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SMART WHEELCHAIR USING TFT TOUCH SCREEN

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ABSTRACT: The Smart Wheelchair is a mechanical device which is designed for the movement according to the user's command. As a result, the amount of effort needed by the user to operate a conventional wheelchair is reduced. Moreover, it allows physically challenged people as well as senior citizens to move from one place to another. Different types of smart wheelchairs have been developed in the past, and new generations of wheelchairs are being developed using artificial intelligence and machine learning features. These devices are particularly useful in transporting a user from one location to another location which is nearby. These systems can also be used in nursing homes where senior citizens have mobility issues. These wheelchairs are a godsend for those who have lost their mobility. The aim of this project is to create a similar wheelchair that will improve the user's mobility.

KEYWORDS: Wheelchair, DC Motor, Motor Driver, Touch Screen LCD Display, Battery, Microcontroller

I. INTRODUCTION

More than 2% of the world's population has physical disabilities that necessitate the use of a wheelchair to perform daily activities, but only a small percentage of them have the financial resources to buy one. Manual wheelchairs, on the other hand, have proved to be helpful and have fulfilled the needs of people with minor disabilities. Consider the situation of a person who is unable to walk because of their disabled legs. It turns out that moving around or even within the building, is extremely difficult for such a person. Even to complete his/her daily activities, such a person would require assistance from others. As a result, we present the wheelchair using TFT LCD Touch Screen, which will allow the people with disabilities to roam around freely and complete their day-to-day activities without the need for assistance. This wheelchair uses TFT LCD Touch Screen which is easy and flexible to operate and does not require a strong grip or a force from the user as required in the Joystick controlled wheelchair. This type of wheelchair exhibits a control-strategy that allows the wheelchair to be controlled by a touch operation.

The users can benefit from it on a variety of levels, like senior citizens who can use it to be independent and people with leg disabilities who want to complete themselves by allowing them to roam freely again. Traditional wheelchairs are difficult or impossible to use for some users because they require more effort and, in some cases, an assistance to get them to their desired location. As a result, the primary goal of our project is to bring happiness to people with physical disabilities who will no longer need to depend on others. This project is fully automated, user-friendly, and easy to use, with little to no maintenance. For those who must rely on others and are unable to complete tasks on their own, this wheelchair will make them feel like a part of their body.

II. BACKGROUND OF THE INVENTION

A wheelchair is a device that consists of a chair with several wheels attached to it. Wheelchairs are often used by people with physical disabilities who are unable to walk or stand independently. The handles on most of the wheelchairs are located at the back of the seat which can be used by another person to help the wheelchair user with mobility and navigation. There are also such mobility devices on the market that have benefited from technological advancements. The newer models of these devices use batteries and motors to move from one location to another. Such models of wheelchairs are known as electric powered wheelchairs. A broad variety of assistive and guidance technologies have become available in wheelchair systems in recent years to make life easier for users.

There have been advancements in the development of these wheelchair devices for people with various disabilities and disorders in recent years. These newly constructed wheelchairs are extremely competent in terms of their ability to replace older wheelchairs. Different types of mobility devices are used by different people. Like an individual with minor physical disabilities can use canes, crutches, walkers and other assistive devices, while those with severe physical disabilities can use the wheelchair, motorized scooters and other assistive devices, depending on their needs. There are also some more specialized wheelchairs in the market, such as voice assisted wheelchair (which uses the user's voice as a command to monitor the movement of the wheelchair), gesture controlled wheelchair (which uses smart gadgets installed on the user's body to control the movement of the wheelchair), and so on. Although advanced wheelchairs have many controls, there are some drawbacks, such as the fact that it cannot be used by fully paralyzed people or people with mental disabilities because it is too dangerous for them to drive, as this machine needs continuous fine and precise control, which they may not be able to do at times.

A. OBJECTIVES:

A senior citizen or a person with physical disabilities who travel from one place to another in manual or traditional wheelchair needs assistance, which makes them feel like a burden on others. As a result, by providing them with this wheelchair, they would be able to travel from one place to another without requiring any assistance. The following are the primary goals of this invention:

- To design a wheelchair that will increase a physically disabled person's personal mobility independence.
- To create a mobility system that is easy to use and eliminates muscle soreness that can occur when using a manually powered wheelchair.
- To make it as cost-effective as possible so that everyone with a disability can use it.

