Exoskeleton Arm - The First Step of Real Life Iron Suit

Supervisor- Associate Professor DR. MD. KHALILUR RHAMAN

CONDUCTED BY:
Md. Sadiur Rahman - 10321035

Md. Tanjil Rashid Avi - 10121026

BRAC
UNIVERSITY
Inspiring Excellence

Department of Electrical and Electronics Engineering
School of Engineering and Computer Science
BRAC University
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Md. Sadiur Rahman (ID: 10321035)

Md. Tanjil Rashid Avi (ID: 10121026)

Supervisor

DR. MD. KHALILUR RHAMAN

Department of Electrical and Electronics Engineering
BRAC UNIVERSITY

DECLARATION

We declare that this dissertation is the product of our own work, that it has not been submitted before for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged as complete references.

Signature of Supervisor:

Md. Sadiur Rahman (ID: 10321035)

MD. Tanjil Rashid Avi (ID: 10121026)

Contents

Abstract 4

1 Introduction 5
- 1.1 Motivations 6
- 1.2 Literature Review 6

2 System Architecture 16
- 2.1 Block Diagram 17
- 2.2 Hardware View 18
- 2.3 Circuit Control 20

3 Components & Implementation 23
- 3.1 Glass Motor 23
- 3.2 Arduino Duemilanove 27
- 3.3 12v 30A Opto Isolated Relay Module (1 Channel) 32
- 3.4 Printed Circuit Board 33

4 Result 34

5 Discussion 36

References 37

Appendixes 38

ABSTRACT

Our team is designing an untethered, powered, upper body exoskeleton for use in the fields of rehabilitation and therapeutic application, as well as occupations requiring augmented strength. Though systems exist, past exoskeleton endeavors have led to bulky, expensive, invasive, and tethered solutions. The challenge is to build an exoskeleton system that is inexpensive, streamlined, and wireless. Our solution is unique in that it will be a low-cost, ergonomic device actuated through sensors measuring the user's motion. Through onboard sensing, the skeleton can provide rich data, such as range of motion for use in physical therapy. This data can be used by doctors and patients to more accurately track improvement over time. With its low cost, hospitals could employ multiple devices and aid a larger audience of patients; the devices could even be used at home for physical therapy, which would dramatically increase quality of life for patients. Outside of physical therapy, augmented strength is applicable to physically intensive occupations, as well as search and rescue operations. Each year, thousands of workers must take leave due to injuries triggered by heavy lifting; with augmented strength, workers could avoid harmful situations.

INTRODUCTION

Surviving a stroke or debilitating injury is often the start of a very long ordeal. Physical therapy can be slow and strenuous with no guarantee of recovery. Robotic exoskeletons can sometimes provide the support a ravaged body needs to heal—and strength when it can't—but they typically cost more than a car and must be anchored to a wall and plugged into a socket.

For this reason we are trying to build an efficient, lightweight, and surprisingly powerful robotic limb. Its actuator, or electronic muscle, could provide resistance during therapeutic exercises and can augment strength, allowing its wearer to lift an additional 40 pounds or 20 kilograms with little effort.

To ensure a slimmer frame than other exoskeletons and make Exoskeleton Arm easier for patients to use, the team situated its actuator in a backpack instead of in the limb itself. They also milled load-bearing parts out of aluminum to limit weight and power consumption. This would allow a patient to use an Exoskeleton Arm at home and a therapist to remotely monitor the exercises.

Potential beneficiaries, including stroke victims and an injured snowboarder, have already reached out to the team with encouraging comments. The positive response to their $2,000 prototype has made Exoskeleton Arm's makers eager to push their invention toward a finished product and, to that end; they are now designing a more refined version.

1.1 Motivations:

Exoskeleton Arm, a battery powered upper-body robotic arm which instantly increases human strength. Augmenting arm strength by forty pounds, Exoskeleton Arm helps rehabilitate people with back injuries, allowing them to rebuild muscle and relearn motor control. The exoskeleton technology also aids those lifting objects as part of their daily work, particularly in construction or delivery-driven positions. Labor, manual transporting is the main cause of injuries in the Bangladesh work force, and four out of five of these injuries will affect the lower back. Combined, upper body injuries cost the Bangladesh approximately $5 billion annually. Exoskeleton Arm is obviously an ingenious design, but the team's use of modern, rapid – and relatively inexpensive – manufacturing techniques makes the project even more compelling. We wanted Exoskeleton Arm to be affordable, as exoskeletons are rarely covered by health insurance. This informed our design decisions and the materials we used. Most structural components are machined from inexpensive aluminum.

1.2 Literature review:

Carrying heavy objects with robotic limb is already being used in Asia, Europe and North America. Heavy companies and factories in the world already use robotic limb carrying heavy objects with many major cities in the United States like Washington D.C., Chicago, Boston and San Francisco also implementing or planning to implement this technique.

Industrial injury or physical disability due to sickness is very common now days. Physical treatment or taking any form of medicines cannot guarantee fully recovery. Robotic exoskeletons can provide them a certain strength which will help them to lead a normal life. The best part of this exoskeleton arm is that the user can carry the entire system on his or her backpack which is very easy to carry from one place to another. Considering all this issues we are trying to make a lightweight, strong and powerful robotic arm. It will allow the user to pick up and move an object which is beyond his limit. Normal average persons can move and carry weights that are twenty kilograms above his limit and we believe our device is capable of carrying much more. To make this exoskeleton arm more users friendly and easy to use we placed the motor and all the relays and circuits on the backpack. These also support the back part of the body and give user the ability to have a support on this back. This allows the user to maintain a proper body balance and life up, carry objects easily.

The integration of human and robot into a single system offers remarkable opportunities for a new generation of assistive technology. Despite the recent prominence of upper limb exoskeletons in assistive applications, the human arm kinematics and dynamics are usually described in single or multiple arm movements that are not associated with any concrete activity of daily living. Moreover, the design of an exoskeleton, which is physically linked to the human body, must have a workspace that matches as close as possible with the workspace of the human body, while at the same time avoid singular configurations of the exoskeleton within the human workspace. The aims of the research reported in this manuscript are to study the kinematics and the dynamics of the human arm during daily activities in a free and unconstrained environment, to study the manipulability of a 7-degree-of-freedom powered exoskeleton arm given the kinematics and the dynamics of the human arm. Kinematic data of the upper limb were acquired with a motion capture system while performing 24 daily activities from six subjects. Utilizing a 7-DOF model of the human arm, the equations of motion were used to calculate joint torques from measured kinematics. In addition, the exoskeleton isotropy was calculated and mapped with respect to the special distribution of the human arm configurations during the 24 daily activities. The results indicate that the kinematic joint distributions representing all 24 actions appear normally distributed except for elbow flexion–extension with the emergence of three modal centers. Velocity and acceleration components of joint torque distributions were normally distributed about 0 Nm, whereas gravitational component distributions varied with joint. Additionally, velocity effects were found to contribute only 1/100th of the total joint torque, whereas acceleration components contribute 1/10th of the total torque at the shoulder and elbow, and nearly half of the total torque at the wrist. These results suggest that the majority of human arm joint torques are devoted to supporting the human arm position in space while compensating gravitational loads whereas a minor portion of the joint torques is dedicated to arm motion itself. A unique axial orientation at the base of the exoskeleton allowed the singular configuration of the shoulder joint to be moved towards the boundary of the human arm workspace while supporting 95% of the arm's workspace. At the same time, this orientation allowed the best exoskeleton manipulability at the most commonly used human arm configuration during ADLs. One of the potential implications of these results might be the need to compensate gravitational load during robotic-assistive rehabilitation treatment. Moreover, results of a manipulability analysis of the exoskeleton system indicate that the singular configuration of the exoskeleton system may be moved out of the human arm physiological workspace while maximizing the overlap between the human arm and the exoskeleton workspaces. The collected database along with kinematic and dynamic analyses may provide a fundamental basis towards the development of assistive technologies for the human arm.

