CORN SPECTRAL IMAGING QUALITY CONTROL

Videometer Application Guides

June 2021

Videometer

The following E-Book is designed to help corn producers and traders worldwide understand the role that spectral imaging can have on corn quality inspection.

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Quality Control With Spectral Imaging

What is spectral imaging?

Spectral imaging is the capturing of spectroscopic information throughout the electromagnetic spectrum and combining it with imaging to show what is not visible to human sight and also beyond.

This technique allows to visualize the **chemical and physical conformation** of the object being pictured, mapping each of its components in singular pixels.

Why is spectral imaging relevant for quality control?

Because spectral imaging enables the visualization of more than what could just be seen by the naked eye, it can efficiently be used for quality control.

Institutions often request food and grain producers to visually inspect their product. However, when conducted manually, visual inspection can lead to subjectiveness, errors and/or misinterpretations. This, in its turn, can cause food safety issues and lower quality standards in foods. Figure 1 shows clearly the cicle of events that errors in manual visual inspection can cause.

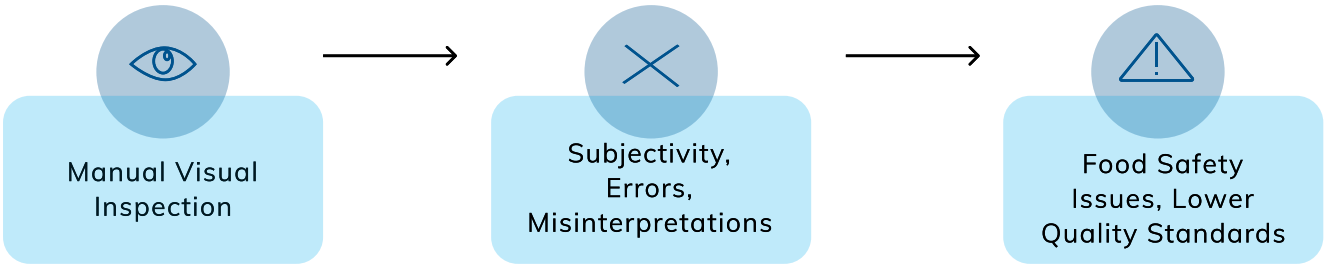


Figure 1:

Spectral imaging represents a good opportunity for companies in the food and grain industry to **standardize, document and enhance** their quality inspection (Boelt et al., 2018).

FROM MANUAL TO AUTOMATED QUALITY INSPECTION

Corn is the **world most produced commodity**, with over 1.000 million tons produced each year (AMIS, 2021).
It is a heterogenous crop – it exists in many varieties and qualities and has a vast number of different usages.

Because of its heterogenous nature, **corn quality factors differ across countries and uses**. Different soils, weather conditions and purposes imply different grading systems (Paulsen et al., 2019). This is why manual quality inspection can be especially strenous to perform on corn.

With spectral imaging, corn can be analyzed objectively in spite of its differences. This technology allows to assess a full range of features of the corn kernel: **color, shape, contour, texture features and more**.

In the following chapters, we will further explain how spectral imaging can be used to enhance corn quality inspection in light of the differen grading systems.

Quality Management Systems And Corn Gradings

Quality Management Systems

Quality Management Systems (QMS) help ensure the health and safety of products for their end-users.

As seen in Figure 2, researchers have proven that these standards generate a broad variety of **benefits for grain producers**, (Laux et al., 2015). In fact, for each $1,00 dollar invested in QMS, grain producers can expect to generate in average $ 1,50-$ 2,00 in returns (Paulsen et al., 2019).

> *"QMS are formalized processes, procedures, and responsibilities for achieving quality processes and objectives"*
>
> (Paulsen et al.:169, 2019).

Figure 2: Benefits of QMS in grain elevator operations (Laux et al., 2015)

With over 1 million companies adopting it, the most popular QMS across 170 countries worldwide is the **ISO9000 series** (www.iso.org).