B. SIGNIFICANCE OF THE STUDY:

The aim of this wheelchair which uses TFT LCD Touch Screen Display is to advance electronic wheelchair technology. The TFT LCD Touch Screen Display will be the primary device used to control as well as monitor the wheelchair's movements. The proponents have come up with this project to help the senior citizens and people with physical disabilities to travel safely and live productive lives. The following people will profit from the findings of this study:

- **The family and friends of the user with disability:**

  The patient would become self-sufficient, removing the need for friends and family to actively help and monitor the patient. In addition, the patient will support friends and family members in completing their tasks on time, alleviating the patient's stress.

- **The user with disability himself:**

  This project would allow a disabled person to roam freely and move from one location to another without needing assistance.

III. LITERATURE REVIEW

In recent years, electric controlled wheelchair using joystick and accelerometer sensor has gained more popularity due to their simple design and user-friendly technology. However, in today's rapidly evolving technological world, technologically advanced wheelchairs are in high demand. Nowadays one finds it difficult to look after a handicapped person on a regular basis. Everyone's personal life is a whirlwind. As a result, the wheelchair will be the main source of assistance for the handicapped and senior citizen, as they feel more at ease and secure in it. They also find it more convenient to travel from one location to another without the assistance of others. This wheelchair provides valuable physical support to the disabled person. So it is necessary to provide a user-friendly advanced wheelchair that is easy to use so that they can travel to their desired destination whenever and wherever they want without any assistance.

The wheelchair is basically made up of three parts: a seat, a frame, and a linking system that connects the seat and the frame. The frame is made up of a chassis with two motorized locomotion units, a support for two electrical gear-motors, two wheel units, and a battery pack. In a tabular configuration, the seat consists of a chair and a pivoting wheel. The pivoting wheels will drive the wheelchair in different directions, and the motorized locomotion units in the frame will be driven by the wheelchair's battery pack.

A. SYNTHESIS OF THE STUDY:

Examples of some of the past and present on-going studies or projects are:

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- Zbigniew Borysiuk, Tadeusz Nowicki, Katarzyna Piechota, Monika Błaszczyszyn, "Neuromuscular, Perceptual, and Temporal Determinants of Movement Patterns in Wheelchair Fencing: Preliminary Study", *BioMed Research International*, vol. 2020, ArticleID 6584832, 8 pages, 2020. https://doi.org/10.1155/2020/6584832
- Juanxiu Liu, Yifei Wu, Jian Guo, Qingwei Chen, "High-Order Sliding Mode-Based Synchronous Control of a Novel Stair-Climbing Wheelchair Robot", *Journal of Control Science and Engineering*, vol. 2015, Article ID 680809, 16 pages, 2015. https://doi.org/10.1155/2015/680809
- Norihiro Sugita, Makoto Yoshizawa, Yoshihisa Kojima, Makoto Abe, Noriyasu Homma, Kazunori Seki, Nobuyasu Handa, "Evaluation of Motor Performances of Hemiplegic Patients Using a Virtual Cycling Wheelchair: An Exploratory Trial", *Computational and Mathematical Methods in Medicine*, vol. 2013, Article ID 512965, 6 pages, 2013. https://doi.org/10.1155/2013/51296

