

CT foot loader

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Problem Statement

While nearly all feet radiographs are shot with the patient bearing weight, computed tomography (CT) scans of the feet and ankles are currently done in non-weight bearing conditions. A device is needed that applies a load to the feet while the patient is lying on the CT table, thus better simulating the anatomic alignment of the bones and tissues under physiologic loading.

Background and Motivation

CT provides detailed, three-dimensional reconstructions of x-ray projections [1]. For the ankles and feet, CT is used to find anatomic subtleties that are not visible in normal radiographs. It is often used for patients suffering from chronic, unexplainable foot pain. Our client's areas of interest include the Lisfranc joint and the posterior tibial tendon.



The GE Lightspeed CT scanner that the device will be used with.

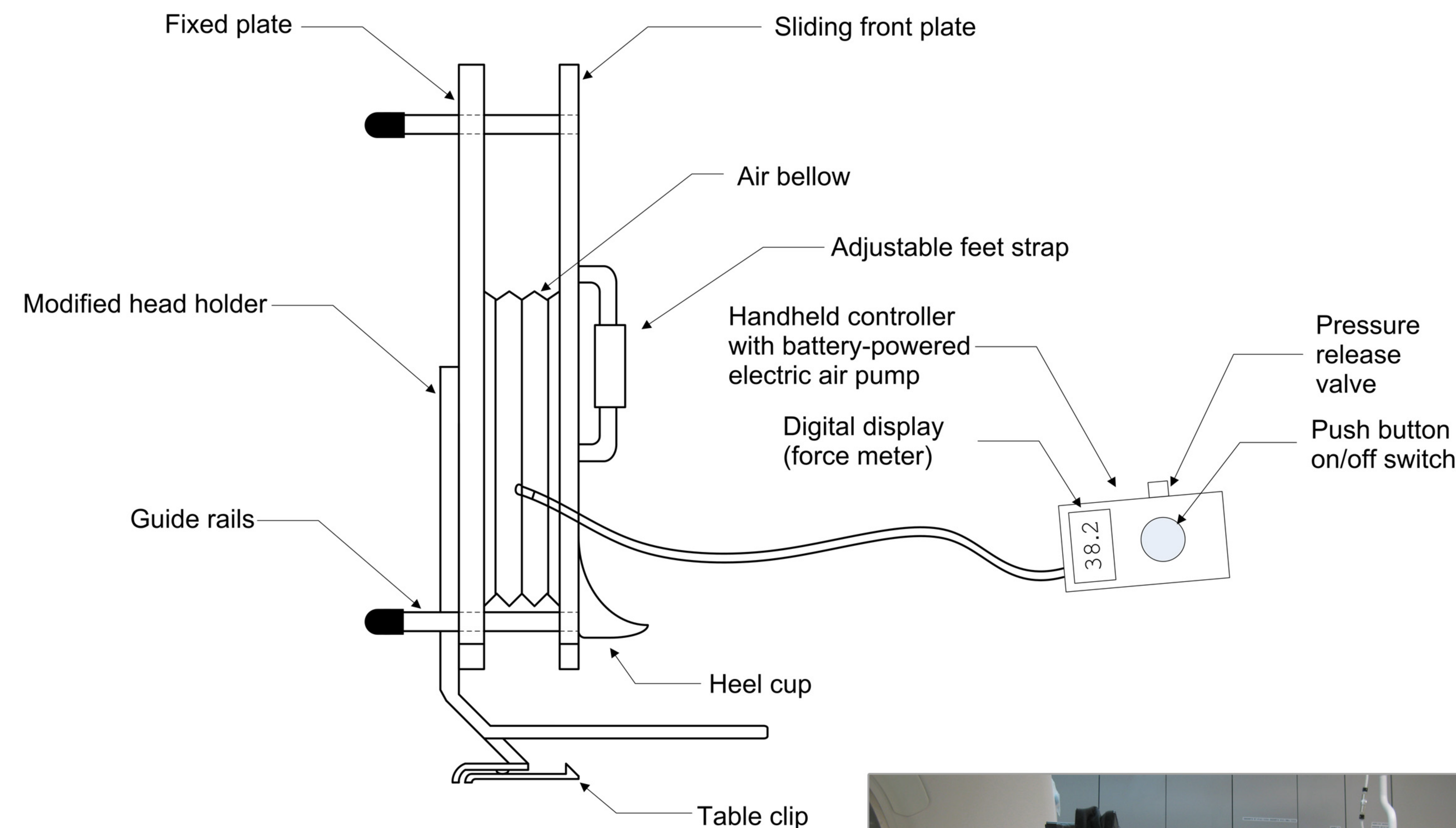
It is hypothesized that such anatomic subtleties may only be visible in load-bearing conditions. There is currently no standard protocol for CT imaging of the feet and ankles, making it difficult to compare images. This device would not only simulate load-bearing conditions but would also help establish a standard feet and ankle position, with the feet together and upright.

