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Development and Fabrication of Foldable Portable Hybrid Crutches

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Abstract: Crutches and canes are widely used around the world as a means of providing stability and support for those who need them; the elderly population in particular utilizes these devices the most. It is very difficult for people with physical disability to maneuver. They always need a support or they use crutches to move. Moving using crutches is a very hard task. This task is very straining since this involves lot of manual effort. This is even difficult for a long distance.There are numerous products in the market that attempt to add a seat to the crutch or cane in an effort to alleviate the stress of standing for too long. However, there is no product involving electrical assistance to the crutches.Here is a step ahead to build a device which can accommodate both manual and motorized version. The goal of this workt is to design and build a device that can be used as either as crutch or as a electric scooter so that when user is tire, it can be unfolded and be used as electric scooter reducing strain on user. A first generation prototype was successfully fabricated using available mild steel raw material, motor, battery, control system etc. The prototype underwent load and dynamic tests in addition to this overall usability tests.

Keywords: Portable Hybrid Crutch, foldable, morised crutch, Advance Breaking, Throttle system

1.0 Introduction

Everyone can relate to someone who has, or has had some sort of single lower leg injury or condition. Whether it is a sprained ankle or broken foot, we all know someone. That said, according to the Cleveland Clinic there are over 23,000 reported ankle sprains in the United States each day. That is a very large number of just one type of injury that would justify the use of a single leg mobility device. Currently [1], there are many products on the market to provide mobility to people with single leg injuries or conditions. According to medical device distributors however; there is a shift from conventional mobility devices like crutches and canes, to more mobile and innovative devices [2].There are very less or even no, electric scooter that are foldable and which could be also used as a mechanical crutches. This is where the need exists.

Single leg mobility devices provide individuals who have a single leg injury the ability to be more mobile and self-sufficient. Devices currently on the market include crutches, canes, and prosthetics; all of which have their advantages and disadvantages.

Starting from the simple cane crutch to the high end portable hybrid crutches (PHC), ergonomics plays a vital role in the design and development of the crutches [1,3]. Some folding canes have the same functionality as the basic cane but have the added benefit of being foldable. This makes it easier for the user to transport the cane or store it in a smaller place[4,5]. In order for the folding function to be useful the user must have the physical and cognitive ability to operate the folding mechanism; some folding mechanisms [6][may be more difficult to operate than others. Users of quad canes may also have problems with the large base coming into contact with their feet during walking, which can pose a tripping risk [7]. There are also tripod canes which often have an attached seat. This cane helps those users who cannot walk far distances without a break or cannot stand for long periods of time by giving them a portable seat. They also are bulky and are not easily stored.

While there are many benefits to crutch use, there are also some drawbacks that should be taken into account before using them [8-10]Since the elderly population is more susceptible to injuries, they should take care when operating crutches, especially auxiliary crutches. Auxiliary crutches have been known to cause injuries such as upper-limb overuse injuries, shoulder-joint degeneration, injuries to the arms, hands and pectoral areas, and carpal tunnel syndrome [11]. Many of these injuries can be attributed to the fact that auxiliary crutches are designed to take much more bodyweight than other types of crutches. Therefore, there are larger forces acting on the user's body, especially the underarm, resulting in injuries[12]. Additionally, since crutches take so much weight off of the body, the user must have sufficient arm strength, balance, and coordination to use them properly and effectively.

The main objective of this work is to convert the conventional crutches into foldable electric scooter. So that the user can use it as a scooter and use it also a manual crutches when needed so that he doesn't get tired.

2.0 Materials and Fabrication of the PHC

Currently, over 6.8 million people use personal mobility devices and of those, 40% are estimated to be unable to perform their desired daily activities. The main target in this work is to serve the patient above twelve years with a single lower leg injury or disability condition. This device is specially designed to aid in the recovery from injuries, conditions and surgical procedures of the lower limb. The review of the literature and the market survey has revealed that, there is no single leg mobility scooter that can easily be folded and stored when not in use. Based on the above facts a portable hybrid cane scooter to fit this need, has been developed as shown in the figure 1.

