Prototype designs for cost effective continuous weighing systems

Nathan

September 7, 2016

Contents

1 Introduction

Compartment 7 in our smart-house aims to be a sophisticated gravimetrics system, where plants can be under controlled environments, automatically weighed and watered over time.

Typically this would require very precise, expensive and specialist equipment to perform. Our aim is to find a cost effective way to do this. We will be working off the rough idea that a professional implementation would cost in the range of £1000 per plant, at current we have space for and aim to facilitate up-to 120 plants at any-one time therefore a complete system with a cost lower than £1000 per plant and/or an overall cost less than £120,000

At current we have the facility to read the weight of each individual plant, water and collect information into a database. However some issues have been uncovered that make this system unsuitable for scientific experiments.

1.1 What is the problem with the current solution?

The main issue that we have encountered when working with the current implementation is that some of the weighing results that we gathered were seeming off and inconsistent with previous readings and expectations. Investigation into this led us to believe that the typical load-cell used in a laboratory scale are ill-suited for continuous weighing.

Load-cells by their nature are very sensitive to changes in their environment in particular temperature. In a green-house environment this quickly becomes a problem. Through a series of tests we discovered a potential drift in scale readings of $\pm 10\%$

1.2 Why a software approach isn't possible

TODO

1.3 How a hardware approach could be the solution

TODO

2 Solutions

For each of these proposed solutions we work off some assumptions about the weights that we will be working with. At most we can assume we will not have to handle plants that are over 10kg in weight, and we would take into account that each scale is around 1kg as well. At current our benches/tables consist of 2×2 smaller benches. Each of these smaller benches hold 4 plants so we will aim for each section of a bench to hold/lift a minimum of

44kg and for a complete bench to hold/lift a minimum of 176kg. To be safe our prototypes will aim above this where possible within the scope.

2.1 Linear Actuators

The use of linear actuators would use electrically powered stepper motors to produce upwards or downwards movements.

2.1.1 Design

When using linear actuators we have two options, either lift the plants from the balances, or else lift the balances to the plants. I think both are viable options and that by prototyping both options we can better see which has a more practical application within the Gravimetrics system.

2.1.1.1 Lifting balances

Here we would lift a load-cell (the cylinder) up to a plat above it. This method allows for the loadcells to be given some time without being stressed with weights on them (which could damage the hardware if left in constant strain).

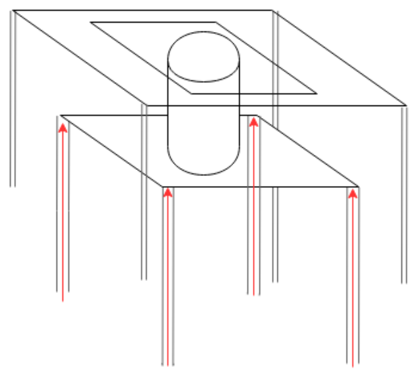

Figure 1: Lifting scales to the plants using actuators

2.1.1.2 Lifting plants

Alternately we could attempt to lift the plants themselves. This could be more simple to implement. Holding the plants above the load cells using the actuators would not necessarily be a strain as they are perfectly capable of holding at a specific height.

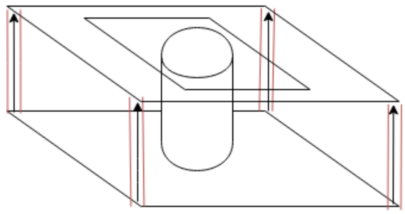

Figure 2: Lifting plants using actuators

2.1.2 Prototype Proposal

For the prototype of this system we would hope to be able to lift a single bench of 4 plants a minimum of 10mm away from the load-cells. Too small a movement and we run the risk of a dip in the bench material due to weight. We must also take into account the possibility of losing track of the current actuator height and so under/over lifting needs to have buffer room which anything less than 10mm couldn't provide comfortably.

2.1.2.1 Parts List

Part	Supplier	Part No	Quantity	Price
Linear Actuator	RS	764-3471	1	£176.69
Actuator Controller	RS	918-1372	1	£48.64
Various fittings	RS	X	X	£15
Total				£240.33

2.1.2.2 Estimated Cost

TODO

2.1.3 Benefits

TODO

2.1.4 Possible issues

TODO

2.1.4.1 Maintainability
TODO

2.2 Scissor Jack

The scissor jack is perhaps one of the simplest mechanisms and would require the least amount of work in order to setup a brief example. However it would require the user to manually move it initially (However a DC motor could be used in the future to provide and more automated mechanism).

2.2.1 Design

The design again being simple would require the load-cell to be balanced upon the scissor jack, we then apply a turning motion to raise the balance to the plants which by taking the weight of the plant pot (cut through the table) we can proceed to read the weight of the load cells.

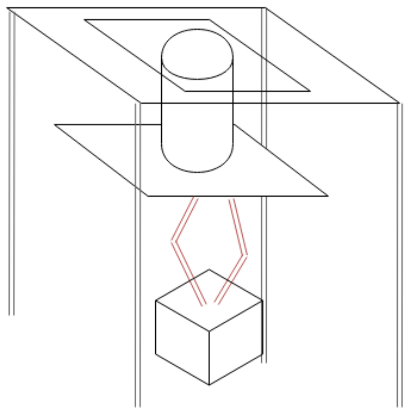

Figure 3: Lifting scales to the plants using actuators

2.2.2 Prototype Proposal

For this proposed prototype all we require (that is unique to this prototype) is the scissor jack itself. Other materials such as aluminium for the frame of the holder and lifter is something that we can re-use between prototypes.

