

Utilization of Open Source Technology to Create Cost-Effective Microscope Camera Systems for Teaching

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Abstract

Background: Open source technologies and mobile innovations have radically changed the way people interact with technology. These innovations and advancements have been used across various disciplines and already have a significant impact. Microscopy, with focus on visually appealing contrasting colors for better appreciation of morphology, forms the core of the disciplines such as Pathology, microbiology, and anatomy. Here, learning happens with the aid of multi-head microscopes and digital camera systems for teaching larger groups and in organizing interactive sessions for students or faculty of other departments. **Methods:** The cost of the original equipment manufacturer (OEM) camera systems in bringing this useful technology at all the locations is a limiting factor. To avoid this, we have used the low-cost technologies like Raspberry Pi, Mobile high definition link and 3D printing for adapters to create portable camera systems. **Results:** Adopting these open source technologies enabled us to convert any binocular or trinocular microscope be connected to a projector or HD television at a fraction of the cost of the OEM camera systems with comparable quality. **Conclusion:** These systems, in addition to being cost-effective, have also provided the added advantage of portability, thus providing the much-needed flexibility at various teaching locations.

Keywords: Mobile high-definition link, pathology teaching, Raspberry Pi

INTRODUCTION

Open source concept is reducing the cost of access to useful technologies for wider uptake. This crossover of open source technology into the medical field is happening worldwide which is gathering pace because of the cost-effectiveness. One such example is “Raspberry Pi” (RPI) which has enabled in bringing the computational power to the masses at an economical price point.^[1] This has sparked the innovative spree in utilizing this technology in various fields such as Do-It-Yourself enthusiasts and network management systems.

Pathology, being a subject with majority of the learning hinging on the visually appealing morphological changes, is not immune to these advances in technology. The multi-head teaching microscopes are aided by the original equipment manufacturer (OEM) camera systems connected to a high-definition (HD) television (TV) or an HD projection system in interacting with larger groups of students and in case discussions with the clinicians. However, the advanced camera technologies are expensive, and they are not interchangeable with different microscopes or portable.

So, to bring in the advantages of the OEM camera systems with HD images and video at much lower cost we have adopted the technologies such as RPI camera system and mobile HD link (MHL) systems in teaching-learning of pathology.

TECHNICAL BACKGROUND

Raspberry Pi system

RPI is the credit card-sized, single-board computer with built-in Wi-Fi, Bluetooth, four full-sized USB ports, reasonably powerful processor and RAM (1.2GHz, 1GB), and micro-SD memory card which acts as the hard drive running Raspbian Operating System (OS) as well as acts to store the files. It is powered by

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a battery bank or a micro-USB mobile charger. Pairing it with the RPI camera, a Sony HD camera (IMX219 8MP sensor) with 30 frames per second which enables smooth movement on the screen while moving the field, delivers a high definition image to the HD LED TV or HD projection system.^[1,2]

After installing the Raspbian OS, multiple methods were tried for streaming the video, from terminal-based one-line commands to graphical user interface (GUI) enabled click and start programs which were available for free from the various forums of the online Raspberry Pi community. Among these options, the GUI system named RPI camera controller (RPICC) was easier to use with various options to control the video capture time, white balance, parameters such as resolution, and quality that can be customized.

Mobile high-definition link system

The MHL technology enables in streaming and duplicating the mobile screen when connected to an HD TV. A list of mobiles with inbuilt MHL capability is provided at <http://www.mhltech.org/devices.aspx> Any mobile with the MHL technology can be used to stream the images when paired with an adaptor and MHL cable available in the open market.^[3]

Adapters for Raspberry Pi system

Using open source designs from the three-dimensional (3D) design websites such as Thingiverse was downloaded and modified for the Olympus trinocular, Nikon trinocular microscopes as needed using the 3D builder software available in Windows 10.^[4] The design was printed using commercial 3D print services provider.