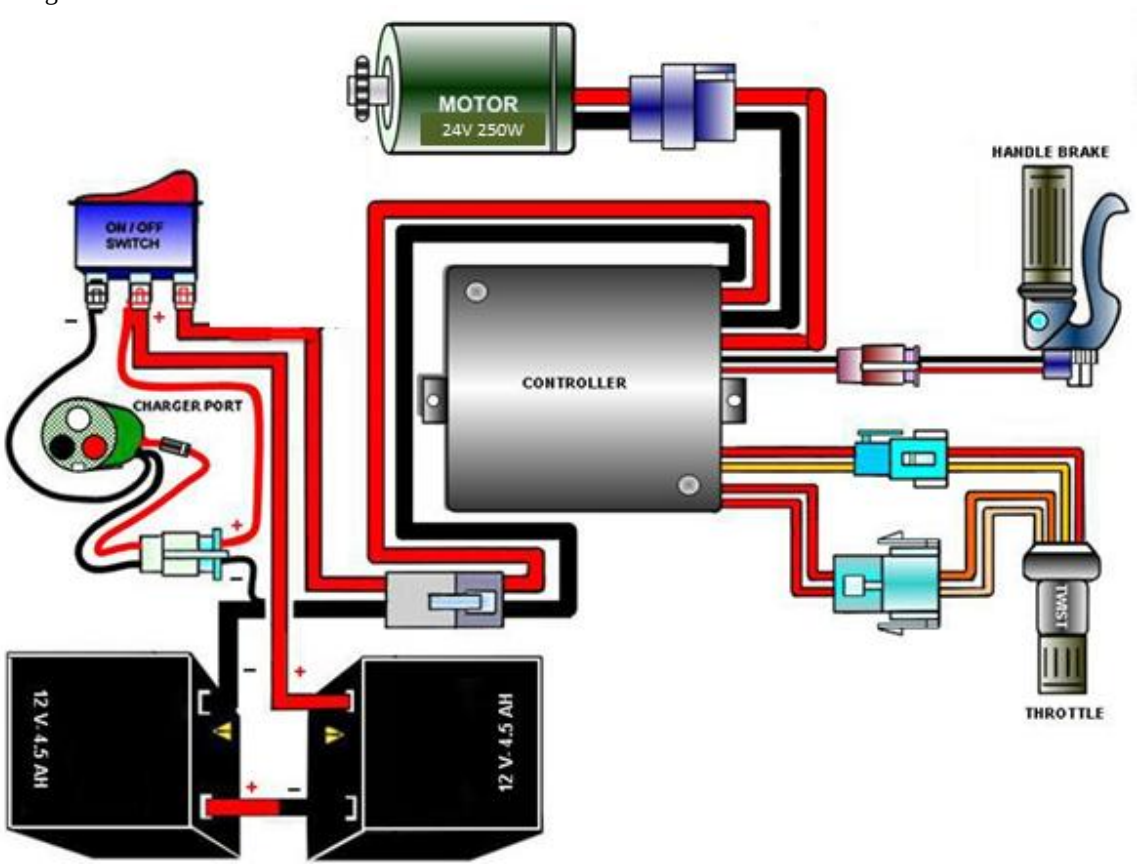

Figure 1. Schematic diagram of the flow control through the components

During working the signal is sent to the motor control. The switch is connectrd to throttle that sends ON/OFF signal to the control unit. The control unit sends the signal to the permanent magnet motor. The wheel is coupled to motor through chain.

2.1 Fabrication details

The main components of the fabricated PHC are the DC motor , controller and the breaking system. The details of which have been discussed below,

The ZY 1020 DC motor is a permanent magnet motor with very good efficiency and relability. With brushless DC motors, it is the rotor that is a permanent magnet. Changing speed of the rotating magnetic field effects rotor speed control. Torque is controlled here by varying the magnitude of the magnetic flux of the stator. (The flux, in turn, is controlled by changing stator current). These motors are relatively efficient due to the absence of brushes and can achieve average efficiencies of about 84% for both motor and controller together. Control, however, is a bit complex.

Figure 2. ZY 1020 DC motor.

Microcontroller used in this PHC is ATmega8. The ATmega8 is a low-power CMOS 8-bit microcontroller based on the AVR RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega8 achieves throughputs approaching 1 MIPS per MHz, allowing the system designer to optimize power consumption versus processing speed.

