Strain Gauge Demonstration Apparatus

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Abstract

The goal of this project is to build a multifunctional desktop laboratory system to measure the strain under different types of loading with a data acquisition system. The load types include axial load, bending, torsion, and internal pressure. The principle of the system is to use strain gauges as sensors, through the Wheatstone bridge circuit and an analog-digital conversion process, the results would be displayed to the desktop by Arduino-based programs. The development of the system aims at filling in the gaps of laboratory devices in strain measurement, as well as emphasizing educational purposes.

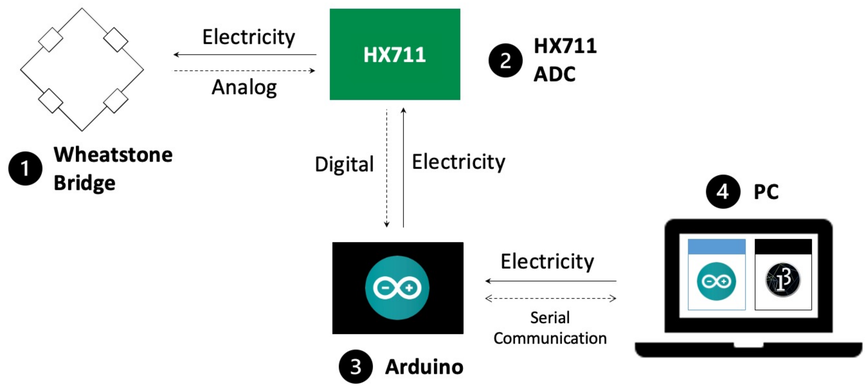
Result

The final product of an individual device is composed of a load cell (modeled in Method section) and the corresponding circuit box containing the electronics. Also, two programs (one on Arduino and one on Processing) need to be installed on the PC to run the device.

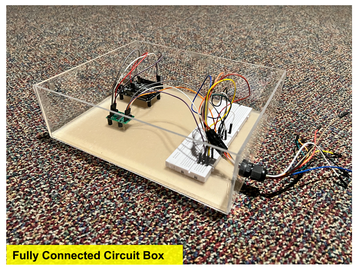
The housing of the circuit box is composed of acrylic board. The breadboard, HX711 and Arduino are glued to the base and connected with Dupont cables.

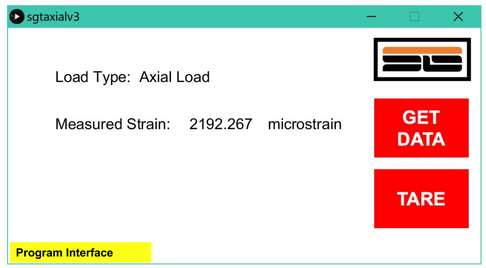
The program can acquire data from Arduino and process them on Processing. Its current version is also capable of “Taring” as a measure of erasing the strain offsets.

System Functionality



The source of energy of the system is electricity, which is provided by the PC through a USB port. It will be powering the Arduino board, HX711 module, as well as generating a voltage on the Wheatstone bridge circuit to activate the strain gauges. Meanwhile, the signal transfer of the system includes analog-digital conversion on HX711, and serial communication between the Arduino board and the programs installed on the PC.


Fully Connected Circuit Box



Program Interface

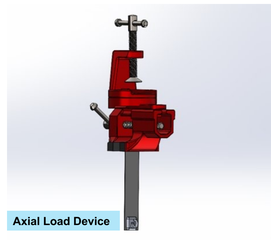
Future Work

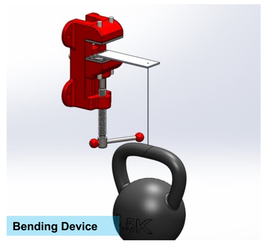
- Create a “Writing to File” function for the program to achieve data acquisition
- Try a new method to replace the Wheatstone bridge to reduce the size of the circuit part.
- Design unique clamps for each load cell to make the measurement more stable

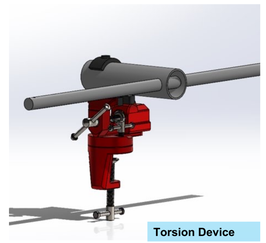
Method

Based on the loading mechanisms of each load type discussed, the team made unique design for each individual device. The axial load device has the load cell vertically aligned, thus allowing the force in line with the axial direction of the metal. In contrast, the bending device has a horizontal alignment with the load acting downwards, which creates a bending moment on the clamped location. The torsion device applies a handle through the metal pipe, which pressing the handle would impose a torque radially on the pipe.

The team also made different bridge allocations for each device, which would result in different amounts of amplifiers. For the axial load device, an “idle” strain gauge was designed to compensate for temperature and strain offsets.


Axial Load Device


Bending Device


Torsion Device

Circuit	Half Bridge (with compensation)
Gauge Alignment	One attached to the metal and another to the table
Strain Amplifier	1 time (offset countered)

Circuit	Half Bridge
Gauge Alignment	On top and bottom of the metal
Strain Amplifier	2 times

Circuit	Full Bridge
Gauge Alignment	All gauges aligned at 45° angles
Strain Amplifier	4 times

Different from the other devices, the internal pressure device was not a design requirement to the team. Therefore, an existing apparatus developed by Armfield Engineering® was borrowed for conducting strain-related design experiments.


Internal Pressure Device

Acknowledgements

The design project is supported by the College of Engineering, Informatics, and Applied Sciences and the client Prof. David Willy.
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