points, were controlled traffic farming, weed patches in the field, residual N considered, a layer of soil density, and purchase of biomass images from satellite providers. The difference in ranking between the two respondent groups for those features varied from 0.2 to 0.6 points. The biggest difference in ranking between the two respondent groups varied from 0.35 to 0.52 points. Those were online sensor readings, soil scanner, purchase of

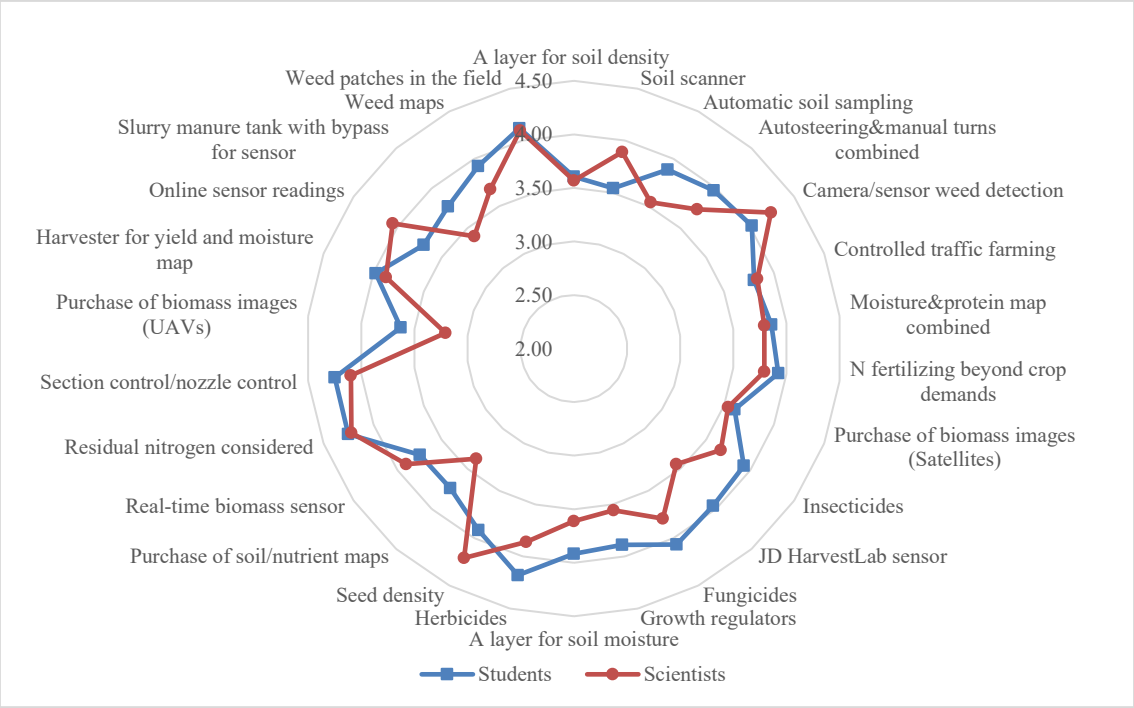

Figure 1: A spider graph illustrating students' and scientists' ranking of the importance of the PF features.

soil/nutrient maps, slurry manure tank with bypass sensor, purchase of biomass images from UAV providers, and John Deere HarvestLab sensor.

There was a difference in the preferences of scientists and students. The PF features that were highest ranked by scientists included camera/sensor weed detection, residual N considered, and seed density. Students, at the same time, preferred residual N with the consideration of the section control/nozzle control, and use of herbicides. Compared to the scientists, the purchase of biomass images (by using UAVs), the purchase of soil/nutrient maps, and a slurry manure tank with a bypass for the sensor, were the least ranked PF features. The lowest ranking from students included soil scanner, purchase of biomass images (through satellites), and a layer for soil density. All of the PF features that were highest ranked by both respondent groups corresponded to the decision of the consortium and were the biggest part of the features list that was implemented in the second version of the DCL.

Students feedbacks

Several questions were delivered to the students, who were involved in agricultural studies. Out of the total 135 replies to the question "What was it like to play the game with the PF DLC?", 40 % of the students characterised the DLCs as 'quite good fun', and 26 % as 'good fun'; 22 % agreed on it being 'neither fun nor boring'. On the question "How likely are you to adopt PF on a farm?", 24 % of the students indicated that they were 'very likely', 34 % said that they would be 'somewhat likely', and 18 % of the respondents were 'neutral'. Among many best impressions about the PF DLC, the most often used terms were the realism of the game, the introduction of soil testing and variable rate as well as insights into farming and learning about management practices. Students also indicated that as a result of playing the game, they learned more about the importance of PF and the application of its specific technologies, and about inputs and costs that

should be considered when managing a farm. The above-provided information was combined with replies from the questionnaire that were disseminated after the release of the first version of DLC and after the release of the second one.

