Survey on Integrated Power Optimization with Battery Friendly Algorithms Survey in Wireless Capsule Endoscopy

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Abstract
The world is going towards continuous enhancement and development in medical health sector for the purpose of safety of human life. Therefore, when considering the Wireless Body Area Network the significant step to do research of transmission of data with greater data rates among the sensor nodes and working on power efficiency of battery-driven devices used in wireless body area Network. Charging limitation is major and serious problem for the Wireless Body Area Network Therefore, it is required to do research and find out the optimal solution to make this technology or battery-friendly technology. In this research we have addressed the solution that we can increase the battery life time with variable data transmission rates from medical equipment of wireless body area network. Wireless capsule endoscopy is application of wireless body area network which analyzes patient's gastrointestinal tract by capturing images and visualization at workstation. As it is relatively new technology and Wireless Capsule Endoscopy systems are not widely applied in clinic because of low data rate and low resolution but if some systems have the higher data rate and high resolution makes them power inefficient and hence they are not battery friendly. The main problem with wireless capsule endoscopy is that limited battery life time due to various causes such as very high resolution of image transmission and high frame rate, so our main objective is power optimization by reducing the power consumption of battery in Wireless Capsule Endoscopy to make it battery friendly. In order to overcome the problem of limited battery lifetime Integrated power optimization with battery friendly algorithm is enunciated. In terms of frame rate transmission on different buffer sizes have been compared in this thesis report. We have surveyed battery friendly algorithm by keeping in view the image transmission on average frame rate instead of transmitting the images on maximum or minimum frame rates. Suggested algorithms extend the battery lifetime in comparison with previous baseline proposed algorithm. This research majorly focuses on algorithm which has increased the battery lifetime of the capsule.
Keywords:
Wireless capsule endoscopy, Wireless body area network, battery friendly algorithm, Image compressor, Transmission rate.

1. Introduction

Endo means "Inside" and "scope" which means "view". It is a way to show or display the images of inside of the human body. Wireless Capsule Endoscopy (WCE) images gastrointestinal tract of human body as it is shown in Fig 1. When capsule is swallowed by a human, it starts traveling in Gastrointestinal tract of human body, during its travel; it transmits the images of Gastrointestinal tract to a receiver which relates to the waist of patient. Quality of images received by the receiver depends upon the efficiency of endoscopic system. In the event that the framework comprises of the gadgets which devour high force and thus running for restricted time because of capturing high resolution images with good transmission rate of images create a tradeoff between high quality images and lifetime of battery [1].
Remote Body Zone Organization is a useful apparatus for the analysis of maladies identified with the Gastrointestinal plot of human body. The challenging issue with existing wireless capsule endoscopic Technology is the limited battery lifetime of capsule which is because of high resolution images and high transmission data rate of captured frames of images [1].

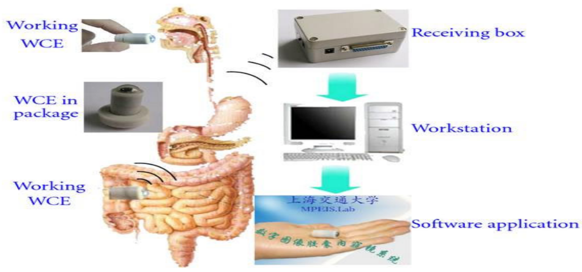

Fig 1. Wireless capsule endoscope (WCE) system

2. Wireless Endoscopy Algorithms

The wireless capsule endoscopy recognizes entire gastrointestinal plot and relate the determination innovation. Wireless capsule endoscopy captures images and sends them to the receiver by its antennas that have transmitter and receiver wirelessly, and data is recorded into data recorder from the patient's gastrointestinal tract. food and drug administration in 2001 approved the first model of wireless capsule endoscopy. After numerous years, this innovation has been acclaimed and give high goal and great battery lifetime and different capacities to examine the

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Gastrointestinal lot by catching great goal pictures and analyze Gastrointestinal lot [2, 3, 31].

