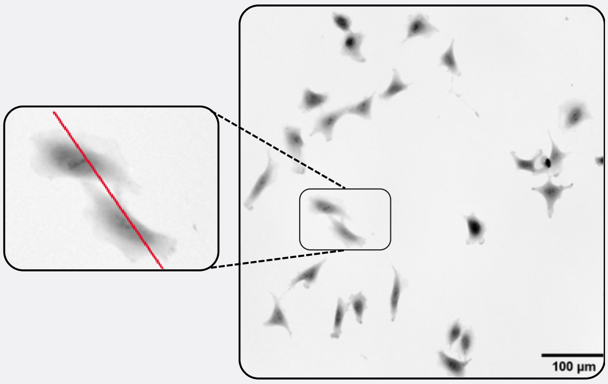
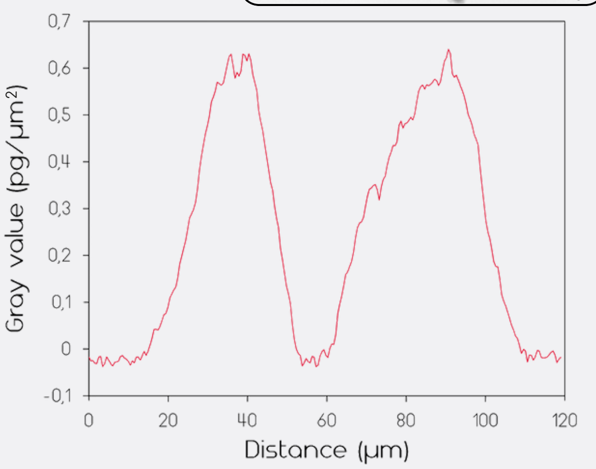
Intelligent QPI

In biomedical research, there is a growing demand for developing methods to be fast, accurate, robust, and provide the most objective results free from experimental conditions. **Quantitative phase imaging (QPI) microscopy and its coupling with advanced data analysis using artificial intelligence (AI) responds to these needs.** Data from Q-Phase microscopes are in an ideal format for further AI analysis, as they provide both visual and quantitative data about the observed cells, making them an ideal candidate for machine learning (ML) model training. Additionally, the QPI method enables non-invasive imaging of living cells without the need for labeling. This allows for direct quantification of cell dry mass - an innovative and highly relevant parameter for studying cell dynamics.

Background homogeneity in QPI: the key to precise AI analysis

A major advantage of QPI over other light microscopy techniques is the **uniformity of acquired data**. The physical principle of QPI ensures **high homogeneity** of the data over time. The contrast of QPI images is based on invariant optical properties of the cells, namely their refractive index. It is this high homogeneity that makes QPI data suitable for **image processing techniques** [1]. The quality of the image data is enhanced using an incoherent light source, which ensures artifact-free data.





Example of A549 cells (10x magnification). Graph points to the homogeneous background value without shadow-cast artifacts.

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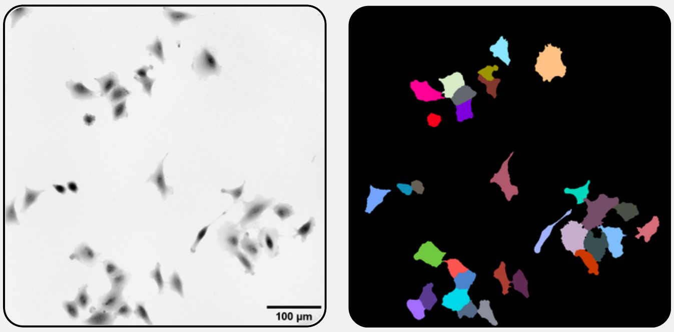
This high detection sensitivity of the microscope gives the cell under study a marked contrast to the background. Such contrasted data is easier and more accurate for performing **foreground-background segmentation**, i.e. distinguishing between the background and the observed cells.

Determine your cell boundaries

Our **software SophiQ** permits **automatic identification of cell edges**, which are shown as segmentation masks. Using segmentation masks is essential for tracking cells, measuring features, and training ML models, particularly neural networks. Integrating AI into image analysis helps automate tasks such as cell detection and classification in high-throughput biomedical imaging.



Example of a segmentation mask of A549 cell type generated by Telight software SophiQ.

