Analysis of the impact of high-resolution monitors in digital pathology

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The work from Randell et al.¹ evaluates the efficiency of pathologists when using different technologies for interpreting microscopic slides: A conventional microscope, a 24-inch 2.3-megapixel single-screen display (1920 × 1200 pixels), and a three-screen 11-megapixel display consisting of three 27-inch 3.6-megapixel displays (each 1440 × 2560 pixels). They measured time to detect areas of interest, time to diagnosis, and user confidence. With the participation of nine consultant pathologists, each of them reviewing three slides with each of the aforementioned technologies, a total number of 81 different slides were used.

In their initial analysis, Randell et al. found a substantial variability in the time taken to make a diagnosis according to the particular slide and they decided to apply a “normalized time to diagnosis” that was defined as the time to diagnosis expressed as a percentage of the mean time to come to a diagnosis for all trials for that slide. Time to first target (to identify the first cancer cell group) was defined as the time elapsed until the participant either passed over an area of cancer at a level of magnification where the feature could be assumed to be visible, paused on an area of cancer or zoomed into an area of cancer.

We find this is a remarkable work since the methodology is very well described, and it is a pioneer study on human and technical aspects on monitors and digital pathology. From the obtained results of this study, it is confirmed that technology did not significantly impact participants’ confidence in the diagnosis. However, the mean time to diagnosis was significantly lower when using a conventional microscope compared with the other two digital slide options, both in slides with cancer and in those without metastasis. Also, they did not found a significant difference, in the mean time to diagnosis, between the single-screen and three-screen displays.

Regarding time to first target, they find that it was lowest on the microscope and highest on the single-screen display. There was no significant difference between the single-screen and three-screen displays in the mean time to detect the first cancer cell group (“first target”).

Although this study was designed to specifically assess the effect of display resolution, not the display size, on time to diagnosis with digital slides, two very different displays were used, and this may affect the results. Furthermore, in multiple screens, users tend to focus on the central screen, and the frame or rim visible on the face of each monitor (bezel) may affect users’ experience. The authors describe other limitations of this study, such as the small number of participants and the limited tasks performed by each user.

COMMENTS

One of the frequently mentioned barriers for the wide adoption of digital slides in pathology daily practice is that reading whole slide images takes more time than reading glass slides with conventional microscopes.¹

Differences found in the aforementioned study can also be related, at least partly, to other technical characteristics of the selected monitors. Apart from the resolution and size, the main differences between the two display models used in this study are pixel pitch (distance between pixels), refresh rate, color depth, contrast ratio, and viewing angle [Table 1].¹ which were better in each of the three-screen 11-megapixel displays (Dell UltraSharp U2711, Dell Computer Corporation, Texas, USA) than in the 24-inch 2.3-megapixel single-screen display (Samsung SyncMaster 2493HM, Samsung Electronics America, NJ, USA).

The same workstation with two Nvidia Quadro graphics cards (NVIDIA Corporation, CA, USA) was used in all
experiments. Since there are different models of Nvidia Quadro for desktop workstations, we cannot be sure if the selected graphic card was optimal for the monitors to achieve optimal performance.

Using multiple displays to create a high-resolution (11-megapixel, 4320 × 2560 pixels) device does not seem to be an optimal solution since users tend to focus on the central screen. In the literature review by Randell et al., they describe that previous studies have focused on display size, and larger displays may help to increase the performance mainly due to better physical navigation, such as turning one’s head, as opposed to the benefits delivered by exploiting peripheral vision to provide context. According to Dr. Krupinski’s work, digital slide search strategies are very different for each group of observers, and medical student searches take about 10 times as long as pathologist searches for identifying regions of interest. Years of experience of consultant pathologists in Randell’s study could be interesting to know.

Another important finding in the behavioral analysis of the aforementioned paper is that users tend to use the main screen instead of using the overview or slide map to move inside the digital slide. Maybe users were not familiar with slide map functionality. Furthermore, the authors describe a previous experience, when navigation was restricted to the overview, where they found no significant difference in the time to diagnosis between the microscope and the three-screen display. We agree that participants’ increased familiarity with the microscope may be one of the main reasons why Randell et al. conclude that performing diagnoses using virtual slides can take pathologists significantly longer than with glass slides.

Applying a “normalized time to diagnosis” is a good contribution of Randell’s study that may help future studies focused on understanding an efficient use of digital pathology.

Medical diagnostic monitors with a resolution between 4- and 6-megapixels and 30-inches are becoming popular in digital pathology. In addition, recently, 4K monitors (4096 × 2160 resolution and a 1.9:1 aspect ratio) have become widely available. This standard arises from the movie industry to improve user perception in the cinema theater. Will 4K medical-grade monitors improve the pathologist experience with digital pathology? They offer a resolution of about 8.8 million pixels. But having higher resolution is not enough to become popular. Additional advantages such as improvements in sharpness, color depth (already available in some medical monitor manufacturers solutions), or the combination of a 4K resolution with touch-screen can make the difference for these displays to become widely adopted.

When higher-resolution displays are used, the distance between pixels also decreases (from 0.29 mm in the 24” display to only 0.116 mm in a 27” 5K monitor like Dell UP2715K). If the same digital slide is used, this means that objects will look smaller in larger monitors when maximum original magnification is reached. If participants are placed at a longer distance when using high-resolution monitors, there is a higher probability that they will miss small objects.

Finally, the main factor related to pathologist time to diagnosis is the experience in the specific task under evaluation. Detecting metastatic cells in lymph nodes
can be considered a simple task for pathologists, but those performing this task routinely will probably perform better, independent of the technology they use.

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