The Use of Additive Manufacturing in Automated Scientific Equipment

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Abstract

Innovation in scientific instruments is one of the crucial factors in promoting scientific research, and keeping costs down enables low budget labs to contribute to their respective fields without becoming economically crippled. The purpose of this project was to develop an autonomous feeder that will allow *Mus musculus* research teams to either automatically feed after a specified time period, or in response to working for food in the form of providing a "nose poke" into an infrared sensor. Both allow for the mice to be tested in a completely human free environment, allowing for whatever experiments are run to have no interruptions due to mice being fed by a researcher. Although some autonomous mouse feeding systems already exist, this project sought to mitigate the cost using 3D printing technologies (also known as additive manufacturing), allowing labs to examine more animals with existing funding. This design uses 3D printing to take advantage of more complex shapes, while still costing less than a conventional machined prototype. With the ability to manufacture more complex shapes, the system was designed to be very user friendly during assembly and disassembly of the mechanical system. This also allows for cheap iterations of a prototype while still having parts easily suited for injection molding in mass production at a later date. This project focused on the mechanical development of the feeder which was later integrated with electronics.

Background

Accurate lab equipment can be one of the major costs associated with running a research lab. This is especially true when a particular piece of lab equipment has no direct competitor. This makes certain new methods for experimentation costly for labs to develop, and very rare for those that do use them. Current automated rodent feeding systems are rare and very costly to the labs employing them. As such it is a technology that is rarely used in smaller labs, however the data is still very valuable despite its cost. In order to mitigate this cost barrier, labs could commision or create their own lab equipment for a drastic reduction in costs. With the development of 3D printing, it is increasingly more feasible for a lab to generate custom equipment to replace equipment that is normally expensive.

Objective

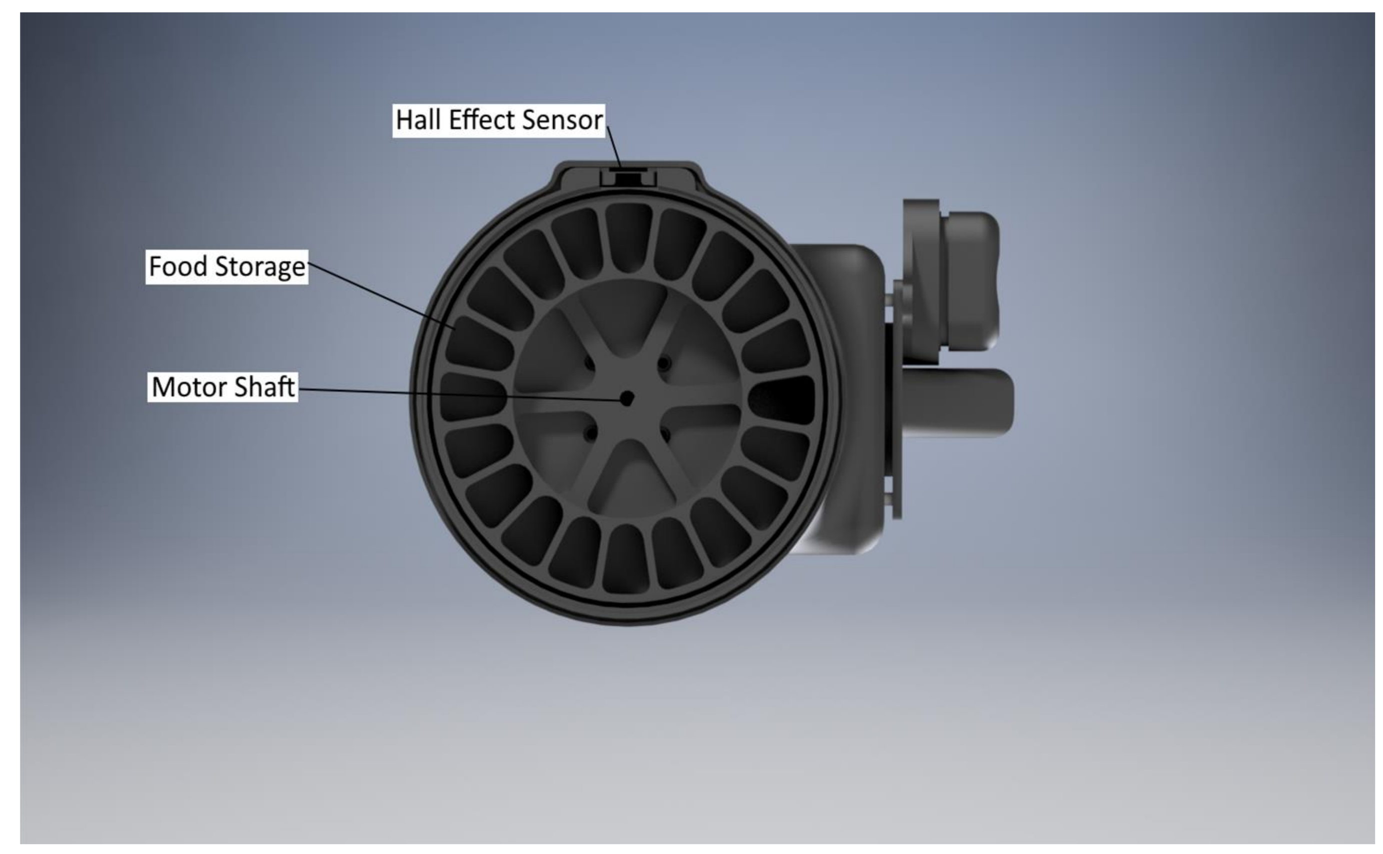
Produce a set of eight automated rodent feeders while taking advantage of 3D printing technologies. In order to fulfill the needs of the lab, the feeders needed to meet the following specifications: The feeders needed to be capable of storing and dispensing up to nineteen food pellets, accurately record nose poke inputs by a mouse, dispense the proper amount of food at each feeding, and all of the components need to be cheap, easy to manufacture, and simple to assemble.

