MESUTRONIC
Metal Detection made in Germany

IMAGE PROCESSING FUNCTIONS FOR THE easySCOPE X-RAY INSPECTION SYSTEM

Version 02/2021

CONTENTS

(s) = Included in standard scope of delivery

(o) = Can be activated for a fee via activation code

Version 02/2021

1 Foreign body detection

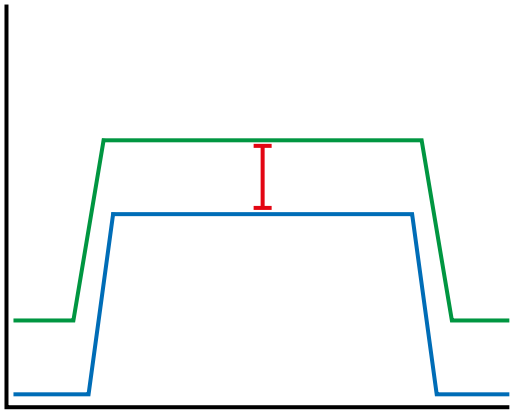
The primary function of X-ray inspection systems in the food industry is to detect potentially hazardous foreign bodies to protect end users. For this purpose, X-ray emitters and receivers generate gray value images that are analyzed using image processing software. The following functions are performed in fractions of a second using a large number of individual computing operations.

1.1 Threshold value evaluation (s)

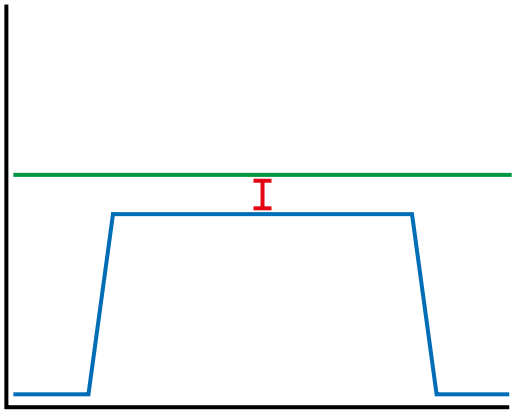
When a product passes through the X-ray inspection system, an image of gray tones is generated. Products that let a small amount of X-rays pass through appear dark. On the other hand, products or parts of products that let a lot of X-rays pass appear light.

The darker the area, the higher its so-called „gray value". If a search is now made for foreign bodies, a gray value is specified that is higher than the highest value determined in the good product. If a contamination in the product now passes through the X-ray inspection system, the accumulated gray value exceeds this threshold.

This works best with products of uniform density and thickness. If there are large variations, the foreign body could, in simple terms, be „lost" in a bright area, since the added gray value of the product and contamination does not exceed the set threshold.



Constant product with adaptive threshold



Constant product with fixed threshold

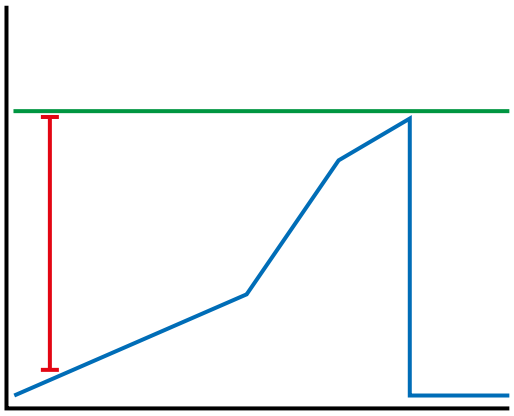
Product effect Threshold Minimum signal foreign body

1.2 Adaptive threshold evaluation (s)

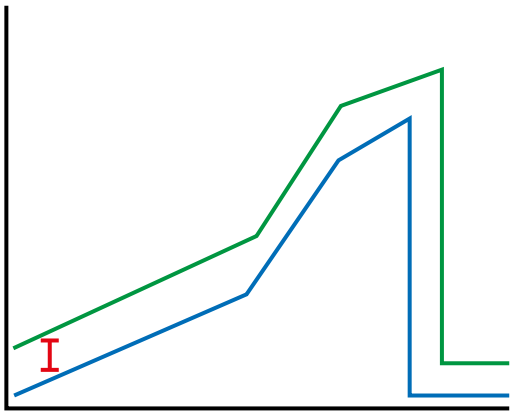
This evaluation method provides better results than the simple threshold evaluation, especially for inconsistent products. The behavior of each individual pixel of the gray value image is compared with the surrounding pixels. Several algorithms then evaluate the differences considering various criteria.

