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Design and Implementation of an Arduino-Based Smart Wheelchair for the Disabled with Joystick and Autonomous Navigation Modes

Author: Arishthha Chavan

I. ABSTRACT
Although wheelchairs provide users with a higher level of independence, some still struggle with fatigue or injuries in moving the wheel and it can be a tedious task for them to move about. This article describes the outline for the design of a wheelchair that utilises a microcontroller to allow users to move the wheelchair with the help of a joystick or even allows the wheelchair to move autonomously. An Arduino is connected along with IR sensors, to detect both obstacles in the path and edges, such as curbs, to prevent crashing or falling off during the use of the automated mode. The joystick mode, however, is completely manual and will move solely according to the users' mapping on the joystick. A switch is integrated that when clicked changes between the two modes.

Keywords: **independence, microcontroller, joystick, autonomously, Arduino, IR sensors**

II. INTRODUCTION

Background

Wheelchairs are the most commonly used assistance among differently abled people. However, a report by WHO claims that only a small percentage of those requiring this support have access to it, with even fewer being able to access the right wheelchair for them. Furthermore, wheelchairs may not always be easy to operate and users still often face multiple issues such as in transport, in toilets, opening doorways and more. This can often lead to them being helpless, getting stuck or even getting injured while trying to face these tasks.

For example in 2003, The National Electronic Injury Surveillance System, NEISS, reported that more than 10,000 injuries in the US were caused by wheelchair accidents, most being due to tripping and falling.

Objectives

The aim is to design an effective mechanism that does not completely change the principles of a wheelchair yet adds onto it in turn both increasing mobility efficiency as well as ensuring the wheelchair is user-friendly and easy to operate.

III. LITERATURE REVIEW

Research in Arduino-Based Mobility Solutions

A company named LUCI has created a wheelchair accessory that uses sensor technology to improve wheelchair mobility and focuses on preventing collisions with obstacles and preventing falling or dropping off of edges. These features are similar to the ones tested in my wheelchair prototype, namely obstacle avoidance and edge detection.

LUCI incorporates eight sensors to obtain a 360° monitoring of the environment around the wheelchair. The system is coordinated by the 'LuciLink Hub', which makes use of an i.MX 8M processor. The sensors are even backed by Intel RealSense depth cameras which give better input making it a safer system that does not entirely rely upon sensors.

Another university-student-founded startup, Adventus Robotics, has invented a wheelchair that is powered by AI to make it autonomous. This technology employs multiple sensors, including cameras, alongside LiDAR devices to improve efficiency to a maximum. This product even accounts for user's personal issues, such as motion sickness, by providing a user interface that allows for customisation. The system was made to be targeted towards patients with diseases such as Parkinsons who find it hard to control wheelchairs manually. However this appliance works with mapping and is best used when in a previously mapped environment such as your home or a hospital. It is not as reliable for newer locations and hence has a huge limitation in these fields.

Gaps in Existing Work

The existing wheelchairs all focus on one sole mode: either making it entirely autonomous, or partially assisted. No designs so far allow for a dual mode, restricting users to choose to stick to the best one.

Our wheelchair also allows a high level of customer comfort and customisability in the design to generate the best experience for the user.

IV. SYSTEM DESIGN AND ARCHITECTURE

Overview of System Components

A) Hardware Components:

1. Arduino Nano Microcontroller
2. IR sensors (4)
3. Joystick
4. Motors (2)
5. Wheels
6. 11.1V L-ion Battery
7. Switch PCB
8. Wheelchair structure

