



- 1 Walnuts on a conveyor belt.
- 2 Impact sound waveform with marked region of interest.
- 3 Spectrogram of sound data for sound detection.

AUTOMATICALLY ASSURING QUALITY WITH SMART SOUND ANALYSIS

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Identification of Material without Contact

A complete inspection of processed raw materials and intermediate and finished products in the manufacturing process requires methods for the evaluation of products, which determine their properties non-invasively, at high throughput, online and without special sample preparation in order, for instance, to make grading decisions.

In a number of applications, optical systems are unable to access certain product parameters, such as the conditions inside edible nuts. The analysis of the acoustic properties of a material at impact on a solid surface furnishes a solution to this problem.

The systems developed at the Fraunhofer IFF identify materials, such as different species of nuts, and material properties not visibly recognizable by external features, such

as kernel condition or the presence of the kernel in the shell, without contact. They use highly sensitive microphone arrays and structure-born noise technology to produce a high-dimensional, unique acoustic fingerprint of a material.

Analysis with Artificial Intelligence

The challenge is the interpretation of the complex high-dimensional signal patterns produced when sound is recorded. To this end, the hardware sensor system, the microphone in this case, must be combined with a software model to detect sound. This approach is also called "soft sensing".

The creation of analysis models based on simple reference databases and physical testing of the correlation of sounds and product properties is involved and expensive and produces less robust methods.



The Fraunhofer IFF relies on another more efficient approach. We take advantage of self-learning systems to model the correlation between acoustic signature and target parameters, whether these are material identity or inner material condition. We process data smartly with machine learning as a key element. Models based on systematically collected reference data are generated, which facilitate real-time processing of acoustic data in the manufacturing process.

This enables us to create a solution customized to your needs in very short time. Moreover, the frequency range matching your needs can be identified in parallel. This opens the door to affordable and customized measurement systems for the inspection of your products.

Applications

1. Online quality assurance for product classification
2. Real-time grading system control

Technology Partner for Quality Assurance

As your technology partner, we will develop and implement quality assurance systems customized for our clients' needs:

1. Systematic Data Collection

We systematically collect sound data at your facilities or in our spectral laboratory. If necessary, supporting target parameters

specifying a product's condition can be collected in contracted food laboratories. The data collected covers the stipulated complex of problems.

2. Measurement Model Development

Taking the collected data as the starting point, a measurement model is created, which establishes the non-trivial correlation between acoustic data and target parameters, such as material identity. Drawing on a range of machine learning methods, we select or modify the best model for your needs.

3. Model Validation

We fully validate the measurement model, thus enabling us to provide information on expected measuring accuracies, processing times and requisite frequency ranges. This validation is the basis for subsequent system development.

4. System Development and Integration

Based on the findings of the model validation, we customize a quality control system for you based on sound recordings and optimized data analysis. This system can be integrated in your existing manufacturing systems.

Sound Analysis – Benefits at a Glance

1. Automatic: Analysis during production does not require any manual procedures.
2. Online: Data is analyzed in the production cycle and can be used to immediately mark or grade goods or to intervene in the production process.
3. Integrated: The system uses compact and robust microphone sensor technology that can be integrated in your production process. Results of data analysis can be integrated in existing data acquisition and control systems.
4. Noninvasive: The method of measurement does not affect your product.
5. Optimized: You get an inspection system with hardware and software customized to your needs.

1 System configuration with conveyor, microphone array and impact plate.

2 Walnuts identical in appearance but different on the inside.