*IOSR Journal of Nursing and Health Science (IOSR-JNHS)*
*e-ISSN: 2320–1959.p- ISSN: 2320–1940 Volume 9, Issue 2 Ser. I (Mar - Apr. 2020), PP 26-31*
*www.iosrjournals.org*

# Design and Testing of Wireless Endoscope System for Diagnosis of Gastro-Intestinal Tract Diseases

Fahad Mushabbab Ghafil alotaibi[1], K. Prahlad Rao[1] and Naif D. Alotaibi[1]
*[1]Department of Electrical and Computer Engineering, Faculty of Engineering, King Abdulaziz University, Jeddah, Saudi Arabia*

***Abstract***
***Background**: Endoscopy is a clinical procedure of inserting a long thin tube carrying a camera into the body to observe organs and tissue inside the body. Since two decades, capsule endoscope has been using as an important tool for diagnosis of Gastro-intestinal diseases. However, the shape of this device is an issue which rises risk of getting struck inside the tract. Therefore, we have designed and developed spherical shaped sensor for wireless endoscopic applications.*
***Materials and Methods:** In the new design of wireless endoscopy system, we used CMOS camera as image sensor, LEDs for light source, a reed switch and a pair of batteries. These are covered by transparent and biocompatible polymer in spherical shape. The diameter is 12 mm. The newly designed spherical shape is easy in oral uptaking like a pill by mouth and smooth exit through anus after the procedure is completed.*
***Results**: The power consumption of our wireless endoscope system is considerably less and the resolution of output images is reasonably good. Each output image received by an external unit and displayed on a computer measuring 400x400 pixels size, has a 8 bit resolution and a series of such images can be compressed at a arte of 32 frames per second.*
***Conclusions**: The shape of image sensing module in the newly designed wireless endoscope system has been optimized to 12 mm diameter. The system is therefore, better for continuous monitoring of GI tract and internal organs. The miniature size makes it possible to view the deeper and curved parts of internal organs. We tested the performance of the system with objects and planned to proceed the trial on animals after approval from ethical committee. As rf (radio frequency) transmitter and receiver will be incorporated in the system to facilitate wireless data transmission.*
***Key words**: Wireless endoscopy, GI tract, CMOS camera, White light source, data transmission.*

---

Date of Submission: 20-02-2020 Date of Acceptance: 04-03-2020

---

## I. Introduction

Gastrointestinal (GI) diseases are those which are affecting the gastrointestinal tract or digestive tract; affecting the esophagus, stomach, small intestine, large intestine, the rectum and other organs. Examples of such disease include GI cancers, colorectal polyps, intestinal dysplasia, ulcerative colitis, Crohn's disease, peptic ulcers, gastro-esophageal reflux disease etc.; with varying symptoms from abdominal pain or cramping, diarrhea, constipation and rectal bleeding [1] . Diagnostic techniques and methods have been developed and utilized over the years for monitoring and evaluation of the above mentioned maladies, however few of them have proven inefficient running into complications in the treatment and management of GI diseases [2].

Clinically used flexible wire endoscopy has a tiny camera fixed at its one end passed through the GI tract for investigation. During the procedure the patient will be sedated and need to be hospitalized during the test. The flexible endoscopy allow the diagnosis within the esophagus, stomach and some parts of the small intestine, however, it is still hard to reach the deepest parts of the small intestine and observe meticulously. Persistent heart burn, bleeding, nausea, vomiting, pain, difficulty in swallowing and unexplained weight loss caused by flexible wire endoscopy increases concern among patients.

Recently introduced wireless capsule endoscopy (WCE) [3] technique has a main impact in the field of endoscopy as it can reduce the level of patients problem in flexible wire endoscope and also can be captured until the small intestine of the gastrointestinal (GI) tract. Previously it was impossible to examine tissues of the small intestine without surgical intervention [4].