For patients undergoing physical therapy, a powered upper-body exoskeleton fitted around the injured limb can increase range of motion and rebuild muscle strength. Exoskeletons are also emerging as tools for augmenting able-bodied performance.

As our fourth-year undergraduate capstone project, they designed and built a controllable, wireless exoskeleton called Titan Arm. Titan Arm is capable of lifting more than 40 pounds while providing precise metrics on the angle of the elbow.

They designed and built this proof-of-concept arm in just eight months. They constructed a working prototype consisting of custom frame elements that we milled ourselves, a brushed DC motor, two 18.5 V lithium polymer batteries, a cable drive transmission, a mechanical brake, Hall effect sensors, and other components. They relied on MATLAB for evaluating early design decisions and plotting data streamed wirelessly from the arm’s sensors.

2-year-old Emma wanted to play with blocks, but a condition called arthrogryposis *multiplex* congenital (AMC) meant she couldn’t to lift her own arms, although able to walk. It is a nonprogressive condition that causes stiff joints and very underdeveloped muscles. Medical experts warned that AMC would prevent Emma from ever experiencing any sort of normalcy. So researchers at a Delaware hospital 3D printed a durable custom device exoskeleton with the tiny, lightweight custom parts. It was manufactured using a 3D printer so as to create a prosthetic light enough for young Emma to continue walking around freely.

The exoskeleton was based on another piece of robotics developed by the Nemours/Alfred I. DuPont Hospital for Children in Wilmington, Delaware called the Wilmington Robotic Exoskeleton (WREX), an orthopedic apparatus for the arm made from hinged bars and resistance bands that helps children with very little residual strength to move their arms in space. While WREX was able to help arthrogryposis sufferers as young as six, it was built into a wheelchairand was too heavy and bulky for a two year old to make use of regularly.

For Emma to wear the WREX outside the workshop, it needed to be scaled down in size and weight. The parts would be too small and detailed for the workshop’s CNC system to fabricate. This is where the 3D printing process comes in. The nature of 3D printing also makes it pretty easy to scale production – and in this case Stratasys's Dimension 3D printer has made it easy for Emma's doctors to fabricate robotic "jacket's" to keep up with her growth and that of a further fourteen subsequent child patients. The 3D-printed WREX turned out to be durable enough for everyday use. Emma wears it at home, at preschool, and during occupational therapy.

This, as far as 3D printing is concerned, is the best applications of the technology. The driving factor behind any new technology should primarily be for humans to live their lives with normalcy & health.

Titan Arm won first place and $10,000 at the Cornell Cup USA student engineering competition, as well as winning second place in the senior design project competition sponsored by Penn’s School of Engineering and Applied Science. Titan also won the James Dyson Award, beating out over 650 applications from 18 countries. This was the first time that an American team has won the award.

Their capstone project team consisted of four mechanical engineering students. They came together as a team late in our third year. Joining the two of them were Niko Vladimir, who has a strong interest in mechatronics, and Elizabeth Beattie, who has years of experience in orthopedics. They found they had complementary skills that spanned mechatronics, electronics, orthopedics, manufacturing, mechanical design, and embedded systems.

The four of them had another important thing in common: several years of experience with MATLAB—or as we call it, “an engineer’s best friend.”

Throughout each year of the mechanical engineering curriculum, they used MATLAB and Simulink to apply the concepts and theory learned in class, developing the skills they would use to design the Titan Arm system.

They began solving problems with MATLAB in ***MEAM 105: an Introduction to Scientific Computing***. In this first-year course they used MATLAB to simulate physical and chemical systems, analyze experimental data, conduct Monte Carlo numerical experiments, and interact with sensors and actuators. The following year, in ***MEAM 248: Sophomore Design Lab***, they used MATLAB to model, simulate, and visualize a passive dynamic walking robot moving down an inclined plane. This course was taught by Dr. Jonathan Fiene, who was also their advisor on the Titan Arm project. Third-year assignments with MATLAB included data acquisition and processing. For example, they performed rocket motor testing by acquiring strain gauge data from a metal beam with Data Acquisition Toolbox™ and calculating the thrust curves with MATLAB.

In their introductory course on control systems, they used Simulink to develop a controller for a model train set in which one train followed another around a track. The goal was to control the velocity of the trailing train to maintain a set distance behind the leading train even if it changed speeds. they built a Simulink model of the system, developed a proportional-integral-derivative (PID) controller, and tuned the gains to meet the project requirements.

Before designing Titan Arm, they consulted a physical therapist in the University of Pennsylvania Health System. The therapist told us that rehabilitation of an injured limb focuses on improving the patient’s strength and range of motion. Based on these early talks, they knew that Titan Arm would need sensors to provide data on the angle of the elbow joint, a wireless communication link to transmit this data, and a way to visualize it. Before they could do any of that work, however, they had to design the actual arm.

Their initial idea was to mimic the muscles in the human arm, using actuators in place of biceps and triceps muscles to flex and extend the exoskeleton's elbow joint. When they modeled and analyzed this design in MATLAB, they discovered that it would require two actuators (in this case, motors) because the biceps and triceps muscles flex at different rates. To keep down costs, we adopted a simpler design in which a single motor actuates the elbow joint via a cable drive transmission.

They used MATLAB to guide several other early design decisions. For example, they performed analysis in MATLAB to calculate and visualize the arm's joint space, or the space within which it could move. Their teammate Elizabeth used MATLAB to evaluate cable strength during mechanical tests in which she applied a tensile force to various cables and measured the resulting displacement.

When they began designing the Titan Arm control system, they used Simulink to try out ideas, including PID and proportional-integral (PI) controllers. Their simulations showed that a simple proportional velocity controller would meet our requirements.

As the project progressed, they constructed a prototype exoskeleton frame and mounted the motor, the transmission, the braking system, and four Hall Effect sensors, including one at the elbow joint and three at the shoulder joint. These sensors provided the detailed data on the position of the arm that physical therapists need to monitor and measure improvements in range of motion. A Beagle Bone board mounted near the arm's batteries acquires data from the Hall effect sensors and transmits it wirelessly via UDP. They wrote a MATLAB script that runs on an Intel DE2i board to process the UDP packets and display the data graphically as it streams live from Titan Arm. MATLAB really helped the design process at the testing stage. It allowed us to quickly try different parameters and visualize the results immediately, without having to wait to post process the data.

After presenting the completed Titan Arm as their capstone project and receiving their Cornell Cup award, the four members of team graduated with bachelor’s degrees in mechanical engineering. They have continued to use the design skills that was developed on the project, as well as the experience they gained with MATLAB and Simulink. Elizabeth is pursuing a Ph.D. at Penn, and Niko is working as a mechanical engineer at IDEO.

