

A simple controller for neutron computed tomography that interfaces nearly every camera

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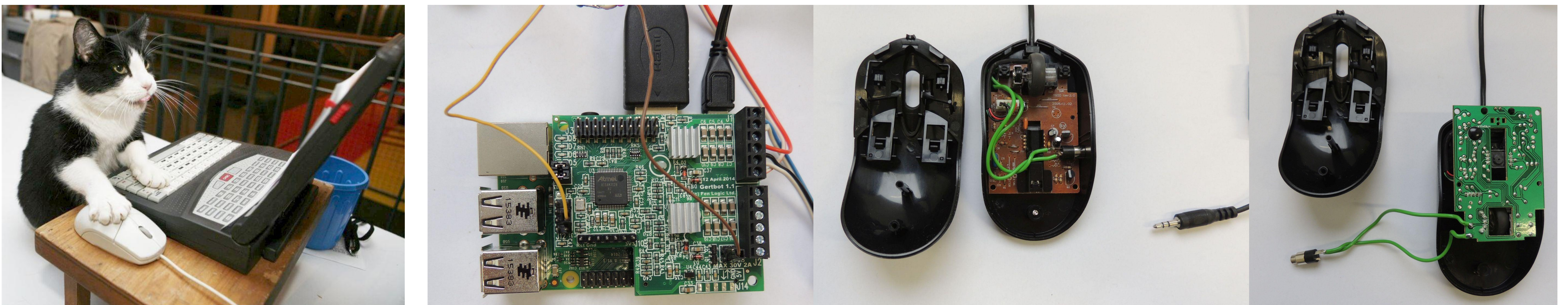
Introduction

Neutron computed tomography is now being introduced even at smaller and older reactors. Operators are often faced with a Hen-and-Egg problem: First, they have to show that they can do tomography before they can obtain a budget to build a tomography system. In other cases, a setup has to be installed in an environment with such high radiation levels that the expected lifetime of the camera is rather limited. In both cases, the use of cheaper components is preferred.

For these cases, a cheap tomography controller was developed that can drive two stepper motors (a rotation table and an optional translation table) and control an external camera with a trigger signal that either interfaces a hardware trigger input on the camera if available, or simulates the mouse in the camera control program to start each image capture by mouse click. A stepper motor was fitted with a toothed belt and a pair of toothed-belt wheels to create a simple gear reduction, since the typical 200 steps per rotation of a single stepper motor are insufficient for computed tomography. The system is operated by a simply Python script.

It must be stressed that the system described here is NOT a professional system for computed tomography, it is a hack to get a test setup working quickly. There is no replacement for a precision rotation table, and professional camera control software.

Key components



Low-cost cooled CCD cameras usually do not have hardware trigger input that allows for synchronizing an image sequence for tomography with the movement of the rotation table. Some offer a programming kit to write your own control software, but this is a tedious path. It is much more convenient to use the original camera control program to trigger individual image frames by mouse click, and rotate the table after each image. You can do this yourself, OR you can ask your cat to record a tomography sequence, OR you can ask a Raspberry Pi computer to rotate your table and click your mouse. The key for the last solution is so elementary that nobody ever did it before: Simply solder two wires to the left mouse button on the computer controlling the camera, and let the Raspberry Pi click your mouse once the pointer is positioned over the 'Image'-button on the camera PC. This image sequence shows the cat, the Raspberry Pi with a piggyback motor controller board called the 'gertbot', and the mouse with the additional cable on the mouse button.

Setting up the tomography system – and a crude camera box



The picture on the left shows all components of the Raspberry Pi tomography controller. The gertbot board controls the stepper motor and the mouse button on the mouse for the camera computer. The stepper motor was then used to build a crude rotation table with a 1:5 reduction done with a toothed belt and cogwheels so one rotation takes 1000 steps instead of only 200 on the motor. Finally, an old desktop radiation monitor was converted into a camera box, using two pocket mirrors, black tape, a cooled CCD camera and a 5 cm piece of ZnS+LiF(Cu) neutron scintillation screen taped to piece of paper. This setup is very crude and inaccurate, just to show that everybody can do much better than that with simple means. No beam time was available to do a full tomography, but a first neutron radiography of a clock is shown in the last picture, with the mirror gap in the center.

Conclusion

This setup and controller hack is no replacement for a professional camera, a precise rotation table and proprietary motion control and tomography software, but it will produce first results that demonstrate basic capabilities and can be used to apply for funding for further development. The mouse hack can be used on any control program that does not provide a programming interface to other control software. Cheap (<\$500), but high-quality cameras have recently become available from the website below, mostly intended for astronomy. Detailed instructions including the control software will be made available for download on the web site of the International Society for Neutron Radiology. The only crucial item is the neutron scintillation screen. In a different publication, a software path from image recording through tomographic reconstruction to 3D imaging and analysis is shown with free software. Building your own first inexpensive tomography system will help to understand the method in detail, so a professional system can be planned and built once appropriate funding becomes available, and the new understanding will help to control and master the new system to the maximum possible extent. Help is available by the authors.

www.raspberrypi.org

www.farnell.com

www.gertbot.com

<https://astronomy-imaging-camera.com/>

www.isnr.de/index.php/tools