Wireless Sensor network includes considerable number of easy use of sensors, cost effective and optimized power which relatively smallish in size can easily use for diagnosis. In wireless networking latest advancement shows embedded technologies and Micro-Electro-Mechanical Systems (MEMS) makes Wireless Sensors Networks (WSN) magical power to attract for the solution of many potential applications like in health care, intelligence transportation, ecological monitoring and home automation [4].

Wireless Sensors Networks sensor nodes consist bounded energy budget and power operated battery, while in unreachable circumstances it is not easy for drained sensor to replace with new battery or to recharge it. It is inoperable and incommoding.

In education it can be observe that in order to strong battery backup power there is a need of greater charge capacity for a network. As Wireless Sensors Networks deal with micro level technology and effective battery backup therefore it should be relatively tiny and light. The digital integration technology hard to contribute in it to continue this pace for further assistance [5, 28].

In resultant it becomes the challenging issue for the designer to overcome this battery hunger packet transmission problem, various approaches already presented for strong battery backup [6]-[9].
For instance, it was observed that regarding the sensors optimal planning, for boosting network lifetime and decreasing power dissipation in cluster-based network [9].

It reveals the point of view about energy efficient algorithm (i.e., Lazy Packet Scheme) in which strategies were discussed about how to improve the duration of transmission through minimizing the transmission energy over wireless medium. Taking the view of electrochemical properties meanwhile boosting the battery lifetime is not considerable by lowering the energy consumption of a battery [10].

This may be outstretched that according to the battery characteristics if we design efficient algorithm it can boost up the lifespan of any storage through injecting assumed relaxation duration between two packets in order to get improved charge capacity.

Some recent existing work related to such algorithms are; hold on MAC schemes, algorithm for task scheduling and battery aware routing whereas power optimization, battery properties and battery models. The minimal usage of battery power was promised in such scenarios until the workload finishes.

The stochastic model is developed with burst discharge process to track out charge recovery discussed in [11, 12]. In [12] author stated for the storage nonlinearity for task scheduling, for that he discussed few algorithms related to load current profile and shaping. The authors seeing the nodes in the system and faceoff the channels complexity through proposed novel battery aware MAC scheduling scheme [13]. Compensating the latency of some network components of interlinked systems a scheduling scheme is presents, so that decaying factor is improved and remains battery friendly in [14].

The author [15, 16] gives light on routing algorithm for battery aware; through utilizing rate limit impact and battery recuperation impact that improves the battery life expectancy.
Endoscopy can detect various body parameters such as inflammation, different infections inside human body, tumors, and ulcers.

Table 1 Food and drug administration approved wireless capsule systems and specifications [6].

Wireless Capsule Endoscopy company	Field of View	Images/seC	Battery lifetime	Resolution
EndoCapsule;	145’	2	8 hours	512*512
PillCam SB2;	156’	2	8 hours	256*256
PillCam SB2EX;	156’	**2**	12 hours	256*256
MicroCam	170’	3	11 hours	320*320
PillCam ESO2;	169’	18	8 hours	256*256

The world is going toward power optimization where Lifetime of Wireless Capsule and high battery charge consumption is big problem to be resolve. Higher resolution and frame rate is more battery hungry so keeping in see qualities and usefulness of sensor hubs in Wireless Sensors Networks research focuses on extension battery lifetime. Problem is of power consumption due to various reasons such that capturing high-resolution images and transmission of images to the receiver and the light emitting diodes. Table 1 shows the different values of different parameters currently available in markets.

The aim of this research is to propose an effective battery friendly algorithm through which we can extend the battery lifetime of capsule so that it can remain for more than twelve hours inside the human body, in Gastrointestinal tract. So, for that we can minimize rate of power consumption of system and to enhance the energy efficiency of system.

While reducing the image size, the image can be broken into packets having resolution for instance '512*512' (rows and Columns), and resolution is reduced up to '256*256' (rows and columns) as we can see sufficient view. We can also change the field of view angle to extend the battery lifetime as shown in Table 1.

Technology is going towards power efficiencies and the power optimization in devices so the healthcare technology is very use to in every second of life because life of any person is more important than anything so for that purposes to facilitate the patient in more efficient way by power optimization, increasing the battery life time of wireless capsule endoscopy is the key motivation.