IV. CONCEPTUAL FRAMEWORK

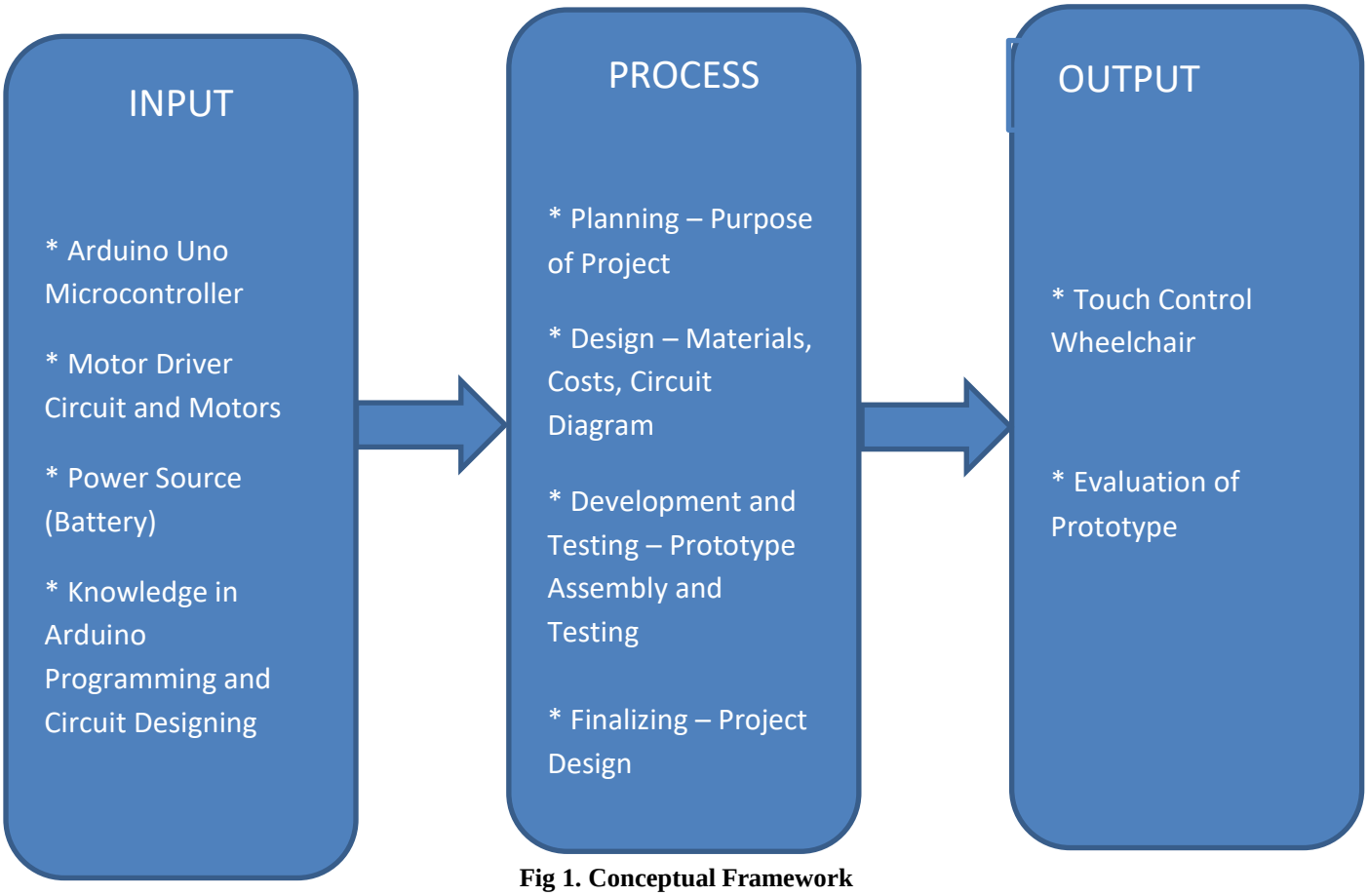

Fig 1. Conceptual Framework

As shown in figure, the conceptual framework's illustration consists of three stages –INPUT, PROCESS and OUTPUT.

The Input Stage consists of different requirements to start the project. These are basically hardware, software and the basic knowledge. The hardware are the basic physical components required to build the project, software gives command to hardware to perform a specific task. On other hand knowledge is guide which can be used to accomplish the project in faster, safer and easier way.

The Process Stage consists of different activities which are to be done during the development of the project. These activities include planning, designing, developing, testing and finalizing. In planning, it involves the purpose of the project i.e., what is the motive of making this project. In designing, it involves the gathering of the material used in this project, estimating the cost and designing the circuit diagram to run the project. In development phase, all components are interfaced physically with each other according to its circuit diagram and source code or logic is developed. Now when the project is fully developed, it is then tested. After successfully testing the project, the overall design is then finalized.

