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Controlling System for Targeted Drug Delivery using ZIGBEE in Wireless Capsule Endoscope

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Abstract: ***The wireless capsule endoscope system is a medical instrument which can be used to visually examine the entire digestive tract wirelessly without any pain or risk associated with the conventional endoscopes. This project is an owe to the technical advancement. The main design challenge is to achieve targeted drug delivery in next-generation wireless capsule endoscopy. It controls the wireless capsule and delivered medicine by using advanced technology. Simultaneously image can be captured by wireless camera that can be embedded into wireless capsule which can transfer the images to outside of pc.***

I. INTRODUCTION

Present industry is increasingly shifting towards automation. Two principle components of today's industrial automations are programmable controllers and robots. In order to aid the tedious work and to serve the mankind, today there is a general tendency to develop an intelligent operation. Capsule endoscope with the size of a normal pill can be easily swallowed by patients of various ages. It takes Pictures throughout the gastrointestinal tract by sending images to an external recorder, and thus, provides useful information for clinic diagnosis of gastrointestinal tract diseases.

However, recent products of capsule endoscope still have some problems: 1) no external guidance control system; 2) time and money consuming; and 3) unable to conduct on-time treatments such as drug delivery and body tissue collection.

The movement of the capsule depends solely on the peristalsis system. These systems are capable of delivering up to 1 ml of medication to a region of the GI tract such as the jejunum, ileum, ascending colon, or descending colon either through the progressive release of medication over a period of time or through a bolus form. The delivery methods employed by these devices prevent the direct targeting of specific pathogens such as tumours or ulcers as the medication is spread over a section of lumen due to the constant movement from peristalsis.

Conventional WCE have sufficiently small geometry to allow them to pass through the small intestines and navigate the ileocolic valve without becoming an obstruction. However, the clinical need to target a specific location or feature within the GI tract for medication delivery or examination of the intestinal wall would require the WCE to stop. Once swallowed, the WCE will pass through the elementary canal. The particular section of interest for diagnosis and treatment is the small intestines as this section is very difficult to access. The small intestines comprise of the duodenum, the jejunum, and the ileum. These three sections make up the longest part of the alimentary canal at 6.25 m [9]. The duodenum is C-shaped and its mouth, the ileocolic valve, extends from the stomach giving this section a degree of stability. The jejunum and the ileum are free to move; however, their natural state is collapsed. For a conventional WCE with dimensions of 11.0 mm diameter × 25.0 mm long, the circumferential and longitudinal amplitudes translate into 421.8 and 911.9 mN, respectively.

II. Need of Wireless Capsule Endoscopy

Current technologies in biomedical engineering focus on reducing pain during diagnostic procedures, thus enabling extensive screening among individuals who are more likely to develop cancer.

Over 3 million people annually in the U.S. alone suffer gastrointestinal (GI) disease serious enough to require hospitalization and 300 000 people die from GI diseases annually in China. Recently, commercialized passive controlled wireless capsule endoscopy, which had been developed since 2000, exploits a swallowable capsule endoscope that includes digital camera, application-specified integrated circuit(ASIC) transmitter, antenna, illuminating LED-assisted imaging, and battery for access to the GI tract .Although capsule endoscopy has achieved great progress compared to traditional invasive endoscopy, it still has many limitations. To control wireless capsule movement, here microcontroller, zigbee and motor are used.

III. Concept and Design Requirements

Conventional WCE have sufficiently small geometry to allow them to pass through the small intestines and navigate the ileocolic valve without becoming an obstruction. However, the clinical need to target a specific location or feature within the GI tract for medication delivery or examination of the intestinal wall would require the WCE to stop. a micro motor concept design capable of resisting peristaltic pressure through the deployment of an integrated holding mechanism and targeted drug delivery through the activation of a gun. The gun has the ability to be positioned and delivered. Simultaneously, the holding mechanism can stay diametrically opposite the gun guaranteeing penetration of the GI tract wall.

3.1 Movement Analysis of the GI Tract

Once swallowed, the WCE will pass through the elementary canal. The particular section of interest for diagnosis and treatment is the small intestines as this section is very difficult to access. The small intestines comprise of the duodenum, the jejunum, and the ileum. These three sections make up the longest part of the alimentary canal at 6.25 m. The duodenum is C-shaped and its mouth, the ileocolic valve, extends from the stomach giving this section a degree of stability. The jejunum and the ileum are free to move; however, their natural state is collapsed. In order to process foodstuff, a liquid mixture called chyme, the small intestines use a series of movement patterns. These patterns, segmentation, and peristalsis cause the chime to progress through the tract. Segmentation is a contraction of the duodenum for the purpose of mixing food. There are two processes involved: they are eccentric contractions and concentric contraction. The first generates very little intraluminal pressure and the second can generate pressures as high as 20 mmHg.