To solve the power consumption problem in wireless capsule endoscopy there are various solutions to propose such important solutions are to reduce resolution but it is disadvantage of image quality and we can compromise over it if we are going with resolution solution and another frame rate reduction is solution so can enhance battery life time. Tilting the angle of camera and antennas to maintain distance to create line of sight between receiving and transmitting antennas to avoid obstacles and losses.

Main concern is battery lifetime of wireless capsule. Current research shows that the maximum battery lifetime is twelve hours as shown in Table 1. So in critical situations, doctors may have to keep the capsule inside the patient's Gastrointestinal tract for long time, more than twelve hours and they also need with high resolution of images [1, 18, 34]. In that situations, if the battery shuts down or it provides no power to the capsule then it is not easy to replace it with another battery or recharge it. So the extension in battery lifetime will make the capsule to remain in the Gastrointestinal tract of human body for more than twelve hours [19,30]. The efficiency of an algorithm can be considered through its battery lifetime that can be extended by reducing the size of image, changing the field of view and image transfer rate.
This paper encompasses several battery friendly algorithms and techniques. It also highlights outstanding strategies, which have been used by few researchers to minimize charge consumption, hence making Wireless Capsule Endoscopy energy efficient.

3. Packet Strategies

Battery-friendly transmission of data packets have also been a main consideration in order reduce battery charge consumption and transmission energy to make wireless capsule endoscopy a battery friendly technology. Ye li and Ali have considered a diagnostic model of a lithium-particle battery in order to propose a battery-friendly packet transmission algorithm for wireless capsule endoscopy system. They have proposed two algorithms 'lazy packet transmission' and 'modified lazy packet transmission'. Lazy packet transmission helps to reduce battery charge consumption while modified lazy packet helps to reduce transmission energy [19, 27, 35].

3.1 System Configuration

Wireless Capsule Endoscope system works like, it takes images store those images, it controls the capsule, it communicates with the work station and so on. The fundamental aspect of this framework contains information recorder and battery as shown in Fig 2 wireless capsule endoscopy system has to perform tasks like imaging the Gastrointestinal tract of human body, then it has to perform compression to compress the image, and then transmit it to the receiver connected outside on the patient's waist.

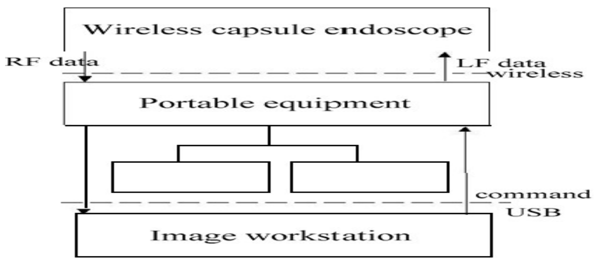

Fig 2. Wireless capsule endoscopy system.

3.1 Energy Proficient Transmission Approach for Remote Body Area Network Dependent on Edge Separation

It is related with transmission of pictures dependent on separation between transmitter (Capsule) and collector connected on the patient's waist. When this distance 'd' is greater than a threshold distance 'dth' i.e. d>dth then transmission energy required is more. When d<dth, then transmission energy required is less to transmit the images to the receiver. Thus controlling the distance'd', we can reduce total energy upto 59.77%. Ye li has shown the results and he has extended battery lifetime by achieving 59.77% saving of total energy. For the distance 'd' much larger than 'dth', he has used offline algorithm, he has achieved saving in total energy of 60.81% [20].

This paper encompasses several battery friendly algorithms and techniques. It also highlights outstanding strategies, which have been used by few researchers to minimize charge consumption, hence making Wireless Capsule Endoscopy energy efficient. Following findings are worthwhile to be considered as:

a. d <dth, the circuit energy is tantamount to transmission energy.

b. Here: threshold distance dth is inferred for the advancement of the absolute energy consumption, d is transmission distance.

c. d >dth, other packet-scheduling algorithms have been thought about so as to fulfill the requirements like cutoff time [20].

