A Remote Controlled Food Dispenser for Animal Research

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Abstract

Today's state of the art BMI and behavioural research usually requires an expensive recording system, which alone costs tens of thousands of euros. It is therefore desirable to cut costs elsewhere without jeopardizing the quality of the scientific outcome. Rewarding animals with food is a common practice in BMI and behavioural research. Commercially available laboratory food dispensers are expensive and have to be replaced frequently. Hence, our proposed design only uses a few very simple parts, which are inexpensive to fabricate. Here, we describe the design and control of these simple food dispensers.

1 Introduction

In order to shed light on a Bidirectional Brain-Machine Interface we aim to introduce an animal model for acquiring predictable neuronal signals by multisite neuronal recordings and stimulation. For that purpose we have developed an experimental arena, where rats are urged to constantly explore. Key aspects of this arena are a Primesense [6] Sensor based 3D rat tracking system not to be discussed her and an assortment of closed-loop computer controlled food dispensers. The basic idea for video controlled food dispensing relies on the rat's affinity to a well known breakfast, Nestlé Cocoa Pops. These little carbohydrate treats are stored in a tube and are to be dispensed one by one by a rotating drum on programmed demand. In the following, we illustrate key design decisions for this type of dispenser.

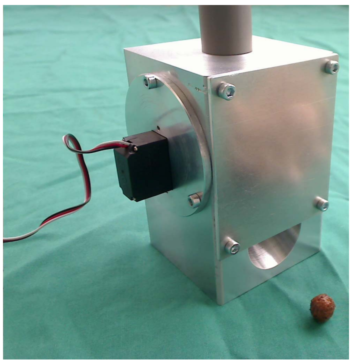

Fig. 1 .Fully assembled food dispenser. The grey tube on top contains the Cocoa Pops. The aluminium front plate obstructs one half of the hole at the front, thus leaving enough space for the Cocoa Pop to get out, but not enough space for the rat to get into it. The servo motor is mounted into a disc shaped aluminium plate. The brown ball in front of the device is a single Cocoa Pop.

2 Materials and Methods

A single food dispenser has been specifically designed to work with Cocoa Pops because of their consistent shape and size. Approx. 50 pieces of these low-calorie [3] treats only weigh about 1 g and are strong stimuli when working with food deprived animals. In addition, Cocoa Pop's can be considered very safe, because their low chocolate content virtually eliminates the risk of severe testicular atrophy due to theobromine. It's therefore highly unlikely for single rat to exceed the critical 250 mg/kg body mass reported by Weinberger et. al. [4.]. A single food dispenser [Fig. 1] consist of just three simple aluminium parts and one miniature servo motor for rotating a plastic drum inside the casing to deliver the food (Nestlé Cocoa Pops) from the tube shaped reservoir to the animal. The servo motor (New Power XL-9HM, 10.0g, 2.5 kg/cm at 6V, 23.2 x 12.0 x 24.8mm) is controlled by an open source SSC-32 servo controller board able to simultaneously control up to 32 servos. Our prototype has been manufactured from aluminium by the university's workshop. The assembled prototype excluding the servo controller board and the servo is worth 10€. The overall material costs for a single food dispenser unit including the cost of one SSC board is below 50€. The dispenser is about 100 mm high (without the reservoir), 60 mm long and 60 mm wide. Five of the dispensers are distributed equally within a circular area having a diameter of 200 cm. The dispensers are secured in place within the circular area by screws. The rat is robustly tracked by a geometry based system using a Primesense [6] Sensor mounted 180 cm above the arena, thus enabling closed-loop control of the food dispensers. The software tracks the animal and checks for collisions of an identified oriented bounding box computed from the convex hull [2] of the segmented animal using the rotating caliper method [2]. A virtual food dispenser placeholder on the control screen matches the position of the actual physical dispenser. The food is then dispensed by a particular dispenser unit, enabling custom paradigms and therefore constrained search paths of the rat.