The frequency of the contractions is dependent on eating patterns, becoming stronger as chyme is being processed. Peristalsis is the process of moving chyme through the intestinal tract from the stomach to the colon by means of a series of muscle contractions acting in a wave pattern. The muscle contraction acts in two planes: circumferential and longitudinal. For a conventional WCE with dimensions of 11.0 mm diameter × 25.0 mm long, the circumferential and longitudinal amplitudes translate into 421.8 and 911.9 mN, respectively. These estimated forces have been used as a guide in the design analysis of the holding mechanism.

3.2 Resisting Peristalsis and Geometrical Constraints

There are three methods employed for halting the progress of a WCE by enabling it to resist the natural movement from peristalsis. One utilizes micro microcontroller mechanisms embedded within the capsule, such as the paddling-based micro motor. The second approach exploits zigbee to control the position of the capsule, and the third ap3proach applies a stimulus to GI tract to inhibit peristalsis.

3.3. Target Technical Specifications

The overall geometry of the micro robotic system will be greatly influenced by the limitations imposed by swallowing and on its ability to navigate natural obstacles such as the ileocolic valve without becoming an obstruction. A patient's ability to swallow a required volume will vary from person to person; therefore, a standard volume must be chosen which will be suitable for the majority of patients. Research carried out by shows that a volume of 3.0 cm3 can be swallowed. This maximum target volume will be required to house all the components necessary to perform targeted therapy and micro scale diagnosis.

3.4. System Operation Overview

The procedure starts with the patient ingesting the WCE. Once the capsule passes through the stomach and enters the small intestines, microcontroller enables wireless ziebee and wireless camera, it can begin to transmit images to the operator via a wireless camera. The real-time images and sensor data will be displayed on an external PC. The operator will use the data to identify an already defined target site. Once the target site has been reached, the operator will remotely deploy the holding mechanism. The operator can now rotate the motors; the position will be based on observational data received just before the deployment of the holding mechanism.

The gun can now be advanced into the GI tract wall and the medication released. The targeting mechanism is designed such that it gives the operator the ability to reposition the gun before the medication is delivered. Finally, the capsule will be dispelled through natural peristalsis movement.

IV. System Specification

Fig 1.1 describes the overview of wireless capsule endoscopy operation and function.