In WCE, the fasting patient will swallow a small electronic capsule-shaped pill, which crossing through the GI tract with the help of peristalsis. While passing through the GI tract, the capsule takes over 55000 images[5] and transmits image data by low power consumption radio-frequency (rf) wireless to a receiver data unit which is attached to the belt in the patient's waist. During the procedure, patient is allowed freedom of movement to perform his daily work but the patient must avoid strenuous activities. It has been mentioned that the battery lifetime of capsule is between 8 - 10 hours. The capsule continuously sends images to the receiver unit, which are then transferred to a computer workstation where the images are processed and then displayed for diagnosis. Generally, the capsule comes out from patient's body nearly after two to three days, otherwise the risk arises which need to surgical intervention to take it out from the body of the patient [6,7]. The shape of the capsule plays an important role as it is to be ingested by the patient. We propose few modifications to the commercially available WCE system and present the performance results to demonstrate its greater resolution and compactness in this paper.

## II. Methodology

*(A) Design*

The wireless endoscope system has two main units: image sensor which captures images continuously throughout its movement in the body and an external unit. The main component is encapsulated by biocompatible polymer which is shaped in spherical form. It contain lens and CMOS technology based camera, two silver oxide batteries, white color emitting LEDs, a lead switch and an rf communication board. The second part of the system is comprised of an external unit which contains receiver unit and computer. The receiver unit has rf receiver and a data recorder. For processing and display of images, a dedicated computer is employed. Fig 1 shows the schematic of the wireless endoscopy system.

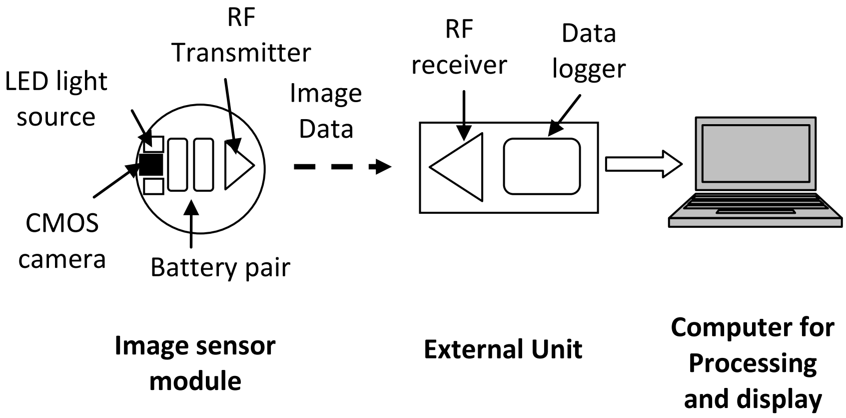


**Fig 1.** Schematic Diagram of Wireless Endoscope System.

*(B) Hardware Implementation*

Components used in the system are carefully selected based on desired characteristics to meet our objective. Main components and their assembly in the system are described below.

*CMOS camera:*

Image sensor is a semiconductor device which converts light intensity in to electric signals. Old and traditional cameras have been replaced by digital image sensors because of the speed and higher resolution characteristics. Mainly two types of image sensors are commonly available and they are based on CMOS (complementary metal oxide semiconductor) and CCD (charge coupled device) technology. CMOS camera produces finest quality of image output and the CMOS technology is more flexible than the CCD technology because of the fact that each pixel can be read individually. Another advantage of CMOS is that it consumes less power due to which it is considered as low power sensor. With limited power on board, functional tools cannot be added for multiple purposes, monitoring temperature, pressure and transit time[8]. These characteristics make the CMOS camera best choice for endoscopy system development. We have used the CMOS camera that delivers 32 frames in second. Fig 2 shows the tiny CMOS camera which is used in our endoscope system.