2.1 Design considerations

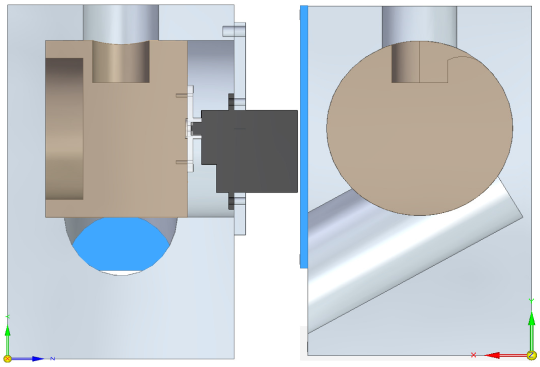

Fig. 2 Two cross sections of the food dispenser. A single Cocoa Pop per turn is transported from a tubular reservoir (not shown) at the top of the dispenser by a servo powered rotating drum made from PVC. The rounded edge of drum's inlet hole gently pushes remaining Cocoa Pops back into the reservoir. About one half of the dispensing outlet is obstructed by an aluminium plate to prevent rats from getting into the channel.

The food dispenser has been designed with Siemens Solid Edge ST4 [5] specifically to work with Cocoa Pops, because of their consistent shape and size. The device was supposed to have only one moving part – the plastic center drum – to deliver the Cocoa Pops from a tubular reservoir to the rat. The servo motor is small, yet strong enough to rotate the drum with a speed of up to 0.1 sec/60° and a torque of 2.5 kg/cm. It's only attached to the plastic drum by a central plastic cross that comes with each servo and it's held in place by just two screws and the disc shaped servo plate. Using a servo also means it's easy to control by either a servo controller board or just a micro controller and a few lines of assembler code. The servo plate is held in place by three screws. The servo, the plate and the drum can be pulled out in one piece [Fig. 3] for easy cleaning. The casing is easily fabricated from a single block of e.g. aluminium. Currently, about one half of the dispensing outlet is obstructed by an aluminium plate to prevent rats from getting into the channel. When working with mice, the channel's access might be further obstructed by a larger front plate.

2.2 Food reservoir

The reservoir containing the food is a PVC tube and has a diameter slightly larger than than the largest diameter we could measure among the Cocoa Pops. Therefore, the Cocoa Pops will stack up onto each other without jamming the transportation drum's inlet. The reservoir is screw-connected to a top hole of the casing.

2.3 Plastic drum

The drum's responsibility is transporting exactly one Cocoa Pop per turn from the reservoir to the animal. It's made from PVC plastic, to comply with the servo's torque of 2.5 kg/cm. The key design feature of the drum is the shape of the hole, which takes only a single Cocoa Pop. And because the Cocoa Pops are stacked up onto each other, they will fall in to the hole by themselves. Like the tube reservoir, the hole's diameter and depth is slightly larger than the largest Cocoa Pop we could find. The most crucial part, however, is the rounded 30° slope opposite to the turning direction to gently push remaining coco pops back into the reservoir to prevent jamming and inadvertently turning the food dispenser into a grinder.

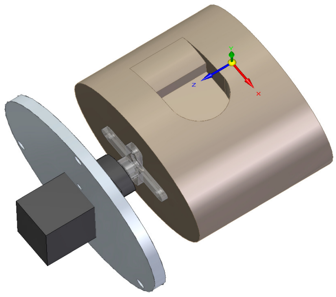

Fig. 3 The plastic drum is attached to the servo motor with the plastic cross, which comes with every servo motor. The servo motor itself is mounted into the disc shaped plate by two screws. The drum's position is upward with the hole facing the food reservoir. To deliver the food, the drum turns in x-direction.

2.4 Servo plate

The servo plate holds the servo motor in place. The plate has a rectangular hole for the servo. In addition, two screws secure the servo in place. The moving axis of the servo is exactly in the center of the plate. With just three screws the servo plate can be easily removed from the casing for cleaning or replacing the servo.

