

WHEELCHAIR-MOUNTED DOG TREAT DISPENSER

PROPOSAL

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Executive Summary

Currently, 15% of the world's population suffers from some sort of disability. Of that 15%, 4% suffer from an advanced disability such as cerebral palsy and multiple sclerosis ("Disability Impacts"). Many of the people who suffer from such diseases are wheelchair bound and use a service dog in order to assist them in their daily lives.

While their service dogs are fully trained upon reception, the dogs must go through yearly tests in order for them to keep their certifications up to date ("Service Dogs of Virginia"). To keep the dogs well trained, they must be constantly exposed to the training conditions to help them remember their "tricks." Due to the high cost involved with training the service dogs, most owners would prefer to train the dogs themselves, which normally involves some sort of reward for the dog (e.g. a treat). This presents a problem for people suffering from disabilities; they are not able to complete certain tasks easily such as rewarding their dog because of their disability.

This project intends to correct this problem by developing a treat dispenser that will work with a variety of wheelchairs and will comprise of a universal input for plethora of input devices to activate the treat dispenser, such as a switch or a button. The treat dispenser will also be small enough so the wheelchair in which it is mounted on can fit through doors and will not impede the functionality of the wheelchair. A highlight of this project will be the ability to recreate the dog treat dispenser from relatively household items. This will allow the treat dispenser to be cheap and will be able to serve a multitude of people in need.

Problem Statement

The wheelchair is one of the most commonly used assistive devices for increasing and enhancing personal mobility, which is a necessity for being an independent and productive member of society. There are many conditions and afflictions which may result in the need of a wheelchair such as multiple sclerosis, cerebral palsy and muscular dystrophies. Disabled individuals who are wheel-chair bound accompanied by service dogs account for .9 percent of the U.S. population (“Disability Impacts”). These highly trained canines can provide independence to their owners and significantly enhance their quality of life. These dogs are capable of completing a wide range of tasks from opening doors, retrieving dropped items and pushing their partners up ramps. These dogs are an integral part of these individuals lives and must go through extensive training to earn this role (Hall 51). In order to achieve maximum performance from these dogs, frequent rewards in the form of verbal affirmations and treats are required. Rewarding the dog is essential. It not only increases the emotional relationship between the dog and the owner but most importantly, provides the dog with much needed positive reinforcement.

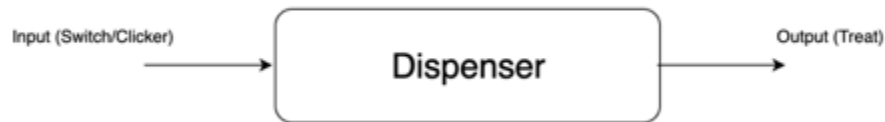
This project was undertaken at the request of The Service Dogs of Virginia, a non-profit organization that raises, trains, and places dogs to assist people with disabilities due to the failure of several designs that have attempted to ameliorate the burden to create an effective standard of assistance. The main challenge users who have limited or no hand mobility at all is giving the dog a treat. There have been several great ideas and attempts to create an adaptive treat dispenser that could be integrated seamlessly to a wheelchair, but there are none that are commercially available as of today. Despite the numerous attempts made to make this merchandise commercially accessible to the public it has failed repeatedly due to design limitations such as;

the dispenser being too large to be seamlessly embed into a wheelchair as well as there being malfunctions with getting the dispenser to release the desired number of treats appropriately.

While there have been few designs that have overcome these setbacks, they too have proven to be futile as a result of the dispenser bowl being too small, and fiscal challenges due to the expenses of printing and dipping into a food safe coating.

Approach

Fig: Level 0 (External Systems Diagram)



A. Problem Analysis

Customer pointed out the flaws of the previous designs and attempts on creating a good final product. The issues are as follows:

A1. Design being too big

Almost all the doors in households or public places in the U.S. passes bare minimum requirement for Americans with Disabilities Acts (ADA) which means wheelchairs narrowly manage to pass by. With the previous design being too big, it limits the mobility of the wheelchairs when fitted by big dispensers

Customer suggested design to be mounted on the side of the wheelchair. Faculty Supervisor suggested mounting on the front.

A2. Hard to reproduce

Customer requested the design to be easy to reproduce, which means finding the parts and assembling the device must be easy to ordinary person with very few to no engineering skills. All the previous designs used microcontrollers (especially Arduino's) for controlling the dispense of the treats that required certain degree of programming skills to build the design.

Some of the designs used 3D printers to build the parts. 3D prints are expensive, time consuming and not food safe.

Customer requested the design to be easily reproducible i.e. people with very few to zero programming skills can build the design with ease. The parts for the design should be easily found in the market and food safe for latter production of the design. Faculty Supervisor suggested the use of 555 timer as an alternate design to microcontroller.

A3. Difficulty in getting right number of treats to dispense

Customer stated the problem in dispensing consistent number of treats every time in some of the preliminary designs.

