Computer Interfacing of a Granular Material Experiment

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Introduction

Objective

The physics of granular material helps understand various different phenomenons which are still being studied today by physicists. Phenomenon that can be observe are avalanches of a sandpile where the sand acts as the granular material. An experiment previously conducted by Ryan Cress in 2008 at Moravian College attempted to observe the inertial and frictional effects due to mass differences.

Cress's research was improved within two main areas of the experimental set-up including the counting and pellet dropping mechanisms. The use of a balance and a data interface enabled a more efficient way to observe the magnitude of the avalanches associated with the counting mechanism.The pellet dropping mechanism was altered in order to allow the pile of pellets to stabilize before an additional pellet was dropped. With these changes, different inertial and frictional effects as well as avalanche frequencies are to be observed.

Background

- Granular material: a collection of distinct macroscopic particles that are always in contact.
- The most simple example is a sandpile.
- In a sandpile each grain touches a few other and these "short range" interactions are observed to determine they affect the whole pile.
- An avalanche is one of the effects of these interactions.
- Avalanches occur when the slope of the sandpile surpasses the critical angle of repose.

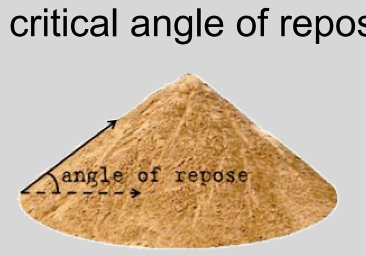

Figure 1: The angle of repose associated with this sandpile.

- Importance of granular materials:
  - Exhibit different properties depending on conditions.
    - Can take shape of a container like a liquid
    - Single grain is an solid
  - Relevant in industrial processes, agriculture, and construction.
    - The collapse of the silo occurred due to the different properties of granular material.
    - Leads to understanding forces and strains with granular materials in order to build efficient and proper structures.

Figure 2: A collapsed silo containing granular material.

Constituent Particles

The pellets illustrated in Figure 4 act as granular material.

Used the pellets because of:
- simplicity
- easiness to handle
- uniformity
- variety

Different masses and texture of the pellets will be used in order to observe how these changes affect the collision and friction of the pellets.

Figure 3: Pellet pile that acts our sand pile on the base plate.

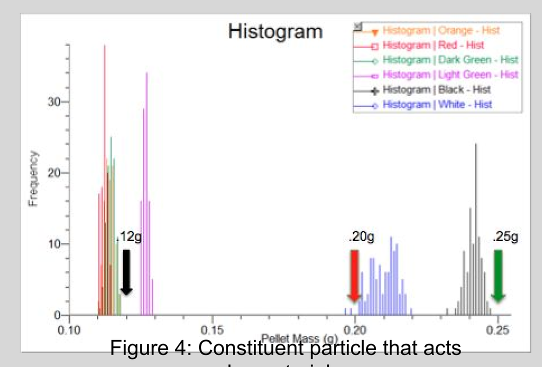

Figure 4: Constituent particle that acts as our granular material.

Uniformity of the Pellet Mass

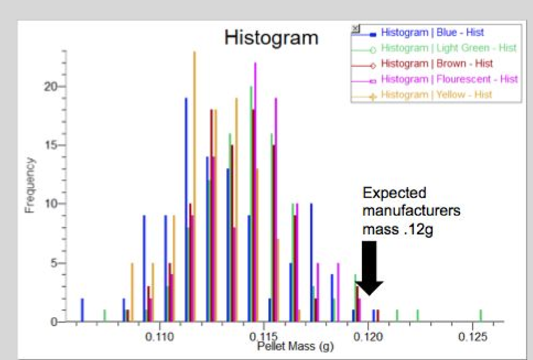

Figure 5: Results of Histogram ranging from .105g to .126g.

Figure 6: Results of Histogram ranging from .111g to .25g.

Histogram was made of the pellets in order to understand their uniformity. To create these histograms, 100 pellets of each designated color were weighed on the Mettler Toledo balance, which will be used throughout the experiment.

