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MULTICHANNEL SORTING OF FOOD BASED ON IMAGE PROCESSING

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ABSTRACT

For quality control and price determination of natural products like for example wheat in mills or in grain storage units, it is necessary to evaluate the current state of the product.

In the case of wheat this is done by lab assistants through a manually held sight check of a sample of the delivered product. The wheat is examined on different types of damage for example special types of mould, fractions, stones or insects which is generally called Besatz. Those different classes of Besatz are sorted afterwards and weighed to determine the mass percentage of each class in the amount of wheat.

Because of the inconstancy and exertion of the manual Besatz analysis, the goal is to develop an automatic detection and sorting process which is reliable and fast and can be applied for different natural products.

Index Terms - Sorting, Image Processing, food analysis

1. INTRODUCTION

With the rising demand on quality and security of food, the automatic and fast analysis of natural products, particularly through the application of image processing, gains increasing importance. The extraction and analysis of control samples of grain in mills and silo plants serves the avoidance of storing contaminated deliveries and to determine their composition. As criteria of refund to the manual Besatz analysis, the automatic Besatz analysis offers a higher reliability with a faster process speed on the base of image processing.

2. PROBLEM SETTING

For the acceptance by the German and accordingly the European administration and for the comparability with the results of previous methods, the per cents by weight of the single fractions of material have to be determined. Therefore a sorting of the recognized objects in separate classes is necessary.

The relevance of the Besatz analysis is also recognized by the need of creating a probe reserve (A- and B-probe) for potential judicial aspects. The determination of the probe content, the Besatz analysis, is currently executed manually. A probe, similar to figure 1, is being extracted and roughly sieved and separated by size. After this the sieved fractions are visually controlled by a trained lab assistant and the Besatz is sorted manually [1]. In a final step the separated fractions are weighed. The result of the analysis is documented in mass portion or rather mass percent. The flow-rate of the very subjective manual analysis is about 5 gram per minute.

Figure 1: Components of a wheat sample with Besatz.

3. AUTOMATED ANALYSIS

The automatic analysis is based on image acquisition and –identification. Thereby four main compositions are established:

1. On-belt detection with linescan camera
2. On-belt detection with matrix camera
3. Free-fall detection on belt with linescan camera
4. Free-fall detection on belt with matrix camera

The individual approaches offer special advantages depending on the demand on speed, precision and completeness of the detection process. The analysis of control samples in a laboratory mainly asks for a high precision. The results have to be similar to those from the educated lab assistant. The best method for the complete analysis in a high precision is the on-belt detection shown in figure 2.

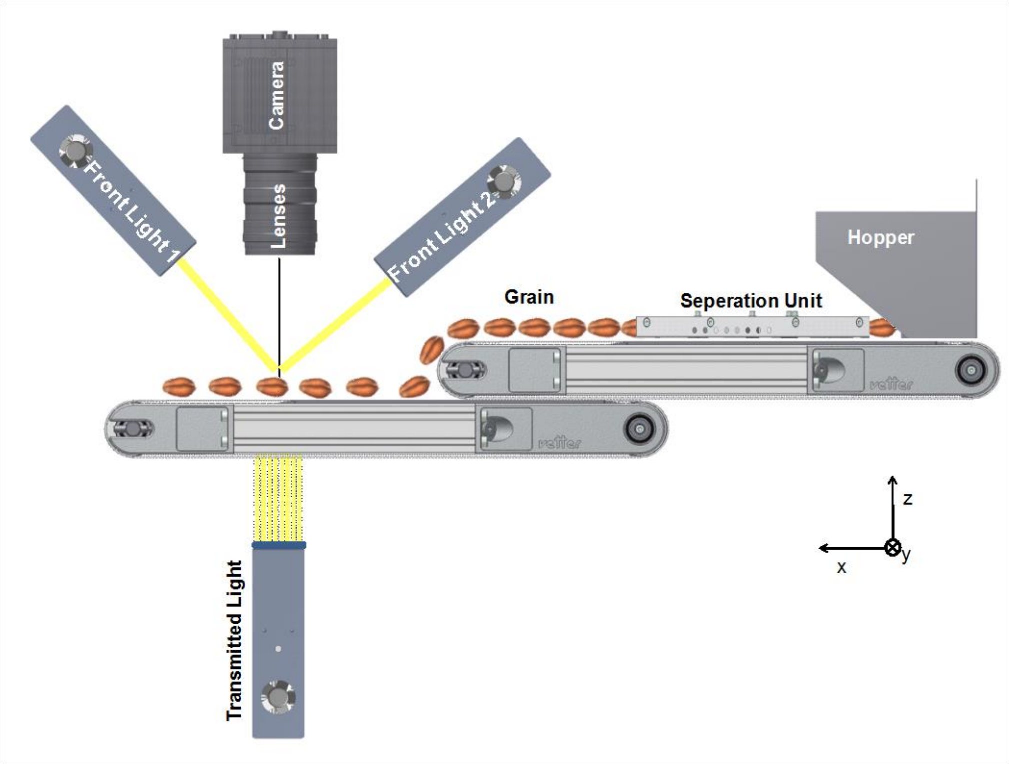

Figure 2: Priciple of the on-belt detection.