The two of them are pursuing postgraduate degrees, and continuing to develop the Titan Arm. Currently they are exploring the use of electromyography as a way to control the arm with the nerve signals that normally control muscles, which could lead to the use of Titan Arm as an assistive technology.

Upper-limb impairment after stroke is caused by weakness, loss of individual joint control, spasticity, and abnormal synergies. Upper-limb movement frequently involves abnormal, stereotyped, and fixed synergies, likely related to the increased use of sub-cortical networks following the stroke. The flexible coordination of the shoulder and elbow joints is also disrupted. New methods for motor learning, based on the stimulation of activity-dependent neural plasticity have been developed. These include robots that can adaptively assist active movements and generate many movement repetitions. However, most of these robots only control the movement of the hand in space. The aim of the present text is to analyze the potential of robotic exoskeletons to specifically rehabilitate joint motion and particularly inter-joint coordination. First, a review of studies on upper-limb coordination in stroke patients is presented and the potential for recovery of coordination is examined. Second, issues relating to the mechanical design of exoskeletons and the transmission of constraints between the robotic and human limbs are discussed. The third section considers the development of different methods to control exoskeletons: existing rehabilitation devices and approaches to the control and rehabilitation of joint coordination’s are then reviewed, along with preliminary clinical results available. Finally, perspectives and future strategies for the design of control mechanisms for rehabilitation exoskeletons are discussed.

Rehabilitation robots are, currently, being explored for training of neural impaired subjects or for assistance of those with weak limbs. Intensive training of neutrally impaired subjects, with quantifiable outcomes, is the eventual goal of these robot exoskeletons. Conventional arm exoskeletons for rehabilitation are bulky and heavy. In recent years, the authors have proposed to make lightweight exoskeletons for rehabilitation by replacing the rigid links of the exoskeleton with lightweight cuffs fixed to the moving limb segments of the human arm. Cables are routed through these cuffs, which are driven by motors, to move the limb segments relative to each other. However, a scientific limitation of a cable-driven system is that each cable can only pull but not push. This paper is the first to demonstrate via experiments with cable-driven arm exoskeleton (CAREX) that it is possible to achieve desired forces on the hand, i.e., both pull and push, in any direction as required in neural training. In this research, an anthropomorphic arm was used to bench test the design and control concepts proposed in CAREX. As described in this paper, CAREX was attached to the limb segments of a five degree-of-freedom anthropomorphic arm instrumented with joint sensors. The cuffs of CAREX were designed to have adjustable cable routing points to optimize the “tensioned” workspace of the anthropomorphic arm. Simulation results of force field for training and rehabilitation of the arm are first presented. Experiments are conducted to show the performance of a CAREX force field controller when human subjects pull the end-effectors of the anthropomorphic arm to travel on prescribed paths. The human-exoskeleton interface is also presented at the end of this paper to demonstrate the feasibility of CAREX on human arm.

Foot soldiers thrive on their shooting skills, but learning expert marksmanship can take a long, long time. US Army researchers could soon have a robotic shortcut to improving those skills, however. They're working on MAXFAS, an arm exoskeleton that uses cable-activated arm braces to correct involuntary arm shakes while you're shooting -- think of it like a stabilized camera. The carbon fiber body is light enough that it doesn't weigh you down, and it's smart enough to detect the differences between purposeful movements (such as aiming) and tremors.

The machinery is currently fixed in place, so it would mostly be useful in the short term as a way to teach proficiency to recruits and anyone who needs brushing up. In early tests, the developers noticed that people who'd worn MAXFAS were better shots even after taking it off. Eventually, though, there could be a truly mobile version that gives troops a boost in the field. You could one day see armies full of crack shots that aren't easily thrown off by fatigue or the chaos of war.

A robotic device invented by engineering students could help its wearer carry an additional 40 pounds (18 kg). That's equivalent to a four-year old child. Instead of feeling the full weight of their body, the robot arm would make lifting the child feels as easy as lifting a cup of tea.

Titan Arm looks and sounds like part of a superhero's costume, but its creators say it's designed for ordinary people - those who need either physical rehabilitation or a little extra muscle for their job. In technical terms, the apparatus is an untethered, upper-body exoskeleton; to the layman, it's essentially a battery-powered arm brace attached to a backpack.

Titan Arm's cost-efficient design has won the team accolades and at least $75,000 (£45,580) in prize money. 'They built something that people can relate to,' said Robert Carpick, chairman of University of Pennsylvania's mechanical engineering department. 'Of course it appeals clearly to what we've all seen in so many science-fiction movies of superhuman strength being endowed by an exoskeleton.' The project builds on existing studies of such body equipment, sometimes called 'wearable robots.' Research companies have built lower-body exoskeletons that help paralyzed people walk, though current models aren't approved for retail and can cost up to $100,000 (£60,780). The Penn students were moved by the power of that concept - restoring mobility to those who have suffered traumas - as well as the idea of preventing injuries in those who perform repetitive heavy-lifting tasks, said team member Nick Parrotta. 'When they started talking to physical therapists and prospective users, or people who have gone through these types of injuries, they just kept on getting more and more motivated,' said Mr Parrotta. For a project last year, Mr. Parrotta and classmates Elizabeth Beattie, Nick McGill and Niko Vladimirov set out to develop an affordable, lightweight suit for the right arm. They modeled pieces using 3D printers and computer design programs, eventually making most components out of aluminum, Ms Beattie said. The final product cost less than $2,000 (£1,217) and weighs 18lb (8kg) - less than the backpack that Ms Beattie usually carries. A handheld joystick controls motorized cables that raise and lower the arm; sensors measure the wearer's range of motion to help track rehab progress. Since it’s unveiling, Titan Arm has won the $10,000 (£6,086) Intel Cornell Cup USA and the $65,000 (£39,559) James Dyson Award. The resulting publicity generated a slew of interest from potential users, including grandparents who find it hard to lift their grandchildren.

They found out that some people can't even lift a cast-iron pan to cook dinner,' Mr McGill said.

Experts say the aging population represents a potentially big customer base for exoskeletons, which originally were researched for military applications.
'There is certainly a market, but it's slowly emerging because the systems are not perfect as yet,' said Paolo Bonato, director of the Motion Analysis Lab at Spaulding Rehabilitation Hospital in Boston. He noted, though, that its low cost represent parts only, not the salaries or marketing built into the price of other products. Mr. Park's research is focused on making exoskeletons less noticeable - 'more like a Spider-Man suit than an Iron Man suit,' he said. The Titan team hopes to refine their prototype, although three members are now busy with graduate studies at Penn and one is working on the West Coast. Among the considerations, Mr. Parrotta said, are different control strategies and more innovative materials and manufacturing.

Chapter-2

System Architecture

Our system is an arduino based exoskeleton arm which uses codes as an encryption method for the proper lifting up an object. The user can pick up objects which are beyond his capability. The user can lift and put an object down very easily using two buttons.

The entire system is very easy to use. This exoskeleton arm is so user friendly that the user can easily operate it. With using only two buttons the user can pick up and put things down. This exoskeleton arm will provide extra-strength on user’s arm which will allow the user to easily pick and put down objects without any hassle. The exoskeleton arm controlling motor and circuit is setup on backpack which allows the user to carry this entire system with him or her anywhere he wants.

