Original Article

Teaching Digital Pathology: The International School of Digital Pathology and Proposed Syllabus

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Abstract

Digital pathology is an interdisciplinary field where competency in pathology, laboratory techniques, informatics, computer science, information systems, engineering, and even biology converge. This implies that teaching students about digital pathology requires coverage, expertise, and hands-on experience in all these disciplines. With this in mind, a syllabus was developed for a digital pathology summer school aimed at professionals in the aforementioned fields, as well as trainees and doctoral students. The aim of this communication is to share the context, rationale, and syllabus for this school of digital pathology.

Keywords: Curriculum, digital pathology, teaching

Introduction

The school of digital pathology is an activity organized by AIDPATH.[1] AIDPATH is an Industry Academia Partnerships and Pathways project of the Marie Curie Action European Union's FP7 Framework Programme started in 2013.[2] To date, the AIDPATH collaboration has fostered digital pathology through a series of international activities including networking, workshops, summer schools, and conferences. The AIDPATH project is focused on research, training, and knowledge sharing in the emerging multidisciplinary field of digital pathology.

Digital Pathology School

A proof of concept of the school was first held in the city of Monza in Italy in June 2015. The second summer school, organized by the University of Udine in conjunction with the Centro Di Riferimento Oncologico (CRO), was held in September 2016 on the Campus of the Oncologic Reference Center in Aviano, Italy.[3] Both events were sponsored by Roche. The school was officially recognized as a course at the University of Udine. It ran for a week and comprised theoretical lessons [Figure 1] and practical activities. Participants (19 students and 5 observers) included pathologists, hematologists, pathology laboratory technicians, biotechnologists, biologists, clinical engineers, health informaticians, computer scientists, and researchers in various fields. Although the motives of why participants attended and how their participation impacted the

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Figure 1: Didactic sessions at the school of digital pathology

subsequent activity were not formally collected, most of the students attended because they were either already using digital pathology without formal training or because their institution was going to acquire a scanner.

A questionnaire distributed to these students afterward showed a very positive response to the school. The final survey median evaluations were three out of four for pertinence, educational quality, and effectiveness. However, the relevance of various topics differed for students originating from different backgrounds. In particular, four (21%) students felt that some of the practical sessions were geared too specifically toward pathologists. While the median evaluation for the school's length was overall deemed to be "adequate," six (32%) students felt that it was too long.

Digital Pathology Syllabus

The course was aimed at teaching students the fundamentals of digital imaging and instructing them on the utilization of digital pathology as a tool for advancing pathology practice. The syllabus [Table 1] was developed collaboratively by most of the teachers of the school. Faculty felt that it was important to stress the technical aspects of digital imaging, digital slide workflow, applications including organizational processes to support telepathology services, regulations and guidelines, image analysis, and novel imaging techniques. All these topics were not covered in-depth, because the course was limited to only 1 week. Moreover, to condense the program and avoid overlap, some topics were blended; for example, by integrating acquisition technologies with workflow issues. Most of the sections of the syllabus are of general applicability. However, local laws largely influence legal and regulatory aspects of digital pathology. As students were mostly Europeans, particularly from Italy, this aspect of the curriculum focused on European and Italian rules. Practical sessions were mostly devoted toward hands-on experience pertaining to imaging workflow using a sample commercial system (i.e., image acquisition, visualization, case management, and image analysis with FDA- and CE-approved algorithms). During the practical session, other systems were illustrated, including both commercial and freely available software. Volunteers also had the opportunity to partake in an image quality evaluation study.

Table 1: Overview of the digital pathology school syllabus

1. Introduction to digital pathology
   - 1.1. History
   - 1.2. Basics of digital imaging
     - 1.2.1. Image representation
     - 1.2.2. Color representation
     - 1.2.3. The concept of resolution
     - 1.2.4. Sensors
   - 1.3. Main applications (with available evidence)
   - 1.4. Digital pathology in routine practice
   - 1.5. Digital pathology in nonclinical settings (e.g., research, biomarker discovery)
   - 1.6. Open issues (including regulatory issues)
2. Digital slide workflow
   - 2.1. Preimaging parameters
   - 2.2. Acquisition
     - 2.2.1. Storage and image management
   - 2.3. Visualization (workstations)
   - 2.4. Image sharing (e.g., telepathology)
   - 2.5. Service organization
3. Technical aspects
   - 3.1. Hardware (e.g., digital cameras, optics, scanners, servers)
   - 3.2. Software (e.g., image viewers, networking)
   - 3.3. Interoperability: Technical standards
   - 3.4. Security and privacy: Technical and legal aspects
   - 3.5. Digital pathology-related guidelines and recommendations
4. Image analysis
   - 4.1. Basics of image processing and analysis
   - 4.2. Basics of stereology
   - 4.3. Image quality metrics
   - 4.4. Current applications to digital pathology
     - 4.4.1. Marker quantification
     - 4.4.2. Relevant area recognition (e.g., tumor tissue, lymphocyte infiltration)
     - 4.4.3. Rare event detection (e.g., mitosis, circulating tumor cells)
   - 4.5. Open research challenges
5. Novel imaging techniques
   - 5.1. Confocal and deconvolution microscopy
   - 5.2. Multispectral microscopy
   - 5.3. Super-resolution microscopy
   - 5.4. No-stain techniques
   - 5.5. Emerging technologies for human-computer interaction