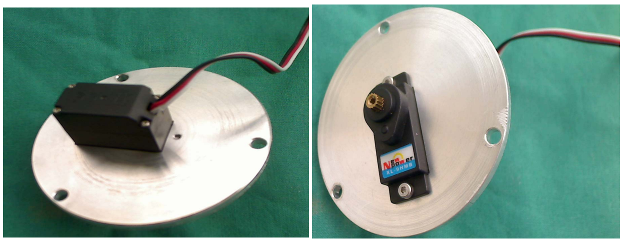

Fig. 4 The servo plate holds the servo in place and is connected to the casing by three screws.

2.5 Front plate

The size of the front plate obstructs about 50% of the dispensing channel to effectively keep out rats while scavenging for more food. Mice might still fit into that dispensing channel, which then requires a larger front plate to obstruct the dispensing channel to a higher degree.

2.6 Casing

The casing [Fig. 5] (10x6x6cm) gives the dispenser it's overall shape. All other parts attach to the casing in one way or another. The casing has a hole milled into it at an angle of 30° (upwards) to let the Cocoa Pops out and another hole at the top for letting Cocoa Pops in. The large 50 cm deep third hole with its center at 35 cm from the top and a diameter of 50 cm provides the place for the plastic transport drum.

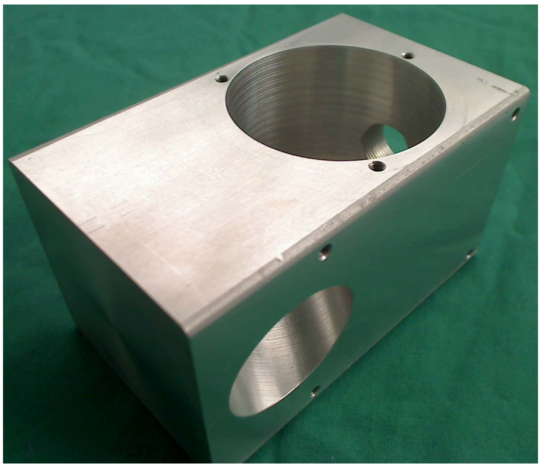

Fig. 5 The casing defines the shape of the dispenser and takes all other parts. The removed front plate reveals the conical hole for dispensing the Cocoa Pops.

3 Closed-loop Food Dispensing

Our experimental setup utilizes an assortment of closed-loop computer controlled food dispensers to keep the rat constantly exploring the environment, while being tracked by our Primesense [6] Sensor based 3D rat tracking-system. The rat has to be in a predefined proximity [Fig. 6, 7] of the food dispenser in order to be fed a single Cocoa Pop by a particular food dispenser.

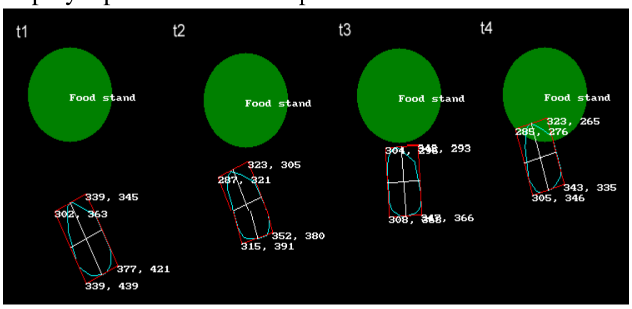

Fig. 6 This series of four screenshots, taken from our tracking-system's control screen, illustrates a rat approaching the predefined area (green circle) around a food dispenser. A single Cocoa Pop is dispensed if the tracked rat enters the area. The tracked rat's contour is enclosed by an oriented bounding box. The numbers displayed at each corner of the bounding box are position coordinates matching the rat's actual position.