Requirements

The device must:

- have no radiopaque materials within the scanning field, from the ankle to bottom of foot.
- apply a force of up to 50 lbs. to the feet.
- measure the load with an accuracy of ± 3 lb.
- securely hold the feet in an upright position.
- be easily movable by one technician.
- be able to be cleaned with common disinfectants.

Final Design



Operation

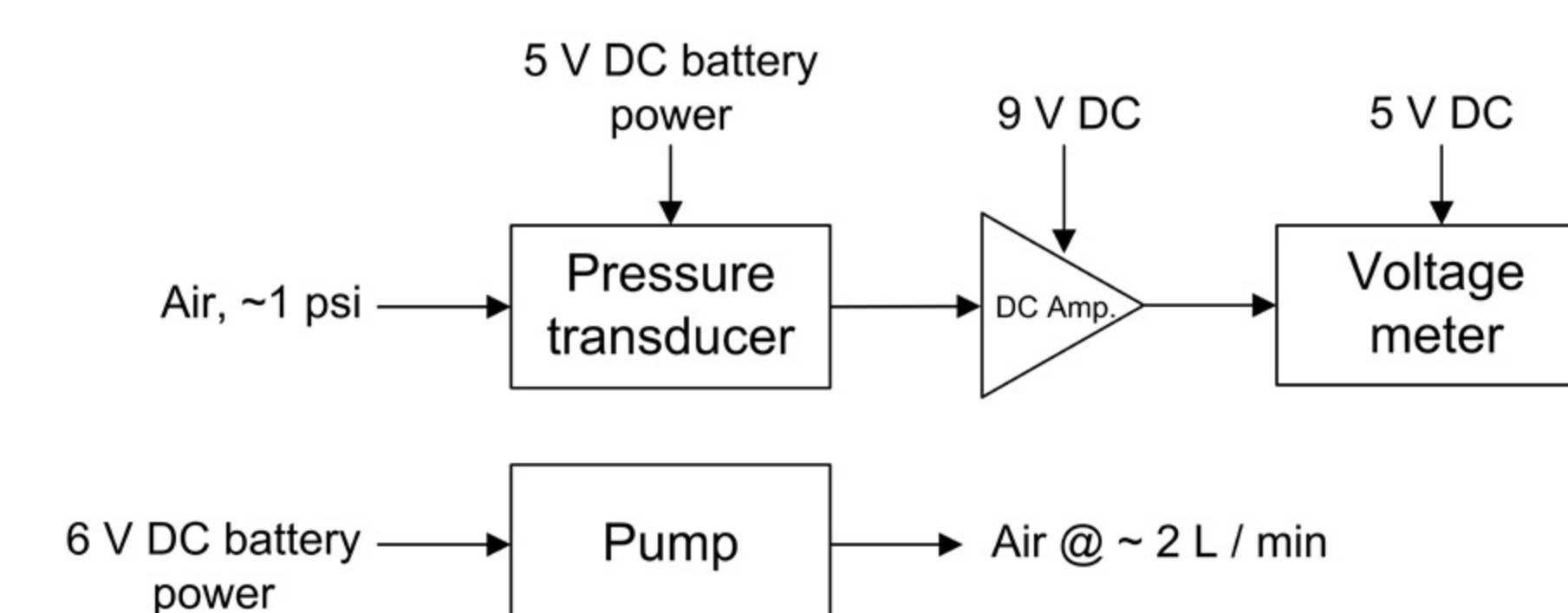
- Technician straps the patient's feet into device and legs to the table.
- Controller is turned on via electromechanical switch.
- Patient activates pump via separate switch.
- Air bladder inflates, pushing plate against feet with increasing force.
- Patient turns off pump at desired force, shown on LED display.
- Force remains stable and is recorded by technician.
- CT scan commences.