A4. Must work for people with disabilities

Wheelchair bound people have limited mobility of their body parts like head, hands, legs or fingers. The design should be simple enough to dispense the treat at the click of a button.

A5. Durability

The dispenser should be durable and weatherproof. Dispenser must handle the vibrations from the wheelchair. Dispenser should be strong enough to handle knocks from service dogs, people, getting bumped etc.

A6. Material Selection

Customer requested to use food safe materials for the dispenser to avoid health related hazards. Most of the early models used a 3D printed parts which possess health risks to the service dogs.

A7. Jamming problem

Customer noted jamming problem with some of the earlier designs. The treats are jammed in the dispenser or the parts of the machine are stuck.

B. Approach

Our team will focus on finding the best solutions to all the problems faced by previous designs and attempts.

B1. Body

The body of the dispenser shall be compact so as not to obstruct the mobility of the wheelchair. It will be fitted with a universal wheelchair mount to accommodate different sizes of wheelchair. It will be designed to endure all kinds of weather and shall be sturdy enough to handle the wheelchair vibrations, and bumps. The team will target to find the materials that are easily available in the market to build the design. The parts that come in contact with the treats will be food friendly (stainless steel will probably be used). The circuit design will be simple to be built by people with zero circuit knowledge. The team will use 555 timers to time and control dispensing mechanism.

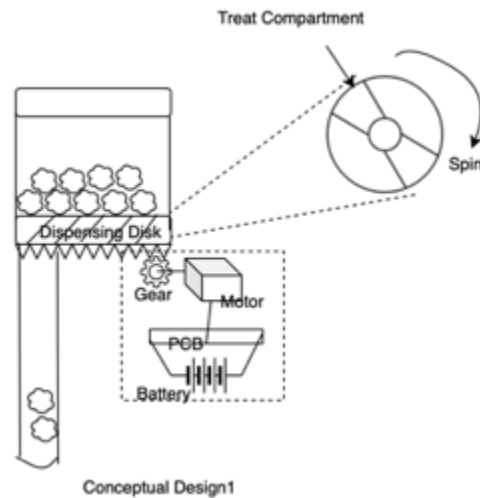
B2. Input

The input to the dispenser will be a physical touch button with a mono signal. The dispenser shall be designed with self unjamming mechanism to avoid the jamming problem. The team shall also work on different input/activation method for the dispenser like RC signals, accelerometer.

B3. Output

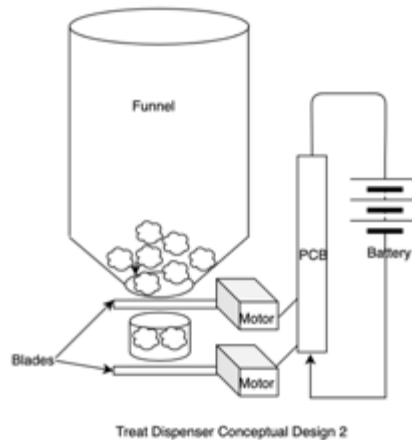
The team shall primarily focus to design a dispenser that dispenses the consistent number of treat every time on a single click of the button. It will also be fitted with a food holding tray to hold the dispensed treat.

B4. Dispensing mechanism Design 1



This design has a dispensing disk fitted at the end of a pipe. The dispensing disk is designed with gear teeth on the edges for the rotation of the disk. The rotation of the disk is controlled by the spur gear fitted right next to the disk. One rotation of the spur gear dispenses 2-3 treats at a time. Spur gear is powered by either a dc motor or a servo.

B5. Dispensing mechanism Design 2



In our alternate design, the dispenser has a funnel that holds the treats to be dispensed. Dispensing will be controlled by two blades fitted right beneath the funnel and the treat measurement pipe. The motors that move the blades are fetched instructions from PCB board which takes input from the user and is powered by battery.

C. Introduction to background knowledge/phenomenology supporting the project

This project will require a considerable amount of time and effort from all the members of the team. Our team has created the conceptual designs that we think will satisfy all the requirements of the project. Next step is researching on the parts that will be used together for building the design. Our goal is to find the parts that can be easily found on the market and bring it together to build the design. Moving on, the project will require the circuit building skills of the team. Our team will work closely in building the circuit and designing PCB for the project. To keep the simplicity in the design, our team shall restrict the use of microcontroller and use 555 timer or other forms of controllers. After the PCB is manufactured and the parts are decided, we will work on housing the parts and finally mounting the device to the wheelchair.

D. Product Testing

After the completion of both designs, the treat dispensers will be tested by our team to measure the devices' performance, quality and safety standards. The device will be tested to verify the requirements of the specifications. The device shall be tested to determine if it solves the current problems faced by the customer. The device will also be tested to identify any potential cost savings for the production. The team will then work on to troubleshoot any problems encountered or modify the designs if required. The team shall keep its eyes on how the device is performing functionally for consistent dispensing.

E. Treat Dispenser Project Requirements

E1. Mission Requirements:

The device shall assist people with disabilities to provide treats to the service dogs.