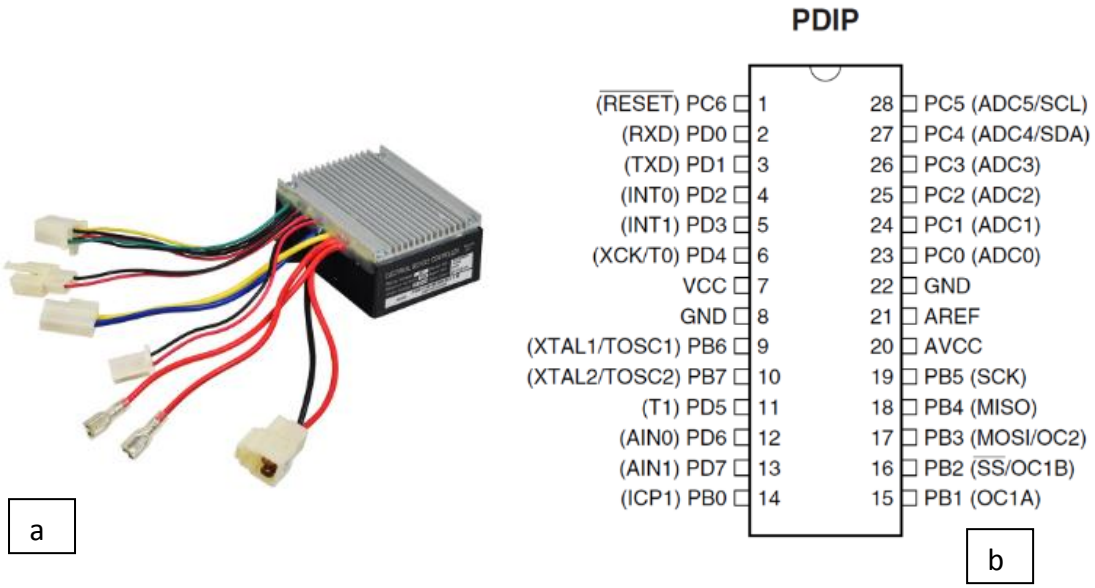

Figure 3.ATmega 8 bit microcontroller, a) Photographic view, b) Pin Configuration

Other components like wheels and break of the standard make have been used as shown in figure 4. The readily available wheels and the breaking mechanisms to suit the requirements were utilised for the fabrication.

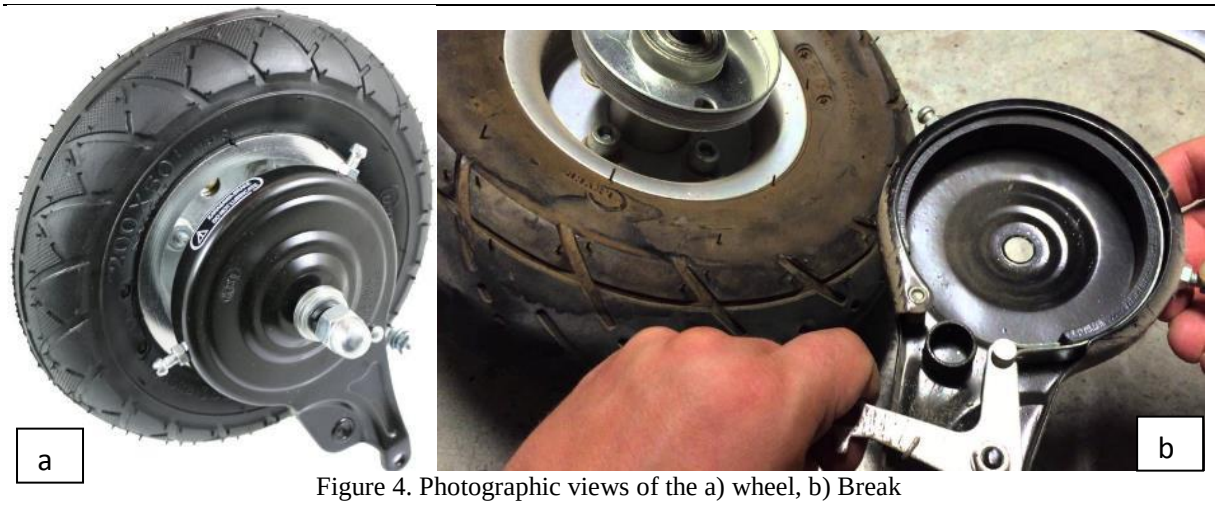

Figure 4. Photographic views of the a) wheel, b) Break

Another important component of the PHC is the throttle, which is as shown in the figure 5.

