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Review Paper on Wireless Power Transmission System of Video Capsule Endoscopy

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Abstract

With the help of Wireless Capsule Endoscopy (WCE), the small intestine can be seen in great detail on film. With WCE, a single session can generate almost 8 hours of footage. Its interpretation is a laborious job that demands extensive knowledge and is very stressful. In order to pre-process WCE footage and assist clinicians with its interpretation, the Model of Deformable Rings (MDR) was created. A streamlined simulation of a capsule's motion is used by the MDR to easily match (register) successive video frames. In essence, it computes motion descriptive properties and generates a two-dimensional model of the interior surface of the GI tract. The video segments that show seminary contractions, peristalsis, refraction phases, and areas of capsule retention are identified using the motion-descriptive characteristics. The experimental findings show that the MDR method increases the number of gastrointestinal landmarks and pathologies found.

Keywords- Video Capsule endoscope; inductive coupling; Helmholtz coil.

1 INTRODUCTION

A relatively new diagnostic instrument, video capsule endoscopy (VCE) was developed over the course of two decades. With this technique, we can evaluate the esophagus, stomach, small intestine, and colon while sparing the patients from exposure to external radiation. Video small bowel capsule endoscopy can be used to diagnose various small intestinal disorders. (SBCE). Video colon capsule endoscopy is one way to identify colon cancer. (CCE). Video esophageal capsule endoscopy (ECE) is a treatment choice for some esophageal diseases when patients are unable to tolerate optical endoscopy. Video SBCE has a significant effect on the diagnostic evaluation in clinical gastroenterology. This essay will discuss diagnostic implications, contraindications, complications, technical considerations, and how to interpret capsule endoscopy.

2 LITERATURE SURVEY

2.1 The potential for diagnosis

The small intestine is the gastrointestinal tract's largest organ, measuring an average of 9 to 15 feet [1]. The duodenum (9 inches long), the jejunum (40 percent of the middle part), and the ileum are its three sections. (60 percent of the distal portion). The gastrointestinal system was once referred to as the "dark world" or the "black box" because traditional upper endoscopies, colonoscopies, and push enteroscopies cannot fully visualise the small bowel mucosa. The entire small bowel mucosal visualisation procedure was revolutionised by SBCE when it first joined our clinical practise in 2001 [2]. This was done painlessly and remotely. Since its development, this technology has become recognised as a potent first-line diagnostic tool for assessing a range of small bowel diseases. It is typically finished. Determine the source of overt or hidden obscure gastrointestinal bleeding (OGIB) when esophagogastroduodenoscopy (EGD) and colonoscopy are negative [3]. One research found that using SBCE quickly—within 3 days of hospital admission—in the case of overt OGIB results in a significantly higher rate of therapeutic intervention, a higher yield of diagnoses, and a concomitant shorter hospital stay [4]. The American Gastroenterology Association (AGA) Institute's clinical practise recommendation of 2017 recommended SBCE in patients with known, relapsed, or suspected Crohn's disease when the active disease is still suspected in the small bowel, after negative imaging tests and a normal ileocolonoscopy. The AGA guidelines for celiac disease patients who continued to have unexplained symptoms despite getting adequate care also recommended SBCE. The AGA guideline suggested SBCE for the

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surveillance of people with polyposis syndromes and small bowel tumours (lymphoma, sarcoma, neuroendocrine tumors, adenocarcinoma, gastrointestinal stromal tumours) [5]. Schulmann et al. performed a prospective study on 29 patients with the familial adenomatous polyposis (FAP) syndrome. In 24% of the FAP patients with duodenal adenomas, they found that more tumours were evident by SBCE in the distal jejunum or ileum [6]. Therefore, SBCE should be considered in FAP patients with multiple duodenal adenomas. Caspari et al. found that SBCE had a higher diagnostic yield than magnetic resonance imaging (MRI) for locating small polyps (5 mm) in individuals with Peutz-Jeghars syndrome (PJS) [7]. Given this, SBCE should be considered for the initial assessment and continued monitoring of PJS patients.

In light of this, SBCE ought to be taken into account when diagnosing and monitoring individuals with PJS. The SBCE is a crucial test for assessing the small intestine's role in intestinal lymphomas and the effectiveness of therapy [8].Non-steroidal anti-inflammatory medications (NSAIDs) can harm the small intestine in a number of ways, including strictures, erosions, ulcers, and "septal disease" [9]. SBCE can evaluate enteropathy brought on by NSAIDs [10]. In 75% of patients, acute graft vs. disease (GVHD) may affect the complete gastrointestinal tract, including the small intestine [11].