E2. Functional Requirements:

1. The device will hold a minimum of a cup of treats at all times to provide rewards for the service animal.
2. The device shall use an accelerometer-based control input so that someone with limited physical mechanics can easily use the dispenser.
3. The device shall use timers to time and control dispensing mechanism.

E3. Operational Requirements:

1. The device will operate and be stored on the side or front of the wheelchair.
2. The device shall be vertically fitted onto the wheelchair to ensure that the device can easily pass through doors.
3. The device will dispense varying number of treats depending on the operators input.
4. The device shall have a self-healing method of unjamming itself to ensure that it can dispense food without much assistance from the owner or other party.
5. The device must be easy to clean.

E4. Input/output Requirements

1. The device will accept input from the operator. The physical input device will vary however, the interface with the primary device will be consistent no matter what.
2. The device will accept dog treats and ingest them into a storage container inside the device.

3. The device will output dog treats through a pipe system that will deliver the food to a food tray.

E5. Technology:

1. Shall use some timers
2. Shall use some form of pipe to move food from storage to destination.
3. Shall use some form of hardening to ensure durability.

Preliminary Design

The automatic dog treat dispenser must implement a design that is robust while being sleek and lightweight. Since the treat dispenser is installed on a wheelchair, it cannot interfere with the normal operations of the wheelchair, nor limit locations that the user can go in the wheelchair. It must be low profile and able to mount anywhere with adjustable tubes to accommodate a low or a high mounting of the device. The device will need to be battery powered to work autonomously from the rest of the wheelchair. It cannot be responsible for draining the wheelchair's power as there are more important functions of a wheelchair than a dog treat dispenser.

The dog treat dispenser should integrate seamlessly with the end user's switches/buttons using a 3.5mm mono-jack as connection. This connection will simply need to close a circuit to trigger the dispenser when activated and remain open otherwise. The project will also include the creation of a switch using accelerometers or some other method (perhaps using fiber and detecting vibrations due to movement). This portion is still to be discussed.

There are four main areas for the automatic treat dispenser: the dog treat storage compartment, the treat staging and dispensing area, the circuitry and mechanism to activate the treat dispenser, and the treat deployment tube.

Treat Staging and Dispensing Area:

The treat staging and dispensing area influences what the mechanism to activate the treat dispenser should be, as well as the dog treat storage compartment. The dog treat storage compartment feeds directly into the dog treat staging and dispensing area, and the circuit has to

work for whatever mechanism is established, so the design must start here. There are three styles of dispensers to be evaluated: gumball machine style, Ferris-wheel style, and stopper style.

1) The gumball machine style consists of a horizontal, circular plate that spins on the axis perpendicular to its center with cut outs to drop the treats through a hole when they are to be dispensed. This plate would have three to four openings around the outside that are just large enough to hold two to three treats side-by-side.

This spinning plate would then sit on top of another plate that has only one hole in it the same shape as the openings in the spinning plate. This plate would be static and should be able to line up with one of the openings in the spinning plate at a time. There would then be one more plate above the spinning plate with an opening that is large enough to let treats filter into one or two of the openings on the spinning plate at a time. The opening would have to be offset from the opening of the bottom plate and towards the start of the rotation after the bottom opening.

These three circular plates would be at the bottom of the dog treat storage compartment so that all the treats sit on top of them and can be filtered in as the spinning plate is activated.

The spinning plate should turn $1/3$ or $1/4$ of a full spin at a time (depending on how many openings) and have an opening line up with the opening in the bottom plate each turn.

Thus, the treats are loaded into the spinning plate one or two openings at a time and then dispensed one opening at a time for each activation. The number of openings will have to be tested to determine what works the best and provides the most consistent results.

2) The Ferris-wheel style consists of a design similar to the gumball machine style, but the mechanism spins vertically instead of horizontally. With this design, only one plate is required. Around the outside perimeter should be pockets/compartments large enough to hold the two to three treats needed at a time. These compartments would have openings that face outward from the center axis of this spinning wheel.

The wheel with compartments around the perimeter would sit inside a round cover that is just large enough to allow the wheel to turn within it. This cover is to keep the treats inside the compartments as the wheel turns. The cover would have one opening at the top and the bottom that are the same size and would line up with the compartments on the wheel.

Again, this wheel would sit below the dog treat storage compartment and treats would filter in one compartment at a time. As the wheel turns, treats are dispensed at the bottom of the wheel one compartment at a time.

This wheel would have four compartments around it so that at any time, one compartment is being loaded with treats, one is loaded with treats and waiting to be dispensed, one is being dispensed, and the other is empty. This way, the wheel only has to make quarter turns each time. Half turns could require too much effort and shorten the life of the electronic mechanisms to be used.

3) The stopper style dispenser employs two stoppers: one to help stage the treats, and one to dispense the treats. The dog treat dispenser should dispense quickly, so the treats should be ready to go when activated. Thus, with this style, there should be one activation when first used where the dispenser is loaded and no treats are dispensed.

