

Review of Motorized Tricycle for the Disabled Person

Tatyaso A. Garande¹, Prof. P.D. Sonawane², Prof. Dr. S.T.Chavan³, Prof. G.S.Barpande⁴

¹ME Mechanical Design Engineering Scholar,
Mechanical Engineering Department, Maharashtra Institute of Technology, Kothrud, Pune, Maharashtra, India

²Assistant Professor, Mechanical Engineering Department, Maharashtra Institute of Technology, Kothrud, Pune, Maharashtra, India

³Professor, Mechanical Engineering Department, Maharashtra Institute of Technology, Kothrud, Pune, Maharashtra, India

⁴Associate Professor, Mechanical Engineering Department, Maharashtra Institute of Technology, Kothrud, Pune, Maharashtra, India

Abstract: Nowadays, transportation is inseparable part of human life. Normal person can travel easily by utilizing the facilities such as bicycles, bikes, cars, public transports, etc., but for disabled persons travelling is not so easy. Depending upon the disability (i.e. which part of body is not in function), disabled person can avail travelling facilities such as tricycles, wheelchairs, customized vehicles like cars, bikes, buses etc. But these facilities are not easily accessible for disabled persons due to some difficulties. This paper discusses these facilities for disabled persons.

Keywords: transportation, disability, tricycle, wheelchair, customized vehicles, disabled person

1. Introduction

In human life transportation is playing very important role from ancient time, due to transportation and communication facilities we say that, world is coming closer and closer. Day by day new vehicles with variety of models are coming into market. Normal person i.e. person without any disability can avail this vehicles easily. But in our society the number of disabled persons is also considerable, some of them born with disability, some get disabled due to accidents (road, workplace, natural calamities, etc.), large number of persons get disabled due to war activities and due to many other factors. Depending upon the severity of disability, the disabled persons can use the transportation facilities; persons with lesser disability can use the facilities as it is for normal persons, some persons are able to use the vehicles with little bit modifications like retrofitted bikes and cars. There are some utilities like wheelchairs, tricycles which are used by the disabled persons. In some cases the disability is so severe that person can't move from one place to other place without help. The persons with hand and leg disability are able to travel but they are unable to use the vehicles for normal persons as it is. So the vehicles are modified (customized vehicles) to make them accessible to the disabled persons.

In this paper we will see the survey of some of the ways available for disabled persons for increasing mobility. Depending upon disabled part of body, different provisions are available like crutches, wheelchairs, tricycles, customized vehicles (retrofitted bikes, cars etc.). Crutches are most commonly used for walking for shorter distances, then manual wheelchairs [1] and hand-cranked tricycles [2] are useful for the persons with leg disability and automatic wheelchairs are designed such that persons with hands & legs disability can be benefited. In automatic wheelchairs many approaches are taken into consideration and depending upon that the control system of wheelchairs is designed, for

example smart wheelchair with control through deictic approach [3], intelligent robotic wheelchair [4], path following, stair climbing wheelchairs [5] etc. Another option of powered tricycles i.e. battery powered or solar powered tricycles [6], [7] is available for persons with leg disability. Currently many disabled persons are using modified vehicles like retrofitted bikes and customized cars which are having all the controls in hand.

2. Wheelchairs

A. Manual

Persons with lower limb disabilities are mainly dependent on manually propelled wheelchairs for the mobility. Manual



Figure 1: Manual Wheelchair [9]

wheelchairs are largely used in hospitals, which are generally driven and controlled by helping person. The manual wheelchair is as shown in Fig.1. If the user himself is

operating it, the controlling and driving of wheelchair is done by hands only. But as compared to legs, the hand work is less efficient and more straining; this leads to lower physical capacity of user. Therefore long term of use of manual wheelchairs is not advisable.

To reduce the local discomfort and fatigue other propulsion mechanisms are available now. This alternative mechanism reduces drawbacks of hand rim driven wheelchairs. Many experiments on lever and crank propelled wheelchairs have shown reduced straining and more efficient working. The tricycle like arrangement as shown in Fig.2, is using these mechanism proper movements of arm shoulder joints is happening, which allows the higher velocity of travel with less physical strain. The new design of wheelchair is improved by considering the guidelines of ergonomics; also many innovations came in picture to improve the suitability of wheelchairs.



Figure 2: Modification of wheelchair like tricycle [10]

B. Automatic

Because of the physical straining, driving of manual wheelchairs is not advisable for many disabled persons; also for the persons with more severe disability unable to drive the manual wheelchairs so there is need of automatic wheelchairs. Nowadays more user friendly wheelchairs are available in market, which are battery powered and controlled automatically or by using joystick.

