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RESEARCH ARTICLE

Gergely, Z *et al*, *The Experiment*,*2016.,Vol.37(2),2259-2270*

A High performance method for sorting White Paprika

Abstract:
The conical type white paprika is considered as one of the popular culinary plants in Hungary and in the area of Central Europe with Hungarian population, and – as it has spread from here – everywhere in Europe. The classifying of the paprika is carried out through a manual process thereby products with specific classifying sizes characterizing the producers are usually to the market. It is acceptable in the domestic market for time being however, in the case if paprika supplied by different producers (subcontractors) where to be prepared for export, the quality properties are not uniform at all. The sorting of paprika manually requires persons with suitable ability and routine thus the management (organization) of the work comes up against difficulty. The most of the sorting machines is suitable for selecting roundish, sub-spherical vegetables and fruits (tomato, potato, apple, apricot, cantaloupe etc.) by applying the weight measurement. Classifying equipments for carrot and cucumber exist, but the cone-shaped paprika presents some additional problems. The function of the system is to qualify the paprika of which most important parameters are its size and shape – measuring them and processing the measured data have to be solved. The record of shape is realized by CCD photoelectric linear array sensors with the help of which the processing with regular accuracy can be provided. An algorithm running in the micro-controller developed by us provides the assorting process; it determines the size fraction from the length and the shoulder-width, the centre-line length, deformation factor, and the area data.
Keywords: paprika sorting, high speed sorting, edge detection, CCD linear array

1. Introduction:

Now the sweet paprika is still picked manually in the small as well as the large-scale plants (farms or works) so white paprika generally with peculiar sizes to the producers is put on the market. This does not fulfil the very severe requirements of today. Since at present there is no accurate device available on the market of sorters for sorting the sweet pointed, white paprika accordingly we set the development of a picking system based on the picture processing as a target.

The rapid propagation of the image processing is closely related to the explosive increase in the data processing rate and the store capacity of computers. But it is still a key problem today as well (especially with the real-time applications) to elaborate successfully algorithms with an acceptable running time.

The image processing starts with shooting and recording pictures. There are several usable options for this, conventional or infrared cameras, X-ray images and ultrasonic detectors as well. The image is usually an intensity picture or map which certain luminance values assigns to the individual points of the objects; the recorded picture may be analogous or digital.

The wide assortment of new optical techniques looks promising in the rapid determination or, at least, estimation of the quality parameters of the crops. A super-rapid pattern recognition system differing from the earlier practice is shown in the following paragraphs; it facilitates the picking processes of the sweet white paprika with acceptable accuracy.

2. Material and Methods:

For achieving a suitable picking performance, the complete recognition of 3 or 4 peppers has to be provided in a second (that is 10,800 to 14,400 paprika per hour at a travel speed of 1 m/s). It requires an extremely high-speed picture processing system and, in addition to this, the amount of data to be processed is also multiplied according to the multi-directional mapping. The complete image processing and recognition process shown in *Figure 1*, the HFPV-I equipment for implementing the process shown in *Figure 2 and 3*.

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It turned out during the investigations that the above demands can be satisfied only by the CCD sensor with a low pixel number – by the line CCD sensors (with the type used by us), the complete pixel data can be read out in very high read-out rate (*Figure 4*). An additional advantage is that the record of contour directly can take place; accordingly, the search of contour through software can be avoided and the recognition algorithm will be speeded up. To measurements used a general problem or target specific measurement system, because choosing the right solution is not always trivial.

An embedded system (with microcontroller basis) was elaborated for the sorting algorithm. The pixel data of the CCD are received by a high-speed Microchip DSP. This unit includes the pattern recognition algorithm as well. The high speed of the DSP provides the real-time running of the algorithm (*Figure 5*). The whole control system as well as the operating software programmes has been developed by us alone. During the experiments the application of PCs was rejected since they did not run reliably in the severe industrial conditions (in spite of their industrial design).

To avoid the time-consuming rolling and moving of the crops, the projection has to be provided from several directions (*Figure 6*). It has been found in the course of our investigation that using more than two cameras does not improve significantly the accuracy, but greatly decreases the rate of processing.

3. Results and Discussion:

Under industrial conditionsitis difficult to ensurethata goodpictureto be created.There are manyproblems to be solvedin the preparationand processingof images. The biggest problem is a low contrast ratio. Another problem caused by shadows and dust on the conveyor belt (*Table 1*). Both effects cause a significant reduction of the contrast. The standard, commonly used threshold algorithms have increased sensitivity of the shadows and dirt. This results in a significant reduction in accuracy. During this process it is very important to the strength and direction of illumination. In addition to these effects, the lighting inequalities need attention.