It is necessary so separate the identified fractions physically from each other in a following sorting process. The main reasons are to fulfill the European norm ICC [2], [3], the comparability with the present manual Besatz analysis and intuitive evaluation of the probe during the receiving process of the material. The physical sorting process is the essential step to a Besatz analysis conforming to standards.

4. IMAGE PROCESSING

Especially because of the big variation of natural products, up to now and worldwide there is no technical solution of the sorting process. Within the research project “QualiKorn”, the task of the automatic analysis of wheat probes was realized. The accuracy of the detection can be compared to human skills but the speed is much higher. Figure 3 shows the 23 different classes of Besatz, each with the reached recognition rate (70-90 %). Those recognition rates are not achieved by the manual detection. The recognition rate shows the relation between correctly recognized objects and all the objects of one class. In the end, the necessary classes are usually less than the analyzed 23 classes. Therefore classes are summarized. The minimal amount of classes are the four main classes: Flawless wheat, ergot, unsound grain and other Besatz. The summarized classes are shown in figure 3 with the colors green, blue, grey and light blue. The flow rate of the automated analysis is about 50 gram per minute and therewith ten times faster than the manual analysis. This high flow rate can be used for analyzing a larger sample and having a higher statistic security or to save time in the process.

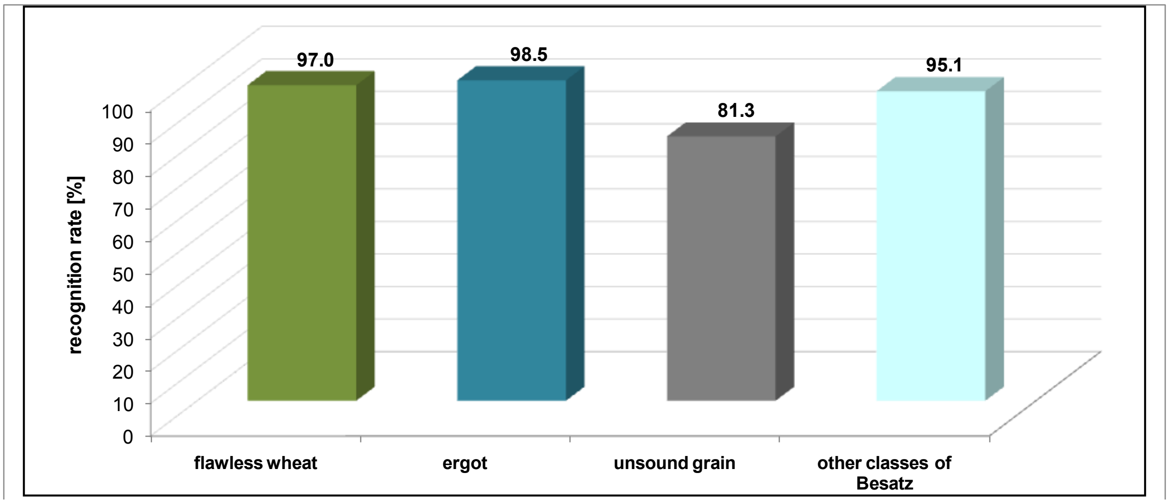

Figure 3: Recognition rates of analyzed wheat.

An important task in the project is the adaption and expansion of the image analyzes to provide the necessary image-, sorting- and position-data. The images were taken by a color linescan camera with three lines and 2048 pixel per line. The reached solution of a single wheat corn can be seen in figure 4.

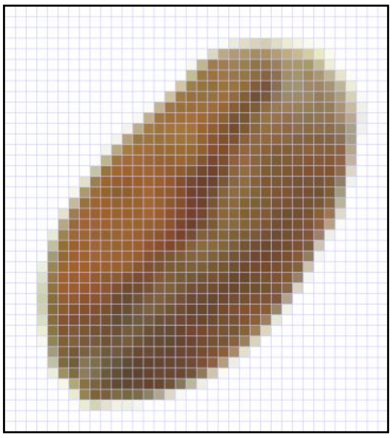
Figure 4: Image of a single corn.

5. SORTING PRINCIPLES

The sorting provides three main goals:

1. Placement of a sample as a physical proof of the single fractions of Besatz (the Besatz analysis itself).
2. Creation of a basis for the exact mass determination of the different fractions of Besatz (to show the mass percentages of the Besatz analysis).
3. The ability for a very exact sorting process of small amounts of for example genuine seed (as a potential of the multichannel sorting process).

