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Creating machine-readable application maps using GIS and geodata

In the scope of the iGreen project, a GIS-based decision support system for farmers has been developed. This so-called Crop Protection Manager aims to support farmers in decisions on crop protection measures. Besides answering questions about necessity of and strategy for such measures, the tool focuses on creating machine-readable application maps using a web based GIS-application. These application maps include legal buffer zones to water bodies and protected terrestric structures, e. g. hedges, where spraying of pesticides is prohibited. In this process private data from the farmer, e. g. field geometries, pesticide and spray nozzle used, as well as public (geo-)data from different public institutions are used.

Keywords
Crop protection, Geographic Information System GIS, geodata, iGreen, legal buffer zones, Crop Protection Manager

Abstract
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Expectations towards the use of pesticides in Germany are high. This is necessary to sustain public acceptance of modern agriculture. Farmers need an efficient data management because complying with rules and requirements regarding planning, application and documentation of pesticide measures causes a high level of information density.

To prevent deposition of pesticides into water bodies as well as other damage to the environment several laws about legal buffer zones to rivers, etc. apply. The instructions coming with each pesticide explain the product specific buffer zones. Certain pesticides require e.g. to keep a distance of 20 m to water bodies if the field slopes more than 2 %. Besides that, legal buffer zones depend as well on the application technique. The drift reduction class of spray nozzles is the important point here. Additional there are specific laws in each Geman state that oblige buffer zones to water bodies and if a district does not have an adequate amount of small landscape features (e. g. hedges) buffer zones to such structures apply, too.

Because of these factors and the necessary documentation proper crop protection is challenging for farmers who want to achieve an optimal and correct implementation. These challenges are even more demanding for agricultural contractors and large-scale farming. Particularly, varying machine operators and aeras of application adversely influence this problem.

In the scope of the iGreen project the so called Crop Protection Manager has been developed to support a proper pesticide application by facilitating its processes for farmers. In iGreen 23 partners from industry, research and public institutions have been working together in an innovation alliance under lead of the German Research Center for Artificial Intelligence (DFKI). The iGreen project was working to develop an infrastructure and communication standards for area-based agricultural extension services over the internet. It aimed to make public as well as farmer´s private data sources available for the extension service to improve its quality and convience of communication and data exchange (www.igreen-projekt.de).

The Crop Protection Manager has been developed as a reference implementation, which is based on the iGreen-IT-Infrastructure to illustrate its functionality. It is an internet-based Decision-Support-System (DSS) for farmers, that supports crop protection decisions on field-plot level. Aim is to optimize and automate the crop protection process as far as possible.

The farmer is given advice in two vital questions:

- Should I conduct a pesticide application on my field? In which time interval should I apply?
- Where on my field am I allowed to apply? Which legal buffer zones to which objects do I have to obey?

In the iGreen project late blight on potatoes has been chosen as an example. In the future an extension to other plant diseases and all permitted agricultural pesticides is planned.

Fig. 1

Steps of the Crop Protection Manager

Process

The advice is carried out in a five-staged process, in which data from the farmer as well as public information and geodata is integrated (**Figure 1**).

1. Data Input in GeoForm

To allow field specific advice, in a first step data from the farmer is necessary. This includes information about cultivated crop, geographic coordinates of the field or spray nozzle used (drift reduction class). For data input a GeoForm on a desktop computer or mobile device (e.g. smartphone or tablet) is used (**Figure 2**).

Fig. 2

GeoForm Crop Protection

2. Simulation of Epidemic Progress based on Meteorological Data

In a second step one of the prediction models for agricultural pests and diseases of ZEPP (implemented on www.isip.de) calculates field specific starting date as well as treatment intervals for pesticide measures. Thus, it answers the question about necessity for a pesticide application [1].

3. Calculation of Buffer-Zones based on Legal Regulations

In a third step the so called Buffer Zone Tool identifies – based on public data – zones inside the field, in which pesticide application is not allowed. The output is a machine-readable application map (**Figure 3**). The following factors are included in the process:

- Pesticide specific buffer zones to water bodies or other landscape structures deserving protection based on infor-

Fig. 3

Functionality of the buffer zone tool

mation from the pesticide database of the German Federal Office of Consumer Protection and Food Safety (BVL) [2]

- Buffer zones that arise from the slope of a field (e.g. > 2 %)
- Buffer zones that arise from spray nozzles used (drift reduction class)
- Buffer zones to water bodies depending on which German state the field is in
- Buffer zones to terrestric structures deserving protection based on the index of small landscape features by the Julius Kühn-Institut (JKI), Federal Research Centre for Cultivated Plants

Base for the field specific calculation is geodata from the German Federal Agency for Cartography and Geodesy (BKG), which contains information about the geographical position of water bodies and landscape structures for whole Germany.

The calculation of the buffer zones is carried out by an online-GIS-application. Within the scope of a complex geo-processing service information and geodata from the sources mentioned above are intersected to identify zones in the field where pesticide spraying is prohibited. The result is a map that defines application zones and legal buffer zones.

It´s important to mention, that the generated application map is only a recommendation for the farmer, which has to be checked for accuracy. Public geodata can be imperfect. Therefore the user has the possibility to edit the map. This is necessary if e.g. a little stream is not included in public data. From a judicial perspective this is important as well, because the driver is the one who carries the legal responsibility for the pesticide application.

