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Head Gesture Controlled Wheelchair

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ABSTRACT: The project is to advance a wheelchair control which is useful to the physically disabled people (especially, quadriplegics and paraplegics) and old aged person with his head gesture recognition using Accelerometer's tilting technology. Enormous expansions have been made in the field of wheelchair technology. However, even these considerable improvements haven't been able to help quadriplegics navigate wheelchair unassisted. This wheelchair is controlled by simple head gestures. It employs a microcontroller which monitors the wheelchair by interpreting the motion intended by operator (user) by his / her head gesture incorporating tilt sensor and moves accordingly in directions like Left, Right, Forward and Backward. The objective of this project is to execute above said goal with efficiency using Design Engineering Methodology. This paper explains the different phases of Design Thinking like objective, empathy, ideation, product development principle and prototype of the Head Gesture Controlled Wheelchair.

KEYWORDS: Wheel Chair, Accelerometer, Microcontroller, DC Motor and Driver Circuit, Transmitter and Receiver Circuit.

I.INTRODUCTION

Design Engineering is a subject in view of design thinking methodology , which help students to observe and empathize with their surroundings to come up with innovative ideas and tackle the problem faced by society [1]. Movement has come to be very important constraint for a good quality of life. Loss of mobility due to age factor or an injury is usually complemented by a loss of self-confidence. Designing a system with independent mobility for such disabled people /stakeholders is our goal for this project. Statistics shows that 43 million people are disabled; about 17% of 250 million people world-wide or 1 out of 5 persons. This paper introduces a head gesture-controlled wheelchair system to control the motor rotation of wheelchair based on head movement of physically challenged person. Our prime focus will remain on affordable cost of head gesture-controlled wheelchair for paraplegic & quadriplegic person [2], [3].

Persons with different disability can get benefit out of it at different level like old age persons can use it for ease out of their tiredness and peoples with leg (and hand or both) disability can try to complete themselves by giving themselves chance to roam again unassisted. Some users find manual or joystick maneuverer wheel chairs difficult or impossible to operate. This smart wheel chair incorporates semi-auto movement control for their operational ease. We present an approach to gesture-based technique which controls the wheelchair using head movements[4]. The main objective of our project is to bring happiness to the stakeholders who will not have to depend on others any more. The project is fully automated and is easy to use having less maintenance. As the wheelchair motion is controllable, it will be like a part of body for those who have to be dependent on others and can do the work on their own. Also, it's an effort to uplift the moral of people with mortal impairment [5].

II.SUPPORTING DEVICES

Supporting devices are devices that facilitates an individual to do somewhat that might not else be able to do well or at all. Due to the complications that physically disabled individuals suffer on their everyday lives, which makes them constrained and otherwise incapable of undergoing things that they somehow wanted to do, these devices were created. As per statement given by Hearing Loss Association of North Carolina, the term supporting devices are used for device that assist people overcome a handicap such as a mobility, vision, mental, dexterity or hearing loss [6].

A. Brief History of Personnel Mobility Supporting Devices:

People are using personal mobility devices for many hundreds of years. Their history and value to society is well documented and known. Wheelchairs and mobility scooters, two popular types of mobility devices, are significantly improved upon over the years, but there are many more devices as well that have been used for thousands of years. After the discovery of the motorized wheelchair, tremendous improvements were discovered. Manualwheelchairs became far simpler and controllable. Many athletes who were mobility challenged pushed for even more athletic models and there were numerous innovations in the technology that was at the back of the motorized wheelchair[10]. Social Mobility scooters were first launched in the late 1960's and by the early 1970's they had become a very common choice to the powered wheelchair. Social Mobility scooters are more reliable for people who are able to roam for short distance, but find it embarrassing to do so over prolonged periods of time. A mobility scooter cannot be drawn up to a table or writing desk as easily as a wheelchair [9].

Modern movement devices are extremely advanced, are electric powered, and include rechargeable batteries. The exact range of these devices can differ, but some of them are able to take a trip over 40 miles per charge. Also there have been immense modernization in non-motorized devices. The walker is a non-motorized motion device that has been utilized in some shape or form as long as the wheelchair. Modern walkers often feature front wheels and are called rolling walkers or rollators. These types of devices are excellent because you can push the stroller instead of having to lift it with additional features of hand break [4].

