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The Microscopy Software Evolution: Advantages and Challenges

The history of microscopy dates back several centuries, but development leapt with the first 'compound microscope' in the 1600s. During the twentieth century, electron & x-ray microscopy and other imaging modalities pushed visualisation boundaries further, showcasing single atoms' first images. However, hardware technology advances required support from software to control these systems and process & analyse the data.

We reached a point where software is starting to grow more rapidly than the hardware developments, not only because of the introduction of artificial intelligence but also because older algorithms that got somewhat lost in the mists of time are re-introduced to the scientific society, often without much explanation or background on how they work. These algorithms used to be heavily resource-demanding and were slow for that time's computers or designed for other applications. New processing power, such as GPU-computing, now performs calculations in near-realtime, with often remarkable results. Background subtraction and deconvolution are two examples of such 'older' technologies that are seeing a revival. However, one may not overlook the fact that such processing may affect quantifiability or introduce artefacts.

Additionally, e.g., to provide super-resolution images, a combination of optics (hardware) and algorithms (software) is required, as used in structured illumination or single-molecule light microscopy. These technologies bring science to a new level in terms of imaging, and the combination of hardware with software is compelling. However, one must remain cautious regarding artefacts, noise amplification and possible loss of linearity between images, as both hardware and software must be designed to avoid this.

ZEISS invested heavily in whole-system linearity & sensitivity with, e.g., but not limited to, Airyscan, lattice-SIM, lattice light sheet and deconvolution. Whole-system sensitivity is imperative for all ZEISS systems. To not affect the biochemical cycles in a cell, illumination (radiation) power must be as low as possible, and detection efficiency (QE) as high as possible. However, a high whole-system S/N will also neutralise potential artefacts or noise amplification effects to show up in the final image after image processing. Linear image acquisition and processing will safeguard the quantifiability of the data.