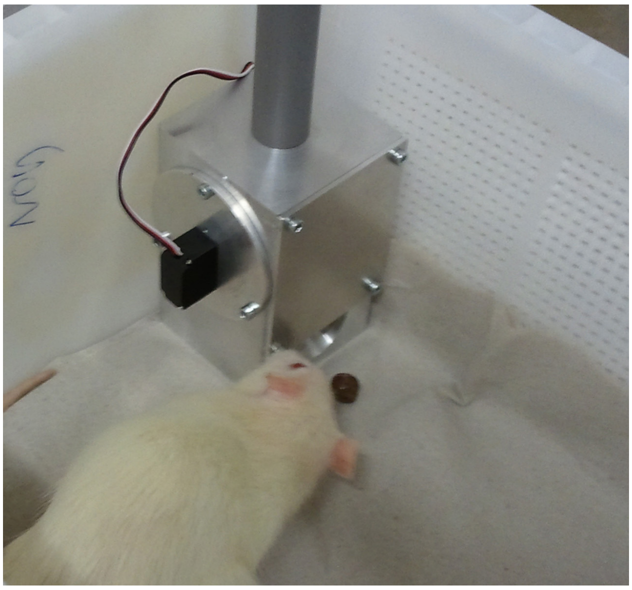

Fig. 7 A rat has just come into close proximity of the food dispenser. A single Cocoa Pop is visible in front of the dispenser's outlet.

4 Results

We have presented a cost effective food dispenser, which can be controlled remotely by our custom made animal tracking software.

5 Conclusion

The simple design of the dispenser provides a simple and cost effective way to feed animals according to experimental paradigms and can be made out of inexpensive parts and materials. Currently, several exploration paradigms are being tested. We add an appendix to foster easy reproduction of the system in the relevant labs.

6 References

[1] Godfried T. Toussaint. Solving geometric problems with the rotating calipers. In Proc. MELECON ’83, Athens, 1983.

[2] R.L. Graham. An efficient algorithm for determining the convex hull of a finite planar set. Information Processing Letters, 1:132–133, 1972.

[3] Nutrional facts of Cocoa Pops.

[4] Weinberger, M.A., Friedman, L., Farber, T.M., Moreland, F.M., Peters, E.L., Gilmore, C.E. and Khan, M.A. 1978. Testicular atrophy and impaired spermatogenesis in rats fed high levels of the methylxanthines caffeine, theobromine, or theophylline. Journal of Environmental Pathology and Toxicology 1:669-688.

[5] Siemens Solid Edge ST4

[6] Primesense Corporation

7 Appendix

Here, we provide all the necessary technical drawings to help building our food dispenser. **Note**: Get the electronic version of this paper in order to read the technical drawings or contact the author to get the STL files and the electronic version.

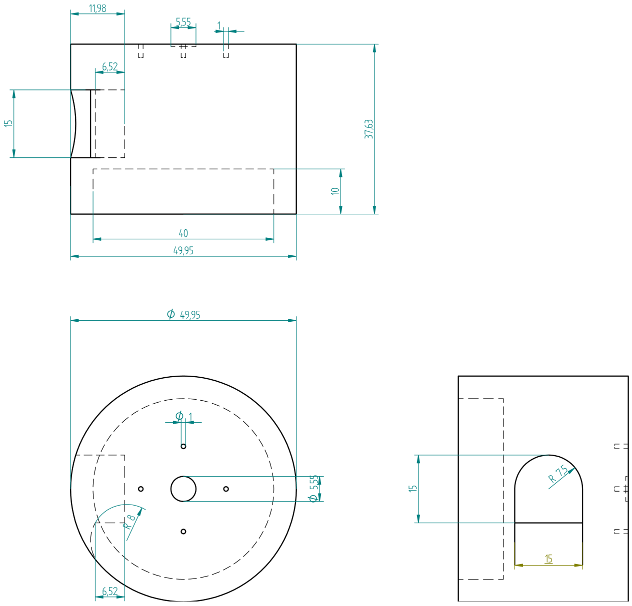

Fig. 8 This technical drawing illustrates the casing. The dotted lines on the right hand side of the the upper image are there to help fabrication on a CNC machine. That is, they tell you the dimensions and the angle for milling the hole, which lets the Cocoa Pops dropping out out of the device.

