

## Mobile whole slide imaging with Indian twist

Editor,

Microscopic observation of the tissues has come a long way from the time of Anton van Leeuwenhoek to today's sophisticated techniques. The humble glass slide has withstood the test of time and is relevant and used even today. These slides are being digitized world over with various companies offering a wide range of whole slide imaging (WSI) digitizers.

Even though the advantages are many, these WSI scanners are not being widely used due to their prohibitive cost of acquisition ranging from about \$73,000 to \$12,5000 for single slide to twenty slide loader, respectively. In addition, digital storage and maintenance costs increase the cost further.

Mobile WSI (mWSI), with the increasing processing capacity, pixels in the camera and slimmer designs mobile altogether has become a very powerful digital tool.

World over many pathology residents and pathologists capture single field view pictures of important spots on the slide for a later review or reference whereas the mWSI uses the panorama picture capture in the dedicated app, and these images are stitched together using an image processing software.<sup>[1]</sup>

In era of open source, we have made an attempt using the default camera app and the proprietary software of Microsoft research laboratory – Image Composite Editor® (ICE); the images or video are processed to form a virtual slide;<sup>[2]</sup> thus, making it free of cost and easy to use.

We have used the Nikon microscope and a mobile phone mount made of the cardboard [Figure 1] to acquire the images. The mobiles tested were One plus Two and Apple iPhone 6 plus. The images were acquired in the panorama mode and in both the phones the default camera app was used.

Image acquisition was started from one corner of the slide, and multiple, serial panoramas were taken in horizontal axis until the whole tissue was captured. Then, the field was changed vertically downward to start capturing again horizontally, in this zigzag pattern whole slide was captured [Figure 2a]. In case of utilizing the even more user-friendly option of video mode for creating the digital slide, the process was a continuous capture of video without stopping after reaching the limit of the panorama.



**Figure 1: (a) Mobile phone mount made of the cardboard. (b) Nikon microscope. (c) Mount attached to the eye-piece of microscope**

The images acquisition process took about 15–30 min in the  $\times 400$  magnification and 10–15 min in cases of  $\times 100$  and  $\times 200$  magnification, respectively. We also used the same process to acquire the image in  $\times 1000$  oil immersion objective.

The images were then transferred to a computer and the ICE program, then stitched the panoramic strips and generated a final complete picture of the slide [Figure 2b]. To stitch all panoramas, the software requirement was of at least 15% overlap in both the axes.

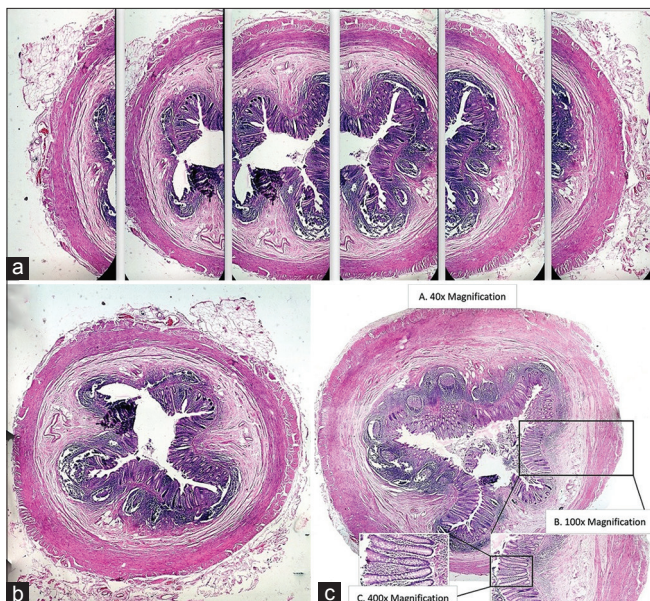
This process was also evaluated with Gigapan, PT Gui, Hugin, bimostitch app and photostitcher software. Among these, the ICE had a very good stitching performance which was both fast and also gave consistent results. The software options and the entire process in the ICE were also easy to understand.

The images were saved in portable network graphics (PNG) format as well as Joint Photographic Expert Group (JPEG), PNG was preferred to JPEG due to ease of use. The average size of the digitized slide ranged from 120MB to 200MB in case of the  $\times 400$  magnification depending on the tissue section under study. Histopathology, hematopathology and cytopathology slides were used to generate virtual slides.

The images were managed on a computer by making simple folder arrangement of the files and did not require a dedicated software program to retrieve, review, or for archival purposes which was the case with WSI scanners.

The images created in PNG format were of diagnostic quality. The images can be viewed in the computer, mobiles, and tablets without using any additional software.

The image clarity, when compared to the glass slides, is equally good and the zoom in feature in the digital slide changes the magnification seamlessly from  $\times 40$  to  $\times 1000$ .



**Figure 2: (a) Individual panorama strips captured. (b) Final image after stitching individual panorama strips. (c) Various magnifications of the stitched image**

With this very economical modality, we stored the rare and important slides in digital format.

The slides can be shared with the help of Bluetooth® or local area network (LAN)/wireless LAN technology without the need of high-bandwidth internet.

The mWSI technique we used, has made the creation of digital slide easy using the mobile and under 10MB of a software program which was easy to follow. All we needed to do was capture the image either in panorama mode or video mode, copy to computer, and click generate in the ICE software which created beautiful, clear digital images of the slides

This system helped us in creating a digital slide library of our own for the undergraduate students without spending even a rupee from the department's resources. This also helped in making digital slides of the important rare cases, also the slide data footprint was also very small.

This system enabled us to have a free alternative for the expensive slide scanners available commercially and also without using dedicated apps and motorized mechanical stages for the mWSI which were not available to us.<sup>[1]</sup>

While working with digitized slides using tablets and where applicable in cases of a stylus input enabled tablets, it was a breeze to teach as the slides can be marked and arrows drawn without the use of any additional software programs.

To conclude, mobiles are already being used in different fields of telemedicine; but in pathology, it was not integrated to that extent.

With mWSI, a new horizon has been opened in telepathology. This is first of its kind approach, which can make digitization and archiving of slides simple, free of cost, and feasible in resource poor institutions of developing countries. We plan to make this technique more robust and intend to participate in International mWSI validation program in near future.<sup>[3,4]</sup>

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**Conflicts of interest**

There are no conflicts of interest.

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