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WHEELCHAIR OPERATION BY MEMS WITH STAIR CLIMBING MECHANISM

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Abstract: *This project is to develop a wheelchair which can be controlled with hand gesture. Manual movement of standard wheelchair can be difficult for a patient or people with mobility impairment. It also integrates stair climbing mechanism via track system that allows both ascent and decent motion with stability and size not more than any standard wheelchair and with maintaining aesthetics and low cost fabrication of the mechanism. Thus, wheelchair of this kind has been developed to overcome difficulties like application of manual effort for motion and disability of standard wheelchair being able to climb stairs. Wheelchair works with the help of DC motors and battery.*

Keywords: Wheelchair, MEMS, Hand gesture controlled, Stair-climbing mechanism.

1.0 Introduction:

A wheelchair consists of 4 wheels 2 large at back and 2 small at front, used when walking is difficult or impossible that is because of illness, injury, old age related problems, or disability. These can includes spinal cord injuries (paraplegia, Hemiplegia, and quadriplegia), broken leg(s), cerebral palsy, brain injury, Osteogenesis imperfecta a.k.a. brittle bones, motor neurone diseases (MND), multiple sclerosis (MS), muscular dystrophy (MD), Spina bifida, and more. This wheelchair can include special features for seating comforts, automated controls, they can also be used for special sports activities and also that can be used on beaches. There are different types of wheelchair that are run by batteries and motors that can be moved manually forced by the used with the help of hand or with help of someone pushing from behind. The electric wheelchair may be guided with different kinds of controls.

1.0.1 Accessories:

There are a wide range of accessories for wheelchairs. There are cushions, cup holders, seatbelts, storage bags, lights, and more. Cushions are used for comfort and posture. If a wheelchair user does not have proper posture with his/her wheelchair, the user will add a cushion to the seat. A wheelchair user uses seatbelts for security or posture. Some wheelchair users want to use a seatbelt to make sure they never fall out of the wheelchair. Other wheelchair users use a seatbelt because they can sit up straight on their own.

1.0.2 Electronic Powered wheelchair:

It is the type of wheelchair which is powered by mean of electricity. This usually includes batteries and electric motors fixed inside the frame. It can be operated by an individual with the joystick or hand switches, which are used to guide the wheelchair. Mainly switches or joysticks are situated either on the armrests or on upper rear of the frame. There are several options for the manual joystick, including headswitch, chin-operated joysticks, sip-and-puff controllers or other different controls, which can generate independent operations of the wheelchair for different users with variable motor impairments.

1.0.3 MEMS controlled Wheelchair _(Hand-Gesture controlled)

Wheelchair is controlled with the help of accelerometer and gyroscopic sensor. As per the movement of the hand, front, reverse and side motions are controlled. The declination of angle of the hand in forward direction will move the chair forward while inclination of the hand backwards will help in reverse motion of the chair. The angle of the hand can also be programmed in such a way that the higher the angle of the motion of the wrist, the higher the acceleration of the wheelchair and vice versa.

As shown in **figure** the motion of hand to control movement of wheelchair.

Reverse

Forward

Side Ways

1.0.4 Stair-climbing Wheelchair

Electronic battery-powered stair-climbing wheelchair acts as a convenient mobility device to assist people with disabilities climb up and down the stairs. With various features, it is the number one choice among users. Made of aluminium alloy metal, the wheelchair is lightweight and foldable making it easy to carry it anywhere. The chair can carry up to 100 kgs of weight and climb approximately 7 inch step. It is suitable to use indoor or outdoor, public buildings and private homes. With an integrated automatic braking system, the electronic brake locks tracks during stops on ascent or descent and can be stopped instantaneously. This unique product can help physically challenged patients to climb differing types of stairways with minimal effort.

The wheelchair has stable and self-supporting tracks grip that makes climbing the stairs secure. It is easy to use for one operator to move disabled individuals up and down stairs.

1.0.5 Objective:

While many manual and electronic wheelchairs are on the market, an adequate low-cost MEMS with stair climbing wheelchair is lacking. As per the market survey carried out it has been determined that the wheelchairs having stair climbing mechanism are highly expensive, also micro-electromechanical system (MEMS) integrated wheelchairs are expensive. Market has also observed demand of a wheelchair that integrates both MEMS system as well as stairs climbing mechanism.