To resolve this problem, we created a self-developed algorithm for performing the analysis of images (*Figure 7*). This algorithm is based on the edge analysis of image slices. The edge detectionalgorithmcontinuouslyanalyzes theimageslicesfromthecameras, and on the intensityfunctionsearchesthekey points.Faults can bedue tothe intensitydifferenceeliminatedcompletely (ideally).The figure showsthat themorphologicalanalysisalgorithmfindsvery high accuracyto the actualedges. Test results of the composite imageslicesalgorithm are shown in *Figure 8 and 9.*

Not only the pepper dimensions are relevant, very important tospecifythe degree ofdeformationas well. The working of the determining themalformationalgorithm in a very simplified form is as follows: As it was mentioned above, only the contour of the pepper is recorded during the measurement. The elimination (image rejection) of the stalk is a serious problem; it is solved by differential map identification process (*Figure 10*).The stalk position is where the value is obtained extremes.

The firststep for determiningthe malformation: The centre-line is constructed and its length is accurately computed with small triangles. The values gained in this way are compared to the length of the line drawn between the first and the last centre points of the paprika body. The quotient of the two length values is the centre-line curvature degree. By this method, the curvature invisible in profile also can be filtered out.

The examinations was necessary to develop a characteristic method shape of the pepper that lets you specify the main characteristics of the pepper. The shape of the fruit analyze the data reducing method for describe shape and countless available to use, but it quickly became clear during in the investigation to characterize the object pepper creating a unique data reduction methods are required. The reduction algorithm is that few of the most important parameters by recording parameters of the paprika can be determined, and the rapid comparison of the measured values can be carried out. The developed method is based on the famous points of the pepper crop in the designation

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and determination of parameters describing the curvature.

Ifthat is done, there is second step for determining the global deformation: Determination of malformation continued by calculating the centre of gravity of plane figure. After that will be assigned to P_1, P_2, P_3, $P_4$and M_1, M_2points, are defined in the γ_1 and γ_2 angle (*Figure 11*). The ratio of the two angles determines the degree of deformity (g quotient) factor:

$$g = \begin{cases} \left|\frac{\gamma_1}{\gamma_2}\right|, & if\ |\gamma_1| \geq |\gamma_2|; \\ \left|\frac{\gamma_2}{\gamma_1}\right|, & if\ |\gamma_1| < |\gamma_2|. \end{cases} \quad [-]$$

With this method, the global malformations are alsodetermined (this ismainlyimportantfor longpaprika, e.g. green hot peppers). For regularpaprika (without malformation) the value ofthecoefficientis 1. Because the determination of thecenter line length and direction does not givea clear result for malformation, so comparingthe twoquotient ofthese two stepsis essential. In this way,the deformationrategives usveryquickly identifyandaccurateresults.

During the beginning phase of the research, many pattern-recognition algorithms had been tested but their running times were not acceptable. With the most algorithms, the re-simplification and the transformation of the pictures caused significant time losses. The time distribution of the processes in a general shape recognition algorithm running in the PC can be seen in *Figure 12*.

The elaboration of the algorithm, particular attention was paid to the accuracy and the running rate suiting the requirements. In our self-developed system, the first processing of the data begins already in the camera during the reading-in accordingly the DSP receives the preliminary processed, suitably formatted and packed data flow. With this method, the amount of unnecessary transferred data could have been significantly decreased; accordingly, we managed to reduce the transfer time to its fraction, and minimize the time of transformation jobs as well.

The paprika colour can affect the accuracy of the algorithm, this appears most strongly in the case of green peppers. The conventional threshold-based algorithm works quite large, up to 50% error, if the pepper colour is green. Slightly better the error rate when testing with red pepper (but still high). In case of white pepper is a significant error rate, it is mainly due the low noise and error tolerance.

It can be concluded using local operating procedures for the adaptive thresholding white and red colored fruit varieties contour recognition further improved. Similar to the case of an established level thresholding major problem in green and yellow-green fruits, but contrary to expectation contour recognition the errors did not cease completely. NICK procedure on the basis of the measurements that are being the developed measuring work environment in all respects with greater accuracy than operating under a similar principle Niblack algorithm.

The test results are shown in *Figure 13, 14* and *15*. The figures show that using self-developed edge detection algorithm greatly reduced the number of incorrect data. For white and red pepper the number of bad data is completely eliminated, for the green and yellow paprika, errors decreased significantly. Both results were significantly below the allowable 5% error margin.