2.1 Block Diagram

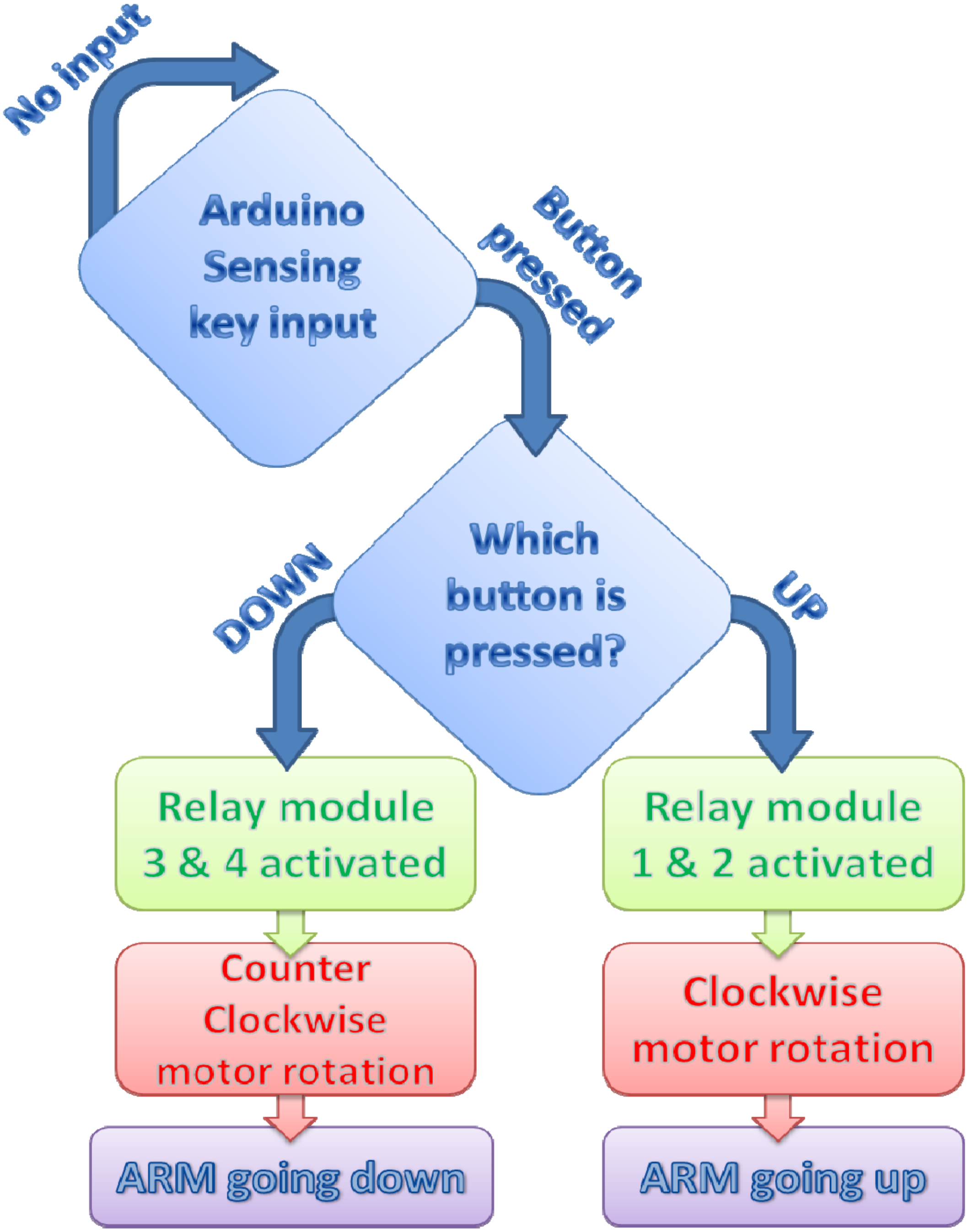
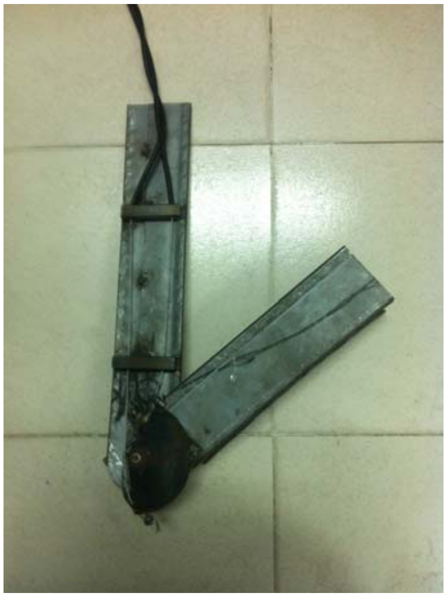

No input
Arduino Sensing key input
Button pressed
Which button is pressed?
DOWN
UP
Relay module 3 & 4 activated
Relay module 1 & 2 activated
Counter Clockwise motor rotation
Clockwise motor rotation
ARM going down
ARM going up

