Electronic Wheelchair for Physically Disabled Persons

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Abstract
This paper highlights various physical disorders and its associated disabilities. Plenty of wheel chair have been designed so far. A wheel chair which can assist the disabled people in their day to day life became a necessity. It is possible if their other organs of the body assist the electronic gadgets. Proposed method helps the physically challenged people to make their journey through electronic assisted module which works on signal processing over speech and image. This system works via speech or through recognition of hand gesture. To overcome the loss of signal because of real time inputs, different signal enhancement techniques are introduced to achieve high rate of accuracy and stability. The system's response time is very much considerable as the delays of the system are quite reduced. The operating system created to work on gestures and speech was tested on the test bed with different sets of data. Results marked prominent impression over the conventional ones with accuracy rate of 84.66% in case of image processing and 82.33% in speech signal processing. The refinement of the electronic wheelchair is going to definitely help many suffering from the disease.

Keywords: Disability, Electronic Wheelchair, Feature Extraction, Motion Detection, Signal Enhancement

1. Introduction
This proposed system is basically helpful for incapacitated persons who are enduring with Parkinson's sickness or physically debilitated or immobile patients. These kind of persons can't move on their own. They generally rely upon different persons. This proposed technique is extremely helpful to debilitated persons as it can help them to move themselves without even the assistance of any human. Conventional wheelchairs utilized belts as a part of the drive-train. The engine turned a rotor which had a belt wrapped around it and the belt had the ability to rotate the wheels. Today's wheelchair engine turned into gears which forces the wheels to rotate. Direct commute is more dependable and needs less maintenance. Basically, this wheelchair was called as hot seats until have an advertiser announce this item to the general population as an electric wheel seat. This wheel chair have ingredients like batteries, engine, water powered framework and the adjustable seat. Moreover, utilizing the drive instruments to make the drive more easier.

The paper is divided into four sections: (1) Literature Review describing the conventional wheel chairs operation; (2) Materials and methods is containing the methods adopted for the research along with the algorithm and other parametric details; (3) Results and discussions highlights the significance and effectiveness of this technique over others followed by conclusions.

2. Literature Review
Wheelchair structure is one of the fundamental vehicle used in case of disabilities. But it needs human energy to move it. Moreover it can't be used for a long extended period as the customer will lose its energy in moving the seat using his or her own specific essentialness. The other issue could be the vicinity of wheel near seat is also less pleasant. The limited compartment is really basic and has no spaces to store the customer's things and stuff.

2.1 Wheelchair
Wheelchair is an adaptability contraption in which the
customer sits. The device is incited either physically turning the wheels by the hand or by method for distinctive robotized structures. Wheelchairs are used by people for whom walking is troublesome or unfathomable as a result of infirmity like physiological or physical, harm or impairment. People with both sitting and walking insufficiency routinely need to use an wheel seat. The most prompt record of wheelchairs does a reversal to the 6th century and was found engraved on a stone slate in China⁴.

2.2 Handicapped
Impairment can be characterized as the loss of capacity or glitch of the human bodies. Impediment can be classified into a few sorts. The state of being not able to execute as a result of physical or mental unfitness, for example, perusing inability and listening to hindrance (Robert Feeney Associates, 2002). It is similitude with inability or disablement.

2.3 Types of Conventional Wheelchair
Nowadays, there are various kind of wheelchairs that is open in the business. It is layout considering unmistakable shapes and limits. The various types of wheelchair are manual wheelchair, electric controlled wheelchair, sport wheelchair and shoreline wheelchair; each one of having different structure and function.

2.3.1 Manual Wheelchair
Manual wheelchairs are those that obligate human vitality to move them. Various manual wheelchairs can be crumpled for limit or circumstance into a vehicle, though display day wheelchairs are practically as obligated to be inflexible encompassed.

2.3.2 Electric Powered Wheelchair
Three general styles of Electric Powered Wheel seats (EPW) exist: Back, center, front wheel driven or four wheels driven. Each style has particular dealing with characteristics. EPW are confined by means of seat coupled models which was brought into the market after manual seats, with a sling-style seat and packaging, where as others have ‘Captain’s Seat’ seating like that of a vehicles. EPW run the extent from little and helpful models, which can be broken down or destroyed, to broad and overpowersing full-highlighted seats. EPW may be formed especially for indoor usage, outside utilization or both. They are all around prescribed for persons who experience issues using a manual seat due to arm, hand, shoulder or more expansive disabling conditions and don’t have the leg strength to move a manual seat with their feet⁴.