The effects during the normal operation investigated of the conveyor normal contamination. The presence of dirt is unfavourable during the preparation of the camera image recordings, because the contrast ratio decreases greater and greater the probability of erroneous contour recordings created.The *Figure 16* shows the effects of the operation of the dirt in edge detector procedure. I tried out during the tests that the fruit shape and kind of relation they are more varied. The data in table established that failure to create a normal situation where the number of defective contour recordings, error rates have increased significantly (during the test, the number of repetitions was five). It is interesting that in the case of the wet conveyor belt was not erroneous data record, this is due to the water surface due to the light sources is less strongly scattered in the direction of the cameras, as a result, a short time of an effect

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emerged, which caused the picture recording perspective, it appears that the background "blacker" was.

4. Conclusion:

When searching for the method of sorting, we have found that using the line CCD sensor is the most suitable process for recording contour.

The development of the measuring system was completed; the microcontroller- and edge detection algorithm based pattern recognition seems viable for the further applications as well. The correct determination of the parameters required by the standard is provided by the algorithm. Even in its present state, the algorithm is capable of recognizing easily the malformed peppers.

In order to filter out the malformed harvests worked out the paprika contour description appropriate procedure, which is 95 % significance level, a parameter can describe the main characteristics of the paprika harvest, but it was found to describe the degree of curvature, an additional parameter is sufficient.

The designed measuring system and the algorithm very well performed its part during the long-term tests. The prototype system is working continuously at present as well; the evaluation of the data is also continuous.

Acknowledgements:

The experimental system was constructed by the 'Furafol Hungary' Ltd. We owe Viktor Madar and 'Furafol Hungary' Ltd. thanks for their help and collaboration in our measurement and the required testing program.

Figures:

