

AI Assisted Sperm Detection from Sexual Assault Case Samples — Validation and Implementation of MetaSystems Metafer Sperm Finder DNN

Silja Erg

MSc of Genetic Engineering, Senior DNA specialist, Estonian Forensic Science Institute, Tallinn, Estonia, e-mail: silja.erg@ekei.ee

MetaSystems Metafer Sperm Finder DNN automated scanning is used to detect sperm candidates on microscopy slides. The system was validated and accredited, proved to be robust, sensitive and suitable for routine crime scene sample analysis.

Keywords: semen confirmatory test; microscopy; artificial intelligence.

Виявлення сперми за допомогою штучного інтелекту у зразках, отриманих у справах про сексуальне насильство, — валідація та впровадження *MetaSystems Metafer Sperm Finder DNN*

Сілья Ерг

Автоматизованим скануванням MetaSystems Metafer Sperm Finder DNN послуговуються для виявлення сперматозоїдів-кандидатів на предметних скельцях для мікроскопії. Система пройшла валідацію та акредитацію, довела свою надійність, чутливість і придатність для рутинного аналізу зразків з місця злочину.

Ключові слова: підтверджувальний тест сперми; мікроскопія; штучний інтелект.

The aim of this work was to validate and implement a semi-automated digital pathology system by MetaSystems for searching sperm cells in evidence samples collected from scene or involved persons of sexual assault cases. The microscope includes analysis software Metafer with artificial intelligence (AI) based automatic object detection and image classifier algorithm Sperm Finder DNN. The AI is designed to aid the search in cooperation with the human operator. The system detects, photographs, locates and rates/ranks material (cells and background noise) found on the microscopy slide, after which findings are analyzed and confirmed by the expert.

Typically, casework sample quality and source have high variability which presents several issues during staining and makes cytological analysis somewhat unpredictable. Typical problems include for example — low or high amount of material, low amount of absence of sperm cells, mixture of unknown materials and biological fluids, presence of objects with high similarity to a stained sperm head (e.g. neutrophil nuclei from degraded white blood cells, yeast cells, condom oil droplets, glass defects, etc.).

Manual analysis of negative microscopy slides or slides consisting very few sperms is extremely time consuming,

but typically around ~80—90 % trace samples were found to be negative for sperms over the years. The new device was validated to help aid the search for sperm cells, decrease hands-on time of analysis and increase sensitivity of search results.

In addition to routine work, the automated scanning opened new opportunities to research known issues of sample preparation methods — cell release efficacy from sample materials. Tests showed that efficacy of release of intact sperm cells from several sample matrix materials, is arguably low — even in widely used materials used for crime investigations like cotton swabs or common textiles used in clothing. Due to this reason, considerable manual processing is still required to prepare microscopy slides before analysis. Sample preparation methods require further research.

The MetaSystems device (including two AI algorithms) was validated using ~400 casework samples and ~600 test

samples, tested parameters included sensitivity, repeatability, reproducibility, robustness, concordance, mixture analysis, traceability. Robustness of the Sperm Finder DNN algorithm was tested on crime scene samples from previous years (including trace samples from the scene and gynecological/andrological samples) and test samples of mixtures of different tissues and background noise (semen, saliva, epithelial cells, blood, yeast, dirt, textile and other sample matrix residue).

The validated device and software proved to be robust, had increased analysis sensitivity and was found to be suitable for analyzing sexual assault casework samples. MetaSystems Metafer Sperm Finder DNN was validated according to ENFSI recommendations [1], accredited by external institute (Estonian Centre for Standardisation and Accreditation) and implemented into Estonian forensic casework routine in 2025 (Estonian Forensic Science Institute).