The physical provide and the determination of masses of the analyzed probe, are challenges which cannot be solved only by image processing. The optical analysis gives the number of objects in each class. Furthermore, the images of every single object are available for a potential control of the result. For the acceptance of the German and European authorities it is necessary to know the weight percent of each class. Therefore, a sorting process has to fulfill the following demand:

- The amount of sortable classes should correspond to the number (for example 4,…, 23) of a given specification.
- The flow rate of the sorting process must not be lower than the flow rate of the automatic analyzing process by image processing.

Until now, there is no technical solution that fulfills those two contrary demands of a high number of classes to be sorted and a high sorting speed.

The dissertations of K. Anding [4] and D. Garten [5] show possible solutions related to the recognition.

Similar to the recognition there are also many different basic principles for the sorting process. The two main principles are the free-fall recognition and on-belt recognition. Mostly applied is the free-fall recognition, thus the sorting by using gravity, illustrated in figure 5. It is based on blowing single objects out of the falling volume stream. An advantage is the high flow rate, a disadvantage is the limited number of classes. Common sorting procedures allow basically the separation in only two classes “good/unusable”. With the on-belt principle, single objects are located on a belt and being separated in their classes with an adequate fixture. The object position has to known exactly. With a high number of classes and a small flow rate the advantages and disadvantages are contrary to the free-fall method.

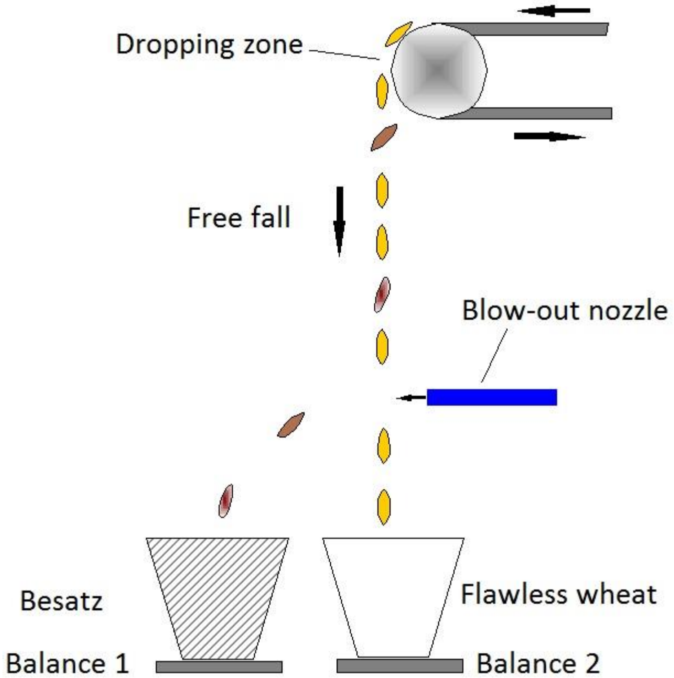

Figure 5: Basic free-fall principle with weighting.

The position in x- and y-position on the belt and the class of each object is known in every moment through the image registration and analyzing and belt speed. A sorting fixture can transport the single objects very accurately to their class by a very even belt speed.

A technical basic principle is suction of objects by under pressure. The suction has to be possible over the whole width of the volume stream on the belt. An interesting idea would be to locate a few suction bridges along the flow direction of the objects. The number of suction modules is determinate by the number of classes which have to be separated physically. Figure 6 shows a possible way of this technique with a volume stream of wheat and Besatz. Each suction bridge would be responsible for one of the classes (figure 2), which means that the different fractions are removed one by one from the volume stream and put into their recipient. These recipients could be weighed directly in the sorting machine or as a cheaper way be taken out of the sorting machine and weighed manually outside.

The effort of sorting a high number of classes would be pretty huge. A proposal in [6] indicates to handle the suction with a single tube which is removed positioned over the object with a step motor. An advantage would be the lesser modification in case of increasing the number of classes, a disadvantage is the higher sorting time.

