Development of an Integrated Automatic Neutron Tomography Control System

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Abstract

Neutron tomography is useful 3D imaging process combining together 2D images with known angle separation. Manually rotating samples and gathering images is far too inaccurate and time-consuming to be operated manually. We therefore designed and constructed an Arduino control system that interacts with an Andor scientific camera and Shinano Kenshi SST42D stepper motor/stage assembly to produce consistent 2D images with known angle separations for a full rotation of the sample with human operation only needed to start and reset it. With this system, performing neutron tomography is now feasible, worthwhile, and reproducible on the Maryland University Training Reactor. Initial imaging of a LEGO figurine was accurate, but had low resolution and precision. We hypothesize that future use of the motor encoder attached to the motor, fixing the motor assembly to the platform, and camera and imaging technique changes may improve this.

Methods

- The stepper motor and stage assembly's pinout was not given and therefore experimentally determined
- A TB6600 stepper motor driver was connected to the assembly and powered by a 24V power supply
- To operate the system, all TB6600 DIP switches must be turned off and DB9 pins 6-9 on the stepper motor are connected to B-, B+, A-, and A+ on the motor driver
- An Arduino Uno R3 was connected to the motor driver and powered with a 9VDC supply
- The Arduino signaled the TB6600 when to pulse the motor (we used constant 50% duty cycle), what direction to turn, and when to enable or disable it
- SMB connectors interfaced the Arduino with the camera
- A 5V TTL high signal sent to the ext. trigger port of the camera makes the camera start taking a photo
- A 5V TTL high signal coming from the shutter port of the camera means the shutter is open (taking a photo), and low means it is closed (not taking a photo)
- A 1-way knob switch using the Arduino's built-in pullup resistor starts or stops and resets image acquisition
- An Arduino program was written and loaded which waits for the switch to be turned on, sends a trigger signal to the camera, waits while the shutter is open, turns the motor to turn the desired amount once closed, and repeats for the user-specified number of images
- Tomography was conducted on an R2D2 LEGO figurine taking 60 photos 6 degrees apart for 5 minutes each

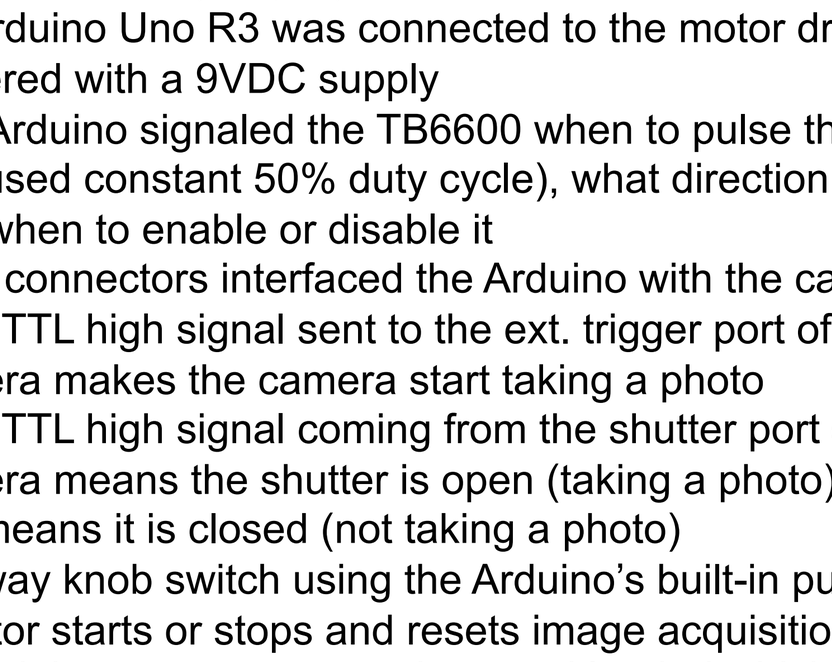

Figure 1: An electrical schematic of the control system constructed, made with Eagle

Results

After subtracting the background image from the R2D2 images acquired and reconstructing in external software, the resulting tomography matched in shape and orientation, exposing air pockets inside. Thin features like the shoulder joints and feet connections were less well defined and had lower attenuation than large or thick areas like the main body.