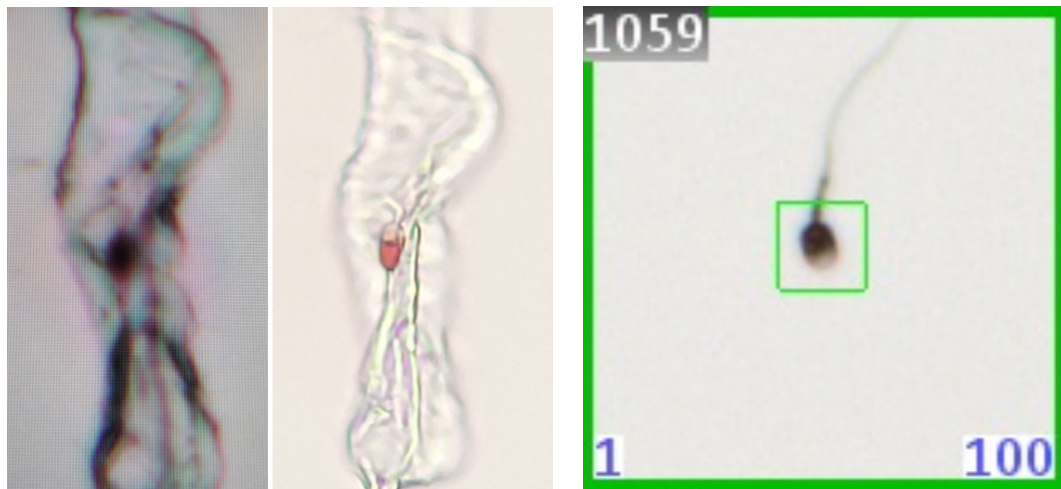


Fig. 1. Human confirmed findings of sperm cells that were initially scanned and detected automatically by Metafer software (including Sperm Finder DNN) from a microscopy slide

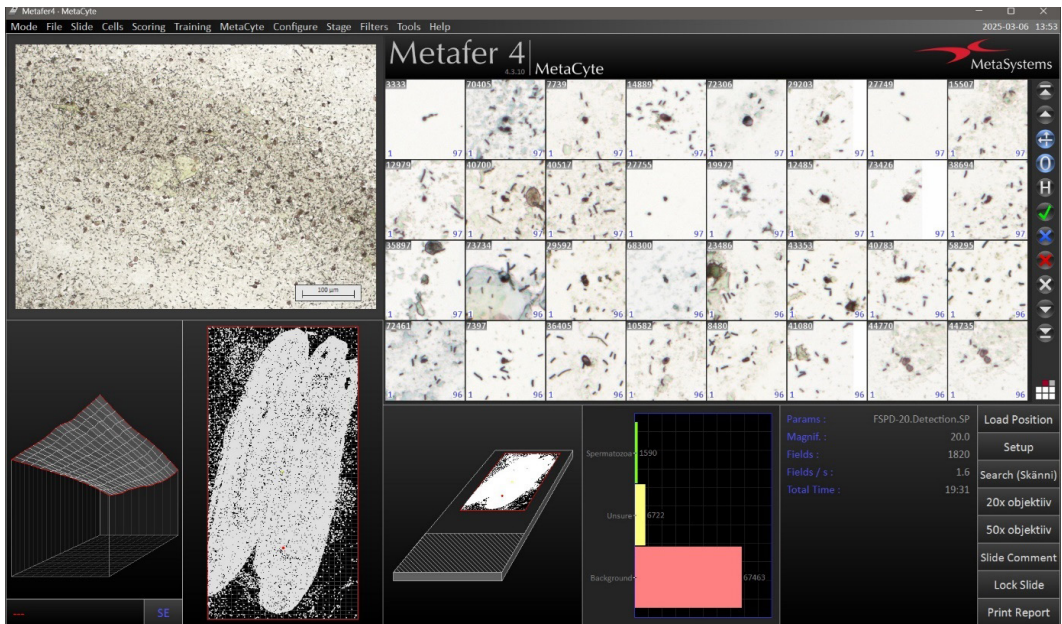


Fig. 2. Overview of automatically detected and photographed objects — each object (e.g. cells, dust, bacteria, reagent bubbles) rated by similarity to a sperm cell (ranked from 100 % to 0 % likeness to a sperm cell)

References

1. Guideline for Internal Validation / Verification of Various Aspects of the DNA Profiling Process. Document DNA-GDL-002. Is. No. 001. 10.05.2023 / ENFSI : web. URL: <https://enfsi.eu/wp-content/uploads/2024/02/ENFSI-Validation-Guideline-04012024.pdf> (date accessed: 10.04.2025).