3.2 Green and Agreeable Media Transmission Calculations for Remote Body-Sensor-Organizations

Wireless body sensor nodes contributes a lot in medical health adapting an easy and cost-effective way of diagnosis. Its applications also include remote monitoring of a patient wherever the patient be, doctor can remotely diagnose him/her. So wireless body sensor nodes must be power and energy-efficient in order to be able to perform all of these tasks.

Wireless body sensor nodes is helpful to doctors and patients because it can provide early interventions to have remote communication between them. Specialist can view the display of patient on a video supportive display on his clinic. Furthermore, it is helpful for the specialists to be on time in critical situations.

3.3 Overview of an Image Compressor

A major component of wireless capsule endoscopy system is image compressor, hence operation of wireless capsule endoscopy framework is additionally reliant on the

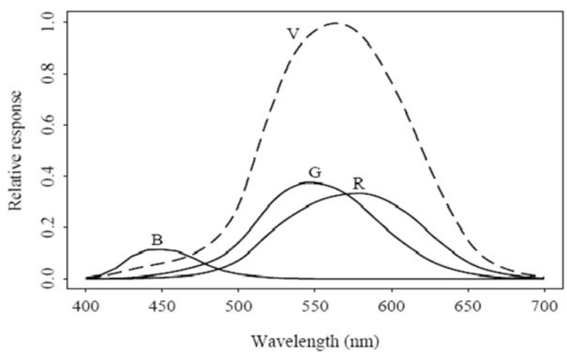

Fig 3. Reaction of eye towards various frequency [23].

plan of its picture blower [21]. It is shown in Fig 3 that out of total of energy consumption, 63% of it is consumed during Radio Frequency transmission of images.

To reduce this consumption, an efficient image compression technique must be proposed without any compromise on the quality of image when reconstructed. Compression helps to reduce energy consumption as in a compressed image, less amount of bits is present and hence their transmission costs less energy [22, 34].

3.4 Lossless Image Compressor

This method of compression is helpful to remove or reduce the redundancies of Human Visual System, and the response of human eye to different wavelengths of different colors shown in Fig 3 [23,26].

Image compression is shown in Fig 4. In this method has been used where we do not any loss of data. In this method there is no noise present in images except the impulse response of channel. It exploits spatial redundancies when the correlation between the adjacent pixels of an image has very low rate. This method uses a compression ratio in the range of 20-50% [24].

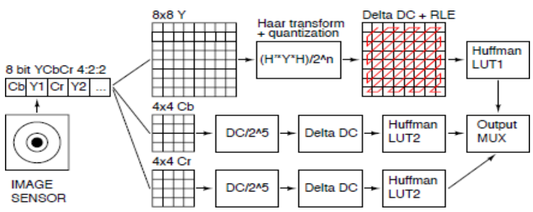

Fig 4. Efficient wireless capsule endoscopy image compression algorithms [25].

There are two broad categories to categorize lossless compression techniques based on different coding and are discussed below and their comparison is also made.

3.4.1 Fixed Length Coding

This is one of the techniques to achieve lossless compression. In this technique we consider the probability of occurring of symbols is likely and we represent each symbol with a code word of fixed length. Practically this is not going to happen that each symbol will have same probability of occurrence. So instead of using fixed length coding, binary, gray-scale and ASCII is preferred [24].

3.4.2 Variable Length Coding

This technique is preferred over fixed length coding technique, because using this technique we can assign different number of bits on the basis of occurrence of any symbol. So assigning number of bits to any symbol depends upon its probability of occurrence. Therefore we require less number of bits for symbols having greater probability of occurrence. Run length coding, Huffman coding, Arithmetic coding are instance of variable length coding [24, 29].

3.4.3 Lossy Image Compressor

In order to have higher value of compression ratio, lossy compressors are useful. In lossy compressor, we truncate some of the redundant information from image permanently. Different techniques like plane convertor, Chroma sub-sampling use lossy compressors.

In wireless capsule endoscopy, an algorithm was developed in which without compromising on the quality of image, we can compress it. Hence it reduces the amount data bits required to store the information content in an image, therefore making wireless capsule endoscopy energy efficient.

