Scientists use machine learning to help doctors find veins for no-fuss blood draws

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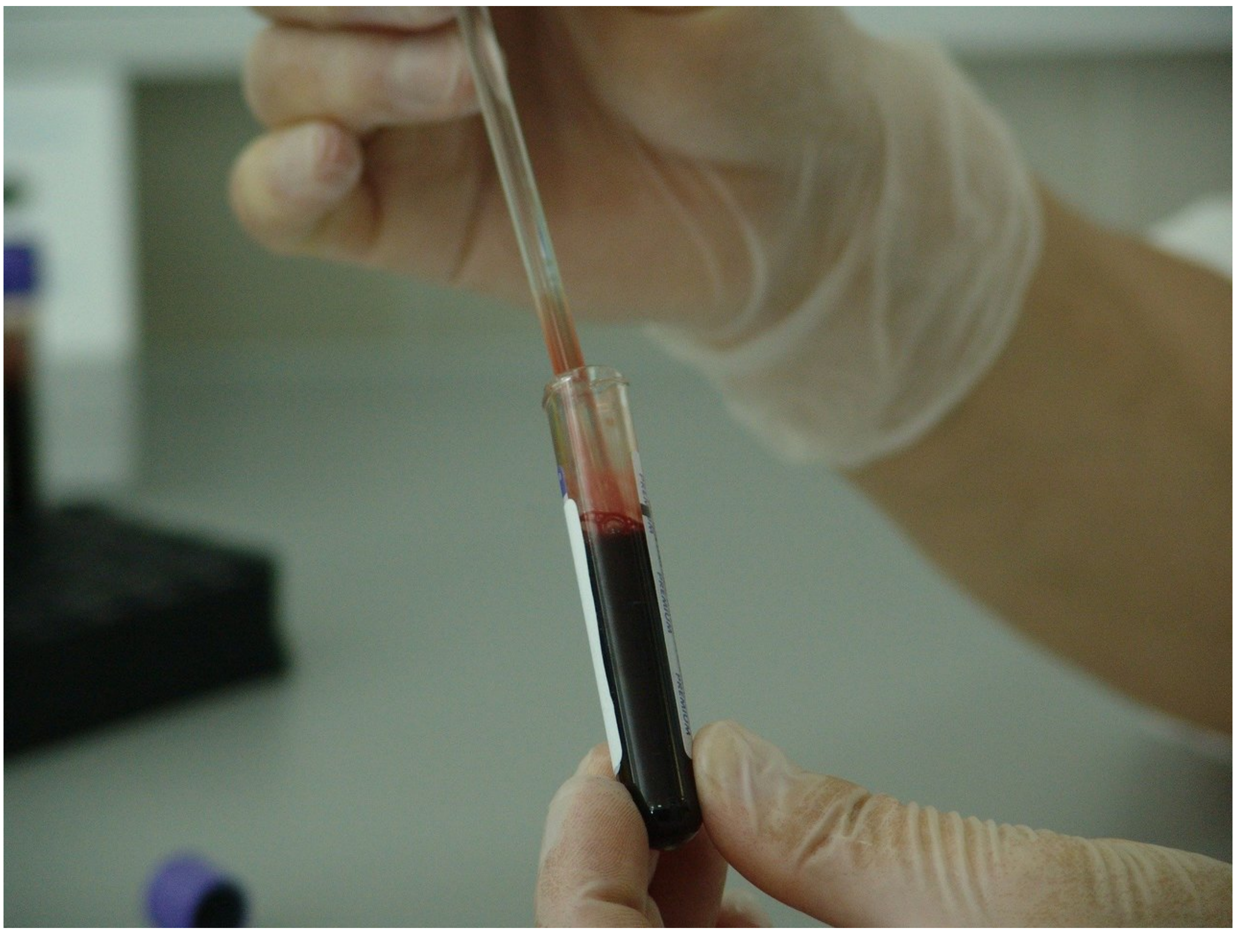

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Researchers from Skoltech have developed an early prototype of a medical imaging system that uses neural networks to analyze near-infrared images of veins and project a venous pattern onto a patient's body—this may make blood draws much easier and less of a nuisance for patients with difficult access to veins. The paper was published in the proceedings of the *16th International Conference on Control, Automation, Robotics and Vision (ICARCV).*

According to data cited in the paper, out of approximately 20 million blood tests performed globally every day, almost 45% are estimated to involve some degree of discomfort for the patient whose veins are harder to access due to medical conditions such as diabetes, a particularly young age, or simply individual characteristics of the body. In these cases, when veins are hardly discernible and non-palpable, even experienced medical professionals have to turn to technical aids or risk multiple or inaccurate punctures, which can even have health consequences, especially for older adults.

