Short Communication

Virtual microscopy made economical and effortless using the Foldscope and a smartphone with screen mirroring

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Abstract

Context: Virtual Microscopy.

Aim: The aim of this study was to demonstrate, as a proof of concept, the integration of a Foldscope, along with a smartphone and screen mirroring devices, into the regular academic teaching program for use with all types of regular slides for economical virtual microscopy.

Setting, Design & Methods: For the purpose of this demonstration, a microscopic slide of a ground section of a tooth, a smartphone (iPhone6), a Foldscope and an Apple TV module were chosen to demonstrate the integration of a low-cost unbreakable microscope along with a smartphone to facilitate immediate viewing, capture, sharing and even projection of the image by screen mirroring, if required, in a classroom setting.

Conclusion: The Foldscope microscope (Foldscope Instruments, Palo Alto, CA, USA) invented by Manu Prakash is an extremely economical, Origami style, fold to assemble microscope available from popular online retailers at approximately Rupees 500 aimed at simplifying and enabling diagnostics and education worldwide. The Foldscope, integrated with a smartphone, allows for easy screen casting thus proving invaluable as an educational tool by creating an effortless bridge between analogue input and digital output, facilitating instant digitization of slides for viewing, display, communication and storage. This article demonstrates the use of the Foldscope for virtual microscopy in a classroom scenario, by employing the screen mirroring capabilities of a smartphone.

Keywords: Foldscope, Virtual Microscopy, Microscope, screen mirroring

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INTRODUCTION

Human fascination with the prospect of seeing what the naked eye cannot normally see has led to the evolution of microscopy to what it is today.[1,2] Leeuwenhoek's handheld single-lens microscope has evolved to the 21st century Foldscope, coinvented by Manu Prakash and Jim Cybulski. All the main components are originally just outlines, with edge perforations, printed onto a polymer-coated A4-sized sheet from which the components are snapped out, folded to shape and assembled. It is also supplied with the customized tiny glass ball lenses, along with an LED light source running on a watch battery and magnetic strip adapters that can be affixed both to the microscope and the rear cover of a smartphone, thus allowing a phone camera

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to capture what the microscope has to display allowing easier viewing.[3] Visualization or visual perception is a process of not only being able to see but also of being able to comprehend. There is often a degree of confusion over what is being referred to under the microscope even if a pointer is used to point towards the region of interest on a slide. A projected image of the microscopic view is thus of immense value in an educational setting.

MATERIALS AND METHODS

The materials used for this demonstration as shown in Figures 1 and 2 were as follows:

1. An Apple iPhone 6 and an android 4.4 Phablet Chuwi VX1
2. An android-based screen mirroring device – Miracast HDMI dongle
3. An iOS-based screen mirroring device – Apple TV module
4. A Foldscope with phone mounting strips and LED light source
5. A demo slide – ground section of a tooth to demonstrate the dentino-enamel junction.

The Foldscope with the slide was attached to align with the rear camera of an iPhone 6. The iPhone was set in screen mirroring mode. For the purpose of demonstration, the Apple TV module was linked to a 40" LED TV monitor [Figure 2]. The same could be done with a projector by way of the HDMI connectivity. The phone screen displaying the field of view of the attached Foldcope and slide was mirrored live using the screen mirroring option of the phone. Now any change in the field of view, made by shifting or panning the slide, was visible to the students live on the monitor screen by way of direct live screen mirroring from the phone. Images could also be saved to the camera gallery if required [Figures 3 and 4]. Phablets or tablets with larger screens could be used for a better instant on-screen visibility. Android devices (Kit Kat 4.4) would require a Miracast dongle for screen mirroring.

RESULTS

The integration of the Foldscope to the phone and performing screen mirroring was easy and without any major effort. The absence of wires allows the instructor to actually walk around with the Foldscope and phone in hand during a lecture. During a detailed discussion, the live mirroring allows for a live panning across the microscopic field of view of the entire slide allowing all aspects to be discussed with the actual field of view of relevance made visible.