The Output Stage consists of the finalized project which is ready to be used i.e., the project is now completely ready to be used by the user.

V. COMPONENTS DESCRIPTION

1. Arduino Mega

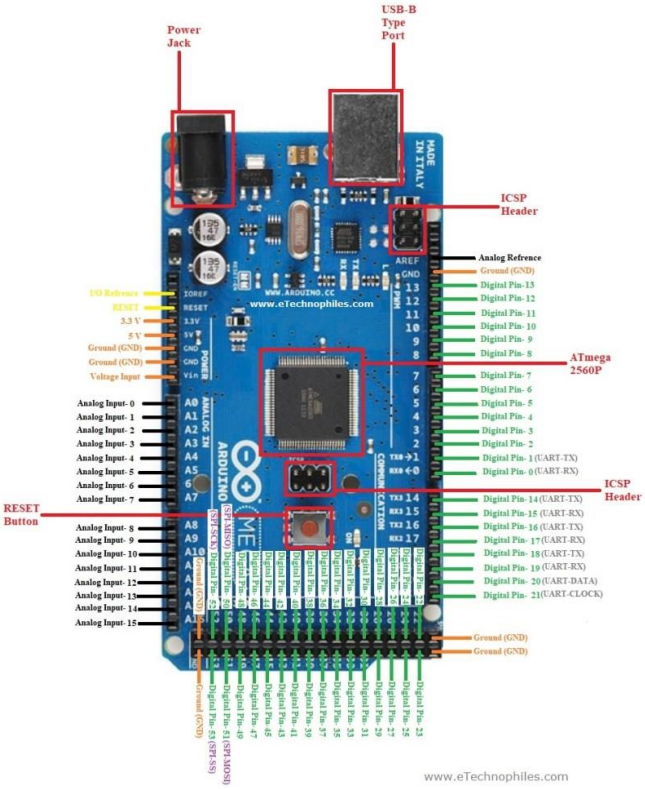

Fig 2. Arduino Mega

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Mega 2560 board is compatible with most shields designed for the Uno and the former boards Duemilanove or Diecimila.

FEATURES:

Microcontroller	ATmega2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	54 (of which 15 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz
LED_BUILTIN	13
Length	101.52 mm
Width	53.3 mm
Weight	37 g

PIN CONFIGURATIONS:

Vin	It is input voltage pin which will provide input supply from an external source
5V	It is used to give supply of 5V to the board as well as onboard components
3.3V	It is used to give supply of 3.3V to the board as well as onboard components
GND	It is used as a ground to Arduino board
Reset	It is used to reset the microcontroller
Analog Pins (A0 – A15)	It is used as an analog pins
Digital Pins (0 – 53)	It is used as an digital pins
Serial Pins (TXD – RXD)	It is used for communication between Arduino board and other devices
PWM Pins (2-13, 44-46)	It is used to convert digital signal into analog signal
SPI Pins (50 -53)	It is used for Serial Peripheral Interface communication
LED Pin (13)	It is an inbuilt LED pin when becomes high, LED on board glows
AREF	It is an analog reference pin, used to provide reference voltage from external power supply
IOREF	It provides voltage reference with which microcontroller operates

2. DC Motor

Fig 3. DC Motor

Motor is the most essential part of the electric wheelchair as it provides motion to the system. The operation of motor is based on simple electromagnetism. The current carrying conductor generates magnetic field; when this is placed in an external magnetic field, it will experience a force proportional to the current in the conductor, and to the strength of the external magnetic field. The internal configuration of a DC motor is designed to harness the magnetic interaction between a current-carrying conductor and an external magnetic field to generate rotational motion.

