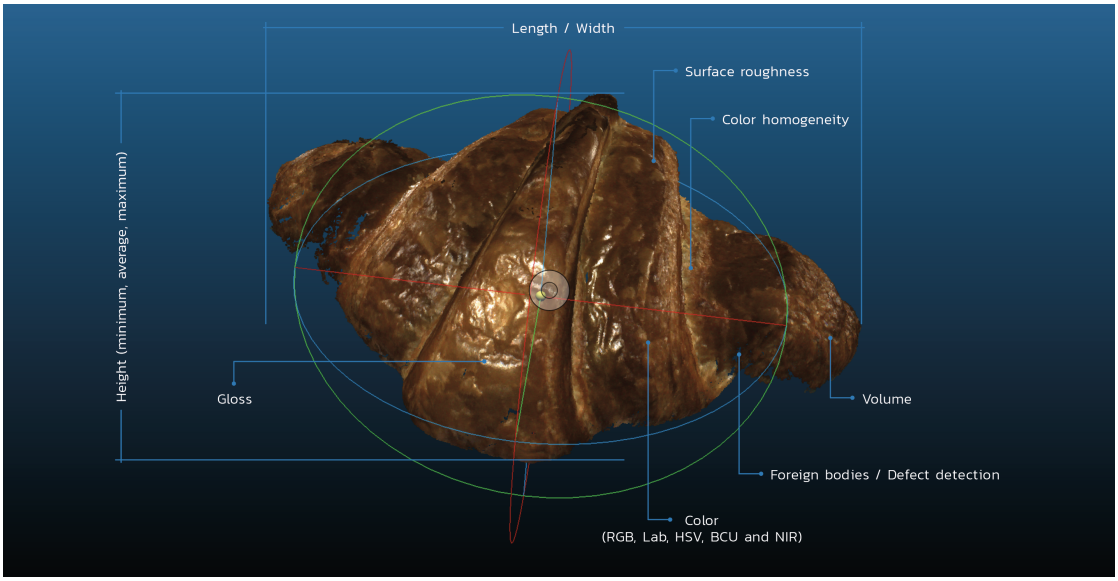
ScanRG

BAKEMETER parameter description



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1 Introduction

This document provides a description of parameters measured by ScanRG BAKEMETER and INLINER devices.

The parameters are calculated from the colored 3D point clouds captured by the N1 multispectral 3D scanner. Since the point clouds do not provide the necessary quality criteria directly, a set of generic and user defined parameters like product height, volume, average color, gloss, etc. is calculated. These parameters are applied for the quality assessment of the product. Out of specification products are marked by red signal lamp on BAKEMETER systems, or sorted out by for example compressed air nozzles on INLINER systems.

The calculated parameters describe the 3D shape and the color of the product. In many cases, there are multiple parameters describing the same physical quantity using different algorithms or settings. For instance, there are multiple parameters for the height of the product. The parameters HEIGHT, HEIGHT MAX03, HEIGHT MAX10 describe the highest point of the product, the 97th and the 90th percentile of the height histogram, respectively. This is done to adapt the system to different tasks. For instance, the HEIGHT parameter (i.e. the highest point) shall be used for the packaging of the product, whereas the HEIGHT MAX10 is rather useful for product quality analysis.

Another reason for using different algorithms for the same physical quantity is that some algorithms work better for some specific tasks than the others.

Note that not every parameter makes sense for all products, for example the diameter doesn't make sense for non-round products.

A few computationally intensive parameters as well as the user defined parameters are not calculated and return 0.0 by default. Please contact our support for more detail.

Each parameter is identified by its ID and name, s. Fig 1. The ID can not be changed. The parameter name can be modified on request.

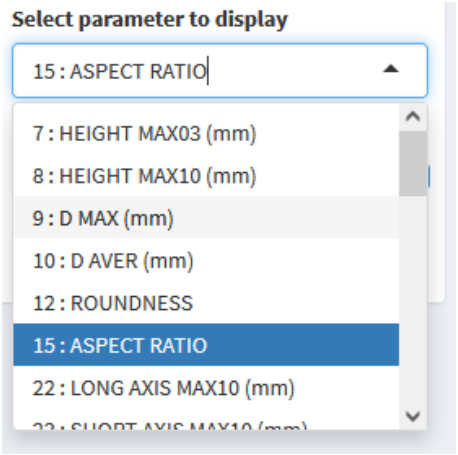

Figure 1: Parameter selection from the BAKEMETER UI

To improve the usability, some parameters are deactivated on the UI side. Please

contact our support for details.