A simple example here is a typical wedge of cheese. If it runs lengthwise through the X-ray system, the gray value slowly increases the thicker the wedge becomes towards the end. The threshold is adaptively increased again and again to account for this slow (and thus previously learned to belong to the good product) increase in gray value.

If a foreign body in the middle of the wedge causes a rapid increase in the gray value, this causes an alarm, even if the maximum gray value of the cheese at the end of the wedge has not been reached. The sudden increase has exceeded the adaptive threshold.



Variable product with fixed threshold

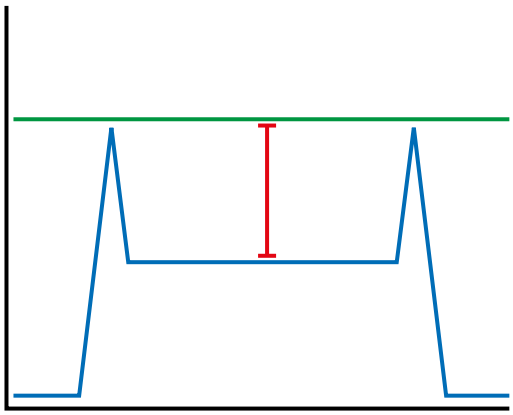


Variable product with adaptive threshold

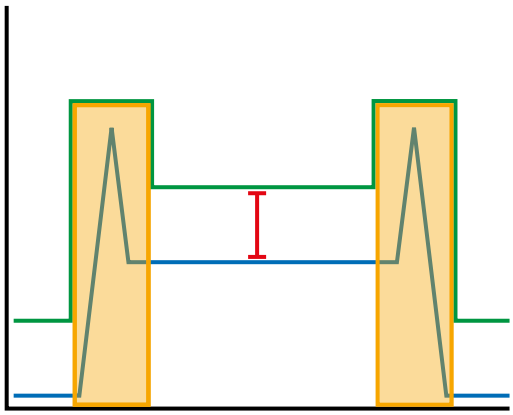
Product effect Threshold Minimum signal foreign body

1.3 Edge suppression (s)

The edge suppression function is used for products that have a much denser edge than the product itself. To avoid effects of this edge, which is irrelevant for the detection of foreign bodies, on the evaluation algorithms, a mask can be placed over it from the beginning. Thus, this area of the product is completely ignored and the detection of foreign bodies in the rest of the product is improved.



Typical product with strong edge signal without edge suppression

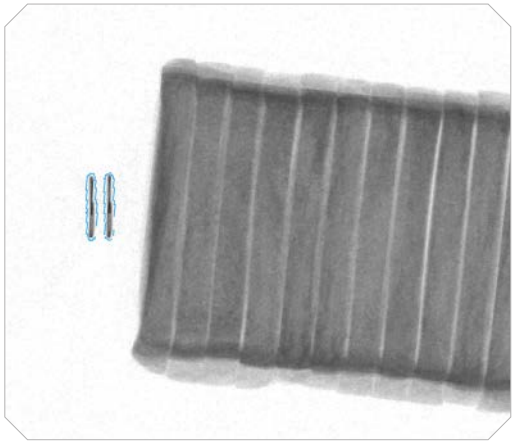


Typical product with strong edge signal with edge suppression activated

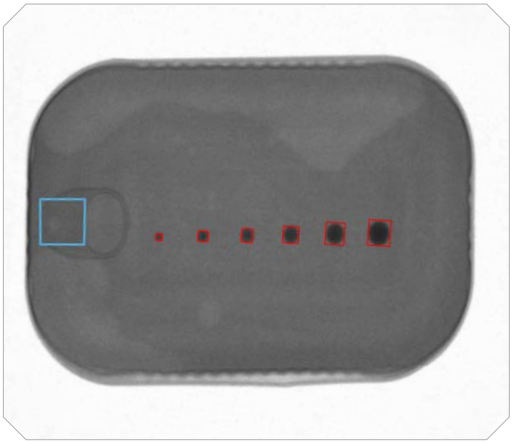
Product effect Threshold Edge area Minimum signal foreign body

1.4 Clip masking (o)

The optional clip masking feature allows the X-ray system to distinguish clips of the same shape or similar closures from foreign bodies. The feature recognizes the previously taught shape and density of the clip and ignores it with respect to the foreign body search.



