Photonic sensing solutions for industry

Janne Paaso[1], Andrei Baraian[1], Vili Kellokumpu[1], Pekka Kilpeläinen[1], Tuomas Soudunsaari[1], Tuomas Seppälä[1], Juha Lallukka[1], Pekka Suopajärvi[2]

[1]*Sensing solutions research area, VTT Technical Research Centre of Finland, Oulu, Finland*

[2]*Valmet Automation, Oulu, Finland*

Contact: janne.paaso@vtt.fi

VTT Technical Research Centre of Finland is a state-owned multidisciplinary research centre, which focuses on applied research in fields ranging from artificial intelligence to food production, and from sensing solutions to smart industry, to name only a few.

During the last decades, the industrial photonics sensing field has changed dramatically, as low-cost micro-spectrometers have entered the market, and the performance of various cameras has been continuously increasing, but prices decreasing. Another big trend has been the use of artificial intelligence (AI) methods and high computational power in everyday life, e.g. in social media. Taken together, these developments make possible low-cost spectroscopic sensors, AI-assisted industrial machine vision systems, high-resolution multi-sensor imaging for industrial applications, and their combinations. In this presentation, we show some examples of such industrial sensing solutions, and discuss the challenges encountered in practical applications.

There are a number of hand-held near-infrared (NIR) spectrometers on the market. However, most of them need a contact with the sample or a static sample, which makes many industrial applications impossible. VTT has developed a hand-held NIR spectrometer prototype capable of measuring from a distance of 0 - 300 mm in a couple of seconds. The prototype can be used in two modes: to measure the full NIR spectrum or to measure the concentration of the analyte of interest based on a pre-defined calibration method.

AI methods are only starting to enter the industrial sensing field. This is due to two reasons: first, AI techniques require a lot of annotated data. In industrial applications, the amount of annotated data is limited, and laborious to obtain. Second, industrial sensors and instruments need to be very robust and reliable. Therefore, an AI-enhanced instrument has to be "self-aware", meaning that it must be able to assess the reliability of its data. These challenges can be solved by using semi-supervised or unsupervised learning methods. We show several examples of applying these methods in the paper industry and in the minerals processing industry.

Sorting of particles is one of the traditional industrial applications of photonic sensors. It is usually based on only one camera with a relatively low resolution. The advent of high-resolution and high-speed cameras and high computational speed make possible to combine the information from two cameras in real time to classify the particles on a conveyor belt in high speed. In this presentation, we show the combination of a high-resolution X-ray transmission camera and a stereovision camera for mineral sorting applications.

Despite the technological advances, there are some challenges. These include, among others, building accurate, reliable and easily updateable AI models for spectroscopic and camera-based systems without laborious manual annotation, dealing with large amounts of data in real time, and making the sensors easy to use and desirable for the users.

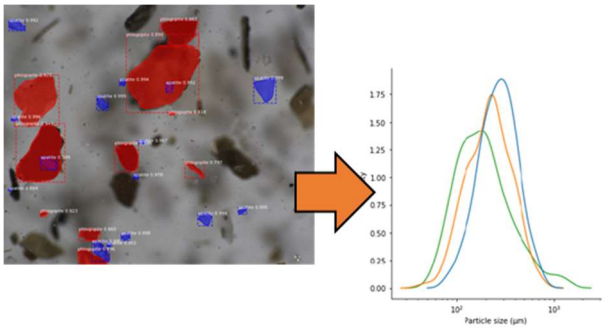

Fig. 1: AI-assisted particle size estimation.

Fig. 2: Hand-held NIR spectrometer prototype.