

# Foreign Object Inspection System Using AI and Near-Infrared Camera

## 1. Introduction

A series of news reports concerning food contamination involving various types of foreign objects such as plastic fragments, vinyl fragments, insects and metal fragments have appeared recently, heightening concern about the safety of food products<sup>1)</sup>. Food manufacturers also position foreign matter contamination as a critical control item for quality control. In inspections for foreign objects, visual inspections by human inspectors are performed in addition to inspections using metal detectors and X-ray inspection systems. However, in spite of these efforts, some foreign objects are not detected, and it is also difficult to secure inspection personnel to perform visual inspections due to labor shortages. Therefore, further performance improvement in foreign object inspection devices is required.

## 2. Foreign Object Inspection by Near-Infrared Camera

### 2.1 Foreign Object Inspection by Near-Infrared Light

Metal detectors and X-ray inspection devices can be mentioned as foreign object inspection devices which are currently in general use. However, detection of low-density plastics is not a strong point of these devices. In particular, a reliable method for detecting hard plastic fragments is needed, as they may cause physical injury, such as chipped teeth, if accidentally put into a mouth.

Use of wavelengths in the near-infrared band is a suitable method for detecting plastic fragments. Since many plastic fragments display a characteristic absorption peak in the near-infrared wavelength band, foreign contaminants in food can be detected by capturing that spectrum.

### 2.2 Near-Infrared 3-Wavelength Camera

Foods and plastics can be distinguished by investigating the spectrum in the near-infrared region, but measurement of the entire spectrum is difficult in terms

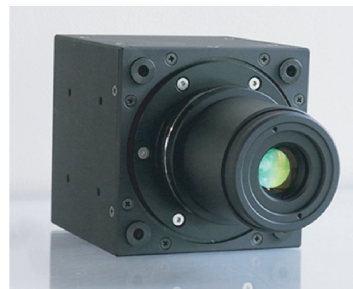
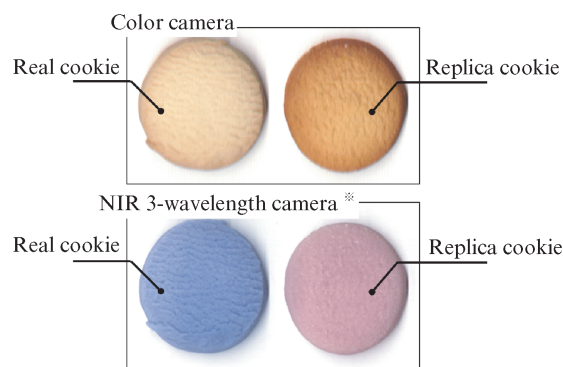


Photo 1 Near infrared 3-wavelength camera



※ Imaging by mapping 1 200 nm to blue, 1 400 nm to green, and 1600 nm to red.

Fig. 1 Example of near-infrared 3-wavelength camera imaging

of inspection speed and equipment cost. Therefore, JFE Techno-Research Corporation developed a near-infrared 3-wavelength camera which is capable of measuring three important wavelengths from the near-infrared wavelength region (**Photo 1**). As the three wavelengths, 1 200 nm, 1 400 nm and 1 600 nm were selected. At the 1 200 nm wavelength, plastics easily shown absorption, while 1 400 nm is a wavelength that shows absorption due to water, and 1 600 nm was selected as a reference wavelength which does not display an absorption peak. **Figure 1** shows an example of imaging using the near-infrared 3-wavelength camera. The objects of imaging are a real cookie and a replica cookie made of resin. Although both cookies are visible in the color camera image, when the near-infrared 3-wavelength camera is used, they can be clearly imaged as different objects. Plastic foreign matter in foods is detected by using this feature.

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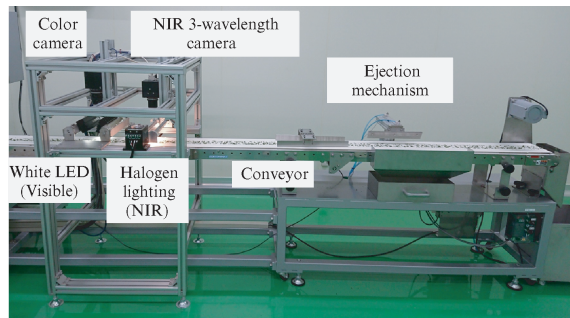


Photo 2 NIR foreign object inspection system

### 2.3 NIR Foreign Object Detection System

**Photo 2** shows an example of a NIR (near-infrared) foreign object detection system. The system consists of a near-infrared 3-wavelength camera and a color camera for image inspection. Halogen lighting is used as the light source for the near-infrared 3-wavelength camera because it emits light broadly across the NIR spectrum. White LED lighting is used with the color camera. Inspection for foreign objects is carried out while capturing images of the inspection targets being carried on the conveyor, and when a foreign object is detected, it is discharged by a discharge mechanism located in the downstream part of the conveyor.