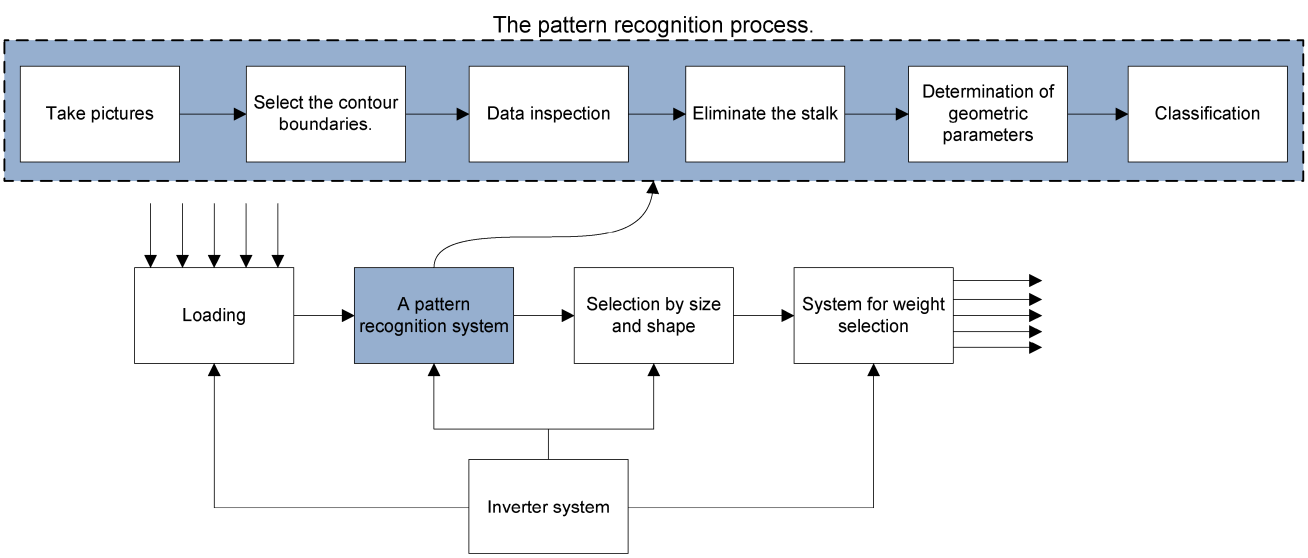

Figure 1: The complete paprika sorting process

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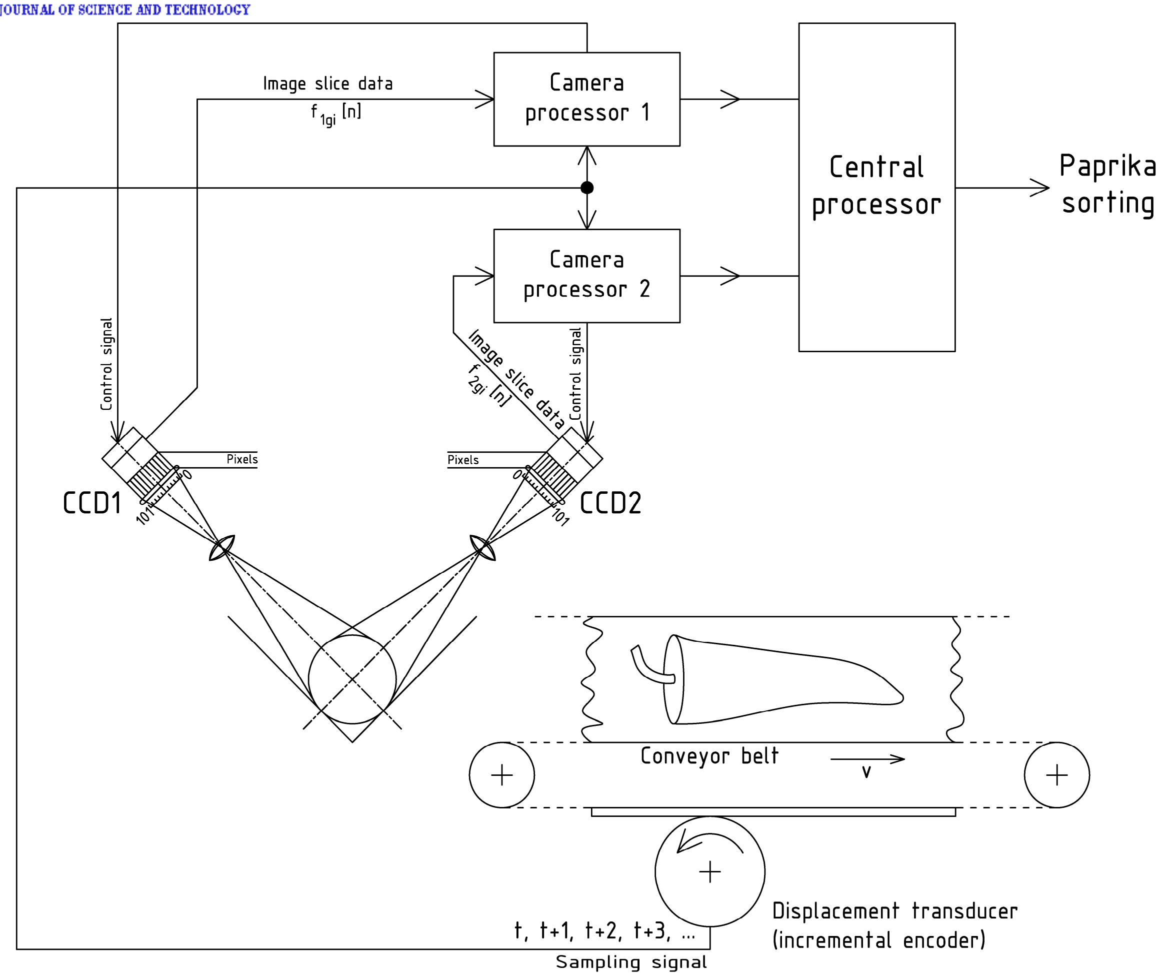

Figure 2: The simplified schematic diagram of the image sensing (without illumination)

Figure 3: The HFPV-I series paprika grading machine

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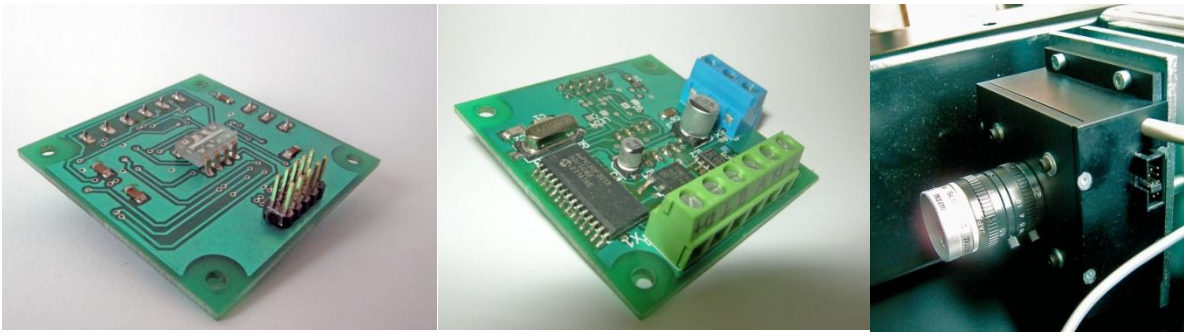