Specifications:

- Voltage: 12 - 24 V DC
- Load speed range: 15 - 35 RPM
- Load output power: 50 – 90 W

3. Motor Driver

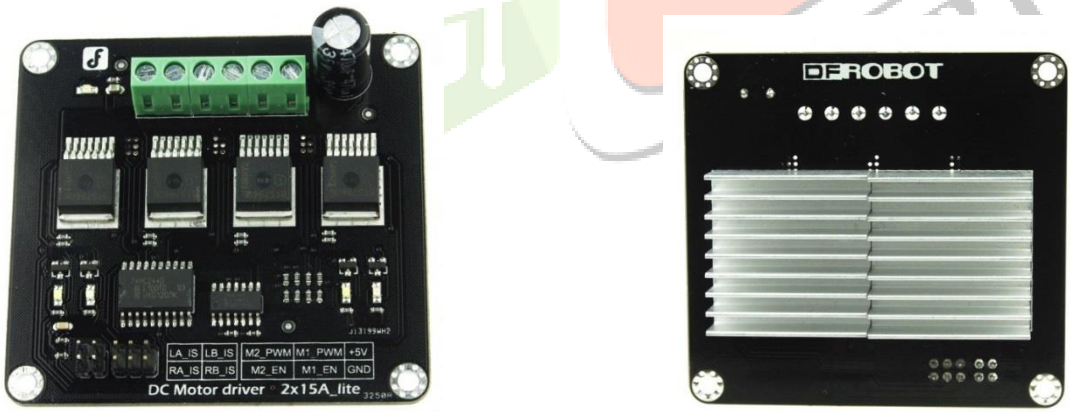

Fig 4. Motor Driver

The output provided by the microcontroller is not sufficient to drive the motor in both directions at high current. Hence, the motor driver is used to control the motor. This DC Motor Driver can be used in 4WD mobile robot platforms, combat robots, smart car competition, to drive pumps, electric fans, conveyors, etc. This module uses 4 high-performance & high-current driver chips BTS7960 with the function of current short, over temperature, over voltage protection. It can control 2 motors with only 4 digital IO at the same time. Dual 15A@13.8V max output current, good responsiveness & braking performance. Four indicator LEDs are provided for easy and convenient debugging without motors. This DC Motor Driver module is directly compatible with Arduino.

Specifications:

- Input Voltage: 4.8 - 35V (It uses BTS7960 half bridge motor driver IC)
- Maximum output current: 15A@13.8V per channel
- Peak output current: 20A@13.8V per channel
- PWM capability: up to 25 kHz
- Interfaces: 4 digital IO (2 PWM output include)
- Driving mode: Dual high-power H-bridge driver
- Other specifications:
  - Galvanic isolation to protect the microcontroller
  - Dual current detection diagnostic functions
  - Short circuit, overheating, over-voltage protection
- Size: 73x68x14mm
- For applications of more than 15A per channel
  - Fast switching might damage the board, best to smooth it by software
  - Avoid higher rating motors, and use lower PWM whenever possible

PIN CONFIGURATIONS:

Pin	Description
+5V	5V power supply input
GND	Common ground
M1_PWM	Motor 1 PWM speed control input
M1_EN	Motor 1 direction control input
LA_IS	Motor 1 current sense and diagnostic output 1
RA_IS	Motor 1 current sense and diagnostic output 2
M2_PWM	Motor 2 PWM speed control input
M2_EN	Motor 2 direction control input
LB_IS	Motor 2 current sense and diagnostic output 1
RB_IS	Motor 2 current sense and diagnostic output 2

4. Lead Acid Battery

Fig 5. Lead Acid Battery

The lead acid storage batteries are high quality, maintenance free batteries produced with advanced battery manufacturing technologies and high purity materials. It is formed by dipping lead peroxide plate and sponge lead plate in dilute sulfuric acid. A load is connected externally between these plates. In diluted sulfuric acid the molecules of the acid split into positive hydrogen ions (H+) and negative sulfate ions (SO42-). These batteries have long life span, high specific energy and low self-discharge rate.

