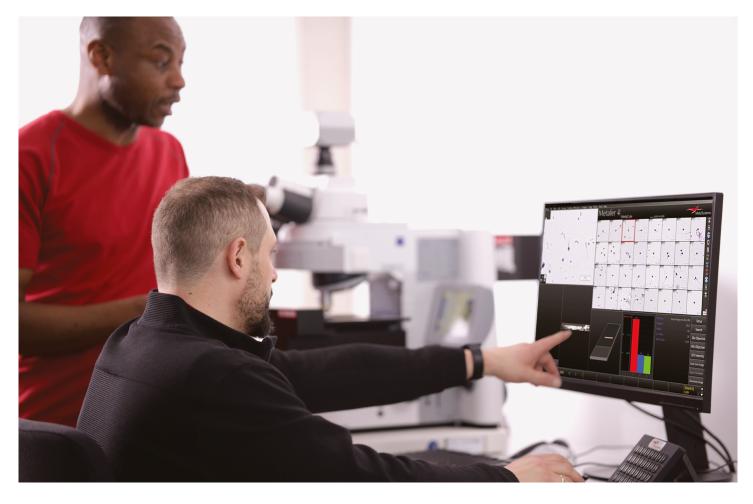# Customization Package Sperm Detection

Our proposed Metafer-based workflow for forensic sperm detection, implemented and validated by users worldwide, leverages artificial intelligence with Deep Neural Networks (DNN) to detect sperm cells in standard forensic samples, even in challenging conditions such as degradation, concealment, or absence of tails.

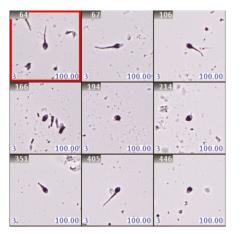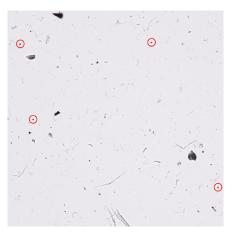**INFO DOSSIER**

MetaSystems

What do we offer with our Customization Packages (CP)?

- Customization packages are a service offered to tailor workflows to the specific needs of individual labs.
- The workflows combine advanced imaging software with deep learning techniques.
- Workflow recommendations are based on previous installations and the expertise of application specialists.
- The packages support the adaptation and optimization of the Metafer platform to meet laboratory-specific requirements.
- We provide expert support throughout the customization process.

Why is the Forensic Sperm Detection (FSPD) Customization Package significant?

- Sperm detection through microscopy is a common component of forensic laboratory procedures.
- Significant backlogs exist in many forensic labs for processing sexual violence cases.
- Using manual microscopy for sperm detection is time-intensive and requires the skills of trained personnel.
- The CP leverages Deep Neural Networks (DNN) to accelerate and optimize the detection workflow.

How has the FSPD Customization Package been received globally?

- The FSPD Customization Package has already been successfully implemented in forensic laboratories worldwide.
- Validations show enhanced sensitivity of automated sperm detection compared with manual search.
- Repeatability, reproducibility, and analysis time were determined to meet the needs of a forensic laboratory.
- The implementation of the adjustment package has demonstrated its potential to ease the workload of forensic experts.

Images of the Metafer installation (top), sperm cell gallery (center), and a field of view marking detected sperm cells (bottom). ▲

REFERENCES AND TESTIMONIALS

The automated microscope and image analysis system was found to be fit for purpose for sperm microscopy at the National Forensics Center.

Mobäck *et al*. (2024) Implementation of an AI system for automatic sperm identification; In: Butler *et al*., 30th Congress of the International Society for Forensic Genetics, Santiago de Compostela, 9-13 September 2024: proceedings. pp. 955 *ff*.

The ASpD [*Automated microscopic Sperm Detection; FSPD*] has been shown to be more sensitive than conventional microscopy and to greatly reduce personnel time.

Kumme *et al*. (2024) Establishment and validation of automated microscopic sperm detection using Deep Neural Network-based analysis software in a forensic routine laboratory. Poster on ISFG 2024, Santiago de Compostela, Spain.

The new AI method showed increased sensitivity, which explained all of the non-concordant results. [...] Repeatability and reproducibility is suitable for work with forensic trace samples.

Erg, S *et al*. (2024) Validation of sperm detection scanning system by MetaSystems. Poster on ISFG 2024, Santiago de Compostela, Spain.
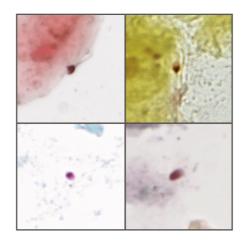
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Compatibility

- Customizable for integration into existing workflows.

- Compatible with transmitted light stains: Christmas Tree, Baecchi, and H&E (DNN).

- Extendable to the Sperm Hy-Liter kit (Non-DNN).

Traceability and Documentation

- Neon software ensures secure case and data management.