Figure 4: The self-developed line CCD panel (left), the camera processor panel (middle) and the boxed design (right)

Figure 5: The self-developed central processing panel

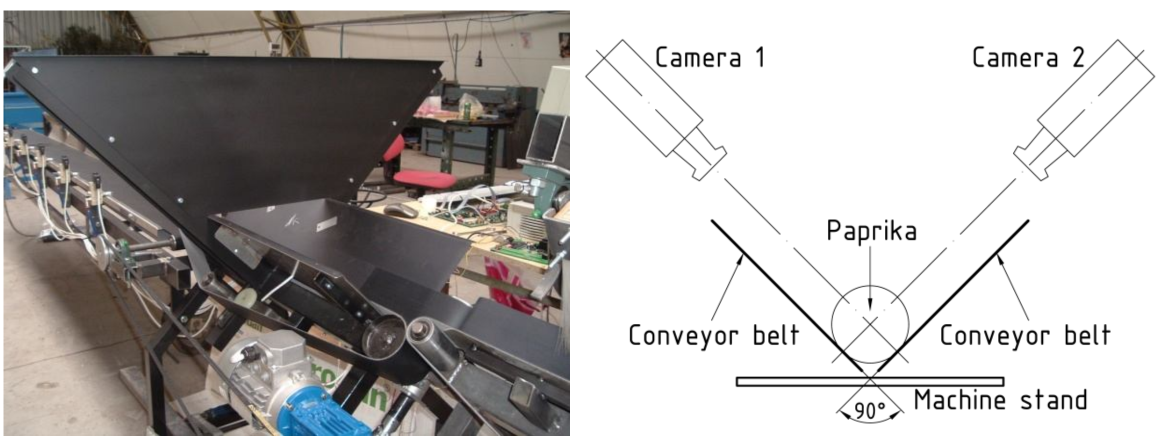

Figure 6: Projection from two directions

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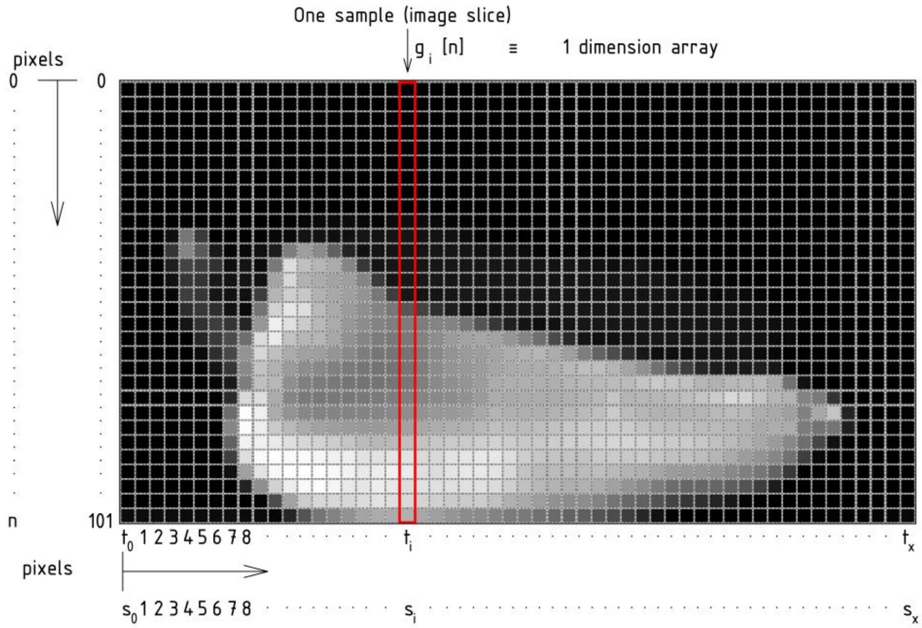