Conclusion

Education plays an important role in the future of the specialty of pathology informatics.[4] The success of pathology informatics relies not only on educating pathologists, but also on ensuring the competency of allied professionals (e.g., medical technologists) in informatics.[5] The same is true for digital pathology. Fellowships are one mechanism to engage young pathologists.[6] The digital pathology school established by AIDPATH is another valuable effort helping to promote the

Table 2: Applicability of the digital pathology school syllabus for different students

Syllabus topic*	Pathologist	Laboratory technician	Biological scientist	Computer scientist	Systems manager	Health-care administrator
1.1	Yes	Yes	Yes	Yes	Partly	Partly
1.2	Yes	Yes	Yes	No	No	No
1.3	Yes	Yes	Yes	Yes	Yes	Yes
1.4	Yes	Yes	Partly	Yes	Yes	Yes
1.5	Yes	Yes	Yes	Yes	No	No
1.6	Yes	Yes	Yes	Yes	Yes	Yes
2.1	Yes	Yes	Yes	No	No	No
2.2	Yes	Yes	Yes	Yes	Yes	No
2.3	Yes	Yes	Yes	Yes	Yes	Yes
2.4	Yes	Yes	Yes	Yes	Yes	No
2.5	Yes	Yes	Yes	Partly	Yes	No
2.6	Yes	Yes	No	No	Yes	Yes
3.1	Yes	Yes	Yes	Yes	Yes	No
3.2	Yes	Yes	Yes	Yes	Yes	No
3.3	Partly	Partly	Partly	Yes	Yes	Partly
3.4	Partly	Partly	No	Yes	Yes	Yes
3.5	Yes	Yes	Yes	Yes	Yes	Yes
4.1	Yes	Yes	Yes	No	No	No
4.2	Yes	No	Yes	Yes	No	No
4.3	Yes	Partly	Partly	Yes	Partly	No
4.4	Yes	Yes	Yes	Yes	Yes	Partly
4.5	Yes	Partly	Yes	Yes	No	No
5.1	Partly	Partly	Yes	Yes	No	No
5.2	Yes	Partly	Yes	Yes	No	No
5.3	Yes	Partly	Yes	Yes	No	No
5.4	Yes	Partly	Yes	Yes	No	No
5.5	Yes	Yes	Partly	Yes	Yes	No

*Refer to Table 1 for syllabus topics

adoption of digital pathology. Trying to cover the breadth and depth of topics relevant to digital imaging in pathology in 1 week was challenging. Moreover, after surveying students, it was apparent that not all topics were of interest to every student, at least at the same level of depth. Table 2 is a proposed interest matrix for different professionals who are involved with digital pathology. This matrix was developed by speculating on informally collected opinions of participants. The intent is to better refine this syllabus with more focused surveys in subsequent editions of the school. For health-care administrators interested in deciding whether to implement digital pathology solutions in their laboratory or hospitals, the syllabus could be specifically tailored toward discussion on the business case for adopting digital pathology, service organization, and guidelines and regulatory issues rather than just the technical aspects of digital imaging.

Given the success experienced to date, the school will be replicated again by another AIDPATH partner in 2017. Offering specialized parallel tracks for pathologists and nonpathologists from around the world is being taken into consideration, although the heterogeneity of the audience backgrounds by itself might provide added value, in a topic inherently interdisciplinary like digital pathology.

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Conflicts of interest

There are no conflicts of interest.

References

1. AIDPATH Summer School. Available from: http://www.mitel.dimi.uniud.it/issdp/. [Last accessed on 2017 Feb 04].
2. AIDPATH Project. Available from: http://www.aidpath.eu/. [Last accessed on 2017 Feb 14].
3. Program of the International Summer School in Digital Pathology. Available from: http://www.mitel.dimi.uniud.it/issdp/programme.html. [Last accessed on 2017 Feb 04].
4. Henricks WH, Karcher DS, Harrison JH Jr., Sinard JH, Riben MW, Boyer PJ, *et al.* Pathology informatics essentials for residents: A flexible informatics curriculum linked to accreditation council for graduate medical education milestones. Arch Pathol Lab Med 2017;141:113-24.
5. Modery J, Khalbuss WE, Pantanowitz L. All aboard: Cytotechnology student training in pathology informatics. J Pathol Inform 2012;3:6.
6. Williams BJ, Treanor D. A novel leadership fellowship in digital pathology. J Pathol Inform 2016;7:39.