Non-Destructive Quality Control using a Multi-Sensory Fruit Scanner with NIR and Microwaves

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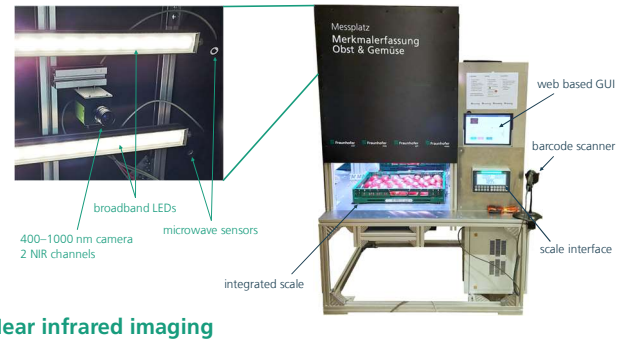
In wholesale trades, the screening of incoming fruit and vegetables is essential to maintain continuous quality assurance. A multisensory scanner can not only automate the quality control, but also enhance it with non-perceptual information using NIR and radar sensors. Combined with machine learning evaluation, properties like ripeness, freshness and hidden defects can be detected fast and reliably in a non-destructive way.

Assessing the quality of fruit and vegetables

Crates of incoming fruits and vegetables in wholesales are usually screened by trained employees. This is where our multimodal sensor system applies. The crates can be captured just with the touch of a button. In the first project stage, the scanner is used for data acquisition. A barcode scanner and an easy-to-use touch interface enable quick label (*OK* / *Not OK*) and meta data assignment by the user. Later the device has the purpose of workflow integrated automated quality evaluation.

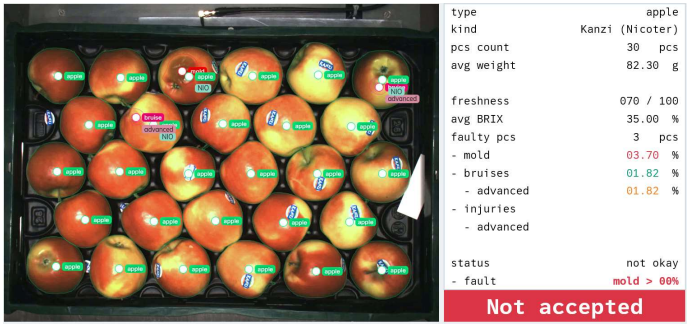
The system setup
Currently, the scanner is equipped with microwave (radar) sensors, a scale and a five channel VIS-NIR area camera having two broad near infrared bands. The covered wavelengths range from 400 – 1000 nm. A broadband LED light source is used for illumination. With an additional barcode scanner, information from the delivery bill can be tracked and linked.



Near infrared imaging

Near infrared (NIR) sensors allow image capturing in non-visible ranges of light between approx. 700 and 1000 nm. These wavelengths can uncover defects and bruises as far as under the peel. Wide band sensors have the advantage of making fruit defects more visible by hiding texture and colors while being quick and inexpensive at the same time. This is particularly noticeable on dark surfaces like avocado skin, but increases the defect visibility on other fruit as well. With narrow bands even chemical characteristics like sugar level (*BRIX value*) or water content can be indicated. Hence, NIR imaging facilitates quality control and enables the determination of food freshness and ripeness.

NIR sensors reveal invisible bruises under the avocado skin.



Example of AI analysis of an apple crate with the fruit scanner.

Automated quality control with machine learning evaluation

The data gathered with the scanner in phase 1 is intended for training machine learning models. Before training, the dataset will be enriched with detailed instance segmentations of defects and other quality aspects manually rated by experts. The resulting data serves as multi-dimensional input for deep neural networks learning to predict bruises, mold and other defects as well as the overall acceptability of the fruit crate. The aim is to create a real-time application that analyses the multisensory information on premise and thereby facilitates and enhances quality control.

Targeted use-cases
With the currently integrated sensors, we aim to predict:
- kind, number and location of fruits
- defects such as bruises, injuries, mold
- other faults like missing or wrong fruits and foreign bodies in the crate

Later, using NIR sensors with more bands, specific spectra can be assessed and converted into interpretable chemometrics with machine learning methods. In the long-term, the goal is the prediction of freshness and ripeness as well as flavor factors such as sugar content and acidity.

ERP integration

To provide a fully integrated quality monitoring system for wholesale trades, we plan to exchange data automatically with an ERP system. Thus, we can include the existing knowledge about product details from the ERP database into the model training. Furthermore, returning the obtained analysis data the ERP system could enable the long-term supervision of conditions and supply chains.

The general objective
In the long term, we hope to facilitate and enhance the incoming goods inspection in wholesale trades, make food quality more controllable, reveal quality related factors in the supply chain and reduce food waste.

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