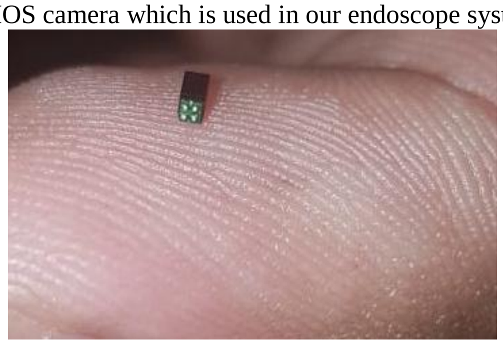

**Fig 2.** CMOS camera

*LED light source:*
Led light is very important part in the endoscope system. The camera can convert light intensity in to electrons, for which light source is very important to get image output. To illuminate inside the body organs enough light is to be produced for getting brighter images. [9]. So in our design, we assembled five bright white light LEDs in a circular shaped PCB (printed circuit board) with aluminum as its base. The light source assembly is shown in Fig 3.

**Fig 3.** Assembly of five bright white light LEDs mounted on circular PCB.

*Power supply:*
We used two sliver-oxide coin shaped batteries as power supply to the sensor and electronic circuit. Sliver-oxide coin battery is selected since it is free from mercury (Hg) because the mercury is very dangerous for the human body[6]. Each battery has around 1.55 volt and 55 mw, thus the two batteries together will supply 3.10 volt and over 110 mw, which is enough to run the sensor and all components for more than 8 hour. Fig 4 shows diagrammatic representation of the battery.

**Fig 4.** Diagram showing the batteries used in the sensor module.

*Reed switch:*
A reed switch is an electromagnetic device which is used to control the flow of electricity into the circuit. Its operation is triggered by magnetic field and is widely used in signal switching applications. The switch is very small in size which can be either operated by a solenoid coil or by using a permanent magnet which make it possible to operate remotely. We used the reed switch with normally closed, that mean normal connect the electrical current without magnetic affect. When there is magnetic field due to the flow of current, it will power-off the sensor module. Few types of commercially available reed switches are shown in Fig 5.

**Fig 5**. Reed switches in different models.

*RF (Radio frequency) unit:*

Wireless endoscope is advantageous than with the wire. In the wireless module, the signal transfers from inside image sensor to the signal receiver which is placed outside the body of the patient. The rf unit works at radio frequency, typically 4 MHz value. The data transfer takes place without wire connectivity between the sensor and external unit. Due to some technical and ethical problems, we will use this unit in our improvised endoscope system. However, we demonstrate our results with wire connectivity.

*External unit:*

The receiver is an external component that receives signals from image sensor of the endoscope system. It receives the compressed images from the sensor module then sends to a decoder for decoding the signal and it communicates with the work station. The work station having a computer where it is processed and images are displayed on the monitor.


**Fig 6.** An external unit of endoscope system.

## III. Results

The components described in above, have been selected after a thorough study. There were several issues including technical and non-technical. The CMOS camera is very small in size (3mm x 3mm) which is most desirable criteria because the patient will uptake through mouth without discomfort while swallowing for the diagnosis purposes. The tiny camera is also used for non-biomedical applications such as spying, military and sensitive applications. Therefore, we procured the camera after replying several queries asked by the supplier. As far technical difficulties are concerned, it is very difficult to solder the connecting electrical wires to the camera terminals. From bare eyes, it is highly difficult to see the terminals. Therefore, a specialized microscopic viewing and soldering technique is required for its connections. Despite of all difficulties, the components have been assembled with utmost care. Fig. 7 shows the module of image sensor after its fabrication.

