J Pathol Inform

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Editorial

Computer aided diagnostic tools aim to empower rather than replace pathologists: Lessons learned from computational chess

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Received: 17 March 11 Accepted: 02 May 11 Published: 14 June 11

This article may be cited as:
Hipp J, Flotte T, Monaco J, Cheng J, Madabhushi A, Yagi Y, *et al*. Computer aided diagnostic tools aim to empower rather than replace pathologists: Lessons learned from computational chess. J Pathol Inform 2011;2:25.

Available FREE in open access from: http://www.jpathinformatics.org/text.asp?2011/2/1/25/82050

COMPUTER AIDED DIAGNOSIS: NEW HORIZONS IN DIAGNOSTIC PATHOLOGY

The recent availability of digital whole slide imaging (WSI) data sets from glass slides creates new opportunities for possible deployment of computer aided diagnostic (CAD) technologies.[1-7] Use of CAD has the potential to improve the practice of pathology in various ways by helping the pathologist: in the screening of slides, the provisioning for real time clinical decision support tools, the instantiation of additional automated layers of quality assurance and diagnostic consistency, and lastly, imparting a quantitative component to the practice of diagnostic pathology.[4]

As observed by Thomas Kuhn, scientific revolutions – such as the computational and informatics revolution that characterize our times – can generate fears and resistance from a conservative worldview in the same way the contemporary circumstance of proposed adoption of smart digital pathology technologies, such as CAD, may be seen as a threat that "will replace the human," and in this case, the pathologist. Instead, we would rather believe that properly leveraging the strength of informatics and computation can be of valuable assistance, making pathologists better and more efficient. Akin to Polymerase Chain Reaction (PCR) for the molecular biologist, and immunohistochemistry for the pathologist, CAD technology provides many examples of how widespread adoption will require proper use and clinical interpretation by pathologists. Accordingly, lessons learned from the computational chess community can illustrate how CAD may be incorporated successfully into the practice of pathology.

"HOW CAD CAN BE INTEGRATED INTO THE PRACTICE OF PATHOLOGY"

A classic example of how CAD has been applied to pathology practice and be seen with automated screening of pap smears. CAD technology has been shown to improve efficiency, accuracy and consistency, while freeing skilled pathologists and cytotechnologists from the monotonous and therefore error-prone screening of large numbers of smears.[8] In a similar vein, the

Access this article online
Quick Response Code:
Website: www.jpathinformatics.org
DOI: 10.4103/2153-3539.82050

evaluation of multiple prostate biopsies for prostate cancer is hampered by & larger number of slides/cores/sections, (potentially) small foci of cancer, and the need for consistency in diagnosis and grading.[4] Like the automated pap screening devices, CAD approaches hold the potential of greatly assisting the reviewing pathologist by pre-screening prostate tissue sections to highlight those areas that are likely to contain cancer and perhaps, as an added metric of performance, contributing towards the goal of attaining greater consistency in grading.[4,7,9]

There are other important examples from dermatopathology, infectious disease, and consultative practice. Mitotic figures are often important but not diagnostic of melanoma in biopsies of atypical melanocytic lesions. In those that are less than 1 mm in thickness, the proper mitotic count may signify the difference between requiring and not requiring follow on sentinel lymph node biopsy. For the diagnosis of infectious diseases, we may eventually use microchips that can identify every known pathogen, but in the interim, we remain dependent upon special stains, where potential use of CAD could assist with the rapid identification of rare small organisms, such as mycobacteria or spirochetes. For rare and unusual tumors, CAD could assist those pathologists who have not yet been amassed sufficient experience with certain diagnostic entities, to be able to identify them with confidence. CAD could also assist in the screening of tissue sections, such as those encountered with sentinel lymph nodes, where there is a need to identify micrometastases - a laborious task that is prone to error.

Many challenges in applying CAD to an all digital workflow will be in the transport, storage, retrieval, and analysis of digital slides. The majority of these operational issues can be addressed through the effective use of Grid technologies.[10] Grid computing enables the plurality of connected users to simultaneously access a single web presence, even though the overall application may be implemented as a geographically diverse collection of separate data centers, thus confering both enhanced reliability and response times.[10] Integration of this emerging type of software hosting model will allow those users of ordinary desktop/laptop PCs to perform tasks normally reserved for high-throughput computation settings (enabled by the reality that *the actual computation will be taking place* within a high-performance data center or centers). Consequently, we envision that the expanding use of automated feature identification applications in digital pathology will usher in another large revolution in the practice of pathology similar to the advent of immunohistochemistry or the use of light microscopy. Such technology will not replace, but rather, assist pathologists with their rendering of the best possible decisions regarding difficult cases.

LESSONS LEARNED FROM CHESS

In his work on "the Cyborg Advantage", Clive Thompson described the different advantages possessed by humans and computers (summarized below).[11] A computer's advantage lies in its ability to perform high-speed calculations, covering millions of possible moves in search of an optimal one, while a human relies on strategy and intuition perfected by years of experience and study. Computational approaches in this regard are thus tactically superior, whereas, human chess performance is strategically superior (advancedchess.netfirms.com).

In 1997, IBM's Deep Blue supercomputer beat the international grand champion Garry Kasparov. Afterward, Kasparov created the field known as "advanced chess" – a game format in which players are assisted by off-the-shelf computer chess programs, which serve in the role of offering a selection of possible moves that are based upon the current position of game pieces.

In 2005, Kasparov created an online tournament comprised of grandmasters, supercomputers, and computer-assisted humans. Ironically, the overall winner was a pair of amateur players (less than 30 years old!) who participated in the competition with nothing more than an average personal computer running an inexpensive chess program. Their advantage stemmed from their ability to know when to effectively leverage the computer's assistance, and when to consult and/or ignore the computer's advice.[11] Kasparov later said that a weak human with a machine can outperform a strong human with a machine if the weak human has a better cognitive process.[11] Therefore, the most brilliant chess players, worldwide, are neither high-end machines nor high-end humans but surprisingly, those average-playing-ability chess players who are effective with the blending of their experience with the exhaustive thoroughness as made possible by computational decision support.[11]

Can "advanced chess" offer a new paradigm for the integration of computers into pathology? The decision support approach could in theory effectively serve as potential decision support tools for pathologists upon completion of appropriate optimization and validation. The improving quantitative algorithmic performance of CAD algorithms reported to date gives hope that there will be continued evolutionary improvement in WSI algorithmic performance, leading to highly accurate tools. The greater challenge for the specialty lies in our ability to integrate such tools into our core workflow and practice approach. We believe the experiences of computational chess, as accrued to date, are encouraging for the plausible deployment in our field of what might one day be termed "advanced pathology."

DISCLOSURE/CONFLICT OF INTEREST

AM and JM are majority stockholders in Ibris Inc.

ACKNOWLEDGMENTS

This work was made possible via grants from the National Cancer Institute (Grant Nos. R01CA136535-01, R01CA14077201, and R03CA143991-01); and the Cancer Institute of New Jersey; and at the University of Michigan by Clinical Translational Science Award (CTSA) 5ULRR02498603 PI Ken Pienta.

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