Measuring the Load

- Air pressure in bladder relates linearly to load:
 $\text{Pressure} = \text{Force} / \text{Area}$
- The air bladder's surface area is $\sim 64 \text{ in}^2$ so pressures of $< 1 \text{ psi}$ are enough to generate sufficient force.
- A pressure transducer converts the pressure to an electrical signal. The voltage of resulting signal is linearly and directly related to the pressure.
- The transducer's output is fed to a panel meter that measures and displays the voltage. The system was calibrated with known weights and displays the load in pounds.



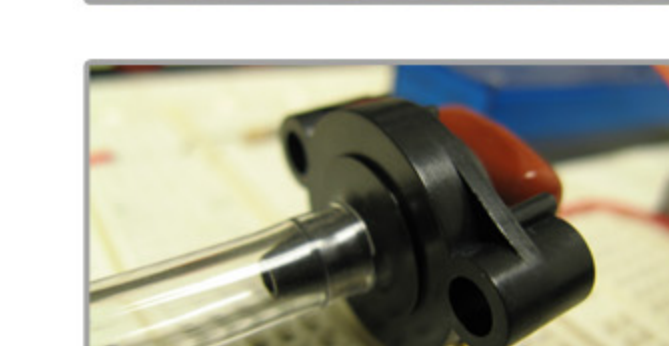
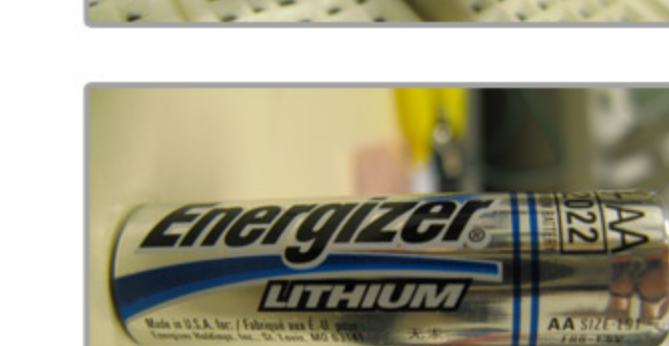
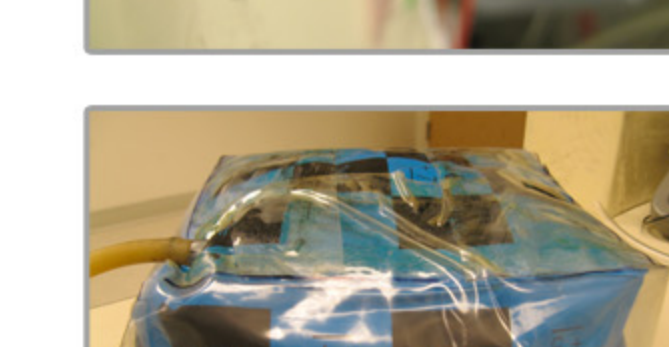


The device attached to a CT table with a phantom foot strapped in. When run through a scan, the device generated no noticeable image artifacts.



Electrical control circuit block diagram.

Components and costs

	Volt meter, panel mount Datel	\$55
	Diaphragm pump, 6 V DC Hargraves Fluidics	\$48
	Pressure sensor Freescale Semiconductor	\$18
	Lithium batteries, 6 AA Energizer	\$15
	Air bladder	\$4
	Miscellaneous: materials, hardware, tubing, fittings, electrical components, adhesive, straps, heel cups, etc.	\$70

*the head holder was donated by GE Healthcare and the sheets of thermoset laminate were donated by Norplex-Micarta

Total: \$210

Future Work

- Conduct research study to determine the effects of loading the feet during a CT scan.
- Pursue patent through the Wisconsin Alumni Research Foundation.
- Mount electrical circuit into handheld controller.
- Implement digital circuitry with microprocessor to improve force measurement accuracy.

References and Acknowledgements

1. Smith, H. Computed tomography. GE Healthcare Medycyclopaedia **2006**, 3 (2006) http://www.medycyclopaedia.com/library/radiology/chapter04/4_2.aspx.

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