In joystick controlled wheelchairs all movements are depends upon the position or movement of joystick such as neutral position-no movement, forward-backward motion, right-left position-turning, etc., also other buttons like start, stop, horn are provided. Fig.3 shows the typical joystick used for the wheelchairs.

There are many disabled persons who unable to move their hands and legs due to severity of disability. For them operating the joystick is also very difficult task, in such conditions the wheelchairs are designed with mobility assistance i.e. the motion is semi-autonomous or completely autonomous. The mobility assistance is useful for moving wheelchair in the complicated environment by avoiding the obstacles.



Figure 3: Typical Joystick for Wheelchairs

Smart wheelchair: As explained above there are many persons who cannot do movements of their limbs due to several reasons such as cerebral palsy, cognitive impairment or fatigue. The smart wheelchairs which are automatic or semi-automatic in operations can be used to increase the mobility of user with severe motor impairment. The operations are controlled by using user-machine interface. But there is no single solution available which will complete all the requirements from the particular wheelchair of the different users. The improvement in wheelchairs control is done in three ways: by improving assistive technology, the user-machine physical interface and controls which are shared by user and machine. The operations are in three modes 'stop', 'manual', and 'semiautomatic'. In smart wheelchairs inputs are taken by detecting motion of facial parts (i.e. blinking of eye, shaking), by voice and by button switch. The webcams are used to detect the obstacles in semi-automatic mode; also different sensors are used to detect the obstacles and current position of the wheelchairs. This helps to move the wheelchair efficiently without any collision. Mobility assistance is main part in smart wheelchairs.

1. Deictic Approach [3]: This is semiautonomous approach of controlling the wheelchair motion. In this the vision of environment is used as control interface, for moving from one place to other the location within the environment is specified by the user by pointing the interface. After that the wheelchair will move automatically at desired location.



Figure 4: Smart Wheelchair [3]

This approach is used in various fields like mobile robotics, tele-operation. For use of this approach in case of smart wheelchairs, the interface contains a video image of environment and by pointing the targeted location on the video image, the desired location is reached. This is the principle of deictic approach and the Fig.4 shows the smart wheelchair with deictic approach principle.

2. *Intelligent Robotic Wheelchair* [4]: In this type of wheelchairs the mobility assistance functions are designed for three different operators user, caregivers and autonomous behaviors and it is having five operating modes obstacle avoidance, joystick mode, handlebar mode, teleoperation and indoor navigation etc.

3. *Stair climbing wheelchairs* [5]: As like normal person the wheelchair user also needs to go from one floor to other floor of building so for that purpose the stair climbing wheelchairs are designed. For climbing the stairs the wheels of wheelchairs are modified such that climbing action comes into picture. This arrangement is shown in the Fig.4.

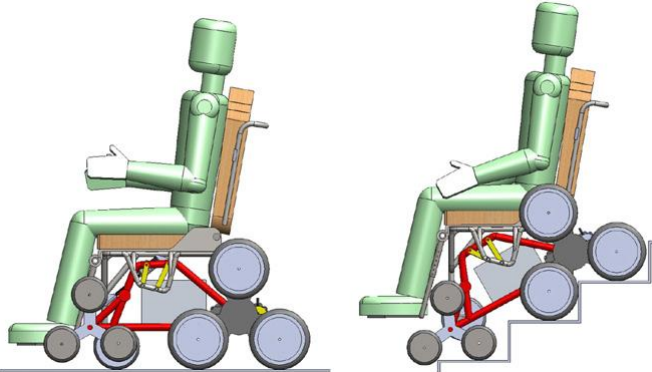


Figure 5: wheelchair on flat surface and on stairs [4]

3. Tricycles

Peoples with lower limbs disability use crutches, wheelchairs, tricycles, customized bikes and vehicles for travelling purposes. From these options some of them are less suitable for long distance travel and some are not affordable for most of the population. From this tricycles are most suitable and affordable for common peoples which are manually driven. The manual tricycle is as shown in Fig.5 is commonly used. The crank is moved by right hand and braking as well as steering is controlled by left hand also reverse arrangement is available. For driving the tricycle the user has to exert the muscular force.

The study shows that the person can travel around 30 km distance in a day with cycling for 3-3.5 hours with speed of 7.5-9.5 km/hour [2]. But complain from users is that the use of this tricycle results in more straining of chest and back muscles and this may result in increase in disability. Also as one hand is more in working (cranking) more fatigue conditions are occurring in short time of travel, so option of two-arm cranking is checked, which is more suitable ergonomically. The Fig.6 shows the actual picture of the manual wheelchair cranked by right hand and controlled by left hand.