Figure 7: The used image processing method

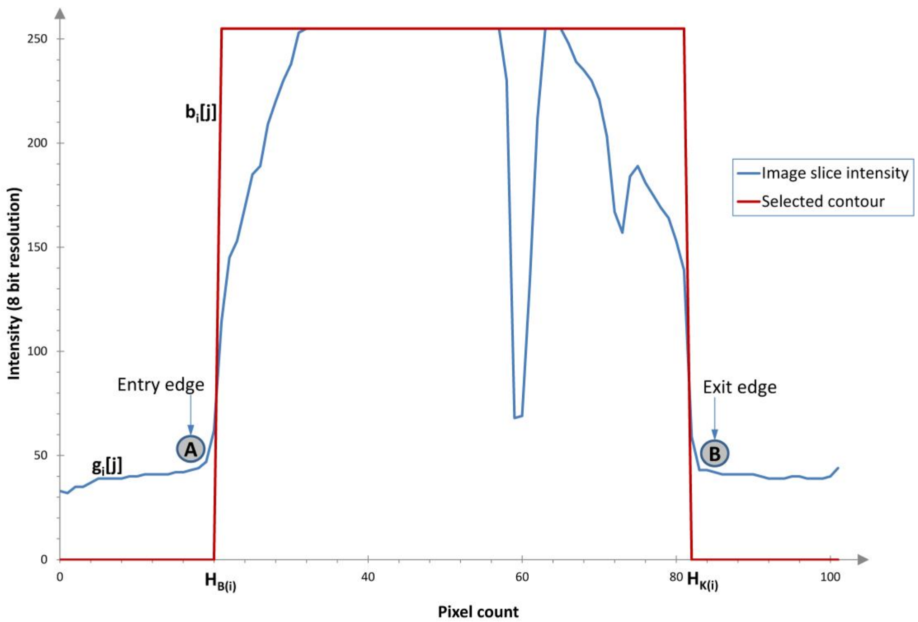

Figure 8: Results of self-developed edge detection of image slices

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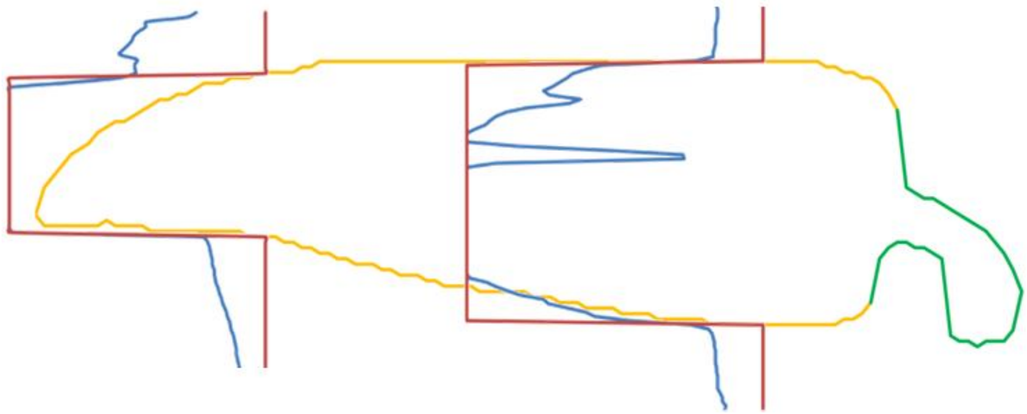

