Detection of Hygiene-relevant Parameters from Cereal Grains based on Intelligent Image Interpretation and Data Mining

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Abstract

We are going on to develop a novel method for the detection of hygiene-relevant parameters from grains of cereal crops based on intelligent image acquisition and interpretation methods as well as data mining method. We present our first case study that describes the data acquisition, the planned image analysis and interpretation method as well as the reasoning methods that can map the automatic acquired parameters of grain to the relevant hygiene parameters. The preliminary results show that with the new computer science methods it is possible to come up with new insights into the quality control of food stuff.

1 Introduction

Fungal contamination of cereals is a serious economic problem throughout the world. Several fungi cause a reduction of grain quality, especially changes in colour and taste [Müller et al., 1997], [Herrman et al, 1998], and [Rodeman, 2003]. However the main riks of fungal damage arise from the production of toxic compounds, known as mycotoxins. Mycotoxins can cause serious adverse health effects. Toxigenic fungi that produces mycotoxins in grains of cereals or oil seeds belong to the genera Aspergillus, Alternaria, Fusarium and Penicillium. The control of this problem is therefore of particularly interest in food safety and quality control programs.

The aim of the research is the development of an automatic image acquisition and image interpretation system for the fast recognition of cereal grains damaged by fungi. Thereby should be developed a data acquisition unit that allows to take the coverage from the grain and allows to place it under a microscope for the acquisition of a digital image. This image should be used in order to automatically determine the number and the kind of fungi spores contained on the grain. For that we have to develop suitable intelligent image analysis and interpretation methods. Based on the enumeration of fungal spore classes we have to develop a method that can map this information to the hygiene-relevant parameters. The work we present here reports the results of our first case study. They show that the proposed methods based on intelligent image analysis and data mining are very suitable to capture the desired information and allow recognizing formerly unknown information that can be helpful to determine the quality of food staff.

2 Material

For the study have been used different quality classes of wheat grains:

1. visual optical perfect grains from a charge where no fungal grains were included,
2. fungal damaged grains,
3. gall-mosquito damaged grains, and
4. visual optical perfect grains taken from a charge of fungal damaged grains.

In total we had 10 samples from each class. Thirty single grains were taken from each sample for further evaluation.

3 Image Data Acquisition

The main problem was to make the coverage on the grains visible under the microscope and make it useable for further digital processing. Therefore we have developed a procedure for taking the coverage from grains and bring it onto a medium that can be placed under a microscope. From there can be acquired a digital image with the help of a digital camera connected with the microscope.

The method of choice was a water-based extraction method. The grains were placed into a boil together with stones. This water-filled boil was shaked for 2 minutes, then the water was filled into a centrifuge and the sediment was put on a slide. This slide was placed under the microscope and an digital image was taken. There are other methods for extracting the coverage from the grain possible but this should not be the main topic of this paper. The resulting digital images are shown in Figure 1a-4a.

4 Intelligent Image Analysis and Interpretation

4.1 Image Analysis

The main aim of the image analysis was to recognize possible fungi spores and process them further for further determination of the type of fungi spore. Here we used our novel case-based object recognition method [Perner et al., 2005] developed for recognizing biological objects with high variation. For the architecture of such a system see Figure 5. The case-based object recognition method uses cases that generalize the original contour of the objects and matches these cases against the contour of the objects in the image. During the match a score is calculated that describes the goodness of the fit between the object and the case. Note the result of this process is not the information what type of fungi spore is contained in the image. The resulting information tells us only if it is highly likely that the considered object is a fungi spore or not. Further evaluation is necessary to determine the kind of fungi spore. This demonstrates the result in the images, see Figure 1b4b. One of the main problem of such a case-based object recognition method is to fill up the case base with a sufficient large enough number of cases. We used our procedure described in [Perner et al., 2004] for that. For the study we have 10 different cases which is not enough as we can see in the image but it allows us to demonstrate the applicability of the method. The method has to be adapted to the specific image quality to show better results as well as more cases have to be learnt by our case acquisition procedure.