2.3.3 Sport Wheel seat
Injured contenders use streamlined diversion wheelchairs for incapacitated amusements that oblige velocity and deftness, for instance, ball, rugby, tennis and dashing. Each wheelchair diversion tends to use specific sorts of wheelchairs and these no more look like their common cousins. They are different in assembling, which keep the appropriate place for the wheels thus giving security in the midst of an sharp turn and made of composite, lightweight materials. Sport wheelchairs are generally not made for common use. Though a couple of customers support the amusement options for customary. Another diversion has been made for powerchair customers called powerchair football or power soccer. It is the fundamental forceful gathering movement for powerchair customers. The Federation Internationale de Powerchair Football Associations (FIPFA) controls the diversion and is arranged in Paris, France with country auxiliaries around the world.

2.3.4 Beach Wheelchair
This wheelchair permits clients to enter into the water thereby giving a superior portability in the sand. There are heaps of diverse models accessible. In numerous nations of Europe, where the Accessible Tourism is all around situated; it necessitates to have a wheelchair whose works consistent even on loose sand.

2.3.5 Electric Wheelchair (ZUMP-3)
Prof. Dr. Rosli Abu Bakar (2008), «Configuration and Development of Simple Electric Wheelchair for Disabled Community (ZUMP-3)». The program was dedicated to impaired individual Miss Siti Hawa Binti Apandi who was a high school young lady with a hereditary ailment called ‘Spinal Muscular Atrophy Type II’ (SMA-2). To defeat this issue, FKM group scientist improved the wheelchair structure according to the requirement of the general data of wheelchair client. It constitutes of four directional touchy joysticks with ergonomic configuration. It is less demanding to use with on/off catch. It additionally
3. Materials and Methods

This section deals with the (1) Identification of suitable general wheel seat for the use of impediment individuals; (2) Redesigning of wheelchair framework for impediment individuals and (3) Analyzing the basic piece of wheelchair configuration utilizing MATLAB firmware. The materials required to construct the wheelchair includes filters, weiner channels, MFCC’s etc.

3.1 FIR Filter

The term compelled drive reaction ascends in light of the way that the channel yield is taken care of as a weighted, limited term aggregate of past, present and potentially future estimations of the channel information i.e. one of the slightest complex FIR channels may be considered as a 3–term moving typical channel of the structure:

\[ y(m) = \frac{1}{3} [x(m+1) + x(m) + x(m-1)] \]  

3.2 Histogram Processing

The histogram of an advanced picture with force levels in the extent \([0, L-1]\) is a discrete capacity:

\[ h(r_m) = r_m \]  

Where \(r_m\) is the force esteem and \(n_k = \text{no. of pixels}\) in the picture with power \(r_k\). Histograms are then standardized by the aggregate number of pixels in the picture. Accepting a \(M \times N\) picture, a standardized histogram shall be:

\[ p(r_m) = \frac{n_m}{MN} , m=0,1, \ldots L-1 \]  

is identified with likelihood of event of \(r_k\) in the picture.

3.2.1 Histogram Equalization

Histogram balance is an average system for upgrading the region of pictures. But we have a photograph which is dominantly dull. By then, its histogram would be skewed towards the lower end of the weak scale and all the photograph subtle segment is squeezed into the dull end of the histogram. In the event, we could stretch out the weak levels at the weak end to make a more solid appropriated histogram, then the photograph would wind up being much clearer.

3.2.2 Histogram Matching

Histogram leveling normally chooses a change limit attempting to convey an yield picture with an uniform histogram. Another framework is to make a photo having an predefined histogram. Discover the histogram \(p(r)\) of the information picture and focus to its balance change:

\[ s = t(j) = (L-1) \int p_j(w) dw \]  

Utilize the predefined PDF \(p_z(j)\) of the yield picture to acquire the change capacity:

\[ G(y) = (L-1) \int p_y(t) dt = s \]  

Locate the reverse change \(y = G - 1(s)\); the mapping from \(s\) to \(y\) would be:

\[ y = G - 1( T(j) ) = G - 1(s) \]  

3.2.3 Local Enhancement

Past structures for histogram changes and histogram facilitating the world are over. In this manner, nearby change is utilized. Depict square or rectangular neighborhood and move inside from pixel to pixel. For every locale, process histogram of the packs in the zone. Get histogram similarity/particular breaking point. Aide faint level of pixel packed in the area. It can utilize new pixel values and past histogram to focus next histogram.