Toast with hidden closure clip



Canned fish with hidden pull ring and detected foreign bodies

2 Quality improvement

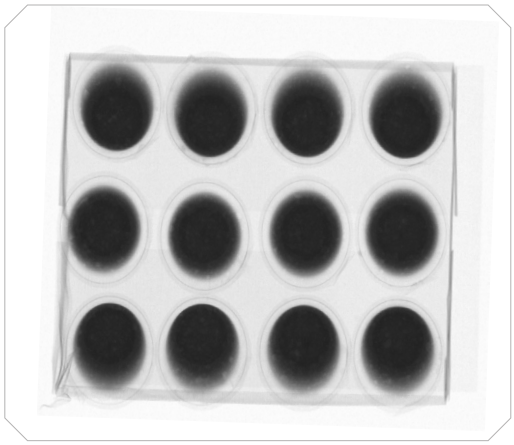
A major advantage of X-ray inspection systems, compared to magnets, sieves or metal detectors, are the additional benefits for increasing product quality. With the help of dozens of individual calculations, functions are implemented that check the gray value image created by the product for a variety of irregularities. If one of these functions detects an abnormality, a quality defect is reported. Defective products identified in this way can now be rejected, optionally also into a separate collection container.

2.1 Clip completeness check (o)

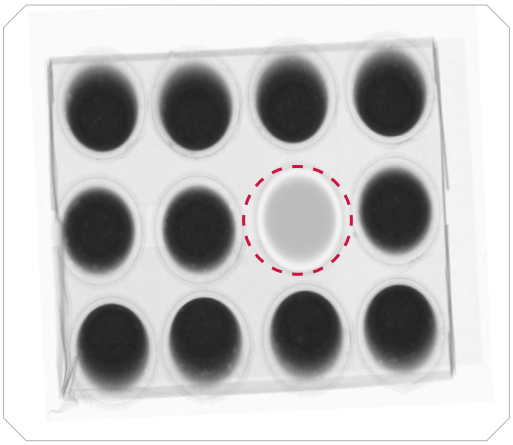
As part of the „Clip masking" function, it is possible to check whether a metallic closure is present on the product as intended. Its shape is first taught by means of teach-in images. Visibly incomplete or deformed clips then lead either to a foreign body message (since the clip masking function does not identify the closure and then ignores it) or to a quality defect (since the clip is recognized as incomplete).

2.2 Weight check (o)

The optional control of the product weight can be an extremely useful additional function, especially when examining collective packaging such as yogurt trays. This is implemented by calculating the mass of the product. To do this, the operator weighs individual reference products, then teaches them in on the X-ray inspection system and adds the data according to the previously determined weight.
The corresponding ratio between the mass and the measured gray value is then calculated. After this, the device can independently determine the weight for all other products of this type. After entering upper and lower tolerances, the foreign body detector now performs the function of an uncalibrated scale. In combination with the segmentation function, individual product components that cannot be checked with a mechanical scale can also be weighed here.



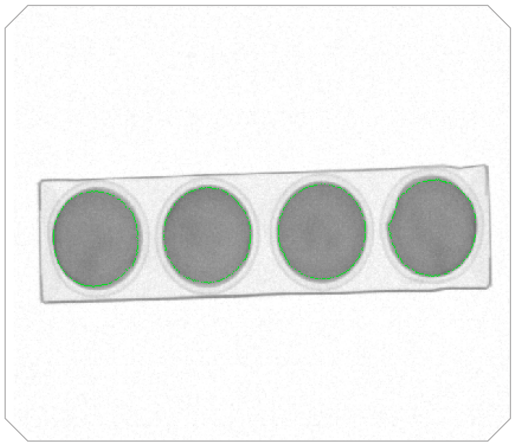
Yogurt tray without defect



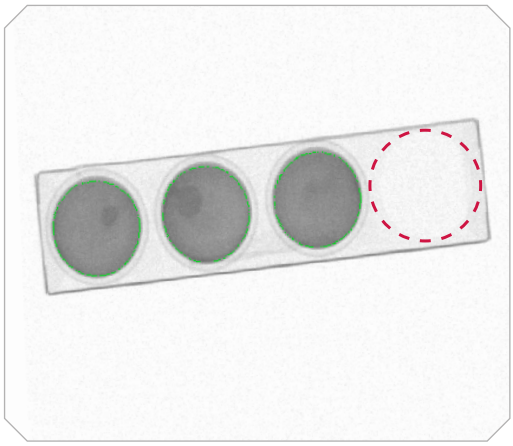
Yogurt tray with underfilled product

2.3 Object counting (s)

This simple function included in the standard scope of supply allows the automatic counting of individual objects within a packaging unit. This is possible for products in collective packaging as well as for product components with clear density differences. If a finer consideration of the completeness of the product is required, the subsequent „Integrity check“ should be used.