This calculation depends on Haar-Wavelet Change, it exploits restricted shading necessity of endoscopic pictures. It utilizes YCbCr shading space with a productive coding of Wavelet Changes. Using YCbCr color space, image can be compressed to a goof compression ratio without compromising on the quality of image [25,33].

A Wireless capsule endoscopy system capable of capturing images with different data rates, calculations are shown in Table 3. We observe clearly that transmission of images with high resolution, and with higher frame rates, demands a larger bandwidth. wireless capsule endoscopy systems make use of different modulate ion schemes, among them binary phase shift keying is most widely used. Frequency Shift Keying is also used because of its robustness to spectral bandwidth requirements. Carson's rule is used to calculate the spectral bandwidth requirement and that is used for the data given in Table 2.

Table 2 Information rate computation model for a regular remote endoscopy application [19]

FR (frame rate) R (resolution) PD (pixel depth) CR (compression ration)	15 fps 640 x 480 px 10 bit/px 25
DR (data rate)	(FR x R x PD)/CR = 1.843 Mbps

It can be clearly seen in Fig 5 that histogram of Cb contains the restricted data content in it among the Y, Cb, Cr segments. Utilizing Haar-Wavelet Change strategy of YCbCr shading space, we can reduce the amount data bits in order to compress the images [11]. Therefore it increases the throughput of image without compromising image quality, and hence making wireless capsule endoscopy system an energy efficient system of diagnosis.

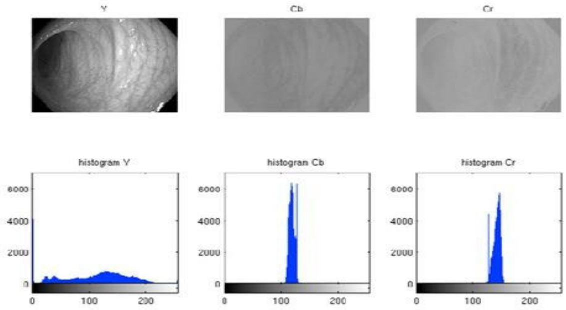

Fig 5. A productive lossy picture blower calculation for remote case endoscopy transmission [25].

4. Suggested Solution

Since the low battery lifetime of wireless capsule is the cause of concern. Current research shows that the maximum battery lifetime is twelve hours as shown in Fig 1; in critical situations, doctors may have to keep the capsule inside the patient's GI tract for long time, more than twelve hours even, in that situations, if the battery shuts down or it provides no power to the capsule then it is not easy to replace it with another battery or recharge it. The extension in battery lifetime will make the capsule to remain in the GI tract of human body for more than twelve hours. We will implement an algorithm through which battery lifetime can be extended to provide a integrated power optimization with battery friendly algorithm, a battery-efficient solution to the doctors. The aim of this survey is to implement an algorithm through which we can extend the battery lifetime of capsule so that it can remain for more than twelve hours inside the human body, in GI tract.
For that reason some strategies may be applied to enhance the lifetime of capsule there are by reducing the size of image, or by changing the Field of view and by implementing efficient battery algorithm.

5. Conclusion

In this article the discussion includes the problems that wireless capsule endoscopy systems encompasses and their all-hardware portion along with their merits and demerits. This article also focuses on the financial considerations and we have shown current market values of wireless capsule endoscopy systems. We also discussed different methodologies adopted to accomplish the task of reducing power consumption in wireless capsule endoscopy systems.

To make it battery friendly, different algorithm that research have used to achieve maximum possible reduction in power consumption of wireless capsule endoscopy systems are discussed. Specifically image compression algorithms, fixed-length, variable- length coding and the work done on the basis of threshold distance between transmitting antenna of Capsule to the receiver of connected images receiving box. Finally, we have discussed the possible solutions regarding existing research based on future research trends.

References

[1] Sodhro, A. H., Li, Y., & Shah, M. A. *Green and friendly media transmission algorithms for wireless body sensor networks*. Multimedia Tools and Applications, 76(19), 20001-20025 (2017).

[2] Yi, C., Wang, L., & Li, Y. *Energy efficient transmission approach for WBAN based on threshold distance*. IEEE sensors journal, 15(9), 5133-5141 (2015).