There would be a space between the two stoppers that is enough to store and stage the two to three treats that need to be dispensed. To keep the dispenser's size as small as possible, it makes sense to have the treats staged vertically between the two stoppers. Thus, there should be a tube between the two stoppers slightly larger than the diameter of a dog treat.

When the automatic dog treat dispenser is activated, the bottom stopper is removed from the tube first, allowing the treats that are staged to drop and be dispensed. This should open long enough to allow up to three treats to drop and then close shortly after that.

Once the bottom stopper is back in place in the tube, the top stopper is removed and treats from the dog treat storage compartment are able to fall into the staging area. This should be removed long enough for three treats to fall in, and then close.

There is a potential hazard with this design in that the top stopper will not be able to go back in place in the tube if a treat falls in the place it should be in. Thus, this top stopper should have a blade on it and be strong enough that it could cut through a treat or break apart a blockage.

The stoppers and tube must all be in an enclosure so that dog treat crumbs do not fall out of the dispenser as the user is wheeling around. There will also be a gasket around the edge of the stoppers to create a seal when in the tubes for the same reason.

Unintentionally dispensed crumbs or treats could lead to negative behavior in the service dogs

All of these designs are susceptible to jamming, and dog treats can sometimes get sticky in humid areas, so preventative measures must be taken. These measures can be taken within the dog treat storage compartment.

Dog Treat Storage Compartment:

The storage area for the dog treats needs to work with whichever dispensing method above is chosen. Each will require a slightly different storage compartment to sit above the dispensing mechanism so that treats are fed into the staging area correctly. Each will require the same construction, however.

The storage compartment will have smooth, easy to clean surfaces, and to be detachable for cleaning. The material used will need to be food safe. It should also be transparent or translucent enough for the user to see the amount of dog treats still available at any time. The bulk of the storage compartment can be made of some kind of food safe plastic or tupperware type container. The compartment will be slim and wide to hold at least a cup of dog treats at a time and ensure the wheelchair's profile is minimally impacted.

All storage compartments should have a funnel type bottom to feed the staging area of each dispensing mechanism with dog treats. Though each style would be slightly different, the overall design is the same. The funnel will have sharp enough slopes so the treats do not get stuck.

The dog treat storage compartment will also have an internal vibrator that activates when the automatic treat dispenser is activated. This is to help ensure that the treats feed into the staging area and jams are broken free. The vibrator can be attached to the outside of the storage compartment.

There will also be a hinged lid on top of the storage compartment with an easy to use latch/clasp for simple refills. The lid will have a seal to make sure the dog treats do not spill out the top of the compartment.

The dog treat storage compartment will be the largest part of the dispenser so it will also have a flat face with some mounting tabs to make it easy to mount anywhere on a wheelchair. The storage compartment will need to be tightly secured to the dispensing mechanism and the rest of the treat dispenser so that no other mounting points will be needed.

Circuitry and Activation Mechanism:

The circuitry in all three design styles will require the use of a timer circuit. This timer circuit will need to activate a motor for long enough to spin the mechanisms in the first two cases and also work out the timing between the two stoppers in the third case.

The circuitry in the first two cases will require a motor to spin the plate/wheel far enough to dispense the treats. The motor speed will be used to time how long it takes for it to spin the plate/wheel to the correct position and the timer circuit will have to be built accordingly to keep the motor activated for that amount of time (“Drive Servos With a 555 Timer IC.”).

Another method would be to use limit switches that are bypassed when the device is activated and then activated right after so that the device stops when a limit is reached. These can be user adjustable for troubleshooting purposes (“Automatic Turn OFF Power Circuit.”).

In the third case, there will be two motors that need to be timed the same from opening to closing (Jezernik). There will also need to be a timer between the two stoppers so that adequate time is allowed between the treats dispensing and the next set of treats being staged. This time

will be at least two times the amount of time the bottom stopper takes to allow the treats to drop to being back in place.

The circuitry will be installed within a sealed container to protect the components from damage. The PCB will be designed so components can be easily replaced and will be mounted on rubber mounts to protect the circuit from vibration damage (Mechatronics). All connections will be solid enough for a long life under normal use.

The circuit will have a 3.5mm mono-jack input to activate the circuit (in place of the shown input switch) and will be battery operated for autonomous operation. The 3.5 mm mono-jack will be the connection point for the switch of user's choice. The circuit itself will look at this portion as a simple switch that closes the circuit when the switch is activated. The lower right circuit depicts the activation circuit. When a button/switch is pressed, it will keep the circuit on for a specified period of time (via the time constant of the 1000uF capacitor), and will turn off the circuit when the capacitor is discharged.

The upper right circuit is the circuit that controls the motor speed. As previously mentioned, it will use a 555 timer chip to create a Pulse Width Modulation signal to drive the motor ("Drive Servos With a 555 Timer IC."). This will spin the motor/servo in a particular direction (e.g. clockwise or counterclockwise) in order to actuate the dispensing mechanism.