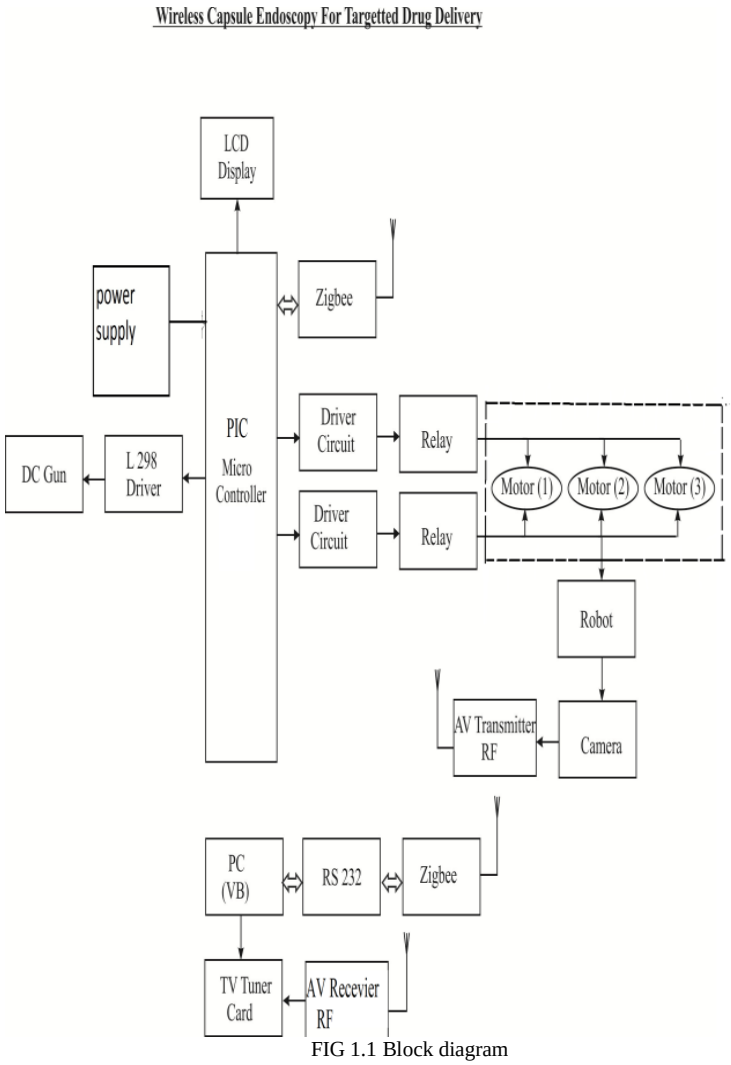

FIG 1.1 Block diagram

4.1 HARDWARE SPECIFICATION

4.1.1 PIC MICROCONTROLLER (16F877)

PIC Microcontroller embedded into capsule, once patient swallow capsule the controller is power on by power supply. Once PIC Microcontroller is power on, it enables all the system inside the capsule. The PIC microcontroller controls motor .gun and wireless camera**.** The PIC start plus development system from microchip technology provides the product development engineer with a highly flexible low cost microcontroller design tool set for all microchip PIC micro devices. The pic start plus development system includes PIC start plus development programmer and MP lab ide.

The PIC start plus programmer gives the product developer ability to program user software in to any of the supported microcontrollers. The PIC start plus software running under MP lab provides for full interactive control over the programmer.

4.1.2 LCD DISPLAY

Liquid crystal displays (LCDs) have materials which combine the properties of both liquids and crystals. Rather than having a melting point, they have a temperature range within which the molecules are almost as mobile as they would be in a liquid, but are grouped together in an ordered form similar to a crystal.

An LCD consists of two glass panels, with the liquid crystal material sand witched in between them. The inner surface of the glass plates are coated with transparent electrodes which define the character, symbols or patterns to be displayed polymeric layers are present in between the electrodes and the liquid crystal, which makes the liquid crystal molecules to maintain a defined orientation angle.

One each polarizer's are pasted outside the two glass panels. This polarizer's would rotate the light rays passing through them to a definite angle, in a particular direction. The LCD's are lightweight with only a few millimetres thickness. Since the LCD's consume less power, they are compatible with low power electronic circuits, and can be powered for long durations. The LCD does don't generate light and so light is needed to read the display.

4.1.3 POWERSUPPLY

The ac voltage, typically 220V rms, is connected to a transformer, which steps that ac voltage down to the level of the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation.

A regulator circuit removes the ripples and also remains the same dc value even if the input dc voltage varies, or the load connected to the output dc voltage changes. This voltage regulation is usually obtained using one of the popular voltage regulator IC units.

4.1.4 ZIGBEE

The mission of the ZigBee Working Group is to bring about the existence of a broad range of interoperable consumer devices by establishing open industry specifications for unlicensed, untethered peripheral, control and entertainment devices requiring the lowest cost and lowest power consumption communications between compliant devices anywhere in and around the home.

The ZigBee specification is a combination of Home RF Lite and the 802.15.4 specification. The spec operates in the 2.4GHz (ISM) radio band - the same band as 802.11b standard, Bluetooth, microwaves and some other devices. It is capable of connecting 255 devices per network. The specification supports data transmission rates of up to 250 Kbps at a range of up to 30 meters. ZigBee's technology is slower than 802.11b (11 Mbps) and Bluetooth (1 Mbps) but it consumes significantly less power.

4.1.5 RELAY

A relay is an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism, but other operating principles are also used. Relays find applications where it is necessary to control a circuit by a low-power signal, or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits, repeating the signal coming in from one circuit and re-transmitting it to another.