[3] Cui, S., Goldsmith, A. J., & Bahai, A. *Energy-constrained modulation optimization*. IEEE transactions on wireless communications, 4(5), 2349-2360 (2005).

[4] Karakus, C., Gurbuz, A. C., & Tavli, B. *Analysis of energy efficiency of compressive sensing in wireless sensor networks*. IEEE Sensors Journal, 13(5), 1999-2008 (2013).

[5] Tang, Q., Yang, L., Giannakis, G. B., & Qin, T. *Battery power efficiency of PPM and FSK in wireless sensor networks.* IEEE Transactions on Wireless Communications, *6*(4), 1308-1319 (2007).

[6] Li, Y., Bakkaloglu, B., & Chakrabarti, C. *A system level energy model and energy-quality evaluation for integrated transceiver front-ends*. IEEE Transactions on Very Large Scale Integration (VLSI) Systems, 15(1), 90-103 (2007).

[7] Anastasi, G., Conti, M., Di Francesco, M., & Passarella, A. *Energy conservation in wireless sensor networks: A survey.* Ad hoc networks, 7(3), 537-568 (2009).

[8] Uysal-Biyikoglu, E., Prabhakar, B., & El Gamal, A. *Energy-efficient packet transmission over a wireless link*. IEEE/ACM Transactions on Networking, 10(4), 487-499 (2002).

[9] Maleki, S., Pandharipande, A., & Leus, G. *Energy-efficient distributed spectrum sensing for cognitive sensor networks*. IEEE sensors journal, 11(3), 565-573 (2010).

[10] Rao, R., & Vrudhula, S. *Battery optimization vs energy optimization: Which to choose and when?*. In ICCAD-2005. IEEE/ACM International Conference on Computer-Aided Design, 2005. (pp. 439-445). IEEE (2005, November).

[11] Nuggehalli, P., Srinivasan, V., & Rao, R. R. *Energy efficient transmission scheduling for delay constrained wireless networks*. IEEE Transactions on wireless communications, 5(3), 531-539 (2006).

[12] Chiasserini, C. F., & Rao, R. R. *Improving battery performance by using traffic shaping techniques*. IEEE Journal on Selected Areas in Communications, 19(7), 1385-1394 (2001).

[13] Jayashree, S., Manoj, B. S., & Murthy, C. S. R. *Next step in MAC evolution: Battery awareness?*. In IEEE Global Telecommunications Conference, 2004. GLOBECOM'04. (Vol. 5, pp. 2786-2790). IEEE (2004, December).

[14] Chowdhury, P., & Chakrabarti, C. *Static task-scheduling algorithms for battery-powered DVS systems*. IEEE transactions on very large scale integration (VLSI) systems, 13(2), 226-237 (2005).

[15] Ma, C., & Yang, Y. *A battery aware scheme for energy efficient coverage and routing in wireless mesh networks*. In IEEE GLOBECOM 2007-IEEE Global Telecommunications Conference (pp. 1113-1117). IEEE (2007, November).

[16] Chang, J. H., & Tassiulas, L. *Maximum lifetime routing in wireless sensor networks*. IEEE/ACM Transactions on networking, 12(4), 609-619 (2004).

[17] Chen, W., Neely, M. J., & Mitra, U. *Energy-efficient transmissions with individual packet delay constraints.* IEEE Transactions on Information Theory, 54(5), 2090-2109 (2008).

[18] Thoné, J., Radiom, S., Turgis, D., Carta, R., Gielen, G., & Puers, R. *Design of a 2 Mbps FSK near-field transmitter for wireless capsule endoscopy*. Sensors and Actuators A: Physical, 156(1), 43-48 (2009).

[19] Sodhro, A. H., Li, Y., & Shah, M. A. *Green and friendly media transmission algorithms for wireless body sensor networks*. Multimedia Tools and Applications, 76(19), 20001-20025 (2017).

[20] Sodhro, A. H., & Li, Y. *Battery-friendly packet transmission strategies for wireless capsule endoscopy*. In The International Conference on Health Informatics (pp. 236-239). Springer, Cham (2014).