It is more noticeable in the ileum than the jejunum, though. Endoscopic observations may include changes in the mucosa's look as well as focal erythema, edema, fragility, exudate, erosion, ulceration, desquamation, and persistent bleeding [12]. A prospective investigation revealed that upper endoscopy plus sigmoidoscopy plus biopsy (from the antrum, trunk, duodenum, distal esophagus, and rectum sigmoid) or ileocolonoscopy plus biopsy (from the rectosigmoid, large intestine, and ileum) equals GV [13]. SBCE should be taken into account if the aforementioned tests are negative and GVHD is confirmed. If the patient is too sick to have an endoscopy or a colonoscopy, SBCE may be used as a substitute diagnostic technique for GVHD. SBCE is also helpful in the assessment of rare illnesses like abeta lipoproteinemia (diffuse white pattern along the intestinal mucosa, occasionally yellow region), variable immunodeficiency virus (CVID) (small nodular lesions spreading throughout the gut) [14]. Villous atrophy) [15] and intestinal lymphangiectasia [16], which is characterised by the accumulation of lymphatic vessels as whitish spots that can be localised or diffuse.

Double-balloon enteroscopy (DBE), single-balloon enteroscopy (SBE), spiral enteroscopy (SE), or other tests of measurement are regarded to be the first-line tests for a typist. COMPUTER TOMORROW There are five explanations for why small intestine haemorrhage or magnetic resonance enterography (MRE) or enterography (CTE) is used to assess mucosal lesions. 1) This exam is non-invasive, effective, and stress-free. An instrument-assisted colonoscopy, on the other hand, is a more invasive process that does not call for anaesthesia. 2) While enteroscopy for SBCE has a 90.6% total success rate, enteroscopy equipment has a lower success rate (DBE: 66%, SBE: 22%) [17, 18]. 3) In OGIB caused by small bowel illness, SBCE and DBE are comparable (60% vs. 57%) [19].

When differences were excluded, the diagnosis of SE in OGIB individuals was marginally lower than in SBE (43.4% vs. 59.6%) [20]. 4) Small bowel lesions that are overlooked by small bowel examinations can be found using SBCE. (CTE and MRE). SBCE can be performed in small regions, which can then be biopsied or treated with assisted endoscopy. Contraindications SBCE contraindications include: 1) A obvious contraindication to SBCE is known minor rectal stenosis. Tongchang Patients with known small bowel Crohn's disease, suspected small bowel disease or stricture, a history of minor surgery, or who are receiving therapy for gastrointestinal disorders should be given capsules. If the unblocked capsule is released within 30 hours, SBCE can be regarded as secure to use [21].

For suspected Crohn's disease without obstructive signs, the European Society for Gastrointestinal Endoscopy (ESGE) does not advise taking Tongchang capsules prior to SBCE [22]. tiny intestine, second. Fistula in the small intestine. 4) Implantable medical devices such as automated implantable cardiac defibrillators (AICD), cardiac pacemakers (PM), and left ventricular assist devices (LVAD). The U.S. Food and Drug Administration (FDA) and video capsule manufacturers Covidien, Olympus, Medtronic, IntroMedic, and Chongqing Jinshan Technology counsel against SBCE for heart patients. The American Society for Gastrointestinal Endoscopy (ASGE) states that SBCE is not recommended for people with heart problems. The electromagnetic interference between SBCE, PM, and AICD has been examined in several in vivo investigations [23–25].

However, SBCE, PM, and AICD did not exhibit EMI. The electromagnetic interference between SBCEs and left ventricular assist devices (LVADs) is not an issue, according to several in vivo studies [26, 27]. SBCE can be done without cardiovascular apparatus, but a collaborative team should be present. 5) There is no evidence to support the safety of SBCE during pregnancy. During the second and third trimesters of pregnancy, the uterus grows larger and puts pressure on the stomach. The SBCE may be hampered by these physiological alterations [28].

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Overall, SBCE is considered a safe and simple test. But certain complications can occur as well, which are discussed as follows.

2.2 Complications

The following are some SBCE side effects:

1) The most concerning consequence is the retention of the video capsule in the small intestine. 75% of the capsules reached the cecum during the 8-hour study time, and they were eliminated 10 to 48 hours later [29]. Video A capsule is said to be retained if it stays in the small intestine for longer than two weeks and needs to be removed or passed [30]. The average chance is about 1-2% in OGIB patients, but it can reach 4-5% in those with Crohn's disease [31, 32]. Patients with malignancy, NSAID-induced enteritis, ischemic enteritis, radiation enteritis, tuberculous enteritis, and postoperative strictures have higher rates of capsule retention as well [33, 34]. Most people continue to have no symptoms. In silent patients without ileus, the ESGE advises managing primary care insurance with drugs (including laxatives, prokinetics, steroids, immunomodulators, and biologics). If this is not feasible, the capsule should be removed via an enteroscopy. The next stage is surgery to remove the capsule (open surgery with laparoscopy or enterotomy), if the blood vessel is unable to do so [22].