Relays found extensive use in telephone exchanges and early computers to perform logical operations. A type of relay that can handle the high power required to directly drive an electric motor is called a contractor. Solid-state relays control power circuits with no moving parts, instead using a semiconductor device triggered by light to perform switching. Relays with calibrated operating characteristics and sometimes multiple operating coils are used to protect electrical circuits from overload or faults; in modern electric power systems these functions are performed by digital instruments still called "protection relays".A simple electromagnetic relay show in figure 1.2

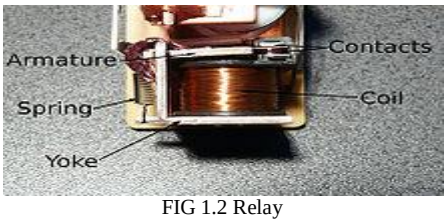

FIG 1.2 Relay

4.1.6 DC MOTOR

In any electric motor, operation is based on simple electromagnetism. A current-carrying conductor generates a magnetic field; when this is then placed in an external magnetic field, it will experience a force proportional to the current in the conductor, and to the strength of the external magnetic field. As you are well aware of from playing with magnets as a kid, opposite (North and South) polarities attract, while like polarities (North and North, South and South) repel. 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. The simple DC motor shown in figure 1.3


FIG 1.3 Dc motor

4.1.7 D.C GUN

The rail gun is extremely simple in concept. A conductive armature is located between two electrically conductive rails which are held rigidly parallel to one another by insulators. Connecting the rails to a source of stored electrical energy (either a capacitor or a homopolar generator) causes a current to flow down one rail, through the armature, and back to the source via the other rail. The current in the rails generates a magnetic field perpendicular to the rails. The current flowing through the armature, within this magnetic field, generates a force which propels the armature down the rails.

4.1.8 DRIVER CIRCUIT

In electronics, a driver is an electrical circuit or other electronic component used to control another circuit or other component, such as a high-power transistor. The term is used, for example, for a specialized computer chip that controls the high-power transistors in AC-to-DC voltage converters. An amplifier can also be considered the driver for loudspeakers, ora constant voltage circuit that keeps an attached component operating within a broad range of input voltages.

The following circuit will allow you to drive a 12V relay using logic voltage (an input of 4V or greater will trip the relay). The circuit has its own 12V power supply making itself contained but the power supply portion can be left out if an external

supply will be used. The circuit shows an output from the power supply that can be used to power other devices but it should be noted that the supply is unregulated and not particularly powerful with the parts stated. The 12V DC output is suitable for powering a few LEDs or low voltage lights but should not be used to power other electronic boards or motors.

4.1.9 RS232

In telecommunications, RS-232 is a standard for serial binary data interconnection between a DTE (Data terminal equipment) and a DCE (Data Circuit-terminating Equipment). It is commonly used in computer serial ports. The standard does not define such elements as character encoding (for example, ASCII, Baudot or EBCDIC), or the framing of characters in the data stream (bits per character, start/stop bits, parity). The standard does not define protocols for error detection or algorithms for data compression.

The standard does not define bit rates for transmission, although the standard says it is intended for bit rates lower than 20,000 bits per second. Many modern devices can exceed this speed (38,400 and 57,600 bit/s being common, and 115,200 and 230,400 bit/s making occasional appearances) while still using RS-232 compatible signal levels.

4.1.10 TV TUNER CARD

A TV tuner card is a computer component that allows television signals to be received by a computer. Most TV tuners also function as video capture cards, allowing them to record television programs onto a hard disk.

4.1.11 WIRELESS CAMERA

Wireless cameras allow the transmission of video to a receiver without having to run video cable. Power is needed at both the camera and receiver locations. Wireless technology is another way to transfer images from your digital camera to a computer, printer, or even the Internet. It's an extension of what thousands of people are already doing with their camera phones. The difference being, with a wireless camera, the emphasis is on photo quality and camera features - not the phone. So you get some of the cool wireless functionality of a camera phone, but in a "real" camera the offers more control and better photo quality.

V. CONCLUSION

The progress in science & technology is a non-stop process. New things and new technology are being invented. As the technology grows day by day, we can imagine about the future in which thing we may occupy every place. The platform can be used for the detection and treatment of pathologies of the GI tract such as Crohn's disease, small intestinal tumours such as lymphoma and small intestinal cancer. The main design challenge is to control the wireless capsule and deliver medicine by using advanced technology. Simultaneously image can be captured by wireless camera that can be embedded into wireless capsule which can transfer the images to outside of pc. It has been shown that the proposed gun mechanism and the holding mechanism achieve the required functionality while occupying a combined volume of less than 470mm3.

This is based on the proposed gun mechanism and holding mechanism consuming a maximum of 28.94 J of energy per operation. The targeted drug delivery platform has the control necessary to target a particular pathogen within the GI tract. It is envisaged that a delivery mechanism capable of delivering 1 ml of medication to the target site can be incorporated into the standard geometry of the WCE, with the combined needle positioning system, holding mechanism, and delivery mechanism (including 1 ml of medication) occupying 60% of the total available volume.

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