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Hardware Configuration

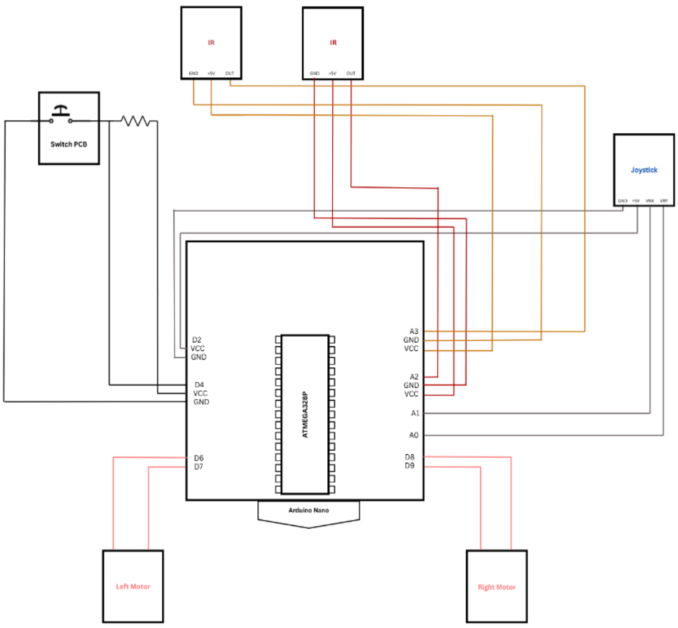

Fig 3.21: Circuit Diagram

The above circuit diagram outlines the entire hardware design of the wheelchair. The switch PCB would be attached to the left arm of the wheelchair. The joystick is originally mounted on the right arm of the wheelchair, however this can be adjusted according to the needs of the user (for example mounting it on the left arm instead for left handed users).
The Arduino model is the Arduino Nano ATmega328P, and a custom made shield is used, as seen down below:
This image also displays the actual circuit connections mapped onto the diagram in Fig 3.21.
The Left IR, as mentioned in the diagram, is used for edge detection whereas the right IR is used for object detection and avoidance.
The left and right motor control the left and right wheels respectively

V. SOFTWARE DESIGN OVERVIEW

The software entirely relies on the Arduino 1.8.19 IDE in the C++ coding language. The algorithm is as so:
A switch is used as a control between the two modes. When the switch is clicked, a variable called 'Count' is incremented. This integer stored in 'Count' translates to the number of times the switch was clicked. If the number of clicks is even, the wheelchair will be operated by the joystick whereas if 'Count' is odd, the wheelchair runs automatically.
To determine the oddity of the integer in the variable, we calculate and compare Count%2. This gives us the remainder of the division of Count by 2. If the remainder is 0, the number is even, and the code for the joystick is run. .
If the remainder is 1, the number is odd, and the code for the automated mode is run.
To run the joystick mode, we have determined the analogue values for each of directions on the joystick: forward, backward, left and right. By mapping these to the x and y axes we have supplied the correct code for each range of values.
The automated mode works entirely on sensor input to move, stop and navigate the course.

VI. IMPLEMENTATION AND TESTING

Prototype Development
The entire model costing is listed below:

TABLE I

MATERIAL COST BREAKDOWN FOR PROTOTYPE UNIT

Component	Quantity	Unit Price (INR)	Total Cost (INR)
DC Motor DIY 3-6V	2	42	84
Arduino ATmega328P 5V Nano	1	330	330
IR Infrared Sensor	4	99	396
Game Controller Sensor Joystick	1	189	189
Tactile Switch	1	100	100
Wood Work	---	~ 1890	1890
Miscellaneous electronics	---	~ 597	597
TOTAL			~*3586*

VII. TESTING PROCEDURE

The prototype was tested in 3 different environments, two of which were indoors and one had an outdoor simulation. One was a plain office room, one a child's bedroom and the last a balcony.
The settings are described separately below:
The office room: The office room had plain white walls and was quite occupied with objects. The center of the room had a table with chairs placed around it and some materials were placed on the ground.
The child's bedroom was quite similar with a bed in the center of the room. Although the floor had no objects on it, there was a carpet present.
Lastly, the balcony was a wider space with only a few potted plants kept around.