Adapters for Mobile High-Definition Link

The adapter for the MHL system was made using a mobile cardboard box, and readymade adapter from an online marketplace was purchased along with the MHL cable which had a micro-USB, HDMI male port, and a USB port for charging.

PROCEDURE

Raspberry Pi system

The Raspberry Pi camera is attached to the board through the dedicated input slot. The custom printed 3D adaptor along with the camera was affixed to the trinocular head using a transparent tape and double-sided adhesive tape as shown in Figure 1. A 16GB MicroSD memory card was used to install the Raspbian OS, available from the website of the manufacturer.^[1] Once the system displays the desktop, in the configuration panel of the RPI, camera should be enabled. For uninterrupted power supply, a 10000 mAH battery power bank was used. Using HDMI cable, the system was connected to the HD LED TV.

Mobile High-Definition Link system

In case of the MHL system, the mobile was mounted on the mounting adapter and attached to the microscope eyepiece and using the MHL cable the mobile was connected to the HD TV as shown in Figure 2. To have a landscape orientation so that the entire TV screen is filled with the image, the mobile was rotated horizontally to mirror the landscape mode. This could not be possible on the trinocular mount as the image is only seen partially with the black bars on the sides in portrait mode, so the eyepiece objective was used.

Table 1 compares the RPI, MHL, and OEM systems in terms of price estimates, usability, feasibility of installation, maintenance, and possible applications and scenarios of use. These systems were chosen to mitigate the cost but at the same time to provide high-definition high-quality images with portability and easy-to-use options. Both the systems are being used in the department in multiple locations, to better understand the pro and cons of each system. The better system will be implemented across the institution in other departments too.