3.2.4 Use of Histogram Statistics for Image Enhancement

Let the force in a picture is represented by a discrete \(k_x\) in \([0, L-1]\) and let \(p(k_x)\) is the standardized histogram. The \(n^{th}\) measurable minute is:

\[ \mu(k_j) = \sum (k_j - m)p_k(k_j) \]  

Where \(m\) is mean & \(j=0 \geq \infty\). For picture intensities, a specimen mean:

\[ m = \frac{1}{MN} \sum f(X,Y) \]
Where X=0 ≥ M-1 & Y=0 ≥ N-1. As already, we may determine worldwide mean and change (for the whole picture) and nearby mean and difference for a predefined sub-picture (a subset of pixels).

3.3 Thresholding Transformations
Thresholding changes are particularly important for division in which we have to partition an object of energy from an establishment\(^{10}\).

3.4 Color based Recognition
If we know the extent of R-B-G values for a particular shading we have to perceive, then while taking care of the photo, we will scan only for those pixels which have R-B-G values in the extent of what we require for recognizing one of the 3 crucial tints – red, green or blue. We will check for each pixel whether the estimation of a certain channel (the higher the value the more the shading is accessible) is higher than particular utmost regard, moreover, the estimations of the other two channels are LESS than particular edge regard\(^{11}\). If the pixel meets that condition, it is thought to be of that the crucial shading.

3.5 Wiener Channels
Wiener channels are a class of flawless straight channels which join direct estimation of fancied sign movement from another related assembling. In the quantifiable way to deal with the arrangement of the quick separating issue, we expect the openness of certain genuine parameters (e.g. mean and relationship points of confinement) of the critical sign and undesirable included substance uproar. The issue is to orchestrate a straight channel with the uproarious information such as data and the crucial way of minimizing the impact of the confusion at the channel yield as indicated by some exact model\(^{12}\). An obliging way to deal with this channel change issue is to minimize the mean-square estimation of the mess up hail that is depicted as the capability between some reaction and the bonafide channel yield. For stationary inputs, the following blueprint is customarily known as the 'Weiner channel'. Its significant design helps to decrease the measure of clamor present in a sign by examination with an estimation of the search for quiet sign. All things are considered as utilized structure for picture remaking, relevant to the present paper, is the excellent Wiener channel. A sort of Wiener denoising channel is proposed which is a globalized way to deal with oversee patch-based denoising.

3.6 Mel Frequency Cepstral Coefficients (MFCC)
The technique for removing MFCCs is (1) Take the Fourier (accomplished for every window) and then map the log amplitudes of the range onto the Mel scale. Triangular covering windows are utilized as a solution.

3.6.1 Mel Scale
To change over between ‘f’ Hertz into ‘m’ Mel:

\[ m = 1127.01048 \log_e \log_e (1 + \frac{f}{700}) \]  

For ‘m’ mel into ‘f’ Hertz:

\[ f = 700(e^{\frac{m}{1127.01048}} - 1) \]

Take the Discrete Cosine Transform of the rundown of Mel log-amplitudes. The amplitudes of the subsequent range are the MFCCs.

3.7 Delta
By separating the MFCC coefficients, locate the first request level of progress.

3.7.1 Delta-delta
Found by separating the delta coefficients to locate the second request level of progress in MFCCs.

3.7.2 Energy
The log vitality of the sign is figured out by utilizing covering triangular windows.

Figure 1 delineates the component extraction in a stream outline.

3.7.3 Dynamic Time Warping (DTW)
Element time distorting is a system that is most pertinent to flags which are skewed or moved in time in respect to one another. Incase, if one sign is contrasted with another sign, that is, the same flag however moved in the x (time) pivot, then a point to point Euclidian correlation will result in expensive mistake. Then again, if the movement is represented, as it is in DTW, the two signs
will be perceived as being fundamentally the same, which they are. DTW is perfect for discourse acknowledgment, where single word shared by two clients is never precisely the same, yet regularly said with contrasting velocity or accentuation.

3.7.4 Feature Extraction
The review of the element extraction is exhibited in the outline beneath. The data documents are either digitized first if not pre-recorded orders and split into brief timelines. The ‘Cepstral coefficient extraction’ returns MFCC coefficients and the Frame Energy. These coefficients and vitality is further handled to determine the Delta-Cepstral and Delta-delta Cepstral coefficients.

The process of speech processing and analysing is broadly depicted in Figure 2 whereas the Cepstral coefficient extraction from fourier transform is shown in Figure 3.

As indicated in Figure 3, fast fourier change is connected to each of the casings of the digitized charge. The following step is to ascertain the edge vitality. The fourier change gives complex values out in its outcome. Keeping in mind the end goal to make utilization of those qualities, it should first be changed over to genuine qualities. The absolute estimation of an intricate number returns the size of the mind boggling numbers in the exhibit in genuine numbers and the genuine numbers are squared to ascertain the vitality.

