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Design of Automated Convertible Wheel Chair cum Stretcher

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***Abstract* – The patient who suffer from back injury or spinal disfunction spends majority of their time on a stretcher as they cannot sit with their back straight like any other healthy human. Whenever these patients want to move say within the hospital area or move from one floor level to another using an elevator, they need a wheelchair in which the disabled person is shifted from bed or another chair. This is in general uncomfortable both for the disabled person or others helping the person. Also, the morale of the persons may be affected as they have to depend on others repeatedly. Hence, there is a need to design of a mobile chair with some amount of automation. In this work a design of a stretcher cum chair, which converts from wheel chair to a stretcher simply with command from the smart phone is given. This design reduces the dependence of the disabled persons on others to maximum extent, and instilling confidence in them while they recuperate.**

***Keywords* – Spinal disfunction, Wheel Chair, Stretcher, Automation, Servo Motors, Bluetooth**

I. INTRODUCTION

As per the statistics available, in India the number of disabled individuals is increasing year by year due to various types of accidents. Physically challenged persons due to back or spinal injury need a constant and regular support of a wheel chair and a stretcher for movement form one location to another, whether it is with in the hospital area or at home. Mobility aids like wheelchairs or stretchers are useful for affected persons for transportation. As the disabled persons move, two different items chair and a stretcher are required and to move them support of a single or a greater number of persons is required making them very dependent on others. This is more demanding if the requirement is in odd hours of time. Wheelchairs and stretchers are the most commonly used medical equipment for the transportation of such persons or patients. The chair acts as a seating support and the stretcher is needed to lie down when they wish to sleep. A wheelchair may be described as a frame with a seat having either three or four wheels at the bottom of the frame to give the desired mobility. A wheelchair enables a disabled person to give better mobility and make them more independent.
Over the years, the evolution of wheelchairs has rapidly changed from a manual wheelchair to motor powered ones. Despite these changes happening, the needs of the disabled people are not fully met with. There is, therefore, a critical requirement to understand the problems faced by the disabled persons and redesign the wheelchairs to satisfy the needs and demands of the end-users. The design must be easy to assemble and has an ease of operation and maintenance. The design must include a simple mechanism, powered by electric motors preferably battery operated. In this work such a design and assembly of dual functional wheelchair cum stretcher is given, that would perform both the desired functions. This equipment provides the benefits of both the wheelchair and stretcher in a single unit. In this design a pair of servo motors are fixed to rear of the structure and the knee bends of the chair cum bed and a microcontroller is used to operate the chair cum stretcher using commands sent through the Bluetooth module and a smart phone either to convert the stretcher to wheelchair or vice versa without another person involvement.

II. LITERATURE SURVEY

Toshihiro Yukawa et al, 2012 [1] used a design with parallel mechanism and a gas spring that is manually used to convert a wheel chair into temporary bed and vice versa. While Padmanabhan M et al, [2] and Rashid Ahmed K et al, [3] used pneumatic cylinders at the hind and knee joints of the stretcher and it is manually operated to convert wheelchair to stretcher and vice versa. A worm wheel unit is attached the main structure at the bottom and is actuated by an electric DC motor operated using a push of a button was used by Smitesh Bobde et al [4] in their design. The worm wheel unit is mounted on a shaft and supported by two end Plummer blocks which will help in transformation. Among the existing wheelchair convertible stretchers available in the market use different types of actuators. About 30% units are electronic based, 28% are hydraulic based, 25% are pneumatic based and the rest 17% are mechanical units purely [5]. Various basic theories related to convertibility of wheelchair into a stretcher are described by Mohit Kumar et al, [6]. In the first option a sliding tubular frame is attached to the back rest of the wheelchair. A handle at the back rest converts the wheelchair into stretcher, when the end-user pulls the handle. In another variation a hydraulically operated scissor lifter mechanism is used to adjust