- User access levels prevent unauthorized modifications.

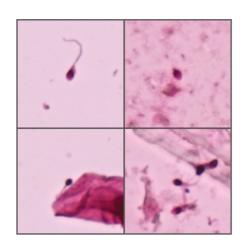- Full documentation provides traceable, legal-grade evidence.

AI-Powered Software

- Pre-trained, lab-adapted DNN detects sperm cells automatically.

- Captures gallery images with assigned quality scores.

- Results are presented to allow for examiner review and confirmation.
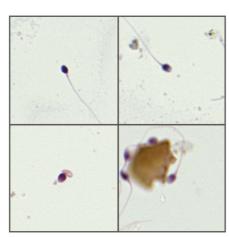
Review and Relocation

- Coordinates stored for precise sperm cell relocation.

- One-click retrieval directly under the microscope.

- Transferable to external microdissection systems.

★ BENEFITS

- Seamless integration into existing laboratory routines with minimal adjustment.
- Optimized forensic workflows that accelerate case processing and increase efficiency.
- Fast and precise relocation of findings for confident result confirmation and downstream analysis.
- Secure and reliable protection of all data and analysis parameters to ensure trustworthiness.

The Customization Package FSPD currently supports samples stained with Christmas Tree stain (top), Baecchi stain (center) and H&E stain (bottom). ▲

IN FOCUS:
DEEP NEURAL NETWORKS

Network Design

- Deep Neural Networks (DNNs) are statistical models inspired by the human brain, composed of multiple computational layers.

- A DNN learns to recognize relevant patterns by being trained on large sets of pre-classified example images.

- Early layers detect simple visual features (e.g., shapes, colors), while deeper layers combine these into higher-level representations (e.g., resembles a spermatozoon).

- Training a DNN requires iterative adjustment of its parameters through back-propagation, improving accuracy until the network can generalize to previously unseen images.

Training Process

- Training images are the only source of knowledge for the DNN and must be correctly pre-classified by professionals.

- Images need to represent the full spectrum of relevant variations to ensure robust feature learning.

- In forensics, this involves expertly annotated microscopy images covering diverse morphological appearances of spermatozoa.

- Training is computationally intensive, often requiring days to weeks.

Operational Integration

- Standard supervised methodologies are used, resulting in static DNNs that cannot be modified during routine use.

- After training, the DNN is tested on a previously unseen validation dataset (typically ~5% of the input data).

- During automated slide scanning, the DNN runs in real time.

- Re-training with laboratory-specific image data allows for improved accuracy for particular sample types or preparation methods.

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METAFER-BASED SCANNING

PROCESSING

- Unattended acquisition of up to 80 slides (expandable to 800).
- Automated scanning and barcode reading.
- Automatic oil application for oil objectives.

IMAGING

- Main scan with 20x magnification.
- Optional objectives: 40x, 63x, or 100x for detailed capture.
- Supports high-resolution imaging with automatic focusing of entire slides.

MICROSCOPY

- High-end microscope Carl Zeiss AxioImager Z2.
- Smart motorization and flexible configuration.
- Integrates with fluorescence imaging.

RESULTS

- Clear display of all objects in the image gallery.
- Shows DNN assignment values.
- One-click relocation of objects under the microscope.

REVIEW

- Quick review and correction on the computer.
- Review available on networked devices.
- Complete digital documentation of all steps.

CoolCube 4

CoolCube 4

Power Supply 232

MetaSystems

About MetaSystems

For almost 40 years, MetaSystems has been developing innovative solutions for automated microscopy-based imaging for the healthcare and biotechnology sectors. Our headquarters are located in the southwest of Germany near Heidelberg.

We are a global company with an international team working in Germany and in our subsidiaries in North and South America, Europe, India, and China. Our customers can be found in institutes, hospitals, and universities in over 100 countries around the world.

We continuously develop our products in close connection with our users, thus combining innovation with tradition. Our modern approaches include an advanced workflow management and the use of artificial intelligence. In many segments, this has enabled us to achieve an international top position.

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MetaSystems software provides, among other functions, features to assist users with image processing. These include, but are not limited to, the use of machine and deep learning algorithms for pattern recognition. The output generated in this process should be regarded as preliminary suggestions and, in any case, mandatorily requires review and assessment by trained experts.

MetaSystems offers **Customization Packages** for application workflows that have been successfully implemented for customer labs using standard Metafer platform functionality. It is expected that they can be implemented for other customer labs using similar workflows and slide preparation procedures. If a Customization Package is purchased, MetaSystems product specialists will - based on their experience from other similar application cases - support the customer lab in adapting the Metafer software configuration to their needs. The performance of the solution will depend on the quality of the customer slides and the expertise of the users, MetaSystems cannot specify or guarantee any performance parameters. The validation of the solution for clinical use is the sole responsibility of the customer lab.

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