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Wireless Control of Powered Wheelchairs with Tongue Motion Using Tongue Drive Assistive Technology

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Abstract - **Tongue Drive system (TDS) is a tongue-operated unobtrusive wireless assistive technology, which can potentially provide people with severe disabilities with effective computer access and environment control. It translates users' intentions into control commands by detecting and classifying their voluntary tongue motion utilizing a small permanent magnet, secured on the tongue, and an array of magnetic sensors mounted on a headset outside the mouth or an orthodontic brace inside.**

Keywords - **Tongue drive system (TDM), LPC2148, RF communication.**

I. Introduction

The paper aims in designing customized interface circuitry by implementing four control strategies to drive a powered wheel chair (PWC) and also control the devices using an external TDS prototype. TDS is an assistive technology that enables individuals to maneuver a powered wheelchair or control a mouse cursor using simple tongue movements can be operated by individuals with high-level spinal cord injuries. The purpose of the present study is to develop a simple wheel chair for the Quadriplegics which assists them to control the movement of wheelchair through their tongue motion using a Hall sensor and two encoders, for controlling it safely.

II. System Description

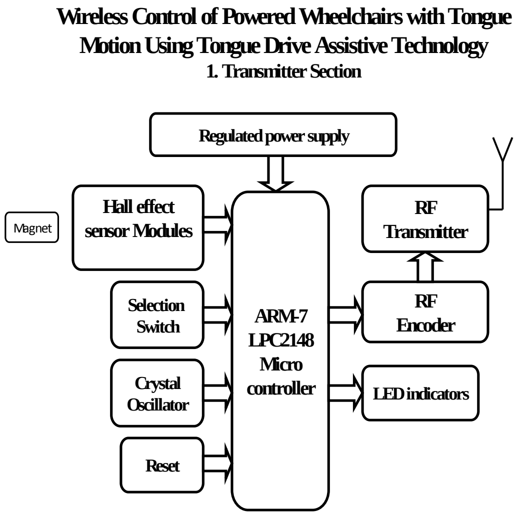
The magnetic sensors are nothing but hall-effect sensors. A Hall Effect sensor is a transducer that varies its output voltage in response to changes in magnetic field. In its simplest form, the sensor operates as an analogue transducer, directly returning a voltage. With a known magnetic field, its distance from the Hall plate can be determined.

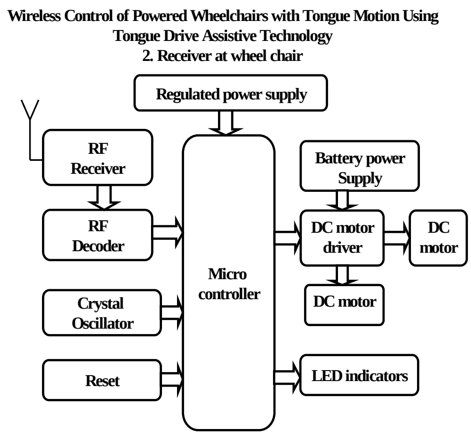
III. TDS Processing

Tongue movements are also fast, accurate and do not require much thinking, concentration or effort. Movement of the magnetic tracer attached to the tongue is detected by an array of magnetic field sensors mounted on a headset outside the mouth or on an orthodontic brace inside the mouth. The sensor output signals are wirelessly transmitted to a portable computer, which can be carried on the user's clothing or wheelchair.

The sensor output signals are processed to determine the relative motion of the magnet with respect to the array of sensors in real-time.

IV. Block Diagram





V. Hall Effect Sensor

The control system consists of Hall Effect sensor and microcontroller.

- The function of a Hall sensor is based on the physical principle of the Hall Effect.
- A voltage is generated transversely to the current flow direction in an electric conductor (the Hall voltage), if a magnetic field is applied perpendicularly to the conductor.
- Holding the current constant can allow for measuring the magnetic flux density.

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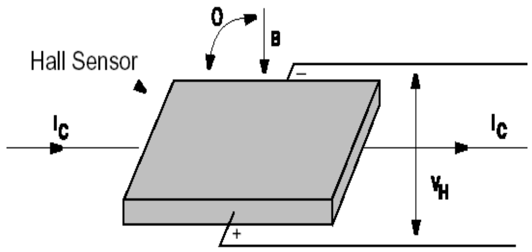
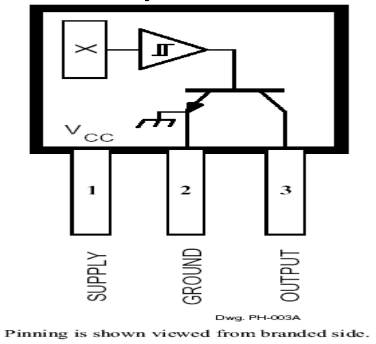
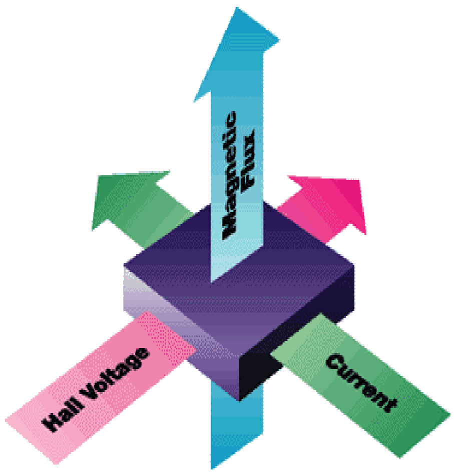