Fig. 1. Assistive Devices

As is usually the case, creatures have significantly improved upon the designs of initial mobility devices. The models and types available today are some of the most consistent and reliable accessible and will make available many years of regular service. The first well-known image of a wheelchair was sculpted into a stone in the 6th century and King Philip II, who was the King of Spain during the 16th century, used a very sophisticated wheelchair that had both armrests and leg rests. In the 18th century the first wheelchair comparable in design to those available today was developed. It had large front wheels and a single wheel in back. By the 19th and 20th century wheelchairs were built of wood and bamboo design [7]. A US patent was issued for this design in 1894 and they were used by veterans of the Civil War and the First World War [8].

The first collapsible wheelchair was designed in 1932, by two engineers, one of whom was injured in a mining accident. In 1950, the first powered wheelchair was constructed. It was designed by an inventor named George Klein and was expected to help veterans of World War II. Unlike the first war, many of the individuals who experienced spinal cord injuries had survived World War II, which created an inflow of disabled veterans. During this time, there were some improvements in manual wheelchair technology, but many quadriplegic individuals were still incapable to use manual wheelchairs deprived of assistance. Klein, backed by the Canadian government and many other scientists, spearheaded the advancement of a motorized wheelchair. Many soldiers and veterans played a part in the devices creation and its layout was billed as one of the first times that rehabilitation engineering had transpired [9].

After the invention of the motorized wheelchair, many more evolutions were produced. Manual wheelchairs became much simpler and controllable Fig. 1. Several athletes who were mobility challenged pushed for more athletic models and there were many enhancements in the technology that was in the wake of the motorized wheelchair [10].Mobility scooters were first introduced in the late 1960's and by the early 1970's they had come to be a very common substitute to the powered wheelchair. Mobility scooters are more intended for individuals who are able to move for short distance, but find it embarrassing to do so over prolonged periods of time. A mobility scooter cannot be dragged up to a table or desk as easily as a wheelchair [9].

A. Background of the Study:

A wheelchair is a device or equipment, essentially a chair that has a number of wheels attached to it. Wheelchairs are used primarily by physically challenged entities who could not move or stand for. Mostly in all wheelchair, there are handles located at the back of a wheel chair that could be utilized by another one to help the user of the wheelchair for steering and navigation. Although there were still conventional manually operated alternatives of such device, the advancement of technology had also been attached to mobility devices. The newer alternatives of these devices use batteries and motors for the pushing capability. Such variants are known as Electric Powered Wheelchairs (EPWs). In recent times, there have been a wide range of assistive and guidance systems available in wheelchair device to make the user's life less complicated.

In recent times, there have been various control systems development that is specialized for people with various disorders and disabilities. The developed systems are highly competitive in replacing the old traditional systems. There are many assistive systems using visual aids like smart wheelchair systems, using joystick and much more. There are even systems based on voice recognition. These functions are very common among people with restricted upper body functions. Although there were pretty few several means of controls existing for the current systems of automated wheelchairs, there are certain disadvantages in these systems as it cannot be used by people of complex disability because they need fine and accurate control which is now and then not possible [8], [11]. The promoters of this prototype project wish to assist these disabled persons by providing a new way of controlling a wheeled chair or seat. The overall aim of this prototype project is to re-establish the sovereignty of the physically challenged persons, empowering them to independently use an electric powered wheelchair [12], [13]. Thus, this prototype project is intellectualized by the investigators to let the stakeholders to control the wheelchair by just the use of their head movements, thus calling this prototype project the head gesture - controlled wheelchair [14].

B. Statement of the Problem:

This project has been developed for the help of disabled persons with their own mobility. This research was started due to the statistic that the current system was not enough adequate to supply the needs of several people. Thus, this research will provide a better concept for the present system.
Problems:

- The lack of self-confidence of a physically challenged person when it comes to his or her personal mobility is invariably observed.
- Pushing a manual wheelchair might cause tiredness and ache on the user's upper body portions (i.e. wrists, shoulders, elbow, and hands).
- For physically challenged persons with weak control, the traditional electronic wheelchair becomes inaccurate because most of the time, the accumulated force on the fingers of those persons may not be sufficient.
- In some cases, it will be challenging for a workable wheelchair user with non - existing finger (due to mishap) to operate the joystick module connected into traditional wheelchairs, thus increasing the problem of moving the wheelchair for the customer's mobility.