the height of the stretcher as per the end-user's convenience. Also, this hydraulic scissor lifter mechanism converts the wheelchair into stretcher. In next option, a geared mechanism used to rotate the central wheel and the seat and back rest are tilted to get the stretcher form. Toshihiro Yukawa et al [1] utilized a 24 V, 192 W electric motor to convert a wheelchair into a temporary bed. A joystick was used to control the velocity. Sumedh J. Suryanshu et al, [7] gave five mechanisms for conversion of wheelchair into stretcher. The end-user moves to the bed using the leg support pad actuated by a pneumatic cylinder. In second option, a conveyor mechanism is used to push the person from chair to bed. The chair provided with guides which revolve the chair by 360 degrees giving more accessibility to the end-user. A movable and extendable board attached to the seat part of the wheelchair is the third option. This extendable board is used to transfer the person from wheelchair to the bed. In the fourth option, a mechanism turns the wheelchair backrest so that it lies on the bed surface. The person can slide over the backrest to the bed. All the three electronically, hydraulically and pneumatically actuated wheelchair convertible stretchers at present are a more expensive whereas the mechanism-based wheelchair convertible stretcher is of less cost.

III. Selection of Components

1. Choice of Material and its Perks

Aluminum is used for the basic structure material as evident from Table 1, Aluminum has comparable and sufficient strength to iron or steel and at the same time its weight is only one third of that for iron or steel. Aluminum extrusions are strong for structural applications and, by extruding, the strength Aluminum parts is distributed to suit the requirements by varying wall thicknesses and internal reinforcement in the profile.

Table I: Comparison of properties for carbon steel, aluminum alloy and stainless steel

Property	Carbon Steel	Aluminum Alloy	Stainless Steel
Grade	S275	EN AW 6061 T4	EN 1.4401 (316)
Yield Strength in MPa	275	110	220
Young's Modulus MPa	$210*10^3$	$70*10^3$	$200*10^3$
% Strain at Fracture	24	12	45
Density Kg/M^3	7850	2700	8000
Thermal Expansion K^{-1}	$12*10^{-6}$	$23.2*10^{-6}$	$16*10^{-6}$
Thermal Conductivity W/m/K	54	250	16

Aluminum extrusions with unique combination of high strength and low weight make them ideal for applications where high strength is needed with limitations on weight. Aluminum combines strength with flexibility and can flex under loads or spring back from the shock of impact which makes it ideal material to carry patients and support motors those are needed to convert wheel chair to stretcher and vice versa.

2. Necessity of Sensors and Actuators

In most of the cases, a multipurpose wheel chair is actuated by either pneumatic or hydraulic power [1]. Both of these arrangements need more accessories like pressurized cylinders, leak proof supply lines and nuisance due to leakage. While in case of mechanism-based transformation, it is expensive and has to be manually operated. Needs more and regular maintenance. Hence, a motor which can be actuated by a suitable battery power and controlled easily is of the choice.

Table III: Table of components described in Figure 4,5 and 6

Component	Units	Color Scheme
Micro Controller	1	Dark Blue
Servo Motor 18 Nm	2	Orange
DC-DC converter	2	Purple
Servo Motor 83 Nm	2	Pink
DC to AC Relay Module	1	Yellow
Aluminum Extrusion Rod	9 m long	Black and Red
Pivot Joint	4	
Caster wheels	4	grey

LiPo 12V 100Ah battery	1	Green
Board for base	4	Blue

The total transformation procedure is actuated by using two pairs of high torque servo motors preferably two 83 Nm servos for the hip joint and two 18 Nm servo motor for the knee joint. The selected servo motors have higher torque than the calculated values, this is done in order to have a factor of safety of 1.2. Here the end-user weight is assumed to be less than or equal to 70 Kg [8] and of height about 1.6 to 1.65 m. These servo motors are enough to handle a person with his upper body weight of about 44 Kg and below knee weight of 4.5 Kg. The cumulative center of gravity of the patient plus the frame is assumed to be at designated joints and is accordingly calculated. 83 Nm servo motors are provided with 220 V DC power supply and a DC to AC converter needs 10V supply. Hence a DC-DC buck converter is used. A micro controller is used to operate the servos and another microcontroller is used to communicate with the end-user using a Bluetooth module. A smart phone is the interface between the microcontroller and the end-user. The micro controller provides Pulses or signals to the Servo motors while the motors draw power from a 12V 100Aah- LiPo Battery. This arrangement reduces manual interference and obviates the fear of hitting a wrong button by mistake as in case of manual operation.