The measured parameters are split into the following groups:

- **Position:** XYZ position of the product on the conveyor belt.
- **Size:** product size in X-, Y- and Z- dimensions.
- **Height:** product height.
- **Diameter:** product diameter.
- **Area:** product surface area.
- **Volume:** product volume.
- **Shape:** shape parameters like long/short axis, aspect ratio, roundness, etc.
- **Roughness:** surface roughness.
- **Crack detection:** crack and scratch signatures.
- **Color:** product colors in visible and near-infrared spectral range.
- **Color index:** normalized colors. Usually more stable compared to absolute color values.
- **Color noise:** color inhomogeneity indices.
- **Gloss:** gloss indices.
- **Meat:** meat and poultry related parameters.
- **User:** user defined parameters.

2 Definitions

In this document, the XYZ coordinate system is used with the Y-axis pointing towards the conveyor belt movement, the X-axis lying in the conveyor belt plane perpendicular to the X-axis, and the Z-axis pointing upwards perpendicular to the conveyor (XY) plane.

3 Parameters

3.1 POSITION group

The parameters of the POSITION group describe the position of the product on conveyor belt, s. Table 1. The X-, Y-, and Z-positions are calculated as the average values of the X-, Y-, or Z- coordinates of the 3D point cloud.

Parameter name	ID	Unit	Description
X	1	mm	X-position
Y	2	mm	Y-position
Z	3	mm	Z-position

Table 1: Parameters of the POSITION group.

3.2 SIZE group

The parameters of the SIZE group are listed in the Table 2. The WIDTH, LENGTH and HEIGHT parameters are calculated as the product dimensions along the X-, Y-, and Z-axis, respectively.

Note that the WIDTH and the LENGTH parameter depend on the product orientation on the conveyor. For orientation independend parameters refer to Table 7.

Parameter name	ID	Unit	Description
WIDTH	4	mm	product width
LENGTH	5	mm	product length
HEIGHT	6	mm	product height, measured between the highest point of the product and the conveyor belt level

Table 2: Parameters of the SIZE group.

3.3 HEIGHT group

The parameters of the HEIGHT group are listed in the Table 3. The parameters HEIGHT MAX03 und HEIGHT MAX10 are calculated as 97th and 90th percentiles of the height histogram, respectively.

Parameter name	ID	Unit	Description
HEIGHT MAX03	7	mm	product height, 3% of the 3D points lie above and 97% lie below this value
HEIGHT MAX10	8	mm	product height, 10% of the 3D points lie above and 90% lie below this value

Table 3: Parameters of the HEIGHT group.

3.4 DIAMETER group

The parameters of the DIAMETER group are listed in the Table 4.

The parameters D AVER and D IN are calculated by averaging the distance between the outer / inner boundary points and the product center. Note that both D AVER and D IN parameters are susceptible to holes in in the product, because the hole edges are detected as the product boundaries and thus are contributing to the calculated value.

Parameter name	ID	Unit	Description
D MAX	9	mm	diameter, calculated as $(WIDTH + LENGTH)/2$
D AVER	10	mm	outer diameter, calculated as the average distance between the products center and its outside boundary multiplied by 2
D IN	11	mm	inner diameter, calculated as the average distance between the products center and its inside boundary multiplied by 2
D OUT HT	27	mm	outer diameter, calculated by Hough transform algorithm
D IN HT	28	mm	inner diameter, calculated by Hough transform algorithm

Table 4: Parameters of the DIAMETER group.

3.5 AREA group

The parameters of the AREA group are listed in the Table 5.

The AREA 3D parameter is calculated as the surface area of the product. Note that this parameter is susceptible to surface roughness, meaning that the increased surface roughness would lead to larger AREA 3D.

The AREA 2D parameter is calculated by projecting the product shape on XY plane. This parameter is largely resistant against variations in surface roughness.

Parameter name	ID	Unit	Description
AREA 2D	73	cm^2	projected area
AREA 3D	74	cm^2	surface area (3D)
VERTEX COUNT	14	-	3D points count

Table 5: Parameters of the AREA group.

3.6 VOLUME group

Note that the volume is calculated based on the assumption that the bottom of the product is flat and lying on the conveyor belt surface. If the products bottom is bent, the

parameter value is overestimated.

Parameter name	ID	Unit	Description
VOLUME	25	cm^3	volume

Table 6: Parameters of the VOLUME group.