Figure 5. Throttle

A standard exide battery is used for the power supply and the entire sent up is fabricated using ASTM 1018 steel L angular, with an yield strength of 370 MPa. The final typical assemblies of the crutch are as shown in figure 6.

Figure 6.Typical Assemblies, a) Motor with chain drive, b) Sprocket wheel

The complete assembly of the PHC is as shown in the figure 7. As stated earlier the fabricated crutch can be used as a scoter as well as it can be folded as used as a manual crutch also.

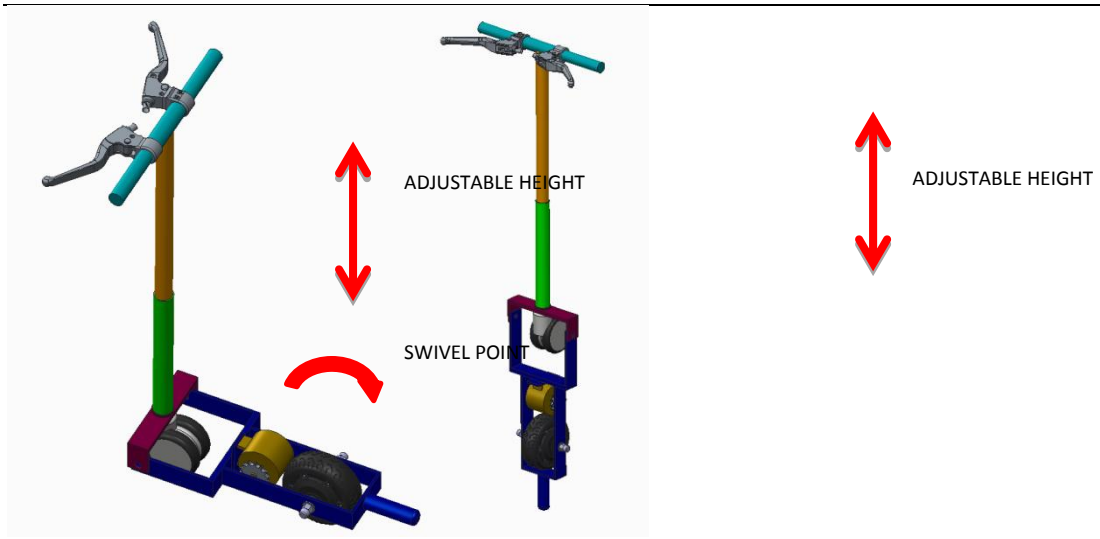

Figure 7.3D model of PHC, a)Front View, b) Side View

3.0 Prototype testing

Manual crutches is modified to fix the BLDC electric motor (250w), that will rotate on power supply controlled with motor driver to control the speed. This system has a decelerating setup to break the crutches. This setup is equipped with ultrasonic sensor to detect the object and to avoid the object by sending the signal to the braking system and obstacle avoidance system. This comprises of an ECU to control the system. Entire structure has been built on foldable linkages to make the crutches portable.

Portable hybrid crutches are designed with the front wheel steering system and with rear wheel drive system through chain sprocket system. Braking is facilitated with the brake shoe in the hub controlled by the cable. Braking is actuated with the help of the brake lever. he speed of the motor is controlled by the accelerator. The foldable feature is ensured with multiple linkages, when needed, the Crutches can be folded and used without motors with manual operation. If needed, the crutches can be unfolded accordingly to be used along with motor. This crutch comes with additional swappable batteries so that you can swap. The battery easily after it gets discharged within few second, and also this can be carried along to reduce weight in manual operation. Also a snap fit sit is provided to use if the rider wants to sit and ride. The actual views of the fabricated PHC is shown in figure 8.The overall weight of the device is around 8 Kgs without battery and is running at an average speed of 10Km/hr with a weight of 65Kgs.