Specifications:

- Capacity: 12Ah
- Nominal Voltage: 12V
- Battery Type: Dry Charged Battery
- Dimensions: 15.1 x 9.8 x 9.5 cm
- Material: High Impact ABS Casing

5. 2.4" TFT LCD Touch Screen Display

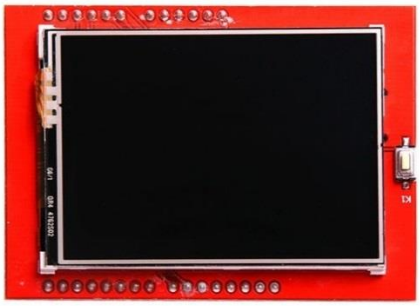

Fig 6. TFT LCD Module

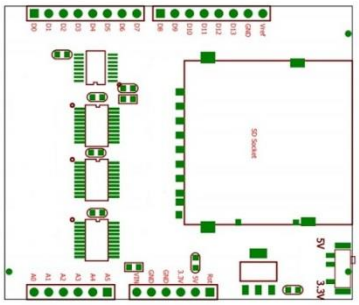

Fig 7. Internal Diagram of TFT LCD Module

A 2.4" TFT LCD module consists of a bright backlight (4 white LEDs) and a colorful 240X320 pixels display. It also features individual RGB pixel control giving a much better resolution than the black and white displays. A resistive touch screen comes pre-installed with the module as a bonus and hence you can easily detect your finger presses anywhere on the screen.

Specifications:

- 2.4" TFT LCD with Touch screen
- Pixels: 240X320
- Operating Voltage: 3.3V
- Operating Mode: SPI and 8-bit mode
- Interface IC: 74LVX245
- SD card option available for displaying bitmap images
- Can be easily interfaced with Arduino (Library available)

PIN CONFIGURATIONS:

Pin Name	Description
GND	Ground terminal of Module
5V	The input voltage will pass to the LCD by the 5V pin.
Vout	The 3.3V output from the onboard regulator
3V3	This pin will attach to the 3V3 volts
RS	The RS pin will help to toggle the data/command registers in the driver
WR	The WR pin which only requires activating when the device needs to write the data on the LCD.
CS	SPI chip select pin
RST	The TFT comes with an auto-reset circuit which gets active on every breakout. However, a user can reset the module using this pin also, in case setup is not resetting clean.
SD_SCK	The SCK pin the common clock pin of the LCD with microcontroller/Arduino

SD_DO	DO pin the data output pin of the SPI communication system.
SD_DI	The DI pin is the data input pin of the SPI communication system.
SD_SS	The SS pin will enable the SPI communication through the signal of the SS pin.
D0 – D7	These pins are used to send the 8-bit parallel data. D0 is the least significant bit while D7 is the most significant one.

VI. DETAILED DESCRIPTION

Fig 8. Wheelchair using TFT LCD Touch Screen Display

First of all, battery is connected to the motor driver which will supply power to the motor driver IC to drive the motors. To direct these motors in a specific direction, the input will be provided to the touch screen by applying a small amount of pressure to a pre-assigned area of it. The output from it will be in analog form which is given as input to ADC pins of the microcontroller. The microcontroller processes and compares the obtained digital values after which it sends instructions to the driver IC to guide the wheelchair's movement. To communicate with the Arduino, TFT LCD Touch Screen Display uses SPI Communication protocol.

