ALEX KACHKINE

Engineer Alex Kachkine indulges their passion for art by purchasing and restoring paintings.

USING DEEP LEARNING TO RESTORE RENAISSANCE ART

Alex Kachkine has turned their conservation work of damaged art into a science. **By Amanda Heidt**

Many of Alex Kachkine's earliest memories revolve around two core passions. One is engineering. Kachkine's great-grandfather built bridges, their grandmother developed autopiloting systems for Soviet fighter jets, and their parents have engineering degrees. Kachkine spent their childhood building things. Following in the family's footsteps, they say, was a foregone conclusion. The other passion — a lifelong interest in art — came about by chance. While on a childhood school trip to the McNay Art Museum in San Antonio, Texas, a tour guide showed the students a seascape by the French Impressionist painter Pierre-Auguste Renoir. The subject is hard to visualize close up; only by stepping back does the image fully resolve.

"I went back to that room and kept walking back and forth in front of this little Renoir piece."

"That was so intriguing to me that I ditched the group, and they had to come find me later," Kachkine recalls. "I went back to that room and kept walking back and forth in front of this little Renoir piece. From that point on, it just became apparent that I really cared about art."

Today, these two preoccupations continue

to be drivers in Kachkine's life, spanning both their career as a graduate researcher in mechanical engineering at the Massachusetts Institute of Technology (MIT) in Cambridge and their extracurricular activities. Kachkine has become an avid art collector and recently developed a restoration method in which they use digital tools to create a 'mask' of pigments that can be printed and varnished onto damaged paintings. The method, detailed in a study published in *Nature*, reduces both the cost and time associated with art restoration and could one day give new life to many of the paintings held in institutional collections — perhaps as many as 70% — that remain hidden from public view owing to damage (A. Kachkine *Nature* **642**, 343–350; 2025).

The obvious path

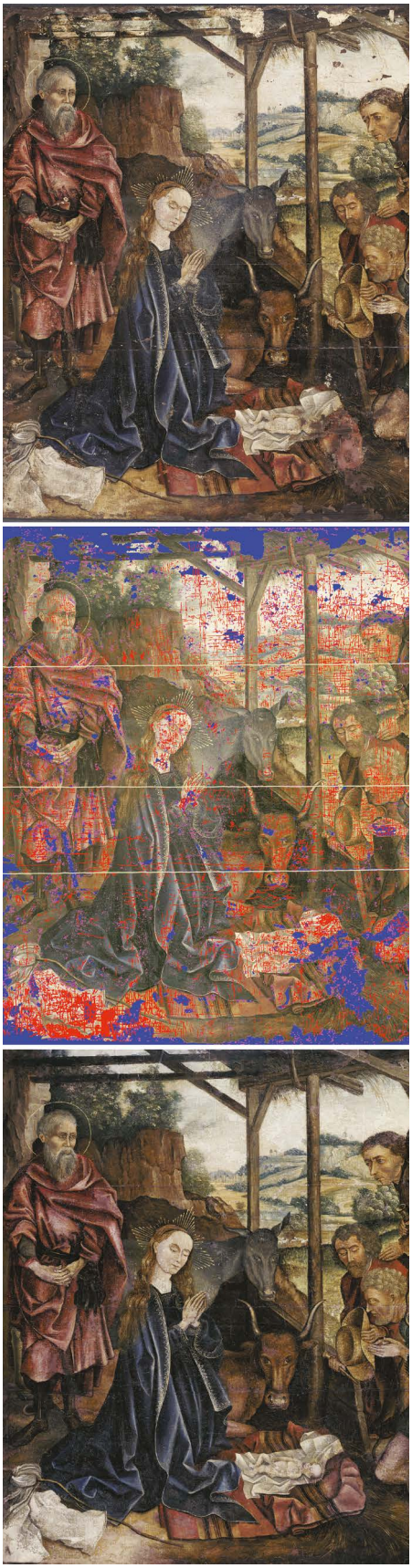
Kachkine's early interest in engineering found a ready outlet in high school, at which they spent their final two years in an accelerated biotechnology course run through Austin Community College in Texas.

Joseph Oleniczak, one of the instructors, began working with Kachkine around 2016, and was immediately struck by their talent. As well as teaching, Oleniczak co-founded a company called Fabrico Technology, also in Austin, to help academics to commercialize their intellectual property. When Kachkine began duel undergraduate degrees in mechanical engineering and economics at the University of Texas at Austin in 2018, Oleniczak hired them to create the hardware and software for a bacterium-detection assay being developed by researchers at the university.

"Of all of the students that I've had — and I've had some phenomenal ones — Alex is the only one we've ever brought on," Oleniczak says. Fabrico eventually licensed Kachkine's inventions back to them so that they could start their own company, GeneTiger, that same year. Early in the COVID-19 pandemic, Kachkine received a grant from the US National Science Foundation to develop a SARS-CoV-2 detection assay, which the University of Texas at Austin used to screen employees on campus.