QPI with advanced machine learning methods can be implemented as a tool for:

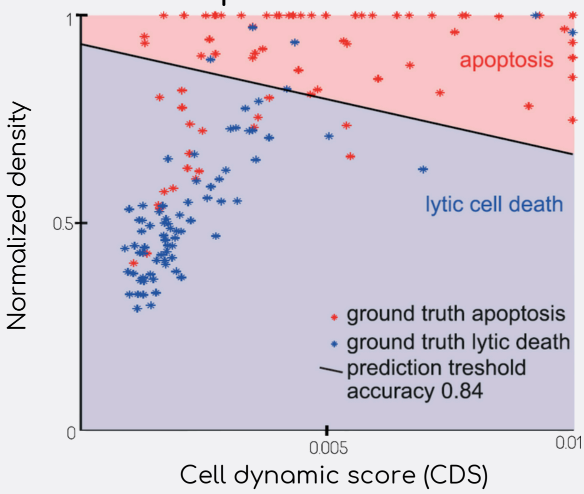
- automated detection
- cell segmentation
- cell tracking
- classification of cells and intracellular structures
- analysis of key cellular processes

QPI and AI

Advanced image analysis with machine learning - a study example

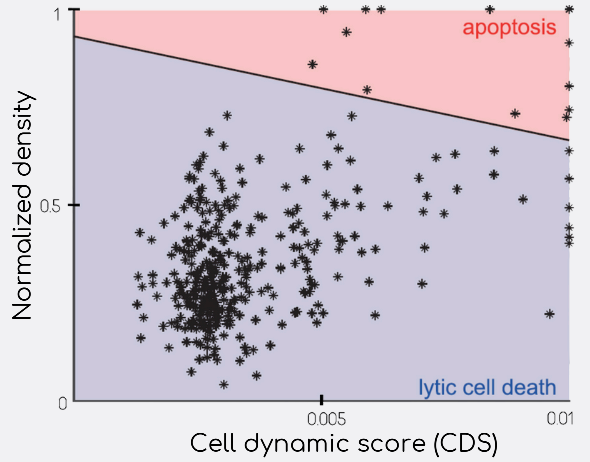
This study highlights an example of how AI models trained on **QPI data can automatically detect and classify cell death** [2]. Scientists applied the long short-term memory (LSTM) neural network to automatically detect the time point of cell death from extracted features (mass, area, density, etc.) of segmented and tracked LNCaP, DU-145, and PNT1A cells. For cell death type classification, only 2 features were selected: mass density (pg/pixel) and cell dynamic score (CDS) – features introduced by the authors. These features served as an input for the machine learning algorithm for cell death distinction. **As a result, their method identified cell death subroutines based on patterns in the time-lapse QPI data,** achieving 75.6 % accuracy for DU-145 cells compared to a manual detection method depending on fluorescence signal analysis.

0.1 µM doxorubicin



Classification of cell death type in DU-145 cells (N = 160) based on automatic detection method. Blue points represent manually annotated necrotic cells. Red points are manually annotated apoptotic cells. Cells were treated with doxorubicin. Original graph from [2].

0.1 µM doxorubicin + 10 µM z-VAD-fmk



Classification of DU-145 cells based on automatic detection method without manual annotation. Each **point** represents one cell (N = 381). Inhibitor of apoptosis z-VAD-fmk causes increased progression of lytic cell death (necrosis). Original graph from [2].

Conclusion

The Q-Phase microscope enables easy, noninvasive time-lapse observation and provides **detailed information about changes in cell mass distribution** that are unrecognizable to the naked eye. Morphological and dynamic features extracted from a large amount of QPI images in combination with ML methods e.g. LSTM neural network for cell death distinction, bring a significant advantage to many applications by providing more accurate, efficient, and detailed data analysis. **QPI data helps researchers detect cell death types, evaluate cancer cell response to chemotherapy, and assess toxicity.**

Complete brochure

References

[1] Vicar, T. et al. Cell segmentation methods for label-free contrast microscopy: review and comprehensive comparison. BMC Bioinformatics 20, 360 (2019).

[2] Vicar, T., Raudenska, M., Gumulec, J. & Balvan, J. The Quantitative-Phase Dynamics of Apoptosis and Lytic Cell Death. Sci. Rep. 10, 1566 (2020).

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