

Digital and computational transition in the pathology lab: when did it start?

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We read with interest the article published in the journal *Pathologica* by Belloni E et al. entitled *Digital transition in pathology lab: a survey from the Lombardy region*¹. The paper is based on the results of a survey promoted by the Coordinamento della Medicina di Laboratorio. The authors pointed out that the “advantages of digital pathology must be balanced against the challenges faced in the structural revision of the pathology workflow”¹.

Pathologica started to fully support digital and computational transition in pathology lab three decades ago with a special article collection entitled *Advances in Quantitative Pathology* (Guest Editors: Rodolfo Montironi, Italy and Paul van Diest, The Netherlands) (Fig. 1)². This special issue dealt with the origins and potential future benefits of digital pathology (DP), decision support systems (DSSs) and artificial intelligence (AI).

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Digital pathology

DP, i.e. digitalization in the field of pathology, is “a proven technology, enabling generation of high-resolution digital images from glass slides”³. It is based on stitching together individual digital adjacent images to achieve virtual slides mapping entire tissue sections (whole slide images). One of the greatest pioneers in the development of DP was the late Prof. Peter H. Bartels, a scientist working at the Optical Sciences Center, University of Arizona, Tucson, AZ, USA. Prof. Bartels’ group, which included one of the authors of the present contribution (RM), described methods and procedures for the assembly of very large-scale microscopic image arrays as multimegapixel images in histopathology⁴. The latest application of DP is in association with confocal microscopy⁵. DP allows the numerical analysis of tissue structures and the measurement of microscopic features^{2,3}. Therefore, it has a fundamental role in tissue interpretation, i.e., image analysis^{2,3}, implementation of DSSs and AI, i.e., computation^{2,3} and adoption of automation and robotics in the field of pathology⁶.

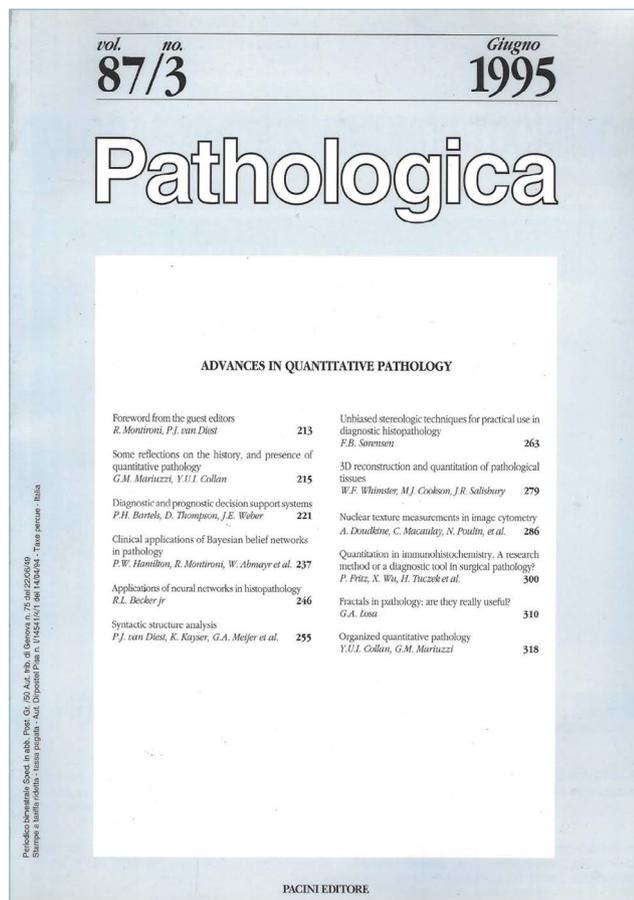


Figure 1. Pathologica: Cover page of the special article collection on *Advances in Quantitative Pathology*.

Decision support systems

DSSs represent the information technologies aimed at the diagnostic and prognostic interpretation of quantitative data. DSSs are implemented as inference networks, automated reasoning systems, case-based reasoning, and expert systems ^{6,7}. In inference networks and automated reasoning systems, the emphasis is on uncertainty assessment of a given decision sequence. In case-based reasoning, the emphasis is on prognostic assessment for an individual patient. In expert systems, the emphasis is on diagnostic or prognostic assessment, by making available a comprehensive knowledge base of facts and professional experience. Although the emphasis is slightly different in these kinds of DSSs, much of the methodology is shared. AI-enabled DSSs have been developed ⁶.

An example of a successful DDS developed by our group is the identification of Prostate cancer (PCa) with a cribriform pattern. A knowledge-guided procedure following a model-based reasoning process was

developed in the context of a set of interacting expert systems for machine vision in histometry. “The cribriformity index was defined as the ratio of the form factor of the gland’s interior lumen outline to the form factor of the gland’s basement membrane” ⁷. Correct segmentation of approximately 70-80% of cribriform glands was attained, i.e., outlining of histologic components agreed with visual assessment ⁷.

Artificial Intelligence

The term AI describes a machine’s capacity to carry out operations that ordinarily require the pathologist’s intellect. A branch of AI known as “machine learning” uses algorithms to give AI systems the ability to learn from data and get better over time. Artificial neural networks are used in deep learning (DL), a type of machine learning ⁸. DL techniques are particularly useful in analyzing digital slides due to their ability to recognize subtle patterns and features that are not easily identifiable by pathologists ⁹.

“DP facilitates AI-based image analysis to aid pathologists in diagnostic tasks”, including “tumor segmentation, disease classification, detection, quantitation and grading, rare object identification, and outcome prediction” ³. An example of a successful application of AI to PCa grading is that by Ambrosini et al. ¹⁰ who developed a method to automatically detect cribriform PCa in digital images of prostate biopsies. The authors used “a convolutional neural network to automatically detect and localize cribriform growth patterns in prostate biopsy images.” Their system was able to detect cribriform regions in PCa.

Conclusions: when did it start?

An answer could come from a past issue of the journal Pathologica published 3 decades ago ².

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

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AUTHORS’ CONTRIBUTION

Conceptualization: R.M.; data acquisition: R.M. and A.Ci.; writing – original draft preparation: A.Ci., R.M.; writing – review and editing: R.M. and A.Ci.; and supervision: L.C. and A.L.B.

All authors have read and agreed to the published version of the manuscript.

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