C. Objectives of the Study:

The advancement of this project plan is for the improvement of the current executed system throughout the market. It could be said that this research will contain the solution for such problems present in the current system. The objectives of this research will be the known aid for the complicated problems or complications found on the current system.
Objectives:

- To build up a wheelchair that will increase the self-confidence of a physically challenged person when it comes to his or her personal mobility. To create a social mobility gadget that is easy to use and will decrease the possible tiredness and discomfort that the user might experience when using a manually driven wheelchair.
- To present a controller module which will empower a user with shaky grip to control or influence the movement of the established mobility device by moving the controller to a certain direction.
- To facilitate a potential user with no finger tips to control the developed motion device

III.SIGNIIFICANCE

This prototype project head gesture-controlled wheelchair objects to develop an innovation on electronic wheelchair technology. The head gesture will be used as the principal direction controller of the project prototype. The promoters have come up with this project in order to help the users with disability to be slightly independent when it comes to controlling their individual traveling or strolling companion, the wheelchair. The outcomes of this research will benefit the following.

A. The friends and family of the person with disability

The patient will become a little independent or self-dependent, it only indicates that the time his loved ones need to watch the patient will be decreased, thus if this happens, they'll be having more time to complete the work that is considered necessary to be done.

B. The person with disability itself

This is a project expected to help them become self-dependent, it only implies that they will be the greatest recipients of this project, thus, this project will give them the self-sufficiency to feel or feel once more that they are rather independent, they are free in a true sense.

IV.HARDWARE IMPLEMENTATION

A. ADLX335 Accelerometer

The ADXL335 is a small, thin, low power, complete 3-axis accelerometer with signal conditioned voltage outputs. The product measures acceleration with a minimum full-scale range of ±3 g Fig 2.

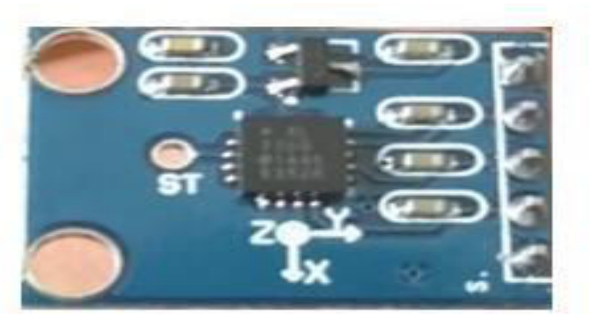

Fig. 2. ADXL335 Accelerometer

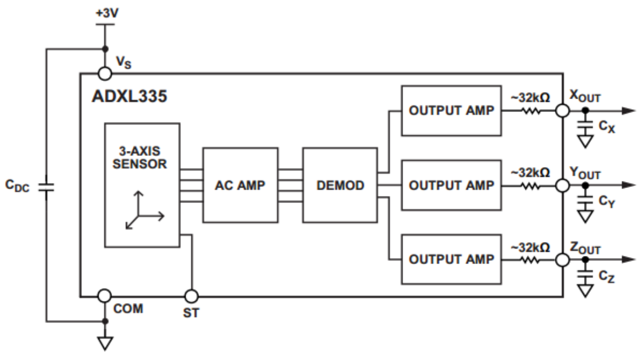

Fig. 3. ADXL335 Functional Block Diagram

It contains a polysilicon surface micro - machined sensor and signal conditioning circuitry to implement an open-loop acceleration measurement architecture. The output signals are analogy voltages that are proportional to acceleration. It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration. The user selects the bandwidth of the accelerometer using the CX, CY, and CZ capacitors at the XOUT, YOUT, and ZOUT pins. Bandwidths can be selected to suit the application, with a range of 0.5 Hz to 1600 Hz for the X and Y axes, and a range of 0.5 Hz to 550 Hz for the Z axis Fig.3.

- Voltage Consumption: 1.8 – 3.6 V DC
- Low Power: 40 µA
- Output Changes at Different Axis Pins: ±150 to ±600 mV

B. Arduino Uno (Atmega328p Microcontroller)

Arduino is a prototyping platform which offers a flexible easy-to-use hardware and software. It provides easier components interfacing feature and a better programming support. Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, 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 an AC-to-DC adapter or battery to get started. "Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform Fig. 4.