Figure 6: Hand cranked tricycle [2]

As advancement in technology is going on, day by day easier solutions for the problems available are coming in existence. So more suitable options are available for giving the drive to the tricycle like battery operated electric motors. The battery operated tricycle which is having solar panels i.e. photovoltaic cells for charging the battery is as shown in Fig.7 [6]. Therefore for driving the tricycle we can use the solar power in combination with electric motors and battery.



Figure 7: Solar-powered tricycle end design [6]

As charging the battery by solar panel alone takes around 8 hours, so the hybrid model (pedal or motor power) is more advisable. This tricycle is tested on road with three conditions wind without panel, wind with panel and no wind with panel and the results are as shown in Table 1 and table 2.

Table 1: Pedaling vs Motor powered tricycle [6]

| Features | Pedaling | Motor Powered | |
|-------------------|----------|---------------|--------|
| | | Calculated | Tested |
| Speed (m/s) | 5.39 | 7.07 | 6.89 |
| Torque (Nm) | 3.7 | 16.7 | Varies |
| Power (W) | 65.8 | 864 | 864 |
| Travel range (km) | varies | 42.3 | - |
| Travel time (min) | varies | 99.7 | 95.0 |

Table 2: Test-run results of tricycle [6]

| Features | Wind (W_{NP}) | Panel connected | |
|---------------------|-------------------|-----------------|----------------------|
| | | Windy (W_p) | Not windy (NW_p) |
| Average speed (m/s) | 7.7 (0.7) | 6.89 (0.2) | 7.08 (0.1) |
| Travel time (min) | 87.3 (1.5) | 95.0 (1.0) | 100.1 (3.0) |
| Travel range (km) | 39.3 (0.91) | 42.3 (1.09) | 42.5 (1.52) |

Note: Standard deviation in bracket

4. Retrofitted Bikes and Modified Cars

Nowadays we often see the retrofitted bikes on road, which are fitted with one or two extra wheels on rear side of bike. In India, these vehicles are retrofitted by authorized workshop holders by ARAI, Pune, India. The Fig.8 shows the retrofitted bike used by the most of the disabled persons. These vehicles are useful for the persons with leg disability i.e. the persons who are using manual wheelchairs, tricycles and crutches or can walk with dummy leg etc.



Figure 8: Retrofitted Bike

Use of these vehicles is possible only for those, who can sit on bike without any help i.e. for using these vehicles the disabled person should be able to come out from his wheelchair or tricycle and sit on bike independently. As many disabled persons are unable to come out from wheelchairs and sit on the bike, this bike is useful for limited number of persons. One solution may possible to avoid above difficulty is to provide the vehicle which will accommodate the user with his wheelchair can be designed.

The modified cars also available for the disabled person, all the controls of cars i.e. clutch, accelerator, brakes etc. are modified such that, they can be easily & efficiently operated by the disabled person. The knob like arrangement is also provided on the steering which can be operated by the single hand. Note that this arrangement is useful only for those

people who are disabled by legs only and having all other body parts working as normal person. One of the cars having modified arrangement of clutch, brake and accelerator is shown in fig.9.



Figure 9: Modified controls of car [11]

In the cases where the disabled person could not come outside the wheelchair, specially designed ramps are provided to get inside the car with the wheelchair and then the wheelchair can be moved in the place of driver's seat and same modified car can be used by the disabled person, only difference is that the wheelchair occupants get inside and outside the car by sitting on the wheelchair itself.

5. Summary

There are various solutions available for travelling for the disabled persons like wheelchairs (manual, automatic), tricycles (manual, powered), modified bikes and cars.

1. The wheelchairs are useful for short distance travel. The manual wheelchairs need physical work from user or care taker.
2. The tricycles can be used for some more distance than wheelchairs but are not useful for long distance travel and also gives more physical strain to user.
3. The retrofitted bikes can be used for longer distance travel. But for using bikes the wheelchair user should be capable to come out and in from the wheelchair to take the position on bike. So the bike is not useful for most of the wheelchair users.
4. In case of modified cars also, the user needs to come out from the wheelchair. But nowadays the ramp provision is there for some of the cars, so by climbing the ramp the wheelchair user can drive his wheelchair inside the car and take the position of driver.

From above options only car is fulfilling most the requirements of the disabled persons (leg disability). But for most of the population option of car is not affordable. So there is need of solution to the problems faced by disabled persons discussed above, which will be less costly and allows the disabled person to take the drivers position without coming out from the wheelchair.

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