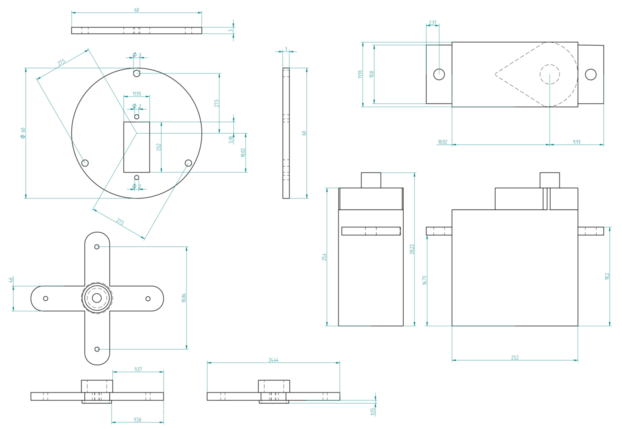

Fig. 9 This technical drawing illustrates the rotating plastic drum for delivering a single Cocoa Pop per turn from the reservoir to the animal. Note, that the drum's diameter has to be slightly smaller than the 50 cm diameter of the casing's hole to reduce friction and stress on the servo motor.

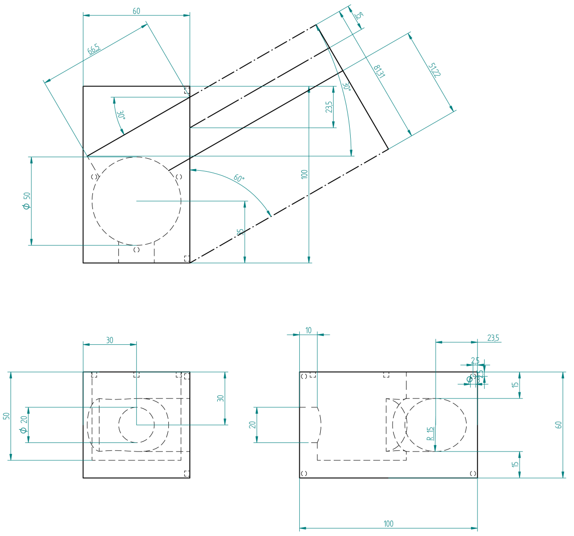

Fig. 10 This technical drawing illustrates the servo plate. It also shows technical drawings of the New Power XL-9HM servo. The dimensions of the servo and the plastic that comes with each new servo have been determined by carefully measuring a servo with a digital caliper and then reconstructing it with Solid Edge ST4.

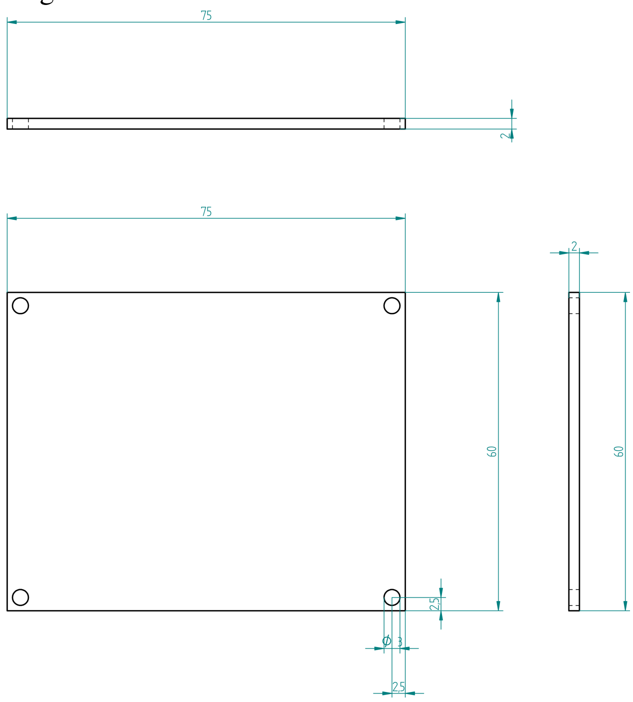

Fig. 11 This technical drawing illustrates the front plate needed for keeping animals outside the device.