AI could speed up the diagnosis of urinary tract infections

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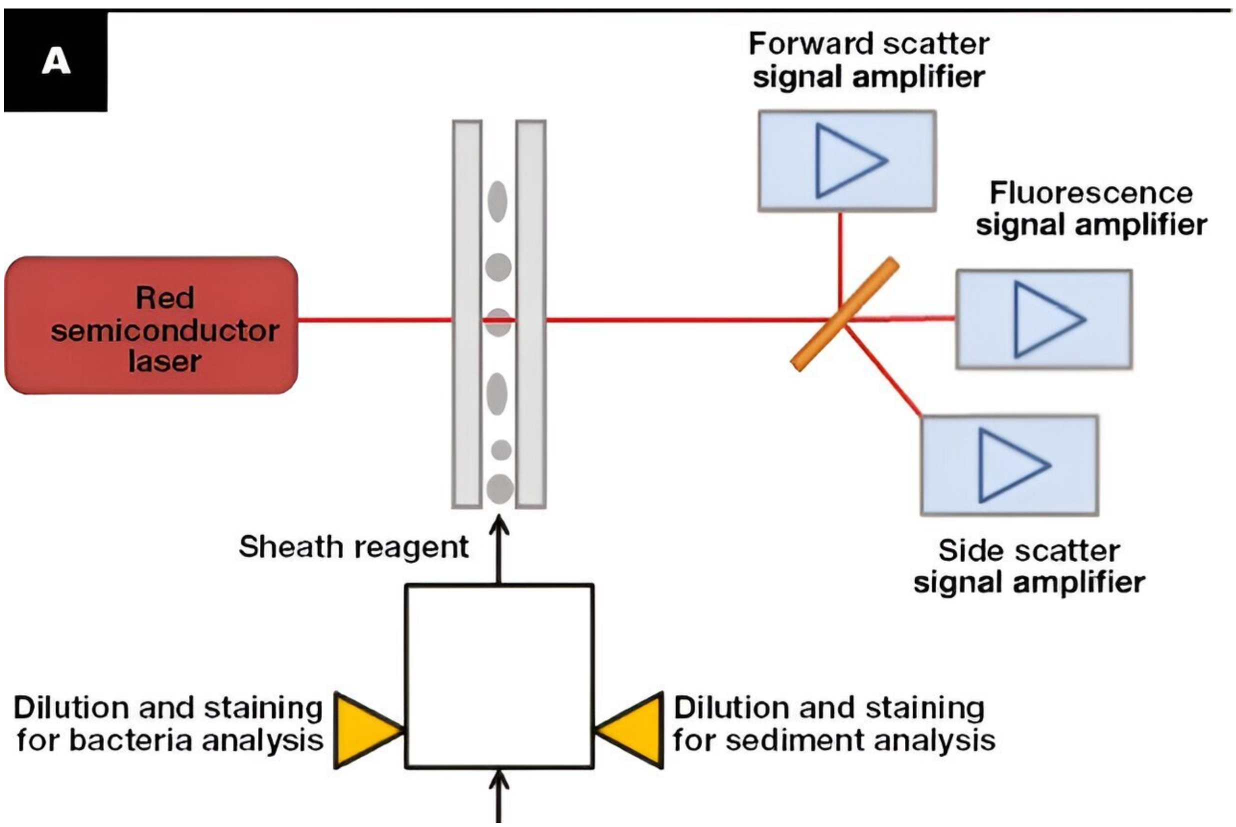

A, Schematics of the architecture of the automated urine analyzer. B, Scatterplots and particle classification of the Sysmex UF-1000i. The left graph shows forward scatter of the sediment channel (S FSC) against fluorescence high gain of the same channel (S FLH). The right graph shows forward scatter of the sediment channel (S FSC) against fluorescence low gain of the same channel (S FLL). Every dot represents an object detected by the cytometer. The device has an internal proprietary clustering algorithm classifying objects into different classes (white blood cells [WBC], red blood cells [RBC], yeast [YLC], endothelial cells [EC]). Credit: *American Journal of Clinical Pathology* (2023). DOI: 10.1093/ajcp/aqad099

Fraunhofer Austria and the AULSS2 Marca Trevigiana Institute in Treviso have developed a method based on artificial intelligence that can reduce the workload of laboratories.