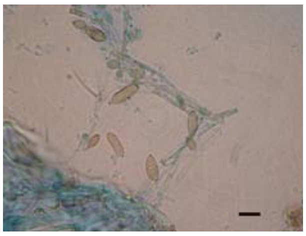


Fig. 1a Coverage of Grain with Cladosporium

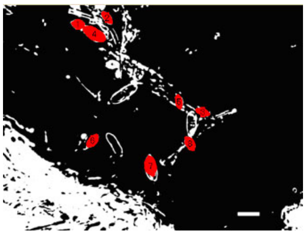


Fig. 1b Segmented Image

Fig. 2a Coverage of Grain with Alternaria Alternata

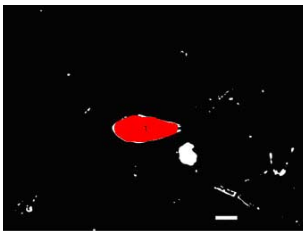


Fig. 2b Segmented Image

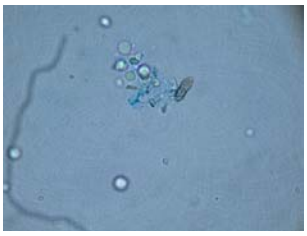


Fig. 3a Coverage of Grain

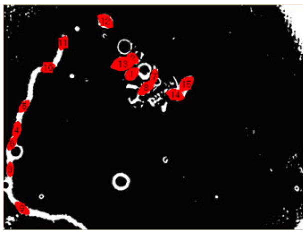


Fig. 3b Segmented Image

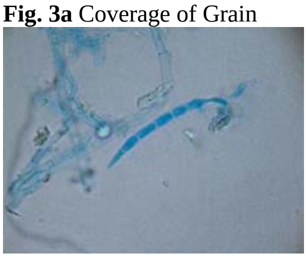


Fig. 4a Coverage of Grain with Fusarium Spore

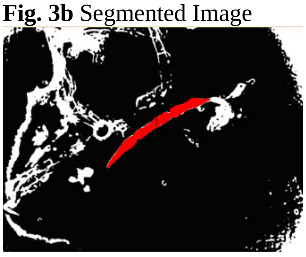
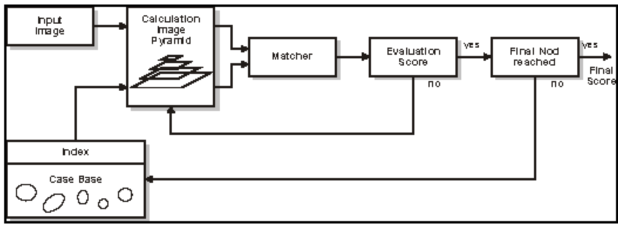


Fig. 4b Segmented Image

Fig. 5 Architecture of a Case-Based Object Recognition System



4.2 Image Interpretation and Data Mining

After the methods have been recognized potential objects that are likely to be fungi spores we have to extract more features from the objects that distinguish the object from background and different fungi spores. Of course one feature is already the shape information used in the matching process but that is not enough for more detailed recognition. The features that have to be calculated for this kind of objects are the inner structure, texture and gray level information. We haven't done that for this kind of objects considered in this publication yet. But we know from our past research on airborne fungi that it is possible to find automatic extractable features to describe fungi spores and use them for classification into different kind of fungi spores. It is left to future work to find the right features for the considered fungi spores in this application and to build the feature extraction procedure for them. Based on this feature set we can construct the classifier. We use decision tree induction based on our tool Decision Master [Perner, 2003]. This gives us a good classifier. As the result we will get the information about the kind of fungi spores contained in the image and the number of fungi spores versa the kind of fungi spores.

5 Mapping of Image Information to Hygiene Relevant Parameter with Data Mining

In this study the kind and the number of fungi spores was determined manually since it was a case study and we haven't developed the fully automatic system yet. The aim of the study was to figure out if the proposed methods can bring out information about hygiene-relevant parameters and besides that new information that can be used to control the quality of food stuff. From the 4x10 different samples a data base was created where the columns of each entry shows the class, that is the optical visual inspection label, the number of Fusarium spores, the number of Alternaria/Ulocladium, the number of Aspergillus/Penicillium, the number of Cladosporium, the number of fungi spores with unknown classification and the total number of fungi spores. Besides that we determined for each charge the Don value based on a ELISA test. In addition to the enumeration of fungal spores the concentration of a main mycotoxin of the genus Fusarium deoxynivalenol (DON) was determined by a commercial enzyme immunoassay screening.

Table 1-4 show that there is a significant difference in the number and the kind of fungi spores for the different charges. Figure 6 shows that DON value corresponds to the visual determined class labels. Grain with a low number of Fusarium spores have low DON values and grain charges with high number of Fusariam spores have high DON values.

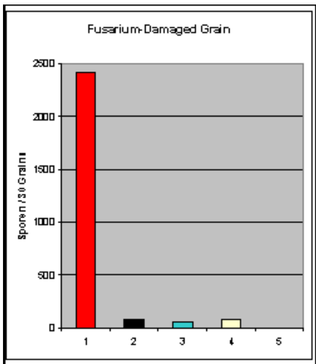


Table 1 Fusarien Damaged Graind

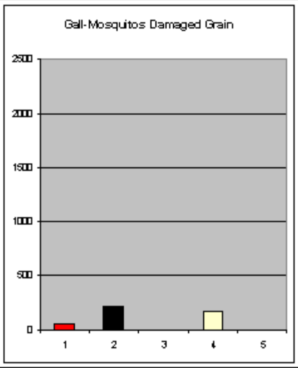


Table 2 Gall-Mosquitos Damaged Grain

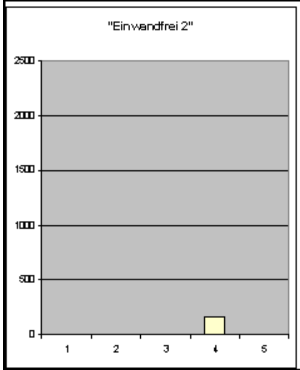


Table 3 Charge "einwandfrei 2"