III. DESIGN SPECIFICATIONS

1. Wheel Chair/ Stretcher Dimensions

A line Diagram of wheelchair cum stretcher in chair position with link dimensions is shown in figure 2. And a line Diagram of wheelchair cum stretcher in stretcher position with link dimensions is shown in figure 3. Both in Figures 2 and 3, red colour lines are used to represent the frame, blue colour lines are used to represent moving links, yellow circles are used for joints, where servo motors will be attached to the frame and green circle in the diagram denote the caster wheels.

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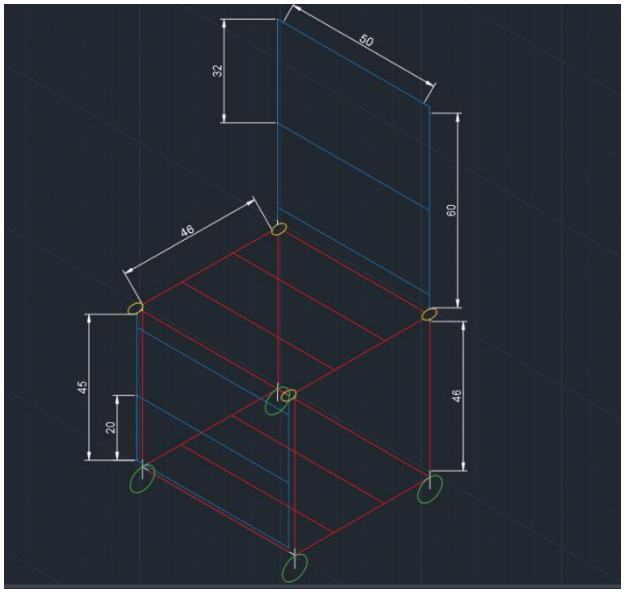