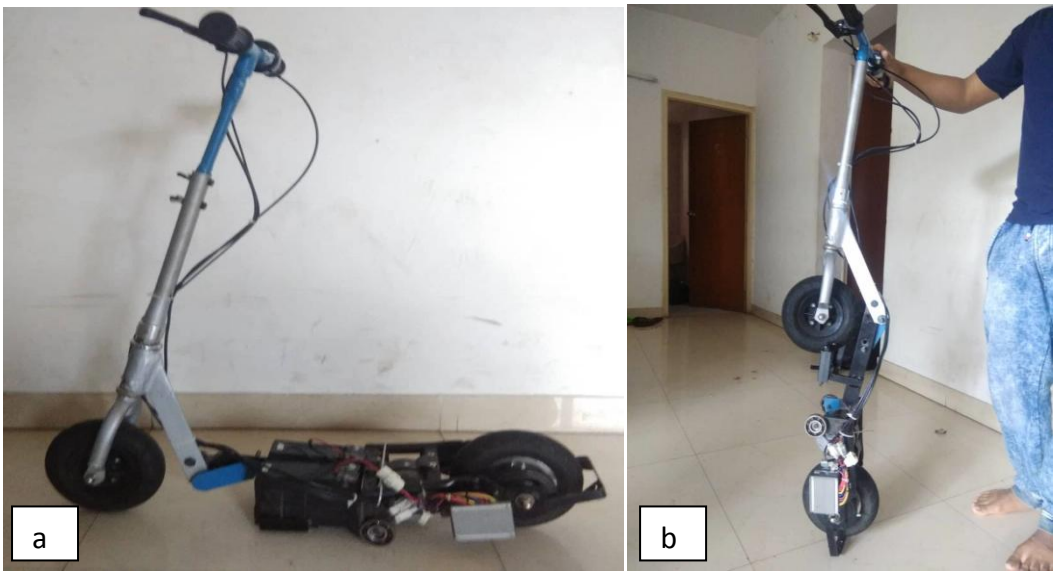

Figure 8. Fabricated PHC, a) Front View, b) Side View

The systems function and drivability of the fabricated PHC has been tested with actual conditions.The testing have been made in two phases. The first phase is functional test, in which the performance testing of the individual components of the system are tested for their rated specifications, which includes motor test, break test, throttle test, etc. The second phase includes actual test of the PHC during usage as shown in figure 9.

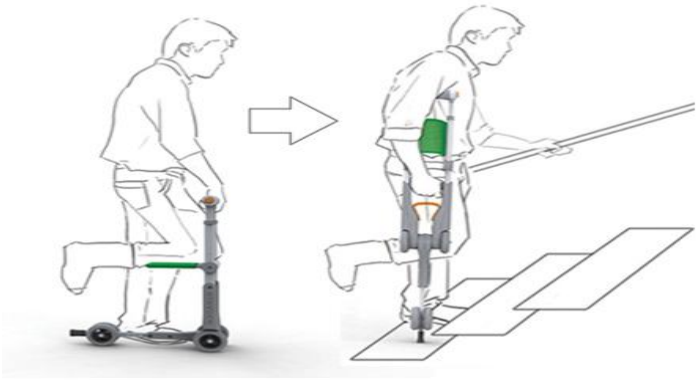

Figure 9.Use of PHC in folded and unfolded state.

As can be seen from the figure 9, these crutches are foldable and can be used for resting of leg on the additional seat and also the hand. Since the fabricated PHC has dual caster wheel for additional grip, balancing not needed. The adjustable height has proved to be very much useful in actual conditions of walk. The whole design has proved to be satisfactory during the actual testing on road.

After performance testing this PHC has proved to have many benefits compared to the early version of crutches like, easily Foldable and portable, very simple in construction and cost effective, light in weight, foldable and can be carried anywhere. This can be controlled manually or automatically with hands free using. This system has also consists of obstacle avoidance system and automated braking system.

4.0 Conclusions

The present study has been focused on the fabrication of the PHC and its performance study. The available crutches in the market have shown many drawbacks, especially for the ankle fractures. In view of this the fabricated PHC has proved its high efficiency and less human fatigue involvement. The PHC is designed with all ergonomic considerations. This has both manual mode and automated mode. Also this has got a unique feature like emergency braking, additional removable seat and swappable batteries. The performance test has shown that this can be utilized by the persons with varied heights, due to the presence of height adjustable handle. Further this can be developed into an autonomous mode by giving more intelligence to the crutches like automated steering, maneuverability. This can be made further light by using Lithium ion battery and using aluminum alloyas the frame material.

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