A particle with charge Q, velocity, V and moving within a magnetic field B, will experience the Lorenz force, F = Q(V x B).This Force is mutually perpendicular to direction of particle velocity and the magnetic field. In a current carrying conductor, the electrons will go to one edge of the conductor and the positive charges will go to the other edge. This gives rise to an electric field E (do to uneven lateral charge distribution), which exerts a force F = QE, which is opposite to the Lorenz force.

This field superimposed with the electric field in the direction of current flow, yields skewed equipotential lines. A voltage is produced that is perpendicular to direction of the current flow, V_H(Hall Voltage). This concept was discovered by Edwin Herbert Hall in 1879



Pin diagram of Hall Effect sensor



The Hall Effect: In a semi-conductive platelet, the Hall voltage is generated by the effect of an external magnetic field acting perpendicularly to the direction of the current.

ARM-7 LPC 2148:

The LPC2141/42/44/46/48 microcontrollers are based on a 16-bit/32-bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combine microcontroller with embedded high speed flash memory ranging from 32 kB to 512 kB. A 128-bit wide memory interface and unique accelerator architecture enable 32-bit code execution at the maximum clock rate. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30 % with minimal performance penalty.

Due to their tiny size and low power consumption, LPC2141/42/44/46/48 are ideal for applications where miniaturization is a key requirement, such as access control and point-of-sale. Serial communications interfaces ranging from a USB 2.0 Full-speed device, multiple UARTs, SPI, SSP to I2C-bus and on-chip SRAM of 8 kB up to 40 kB, make these devices very well suited for communication gateways and protocol converters, soft modems, voice recognition and low end imaging, providing both large buffer size and high processing power. Various 32-bit timers, single or dual 10-bit ADC(s), 10-bit DAC, PWM channels and 45 fast GPIO lines with up to nine edge or level sensitive external interrupt pins make these microcontrollers suitable for industrial control and medical systems.

Key Features:

16-bit/32-bit ARM7TDMI-S microcontroller in a tiny LQFP64 package.

- 8 kB to 40 kB of on-chip static RAM and 32 kB to 512 kB of on-chip flash memory.128-bit wide interface/ accelerator enables high-speed 60 MHz operation.
- In-System Programming/In-Application Programming (ISP/IAP) via on-chip boot loader software. Single flash sector or full chip erase in 400 ms and programming of 256 bytes in 1 ms.
- Embedded ICE RT and Embedded Trace interfaces offer real-time debugging with the on-chip Real Monitor software and high-speed tracing of instruction execution.
- USB 2.0 Full-speed compliant device controller with 2 kB of endpoint RAMS. In addition, the LPC2146/48 provides 8 kB of on-chip RAM accessible to USB by DMA.
- CPU operating voltage range of 3.0 V to 3.6 V (3.3 V ± 10 %) with 5 V tolerant I/O pads.

ARM-7 LPC 2148 Microcontroller interfaces collects data from the Hall Effect sensor and transmits the encoded data through the RF Transmitter. At receiver end RF receiver receives the data through the decoder and fed as input to the micro controller. The controller performs the corresponding actions i.e., wheel chair movement. This hall-effect sensor finds the magnetic field and operates the electrical devices and announces the basic needs depending on input. For example if the user shows the magnet in front of sensor1 then the device will be “ON” for the first time then next time it will be “OFF”. In the same way, if the user shows the magnet in front of sensor2 then another device is going to be controlled. This device is very helpful for paralysis and physically challenged persons.

RF Communication:

In this project 433 MHz RF transmitter and receiver modules are used. These are ideal for remote control applications where low cost and longer range is required. The transmitter operates from a1.5-12V supply, making it ideal for battery-powered applications. The transmitter employs a SAW-stabilized oscillator, ensuring accurate frequency control for best range performance. The manufacturing-friendly SIP style package and low-cost make the STT-433 suitable for high volume applications.

This project uses regulated 5V, 750mA power supply. 7805 three terminal voltage regulator is used for voltage regulation. Bridge type full wave rectifier is used to rectify the ac output of secondary of 230/18V step down transformer.