An accelerometer type switch will also be investigated as a method of activating the treat dispenser. This device would be wireless for easy use, and help those individuals that lack any kind of dexterity. A simple nod could be enough to trigger the accelerometer and activate the treat dispenser

The circuit might also include a small speaker that emits the dog training clicker sounded to pique the interest of the service dog.

Dispensing Tube:

The Dispensing Tube would be the simplest part of the dog treat dispenser. It will consist of a tube that allows the dog treats to easily slide through, and a tray attached at the bottom that will catch the treats and provide a constant location for the service dog to go to for the treats. The tray will be constructed of stainless steel or some hard plastic that will last with constant use by the service dog. It will be big enough for a fairly large service dog's nose to fit in so that it accommodates as many service dogs as possible. The tray will also have provisions for mounting it to a wheel-chair, though these mounts will not be responsible for any of the device's weight. It will simply help to hold the tray in place and ensure the treats are dispensed to the tray.

The dispensing tube will be tightly attached to the bottom of the dispensing mechanism and should be only slightly larger than the opening the treats will be dispensed through. The tube will be flexible so that the storage compartment and dispenser portion can be mounted in a variety of locations and still allow the use of the same tube.

Overall Design:

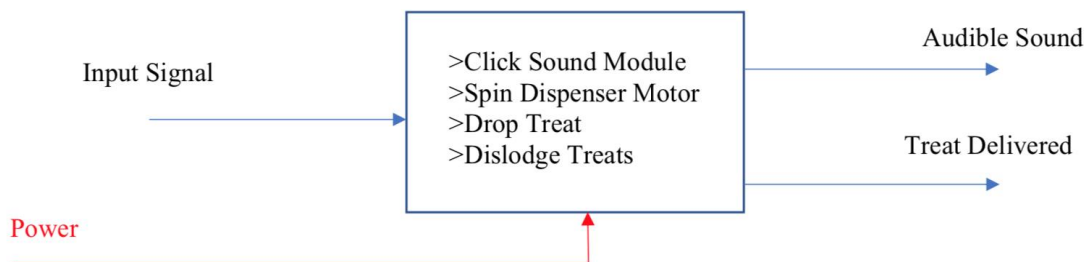
The overall design consists of a treat storage area connected to the treat staging and dispensing mechanism along with PCB that can be mounted anywhere on the wheelchair, though the higher it can be mounted, the better it should work. There is then a flexible dispensing tube connected to the dispensing mechanism that allows the user to dispense the treats to any position on the wheelchair.

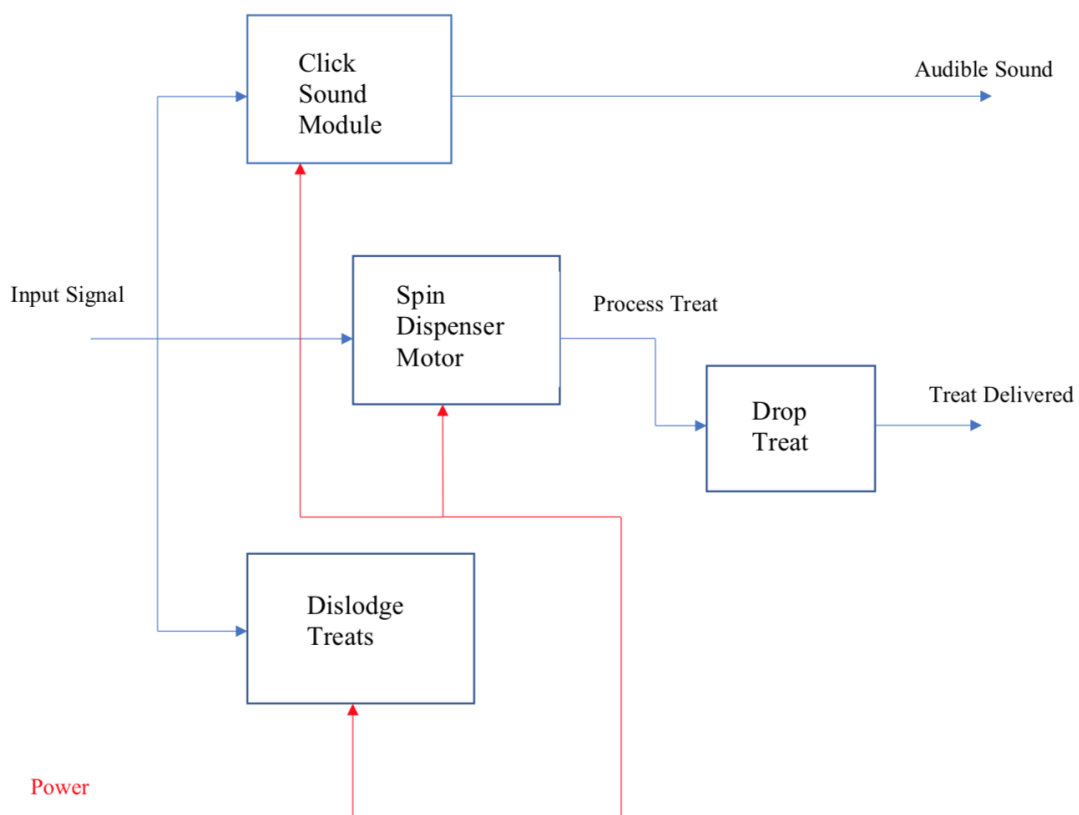
This allows the bulk of the unit to be mounted on the back of the wheelchair where it can be out of sight and not interfere with the user's ability to get through doors or other tight places.