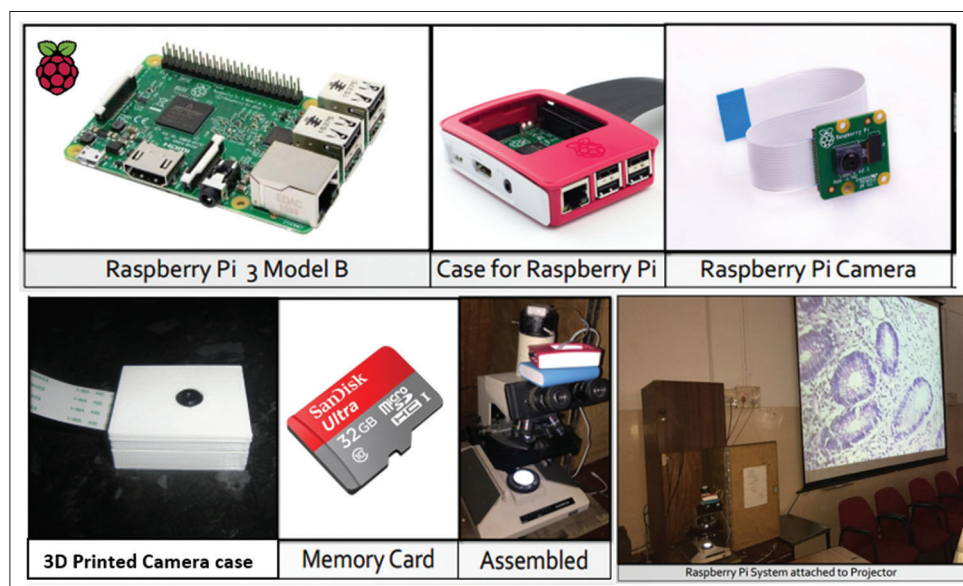


Figure 1: Raspberry Pi camera system

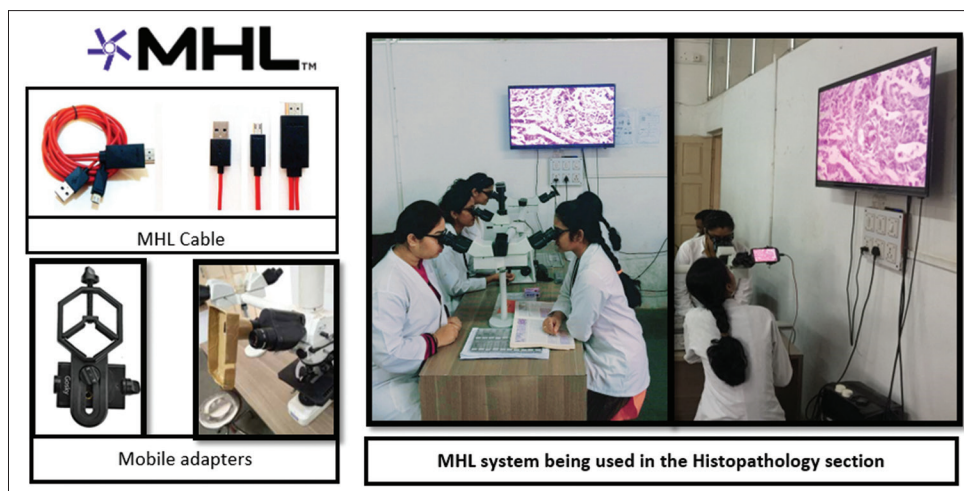


Figure 2: Mobile high-definition link camera system with purchased and DIY cardboard adapters

Table 1: Comparing the Raspberry Pi, mobile high-definition link, and original equipment manufacturer systems

| Serial number | RPI camera system | MHL camera system | OEM camera system |
|-----------------------------|---|---|--|
| Price | INR 6000-8000 USD 90-130 | INR 20,000-45,000 USD 300-700 | INR 50,000-150,000 USD 760-2300 |
| Usability | Universal compatibility | Universal compatibility | Not compatible with different microscope companies |
| Feasibility of installation | Any binocular or trinocular head microscope can be used | Binocular head microscope offers full screen, if setup uses a trinocular head microscope, black bars on the sides are seen | Requires a trinocular head microscope and OEM provided adapter for best results |
| Maintenance | Following the step by step image guides available in the “How to” and “FAQ” sections of the RPI website and many RPI online forums help in installation | This is a simple plugin cable system. However, the initial focusing of the camera to align the eyepiece for perfect picture has a learning curve | Dedicated support personnel from the OEM service provider will set up the system |
| Possible applications | Multiple software applications are available from the open source resources. No requirement of battery, a power bank can be used which makes the system portable | Battery is required, and many mobile camera applications are available free of cost | Software updates and battery is OEM provided. No flexibility for modification for custom needs and requirements |
| | Photomicrograph capture for routine reporting and publication purposes at much lower cost than the OEM | Photomicrograph capture for routine reporting and publication purposes at much lower cost than the OEM | Photomicrograph capture for routine reporting and publication purposes |
| | Teaching activities, slide demonstration sessions for undergraduate and postgraduates. As this is a portable system, it will enable the flexibility in having these sessions in any of the demonstration rooms, practical gallery halls | Teaching activities, slide demonstration sessions for undergraduate and postgraduates. As this is a portable system will enable the flexibility in having these sessions in any of the demonstration rooms, practical gallery halls | Teaching activities, slide demonstration sessions for undergraduate and postgraduates. The system is confined to one location unlike the RPI and MHL |
| | Ability to share the captured images through Wi-Fi and Bluetooth instantaneously | Ability to share the captured images through Wi-Fi and Bluetooth instantaneously | The images taken has to be transferred from the memory card to a computer for the purpose of sharing |
| | To enable conversion of any microscope as a teaching microscope in multiple locations using a single system | To enable conversion of any microscope as a teaching microscope in multiple locations using a single system | The camera system is not compatible with a different model of the same company or with a different manufacturer as the designs are proprietary |

MHL: Mobile high-definition link, OEM: Original equipment manufacturer, RPI: Raspberry Pi

CONCLUSION

Embracing open source technologies and 3D printing enabled us to utilize these portable camera systems to convert any microscope into a teaching microscope at a fraction of the cost of the OEM systems.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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