Sophisticated medical imaging technique proves useful for automotive industry

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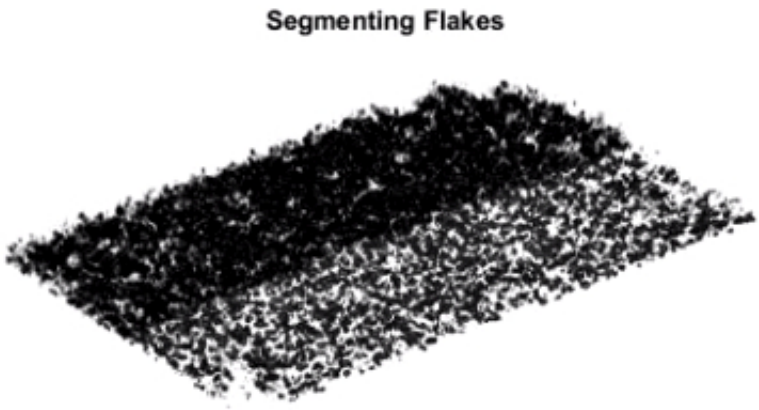

Many of today's cars are coated with paint that exhibits a metallic or glittery shine. The exact sparkle and color you see is determined by the distribution and characteristics of tiny metal flakes used in the paint. A new approach based on the medical imaging technique optical coherence tomography (OCT) provides the car industry with a practical way to automatically analyze these metal flakes, which until now have been difficult to image, in order to improve the efficiency of the automotive finishing process.

"We have demonstrated, for the first time, through OCT and our image analysis approach, we are able to quantitatively and automatically measure the size, number and orientation of metal flakes in industrially applied car paint," said Yaochun Shen, lead researcher on the project and professor at the University of Liverpool, UK. "This approach could be very useful for quality assurance processes used during car manufacturing."

OCT is a light-based technique that acquires real-time cross-sectional images with micron-scale resolution. Since its invention in 1991, medical applications of OCT have quickly expanded, and today doctors routinely use it to diagnose eye diseases. Because of the technology's capabilities and inherent practicality, OCT continues to move into new biomedical applications and is now being explored as a tool for improving manufacturing and industrial processes.

"The painting step is a bottleneck in the manufacturing process," said Shen. "If the finished car paint does not meet requirements, then it must be removed chemically and the car completely repainted. This not only costs time and money but also creates chemical waste and associated environmental issues."

In The Optical Society journal *Optics Express*, Shen and his colleagues report that their method can automatically identify and perform 3D measurements of metal flakes that are just 10- microns in diameter and 1-micron thick. The researchers demonstrated their approach on samples of applied car paint but say that with further development the technique could be used for in-line monitoring, where it could detect problems that occur during the painting process.

"Using the technique for monitoring in-line processes could also help automotive manufacturers better understand the whole coating process," said Shen. "With that better understanding, the car industry may be able

to develop new coating processes or new types of coating."

Non-contact paint analysis

Car paint is a complex structure that is typically made of four layers. The automotive industry currently uses ultrasound imaging to examine car paint in quality assurance checks. Although ultrasound instruments are easy to use, they cannot effectively image the tiny metal flakes used in many modern car paints. Ultrasound measurements also require equipment to be in contact with the sample, which means ultrasound cannot be used for in-line monitoring without interfering with the paint job.

"When the car manufacturer approached us to develop a new technique for analyzing the glittery flakes in car paint, we felt OCT could provide a solution," said Shen. "We use OCT in our ophthalmologic research because of the high resolution and because it can perform measurements without touching the sample. This combination makes it ideal for the analysis the automobile manufacturers needed with production."

To image the flakes, the researchers designed a 3D OCT instrument with very high lateral spatial resolution to distinguish miniscule flakes and a high depth resolution to see the position and orientation of each one. Because a single 3D OCT image contains thousands of flakes—too many to be measured manually—the researchers also developed an algorithm to automatically identify and describe each flake in a sample.

Tests of the technique on five paint samples showed that the OCT system worked well for imaging the top two layers of car paint, which includes the layer with the metal flakes. Using it with the 3D analysis algorithms allowed the researchers to determine the number, size and orientation of metallic flakes within the paint samples.

The researchers say that the current OCT hardware and software is very close to being usable in an industrial setting for analyzing paint that has already been applied. They are currently looking at ways to speed up the measurements so they could be used for real-time monitoring during the application process.

The researchers are also working to apply OCT in other industrial contexts, such as analyzing coatings of pharmaceutical tablets. The quality of these coatings controls drug release rates and OCT could help quantitatively analyze the thickness uniformity of these coatings and check for defects. "Our research with car paint and with pharmaceutical coatings shows that OCT, which has been used for some time for medical applications, can also be used for industrial applications," said Shen.

More information: Jinke Zhang et al, Non-destructive analysis of flake properties in automotive paints with full-field optical coherence tomography and 3D segmentation, *Optics Express* (2017). DOI: 10.1364/OE.25.018614

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