These standards have become the norm, especially in the corn industry. The ISO9000 for corn, indeed, specifies the ways and standards according to which corn should be handled in all stages of the supply chain (Paulsen et al., ANNO).

Consequently, the ISO9000 significantly influences the **corn grading systems** worldwide, that, although similar for many aspects, are still in need for uniformity.

Corn Gradings

As mentioned in the previous pages, corn is a heterogenous crop, whose quality largely depends on a number of contextual factors. That's why corn gradings differ from region to region, where competent authorities give a detailed overview of **limits and percentages** required for the production and trade of high quality corn. (Paulsen et al., 2019).

Although varied, corn gradings worldwide do set focus on a number of **particular features** of corn, illustrated in Figure 3.

In the following pages, we provide some of the most widespread corn gradings and standards worldwide.

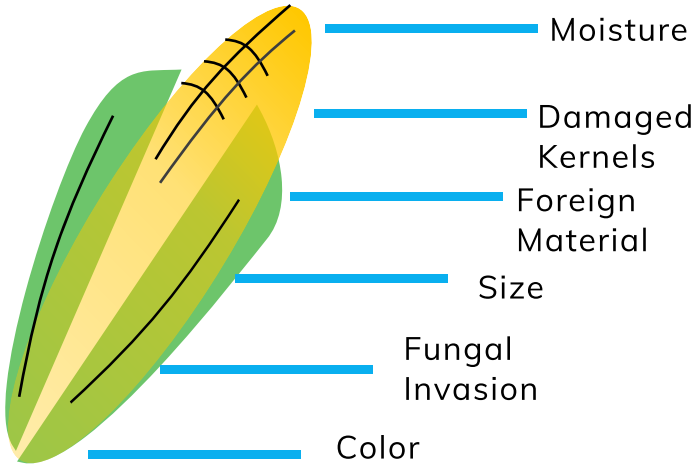


Figure 3: Corn features taken into account for corn grading systems.

USDA Grading System

From gipsa.usda.com

GRADE	MINIMUM LIMITS OF	MAXIMUM LIMITS OF		
	TEST WEIGHT PER BUSHEL (POUNDS)	HEAT DAMAGED KERNELS (%)	DAMAGED KERNELS TOTAL(%)	BROKEN CORN AND FOREIGN MATERIAL (%)
U.S. N. 1	56	0,1	3	2
U.S. N. 2	54	0,2	5	3
U.S. N. 3	52	0,5	7	4
U.S. N. 4	49	1	10	5
U.S. N. 5	46	3	15	7

Codex Standard For Maize

Codex Stan 153-1985 (FAO)

Kernels of other colors:

FACTOR	LIMIT	METHOD
YELLOW MAIZE	MAX: 5.0% by weight of maize of other colours	Visual Inspection
WHITE MAIZE	MAX: 2.0% by weight of maize of other colours	
RED MAIZE	MAX: 5.0% by weight of maize of other colours	
MIXED MAIZE	-	

Kernels of other shape:

FACTOR	LIMIT	METHOD
FLINT MAIZE	Visual Inspection MAX: 5.0% by weight of maize of other shapes	Visual Inspection
DENT MAIZE	MAX: 5.0% by weight of maize of other shapes	
DENT MAIZE	RANGE: 5.0% to 95% by weight of flint maize	

Codex Standard For Maize

Codex Stan 153-1985 (FAO)

Defects

FACTOR	LIMIT	METHOD
BLEMISHED GRAINS	MAX: 7.0% of which diseased grains must not exceed 0.5%	Visual Inspection
BROKEN KERNELS	MAX: 6.0%	ISO 5223-1983 (4.50 mm metal sieve)
OTHER GRAINS	MAX: 2.0%	Visual Inspection