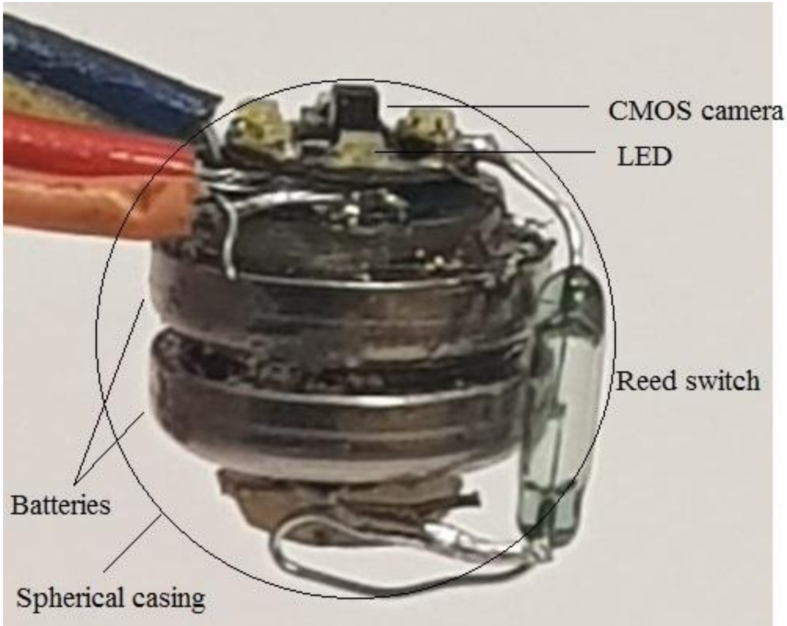


**Fig 7**. Assembled image sensor module.

With a pair of batteries situated in the module, it was switched on from the reed switch. After ensuring the proper working of the module, we tested the resolution of output images. To proceed with this, we have taken a currency note and captured its image from the module. From the displayed output, the security mark which is inscripted in Arabic letters can be clearly seen, which is otherwise not possible to see by bare eyes (Fig 8). It is found that the resolution of a 400x400 image is 8 bit with the video compression rate of 32 frames per second. Such a high resolution output images can efficiently detect any lesion or ulcer like abnormalities present in the GI tract. Therefore, our endoscope system is superior in its output quality, compact spherical in outer shape and cost effective in comparison with commercially available capsule endoscopes. The system will be further tested on animals after getting approval from our ethical committee.

