How to Create an Affordable Fluoroscopy Simulator for Interventional Training

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Learning Objective

Participants will learn how to construct a table top fluoroscopy simulator from affordable, readily available components for interventional training.

Background

The hand-eye-foot coordination required to perform fluoroscopic interventional procedures is difficult to develop. Additionally, considerations to patient safety, radiation safety, and department efficiency limit the hands-on experience trainees receive. In response, simulation use in medical education has increased, allowing for experiential training in a safe, low-risk, and self-paced environment. Unfortunately, simulation devices are expensive and, if available, accessibility is often restricted to protect them from damage. We present a method for creating an affordable fluoroscopic simulator, assembled from readily accessible components, that can be used for teaching trainees basic fluoroscopy technique that is the foundation of interventional procedures.

Software

Raspbian OS 8 was installed on a Raspberry Pi micro SD card, which comes with python pre-installed, as well as drivers needed to access the Logitech webcam.

Open Source Computer Vision Library (OpenCV) 3.1.0 and the RPi.GPIO python module were installed to allow monitoring of the digital inputs for foot pedal control.

The foot pedal was wired into the GPIO4 (Pin #07) and DC Power 3.3V (Pin #01) on the Raspberry Pi. Although a piano sustain pedal was used, it is possible to substitute any momentary foot switch.

Python script allows for keyboard and foot pedal control of full screen video output. On start of the script, a background image is taken of the phantom. Keyboard presses enable image subtraction to highlight changes in the image, such as when a guide wire is introduced. Another key press enables radiograph overlay to simulate the image one might see during an actual procedure. Live image is updated while the foot pedal is pressed to simulate live fluoroscopy.

The python code is available for download from:
https://github.com/andrewgomella

Raspberry Pi 3 Model B Motherboard	$35.91
16gb microSD card	$7.99
Yamaha FC5 Compact Sustain Pedal	$14.36
USB light	$9
Logitech C270 USB Webcam	$20.95
Polyethylene tubing	$7
Loctite plastics binding system	$3.77
Total Cost	**$98.98**

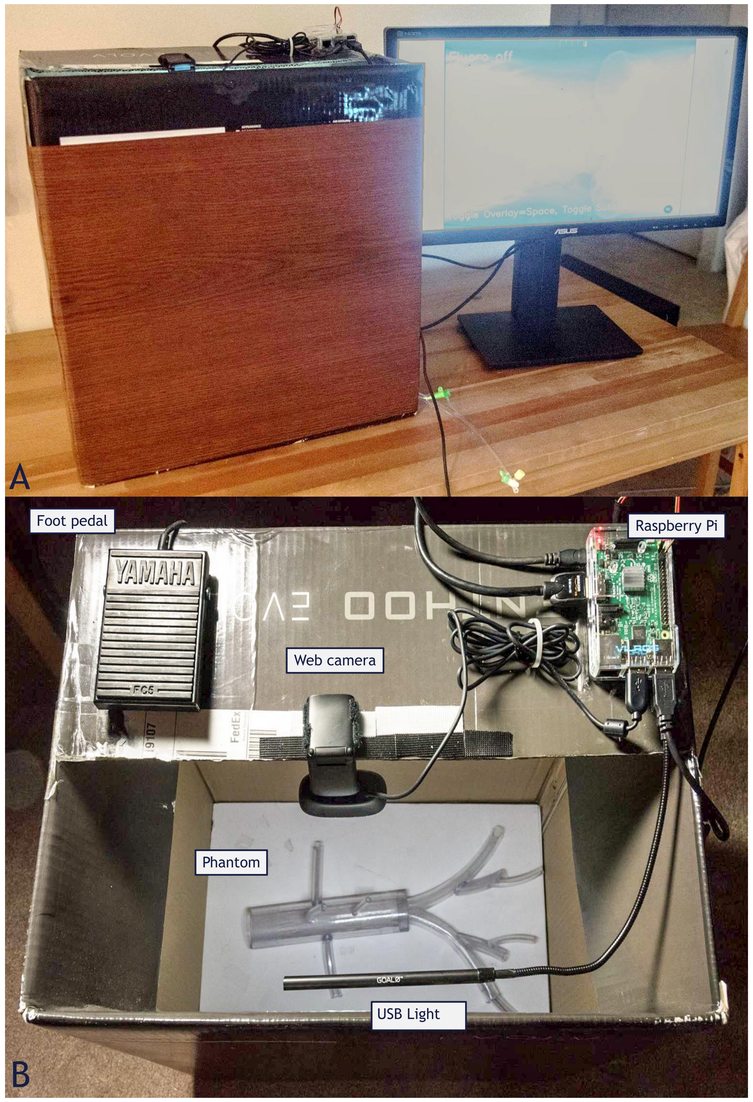

Fig1 *Simulation device (A) view from the front and (B) top-down view.*

Simulator

A web camera and LED light source are secured to a cutout area at the top of a cardboard box and connected to a Raspberry Pi micro-PC. Also connected to the micro-PC is an on-off foot pedal programmed to turn the web camera on and off. Python programming language and OpenCV are used to process and display the web camera image on a PC monitor. We created an abdominal aorta phantom from clear polyethylene tubing, which was placed in a box to obscure the model from the operator's view. A vascular sheath placed into the phantom through a corner of the box creates an access site through which interventional tools can be introduced and manipulated.

This device effectively simulates real-time fluoroscopy, allowing users to practice initiating fluoroscopy with the foot pedal and manipulate tools with only visual feedback from the computer monitor.

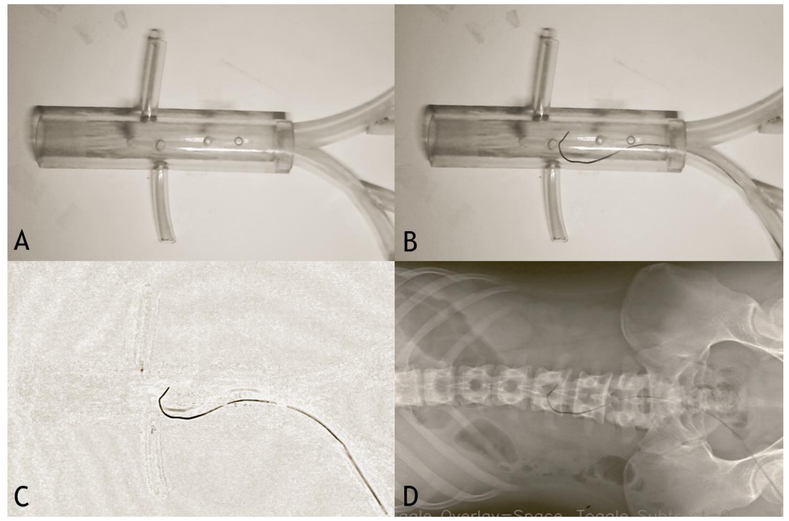

Fig2 *Screen captures from real-time operation of the simulation unit, with different image processing options enabled. (A) Phantom only, (B) guidewire in place, (C) image subtraction, (D) overlay of an anatomically applicable radiograph.*

Conclusion

We have shown that combining a micro-PC, web camera, foot pedal, and phantom can effectively simulate real-time fluoroscopy and provide trainees an opportunity to practice the hand-eye-foot coordination needed for many interventional procedures. Notably, the entire device described (excluding the monitor) totals less than US $100, removing what is often prohibitive cost as a barrier to providing simulation training.