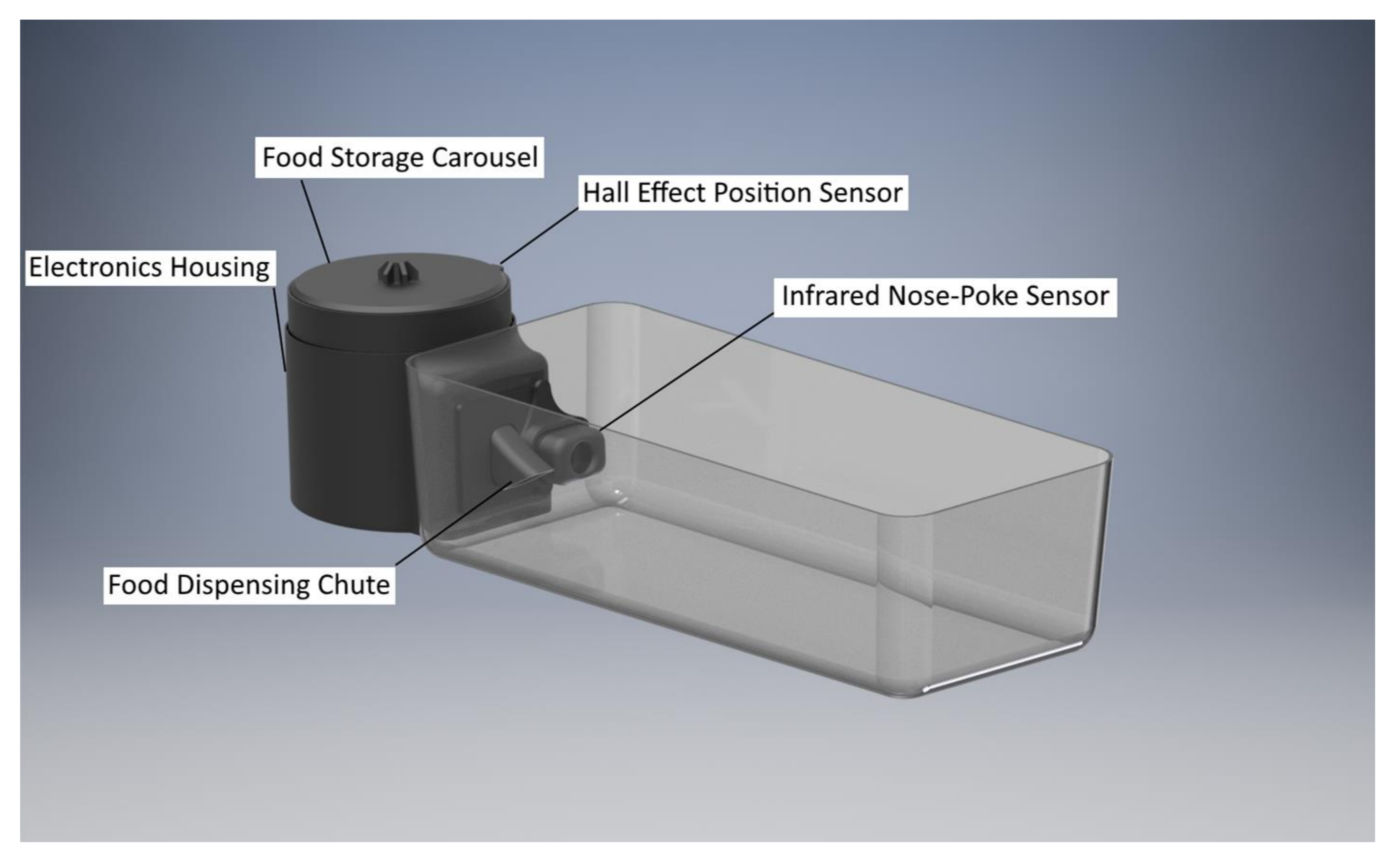
Method

All of the parts for the device were modeled in 3D Cad software, and then printed on a FDM style 3D printer. The design was centered around a carousel containing 19 food pellets, that could be rotated with a nema 11 stepper motor. The carousel itself was printed with embedded magnets pointing radially outward. These magnets in conjunction with a hall effect sensor allow the system to run in a closed feedback loop. This was done to ensure that the proper amount of food is dispensed each time, which in turn allows for more accurate feeding data for the research labs. The nose pokes are sensed using infrared sensors in a custom printed housing which prevents the mice from gnawing on the sensors and attached wiring. Additionally, all parts that would come into contact with food were coated in a food safe resin to create a food safe, easy to clean surface. At every step the parts were designed to fully take advantage of the additive manufacturing process, employing everything from hollow structures to 90 degree internal corners. Another example being that the food chute is one printed piece with a curved channel to transport the food to the cage. A similar machined design would have to be broken into two separate parts, each machined from a larger block. Combining these into a single more complex part keeps the cost down while still retaining all of the functionality. All of these features allow for an end product that has a low production cost. Which allows labs to run a wider variety of experiments without the financial burden.

Discussion

Additive manufacturing was crucial in the construction of each part, as their complex geometries would be impossible to create with traditional machining methods. Hollow structures allowed for significant reductions in material cost and print times. The project was successful in implementing additively manufacturing technology into scientific equipment. By utilizing 3D printing, it was possible to deploy eight of these feeders for use in a *Mus musculus* research lab to study food behaviors. Each of these devices cost under $100 to manufacture, where previous rodent feeding equipment has been known to cost in the tens of thousands of dollars to develop. These feeders are currently being used to gather data relating the amount of effort a mouse will put forward to the amount of food it is receiving in return.





Future Development

With the conclusion of this project, it is feasible that other automated scientific equipment could be made quickly and cheaply for lab use. Currently, a project involving camera tracking of mice in three dimensions is being pursued. Continual development in similar projects would best be carried out if they could be used modularly with each other. This would allow for the freedom to add or remove various automated devices to best suit the needs of a lab. Provided that any individual device became popular, it could be transitioned into a mass producible injection molded version with minimal iteration.

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