

# Novel X-ray imaging technology

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## Introduction

X-ray inspection systems are a standard feature in many ports. These X-ray systems have the unique ability to non-destructively image the contents of entire cargo containers in just a few seconds. It is a difficult task, however, to identify what is in the container based on the obtained X-ray images. The superposition of two images with different contrasts – like in dual-energy X-ray imaging – can enhance the effectiveness of the detection. Here we present a new X-ray imaging technology which introduces an entirely new type of contrast based on movement. This technology can be combined with existing single-energy and dual-energy X-ray imaging methods, opening new possibilities in port security applications.

## Dynamic X-ray imaging – a novel technology

We developed an innovative X-ray imaging technology to reveal previously inaccessible information about hidden movements. The method is sensitive to motions of living creatures or objects.

The novel X-ray imaging technology applies an altered data acquisition sequence and an altered data processing algorithm. The new technology provides two different images at once. One of the two images is the familiar conventional X-ray image. Together with this, a novel ‘dynamic’ image is also acquired that represents hidden local motions. The dynamic image brings a new type of contrast, which is based on motion. Static components disappear from the dynamic image, and moving objects appear brighter if they move faster.

The new technology has several advantages. The novel motion-based contrast opens new alternatives to detect and identify objects or living creatures. The imaging technology can be added to existing X-ray scanner models by a minor software and hardware upgrade, to enable them to detect motion. We obtain the dynamic image together with the conventional image without increasing the necessary measurement cost, time or radiation dose. The dynamic imaging technology provides extra information without sacrificing existing advantages of X-ray imaging.

## Dynamic imaging reveals moving objects

We imaged the clockwork of an alarm clock to illustrate the

capabilities of the new method. The electronic circuitry and the mechanics of the clock appear in the acquired conventional image. In the dynamic image, the still parts disappear, and we find a new contrast which is based on movement. (See Figure 1) The bright green indicates fast, dark red indicates slow movement. The wheels advancing the second, the minute and the hour fingers inside the clock are clearly visible. This demonstrates the large dynamic range of the movements that can be imaged at the same time: the wheels moving the second finger move 3,600 times faster than the wheels moving the hour finger.

## Dynamic imaging reveals hidden pests

One important application of the dynamic imaging technology could be finding stowaway pests in the cargo. Stowaway pests travel hidden within transported goods and may damage the cargo while being shipped. In addition to this, potentially invasive species often travel as stowaway pests and arrive to new territories unnoticed. Although better part of these exotics are harmless, approximately 20 to 30 percent of the introduced species are pests and cause major environmental and economic problems. US legislation has been concerned about the problem for many years. The intention of the Invasive Fish and Wildlife Prevention Act 2012 is to prevent the import of potentially harmful exotic pests. The legislation would empower the US Fish and Wildlife Service to become proactive in stopping harmful invasive species from ever arriving on US shores.

To stop harmful exotics from arriving in the US, or to protect the cargo from stowaway pests, it will be necessary to find the pests in the large volume of transported goods. Finding stowaway pests however, can be extremely difficult. Below (see Figure 2 and Figure 3) we demonstrate how to use the dynamic X-ray imaging technology to find the unwanted stowaways.

We used the dynamic imaging method to visualize pests hidden inside wood or inside packaged food. The conventional X-ray image was unable to detect the hidden insects. The dynamic image clearly highlights the movement generated by the stowaway pest in the cargo: bright green indicates fast, dark red indicates slow movement.

## Dynamic X-ray imaging in port security

Finding stowaway pests is important to protect the cargo as



Figure 1: Image of an electronic clock made with the new technology. The conventional image (left) and the dynamic image (right) were acquired at the same time.



Figure 2: The conventional image (upper) and the dynamic image (lower) of part of the tree branch shown in the photograph (left).

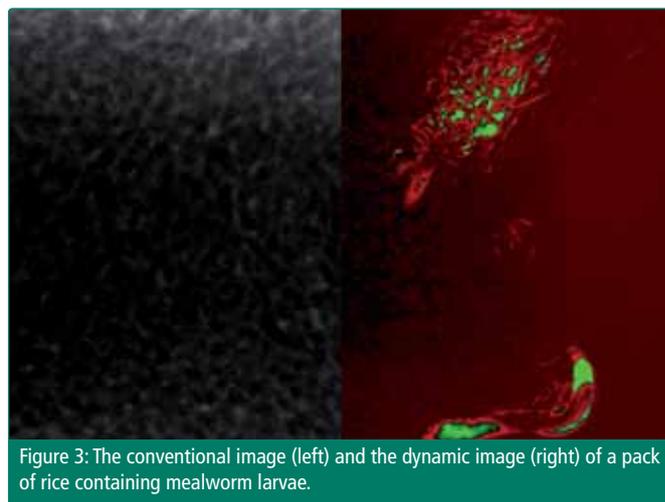


Figure 3: The conventional image (left) and the dynamic image (right) of a pack of rice containing mealworm larvae.

well as our ecological and economic environment, but it is an extremely difficult task. Dynamic X-ray imaging allows direct scanning of shipments for hidden movements, making the search for pests in the cargo much more effective. Besides the above application, dynamic imaging could reveal contraband of exotic animals or the presence of moving machines in the cargo.

The novel dynamic imaging technology can be added to existing X-ray scanners by a minor software and hardware upgrade, facilitating the introduction and spread of the technology.

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**ENQUIRIES**

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