Performance Metrics

Setting / Metric	Office	Bedroom	Balcony
Accuracy of obstacle detection/ cm	1.4	2	1
Response time/ s	1	1	1
Success rate/ %	91.66	95.83	100

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VIII. RESULTS AND DISCUSSION

Observed Performance

The wheelchair seems to work quite well. The switch is quick in switching between modes. The joystick operates smoothly and is perfectly sensitive to the movements. Although the automatic mode could use some work, it stops perfectly at objects and the detection is not an issue. The wheelchair does jerk a bit while stopping however, and this could be something to look into and try to modify.

Strengths of the System

The main strength of the system is that it is made to be cost effective, and targets reaching users regardless of their financial status.

The interface is user friendly. For example, the joystick can be moved and attached to a position where the user finds it more comfortable to use.

Limitations

The wheelchair's major limitation when it comes to the model is the use of IR sensors. This is a drawback as IR sensors are only able to detect light objects since they rely on the reflection of infrared light from the object.

Black is a colour which absorbs all light. Hence there will be no light reflected back. This leads the sensor to believe

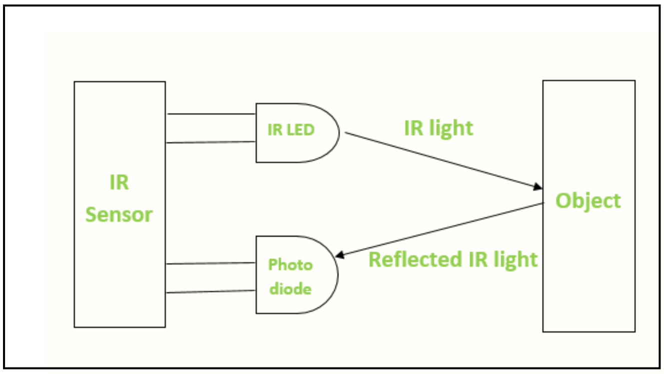

Fig 6.31: Working of an IR sensor

that there is no object in front of it, causing serious issues such as collisions, or stopping at dark floors believing it to be an edge. This would be best fixed by replacing IR sensors with ultrasonic sensors. In place of relying on the reflection of light, ultrasonic sensors emit ultrasonic sound waves and measure the time taken for them to be reflected back, if they are reflected at all.

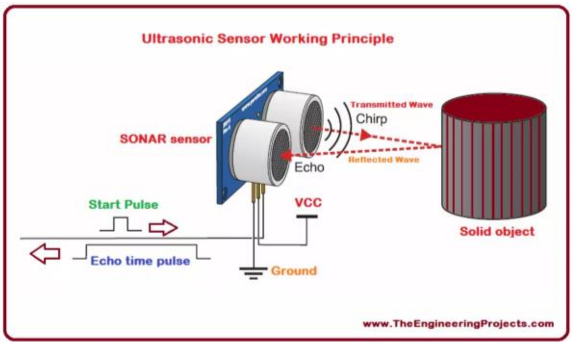

Fig 6.32: Working of an ultrasonic

This would not only solve the issue of skewed object detection but also give us the freedom to determine the distance before making the object stop, adding more precision to the functionality of the design.

The large Scale

On a large scale, this system can be implemented in areas where wheelchair users need more independence in travelling and moving. Additional features we can use are speed control, that could be set by the user and access to Bluetooth features through an app.

The wheelchair would mainly be used in homes, hospitals and anywhere during travel.

The automated mode can be perfected through mapping to allow a GPS system to guide the blind or those with motor limitations.

REFERENCES

https://iris.who.int/bitstream/handle/10665/205041/B4616.pdf?seq
https://vissconext.com/blogs/articles/problems-wheelchair-users-face-and-their-solutions
https://pubmed.ncbi.nlm.nih.gov/8198772/
https://news.ucdenver.edu/from-idea-to-invention-how-this-smart-technology-wheelchair-accessory-became-one-of-time-2020s-best-inventions/
https://luci.com/meet-luci/
https://luci.com/wp-content/uploads/2025/04/629-00011_Rev-B_2025-26-Safety-Report.pdf
https://www.adventusrobotics.com/
https://seas.harvard.edu/news/2020/06/driving-force
https://robu.in/ir-sensor-working/