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Proof is in the pixels

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Computers enlisted in the detection of art copies and forgeries

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PHILADELPHIA — The painting of the lean-faced, bearded man with the penetrating stare is unmistakably a self-portrait by Vincent van Gogh. An art historian can tell by looking at the riot of bold, colorful brushstrokes.

Researchers at Pennsylvania State and Princeton Universities, however, use an analytical tool that surely the troubled Dutch master never imagined: the computer.

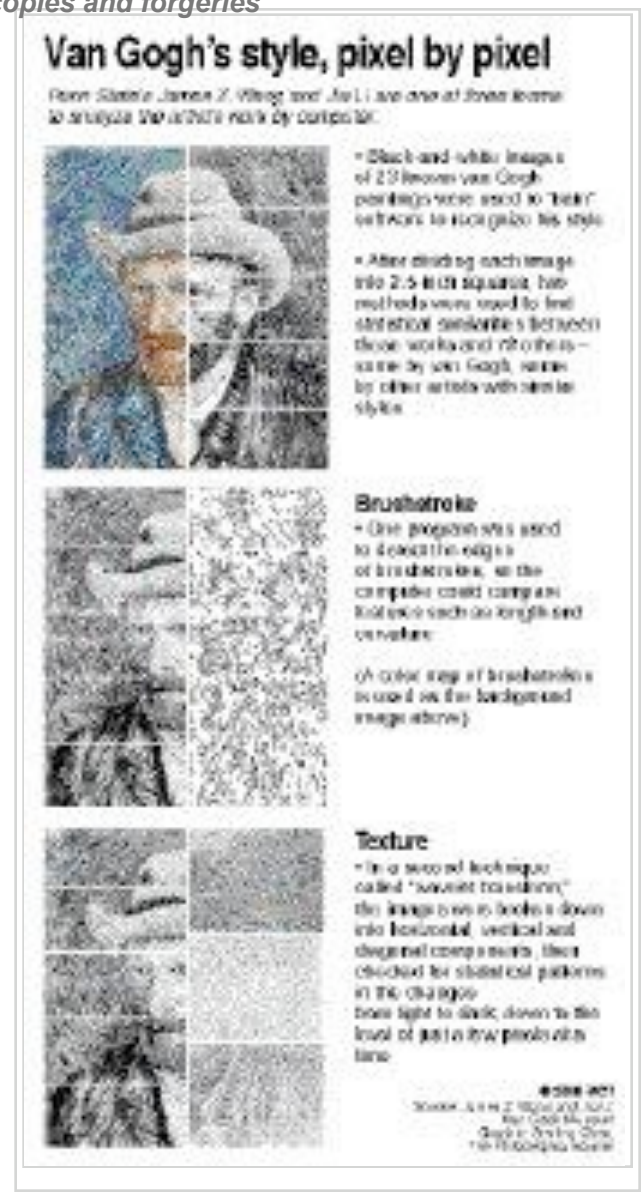
Their method is far from foolproof, but the two teams, along with a third one in the Netherlands, were able to distinguish dozens of van Gogh's works from those painted by others — including an infamous forgery.

A picture, after all, is more than a thousand words. It can be represented as bits of data, just like a bank account or music on a compact disc, and the researchers have sifted this information through the dispassionate filter of statistics.

The authors, who described their results in last month's issue of the engineering journal IEEE Signal Processing, are quick to say that they don't want to replace art historians. Their methods aren't sophisticated enough to do so even if they wanted to.

"Sometimes, a computer is pretty smart," says Penn State's James Z. Wang, one of the authors. "Other times, it may not be."

Yet he and his colleagues predict the computer will become an important tool alongside other scientific techniques that have long been used in art scholarship, such as chemical analysis of paint fragments or the use of X-rays to count threads in a canvas.



They've already won converts at Amsterdam's Van Gogh Museum, which has the world's largest collection of the artist's work.

"It was much more successful than I would have expected," says Ella Hendriks, the museum's head of conservation.