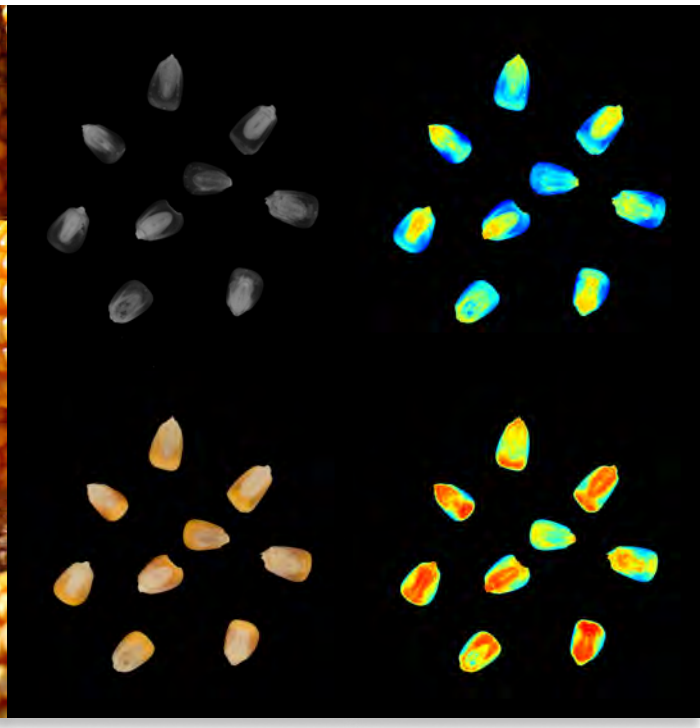
Technical Specifications For European Maize

-

WFP, 1st March, 2011

GENERAL REQUIREMENTS	
Moisture	14 % max
Broken grains	4 % max
Grain impurities	3 % max
Sprouted grains	0.5% max
Live insect Infestation	1% max
Miscellaneous	Natural state, smell and color
Organoleptic	Nil

The Videometer Corn Classification Model



Features

Healthy maize kernels

Burnt Kernels

Broken kernels

Fermented kernels

Germinating kernels

Mold damage kernels

Plant parts (corn cobs and glumes)

Insect damaged maize kernels

Breeding seeds (coated with pesticide)

How does it work?

The Videometer Corn Classification model is a state of the art technology that combines **AI, machine learning and spectral imaging.** It is widely utilized to screen grain samples in the quality control processes.

The samples are analyzed rapidly and according to their size, with a variation or error of about 1%. This means that corn quality control processes can be performed in a **easy, fast and valid** manner.

Each corn kernel in the sample is captured with spectral imaging up to **20 different wavelengths**, and later analyzed for classification. Here, it is sorted in different categories: **healthy kernel, admixture or damaged kernels**, with specification on the type of damage.

Brown mold pixels are marked with red overlay color, healthy surface is shown with blue overlay.