Figure 9: Result of the contour recording process

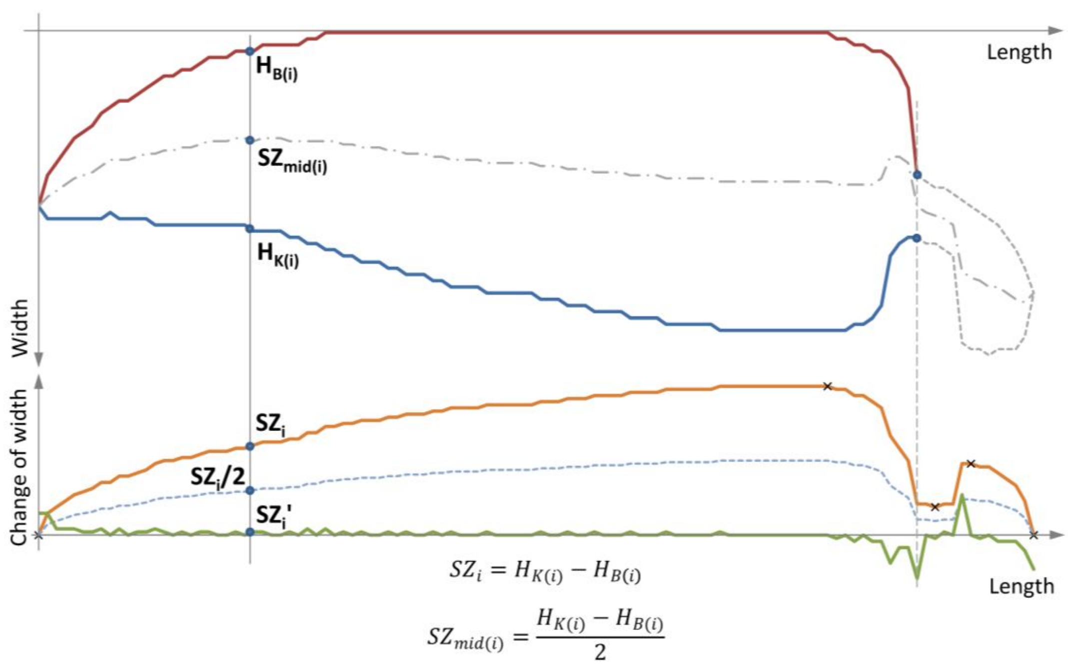

Figure 10: Pedicle elimination

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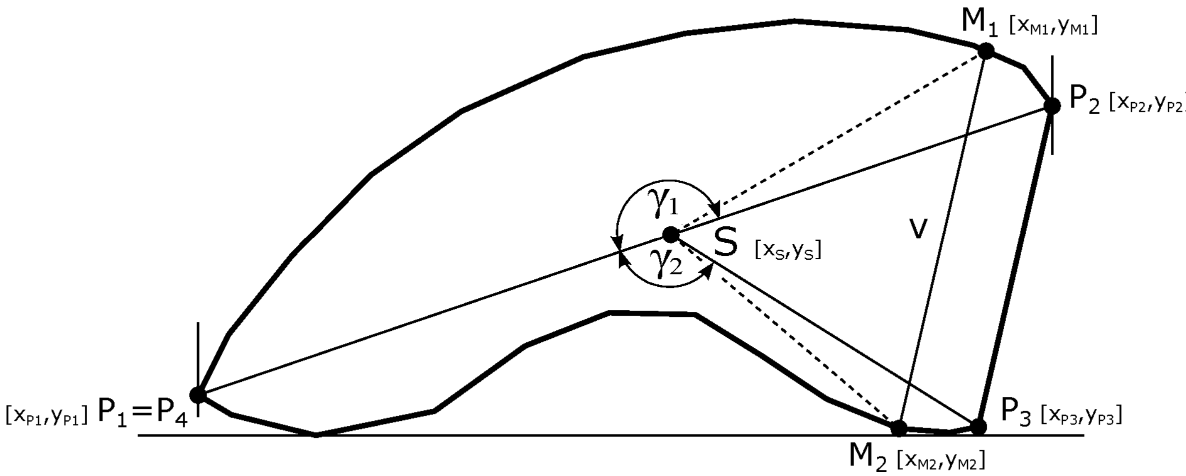

Figure 11: Determination of deformation

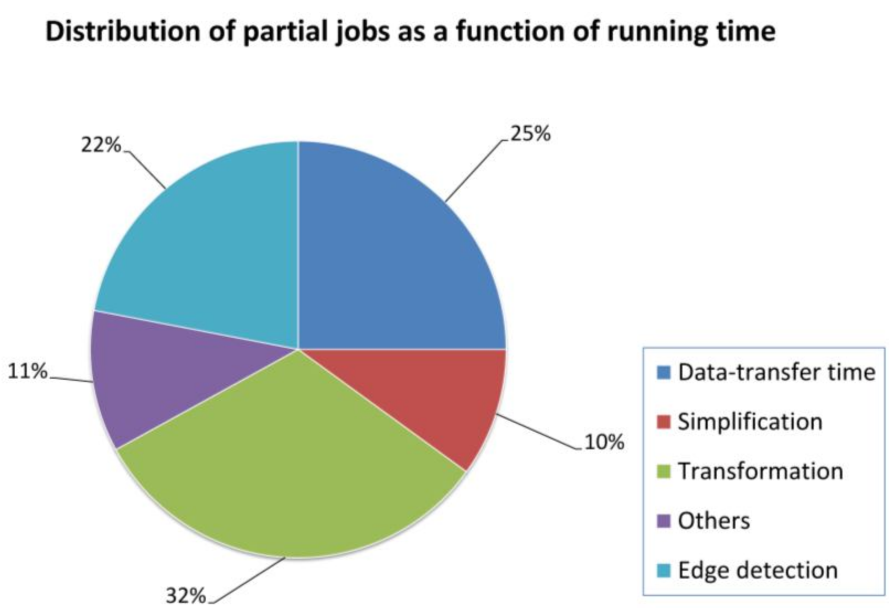

Figure 12: Distribution of the processes during the running time of an algorithm running by PC

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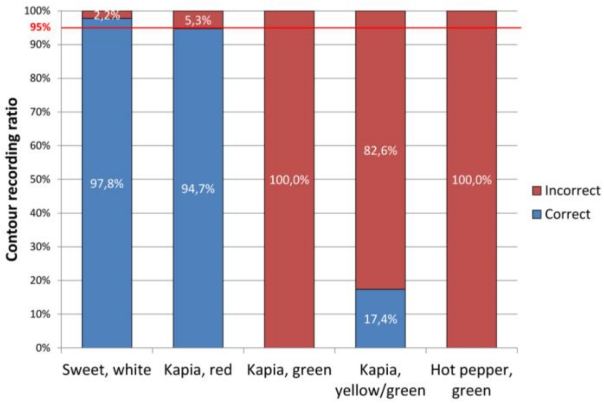