These greatness squares are summed up to shape outline vitality as one of the parameters. The extent squares are additionally passed downstream to the Mel Filter banks for further preparing. The Mel Filter bank are channels outlined in light of the Mel Frequency scale. The Mel recurrence scale is composed with the goal that it speaks to the way human percept the sound. The Discrete Cosine Transform (DCT) is connected on the sign after it is separated by the Mel Filter bank. The resultant of the DCT is the Mel-Frequency Cepstral Coefficient.

3.8 Operational Flow
This sections illustrates the structure of:

- Image processing based system.
- Speech processing based system.

Mode 1: Image processing based system

*Figure 1. Method of feature extraction.*

*Figure 2. Speech signal analysing and processing.*

*Figure 3. Cepstral coefficient extraction process.*

*Figure 4. Block diagram of System mode 1.*
In this mode, the system will work on the colour detection where green color indicates the start of system, blue to stop and red to control the motion of the wheelchair. The concept can be visualised through Figure 4.

**Flow for mode 2:** Speech processing based system.

![Block diagram of system mode 2](image)

**Figure 5.** Block diagram of system mode 2.

Secondary mode used alternative to image processing is speech processing, the system will work on the speech commands of the user (refer Figure 5) and there are 6 commands initially provided to the user which can be recognised by the system as ‘on’ and ‘off’ i.e. one for the initialisation and other for stopping the system; rest four are to control the wheelchair motion as ‘left’, ‘right’, ‘backward’ and ‘forward’ respective to the motion.

**4. Results and Discussion**

In the proposed system, the accuracy and precision is taken at higher preference; in hope to provide the efficient system. Color Recognition module is tested with the three colors i.e. red, green and blue intended for operations like move forward, backward etc. Tests revealed that the average accuracy rate for the successful execution is 84.66 percent (refer Table 1 and Figure 6) which is quite prominent as compared to the existing models.

| Colors | Total tests | Positive Response | Accuracy(%) |
|--------|-------------|-------------------|-------------|
| Red    | 50          | 47                | 94.0        |
| Green  | 50          | 38                | 76.0        |
| Blue   | 50          | 42                | 84.0        |

**Table 1.** Accuracy statistics (Mode 1)

In case color recognition system becomes faulty, then an alternate module is provided which uses speech recognition to serve the purpose. Various responses have been recorded during the simulation whose average accuracy rate comes out to be 82.33 (refer Table 2 and Figure 7) which is marginally high as compared to the existing e-wheelchairs.

| Commands | Total test Responses | Positive Responses | Accuracy (%) |
|----------|----------------------|--------------------|--------------|
| On       | 50                   | 40                 | 80.0         |
| Off      | 50                   | 43                 | 86.0         |
| Backward | 50                   | 37                 | 74.0         |
| Forward  | 50                   | 40                 | 80.0         |
| Left     | 50                   | 45                 | 90.0         |
| Right    | 50                   | 42                 | 84.0         |

**Table 2.** Accuracy statistics (Mode 2)

Execution time in a wheelchair decides the efficiency of a technique. A little delay can take away the life of the patient. So, the execution time is considered to be an
essential parameter for the measuring the performance of a wheelchair. Analysis of time consumption for different categories have been cited in the Table 3 and depicted in the Figure 8. A significant reduction is noticed in the time consumption of proposed wheelchair as compared to conventional ones.

Table 3. Efficiency analysis of proposed chair (Both Modes)

| QoS Parameters                  | Total time taken (secs) | FPS | Description                                      |
|--------------------------------|-------------------------|-----|--------------------------------------------------|
| Initialization Time            | 36.83                   | --- | No color patch shown to cam.                    |
| Input Absorption Time (IAT)    | 72.43                   | --- | Different color patch is shown.                 |
| Video Initialisation           | 5.076                   | --- | Time consumed only once.                        |
| Detection process              | 16                      | 0.034 | Exists due to real time processing.             |
| Data transfer phase            | 9                       | 0.018 | Delay in data transfer.                         |
| Others initialization/process  | 41.87                   | --- | Consumed by various other factors.              |

Figure 8. Efficiency analysis of proposed chair (Both Modes).

5. Conclusions

The proposed design proved to be an efficient wheelchair working framework driven by color recognition and speech recognition. It is a framework that permits the administrator to associate with and order the framework at different levels of deliberation. A gadget has been designed which could assist a handicap and can give compelling simplicity in his life. Designed wheelchair has extended the existing methodology by offering two ways of fetching instructions i.e. one by speech and the other one through gestures. It is a smart wheelchair which could work even if module stops working. The framework has been tested successfully and it is efficiency in terms of minimum time in execution is found to be commendable. This framework will help to overcome restrictions of existing framework.

6. References

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