"It wasn't really diagnostic, but if there was a positive, we could encourage people to go get a proper PCR test," Kachkine says. "I remember the first day we got a real positive. I'd never had that moment of an invention of mine actually being relevant to someone."

After graduation, Kachkine started looking for jobs but found that many positions required a graduate degree. That's how, in 2021, Kachkine joined the laboratory of Luis Fernando Velásquez-García, a microsystems engineer at MIT. Like Kachkine, Velásquez-García's research group defies easy classification, bridging engineering with fields such as aeronautics, astronautics, satellite technology and nanotechnology, and mass spectrometry.



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From top to bottom: the damaged *Adoration after Martin Schongauer*, an overlaid map revealing the damage and the restored painting after 'masking'.

"The lab is not affiliated with any particular part of the university, and we really are our own distinct thing," Velásquez-García says, adding that when he first came across Kachkine's application, he thought that their core competence in hard science and entrepreneurial mindset would gel well with the group. "That's great for where we work, because we create things that often don't exist yet."

Kachkine's thesis work tackled a long-standing challenge: developing and optimizing ion sources in mass spectrometry. All mass spectrometers include a device for converting the sample material into a stream of charged particles that the machine can analyse. As they dove into the technology, Kachkine realized what a big role evaporation has in the efficiency of mass spectrometers — "we're working with microlitre-scale liquids that disappear in seconds," they explain — yet how little other researchers account for that fact when designing and optimizing their own equipment. "It turns out evaporation is freaking complicated," Kachkine says. When they looked at the papers that had been published over the past decade that highlight improvements in efficiency, many of the unexpected results they found could be explained by evaporation.

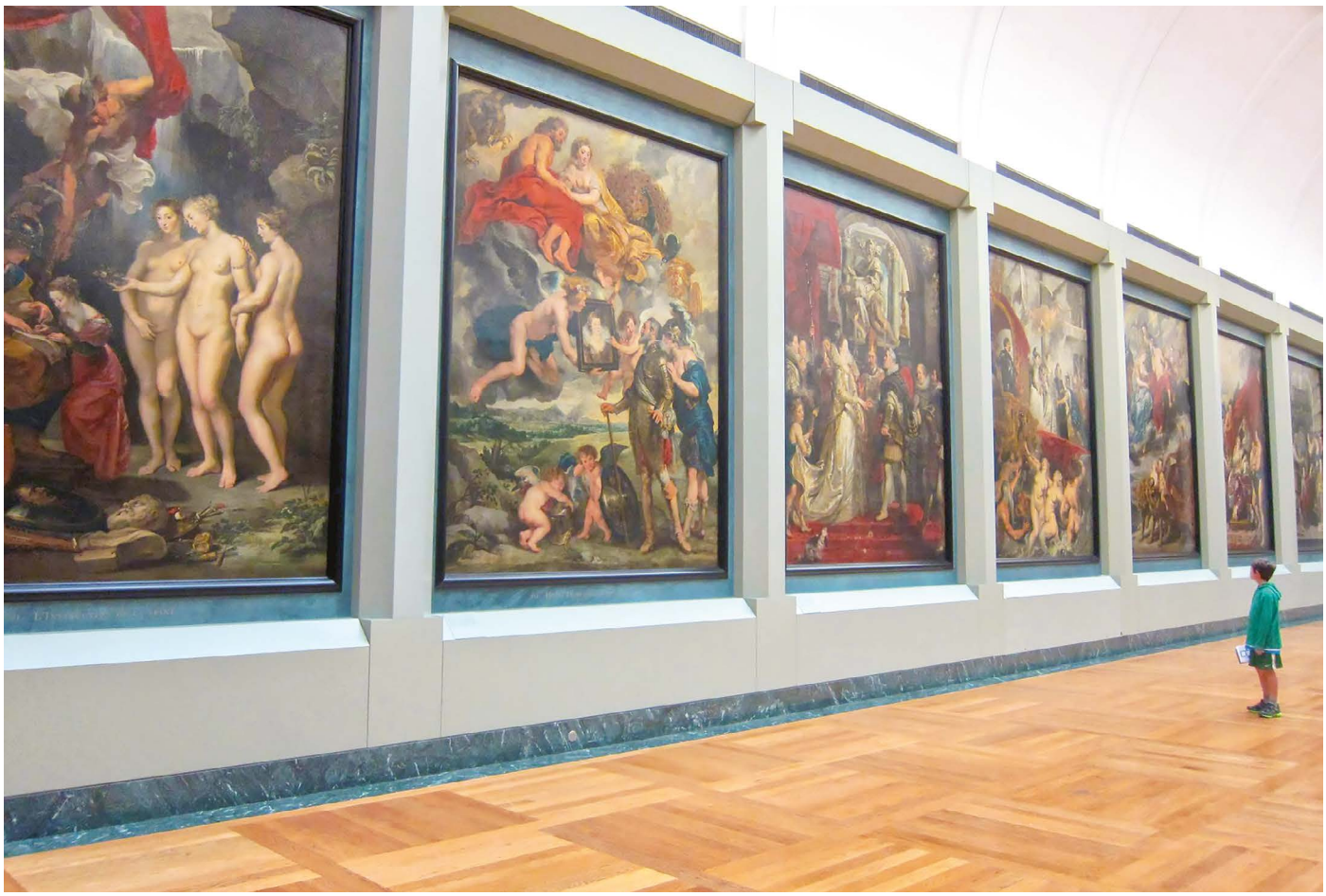
Velásquez-García says that this work, which ultimately allowed the lab to create better, more-efficient devices (A. Kachkine and L. F. Velásquez-García in *21st Int. Conf. Micro and Nanotechnology for Power Generation and Energy Conversion Applications* 38–41; IEEE, 2022) exemplifies Kachkine as a scientist: understated, but methodical and dedicated. "If there's something [they want] to figure out, even if it's complicated, [they] will spend the time," Velásquez-García says.