DLC 2 features and release

The second version of the PF DCL was finalised, and released on April 22nd, 2022. The DLC is available for free and can be downloaded and installed from the GIANTS website (GIANTS Software, 2022). Next to the already eight existing features, six new ones were added to the game: (1) purchase of soil/nutrient maps from a service provider; (2) variable rate seeding/drilling; (3) variable rate weed control with a camera and individual nozzle control; (4) variable rate organic fertilization with HarvestLab Manure Sensing; (5) definition of crop N demand/variable rate fertilization with an online crop biomass sensor; and (6) environmental score. These features are described in the following subsections.

Purchase of soil/nutrient maps from a service provider

This feature allows for saving time as a player avoids performing soil sampling in a manual mode. A decision to add this feature was done based on the fact that after the release of the first DLC with the manual soil sampling, there were many complaints from the students and players of the game that soil sampling requires a lot of time and became annoying at one point.

Variable rate seeding/drilling

It was added to the game for several crops (Figure 2). Three seed rate options are available: low, standard, and high. Adjusting seed rates is available in different zones of each field. The best seed rate has the highest yield potential and increases competitiveness against weeds.

Variable rate weed control and individual nozzle control

In the current DLC, the weeds are not appearing homogeneously distributed in the field, but they may appear in bigger or smaller patches. Since weeds do not grow all over the field, this gives the option to save money on herbicide by using a sprayer with the option

Figure 2: Variable rate seeding/drilling

Figure 3: Variable rate weed control with a camera and individual nozzle control

for “Spot Spraying” (Figure 3). This ensures that each nozzle of the sprayer will only turn on while there are actual weeds below the nozzle. Like this, up to 90 %, less herbicide is applied, reducing costs and protecting the environment. The DLC added the “John Deere R732i PowrSpray” sprayer which included the “See & Spray™” configuration.

Variable rate organic fertilization with HarvestLab Manure Sensing

The DLC added new functionality in the game so that the N concentration in the slurry manure is not homogeneous anymore and constantly varies. The applied N can differ from the expected application rate up to 40 %. To compensate for this, each slurry tanker in the game now has the option to install the manure sensing system from John Deere that has a near-infrared sensor measuring the current N content. As the machine travels across the field, the manure application can be adjusted based on the information obtained from the sensor.

Definition of crop N demand/variable rate fertilization

In the game, there are two sensors available: (i) “active” – the ISARIA PRO Active – that can be used day and night: and (ii) “passive” – the ISARIA PRO Compact – that required daylight to function. By using the information provided by these sensors, real-time variable rate N fertilization can take place.

Environmental score

The environmental score indicates whether a player is growing crops in an environmentally friendly and sustainable way. A total score is available across all the fields, but also the score for each field could be obtained. The score directly affects crop value in the game. The maximum score of 100 will increase the price that a player gets for the crop by 15 %. Several scoring aspects influence the score: N application, liming, weed control, soil sampling, and tillage. More information about the rewarded points can be seen in Table 1.

Table 1. Allocation of points for the environmental score in the game

Step or Field State	Maximum points	Rewarded points
N application	30	
Over-fertilised (+20 kg)		0
Over-fertilised (+10 kg)		15
Optimal (0 kg)		30
Under-fertilised (-10 kg)		25
Under-fertilised (-20 kg)		20
Liming	15	
pH too high (+2)		0
pH too high (+1)		7.5
pH optimal (0)		15
pH too low (-1)		7.5
pH too low (-2)		0
Weed control/herbicides	30	
Spot spraying (See&Spray)		30
Mechanical weed control		20
100% sprayed		15
No weed control		10
Soil sampling	15	
0% of field samples		0
50% of field samples		7.5
100% of field samples		15
Tillage	10	
Plough/deep cultivation		0
Shallow tillage		5
Direct tillage		10

As can be seen in Table 1, different scenarios about the rewarded points were introduced. These scenarios were essential to reward practices that did not utilise the implemented PF technologies to a full extent but only partially. During the discussion, it became evident that the rewarded points should correspond to realistic agricultural practices but at the same time fit the special characteristics of the game and the playing strategies.

Conclusion

This paper describes how the second version of the PF DLC was developed and integrated into the Farming Simulator game. The main challenge was to decide on the PF features to be added to the existing DLC, which would deepen the interest of the players in PF and, at the same time, keep the game not difficult but fun. The PF features that were chosen by the consortium and integrated into the game by GIANTS Software, mainly corresponded to choices that were highest ranked by the respondents through the questionnaire survey. Testing the new DLC with the students resulted in positive feedback and broadened the knowledge of participants of the workshops in PF technologies. The next steps of this study are aimed at a more profound analysis of collected feedback and getting more insights about gamification as a method to disseminate scientific knowledge on PF practices.

Acknowledgements

The work was performed through a project funded by the European Institute of Innovation & Technology (EIT-Food) a co-funded body of the European Union, under the Horizon 2020, the EU Framework Program for Research and Innovation, project number 20224.

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