Thus to meet the market demand, such a wheel chair is designed. To minimize the cost of single unit is an important objective.

2.0 Component Details:

The components that are used in fabrication of the wheelchair are kept under Indian Standards thus all the components are easy to replace and are accessible around the country.

The components that assembled together are:

2.0.1 Wheelchair

Frame
Wheels
Seat
Seat Handles
Leg Rest

2.0.2 MEMS System

MPU6050
Arduino UNO & NANO
Transmitter & Receiver
Motor Driver L298N
DC motor
Battery 12V

2.0.3 Stair-Climbing Mechanism

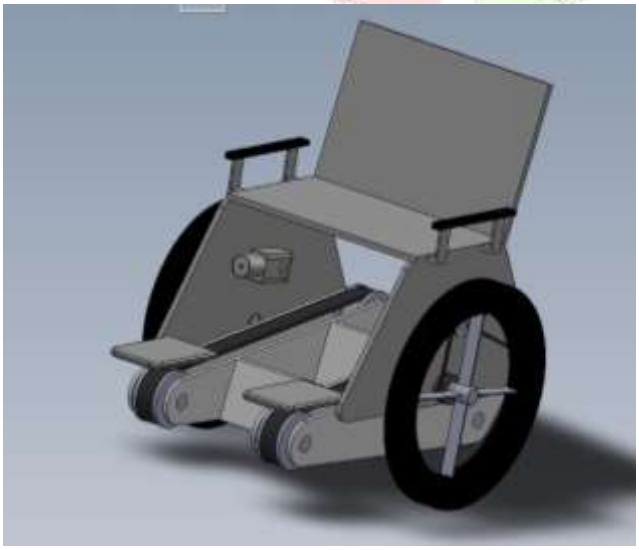
Triangular Frame
Bearings
Gearbox
Actuator
Rubber Tracks

3.0 Construction

Making the most out of the standard design of current wheelchair, modifying it and equipping it with MEMS and SCM a fruitful way for the cost reduction as well as reduction of initial standard medical approvals
Thus the first prototype was designed with the help of Standard wheelchair borrowed from local hospital reduction as well as reduction of initial standard medical approvals

The first problem that faced was the complexity of the cutting and welding of the standard wheelchair and also risk of reducing the integrity of the wheelchair itself. The second problem that was faced and hard to solve was to fit motor with attachment to the wheels.

This made it important to design wheelchair as per the requirements of integration of MEMS system as well as stair-climbing system.



3D model

Material/Standards of the Components:

Frame of Wheelchair	Aluminium
Frame of SCM*	Aluminium
Motor Driver	L298N
Battery	12V DC
Transmitter/Receiver	315MHz
Arduino Boards	NANO/UNO
Accelerometer/Gyroscopic Sensor	MPU6050 6-axis translation and rotation
Tracks	Rubber-black
DC motors	12V-IG35
Actuator	

Here *SCM is stair-climbing mechanism

4.0 Working principle:

The chair will be controlled with MEMS system while the stair-climbing mechanism will be controlled with manual controls. MEMS system will be an integration of two circuits connected to each other wirelessly.

4.0.1 MEMS circuit:

This circuit consists of mainly MPU6050 module connected to Arduino NANO that gets power from a small battery. The signals received from the microprocessor are transmitted through a transmitter.

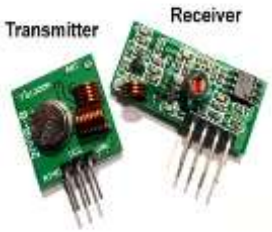
The signal received by the receiver that is located on the wheelchair passes the signals to the arduino UNO that is then distributed to Motor Driver L298N, this driver has capability of driving 2 motors at once. The motor connected to the wheels are the main driving element of the wheel chair. The motors that are to be used in the wheelchairs are DC powered gear motor.