Urinary tract infections are usually diagnosed by means of urine culture: an extract of the urine sample is applied to a plate and examined for bacterial growth under a microscope for the following 24 to 48 hours. However, after this time-consuming procedure, more than two-thirds of samples turn out to be negative.

Being able to filter out these negative samples in advance would significantly reduce the workload in laboratories, and negative test results would be available much more quickly. Artificial intelligence (AI), now developed by the Austrian and Italian research teams, can detect negative samples more accurately than previous methods and can, therefore, reduce the workload in the laboratory by 16 percent.

The algorithm used falls in the category of the so-called interpretable AI: it informs the doctors treating the patient of the reasons why it identified a sample as negative. The study results were published in the *American Journal of Clinical Pathology* and are available for immediate use on suitable machines.

As it is very time-consuming to examine every urine sample in detail, many hospitals already use flow cytometry. In this way, doctors are able to make a pre-selection so that obviously negative or contaminated samples are not sent to the urine culture in the first place. A widely used device for this purpose is the "Sysmex Uf-1000i," whose data the researchers analyzed as part of their study.

This device counts and classifies particles in the sample automatically and outputs more than 40 parameters that can then be used for diagnosis. Previous methods for identifying negative samples, however, used only a few of these parameters—a fact that provided the impetus for the research project.

"We wanted to see whether we can improve the results by including more parameters in the assessment instead of only two or three," explains Giacomo Da Col, head of the project at Fraunhofer Austria. Together with medical doctor Fabio Del Ben from the National Cancer Institute in Aviano, Italy, and a research team, 15,312 samples from 10,534 patients were evaluated.

Decision trees as interpretable AI

However, the researchers had special requirements for the AI to be used in the project, "Especially in medicine, it is important that an AI is not a black box. It makes no sense for an AI to just give an assessment without providing an explanation. Therefore, it was a mandatory requirement for us that our algorithm is transparent and interpretable and that doctors know why a sample was categorized as negative," explains Giacomo Da Col.

One form of AI to which this applies is the so-called decision trees. This methodology is very intuitive and makes it possible to understand its assessments.

The way decision trees work is comparable to the way humans think: they ask and answer certain questions one after the other in order to reach a judgment. The team found that the AI's decision criteria were very similar to those of doctors. The AI also concluded that one of the most important criteria had to be the number of bacteria, closely followed by the patient's age. Unlike previous methods, however, the researchers also considered other parameters.

The final algorithm uses seven of the available parameters, has the required sensitivity of 95%, and can reduce the workload of laboratories by 16% compared to previous methods.

Several rounds of refinement were necessary to achieve this result. "We made several improvements to the decision tree algorithm to increase performance while maintaining interpretability," explains Doriana Cobârzan from Fraunhofer Austria, who played a key role in the development of the AI.

Since the entire decision tree was published in the *American Journal of Clinical Pathology* article, users who use the same flow cytometry device as the research team can immediately program the methodology into their machine and apply it in medical practice right away.

According to project leader Giacomo Da Col, a drawback of the study is that it has been carried out at one hospital so far. The researchers are, therefore, looking for cooperation partners who would like to carry out a similar study at their hospital.

"If, for example, the sampling procedure is different in another hospital, the results may differ. People's diet also has an influence on the analysis of urine samples, so in a region where people have a different diet, the results may differ slightly. It would be desirable to evaluate the algorithm in other hospitals," explains Giacomo Da Col.

More information: Fabio Del Ben et al, A fully interpretable machine learning model for increasing the effectiveness of urine screening, *American Journal of Clinical Pathology* (2023). DOI:

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