But before it could happen, there was a big question. How do you get a bunch of engineers and statisticians to communicate with people in the subjective realm of art?

Answer: Start with someone who is a member of both worlds.

C. Richard Johnson never went to an art museum as a child, and he pursued an early interest in the sciences by attending Georgia Tech.

But once there, he did a study-abroad program in Germany that he calls a "life-changing experience."

He spent hours at a museum in Berlin, becoming captivated by the works of Rembrandt. Later at Stanford University, he earned a Ph.D. in electrical engineering but also found time for his newfound love, with a minor in art history.

Yet it was not until 2005, during a sabbatical from his job as a Cornell University engineering professor, that Johnson looked through the literature for ideas on how he could marry his two talents.

He discovered the work of Penn State's Wang and his wife, Jia Li, who were performing statistical analysis of Chinese paintings. At Princeton, math professor Ingrid Daubechies was pioneering the use of statistics to analyze images from various fields of science and medicine, such as MRIs. And at Maastricht University in the Netherlands, computer scientist Eric Postma had started to analyze the works of van Gogh.

Museums around the world had begun to digitize their collections to aid in conservation and research, but the notion of crunching those reams of data was in its infancy.

So Johnson approached the Van Gogh Museum and offered to organize a conference. In exchange for the use of high-resolution scans from dozens of paintings, the three university teams — Penn State, Princeton and Maastricht — would present their research at the event in Amsterdam.

Like most people, the museum officials were unfamiliar with the statistical techniques involved, but Johnson sold the deal.

"He can talk between the two sides," Wang says. "He is serving as a bridge."

Each team got 101 images from the Amsterdam museum and from another institution in the Netherlands, the Kroeller-Mueller museum. They included 82 that had always been identified as van Goghs, six non-van Goghs that had a similar style and 13 for which the attribution had been questioned at some point.

A description of the technique is not for the faint of heart, but briefly speaking, it involves the use of "wavelets" — mathematical templates that identify characteristic patterns in the painting at a range of scales, from coarse to very fine.

Each team used a slightly different version of the method. Wang and Li, for example, decomposed the images into three components — horizontal, vertical and diagonal — while the Princeton team used six orientations.

Van Gogh's style changed over the years, so Wang and Li used a range of 23 representative paintings to "train" their computer program in what to look for.

The scans were in black and white to allay the museum's concerns that high-resolution color images would leak out to someone who might use them to make reproductions. Wang and Li represented each pixel as some number from zero (black) to 255 (white).

One finding was that when an artist had tried to copy van Gogh's style — whether honestly or with intent to pass off the work as authentic — the painting displayed telltale characteristics at a very small scale.

It wasn't something you could see with the naked eye, says Princeton's Shannon M. Hughes, a Ph.D. student in electrical engineering. But in small clusters of pixels, the computer revealed what she calls "wobbles."

"If someone was trying to copy someone else's work, you can imagine that he or she is probably painting more slowly, more tentatively," Hughes says. As the painter speeds up and slows down during a brushstroke, she speculates, he might deposit varying amounts of paint, whereas van Gogh's own works revealed no such pauses.

All three teams did better than average at picking the real thing. Using several variations of its approach, for example, Princeton correctly classified as many as 55 out of 65 van Goghs. Penn State also used an additional non-wavelet method that identified the outlines of brushstrokes.

All three presented their results at the conference last year. Their paper was published in July.

The research lends itself to more than just telling apart real van Goghs from others. The teams are now pursuing additional challenges, such as telling when certain works were painted. Art historians disagree on when to place three of van Gogh's canvases, either to 1888 when he was in Paris, or a year or two later when the artist painted in Arles and St. Remy.

Other ideas might include analyzing images for certain shades of color or the shapes of objects they depict, Cornell's Johnson says.

It's all still in the rough stages, but as long as museums are amenable, he and his colleagues vow that they will continue.

"Every art historian who does attribution is going to tell you they can see the hand of the artist in the painting," Johnson says. "Is there a way we can support that?"

— The Philadelphia Inquirer