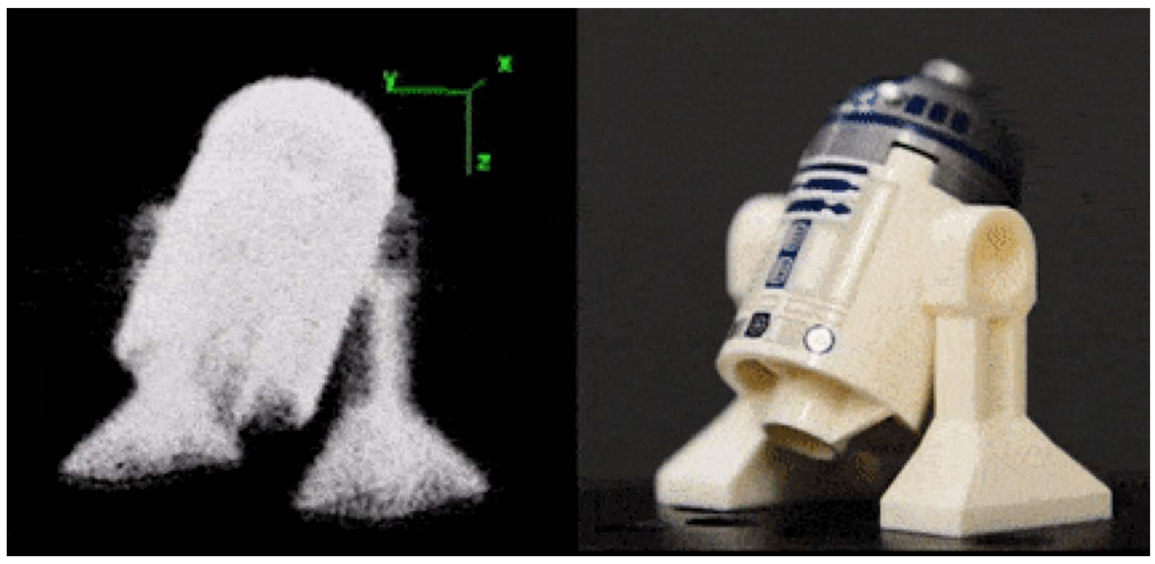

Figure 2: (left) Completed tomography of the R2D2 LEGO figurine. (right) Light image taken of the figurine at roughly the same angle as the tomography.

Discussion

With the right settings set on the Andor camera SDK, the control system developed successfully interacts with the motor assembly and camera to acquire any number of desired tomography images, marking a new experimental capability for the Maryland University Training Reactor.

While the system is functional, many areas can be improved for stability and detail. To reduce possible short circuiting, wiring and soldering may be replaced with multiconnectors and other hardware. Since the motor/stage assembly is not balanced by itself and is instead currently balanced with loose material, attaching the assembly to the platform below it may be a more stable and permanent solution in case of vibration. Imaging for longer may also produce better defined tomography images for thin features and a larger pixel sensor may improve overall image detail.

Appendices

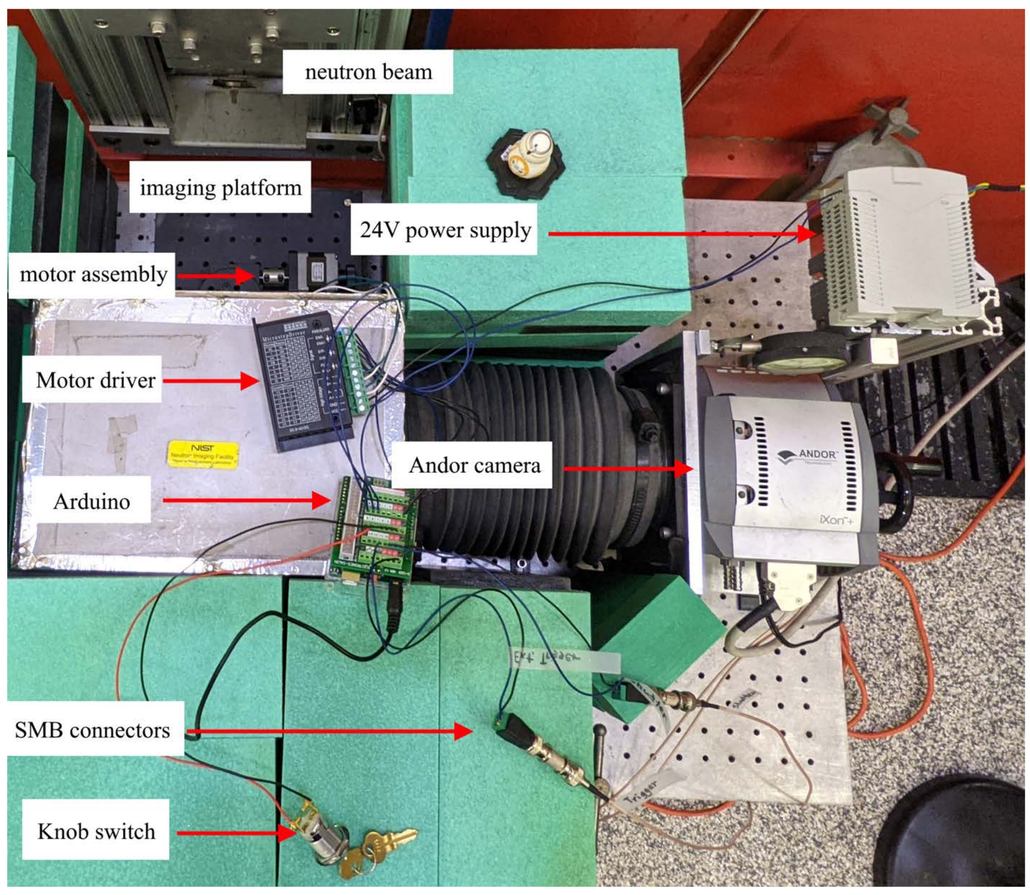

Figure 3: Schematic image of the control system in place on the reactor