This design should provide the most flexibility and use across many wheelchair types.

Functional Decomposition

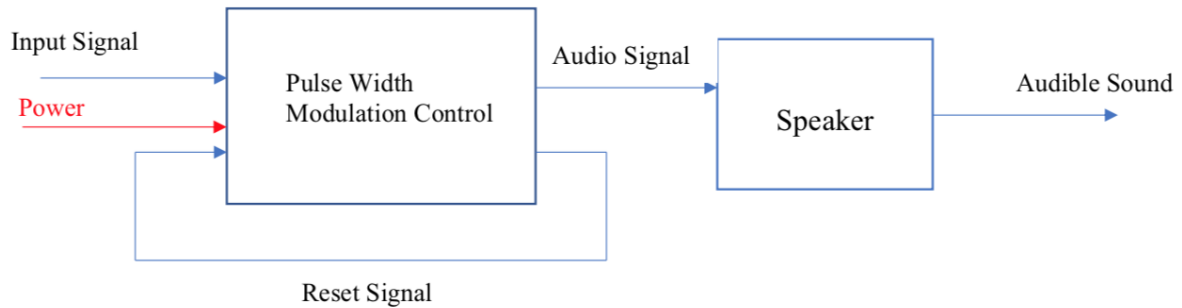
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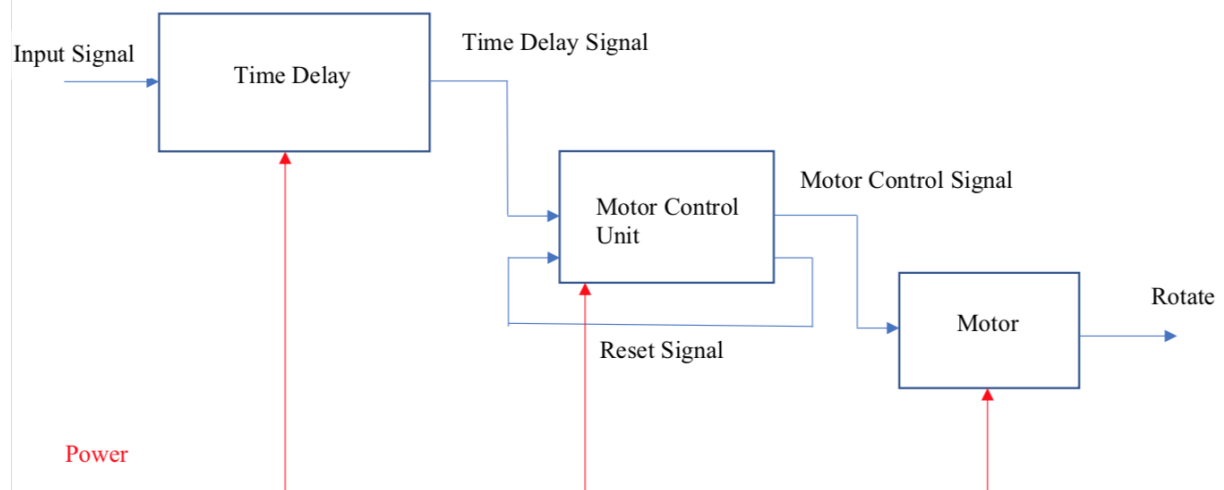
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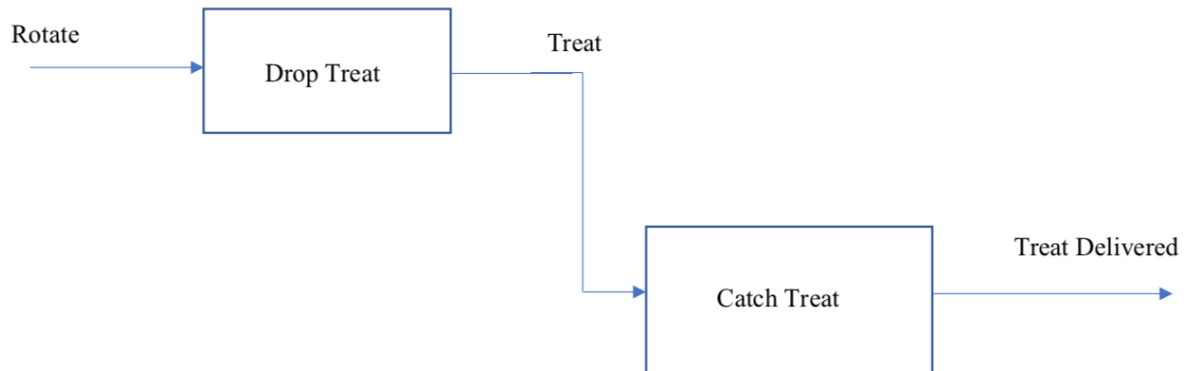
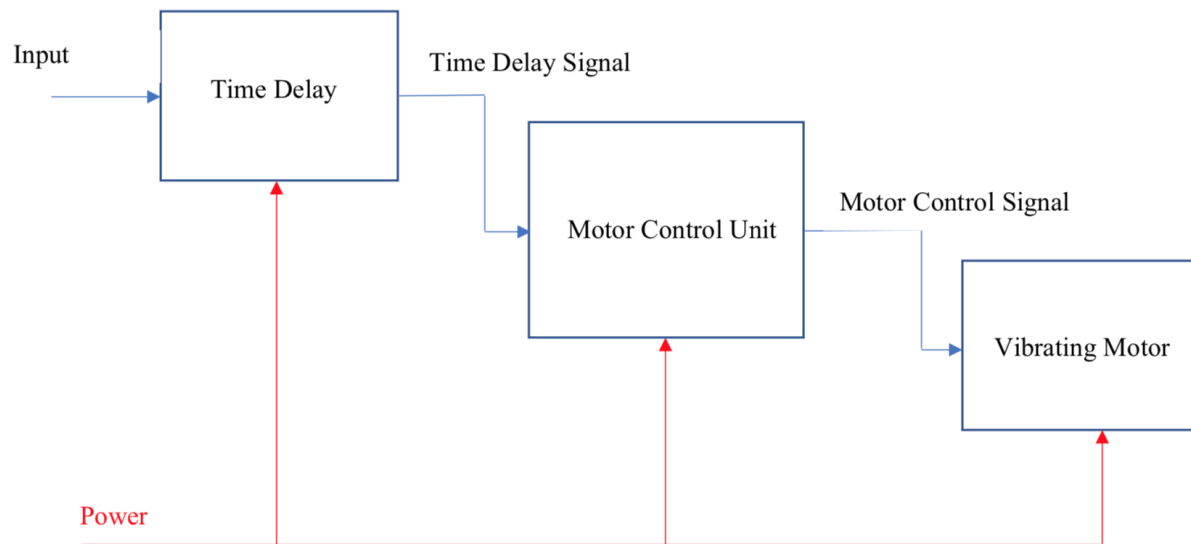
Level 2