Uniformity was tested in order to:
- Reduce error by selecting the most uniform pellets regarding their mass
- Observe manufacturer's expected mass vs. our weighed mass

Experimental Apparatus

Improvements had to be made from the previous apparatus in order to establish better data collection and less error.The pictures below show our new setup which include:

- Dropper and motor (A)
- Funnel (B)
- Mettler Toledo balance with the base plate (C)
- Arduino Interface and computer (D)

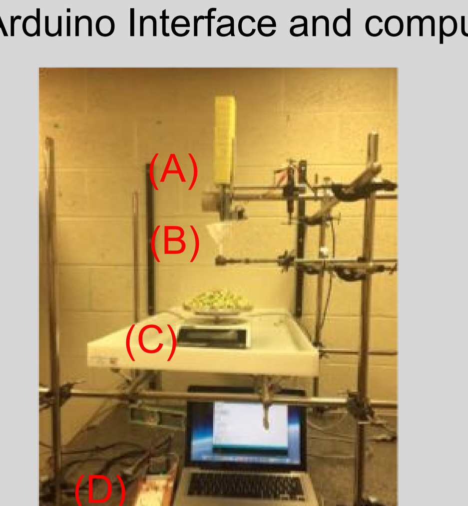

Figure 7: New Experimental Apparatus setup.

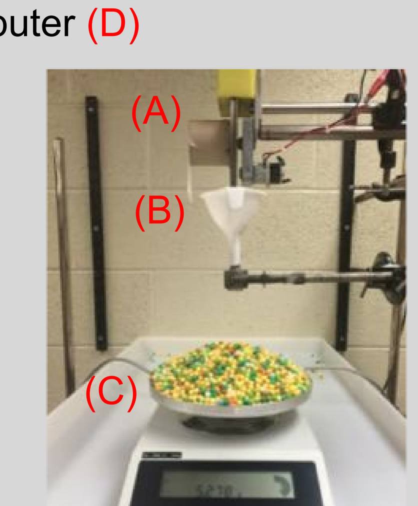

Figure 8: Close up of balance and dropping mechanism.

Computer Interfacing CIrcuits

In order to record data, establish communication with the balance, and control the pellet dropping mechanism a Arduino sketch was developed, which uses C++ programming language.

The three circuits initially built were very basic in order to test the functionality and communication.

Flowchart of Arduino Sketch

- Initial mass will be zero grams because no pellet was dropped at this point. Represented as *i.*
- Starting motor will drop only one bead.
- Read mass off the balance (m) and store in an Excel file.
- If *m>i*, then no avalanche. If *m<i*, then avalanche occurred.

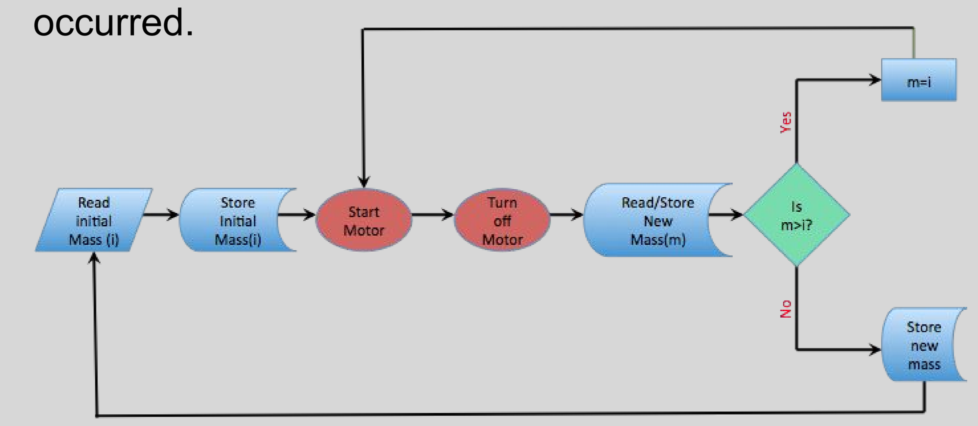

Figure 9: Flowchart that demonstrates the expected functionality of the Arduino sketch

Relay Component

The relay component was programmed to:
- Turn dropper on and off
- Set a delay between drops
- Wait for the stabilization of the pile before an additional drop

The biggest improvement was the stabilization because the reading on the balance needed to be stable before another pellet drop, in order to get the most accurate reading.