Dmitry Dylov, Associate Professor at the Center for Computational and Data-Intensive Science and Engineering (CDISE) and the head of Computational Imaging Group at Skoltech, and his colleagues decided to assemble an intelligent near-infrared vein scanner, which can determine vein contours in an arm or a leg quite accurately, fully automatically, and independently (without any input from the user). They did so by using artificial neural networks and reinforcement learning to better analyze the images and project them back as a visual aid onto the patient's body, adjusting for its shape and position.

"Infrared vein scanners have become commonplace in clinical practice. However, this is the first one that does everything entirely by virtue of modern AI: one neural network cleans and processes the infrared signal, the second one detects contours of the veins, and the third one continuously 'worries' about alignment to assure the contours projected to a patient's arm overlap with the actual veins. Remarkably, all we had to do was to tell the system what is good and what is bad during the training stage, and the neural networks managed to learn the rest by themselves, automatically finding optimal settings for new patients, environments, and even distortions, even if the system has never encountered them," Dmitry Dylov says.

Vito Leli, Skoltech Ph.D. student and the lead author of the published work, notes there are many factors hindering the detection of veins even in the infrared range where the vein contrast is better. "So the instrument was posed to face mostly the algorithmic and the image-processing challenges. We wanted to account for the high variability of the contrast of vasculature among patients (e.g., due to skin tone and thickness, etc.). Our final algorithm is also capable of vasculature detection even for low signal-to-noise ratios (SNR), as validated on a cohort of patients," he adds.

The team assembled a prototype device and tested it in experiments with volunteers, showing it was able to detect the venous pattern in the near-infrared spectrum and then project it back as an image onto people's arms. "Forearms are body parts usually used for blood tests so it was our natural decision to develop a system able to solve the problem of visualizing veins in that specific area. Nothing stops us from using it to image vasculature in other areas needed for other clinical applications, e.g., to assist with installation of a catheter. The gadget is rather compact and flexible for that. As the first step in our research, we collected and NIR forearm's images from the volunteers in Skoltech to train our device and taking photos of forearms is more privacy-friendly than face shots," Alexander Sarachakov, MSc student and coauthor of the paper, says.

A blood test performed with this device would look like this: the patient puts her arm under the device, which immediately searches for veins (in less than a second) and projects them over the forearm. "If the patient moves the forearm, although we do not recommend it during a blood test involving needles, the system will immediately start the realigning procedure," Sarachakov explains.

"The proposed imager can be scaled to other body parts in clinics (for example, facial and leg vessels) and for veterinarian care to aid with complex venipuncture in animals. We stress that we aspired to build an inexpensive hardware configuration, opposite to the existing offerings in the market. Our networks are also made light and flexible for embedding them into existing off-the-shelf controllers," the authors conclude in the paper.

"We are currently working on automatic selection of the best combinations of denoising and segmentation models to make the images cleaner and thus to obtain even better vein recognition. The questions we ask ourselves is how low of the SNR we could work with so that we both check some fundamental limits of the algorithms and also can work with for some inexpensive hardware components. Speaking of which, we are about to start testing the second generation of our hardware prototype which will bring us closer towards the product launching. It is fascinating to work on the border between fundamental science and immediate engineering realization," Oleg Rogov, research scientist and coauthor of the paper, concludes.

More information: Vito M. Leli et al, Near-Infrared-to-Visible Vein Imaging via Convolutional Neural Networks and Reinforcement Learning, *2020 16th International Conference on Control, Automation, Robotics and Vision (ICARCV)* (2021). DOI: 10.1109/ICARCV50220.2020.9305503

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