4. Transfer to Terminal using the non-proprietary ISO-XML Format

The application map is provided using the non-proprietary ISO-XML format [3] which can be applied to terminals of different manufacturers. The file format ISO-XML is becoming more and more established in agricultural engineering. A fact that has as well been promoted during iGreen, in which several machine manufacturers cooperated.

Fig. 4

Application Tasks on Terminals of CCI- (left) and John Deere (right)

Figure 4 shows examples for crop protection tasks on terminals of John Deere and the Competence Center ISOBUS e.V. (CCI).

5. Application and Documentation

Provided that a tractor with GPS and a pesticide sprayer with section control is available, an automated application is possible. Once the sprayer moves into an area of the field that is a buffer zone, the respective section is switched of automatically (**Figure 5**).

Modern terminals are able to record data about pesticide applications. As such, the documentation process is simplified significantly. The protocol file can be used as justification towards public authorities or purchasers. The compliance with legal buffer zones can be proven. Furthermore the information generated can be used for consecutive treatments.

The Crop Protection Manager has been tested successfully on pilot farms in Saxony-Anhalt, Lower Saxony and Rhineland-Palatinate. Additionally combinations of different terminals from several manufacturers have been used to conduct integration tests. To do this the terminals have been connected to on-board computers. The application process was imitated with a simulated GPS-signal (**Figure 6**). For the tests, field geometries have been edited and the virtual GPS-tracks chosen such, that the field boundaries were passed, to check the automatic section control.

Data Privacy Protection

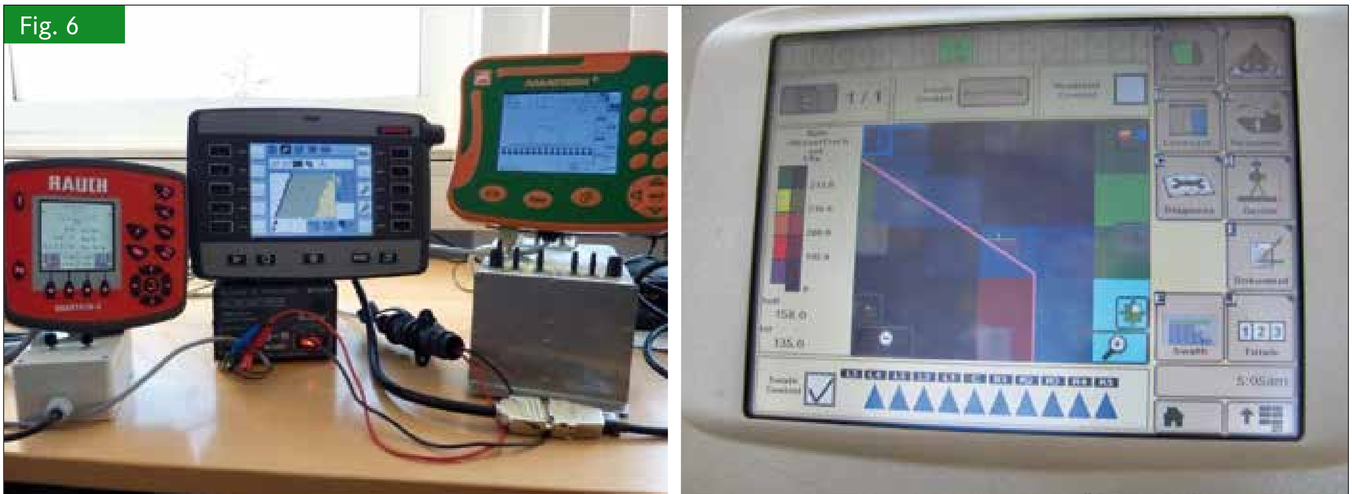
The data entered into the GeoForm as well as the application map created are property of the farmer. No automatic data exchange about pesticide applications with authorities will take place.

Data from public authorities is inserted into the system to improve the DSS, but no information about the user is given back. Data ownership stays with the farmer and is not touched.

Fig. 5

Crop Protection Measure (Foto: ZEPP)

Fig. 6



Combination of Different Terminals and Attachments (Foto: ZEPP)

Benefits for Farmers

Using the Crop Protection Manager and the iGreen-infrastructure brings several benefits:

- Oberservance of legal buffer zones
- Facilitation of a proper pesticide application
- Cost optimization due to automated section control
- Environmentally sound and sustainable use of pesticides
- Automated documentation

Conclusion

The development of the Crop Protection Manager has been finished successfully. It is currently running in a test stage. The iGreen project has been completed. Since for reaching marketability still many details have to be solved and implemented (e.g. inaccuracy of public geodata), ZEPP will continue developing its iGreen results in cooperation with several partners in another project.

The goal is to offer the service in the medium term to every farmer in Germany using the internet portal of ISIP (www.isip.de). As an upgrade direct connections to Farm Management Information Systems (FMIS) are planned to allow the integration of existing private (geo-)data. Furthermore a dynamic integration of several other data sources (pesticide data from public authorities and industry) as well as a system for automated identification of pesticide canisters are intended.

References

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