Portable Doorknob Assistant

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Abstract
Every day people come in contact with doorknobs without even thinking about it. However, for the elderly and people living with motor disorders such as Parkinson’s, the simple task of turning a doorknob can be very challenging. Therefore, the objective of this project was to design a device capable of making the process of gripping and turning a doorknob easier. The approach the group took was to essentially change a doorknob into a door lever, which requires less dexterity to operate. To minimize the amount to work for the user, the device contains a motor that is activated by a switch. Two parts, referred to as grippers, clamp down on the doorknob when the motor is running. When the grippers are in contact with the doorknob, the device acts like a door lever. A pulse timer is used in order to power the motor for a set amount time. The pulse timer and motor are used for both clamping and releasing the grippers to ensure that the device is easy to operate.

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The Need for Project

Many disorders and disabilities can make it difficult for sufferers to complete everyday tasks, such as operating a doorknob. There are a large number of physiological and neurological disorders, diseases, and conditions, which lead to difficulty moving and completing everyday tasks. These include but are not limited to, Parkinson’s disease, Fibromyalgia, Arthritis, Multiple Sclerosis, and Cerebral Palsy. The device that has been designed will assist people suffering from rigidity, lack of fine motor control, palsy, joint pain, partial paralysis, tremors, natural complications from aging, or physical injuries. The ability to open doors on their own could dramatically increase the person’s independence and improve their quality of life.

The Design Project Objectives and Requirements

Design Objectives

The objective of this project was to produce an easy to use doorknob-gripping device to assist individuals with dexterity and motor control problems. The device can grip the doorknob in a way that provides the user with a lever instead of a knob, which is easier for most people.

Design Requirements

In order to design a useful and usable device, the final product had to fulfill certain requirements. The device weighs less than 2lbs, in order to allow a wide range of people to be able to use it. It was also necessary to keep the size small, less than 12”, so that it can be stored in a purse, or on a belt clip, in a convenient way. The device must be affordable for the majority of the population, so a purchase price of no more than 75 dollars was set and materials were reviewed to keep that goal in sight. The grippers must not only exert sufficient force to keep the device on the doorknob, but the material needed to have a high enough coefficient of friction to reduce slipping.

Design Concepts Considered

We developed three major potential designs, each of which has multiple aesthetic and/or functional iterations. In order to develop the optimal product, the group created a large number of potential designs. From these ideas, the design was narrowed down to a portable lever with two gripping surfaces, which contact the doorknob. The lever idea resulted in three major designs, two of which use a motor and drivetrain to work, while the third is purely user powered. All three designs had multiple layout
configurations, as well as multiple handle and grip designs; which were the gripping surfaces have a soft padding layer to conform to various shape doorknobs, as well as a high friction layer to prevent slipping.

**Lead Screw**

The first design uses a lead screw mounted in line with a motor to run a collar both toward and away from the doorknob. This design allows the user to place the device up to a doorknob and press a button; the jaws would then close and hold on to the knob. This design is more compact than the rack and pinion design, however, it is much more complex than the user powered design.

**Rack and Pinion**

The second design uses a rack and pinion for a drivetrain instead of a power screw. In this setup, the motor would be mounted perpendicular to the axis of travel in order to drive the pinion gear. Similar to the power screw design, the user would simply press a button to run the jaws either in or out in order to grip the doorknob. This design is the most complex and bulkiest of the three, but it is less likely to suffer from binding than the lead screw design.

**User Powered**

The last design is a completely mechanical design, based off of how a pipe wrench works. When rotating downward, the jaws of the device tighten around the knob; while rotated upward, the jaws spread apart and allow the user to remove the device from the knob. This design is the most compact and simplex, but requires a higher level of user control and dexterity than the two powered designs.

**Handles**

In order to be comfortable to use, the group investigated multiple handle designs. These included designs with finger grooves to decrease the chance of slipping, handles with a wide flat surface to provide more surface area to hold on to, and plain round handles of varying diameters. All of these designs were brought to a Northeastern University Physical Therapist for professional input.
Recommended Design Concept

Design Description

The final device was designed around the idea that the user has very limited mobility. The team decided to use a lead screw drive train powered by an electric motor. All the components of the device are incorporated into the lever handle making it compact and aesthetically pleasing. The device is 2 inches in diameter and 10 inches long. The gripper arms easily fold away for storage and transport. It is lightweight and easily carried for long durations without becoming a burden for the user. The device is rechargeable and would be sold with a recharging cable and transformer.

Analytical Investigations

The team made several key decisions during the design process. The first and most crucial was the decision to use the lead screw instead of the rack and pinion. This was chosen due to its compact construction in comparison to the rack and pinion. The team also decided to use a rechargeable battery because the user would likely have difficulty handling small batteries. This is especially true considering the original intent was to use a 9V battery, which would need to be pressed into snap terminals. Finally, the team conducted FEA analysis studies on components subject to higher stress concentrations. These studies helped the team choose materials for the collar and dimension the device to withstand the forces that it will be subjected to.

Experimental Investigations

The team started by testing the amount of torque required to turn a doorknob. Nine doorknobs were tested of various makes and models. The team used the results to find a motor that could adequately generate the required torque in the lead screw to grip the knob, while running at a high enough speed to be useful. The team also tested the force required to open a door, but a standard in the American Disabilities Act already has a maximum required force to open an interior door, meaning the results were not needed.

Key Advantages of Recommended Concept

The real advantage of this design is its size and weight. The team was able to make the housing not only act as the supplementary lever handle, but also act as the main support structure on which all the
internal components are mounted to. It is strong, light, small, and ergonomic.

**Financial Issues**

The device the group created is meant to be mass-produced. This would put the device between 60 and 75 dollars, when considering the processes that would be used in mass production. The group spent 460 dollars in designing and testing the prototype. The cost of the prototype was substantially more expensive since materials bought in small quantities cost more; which lead to an estimate of less than 20 dollars each to manufacture. In addition, doorknobs were purchased so the group could adequately test the final design. However, if this product were manufactured on a large scale, the necessary raw materials and labor to assemble it would allow the device to be sold at a lower price. Extruded ABS plastic was used to make the housing for the prototype but for manufacturing purposes, the part would be made from a polyethylene copolymer using injection molding. The initial cost of injection molding is high, due to the cost of the mold, but with large quantities being produced the subsequent cost per unit would end up being low. The collar is the least cost effective part since it requires machining at tight tolerances. The overall cost won’t be driven up much since the rods and screws can be bought in bulk and the motor and battery don’t require any in house labor.

**Recommended Improvements**

There are a few changes that could possibly be made to improve the chosen design. First of which is the motor control circuit; the chosen design uses a timer to run the motor; a good addition to this circuit would be a circuit breaker which would stop the motor at a given current instead of continuing to run. This would help improve product life, but may add an extra unnecessary level of complexity and cost to the design. Additionally, it would be beneficial to the user to incorporate convenience features, such as a small LED flashlight and battery monitor.