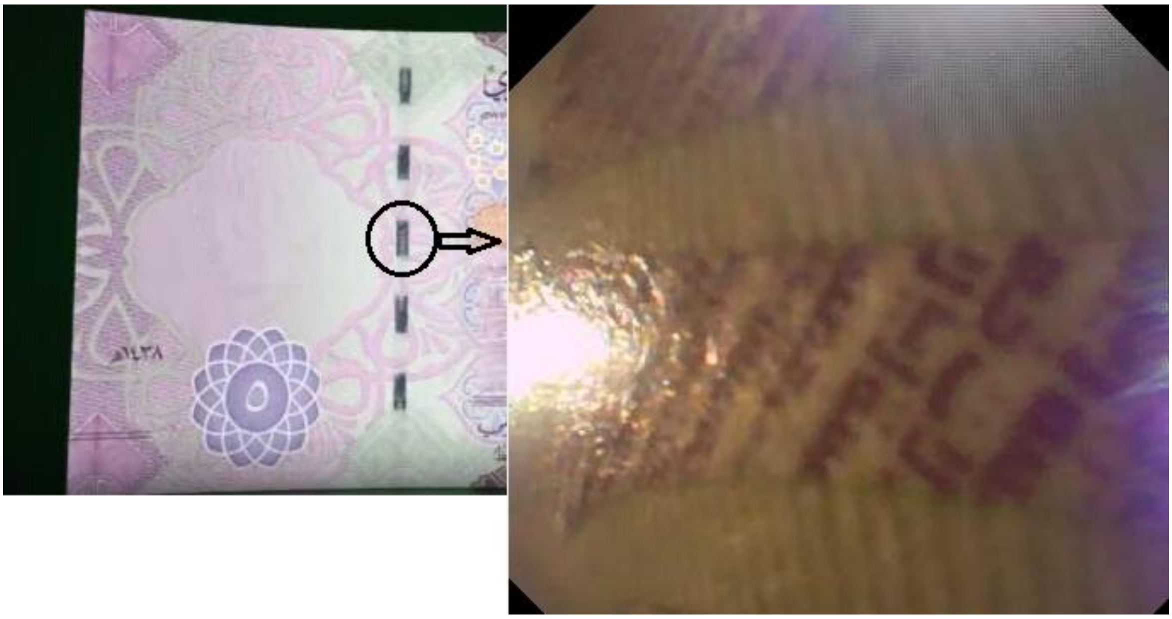

**Fig 8.** Performance evaluation of prototype image sensor module developed for endoscopy applications.

## IV. Conclusion

We have designed and developed a spherical shaped wireless endoscope system and done performance evaluation. The system performance is found satisfactory with its greater capability in the detection of minute objects that come across the spherical shaped wireless image sensor module. The size of the spherical module is 12 mm diameter, which is smallest compared to the presently available commercial product. Our module has acceptable image quality output that can detect lesions, ulcers, hemorrhoids, bleeding and tumors. The data transmission from image sensor to external unit is reasonably good though it is through wires, but will be implemented wireless by using rf unit. Due to optimal number of LEDs and CMOS camera model selection, the power consumption is lower than its competitive models.

## References


[1]. M. C. Mattar, D. Lough, M. J. Pishvaian, and A. Charabaty, "Current management of inflammatory bowel disease and colorectal cancer," *Gastrointest. Cancer Res.*, vol. 4, no. 2, pp. 53–61, 2011.

[2]. N. Kurniawan and M. Keuchel, "Flexible Gastro-intestinal Endoscopy — Clinical Challenges and Technical Achievements," *Comput. Struct. Biotechnol. J.*, vol. 15, pp. 168–179, 2017, doi: 10.1016/j.csbj.2017.01.004.

[3]. J. L. Toennies, G. Tortora, M. Simi, P. Valdastri, and R. J. Webster, "Swallowable medical devices for diagnosis and surgery: The state of the art," *Proc. Inst. Mech. Eng. Part C J. Mech. Eng. Sci.*, vol. 224, no. 7, pp. 1397–1414, 2010, doi: 10.1243/09544062JMES1879.

[4]. D. Faigel and D. Cave, *Capsule Endoscopy*. Philadelphia,Pa ,USA: Saunders,Elsevier, 2008.

[5]. O. Bchir, M. M. Ben Ismail, and N. AlZahrani, "Multiple bleeding detection in wireless capsule endoscopy," *Signal, Image Video Process.*, vol. 13, no. 1, pp. 121–126, 2019, doi: 10.1007/s11760-018-1336-3.

[6]. Z. S. L. Y. Bai1, J. Gao1, B. Song2, Y. Q. Zhou2, D. W. Zou1, "Surgical intervention for capsule endoscope retained at ileal stricture," *NCRM Work. Pap.*, no. 2, pp. 1–10, 2007, doi: 10.1055/s.

[7]. M. Purdy, M. Heikkinen, P. Juvonen, M. Voutilainen, and M. Eskelinen, "Characteristics of patients with a retained wireless capsule endoscope (WCE) necessitating laparotomy for removal of the capsule," *In Vivo (Brooklyn).*, vol. 25, no. 4, pp. 707–710, 2011.

[8]. K. Naveed, S. Ehsan, K. D. McDonald-Maier, and N. Ur Rehman, "A multiscale denoising framework using detection theory with application to images from CMOS/CCD sensors," *Sensors (Switzerland)*, vol. 19, no. 1, 2019, doi: 10.3390/s19010206.

[9]. T. Hu, P. K. Allen, and D. L. Fowler, "In-vivo pan/tilt endoscope with integrated light source," *IEEE Int. Conf. Intell. Robot. Syst.*, pp. 1284–1289, 2007, doi: 10.1109/IROS.2007.4399259.


Fahad Mushabbab Ghafil alotaibi,etal. "Design and Testing of Wireless Endoscope System for Diagnosis of Gastro-Intestinal Tract Diseases." *IOSR Journal of Nursing and Health Science (IOSR-JNHS)*, 9(2), 2020, pp. 26-31.