In detection of foreign objects, the acceptable range is set automatically based on data for normal products, and objects outside that range are judged to be foreign objects. It is possible to set the detection method and arbitrary thresholds for detection.

### 3. Foreign Object Detection by AI

In addition to conventional rule-based standards for judgment of foreign objects, this NIR foreign object detection system is also provided with a foreign object judgment function by AI using deep learning, which enables judgment of foreign objects with higher performance. In foreign object inspections of foods, rule-based inspection methods have limitations, as there are large variations in the shapes of normal products and foreign objects do not necessarily have a fixed shape. In contrast to this, inspection accuracy is improved by using AI because the optimum judgment standard for inspections is set automatically.

**Figure 2** shows an example of detection using AI. These are the results of imaging when a hair was intentionally placed in dried cabbage. Although the hair was not detected in the conventional rule-based inspection, it could be detected by using AI. Thus, the AI-based system makes it possible to detect contaminants such as hairs, lint, insects, etc. that cannot be detected by the conventional method.



Fig. 2 Example of foreign object (hair) detection by AI

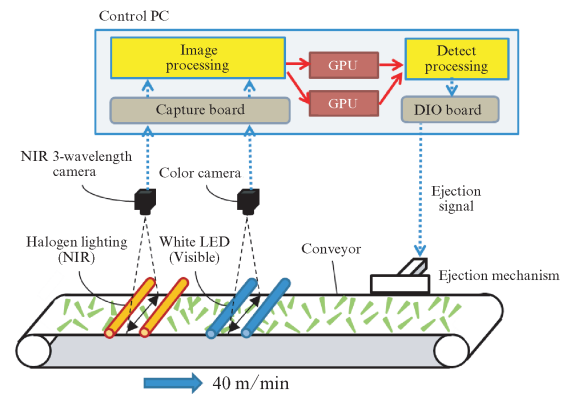


Fig. 3 AI-based inspection system overview

AI judgment processing has a large computational load. However, in order to achieve real-time inspection, separate GPUs were provided for the two cameras, enabling inspection at a conveying speed of 40 m/min. **Figure 3** shows the overview of the AI-based inspection system.

### 4. Example of Application Other than Foreign Object Inspection

Up to this point, this article has presented an example of application of the near-infrared 3-wavelength camera to foreign object inspection. As another application, use in moisture measurements is also possible. Since strong absorption by moisture can be seen, particularly in the wavelength range around 1 400 nm, the amount of moisture can be understood by measuring the degree of near-infrared light absorption by the object of measurement. In the case of the near-infrared 3-wavelength camera, measurement accuracy can be improved by using the wavelength data for the 1 200 nm and 1 600 nm wavelengths in addition to the 1 400 nm wavelength. **Figure 4** shows an example of measurement of the moisture distribution of bread. With conventional moisture meters, it is only possible to determine the total amount of moisture or the amount at a pinpoint location. However, the distribution of moisture can also be measured by using the near-infrared 3-wavelength camera.

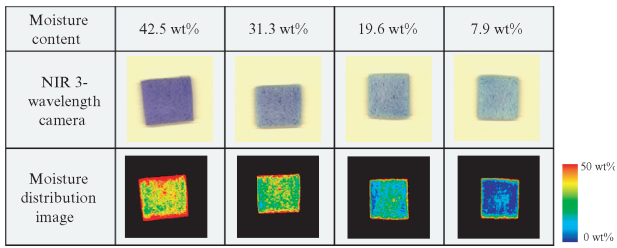


Fig. 4 Example of moisture distribution measurement of bread

## 5. Conclusion

A foreign object inspection system using a near-infrared 3-wavelength camera was developed, and its per-

formance was improved by adding an AI function. In the future, we will continue our efforts to develop foreign object inspection systems with higher performance.

## Reference

- 1) National Consumer Affairs Center of Japan. Shokuhin no ibutsu konnyuu ni kansuru soudan no gaiyou (Overview of consultations on foreign matter contamination in foods). 2015. 9p.

## For Further Information, Please Contact:

Sales Managing Dept., JFE Techno-Research  
 Phone: (81)3-5877-5612  
 Homepage: <https://www.jfe-tec.co.jp/en/>