Accurate to the Dot

Innovative system reads Braille with USB camera

More than 1 Million people in the United States cannot read this text because they are blind. Every tenth of them can read Braille with their fingertips, though. This ability can be vital when it comes to medication packages. An innovative system from Germany makes sure that the raised Braille dots on medication can be reliably identified by touch. The solution uses a USB camera from IDS Imaging Development GmbH and a high-performance machine vision system.

Braille is the method most widely used by the visually impaired to read and write. A combination of up to six raised dots allows representing every letter of the alphabet as well as numbers, musical notes and many other symbols. In the European Union, every medication package must provide key information about the product in Braille code since 2001. In the absence of a similar directive by the US government, just recently a new standard has been proposed by the International Association of Diecutting and Diemaking. This set of guidelines called “Can-Am-Braille” is derived from the European standard. According to the EU directive, at least the name and dosage of the medication has to be embossed on the folding box. However, meeting this requirement is not that easy. Even tiny faults in the manufacture of the folding boxes can have dangerous consequences. For example, just one raised dot that is too small or flat to be felt can be enough to cause unclear or even incorrect dosage information.

A challenging task

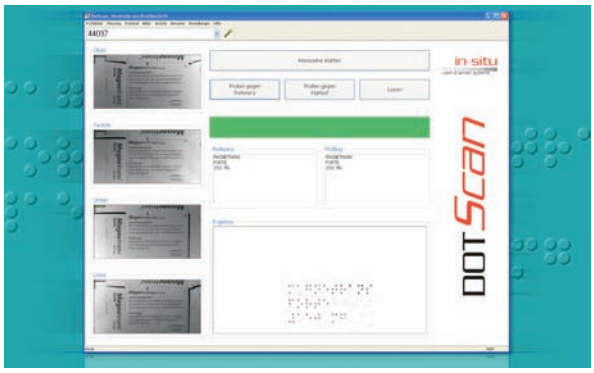
To eliminate those faults, the packaging industry has to implement thorough quality assurance measures. But how can the Braille dots be reliably tested and inspected? The 0.1 to 0.2 mm high dots are indiscernible to untrained fingertips, but visual inspection alone is not suitable either to determine whether the raised dots are actually identifiable by touch. Therefore, mechanical inspection systems have mostly been used so far. They are based on assessing the tactile quality of a Braille dot by measuring its height with fine micrometer screws. This method is not only work and time consuming, but can damage the Braille dots by mechanical contact with the micrometer. There are also alternative solutions involving blind quality assurance personnel or manual inspection using a test film. But these methods additionally have the disadvantage that the test results cannot be adequately documented.

in-situ GmbH, a Munich based specialist for vision and sensor systems, has developed a solution to the problem. The DotScan inspection system allows reliably recognizing Braille dots and evaluating their tactile quality with high precision. Testing is non-contact using a state-of-the-art machine vision system and an industrial camera from IDS's USB uEye series. The monochrome CMOS camera captures 2D images. The height information is then calculated using a shape-from-shading algorithm. Lighting plays a key role in this process: To obtain accurate results, telecentric light sources are required, which illuminate the Braille embossed folding box from four directions at an angle from above. The telecentric light ensures that the 3D shape of a raised dot can be accurately derived from its shading pattern.

Image capture with USB uEye and custom LEDs

For the DotScan system, the system integrators at in-situ have developed custom lamps with a large field of illumination of 150 x 75 mm. High power LEDs produce blue light by using a narrow band filter. “The advantage of blue light is that it has a short wavelength, so there is less reflection and that is better for analyzing the raised dots,” explains Managing Director Rainer Obergrußberger.
After embossing the Braille dots, the box is assembled and pasted. It is then folded flat and positioned on a drawer in the unit. The compact USB camera points at the flat box from above. With a resolution of 1.3 megapixels, the UI-1540SE-M model offers the ideal ratio of accuracy to data volume. The uEye captures 25 frames per second at full resolution, which allows for fast inspection.

The scene to be captured has a very high dynamic range, however. The shading has to be clearly discernible without overexposure in reflecting areas.



The shape of each raised dot is derived from its shading pattern in four images.

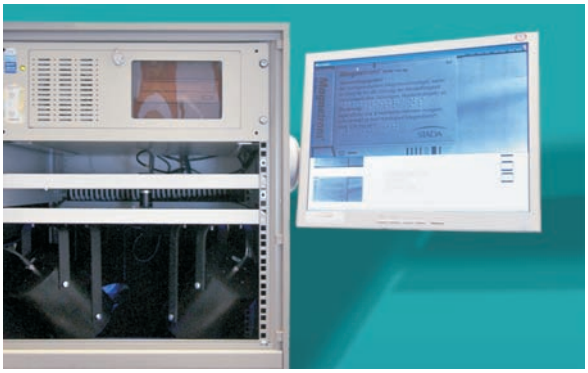
Things are made even more difficult by the fact that the Braille dots are sometimes embossed on a black background, which is a major challenge in image acquisition. For this reason, the camera takes a series of images with different exposure times and superimposes them to determine the required dynamic range.

Easy integration, complex algorithm

To accommodate the quick exposure time changes between the individual images, the developers at in-situ chose the software-triggered image acquisition mode. The camera was integrated using the proprietary uEye API programming interface. “The API is easy to integrate and well documented. And it comes with many sample programs that demonstrate functionality and implementation,” says Technical Manager Sandra Söll. in-situ have been using cameras from IDS for over four years and appreciate the excellent cooperation with the German machine vision specialist.

The main challenge in developing the system was programming the algorithm. The shape-from-shading process was very slow at first and unsuitable for industrial use. After a long development phase, the developers succeeded in significantly improving the process: The image analysis, which initially took 10-20 seconds per image, can now compute up to 20 images per second! The Managing Director at in-situ says in retrospect: “A lot of hard work and time went into the process. But we saw the potential of this method: Shape from shading offers the best price/performance ratio for this application.”
Processing the images is very CPU intensive and performed by a built-in industrial PC. As practically every IPC has a USB 2.0 interface, it was a logical step to choose this interface for connecting the camera. Besides the cost-effective price, Rainer Obergrußberger cites the flexible interface as key criteria for choosing the camera model. USB needs no additional hardware such as frame grabbers, which allows time and cost saving camera integration.

High speed combined with a comparatively low system price sets the DotScan solution apart from competitors: A complete Braille inspection in less than two seconds cannot be achieved using other methods, such as light stripe projection or laser triangulation. In addition, the DotScan system delivers an accuracy of +/- 0.02 mm depending on the surface properties of the folding box. The required calibration is carried out with special calibration standards.
In the field, the Braille inspection is performed by sampling. The system checks not only if the raised dots have the correct shape, but also if the information given in the Braille labeling meets the specifications. Customers usually use a PDF file for this purpose. The DotScan software identifies characters and words from the recognized Braille code. The result can then be compared with the PDF to detect deviations.


High speed and a low system price sets the DotScan system apart from other solutions.

There are different Braille alphabets for different languages and regions. As the innovative system is in use throughout Europe, the most common alphabets come preinstalled. Camera technology and image processing thus help packaging manufacturers save time and cost. Moreover, by scrutinizing Braille labeling “down to the dot,” the system gives visually impaired patients the peace of mind that they can safely locate and dosage their medication.

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