2) The small intestine was not completely examined, which indicates that the capsule did not travel to the cecum. 15% of investigations find it [35]. To prevent the small intestine, the test must be performed again. High reliance, hospitalization, and abdominal surgery were risk factors for incomplete SBCE.

3) Time delay: The capsule remains in the same location in the stomach or intestines for longer than two hours, leaving an incomplete image of the intestines. Patients at risk for lengthy delays are those with slow bowel motions (diabetes, hospitalizations, patients taking opioids).

4) Poor visualization: When performing SBCE, air bubbles, sputum, gastric juice, bile, and food particles in the large intestine can obscure the gut. The indicators of negative images are the masculine gender and the lengthening of the small abdomen. [36].

2.3 Preparation for SBCE

The patient should prepare the stomach at 6 pm the day before the operation by quitting smoking and drinking anything clear after lunch. The most popular mild gastric lavage for SBCE uses 2 L of polyethylene glycol (PEG) [37]. Magnesium citrate, Miralax (polyethylene glycol 3350), and Gatorade are additional hand sanitizers. According to a study conducted in 2014 by Kim et al., patients who received a coffee enema along with 2L of PEG had greater success cleaning their mid to distal small bowel than those who got PEG alone [38]. The choice of bowel preparation should be made in light of the patient's therapeutic situation. After midnight, patients shouldn't consume anything by mouth. The patient should consume two Simethicon tablets the morning of the capsule endoscopy in order to lessen intraluminal bubbles and improve the visibility of small bowel mucosa [39]. The patient must not consume anything after taking the video pill for at least two hours. Two hours after ingesting the capsule, you can drink something clear, and four hours later, you can eat something. While remaining calm, patients should wait 8 hours before exercising after consuming the capsules. Tell patients to avoid all radiation sources, including MRIs, HAM radio, and airport security at this time.

The existing standard does not include good bowel preparation for SBCE. In a prospective study of patients having bowel preparation prior to SBCE, Rosa et al. determined that bowel preparation was sufficient if more than 75% of the small intestine could be seen [40].

Technical Points of Interest The Small Intestine (SB) Capsule, also known as PillCam SB, is shaped like a pill, measuring 11 x 26 mm and weighting less than 4 grammes. It is also the size of a large vitamin pill. An SB capsule, a data recorder, a computer, and the required office software make up the PillCam SB system. During the 8-hour research, a small camera placed inside the SB capsule takes two photos/images per second as it passes through the SB and transmits about 50,000 photos to a data logger fastened to the patient's waist belt. The first SBCE system to reach the US and European markets in 2001 is PillCam SB (previously M2A). The picture is magnified eight times, the angle of view is 1,400, and the depth of field is 1 to 30 months [41]. The PillCam SB2 and PillCam SB3 have improved capabilities over the past 20 years. In contrast to the previous PillCam SB, the PillCam SB2 has a broader viewing angle (1,560 vs. 1,400), more image captures per second (4 vs. 2), and a longer battery life (9 vs. 8 h) [42]. The image resolution is 30% better than the PillCam SB2, and the number of frames per second can be increased to 6 by the PillCam SB3. Unlike the PillCam SB3, which stores captured data in playback mode, the PillCam SB2 stores data in manual mode (4 screens, 28x speed). (4 screens, 28x speed). In terms of

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image analysis, connectivity, and video reading, the software of the PillCam SB3 system (RAPID 8.0 or 8.3 system) is at least 40% more advanced than that of the PillCam SB2 system. [43].

Table 1: Basic design parameters of transmitting coil used in existing studies

Coil	No. of Turns	Wire Guage (AWG)	Self – Inductance (μH)	DC Impedance (Ω)	Resonate (kHz)
Sole. Ø 30	25	16	368.7	NA	58.418
Helm Ø 64	26	38	631	5	181
Helm Ø 69	26	38	621	NA	400
Helm Ø 75	12	12	147	1.5	1000
Sole. Ø 40	66	16	347.6	0.3	36
Helm Ø 32	25	15	NA	NA	50
Helm Ø 30	16	12	187.5	NA	1000