3.7 SHAPE group

The parameters of the SHAPE group are listed in the Table 7.

ROUNDNESS is calculated as $1.0-2*(R_{90}-R_{10})/(R_{90}+R_{10})$, where the R_{90} and R_{10} are the 90th and the 10th percentiles of the radius histogram, respectively. ROUNDNESS is 1 for the perfect circle and <1 for any other shape. Minimum ROUNDNESS value is 0.

The CIRCULARITY is calculated as $4 * \pi * VERTEX\_COUNT/N^2_{boundary}$, where $N_{boundary}$ is the number of boundary points. The CIRCULARITY is 1.0 for the perfect cycle and <1 for non-circular objects.

Parameter name	ID	Unit	Description
ROUNDNESS	12	-	Roundness of the outside boundary
ROUNDNESS IN	13	-	Roundness of the inside boundary, not implemented, returns 0.0
ASPECT RATIO	15	-	aspect ratio, $SHORTAXIS/LONGAXIS$
LONG AXIS	16	mm	long axis, based on average distance
SHORT AXIS	17	mm	short axis, based on average distance
LONG AXIS MAX	18	mm	long axis, based on maximum distance
SHORT AXIS MAX	19	mm	short axis, based on maximum distance
LONG AXIS MAX03	20	mm	long axis, based on 97th percentile
SHORT AXIS MAX03	21	mm	short axis, based on 97th percentile
LONG AXIS MAX10	22	mm	long axis, based on 90th percentile
SHORT AXIS MAX10	23	mm	short axis, based on 90th percentile
CIRCULARITY	24	-	circularity
HOLE COUNT	29	-	counts holes within the product

Table 7: Parameters of the SHAPE group.

3.8 ROUGHNESS group

Parameter name	ID	Unit	Description
ROUGHNESS	26	-	surface roughness

Table 8: Parameters of the ROUGHNESS group.

3.9 CRACK DETECTION group

The CRACK DETECTION group, s. Table 9 contains the parameters for crack detection. These parameters respond to linear defects on the product surface like cracks and scratches.

Parameter name	ID	Unit	Description
CRACK H 0/90	30	-	Crack signature based on height profile, for vertical and horizontal crack orientation
CRACK H 45/135	31	-	Crack signature based on height profile, for diagonal crack orientation
CRACK I 0/90	55	-	Crack signature based on brightness, for vertical and horizontal crack orientation
CRACK I 45/135	56	-	Crack signature based on brightness, for diagonal crack orientation
CRACK HxI 0/90	57	-	Crack signature based on height and brightness, for vertical and horizontal crack orientation
CRACK HxI 45/135	58	-	Crack signature based on height and brightness, for diagonal crack orientation
CRACK HT1	59	-	Crack signature calculated by Hough transform, small detection window
CRACK HT3	60	-	Crack signature calculated by Hough transform, medium detection window
CRACK HT7	61	-	Crack signature calculated by Hough transform, large detection window

Table 9: Parameters of the CRACK DETECTION group.

3.10 COLOR group

The COLOR group, s. Table 10 contains the parameters describing the average color of the product in visible (RED, GREEN, BLUE) and the near-infrared (NIR 730, NIR 940) spectral range.

The RED, BLUE, GREEN, NIR 730, NIR 940, and BRIGHTNESS parameters are calibrated to deliver the same value independent on the product position on the conveyor.

The RED, BLUE, GREEN, NIR 730, NIR 940, and BRIGHTNESS parameters are normalized to 1.0 for the white calibration target.

The I 940 parameter is the raw laser reflectance at 940nm. It is not calibrated, meaning that its value changes depending on the product position on the conveyor. This parameter shall be used in some special rare cases, for standard applications please use NIR 940 instead.

Parameter name	ID	Unit	Description
RED	32	-	Red intensity
GREEN	33	-	Green intensity
BLUE	34	-	Blue intensity
NIR 730	35	-	Near-infrared signal at 730nm
NIR 940	36	-	Near-infrared signal at 940nm, calibrated
I 940	37	-	Near-infrared signal at 940nm, not calibrated
BRIGHTNESS	62	-	Brightness, calculated as an average between the RED, GREEN, BLUE, and NIR 730
VALUE	40	-	Brightness in terms of HSV color model
CIE L	67	-	Lightness in terms of CIELAB color model, value range from 0 to 1.0
BCU	70	-	Baking contrast unit, value range from 0 (dark) to 5.25 (max. brightness)

Table 10: Parameters of the COLOR group.

