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Pin Hole Detection on Cold-Rolled Steel Strips

By Tata Steel | Category: Implemented Innovations

The Cold-Rolling Mill (CRM), Tata Steel rolls premium grade steel strip products for automobile customers. The stringent quality requirement from customers demands defect free product delivery, including holes. Manual detection of smaller holes on the strip moving with higher line speed is highly unreliable. Passing an undetected hole to the customer has serious consequences as it may cause damage to costly equipment like die and can result in rejection of a complete BIW (Body In White). To overcome this challenge, automation has developed image processing-based Hole Detection system, which helps CRM to detect the material with holes and prevents them from reaching customers. This system has been developed and deployed in various lines at the company's CRM plant at Jamshedpur.

The Context

In the automobile industry, primarily owing to increased competition and stressed margins, the demand and expectation from the customer is more stringent than ever. Any passed hole to the customer can potentially result in a severe complaint, and is a dent in Tata Steel's reputation of being a quality product supplier. This solution was envisioned with the intention to bring down the number of customers' complaints to ZERO with respect to holes.

The Innovation

The conventional methods of detecting holes include manual inspection facility and surface inspection systems which is extremely tedious and unreliable, for strips moving with speeds higher than 90 meter/minute. Surface inspections are too general and lack the capability to detect very small size hole (1 mm^2), and can easily get confused between holes and other kind of point defects.

The Hole Detection System (HDS) is essentially a machine vision system comprising of two high resolution cameras, a high intensity LED light box (back-light) and an efficient computational hardware, hosting image processing algorithms to ensure 100% detection of "through holes" in cold rolled sheets. The camera units are placed at the top of the strip being rolled, whereas the rectangular LED light producing uniform illumination along the width of the strip is installed underneath the rolling strip, so that no light reaches the cameras in the absence of any hole. During lab investigations, it was observed that a single camera was not sufficient as it tends to miss the holes farther away from it i.e. towards edges. A multiple camera arrangement helps in reducing obliquity of the holes with respect to the camera, hence increasing the probability of holes getting detected.

Overcoming Challenges

Challenge #1

Design a system that generated very high SNR (Signal-to-Noise Ratio) for holes, and at the same time its response to other kinds of defects must be very low. The optimum imaging architecture was achieved after long experimentation hours and brainstorming sessions.

Challenge #2

While the system was installed on the shop floor, it was extremely difficult to create a very controlled environment for such an installation.

Challenge #3

Selection of light with spectral emission around 450 nm (bluish), and camera whose spectral response peaks around the same wavelength, together addressed two problems simultaneously:

It made the system less sensitive to the ambient lights and their reflection (mostly around 600 nm to 750 nm), and hence solved the false alarm problem.

Since blue light exhibits excellent scattering properties, it helps in capturing holes of size as low as 0.28 mm^2. Also, due to higher scattering angles, even the holes at oblique angles get detected.