Function: Click Sound



Function: Spin Dispenser Motor



Function: Drop TreatFunction: Dislodge Treats

Preliminary Experimentation Plan

For the project team to properly assess the effectiveness of our design we will need to create several use cases in interactions with the dispenser and anticipate how dogs will react before and after the dispenser operates. The project group also must ensure that the dispenser can vary how many treats it dispenses to the dog to ensure that the owner's interaction with the service dog is reflected properly. Per Dr. Neuber's information this is important that the original training the owners received can be done with this dispenser without much fault.

Experimental Plan #1 objective will be to have the device dispense any number of treats from the container that holds the treats to the dog bowl mounted onto the wheel chair. The components of this testing case will be a stopwatch, measuring device, and dog treats. Time is important in this first experiment as it tests how long it takes for user input to be relayed and how the service animal reacts to the outputted dog treat. Time from this experiment will be logged for each service animal we work with to ensure that the response we receive from these animals is not unique. We will focus on ensuring that the device is able to dispense a single treat before moving into our follow up experiments. Both time and observed behavior will determine whether or not the base design would need to go under refactor or not. One thing to note is that jamming in the dispense step may cause the device to malfunction and third party will be ready to provide treats to the dogs in the event the device fails to. A scatter plot chart will be used to compare the time observed for a treat to drop and a bar graph will be used to measure the success and failure of the device. Success will be evaluated if consistency across multiple service dogs is reached and the customer who is leveraging the device believes that it was easy to use.

Our second experiment will then focus on variable user input. Our goal with this design is to ensure that a service animal owner can control how many treats the device can output per run. We will leverage a measuring device, a stopwatch and dog treats similar to experiment one. The testing aspect will be the variable inputs that the owner will perform. The data that the group will collect is whether the device output the correct amount, how long did it take to drop the right amount and whether or not the dog had responded as it normally would given that amount. We will focus on ensuring that the time between input and output is kept as low as possible while ensuring the proper amount of treats matches what the user had requested for. Time will be evaluated on each run to ensure that there are no unique cases based on the service animal or the operator. The device that is being used to input these treats will be independent of the device that is dispensing it as the input device will have the same input connector that is standard for those with mechanical disabilities. A scatter plot chart will be used to compare the time it took for the treat to dispense depending on what the user has inputted. Each input value will have its time compared appropriately while a companion bar graph will demonstrate the successes and failures of the trial runs. If it's determined that the device is constantly outputting the incorrect amount of treats the design team will need to refactor the method of dispensing the treats. Success will be determined when variance on dropped treats reaches zero and the service animal owners user input is properly matching what is being sent to the dispensing device.