3.11 COLOR INDEX group

The COLOR INDEX group, s. Table 11, contains the normalized color signals. Compared to COLOR parameters, the color indices are usually more stable against variation of the product orientation (i.e. rotation and tilt).

Parameter name	ID	Unit	Description
HUE	38	-	Hue in terms of HSV color model, value range 0 .. 360°
SATURATION	39	-	Saturation in terms of HSV color model, value range 0 .. 1.0
SIN H	41	-	Sin(HUE), for special purposes
COS H	42	-	Cos(HUE), for special purposes
NDVI 730	43	-	Normallized difference vegetation index, $NDVI_{730} = (NIR_{730} - RED)/(NIR_{730} + RED)$, value range -1.0 .. 1.0
NDVI 940	44	-	Normallized difference vegetation index, $NDVI_{940} = (NIR_{940} - RED)/(NIR_{940} + RED)$, value range -1.0 .. 1.0
CIE A	67	-	A^* value in terms of CIALAB color space, red-green axis, value range roughly -100 (green) .. +100 (red)
CIE B	68	-	B^* value in terms of CIALAB color space, blue-yellow axis, value range roughly -100 (blue) .. +100 (yellow)

Table 11: Parameters of the COLOR INDEX group.

3.12 COLOR NOISE group

The COLOR NOISE group, s. Table 12, contains the parameters describing the variation of brightness and color of the product. The parameter values are the lowest for the homogeneous smooth images and the highest for the noisy images.

The normal use case for the parameters of the COLOR NOISE group are quantification of toppings in case of baking goods, detection of labels, scratches, etc.

3.13 GLANCE group

The GLANCE group, s. Table 13, contains the parameters describing the product glance. The parameter values are the lowest for mat objects and the highest for glossy objects.

Traditionally the gloss is measured as a light reflectance at different angles of incidence at the same spot on the object. This method is not applicable to our setup, because the angle of incidence can not be changed.

To overcome this, the gloss is measured indirectly, taking use of the fact that the glossy objects show a very non-uniform reflection, i.e. some parts/spots of the object are reflecting much stronger than others, s. for example the image of the croissant below, Fig 2. Compared to this, the non-glossy objects show a more smooth and uniform reflection, s. for example the image of the card reader on Fig 2. The gloss indices GI1, GI2_03 and GI2_10 in Table 13 are evaluating this non-uniformity of the reflection by different methods.

Parameter name	ID	Unit	Description
H NOISE	45	-	Average variation of the product HUE
S NOISE	46	-	Average variation of the product SATURATION
V NOISE	47	-	Average variation of the product VALUE
H NOISE MAX	48	-	Maximum variation of the product HUE
S NOISE MAX	49	-	Maximum variation of the product SATURATION
V NOISE MAX	50	-	Maximum variation of the product VALUE
H NOISE MAX03	51	-	Variation of the product HUE, 97th percentile
S NOISE MAX03	52	-	Variation of the product SATURATION, 97th percentile
V NOISE MAX03	53	-	Variation of the product VALUE, 97th percentile

Table 12: Parameters of the COLOR NOISE group.

(a) Croissant (b) Card reader

Figure 2: Colored 3D scan of glossy (left) and mat (right) objects

3.14 MEAT group

The parameters of the MEAT group, s. Table 14, describe the specific quantities like fat content and blood spot area.

3.15 USER group

The parameters of the USER group, s. Table 15, describe the application specific quantities. The meaning and the calculation method of these parameters varies depending on application. Please contact support for implementation details.

If not defined, the USER1-USER5 parameters return constant 0.

Parameter name	ID	Unit	Description
GI1	64	-	Gloss based on the asymmetry of the reflectance histogram
GI2_03	65	-	Gloss from the spread of the reflectance histogram
GI2_10	66	-	Gloss from the spread of the reflectance histogram

Table 13: Parameters of the GLANCE group.

Parameter name	ID	Unit	Description
FAT FRACTION	71	%	Fat fraction
BLOOD SPOT	72	cm^2	Blood spot size

Table 14: Parameters of the MEAT group.

Parameter name	ID	Unit	Description
USER1	75	user defined	User defined
USER2	76	user defined	User defined
USER3	77	user defined	User defined
USER4	78	user defined	User defined
USER5	79	user defined	User defined

Table 15: Parameters of the USER group.

BAKEMETER parameter description

Dokument ID: 20241206_bakemeter_parameter_gen

Dokumentenversion:

Yes we scan.

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