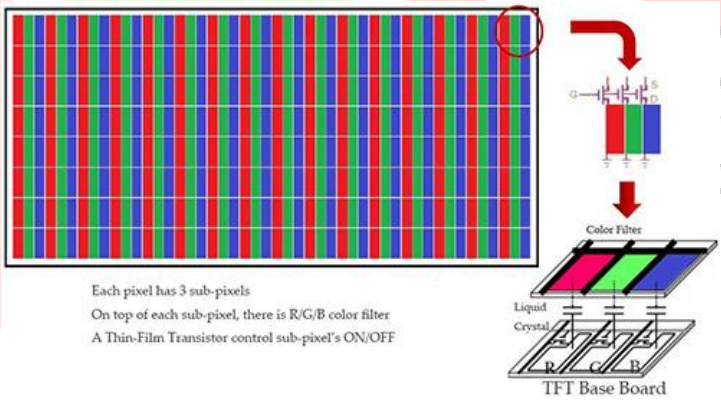

Fig 9. Pixel view of TFT LCD Display

TFT is short for "Thin Film Transistor". Transistors in the color TFT LCD Display are the thin films of amorphous silicon deposited on a glass substrate. As shown in Fig 9, it serves as a control valve to provide a sufficient voltage onto liquid crystals for individual sub-pixels. So this is the reason why TFT LCD displays are also known as Active Matrix display. A liquid crystal sheet is sandwiched between two glass substrates: one with TFTs and transparent pixel electrodes, and the other with a color filter (RGB) and transparent counter electrodes in a TFT LCD. In an active matrix, each pixel is connected to a transistor with a capacitor, which allows each sub-pixel to maintain its charge rather than having an electrical charge to be sent each time it needs to be modified. So when the user presses the screen, the particular pixel will be activated with specific voltage value. Now this analog voltage value is sent to the microcontroller which will be converted to digital via ADC block. After conversion, the digital command or signal will be sent to the driver IC to drive the motors.

Suppose the user presses the screen into the area where the forward command is assigned on to the display; the pixels in that area gets activated with an appropriate voltage which will be in analog form. Now this analog output from the screen will be given as input to the ADC block of the microcontroller to convert it into digital form. After successful conversion, this digital signal will be provided to the driver IC as a command to drive the motors so that the wheelchair can move in forward direction. Similarly when the user presses the screen into the area where the backward command is assigned on to the display; the pixels in that area gets activated with an appropriate voltage which will be in analog form. Now this analog output from the screen will be given as input to the ADC block of the microcontroller to convert it into digital form. After successful conversion, this digital signal will be provided to the driver IC as a command to drive the motors so that the wheelchair can move in backward direction.

Now if the user presses the screen into the area where the left command is assigned on to the display; the pixels in that area gets activated with an appropriate voltage which will be in analog form. Now this analog output from the screen will be given as input to the ADC block of the microcontroller to convert it into digital form. After successful conversion, this digital signal will be provided to the driver IC as a command to drive the motors so that the wheelchair can move in left direction. Similarly when the user presses the screen into the area where the right command is assigned on to the display; the pixels in that area gets activated with an appropriate voltage which will be in analog form. Now this analog output from the screen will be given as input to the ADC block of the microcontroller to convert it into digital form. After successful conversion, this digital signal will be provided to the driver IC as a command to drive the motors so that the wheelchair can move in right direction.

After operating the wheelchair in desired direction, when the user releases the touch or pressure from the screen, then the driver IC will automatically send the stop command to the motors which will eventually stop the motion of the motor. As a result, the wheelchair will come to halt. In order to increase the wheelchair's working ability or life span, it is equipped with a switch that can be used to turn it on or off as required.

A. SCOPE OF THE PROJECT:

- This project will benefit senior citizens as well as disabled individuals to make their life easier and live productive lives.
- One of the five different states of movement i.e., forward, reverse, left turn, right turn, and stop, can be initiated for the movement of the wheelchair.
- To guarantee the user's safety, we chose a low speed, high torque motor. This means, the movement speed of the wheelchair will be slow, but these motors can carry a person of greater or heavier weight.
- The speed of this electric wheelchair can be increased, unlike any other electric wheelchairs, but it is recommended to keep it low for safety reasons.

B. LIMITATIONS:

- This wheelchair could not be used in transportation for longer distances, such as travel between cities, but it could be used for shorter distances, such as indoor transportation.
- This wheelchair is not advisable to be used by fully paralyzed individuals who could not move any part of their body.
- Individuals with severe shakiness should avoid using this wheelchair because it can cause the device to malfunction.
- This wheelchair is not advised to be used by the people with mental illnesses because it will be too dangerous for them to drive as they are not mentally capable or fit.

VII. CONCLUSIONS AND FUTURE WORK

Based from the existing method of controlling powered wheelchair, it is concluded that this wheelchair which uses TFT LCD Touch Screen Display is more user-friendly and easy for the disabled person or senior citizens to use. As this type of wheelchair does not require any extra effort or work from the user as it is totally touch based. So this type of wheelchair is more efficient, flexible, low cost and greatly accepted by the society due to its simple design.

Future improvement in this project can include the use of voice assistance which will help one to travel from one location to other without applying any effort in driving the wheelchair. Further improvements can also include a system with obstacle avoidance, automatic braking system or even a GPS tracking system.

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