Fig. 4. Arduino Uno

Specifications:

- Operating Voltage: 5
- Input Voltage (recommended): 7 – 12 V
- Input Voltage (limit): 6 – 20 V
- Digital I/O Pins: 14
- PWM Digital I/O Pins: 6
- Analog Input Pins: 6
- DC Current per I/O Pin: 20 mA
- DC Current for 3.3 V: 50 mA
- Flash Memory: 32 KB (ATMega328P)
- RAM: 2 KB (ATMega328P)
- Clock Speed: 16 MHz

C. Motor Driver

The output supplied 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.

Fig. 5. BTS7960 Df Robot Motor Driver

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

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 Fig.5.

D. 24 Volt DC Motor

Motors are the most important part of the power wheelchair as they deliver 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

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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 Fig. 6.

Specifications:

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

E. 12 Volt Lead Acid Battery

- 12V, 12Ah battery supply is used to power the whole system.
- It is a lead acid battery which requires to be recharged periodically Fig.7.

Fig. 6. 24 Volt DC Motor

Fig. 7. 12 Volt Lead Acid Battery

V.WORKING PROOF OF CONCEPT

The transmitter consists of ATmega328 microcontroller (Arduino Uno), ADXL335 accelerometer, HT12E encoder and 433MHz RF transmitter module (TX). In this circuit, two analogue outputs from ADXL335 pins (x, y) are connected with input pins (A2, A3) of the microcontroller. Analogue signals are converted to digital signals through the microcontroller. Digital outputs from pins 4, ~5, ~6 and 7 of the microcontroller are directly sent to pins 13, 12, 11 and 10 of encoder IC. This data is encoded and transmitted via RF module TX Fig. 8.

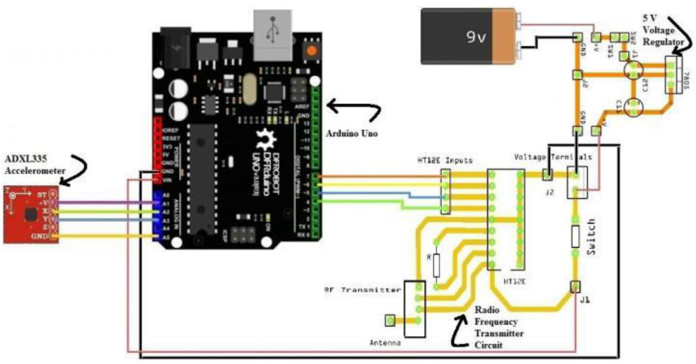

Fig. 8. Transmitter Circuit

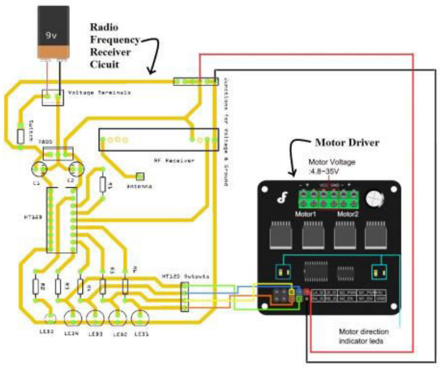

Fig. 9. Receiver Circuit

The receiver part consists of 433MHz RF receiver module (RX), HT12D decoder and Motor driver (Dual Full H-Bridge BTS7960) to run the motors. Here, receiver module RX receives the transmitted signal, which is decoded by decoder IC to get the same digital outputs send by microcontroller. Four outputs of Motor Driver drive two motors. The chair moves as per tilt direction of the accelerometer in the transmitter Fig. 9.

Fig. 10. Assembled Wheelchair

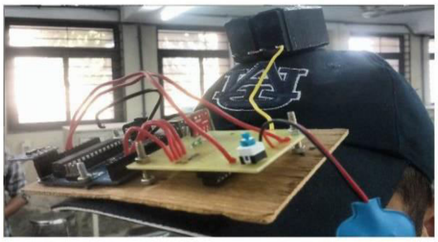

Fig. 11. Transmitter Arrangement on Cap

Fig. 12. Assembly for Receiver and Battery

The project facilitates a person with disability to use a wheelchair with comfort Fig. 10. This wheelchair allows the user to control the movements of the wheelchair just by using a particular body part's (in this case it would be the head) movement in which an accelerometer sensor is mounted Fig. 11.