This Project consists of three Microcontroller Units, Wheel chair and Hall Effect sensors and wireless communication through RF. Wheel chair is made up of High torque Geared DC Motors, the Motors Directions can be changed through the set of instructions given from the Hall Effect sensor and the action of these Instructions is already loaded into the Microcontroller using Embedded C programming. The RF receiver provides the information to the microcontroller (on board computer) from RF transmitter and the controller Judges whether the instruction is right movement or left movement based on the tongue movement and controls the direction. Also the system controls the devices using relay and triac switches.

VI. Softwares Used

1. Keilu Vision4 software for embedded C rogramming.
2. Flash Magic software programmer for dumping code into ARM-7 LPC 2148 Microcontroller.

VII. CODE

WHEEL CHAIR : TRANSMITTER SECTION

```
#include <LPC21xx.H>
#include "lcd_lpc2.h"

#define IODIR_INPUT_DIR 0x00000000

#define IODIR_OUTPUT_DIR 0xFF000000

int main()
{
      lcd_init1();
      lcd_init1();
      lcd_init1();

IODIR0 = IODIR0 | IODIR_INPUT_DIR;
IODIR1 = IODIR1 | IODIR_OUTPUT_DIR;

message(0x80,"WHEEL CHAIR");
while(1)
{
      if((IOPIN0 & 0x00008000)==0)
      {
      message(0xc0,"SW1");
      IOCLR1=0xF0000000;
      IOSET1=IOSET1 | 0x80000000;
      delay(100);
      }

if((IOPIN0 & 0x00010000)==0)
      {
      message(0xc0,"SW2");
      IOCLR1=0xF0000000;
      IOSET1=IOSET1 | 0x40000000;
      delay(100);
      }

if((IOPIN0 & 0x00020000)==0)
      {
      message(0xc0,"SW3");
      IOCLR1=0xF0000000;
      IOSET1=IOSET1 | 0x20000000;
      delay(100);
      }

if((IOPIN0 & 0x000040000)==0)
      {
      message(0xc0,"SW4");
      IOCLR1=0xF0000000;
      IOSET1=IOSET1 | 0x10000000;
      delay(100);
      }
}
}
```

WHEEL CHAIR : RECIEVER SECTION

```
#include <LPC21xx.H>
#include "lcd_lpc2.h"

#define IODIR_INPUT_DIR 0x00000000

#define IODIR_OUTPUT_DIR 0xFF000000

int main()
{
      lcd_init1();
      lcd_init1();
      lcd_init1();

      IODIR0 = IODIR0 |
IODIR_INPUT_DIR;
      IODIR1 = IODIR1 |
IODIR_OUTPUT_DIR;

      message(0x80," RECEIVER SIDE");

while(1)
{
```

```
if((IOPIN0 & 0x00008000)==0x00008000)
      {

      message(0xc0,"FORWORD   ");
            IOCLR1=0xF0000000;
      IOSET1=IOSET1 | 0xA0000000;
                  delay(100);
            }

if((IOPIN0 & 0x00010000)==0x00010000)
      {
      message(0xc0,"LEFT       ");
      IOCLR1=0xF0000000;
      IOSET1=IOSET1 | 0x80000000;
                  delay(100);
      }

if((IOPIN0 & 0x00020000)==0x00020000)
{
      message(0xc0,"RIGHT     ");
      IOCLR1=0xF0000000;
      IOSET1=IOSET1 | 0x40000000;
      delay(100);
}

if((IOPIN0 & 0x00040000)==0x00040000)
{
      message(0xc0,"   STOP  ");
      IOCLR1=0xF0000000;
      IOSET1=IOSET1 | 0xf0000000;
      delay(100);
}
}
```

VIII. Conclusion

Our ultimate goal in developing the TDS is to help people with severe disabilities experience and preserve an independent, self-supportive life. The system uses an array of magnetic sensors to wirelessly track tongue movements by detecting the position and orientation of a permanent magnetic tracer secured on the tongue. The tongue movements can then be translated into various commands for computer access, navigation, or environment control. The current external TDS prototype consists of four magneto-inductive sensors mounted on a face Helmet Laboratory-based human trials on six nondisabled male subjects have demonstrated that the present TDS prototype can help users potentially substitute some of their lost arm and hand functions with tongue movements when accessing a wheel chair by movement of the magnet which is placed on the tongue.

VIII. Future Scope

Our future directions include improving the TDS hardware to make it smaller, faster, and more efficient. We will add more control commands that put the TDS in standby mode and bring it back online. We also plan to substitute the operator feedback in selecting proper tongue movements with automated visual feedback to help the users define their commands more accurately. We intend to link the TDS to PWCs as well as other home and/or office appliances by either directly replacing the original input devices (e.g., joystick, switch array, remote control) with the TDS or building specialized hardware interfaces between them.

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The Coauthor of this paper and currently working as Associate Professor in RGMCET Educational Institutions. He is very good at the Neural Networks and Image Processing subjects, guiding his students all the way through out their careers. He is not only the man of commitment but also humanity. He published so many journals and his working nature will always inspires the young minds.