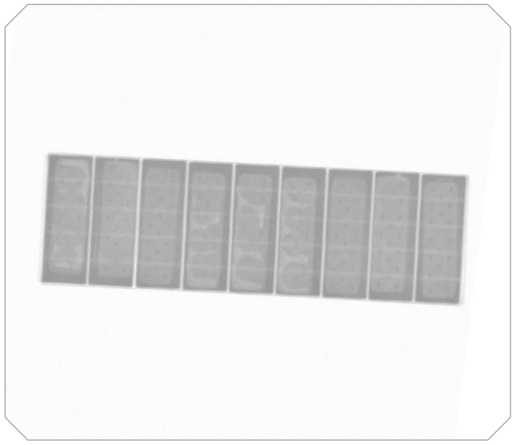
Cups in secondary packaging without missing product



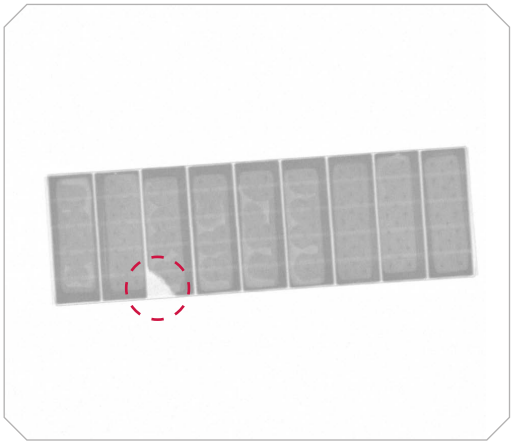
Secondary packed product with missing cup

2.4 Integrity check M1 (o)

By means of the optional „Integrity check“ function, primarily the outer shape of a product is checked. Several algorithms monitor, for example, the length and diameter, the desired thickness, fractures or breakouts. If required, algorithms can be switched on or off individually to take special features of the product into account, such as a particularly irregular shape. This function allows the most extensive inspection of products for quality defects using the most complex calculations. Thus, the most computing power is also used for this purpose.



Collective packaging candy bars without defect



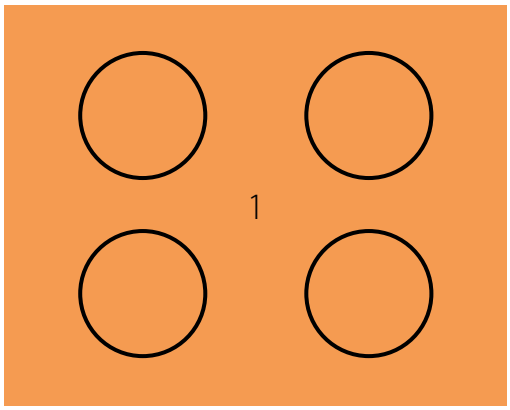
Collective packaging candy bars with damaged single product

3 Segmentation

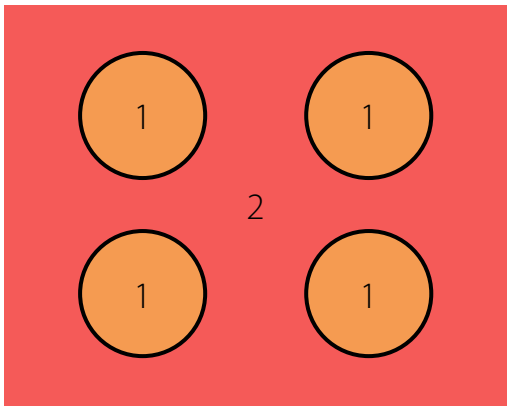
A particularly interesting aspect of quality assurance using X-ray inspection systems is the possibility of viewing zones of an entire product differently. Many packaged products consist of regions of different density and thickness. With a differentiated view of individual areas, the results regarding the detection of foreign bodies or quality defects can often be significantly improved. Various functions are available for this purpose.

3.1 Threshold value segmentation (s)

This selection option allows to generate one or more identical zones within the product. For these zone(s), for example, a separate threshold or edge suppression can be defined within the overall product. A suitable example for this would be a collective packaging with canned fish. It is important here that, in the case of several grouped individual products, their gray values are largely identical. On the other hand, this type of segmentation is independent of rotations of the overall product and requires only low computing capacity.