The accelerometer sensor is associated on an Arduino Uno Microcontroller Board, an open source computing platform based on simple input/output board and uses standard programming language, to process the signals delivered by the accelerometer in order to control the wheelchair's movement. The wheelchair's movement is defined via accelerometer sensor which measures the quantity of static acceleration due to gravity every time it is moved, by doing this the tilt movement could be quantified with respect to the earth.

The data obtained from the accelerometer sensor will be passed on to the Arduino Uno Microcontroller Board for data evaluation and processing. Afterwards, the Arduino Uno Microcontroller Board will transmit a command on to the Motor Driver Circuit which will control the motor's movements based on the signal sent by the microcontroller Fig. 12.

The battery incorporated in this wheelchair could supply power from 2 – 5 hours depending on the user's preference of the device's handling. The head gesture wheelchair has a maximum weighing capacity to carry 90 kg. It is not advised to be used for persons with severe shakiness and / or psychological disability. The proposed wheelchair system is not recommended to be utilized for long distance travels and / or on rocky pathways and sloping surfaces.

A. Scope of the Project:

- The research covers up the formation of an automatic wheelchair system that will benefit the disabled persons.
- The controller uses the movements of a certain body part in which the sensor is located for control or movement, for example the head.
- A precise movement of a head could begin one of five different states of movement, namely forward, reverse, left turn, right turn, and stop.
- In order to guarantee the security of the user, the researchers have chosen a low speed but high torque motor, it indicates that the movement speed will be gradual, but still, due to these motors, the wheelchair could carry a person with larger or heavier weight.
- For stakeholders who wanted to lay down, the head gesture-controlled wheelchair also has a resting back support

B. Limitations of the Project:

- Head gesture-controlled wheelchair could not be utilized as a means of transport for long distances such as going from one town to another, but it could be used for personal, outdoor and short distance transportations.
- It is restricted to be operated by fully paralyzed persons that could not move any part of his or her body, but it could be used by entities who are physically incapable of standing up or walking as long as they can move either one of their hands or head.
- Unlike other conventional electric wheelchairs, it's speed could not be modified because the researchers prefer a low speed operation than an adjustable speed control operation to make sure the user's safety.
- It is not proposed to be used by entities with severe shakiness as it could trigger the sensor to calculate undesirable movement.
- It is not recommended to be utilized by persons with mental illnesses as it is too hazardous to be used by persons that are not mentally capable or fit.

- The proposed wheelchair system is not desirable to be used on inclined surfaces and rocky environments as the wheelchair might not be able to move properly.

VI. RESULTS

Until the present invention, the mobility of the physically disabled was almost entirely limited to the use of the conventional collapsible wheelchair. Manual propulsion (using the hands to pull on the wheel rim to make it turn) is possible only for paraplegics or the equivalent, who have normal upper extremities. Although quadriplegics may be able to push themselves for small distances, this is exhausting and runs the danger of developing wounds on the hands (since the hands do not have full sensation in quadriplegics).

The quadriplegics need a powered drive technique which, in the prior art, has been offered by merely bolting a motor / battery unit onto the back of a portable wheelchair. Many other shortcomings exist with respect to previous art wheelchairs. With respect to the events of daily living, a standard powered wheelchair is only hardly adequate around the house, office or on the sidewalk. The standard wheelchair does not accommodate itself very well to the unattended operation.

Future Usefulness of this work: Persons with different disability can get benefit out of it at different level like old age persons can use it for ease out of their tiredness and peoples with leg disability can try to complete themselves by giving themselves chance to roam again independently. Some users find manual or joystick maneuvered wheel chairs difficult or impossible to operate. This smart wheel chair incorporates semi-auto movement control for their operational ease. We present an approach to gesture-based technique which controls the wheelchair using head movements. A patent has been filed in the Patent Office , India in the month of September, 2018 [17].