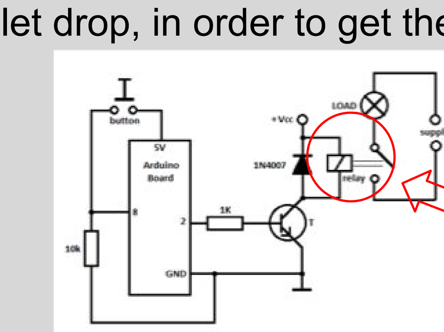

Figure 10: Relay schematic diagram.

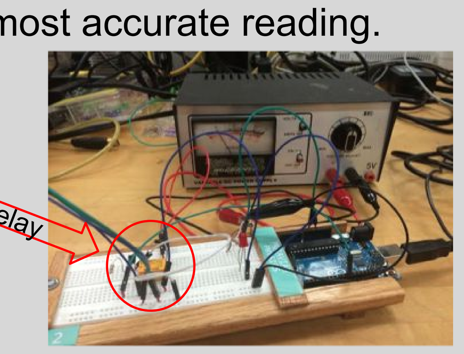

Figure 11: Relay turning on and off an LED based on our delay we programmed.

SD and RS-232 Component

The SD component was programmed to:
- Store data in Excel
- Each stored data reading corresponded with time in milliseconds

The RS-232 component was programmed to:
- Communicate between the balance and Arduino board
- Send commands and receive data
  - S- Send
  - T- Tare

The SD component made observing results easier and could be programmed to store data at particular intervals.

The RS-232 component acting with the balance eliminated the miscount of pellets that fell off the pile during an avalanche which was seen with the photogate component in 2008.

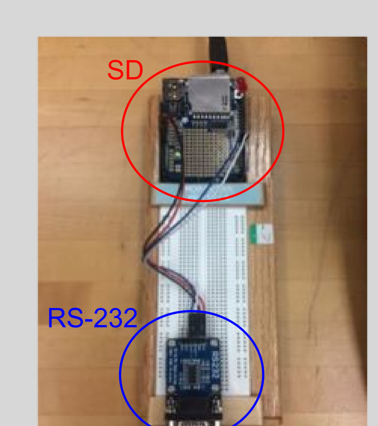

Figure 12: Arduino board along with the SD and RS-232 components.

Results and Discussion

- Figure 13 and 14 displays the data collected from the balance to an Excel file with our computer interfacing.
- The first column of Figures 13 and 14 are values in ASCII decimal which was converted to its representations in the second columns with our interfacing.
- The third column of Figure 13 and 14 is the time associated with each stored data point.
- At least fourteen individual characters were taken to form a string to make data more organized and easier to read.
- Figure 13 represents data in grams while Figure 14 represents data in pieces depending on the balance settings.

83	S	16121
32		16222
32		16323
32		16432
32		16532
32		16632
51	3	16733
49	1	16834
46	.	16934
49	1	17041
49	1	17142
57	9	17243
32		17343
103	g	17444
13		
	17545	
10		
	17651	

Figure 13: Data collection of pellet weight.

83	S	19160
32		19260
32		19360
32		19460
32		19560
32		19670
32		19770
32		19870
32		19970
32		20070
49	1	20170
49	1	20271
32		20380
80	P	20481
67	C	20580
83	S	20680
13		
	20781	
10		
	20881	

Figure 14: Data collection for pellet count.

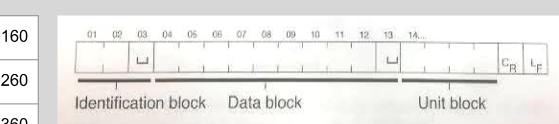

Figure 15: The data format according to the Mettler Toledo Balance manual.

The data format of the balance compared to the data we acquired:
- S represents ID block
- 32 represents space
- Numerical readings represented Data block
- g (grams) or PCS (pieces) represents Unit Block
- 13 represents CR
- 10 represents LF

Conclusion

An Arduino program was developed that enabled the communication from the balance to the computer. With this program, data was obtained in an Excel file that was either mass in grams or piece count. However, there was some unknown error in the coding which caused inaccurate recordings in the file after five minutes. This inconsistent data collection prevented the progression to the next level. Regardless much knowledge was gained with circuitry, programming, and finding solutions to errors that arose.

Acknowledgements

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