Breathing life back into art

In their spare time, Kachkine continued to purchase and restore art, ultimately amassing dozens of works spanning multiple genres, from abstract expressionism to modernism. "Many people put their money into savings accounts, and I put money into art," Kachkine says. "As someone with a degree in economics, I should probably know better, but they bring me a lot of joy."

But to afford their hobby on a student's budget, Kachkine has had to purchase damaged pieces. A few years ago, they bought a late fifteenth century painting known as the *Adoration after Martin Schongauer*, attributed to an unknown artist, that required significant restoration.

Art conservation is fraught with ethical considerations, because a botched job can destroy irreplaceable pieces. It's a balance, Kachkine says, between preserving the artwork and respecting the artist's original intent. They wondered whether they might be able to apply their engineering expertise to bridge the



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As a child, Kachkine was captivated by art.

physical and digital aspects of art restoration.

Kachkine began by generating a high-resolution scan of the damaged painting and using deep-learning tools to flag issues such as cracks and paint losses for infilling. They then wrote an algorithm to compare a digitally restored version of the painting with the damaged one, prioritizing areas where the differences would be most apparent to the human eye. Rather than having to laboriously paint each correction by hand, as a conventional restorer does, Kachkine instead printed a digital mask onto a series of polymer-based films using restoration-quality inks and overlaid them on the physical painting, sealing the stacked films onto the surface with varnish.

It took the better part of a year to conceptualize, design and implement the method. But the result, Kachkine says, "is a restoration process that saves a lot of time and money, while also being reversible, which some people feel is really important to preserving the underlying character of a piece".

Noah Bagazinski, a fellow mechanical engineering student at MIT who met Kachkine during their first year on campus, says that few people know this side of Kachkine, even though they have introduced several of their peers to art over the years. Bagazinski himself has two paintings that he and Kachkine made together hanging in his apartment. "When [they] first told me that [they'd] written a paper on restoring art, I figured it was some technique to restore paint, not a full digital scan reconstruction of the mask of the painting itself," Bagazinski says. "But now I think this is such a classic, Alex-like endeavour, to see a problem and create a new technical tool to fix it."

A bright, if uncertain future

Today, Kachkine remains in Velásquez-García's lab as something of a PhD student in waiting. Although they have passed their qualifying exams, Kachkine has yet to settle on a dissertation topic, and says that getting a doctorate was never their goal: "It was the one thing I promised everyone I would never do."

But their paper on art restoration, which began as something of a distraction while they waited for funding to come through for their engineering research, has given Kachkine a glimpse of a potential future. The positive response from manuscript reviewers has been stronger than they expected, and the work was fulfilling. "There's a vague hope in me that perhaps there are more opportunities tied to this, because I cared about doing it and I'd love to see things progress forward."

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Kachkine would like to improve the precision of printing and aligning the ink films. Refining these techniques would "pave the way for quicker and less-intrusive 'inpainting' methods," they say. From there, Kachkine plans to apply the technique to other pieces in their collection, including a highly damaged Italian panel painting from the seventeenth century and a smaller work by the Flemish painter Pieter Bout from the 1670s.

Whatever they do, those who know Kachkine seem united in their assessment that their future will undoubtedly be successful.

"I could see Alex launching some kind of company — or even several — that probably won't even be related to anything [they're] doing now," says Bagazinski. "But I never worry. Alex is very much the type of person that is going to do what [they want], and [they're] going to do it very well."

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