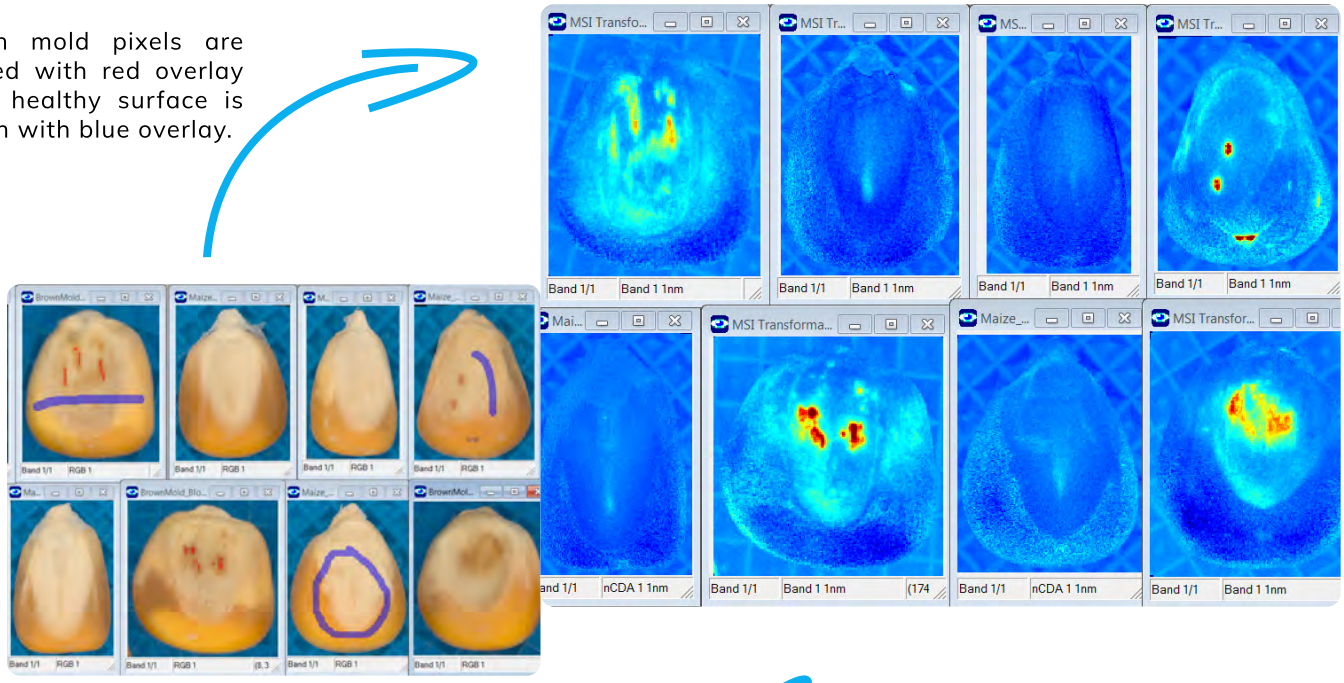


Figure 4: Corn classifier training example with brown mold

Apart from color information, in multispectral imaging, **a whole range of features** can be measured to characterize different aspects of the kernels. This includes shape, contour and texture features.

Machine learning is then applied, as shown in Figure 4, to train the classifier that categorizes each kernel into a number of result classes based on their color, shape, contour and texture features. When the classification model has been trained for the specific corn, it is ready for use. It can always be re-trained when new corn variations occur.

Videometer Technology to Assess Corn Quality

The classification model classifies the contents of a maize sample into **healthy kernels, admixture particles and a number of defected maize categories**. This model is compliant with the specifications set by the grading systems presented in the previous pages, and can be updated to comply with further systems.

Specifications:

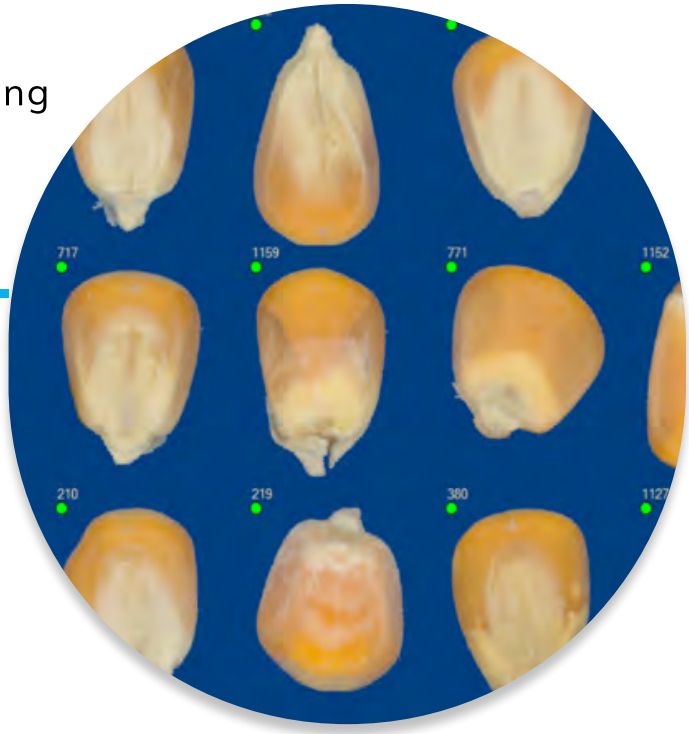
Image resolution: 0.054 mm/pixel

Spectral resolution: up to 20 wavelengths, from 365-970 nm

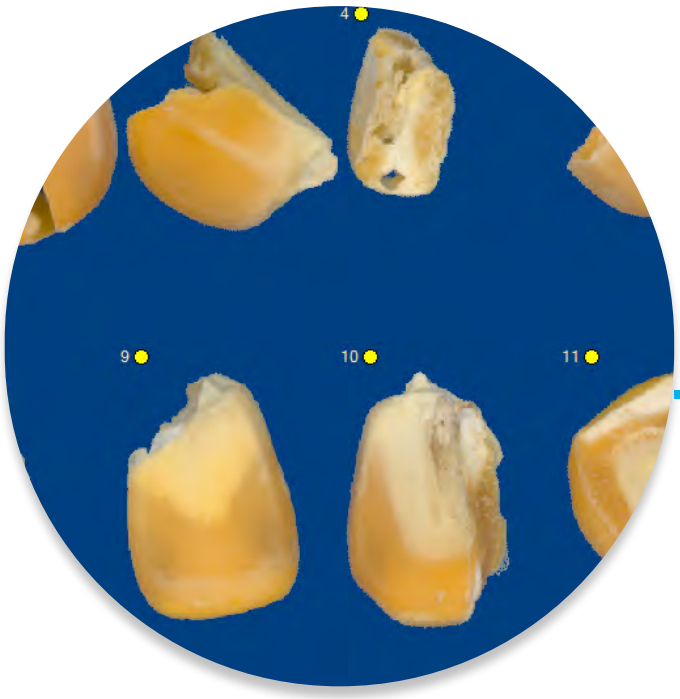
Sample throughput: 300 grams analyzed in 5 minutes using 8 of the wavelengths

Excel report with detected fractions saved for each sample.

Intuitive UI for filtering and examining classification results.