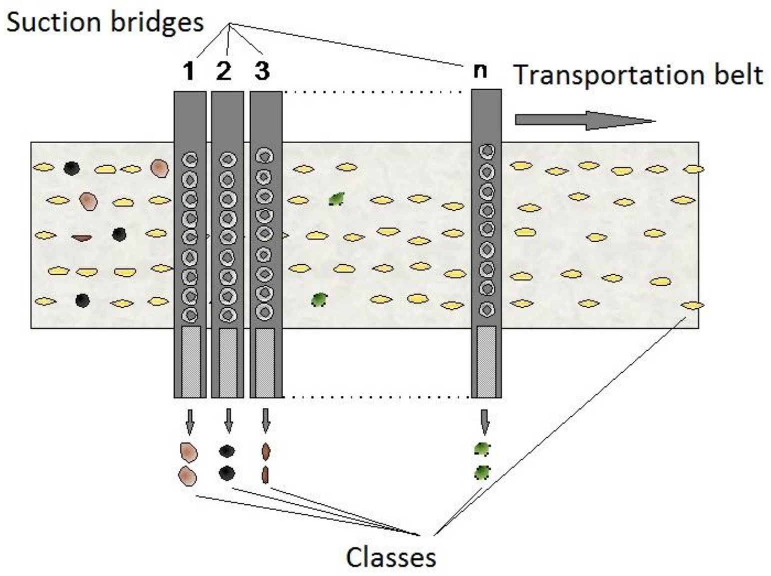

Figure 6: Basis principle of the on-belt multichannel sorting by suction.

Fixed lines on or over the belt could help to lead the objects to be in a defined position in y-direction. This would simplify the coordination of the suction system.

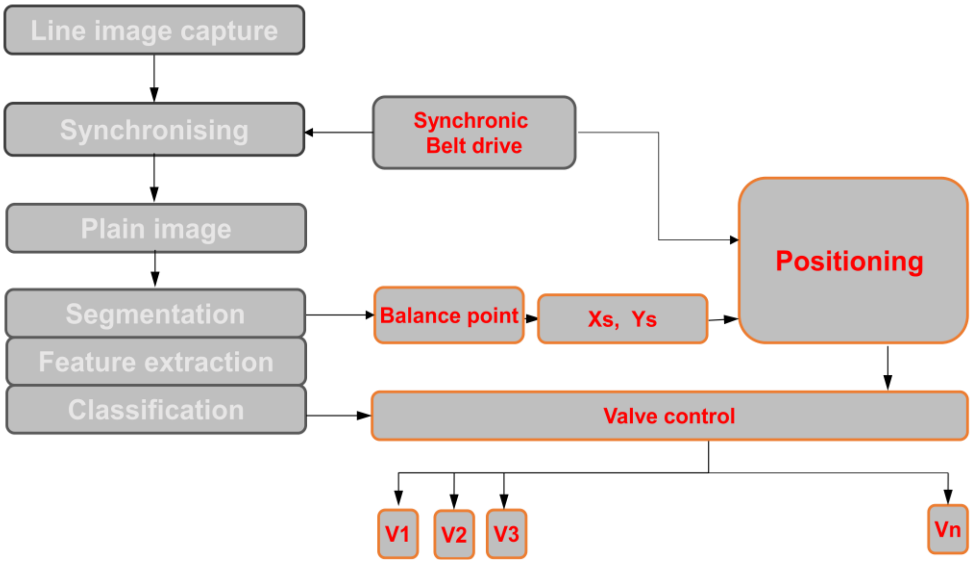

Figure 7: Program sequence of the analysis and sorting procedure.

The image intake of the linescan camera is synchronous to the belt speed which means that recordings are created with a lateral relation in aspect and are stored in connected computer. Like in figure 7 the next step is the segmentation by separating the single objects out of the huge taken image data of one large picture their administration in the storage of the computer. A feature vector, which is compared to the pre-saved features of the reference objects, is calculated for every single object. Then every object is related to the class of objects which features fit with the highest plausibility.

Beside this process of recognition (segmentation, extraction of features and classification), a second process is necessary which begins also with the segmentation. The position data of the single objects are determined. Because of the uneven, plane objects (figure 2), there are just single pixel data initially. For the following determination of position values, binary masks are sufficient. The balance point coordinates X_S and Y_S are calculated from the binary object. Additionally it could be necessary to determine form features like the biggest dimension of the object in X- or Y-direction. These form values are distinctively connected to the concrete object and kept until the end of the sorting process. The correlation to the class and the position of the object indicate steering signals to the pneumatic fast switching valves to suck or to blow out the object. The whole process of recognition, classification and determination of the position of the object has to be finished before the objects reach the sorting zone. Because of the higher object speed in the case of the free-fall principle, it would demand a faster way of data processing than the on-belt method.

6. CHALLANGES AND GOALS

A special challenge indicates the properties of the objects which are sorted. In comparison to technical products, natural products have a much higher variability in size, form, texture, color and mass of each object. In the case of wheat and its Besatz, the sizes reach from 1 mm up to 10 mm, the forms from globes (rapeseed) up to bars (ergot). The surfaces can even or rough. The mass lies between about 0,1 and 1 gram. Figure 8 shows an example of this variability.

Figure 8: Selected objects.

This high variation in property can lead to fail function of the sorting machine. This risk can be handled by a clean and size limiting sample preparation before the analyzing and sorting process. At the same time the technical elements for the transport of the mechanical separation should be designed in a way that a high variety of objects can be analyzed. The goal is to have the possibility to analyze many different types of natural products automatically with a high throughput.

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