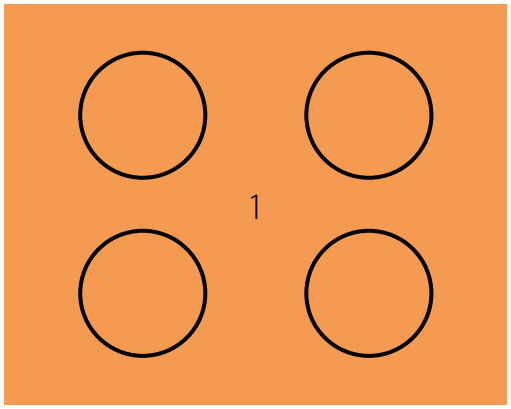
Without segmentation



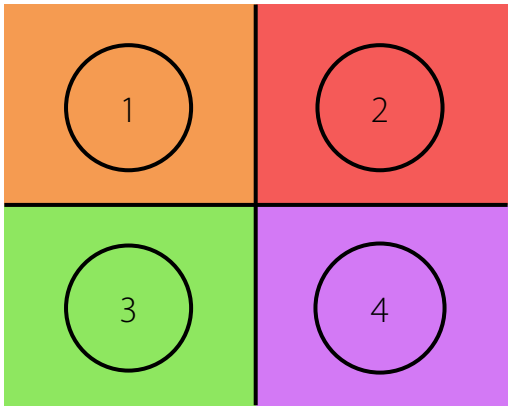
Threshold value segmentation

3.2 Grid segmentation (s)

This function makes it possible to divide the product image into suitable areas using straight horizontal and vertical lines. This also allows products to be divided into individual areas where no differences in the gray values can be detected by the X-ray device. Separate parameters can be defined for each of these segments. Likewise, a defect or foreign body can be assigned to the individual segment, which facilitates follow-up inspection. An example of this would be the examination of individual yogurts in yogurt crates.



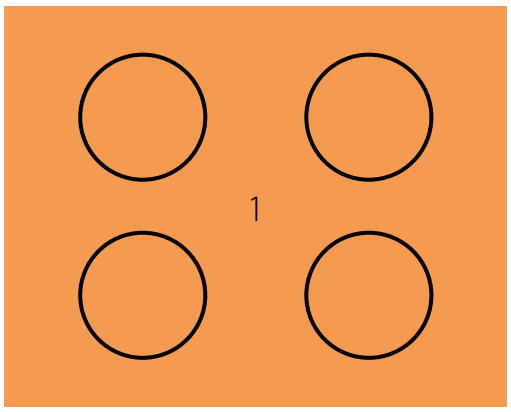
Without segmentation



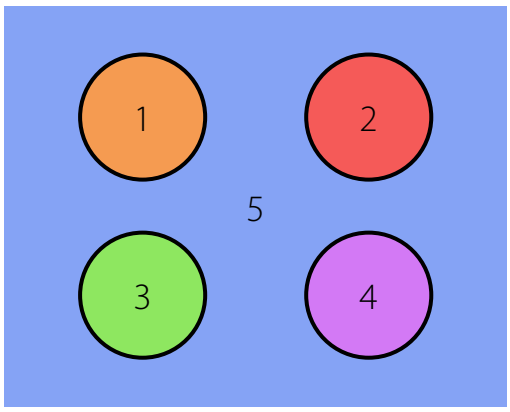
Grid segmentation

3.3 Complex segmentation (s)

Complex segmentation is the most complex way of dividing a product image into individual areas in terms of computing power. After the user has tapped on a region in the product, the X-ray system independently completes the shape of this zone based on the gray values. In this way, even complex product compositions, such as the different chambers of a ready meal, can be examined with highest accuracy in each compartment. However, since the zoning must be redefined for each product run, this type of segmentation requires the most computing power.



Without segmentation



Complex segmentation

4 Application examples
Combine functions – maximize benefits

The strong computing power of the easySCOPE X-ray inspection system allows multiple functionalities to be combined. Nevertheless, no reduction in product throughput has to be accepted. Depending on the application, combinations of the available functions and algorithms enable a very wide range of tasks to be performed. Some example applications in various industries are listed below.

Meat industry: liver sausage with closure clip

Foreign body control:
- Adaptive threshold evaluation (product shape uneven)
- Clip masking (existing closure clip should be ignored)

Quality improvement:
- Clip completeness check

Segmentation:
- not required

In addition to checking for foreign bodies such as metal, glass or stone, the correct fit of the clip is also checked.

Dairy industry: yogurt cups in tray

Foreign body control:
- Threshold value evaluation (product shape even)

Quality improvement:
- Weight check
- Object counting
- Edge suppression (thick edges of the crates with high density)

Segmentation:
- Grid segmentation

In addition to foreign body control, the filling quantities of the individual cups (and thus also completeness) are checked.

Confectionery industry: packaged chocolates

Foreign body control:
- Adaptive threshold evaluation (product shape uneven)

Quality improvement:
- Integrity check M1

Segmentation:
- Grid segmentation

The chocolates are checked for deformation and breakage in their final packaging. In addition, an individual threshold is assigned for each individual chocolate composition to ensure the best possible foreign body control.