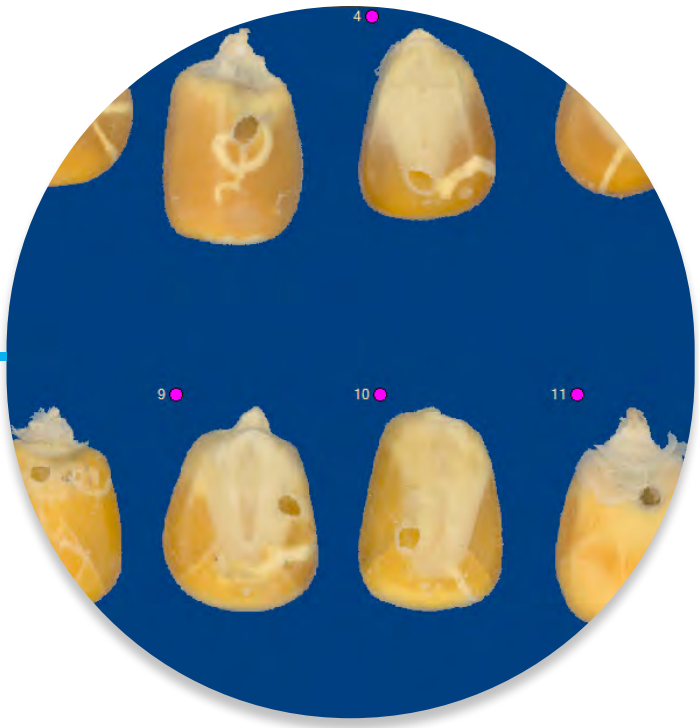


Healthy maize kernels

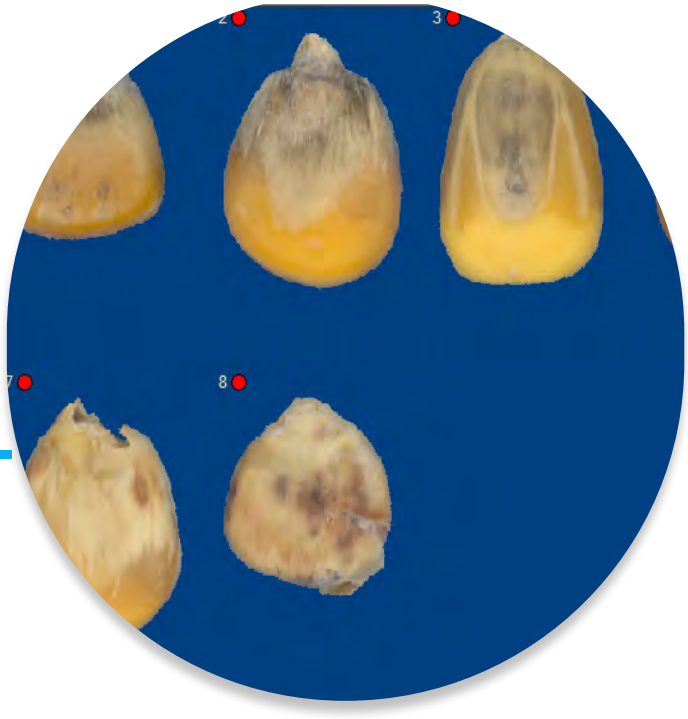


Broken maize kernels

Insect damaged kernels



Fermented and diseased kernels



Mold damaged kernels

Admixture & glumes

The VideometerLab

Spectral Imaging Made Easy

The VideometerLab 4 is a spectral imaging instrument designed for fast and accurate determination of color, texture and chemical composition on surfaces up to 90x90 mm per image.

The instrument is an easy-to-use system integrating illumination, camera and computer technology with advanced statistics. Using strobed LED technology, the VideometerLab 4 combines measurements at up to 20 different wavelengths into a single, high-resolution spectral image.

Every pixel in the image is a reflectance spectrum. The instrument includes UV, Visual and NIR wavelengths and may also include flourescence.

"The VideometerLab recognizes internal and external features of corn, which we wouldn't be able to do manually."

Josh Zangger -
CEO, Zangger Popcorn

VideometerLab with Autofeeder

Enhance the capacity of your VideometerLab System with the Autofeeder option.

The Autofeeder option together with the VideometerLab System provides a high throughput multispectral analysis instrument for granular samples.

The Autofeeder option uses a vibrator to distribute granules from a funnel evenly onto a belt. The belt transports the granules under the VideometerLab scanner and subsequently into a collection box.

Images of the sample are acquired, segmented and analyzed, and a summary report is automatically created at the end of the measurement.

By option the system can be customized with a robot that picks up selected granules, based on the analysis result. The picking system is designed for physical sorting of high value granules, e.g. removal of defect granules (broken, non-germinating, infected).

"The Videometer Technology helps us standardize the popcorn quality control process"

Josh Zangger -
CEO, Zangger Popcorn

About Videometer

Videometer is a world leading provider of spectral imaging technology, machine learning and AI software for analysis of a broad range of products. Our imaging instruments and turnkey solutions allow our worldwide customer base to see, detect, and measure product properties in an accurate, fast, versatile, and non-destructive manner.

The wide range of solutions offered, both in terms of products and applications, make the Videometer instruments unique and flexible in their usage. The instruments come with a practical, easy to use software, which aid the user in his experience.

Spectral Imaging Excellence Since 1999

With more than 20 years in the spectral imaging industry, Videometer provides excellent, high quality and innovative products, documented by a patented technology and more than 300 scientific papers written about them.

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We Measure What You See - and beyond!

Videometer can develop models based on your needs.

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