Fig.1. Isometric Line Diagram of wheelchair with link dimensions using AutoCAD

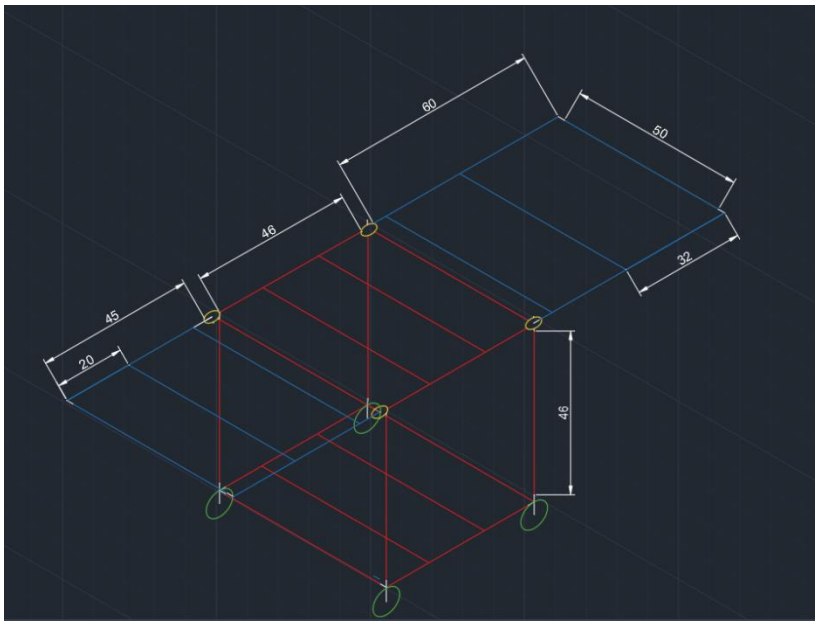

Fig.2. Isometric Line Diagram of stretcher with link dimensions using AutoCAD

2. Circuit Diamgram

The signal flow in the circuit used to operate the wheelchair cum stretcher is shown in figure 4 and in the circuit diagram shown, the red lines are used for signal and the black lines are for the voltage flow. Control signals are sent from the micro controller, Arduino Uno to the actuating servo and all the other elements in the circuit are supplied with suitable voltage.

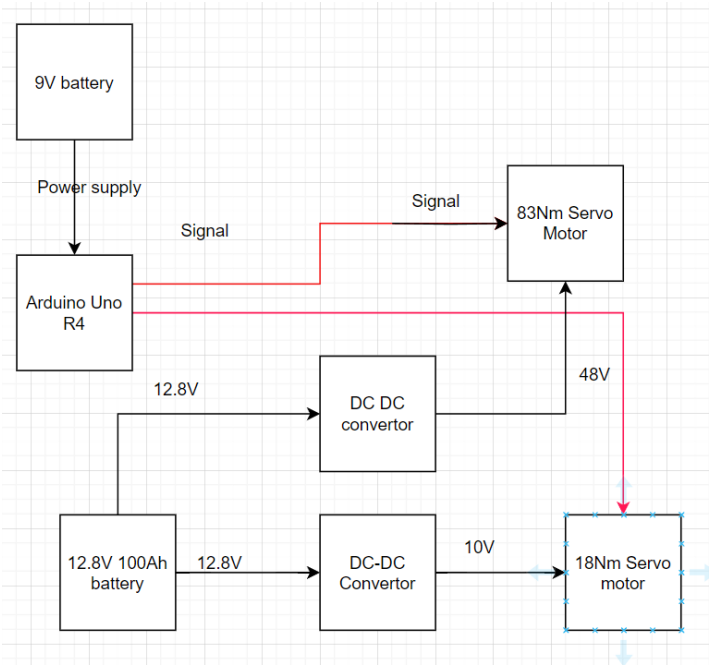

Fig.3. Schematics representation of electrical and electronic system for actuation.

3. Mechanism

When it is required to convert the wheelchair to stretcher form, a signal from the smart phone via Bluetooth is sent to the microcontroller that is operating the joints. With the receipt of the signal the right knee joint and left hip joint rotate by 90 degrees, while the left knee joint and right hip joint rotate in reverse direction by 90 degrees. And reverse action takes place when it is required to convert stretcher to wheel chair position. The knee joint Servo motors are directly connected to the pivot joint so their actuation is direct and main heavy servos are placed on board below the seat part of the chair. A

gear and belt drive system are used to transmit the motion from wheel servos to wheels. The gear is the yellow disc at hip joint in Figure 5.