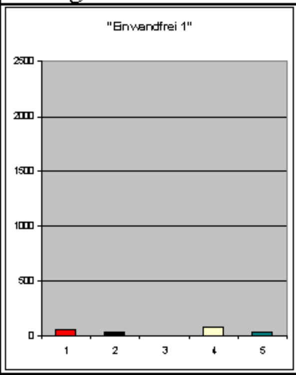


Table 4 Charge "einwandfrei 1"

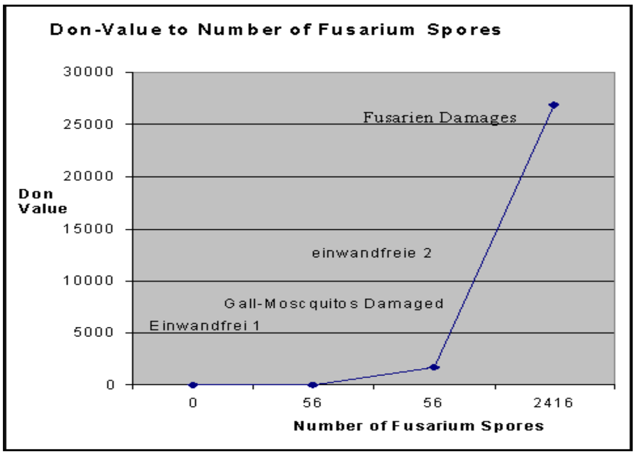


Fig. 6 Don Value to Number of Fusarium Spores

Decision tree induction with Decision Master [Perner, 2003] on an entropy-based criterion was performed in order to find out the relation between the coverage of fungi spores and the class label (mycotoxin value). The induction experiment shows that there is a relation between the number of Cladosporium spores and Fusarium spores respective the class, see Figure 7. It says that grain charges with a high number of Cladosporium spores will have a low number of Fusarium spores. That means these charges are either perfect charges or gall-mosquitoes damaged charges. Whereas charges with low Cladosporium spores can be either charges with a high number of Fusarium spores or a low number of Fusarium spores. Note that charge "einwandfrei 2" (visual perfect grains) has been taken out from a sample with Fusarium damaged grains. It seems that the number of Cladosporium spores indicates this fact. The number of Alternaria and Aspergillus spores did not have a significant influence in this experiment.

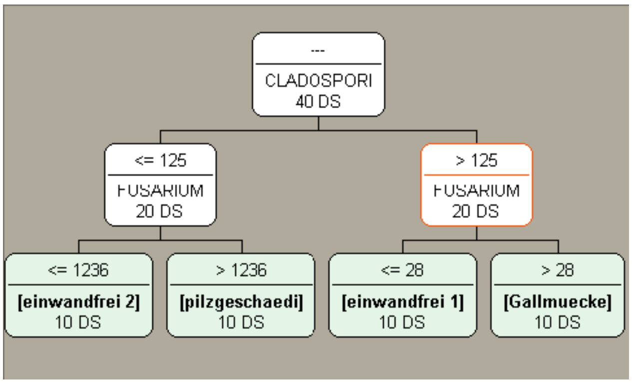


Fig. 7 Decision Tree for the Determination of Grain Quality based on Number and Type of Fusarium Spores

6 Conclusions

We have presented our first results on our case study for the detection of hygiene-relevant parameters from cereal grains based on intelligent image acquisition and interpretation methods as well as data mining method. It is a joint work between computer scientist, food experts and microbiologists. We have shown that data acquisition is an important task and that it has to do with more than data base construction as it is in many data mining experiments. The image acquisition method we have demonstrated in this paper works well and can be fully automated. It can also be constructed in such a way that the coverage from each single grain can be taken off and evaluated based on the intelligent image interpretation and data mining methods. The image analysis on case-based object recognition works well for this task but has to be tuned so that a better object recognition rate can be achieved. From each single object can be extracted image features and these features can be used for classification. It is preferable to construct the classifier based on decision tree induction methods. Once the type and number of fungi spores has been determined this information can be set into relation with the hygiene-relevant parameters. We have shown that the number of Fusarium spores correlate with the DON levels which is a value used for the determination of the mycotoxin concentration. However when considering this experiment as a data mining experiment and applying decision tree induction to the created data base some other important information can be extracted which are more or less hidden before. The next steps of our work will be to improve the image interpretation methods. When we have a fully automatic algorithm we will apply our method to a large number of grain sample. The aim is to come up with a new measurement method for the determination of hygiene-relevant parameters on grains. Besides that we like to discover formerly unknown relations or information based on the material in the coverage of the grain such as different types of fungi spores.

Acknowledgement

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