L298N

MPU6050

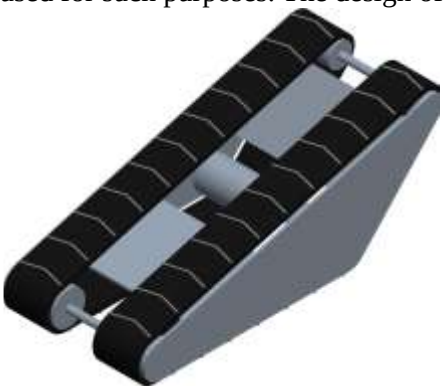
Arduino UNO

JGY- 370 Worm gear motor



4.0.2 Stair-Climbing Mechanism:

As considering several different kinds of stairs that are constructed around the world in several buildings, a basic idea is designed to solve by designing a mechanism that is able to climb a stair with a maximum height of 7 inches vertically. To maintain the centre of the gravity of the total mass of the chair with the person mechanism works in an opposite direction. The person sitting on the chair faces opposite to the direction in which it is travelled. The most suitable design is using rubber tracks. Mainly this rubber tracks are found in military tanks. This rubber tracks have higher grip factor then normal tires and can be used for such purposes. The design of track mechanism is explained in the **figures**.



Tracks and Track system

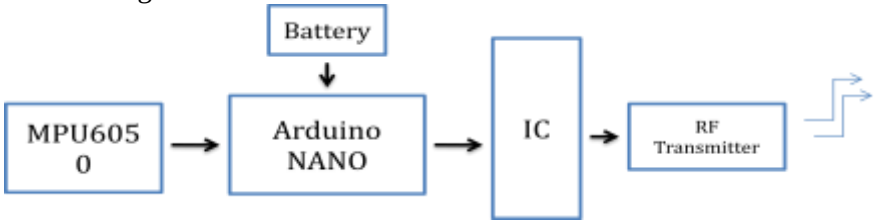
Manual braking mechanism is integrated with the stair climbing system that disconnects the power from the motor thus stopping the rotation at emergency situations.

When the chair starts climbing or descending the stairs, it gets inclined towards the front or rear side. The centre of gravity of the total weight is shifted thus to counter that an actuator is attached between the frame of the wheelchair and stair climbing mechanism. Linear actuator is used as shown in the **fig.**

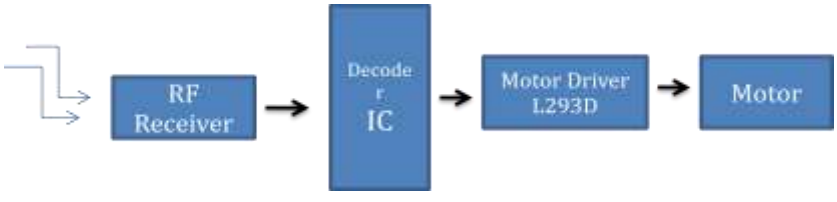
Linear Actuator

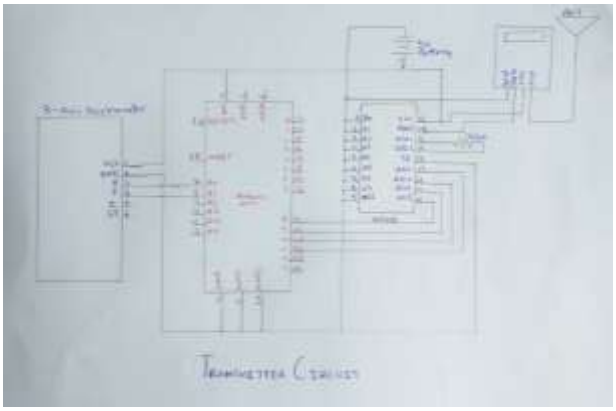
5.0 Schematic Diagram of MEMS flowchart

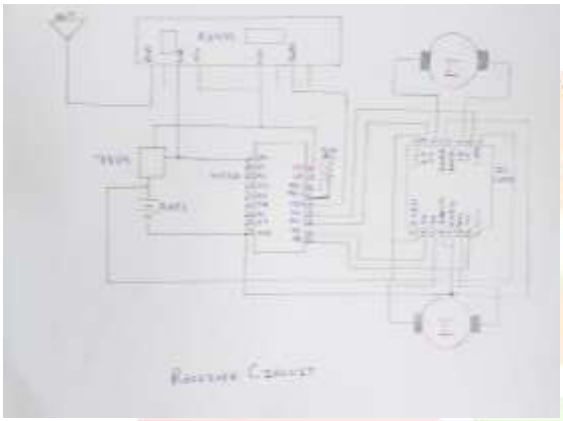
Transmitting circuit:



Receiving circuit:

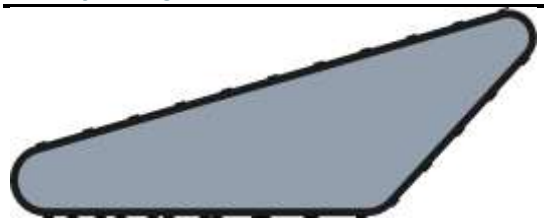




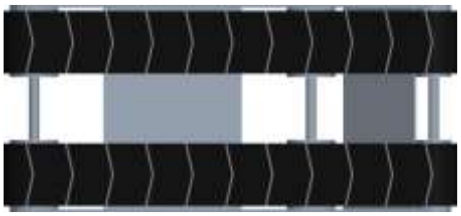


5.0.1 Design of Stair-Climbing mechanism:

Isometric view



Front view



Top view

As the structure shown, this will be attached under the wheelchair attached under the wheel chair. This was designed with the help of 3D modelling software.

The wheel chair will be attached with stair-climbing mechanism with 2 actuators at the front while a bearing mount to give a pivot motion at the back.

6.0 Design Calculation:

Power and torque of the motor required for the Stair climbing mechanism:

The maximum Height of the single stair assumed as 7 inches and base as of the stair as 10 inches. Converting the Inches into millimeter.
We can find torque required for the motor.

$$Slope\ of\ stair\ (\theta) = \tan^{-1}\left(\frac{177.8}{254}\right) = 35^{\circ}$$

$$Total\ mass\ acting\ (including\ setup) = 100kg = 100 * 9.8981N$$

$$Normal\ force\ acting\ (F_n) = mg\cos\theta$$

$$= 100 * 9.81 * cos(35^{\circ})$$

$$= 803.58\ N$$

$$Frictional\ force\ F_f = \mu F_n$$

$$= 0.2 * 803.58$$

$$= 160.7\ N$$

$$Opposing\ force\ (Fo) = mg\sin\theta$$

$$= 100 * 9.81 * \sin(35^{\circ})$$

$$= 562.67\ N$$

$$Torque\ required = (F_f + F_o)r_w$$

$$= (160.7 + 562.67)0.18$$

$$= 130.20\ Nm$$

The Power calculation:
Power= (Torque*RPM)/9.5488
The RPM in the selected motor is 1300.
Therefore the required power is
20W

Power required in the Actuators:

For the load of 120kg (total setup):
The amount of current 8A current is required thus to calculate power

Power= Voltage*current
Thus the voltage and current are 12V and 8A respectively. Therefore the power drawn is
96W

A single actuator is connected between the stair climbing mechanism and the wheel chair. When the wheelchair starts climbing the stairs, the actuator is activated and lifts the wheel chair to maintain the centre of gravity. This is controlled manually with the help of buttons provided on the handle of the wheel chair.

7.0 Future Prospects of this project:

There are several additional changes that can be integrated and will provide better advantage in this project.

- Installing feedback system for the MEMS operation to avoid technical failures.
- Better components can be used for accuracy of the hand motion detection also it can be upgraded with sensors integration on the wheel chair to avoid obstacles
- The wheel chair can be modified to a foldable/flexible chair that can be fitted in to a car that can be helpful to transport it to several places.
- Integration of Stair climbing mechanism with the MEMS for better flexibility.
- Conversion of wheel chair to a bed or vice versa can be very useful in emergency periods.

8.0 Conclusion:

To recapitulate, this system can be helpful in numerous ways for physically challenged people. Not only, it provides good remedy for their problems related to comfort but also it outweighs the issue of staircase climbing without any assistance, which is utterly difficult task for a person in wheel chair.

In terms of comfort, it is very beneficial as they can move from one place to another just by tilting their hand, without making any manual efforts. In simple wheelchair it becomes difficult to shift, as it requires lot of hand effort and climbing a staircase is nearly impossible task to do without other's help. Whereas by adding this system it becomes effortless to move for a person solitarily.

Ultimately amalgamation of two different systems (1.staircase climbing, 2.MEMS), it makes some difficult tasks facile for disable people which can be fruitful to make their world better.

9.0 Acknowledgement

The motivation behind developing Wheel chair operated by MEMS and its key feature of stairs climbing system was to provide support for the disables and make commutation easy for them. This research undertook under the guidance of **Prof. Gaurav Patel** who provided the insights and helped us with their knowledge. The team worked on different areas of the research which helped in yielding the best results.

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