Preliminary Project Plan

List of Major Tasks

- **Hardware procurement (1 Week)**
 - **555 Timers**
 - **Rotary Device**
 - **Switches**
- **Hardware development (3 Weeks)**
 - **PCB Design**
 - **PCB Assembly**
 - **Power evaluation**
 - **Storage Container**
- **System Integration (3 Weeks)**
 - **System rotary design**
 - **Variable output functionality**
 - **Accelerometer functionality**
- **Wheelchair Integration (Weeks)**
 - **Placement verification**
- **User Acceptance Testing (2 Week)**
 - **Experiment #1**
 - **Experiment #2**
- **Data Analysis and Refactor (1 Week)**
 - **Feedback review and data review**
- **Reportings (2 Weeks)**
 - **Initial Progress Report**
 - **Mid-Flight Report**
 - **Final Report**
- **User Acceptance Testing (2 Week)**
 - **Experiment #1**
 - **Experiment #2**
- **Faculty Demos (Part of reporting)**
 - **Demo #1**
 - **Demo #2**
 - **Demo #3**
- **Customer Demo (Part of reporting phase)**
 - **Demo #1**

Gnatt Chart

Potential Problems

Since the automatic dog treat dispenser is mostly a mechanical device and is responsible for moving hard dog treats, failures are almost guaranteed. The simple fact that the device is trying to feed treats that are not necessarily uniform through a dispenser that should work consistently is grounds for discussing methods of overcoming issues like jamming or coming apart. As different design types are being discussed, it is apparent that each design will have its own set of problems that will need to be overcome individually as well.

Since the dog treats have the potential of jamming in the dispenser, the dispensing mechanism will need to be solid and able to push through a blockage up to a certain pressure. There is also a potential to add a vibrating motor to the device to rattle the treats loose in the storage compartment and ensure they feed into the dispensing area correctly. This vibrator could be in the center of the dog treat storage compartment to break up any sticky treats as well. The storage compartment will also need to be watertight as the wheelchair may be used in rain. If the treats get wet, they will not feed through the dispenser correctly and can cause other problems down the road, potentially shortening the life of the dispenser.

A major potential problem is that the service dog will not react to the dog treat dispenser. Since the treat is not coming directly from their owner, there needs to be a means to make the device interest the service dog. One potential solution to this would be to add the clicker sound to the treat dispenser that is emitted any time the device is activated. This clicker sound would be the same sound used to train the service dogs so there should be an immediate response. The dispensing/treat dish at the bottom of the device will also need to have some method to draw the dog's attention to it. The device does not perform its job correctly if the dog is unable to locate the treats easily. This dish should also be in the view of the wheelchair user so that they can confirm the treats were dispensed and that their service dog was able to retrieve the treats.

Another potential problem is to have the device easily wheelchair mountable. The device will need to be small to add flexibility of mounting locations and extendable, flexible tubes will need to be used so the dish can be mounted wherever on the wheelchair independent of the main device location. The device will also need to be robust and shock resistant so it does not fall apart while driving around in the wheelchair, which can have jerk-like movements.

As mentioned before, the entire dog treat track must be food safe. There are multiple sections to the device, so the introduction of connections between parts and having gaps can create unsafe areas for germs and bacteria to grow and develop. Thus, the device needs to be able to come apart fully for complete cleaning. It is a bonus if the dog treat track can be removed from the electronics and made dishwasher safe.

With the treat dispenser mounted to the wheelchair, and being battery powered, there is a potential for the device to lose power and stop working throughout the user's day. The device should either have indications of battery level that can be checked prior to each day's use, and/or have a rechargeable battery. There could also be a warning sound that emits when the battery is getting low and replacement or recharging is recommended. This is so the user does not falsely assume they will be able to start working on a new task with their service dog thinking they will be able to treat their dog all along the way. If they start and the device stops working partway through, there could be negative consequences of the training.

In the stopper-style design, a blade is introduced to help prevent jams and too many treats being dispensed. This also introduces a safety hazard if the blade comes loose. The blade will need to be firmly attached and easily removable so it is not flung on accident and can be cleaned.

The gum-ball and ferris-wheel style designs both introduce spinning wheels/discs, which can easily be jammed if the axis gets filled with gunk or food particles start to build up along the outside of

the discs causing them to scrape against their enclosure. The user will need to be able to open up this section and clean out any jams.

Since there may be some complexities to the design and pieces should come apart for cleaning, there is a potential that the user will not be able to put the dispenser back together. For this reason, the device should be somewhat modular with clear indications on what connects to where. An assembly diagram can also be provided and stuck to the device somewhere for easy reference.

The treat dispenser needs to help strengthen the bond between the disabled person in the wheelchair and the service dog and any problems that might get in the way of that need to be overcome. The device should be as simple to use as possible to make the user's life easier at the end of the day, not complicate anything.

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