Figure 1: Flow Diagram

2.2 Hardware view



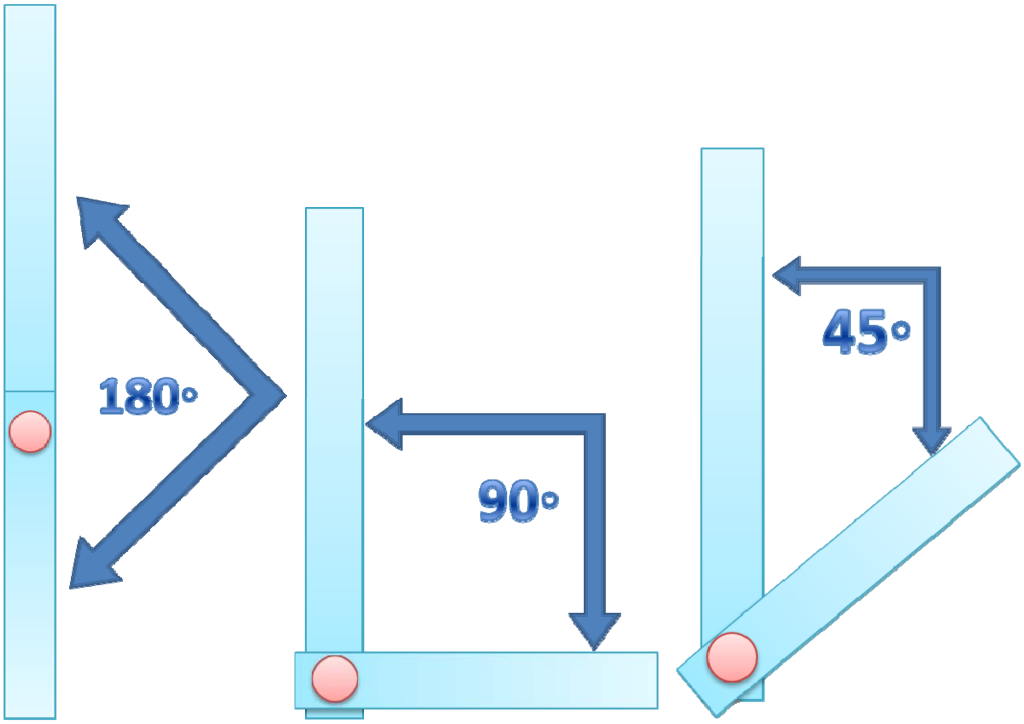


Figure 2: Arm Rotation and Movement

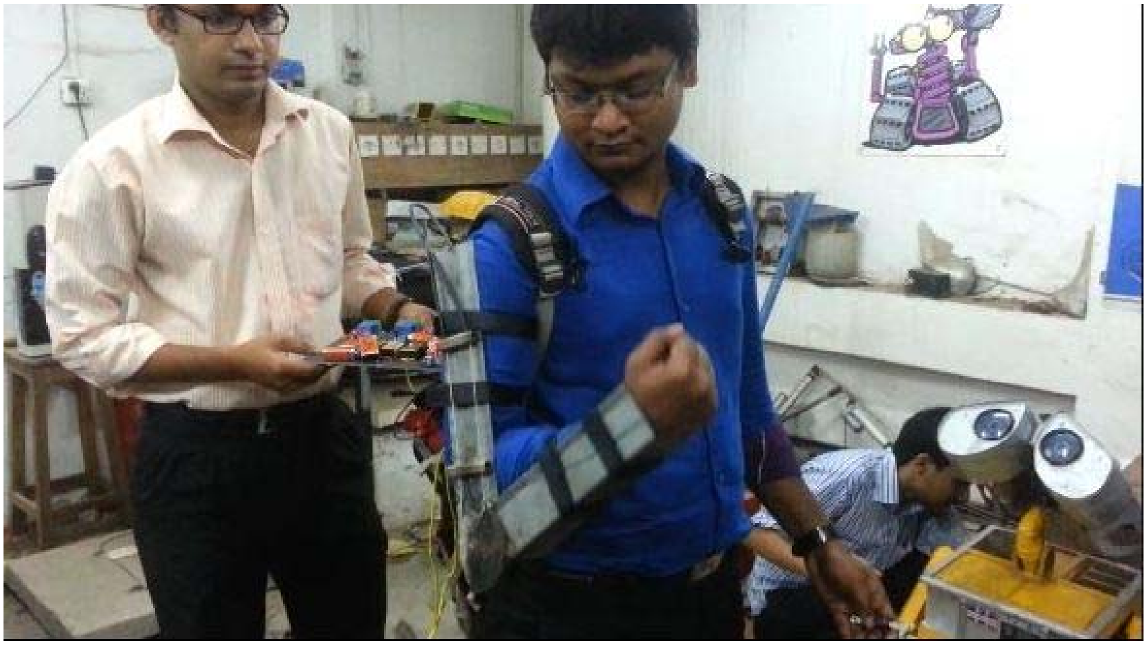


Figure 3: Exoskeleton Arm

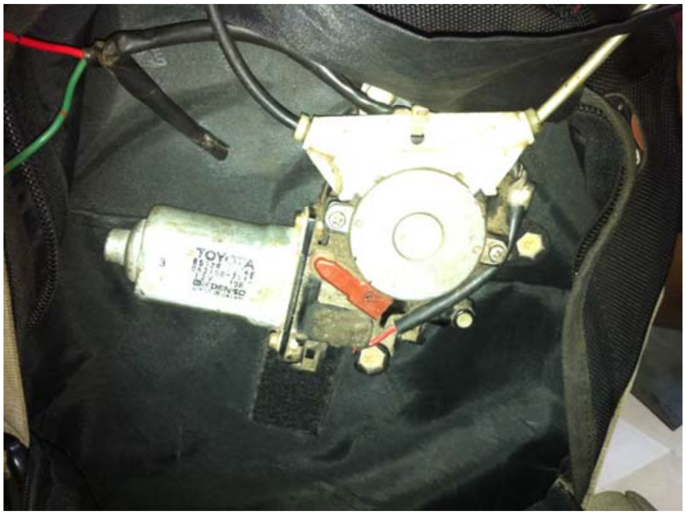


Figure 4: Glass Motor Fixed in Backpack

2.3 Circuit Control

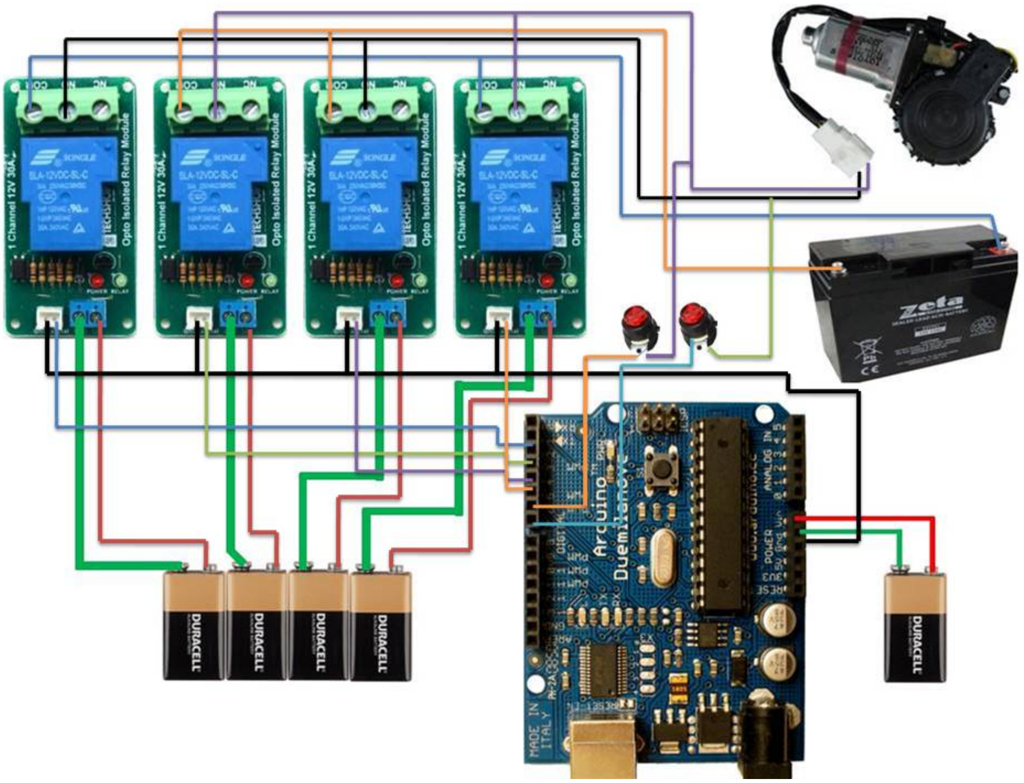


Figure 5: Full Circuit Diagram

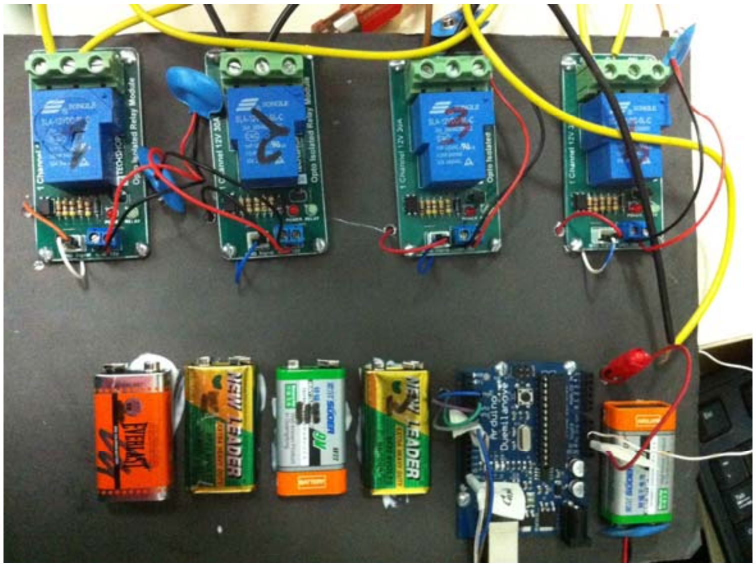


Figure 6: Circuit Board

Here, the circuitry was based on a 9v powered micro-controller (Arduino duemialanove), 12v powered Toyota Glass motor, 12v external power source, 4 30amp 12v opto isolated relay modules etc. Micro-controller is sensing key input where based on each key press it sends a particular signal to the relays. If the 'UP' button is pressed, relay module 1 &2 gets activation signal which let the external power source to power the motor and then it causes the arm going up. Same procedure in a reverse fashion works for the down operation. Each relay is powered by a single unit of 9v battery (follow figure 6). To ensure safety measurement, it is handled that there will be no occurrence where all for relays will be activated which might lead short circuit issue. Each group (1,2 or 3,4) of relays will be deactivated first before triggering the other group. Arm rotation is not bounded by the micro-controller but it is limited by the hardware modeling. This exoskeleton arm has a free rotation of 45 degree to 180 degree which allow users to feel close to human arm movement.

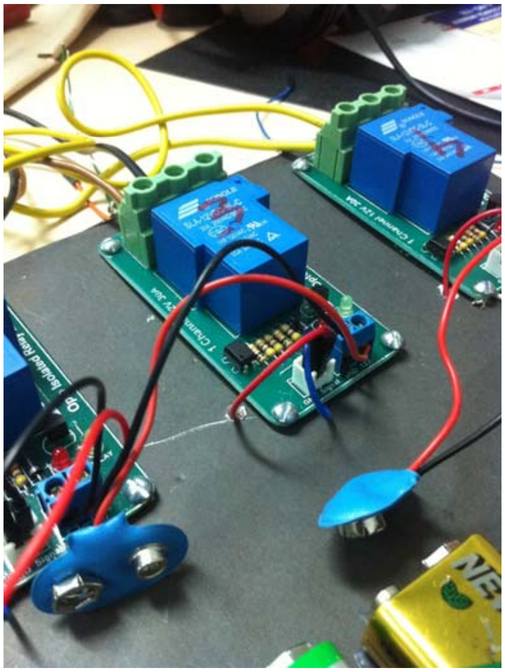


Figure 7: Relay

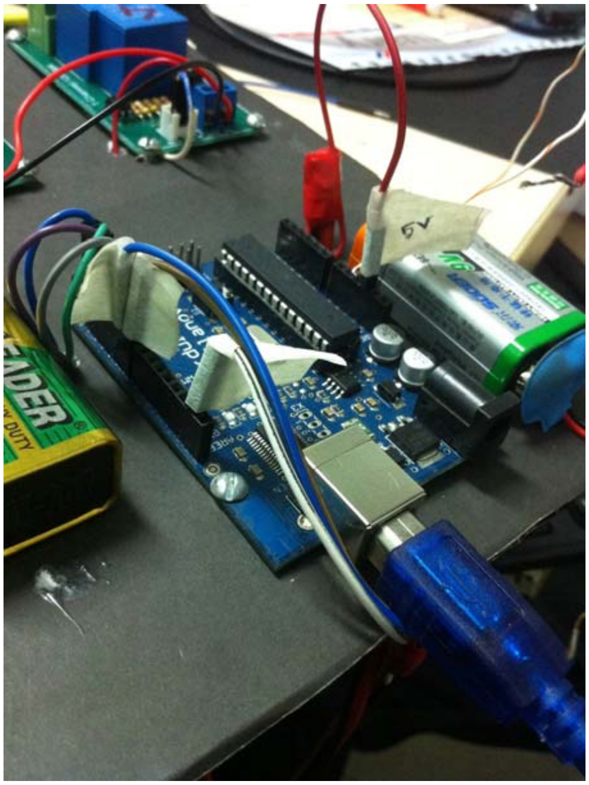


Figure 8: arduino duemilanove

CHAPTER-3

Components & Implementation

3.1 Glass Motor

Another toll-booth, another mile--or at least it seems as if the tollbooths come every mile on this road, with a half mile of traffic idling its leisurely way up to the token monster. Within an arm's length of the bin, you toggle the power window switch with one hand while the other hand fingers a token, preparing to whip it into the basket just as you floor the throttle. All goes as planned--except the window doesn't move, the token bounces back into your face, and you have to jam on the brakes, crack the door and pitch a second token backhanded to keep from getting a ticket as a toll evader, all to the tune of horns blaring from the cars behind you.