VII. CONCLUSION

Based from the existing technique of controlling an automatic wheelchair, it has been concluded that a sensor which senses the head movements of the user would be much more cost-effective. Instead of applying the present way of controlling an automated wheelchair which is by means of a joystick controller fastened on the wheelchair itself, employing this method would facilitate much more control efficiency for the user. It could permit a user to use the wheelchair without exerting or collecting force on their fingers or finger tips, which would be of good help for those who does not have fingers or could not accumulate force on to their fingertips. Therefore, it could be concluded that the head gesture control wheelchair had a better flexibility, efficiency and reliability as compared to the conventional automated wheelchair.

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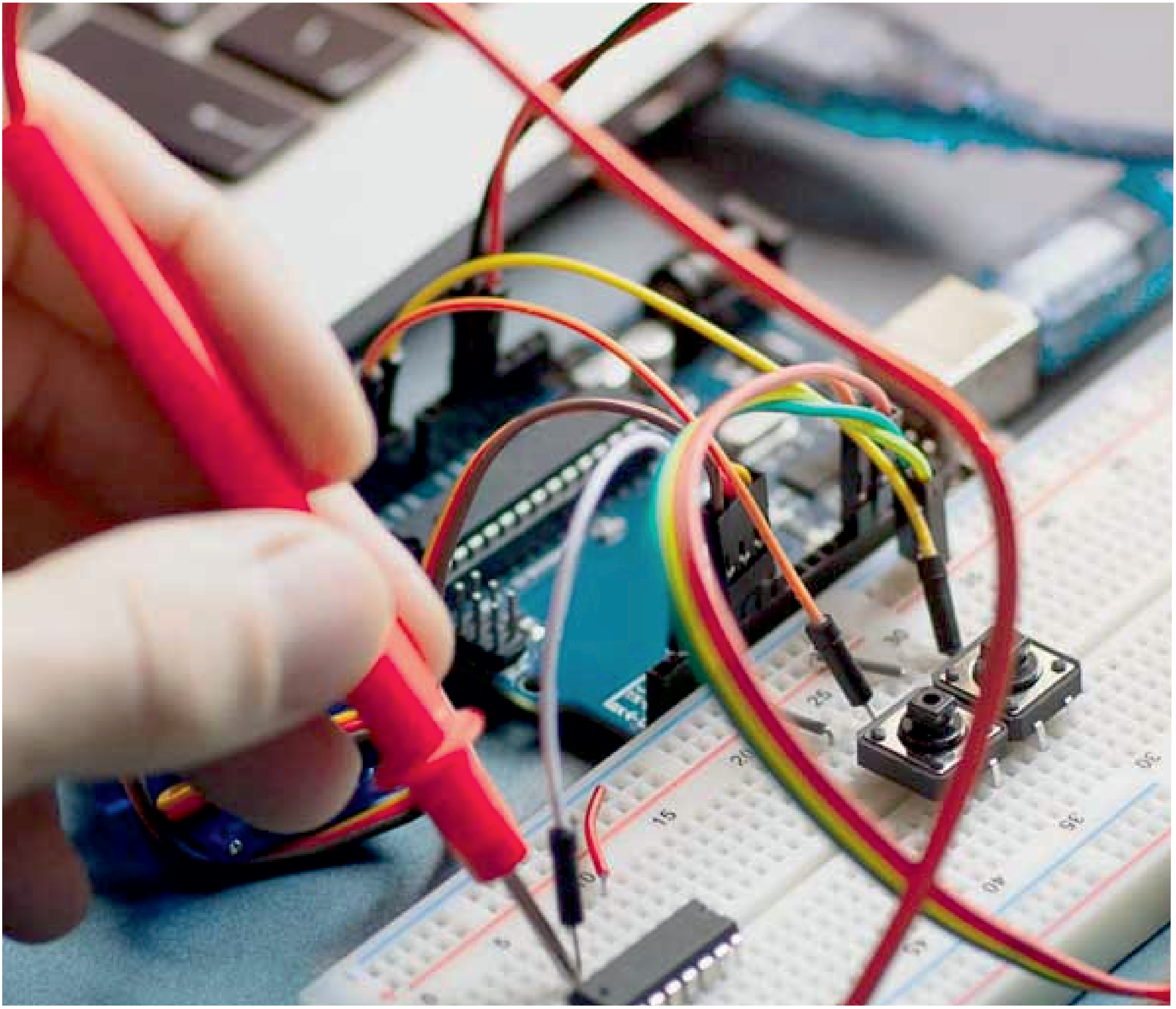

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