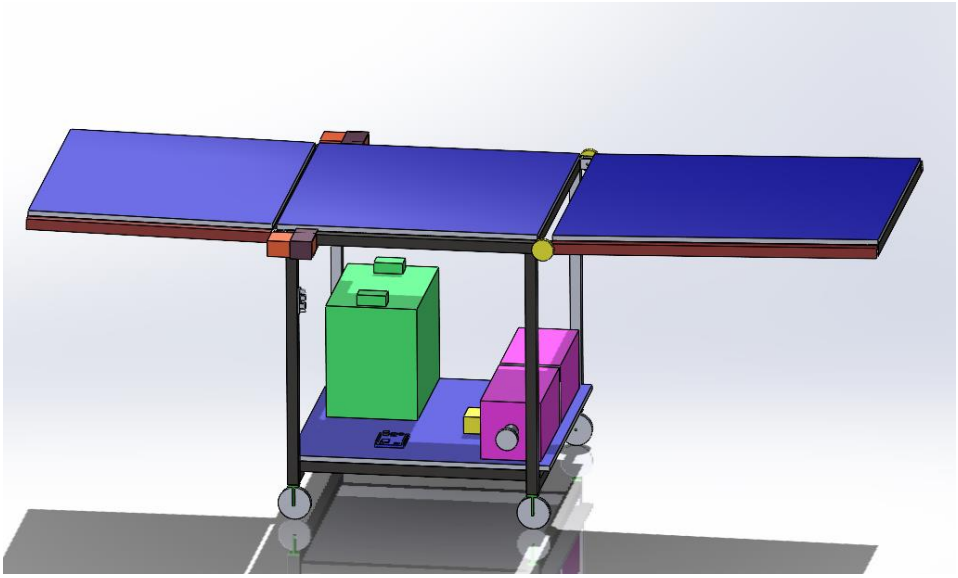

Fig.4. SolidWorks model of wheelchair in stretcher position along with position of all the components in it.

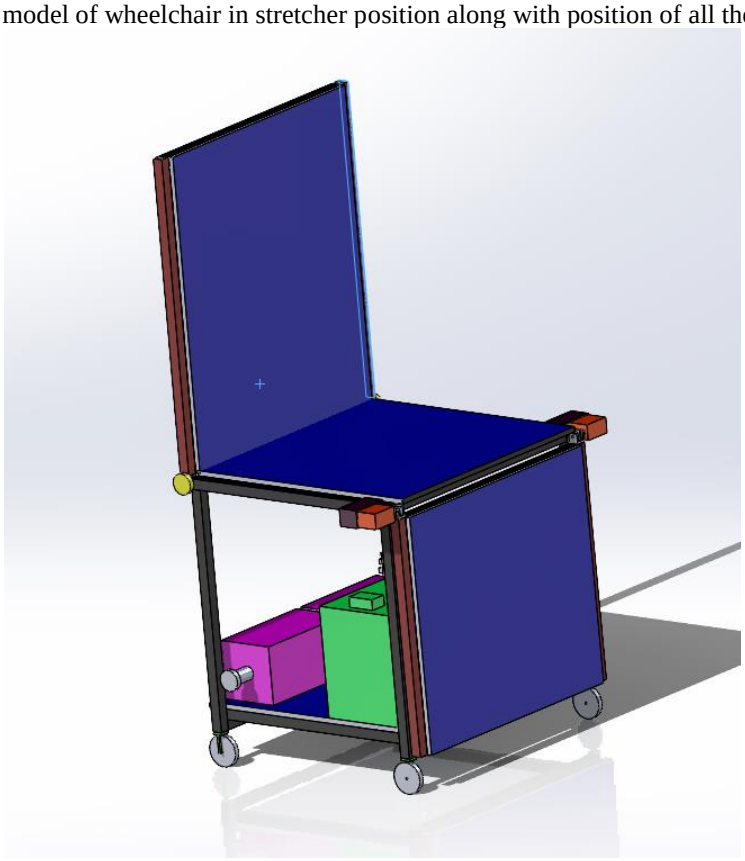

Fig.5. SolidWorks model of wheelchair.

IV. CONCLUSION

Persons with back or spinal injury need a constant and regular support of a wheel chair and a stretcher for movement form one location to another. The Convertible Wheel Chair Stretcher model is designed taking the kinematics of revolution as advantage which enables it to transform between a wheel chair and a stretcher making it possible for paralyzed patients

to either sleep or sit without the need of a third person's support. As and when required the wheelchair is converted to a stretcher, by sending a signal from the smart phone via Bluetooth to the microcontroller which is operating the moving joints. Up on receipt of the signal the right knee joint and left hip joint rotate by 90 degrees from zero position and the left knee joint and right hip joint rotate in reverse direction by 90 degrees to move to zero position. And reverse action takes place when it is required to convert stretcher to wheel chair position

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