Fortunately, power windows are usually one of the more reliable systems on a late-model car. And diagnosis and repair are usually pretty straightforward.

First: Are all of the windows on the fritz? Or just one? If you can't move any of the windows, the first place to look is at the fuse. Window regulators are high-current devices, and the fuse is sized to just barely be able to open all four windows together. Age and a few sticky window channels can pop a fuse. Turn the key to the Run position, but don't start the car.

If the fuse is blown, pushing a window button will do nothing at all: The motor won't groan and the glass won't quiver. If the fuse is good and you can hear the motor, or the glass acts like it wants to move, then you've got some sort of mechanical problem. If not, check the fuse. If the fuse box isn't labeled, check the owner's manual to see which fuse is the culprit. Don't go yanking fuses willy-nilly looking for a bad one--you might interrupt the power to the engine management computer, causing poor drivability for 30 minutes or so--or you might reset all the buttons on your car radio to that undersea-alien rock-gospel station.

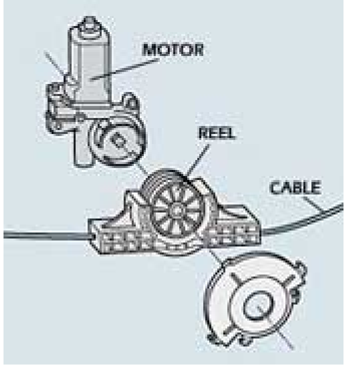
At this point, if you've narrowed the fault down to some electrical problem that's not as simple as a blown fuse you need to round up a schematic of your car's electrical system and a voltmeter or 12v test light. All that's necessary now is to start at the fuse panel and follow the wiring to the switch and from there moves on to the motor, testing along the way for 12 volts. Somewhere, you'll find a loose or corroded connector interrupting the voltage to the motor. Or, the switch itself might be bad. If the driver's door switch won't open the right rear door, but the switch in the door will, look for either a bad switch in the driver's door or a fault in the intervening wiring.

At this point, you probably need to be able to access the inside of the switch panel. On some vehicles, like the one in our lead illustration, you can simply pry the panel up with your fingers and back probe the connectors. Other vehicles may require that you remove the panel.