Figure 1: An android phone/tablet (phablet) – Chuwi VX1 with the magnetic strip connector affixed to the rear camera, an iPhone 6, the Foldscope and a demo slide (ground section/DE Junction)

Figure 2: Apple TV and Miracast Screen Mirroring modules for use with iOS or Android devices, respectively

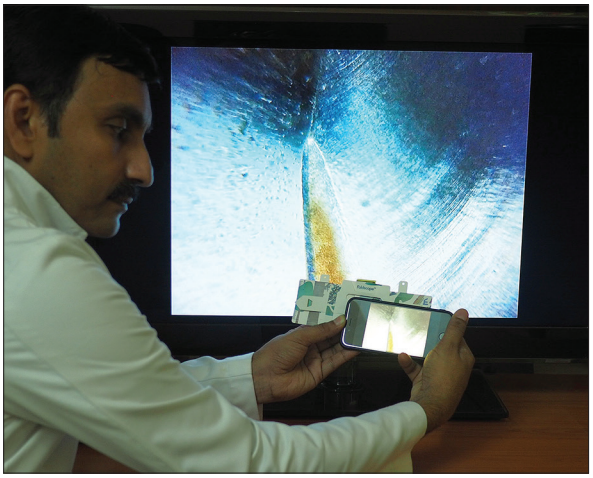

Figure 3: The author demonstrating virtual microscopy using the Foldscope and Screen mirroring

DISCUSSION

Virtual microscopy allows for the transfer and sharing of data viewed under microscopes and also allows the images to be used for teaching.[4,5] Virtual microscopy usually requires a digital microscope and a linked-up computer.

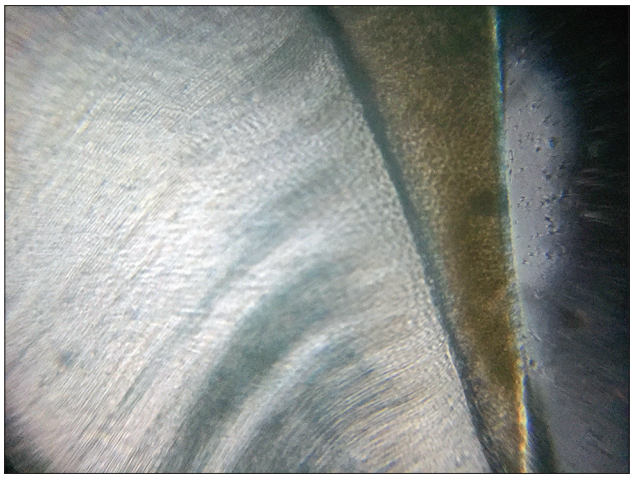

Figure 4: Pinch zooming of a saved image

Figure 5: Saved image subjected to cropping

Digital microscopes are expensive, bulky, fragile, and require both an electrical connection and a laptop to capture the output of the CCD camera mounted at the objective lens to thus allow visualization on the computer screen itself or projection onto a screen by using a linked up projector. The Foldscope is a flexible, unbreakable, and economical, easy to use microscope that is small enough to fit in a standard sized geometry box or one's own shirt or laboratory coat pocket. Once coupled with a smartphone, added functionality is enabled. Images viewed can be saved to the phone gallery. The images can be enhanced for better viewing either by simple pinch zooming or by using photo editing applications such as Adobe Photoshop Express for basic tweaking of the brightness, contrast and also enhancing the region of interest by way of cropping [Figures 4 and 5]. Of much more interest is the capability of using the phone's screen mirroring option to transfer the image onto a screen for viewing during a discussion or a lecture.

CONCLUSION

The Foldscope, by way of integration with a cell phone and screen mirroring, is an invaluable addition to the classroom allowing for an economical, effortless and yet highly effective way of demonstrating things normally hidden to the naked eye. Of added importance is the ability to not only view or display the slides electronically but also the ability to transfer the electronic file from a smartphone or to store it.

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Conflicts of interest

There are no conflicts of interest.

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