User Operated Hoyer Lift

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Abstract
The user-operated Hoyer lift builds on an existing technology and expands its functionality. Hoyer lifts are used in homes or hospital settings to move disabled people from beds to wheel chairs, toilets, or bath tubs. The user-operated Hoyer lift expands the functionality of the Hoyer lift to allow the user to operate it without the assistance of a second person, increasing their independence and dignity. The team was tasked with designing and building an inexpensive self operated Hoyer lift which can be powered by a cordless drill. To add this functionality the team designed a lifting mechanism, drivetrain, and steering system integrated with the lift.

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The Need for Project

In the United States alone there are over 1.25 million wheelchair dependent individuals and 2.5 million more in Europe. Presently many handicapped patients are transfered using a Hoyer lift, which can move them from a bed to a wheelchair or toilet. Although there are several different varieties of Hoyer lifts, only a few products on the market allow for unassisted use by a patient. Furthermore there are no free-standing crane lifts on the market which allow for unassisted patient use. For individuals who are disabled, simply going to the bathroom can be a daunting task requiring the embarrassing, and sometimes costly, assistance of a second person. The user operated Hoyer lift is intended to return independence and dignity to these people.

Cost of the lift is an important consideration. Lifts that are currently available, and offer unassisted operation to the user, cost in the $10,000+ range. These lifts also require modifications to the buildings in which they operate. The user operated Hoyer lift has a target manufacturing cost of $500, and requires no modifications to the buildings in which it operates.

The Design Project Objectives and Requirements

Design Objectives

Design a hoist to lift and transport a wheelchair patient to a toilet or bed, which can be operated by the user alone. The target is to be capable of lifting up to 400lbs weight, and control the manufacturing cost below $500.00. The power is supplied by a cordless drill. The given weight is the capacity for existing products on the market, and $500 is an estimated value based on our design and the existing products’ market prices.
Design Requirements

The design should be able to meet three major requirements: the weight capacity is 400lbs, the manufacturing cost is below $500.00, and the entire system (sling, crane and drive train) is absolutely safe and relatively comfortable to use. The sling should be painless to use, the crane should be easy to operate, and the drive train should be drove at a slow speed (no more than 0.5 miles per hour) and brake for emergency. The whole design should obey the safety code ASME PALD-2009 Safety Standard for Portable Automotive Lifting Device.

Design Concepts Considered

We developed five candidate design concepts of which two fully meet the requirements. In the beginning, we focused on the sling design. First, we fabricated a design of a vest and two leg loops with a lifting point at the chest and two lifting points at each leg. However, during the test process, it turned out that a chest lifting point could apply too much pressure under the arms of the patient, in which case, the patient would experience breathing trouble. Then we considered a design using two boards which can slide beneath the patient and lift the patient like a claw machine. But we could not find the ideal material for thin strong boards with an acceptable price. Then we came up with our final design which is a pair of lifting shorts for the patient to wear all day. The design has two lifting points at each leg like our initial design; however, instead of lifting the chest, we choose to lift the gluteus area where the sling is stiffened for sitting. Also, to keep the user upright, we added one more sling at the back of the waist at a proper angle.

For the crane design, we originally intended to move the crane’s arm which had a pivot at the end to connect the arm and stand. One the arm was lowered, the patient could hook the sling onto the hooks at the end.
of the arm. However, considering the budget limit and the variety in patient heights (e.g. bed, toilet, wheelchair etc.); we switched to our current design. The current design fixes the arm in a certain position, and uses a worm gear winch. The winch, powered by a cordless drill, lowers the rope and hanger. When the hanger reaches the reachable height of the patient, the patient is able to easily hook the sling (with a D ring at the end) onto the hanger.

For the steering and drive train part, we are staying with our initial front wheel steering configuration. Because of the front wheel drive, rear wheel steering configuration offers better maneuverability in tight corridors, like taking a tight corner in a hallway.

**Recommended Design Concept**

The user operated Hoyer lift consists of a lifting mechanism, propulsion system, and steering linkage. The design outlined by the team consists of a free standing crane, equipped with self propulsion and steering system. Both the lifting mechanism, and propulsion and steering, can be operated by a user while riding in a supportive sling. Power for both mechanisms is provided by a cordless drill, which is external to the device. While in use the drill is supported by a holster, so that the user does not have to support its weight. This also prevents it from being accidentally dropped.

The lifting function is performed by a winch which raises and lowers the sling that the user rides in. Power is transmitted to the winch via a roller chain which acts as a flexible torsional drive shaft.

Once suspended in the sling, the user can access the controls which are responsible for moving the lift around the home. Power from the cordless drill is transmitted down a drive shaft, to a differential which is located beneath the lift. From there, power is transmitted to the driving wheels through a system of drive shafts and universal joints.

Steering is controlled by pushing the drill left or right, like using a rudder. This actuates the steering linkage.

Based on cordless tool batteries available on the current market, the team estimates achieving anywhere from 30 to 170 lifts with one charge (number of lifts depends on size of battery pack).
Financial Issues

The total manufacturing cost of the user-operated patient lift prototype in total will be greater than originally anticipated. All parts will cost around 300 USD. We also purchased a base model lift to use at 250 USD. On top of this, expected fabrication cost will be around 200 USD. As we would perform all machining ourselves for our prototype the fabrication costs would be much less. But as this is calculated from the machining costs at $55.00/hr for close to 4 hours of work it would be much more expensive to produce this lift if machining was outsourced to a machinist.

This being said, to commercially produce the lift would lower costs significantly. For one thing, parts could be purchased at a wholesale value instead of one at a time at a marked up price. Parts could be also be machined at a much faster and more economical rate with improved processes. If more off the shelf parts were used such as a small differential gearbox and non-custom steering elements this would lower the cost as well. With the price of steel around $1.50/lb and an estimated weight of the steel needed for the lift around 70lbs this becomes a cost of 105 USD. Additional parts and labor would bring the commercial production cost close to 400 USD total.

Recommended Improvements

It is recognized that the design presented by the team is a proof of concept prototype, which only demonstrates lifting and propulsion capabilities. For a production version of the user operated Hoyer lift to be a viable market option, additional safety features are required. It is recommended that the following functionality be incorporated into the design for safe operation:

- Device should not be able to be operated without presence of a spare battery
- Lifting mechanism should have manual operation capability in case battery runs out.
- Drive train should have manual operation capability in case battery runs out.
- Lift should have ability to carry wireless communication device.