Door panels are held on with a bewildering variety of fasteners. Start by pulling off the entire door pulls and handles. The perimeter of the panel is customarily held on fragile plastic studs intended for one-time use. Pry them up carefully, and you should be able to reuse them.

Once you've got the door panel off, carefully remove the weather sheeting. You'll need to replace this later, and you may need fresh contact cement to do so.

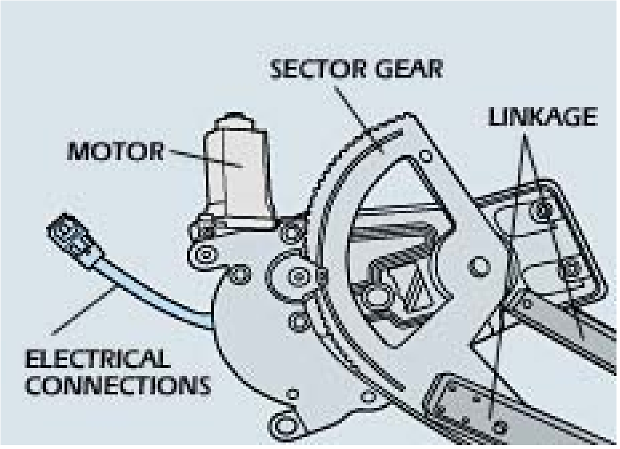
Warning: You now have the ability to put your fingers into places where fingers normally don't go. As our mechanic pal Lefty points out, "A power window motor has enough torque to put a serious hurting' on if it's actuated while errant digits are in the gears."



Reel and cable window regulators are simple mechanisms, but can be fussy about cable routing and may snag if jammed.

Proof Positive

As an absolute proof that the problem is electrical, try running a jumper wire direct from the battery positive terminal to the positive side of the motor to see if it comes alive. Be aware that a few window regulator systems supply 12v constantly, and switch the ground side of the circuit. Check the schematic. Also, most vehicles have the ability to lock--and deactivate--the rear windows. Check this switch if only the rears are balky. Occasionally, the true problem is a duff motor. You'll have to replace it. Otherwise, you can simply trace the wires until you find the problem.



Severe misalignment caused by loose fasteners can jam gear-type regulators.

Replacing a gasket or seal with a new part is generally straightforward. If it's not obvious that the gasket is astray, inspect the entire gasket and channel carefully. Look for damage, but also look for such things as pine sap, fossilized Foot Loops or other foreign objects that might make the window stick or bind. Clean the surface of the gasket and window with lacquer thinner to remove oxidized rubber and scum. There’s a fair amount of friction between the gasket and the window glass. Almost any misalignment can dramatically increase the friction to the point where the motor no longer has enough torque to move the glass properly. Lubricate the entire channel with silicone spray or protestant, because the reduced friction just might get your window working again. It’s also possible that the problem is deeper inside the door. If so, you'll need to pull the door panel and go poking around. Remember to pull the fuse to prevent amputating your fingers.

Lastly, the mechanism that runs the window up and down may be faulty. Whether it's a gear-and-sector, scissors lift or cable-operated mechanism, you'll need to watch it moving up and down a few times. Again, keep your fingers out of the works. Sometimes the problem will be a loose fastener or rivet, sometimes a broken or missing bushing. Cables can bind on the drum or become sticky. Lube all the friction points with white grease. Don't forget there are gaskets in the window track down below the top of the door, and you may need to reglue, repair or lubricate them.

3.2 Arduino Duemilanove

Overview

The Arduino Duemilanove ("2009") is a microcontroller board based on the ATmega168 or ATmega328It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, 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.

"Duemilanove" means 2009 in Italian and is named after the year of its release. The Duemilanove is the latest in a series of USB Arduino boards.

Summary

Microcontroller	ATmega168
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	16 KB (ATmega168) or 32 KB (ATmega328) of which 2 KB used by bootloader

SRAM	1 KB (ATmega168) or 2 KB (ATmega328)
EEPROM	512 bytes (ATmega168) or 1 KB (ATmega328)
Clock Speed	16 MHz

Power

The Arduino Duemilanove can be powered via the USB connection or with an external power supply. The power source is selected automatically.

External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The power pins are as follows:

- VIN. The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- 5V. the regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply.
- 3V3. A 3.3 volt supply generated by the on-board FTDI chip. Maximum current draw is 50 mA.
- GND. Ground pins.

Memory

The ATmega168 has 16 KB of flash memory for storing code (of which 2 KB is used for the boot loader); the ATmega328has 32 KB, (also with 2 KB used for the boot loader). The ATmega168 has 1 KB of SRAM and 512 bytes of EEPROM (which can be read and written with the EEPROM library; the ATmega328 has 2 KB of SRAM and 1 KB of EEPROM.

Input and Output

Each of the 14 digital pins on the Duemilanove can be used as an input or output, using pin Mode, digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

- Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the FTDI USB-to-TTL Serial chip.
- External Interrupts: 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details.
- PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analogWrite() function.
- SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library.
- LED: 13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

The Duemilanove has 6 analog inputs, each of which provides 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analogReference() function. Additionally, some pins have specialized functionality:

- I^{2}C: analog input pins A4 (SDA) and A5 (SCL). Support I^{2}C (TWI) communication using the Wire library.

There are a couple of other pins on the board:

- AREF. Reference voltage for the analog inputs. Used with analogReference().
- Reset. Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

Communication

The Arduino Duemilanove has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega168 and ATmega328 provide UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An FTDI FT232RL on the board channels this serial communication over USB and the FTDI drivers (included with Windows version of the Arduino software) provide a virtual com port to software on the computer. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the FTDI chip and USB connection to the computer (but not for serial communication on pins 0 and 1).

Programming

The Arduino Duemilanove can be programmed with the Arduino software. Select "Arduino Diecimila or Duemilanove w/ ATmega168" or "Arduino Duemilanove w/ ATmega328" from the Tools > Board menu (according to the microcontroller on your board).

The ATmega168 or ATmega328 on the Arduino Duemilanove comes preburned with a boot loader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500protocol.

You can also bypass the boot loader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header.

Automatic (Software) Reset

Rather than requiring a physical press of the reset button before an upload, the Arduino Duemilanove is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the FT232RL is connected to the reset line of the ATmega168 or ATmega328 via a 100 nano farad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the boot loader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload.

The Duemilanove contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It's labeled "RESET-EN". You may also be able to disable the auto-reset by connecting a 110 ohm resistor from 5V to the reset line.

USB over current Protection

The Arduino Duemilanove has a resettable polyfuse that protects your computer's USB ports from short circuits and over current. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

Physical Characteristics

The maximum length and width of the Duemilanove PCB are 2.7 and 2.1 inches respectively, the USB connector and power jack extending beyond the former dimension. Three screw holes allow the board to be attached to a surface or case. Note that the distance between digital pins 7 and 8 is 160 mil (0.16"), not an even multiple of the 100 mil spacing of the other pins.

Arduino can sense the environment by receiving input from a variety of sensors and it can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software on running on a computer (e.g. Flash, Processing, MaxMSP). Arduino is a cross-platform program. You'll have to follow different instructions for your personal OS.