Figure 13:

Results of standard, commonly used one level global thresholding algorithm

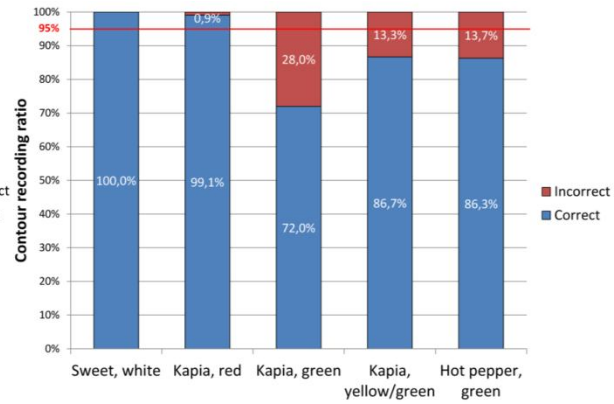

Figure 14:

Results of one level local dynamic, NICK thresholding algorithm

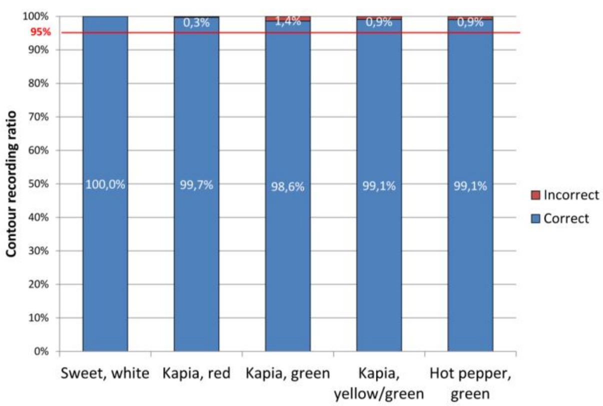

Figure 15:

Results of self-developed edge detection algorithm

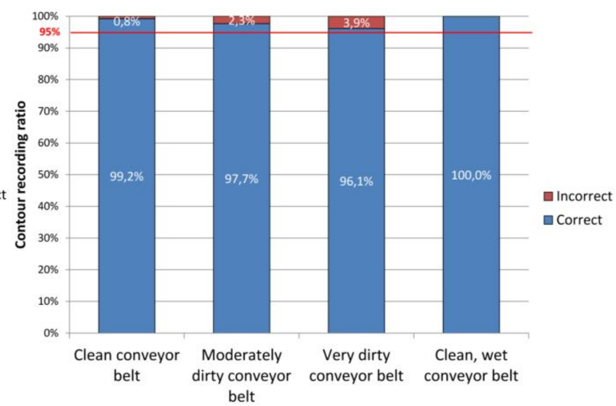

Figure 16:

Results of the self-developed algorithm sensitivity of the conveyor belt contamination level.

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Tables:

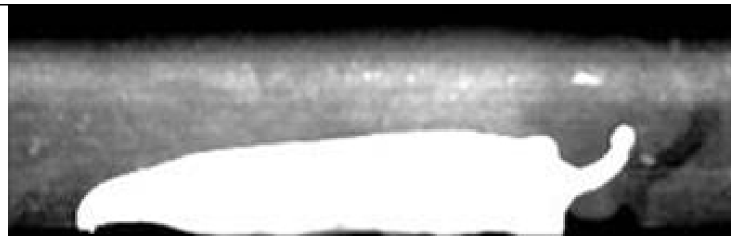
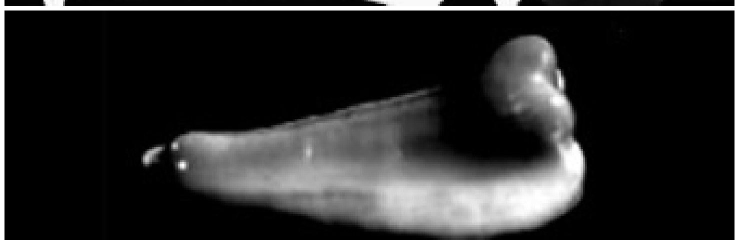
Highlight dirt and shadows	
Large differences in contrast	
Shadows	

Table 1.The main problems in the edge detection process

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