[21] Uysal-Biyikoglu, E., Prabhakar, B., & El Gamal, A. *Energy-efficient packet transmission over a wireless link*. IEEE/ACM Transactions on Networking, 10(4), 487-499 (2002).

[22] Chen, W., Neely, M. J., & Mitra, U. *Energy-efficient transmissions with individual packet delay constraints*. IEEE Transactions on Information Theory, 54(5), 2090-2109 (2008).

[23] Podpora, M., Korbas, G. P., & Kawala-Janik, A. *YUV vs RGB-Choosing a Color Space for Human-Machine Interaction*. In FedCSIS (Position Papers) (pp. 29-34) (2014, October).

[24] McCaffrey, C., Chevalerias, O., O'Mathuna, C., & Twomey, K. *Swallowable-capsule technology*. IEEE Pervasive computing, *7*(1), 23-29 (2008).

[25] Carta, R., Tortora, G., Thoné, J., Lenaerts, B., Valdastri, P., Menciassi, A., ... & Puers, R. *Wireless powering for a self-propelled and steerable endoscopic capsule for stomach inspection.* Biosensors and Bioelectronics, 25(4), 845-851 (2009).

[26] Alizadeh, M., Maghsoudi, O. H., Sharzehi, K., Hemati, H. R., Asl, A. K., & Talebpour, A. *Detection of small bowel tumor in wireless capsule endoscopy images using an adaptive neuro-fuzzy inference system*. Journal of biomedical research, 31(5), 419 (2017).

[27] Liu, G., Yan, G., Kuang, S., & Wang, Y. *Detection of small bowel tumor based on multi-scale curvelet analysis and fractal technology in capsule endoscopy*. Computers in biology and medicine, 70, 131-138 (2016).

[28] Atitallah, M. B., Kachouri, R., Kammoun, M., & Mnif, H. *An efficient implementation of GLCM algorithm in FPGA*. In 2018 International Conference on Internet of Things, Embedded Systems and Communications (IINTEC) (pp. 147-152). IEEE (2018, December).

[29] Cheung, D. Y., Kim, J. S., Shim, K. N., Choi, M. G., & Korean Gut Image Study Group. *The usefulness of capsule endoscopy for small bowel tumors*. Clinical endoscopy, 49(1), 21 (2016).

[30] Tica, O. A., Tica, O., Antal, L., Hatos, A., Popescu, M. I., Pantea Stoian, A., ... & Diaconu, C. C. *Modern oral anticoagulant treatment in patients with atrial fibrillation and heart failure: insights from the clinical practice.* Farmacia, 66(6), 972-976 (2018).

[31] Kotecha, D., Lam, C. S., Van Veldhuisen, D. J., Van Gelder, I. C., Voors, A. A., & Rienstra, M. *Heart failure with preserved ejection fraction and atrial fibrillation: vicious twins*. Journal of the American College of Cardiology, 68(20), 2217-2228 (2016).

[32] Rondonotti, E., Spada, C., Adler, S., May, A., Despott, E. J., Koulaouzidis, A., ... & Riccioni, M. E. *Small-bowel capsule endoscopy and device-assisted enteroscopy for diagnosis and treatment of small-bowel disorders: European Society of Gastrointestinal Endoscopy (ESGE) Technical Review.* Endoscopy, 50(4), 423-46 (2018).

[33] Abdel-Daim, M. M., El-Tawil, O. S., Bungau, S. G., & Atanasov, A. G. Applications of antioxidants in metabolic disorders and degenerative diseases: Mechanistic approach. *Oxidative Medicine and Cellular Longevity*, (*2019*).

[34] Yung, D. E., Plevris, J. N., & Koulaouzidis, A. *Short article: Aspiration of capsule endoscopes: a comprehensive review of the existing literature*. European Journal of Gastroenterology & Hepatology, 29(4), 428-434 (2017).

[35] Tit, D. M., Bungau, S., Iovan, C., Nistor Cseppento, D. C., Endres, L., Sava, C., ... & Furau, C. *Effects of the hormone replacement therapy and of soy isoflavones on bone resorption in postmenopause*. Journal of Clinical Medicine, 7(10), 297 (2018).