2.2.2.1 Parts List

Part	Supplier	Part No	Quantity	Price

Scissor Jack	Screwfix	97595	2	£14.99
Total				£29.98

2.2.2.2 Estimated Cost

The main cost of this is the scissor jack, in addition to smaller parts that are not important to mention I would suggest that the price of this setup to be ¡£30, with the majority being between some aluminium frames and the scissor jack itself.

2.2.3 Benefits

The main benefits of using this type of system are:

- Cheap to setup
- Room to expand to become automated
- Easily maintained
- Parts are widely available and manufacturer doesn't matter

2.2.4 Possible issues

The foreseeable issues are:

- Not initially automated
- Accurately and consistently turning a motor a specific am mount can be

2.2.4.1 Maintainability TODO

2.3 Hanging Basket

TODO

2.3.1 Design

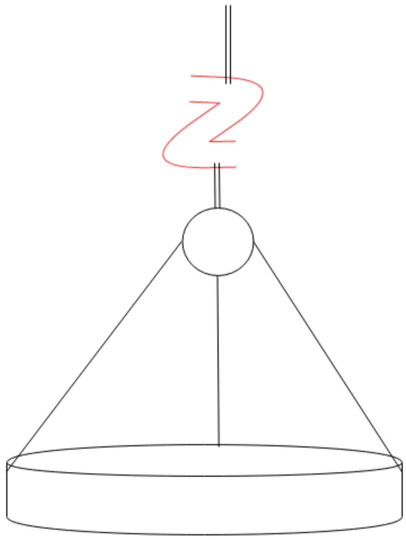

Figure 4: Holding the plants in a basket, with an S-Beam load-cell

2.3.2 Prototype Proposal

TODO

2.3.2.1 Parts List

Part	Supplier	Part No	Quantity	Price
Hanging-basket	Homebase	428809	1	£1.99
S-Beam load-cell	Omega	LCM101	1	£222.00
Amplifier Board	Omega	TXDIN1600S	1	£133
Total				£356.99

2.3.2.2 Estimated Cost

TODO

2.3.3 Benefits

TODO

2.3.4 Possible issues

TODO

2.3.4.1 Maintainability

TODO

2.4 Alternate Load-Cell

TODO

2.4.1 Design

TODO

2.4.2 Prototype Proposal

TODO

2.4.2.1 Parts List

Part	Supplier	Part No	Quantity	Price
Load-cell	Omega	LCM501	1	£249
Amplifier Board	Omega	TXDIN1600S	1	N/A
Total				£249

Both prototype load-cell designs can share an amplifier board as the expense is too much to have duplicate components.

2.4.2.2 Estimated Cost

TODO

2.4.3 Benefits

TODO

2.4.4 Possible issues

TODO

2.4.4.1 Maintainability

2.5 Pneumatic lifting

Pneumatics could be potential solution in that the majority of the cost is in the initial setup. Once a suitable air compressor is available, connecting additional valves and cylinders is very economical.

2.5.1 Design

For the design I would be using a setup that is rather simple and borrow a lot from the linear actuators, the main difference being that this design would incorporate air compressors and pumps in place of electrical powered actuators.

In the diagram given, we can see an air compressor controlled by a servo controller providing a connection to the actuator, these would be controlled by a micro-controller device.

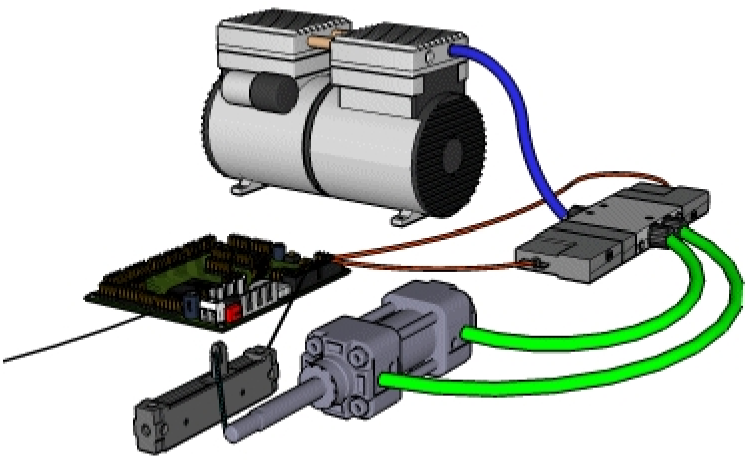

Figure 5: Basic Pneumatic setup using air compressor, servo controller and cylinder[1]

2.5.2 Prototype Proposal

2.5.2.1 Parts List

Part	Supplier	Part No	Quantity	Price
Short-stroke cylinder	Festo	ADVC-32-10-I-P-A	1	N/A
Joining Connectors	RS	812-156	4	£2.40
Extruded Aluminium	aluminium-profile	466-7219	4	£17.99
Solenoid	RS	839-3161	1	£78.26
Solenoid Connector	RS	484-010	1	£1.87
Total				£161.69

2.5.2.2 Estimated Cost

The estimated costs for this prototype would be around £100.52 although additional cost is not calculated for the creating of an additional hook-up point for the current pump.

2.5.3 Benefits

2.5.4 Possible issues

2.5.4.1 Maintainability

2.6 General Parts required

Part	Supplier	Part No	Quantity	Price
Extruded Aluminium	aluminium-profile	466-7219	4	£17.99
Stripboard	RS	100-4328	3	£3.41
Total				£82.19

3 Conclusion

3.1 Total Costs for Prototypes

Prototype	Cost
Linear Actuators	£240.33
Scissor Jack	£29.98
Hanging Basket	£356.99
Alternate load-cell	£249
Pneumatics lifting	£161.69
General parts	£82.19
Total	£1120.18

3.2 Best suited solution

References

[1] User of indestructibles website, user dnicky, `http://www.instructables.com/id/Arduino-Pneumatic-Flight-Simulator`