3.3 12v 30A Opto Isolated Relay Module (1 Channel)

Model: MOD-00065

The standard 1 Channel 12v 30A Opto Isolated Relay Module, using of High-level voltage signals to trigger only needs 3mA current signal to drive the 30A load relay. Use of high-quality power relay, high-withstand voltage transistor, red & green signal lights assures accurate and stable performance. It can be used in various types of power control occasions**.**

Specification:

1. Using of high-quality relay, normally open relay contacts maximum load: AC 0--250V/30A, DC 0-- 30V/30A;
2. Using of high-withstand voltage transistor, strong driving ability, stable performance, trigger current of 3mA;
3**.** Working voltage:12V
4. The relay using of high-level voltage signals to trigger, high-level voltage signals can be DC power supply positive, also can be microcontroller I/O port set high;
5. The power indicator (red LED), relay status indicator (Green LED);

The relay module outputs (3-wire interface with terminal blocks, very convenient)
1.NO: the relay normally open contacts;
2.COM: the Relay common contact;
3.NC: the relay normally closed contacts

3.4 Printed circuit board (PCB)

A printed circuit board (PCB) mechanically supports and electrically connects electronic components using conductive tracks, pads and other features etched from copper sheets laminated onto a non-conductive substrate. PCBs can be single sided (one copper layer), double sided (two copper layers) or multi-layer. Conductors on different layers are connected with plated-through holes called vias. Advanced PCBs may contain components - capacitors, resistors or active devices - embedded in the substrate.

Printed circuit boards are used in all but the simplest electronic products. Alternatives to PCBs include wire wrap and point-to-point construction. PCBs require the additional design effort to lay out the circuit but manufacturing and assembly can be automated. Manufacturing circuits with PCBs is cheaper and faster than with other wiring methods as components are mounted and wired with one single part. Furthermore, operator wiring errors are eliminated.

When the board has only copper connections and no embedded components it is more correctly called a printed wiring board (PWB) or etched wiring board. Although more accurate, the term printed wiring board has fallen into disuse. A PCB populated with electronic components is called a printed circuit assembly (PCA), printed circuit board assembly or PCB assembly (PCBA). The IPC preferred term for assembled boards is circuit card assembly (CCA), for assembled backplanes it is backplane assemblies. The term PCB is used informally both for bare and assembled boards

Chapter-4

Result

The integration of human and robot into a single system offers remarkable opportunities for a new generation of assistive technology. Despite the recent prominence of upper limb exoskeletons in assistive applications, the human arm kinematics and dynamics are usually described in single or multiple arm movements that are not associated with any concrete activity of daily living . Moreover, the design of an exoskeleton, which is physically linked to the human body, must have a workspace that matches as close as possible with the workspace of the human body, while at the same time avoid singular configurations of the exoskeleton within the human workspace. The aims of the research reported in this manuscript are to study the kinematics and the dynamics of the human arm during daily activities in a free and unconstrained environment, to study the manipulability of a 7-degree-of-freedom powered exoskeleton arm given the kinematics and the dynamics of the human arm in ADLs. Kinematic data of the upper limb were acquired with a motion capture system while performing 24 daily activities from six subjects. Utilizing a 7-DOF model of the human arm, the equations of motion were used to calculate joint torques from measured kinematics. In addition, the exoskeleton isotropy was calculated and mapped with respect to the special distribution of the human arm configurations during the 24 daily activities. The results indicate that the kinematic joint distributions representing all 24 actions appear normally distributed except for elbow flexion–extension with the emergence of three modal centers. Velocity and acceleration components of joint torque distributions were normally distributed about 0 Nm, whereas gravitational component distributions varied with joint. Additionally, velocity effects were found to contribute only 1/100th of the total joint torque, whereas acceleration components contribute 1/10th of the total torque at the shoulder and elbow, and nearly half of the total torque at the wrist. These results suggest that the majority of human arm joint torques are devoted to supporting the human arm position in space while compensating gravitational loads whereas a minor portion of the joint torques is dedicated to arm motion itself. A unique axial orientation at the base of the exoskeleton allowed the singular configuration of the shoulder joint to be moved towards the boundary of the human arm workspace while supporting 95% of the arm's workspace. At the same time, this orientation allowed the best exoskeleton manipulability at the most commonly used human arm configuration during ADLs. One of the potential implications of these results might be the need to compensate gravitational load during robotic-assistive rehabilitation treatment. Moreover, results of a manipulability analysis of the exoskeleton system indicate that the singular configuration of the exoskeleton system may be moved out of the human arm physiological workspace while maximizing the overlap between the human arm and the exoskeleton workspaces. The collected database along with kinematic and dynamic analyses may provide a fundamental basis towards the development of assistive technologies for the human arm. With the help of our project we are finally able to give the user extra strength which will allow him or her to pick and move objects which are beyond his capable limit.

Chapter-5

Discussion

Rehabilitation robots have become important tools in stroke rehabilitation. Compared to manual arm training, robot-supported training can be more intensive, of longer duration and more repetitive. Therefore, robots have the potential to improve the rehabilitation process in stroke patients. Whereas a majority of previous work in upper limb rehabilitation robotics has focused on end-effectors-based robots, a shift towards exoskeleton robots is taking place because they offer a better guidance of the human arm, especially for movements with a large range of motion. However, the implementation of an exoskeleton device introduces the challenge of reproducing the motion of the human shoulder, which is one of the most complex joints of the body. Thus, this paper starts with describing a simplified model of the human shoulder. On the basis of that model, a new ergonomic shoulder actuation principle that provides motion of the humorous head is proposed, and its implementation in the exoskeleton arm therapy. In future we are going to try to change the control panel switch easier and we will replace it with pressure sensor. Furthermore we will try our best to make it work with brain waves.

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Appendixes

Exoskeleton arm controlling code with Arduino Duemilanvoe:

```
int rlSw1 = 2; // Go up +Ve
int rlSw2 = 3; // Go up GND
int rlSw3 = 4; // Go down +Ve
int rlSw4 = 5; // Go down GND
int rlSw5 = 6; // Go up Switch
int rlSw6 = 7; // Go down Switch

void setup() {
    // set the switch as an input:
     Serial.begin(9600);
     pinMode(rlSw1, OUTPUT);
     pinMode(rlSw2, OUTPUT);
     pinMode(rlSw3, OUTPUT);
     pinMode(rlSw4, OUTPUT);
     pinMode(rlSw5, INPUT);
     pinMode(rlSw6, INPUT);
 }

 void loop() {
   //int x=digitalRead(rlSw6);
   //int y=digitalRead(rlSw5);
   //Serial.println("x: "+x);
   //Serial.println("y: "+y);
   //Serial.flush();
   if((digitalRead(rlSw6)==HIGH)&&(digitalRead(rlSw5)==LOW)){
   digitalWrite(rlSw1,LOW);
   digitalWrite(rlSw2,LOW);
   delay (2);
   digitalWrite(rlSw4,HIGH);
   digitalWrite(rlSw3,HIGH);
   }else if((digitalRead(rlSw6)==LOW)&&(digitalRead(rlSw5)==HIGH)){
   digitalWrite(rlSw3,LOW);
   digitalWrite(rlSw4,LOW);
   delay (2);
   digitalWrite(rlSw2,HIGH);
   digitalWrite(rlSw1,HIGH);
   }else{
   digitalWrite(rlSw1,LOW);
   digitalWrite(rlSw2,LOW);
   digitalWrite(rlSw4,LOW);
   digitalWrite(rlSw3,LOW);
   }
 }
```