2.4 WCE Clinical Importance

The oesophagus, stomach, and duodenum (upper GI tract), the jejunum, ileum (small bowel), the colon, and the rectum make up the gastrointestinal (GI) system depicted in Figure. The various feature extraction techniques used for the WCE video segmentation task are discussed in this part. These techniques, which are described in depth, make use of the information on color, texture, and motion found in the capsule exams. The distribution of colours in a picture serves as a helpful cue for object recognition and image indexing. The most popular way to depict colour information in images is with a colour distribution histogram. A cursory examination of capsule images leads one to believe that texture characteristics may be crucial in the segmentation of topographic videos. The villi, which are tiny finger-like projections that are present in the small intestine but absent in the nearby regions of the colon and stomach, are the most noticeable texture pattern that differentiates different organs. Villi are necessary for food absorption. The mouth and oesophagus have very unique texture patterns. Additionally, there are several fluids, including saliva, bile, and gastric remnants, each with a unique textural pattern [10].

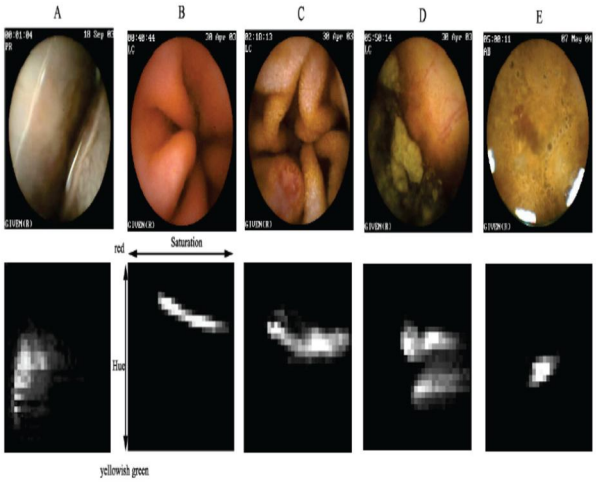

Figure 1: WCE images acquired from A) Mouth B) Stomach, C) Small Intestine, D) Partially occluded Colon E) completely occluded Colon with histogram.

Let us consider a grey-scale image whose intensity can be written I(x, y). The N neighbours of any given pixel p can be denoted as n^i, i = 0..., N − 1. In order to calculate an LBP value, the value of each neighbour n^i is compared to the value of 'p' to establish whether it is greater than or less than 'p'. This can be written as a function mapping each n^i onto a value b_i as follows:

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$$b_i = \begin{cases} 1 \ if \ n^i \geq p \\ 0 \ if \ n^i < p \end{cases}$$ Eqn. (1)

The LBP value for pixel (x_0, y_0) is calculated by concatenating the N binary values into a bit number, which can be described as follows:

$$LBP(x_0, y_0) = \sum_{i=0}^{N-1} b_i 2^i$$ Eqn. (2)

Moreover, following , we calculate LBP, which is invariant to image rotations and reduces the number of possible patterns:

$$LBPri = \min\{ROR(LBP, i) | i = 0, 1, ..., N-1\}$$ Eqn. (3)

where the ROR function shifts the N-bit binary LBP value, i bits to the right, with wrap-around. The number of possible patterns can be further reduced by considering only patternsof a specific type. This is achieved by introducing an extra constraint on pattern uniformity. Given the binary string $b_0 b_1 ... b_{N-1}$, the pattern uniformity is defined as the number of transitions that occur in that string and each transition a change from 0 to 1 or vice-versa including wrap-around.

$$Uniformity = \|b_o - b_{N-1}\| + \sum_{i=0}^{N-2} \|b_i - b_{i+1}\|$$ Eqn. (4)

Any capsule video can be quickly observed to show that various organs have different motion patterns. There are two distinct phases at the entrance: the first phase occurs when the capsule is outside the body of the patient, in which case we cannot predict much about its motion because the capsule may be waiting to be picked up and swallowed, in the hand of the clinician or the patient, in which case there would be some irregular motion pattern; and the second phase occurs when the capsule is inside the body of the patient, in which case we can predict some motion. Once the patient has swallowed the capsule, the second phase starts as the capsule moves clearly and quickly through the lips and down the oesophagus. The capsule initially rolls around in the stomach before reaching the stomach's bottom, where it travels in accordance with the pylorus's contractions until it passes through the valve and enters the small intestine. Mean Absolute Difference (MAD), Mean Squared Error (MSE), and Peak-Signal-to-Noise-Ratio are a few examples of cost functions. (PSNR).

$$MAD = \frac{1}{N^2} \sum_{i=1}^{N} \sum_{j=1}^{N} |C_{ij} - P_{ij}|$$ Eqn. (5)

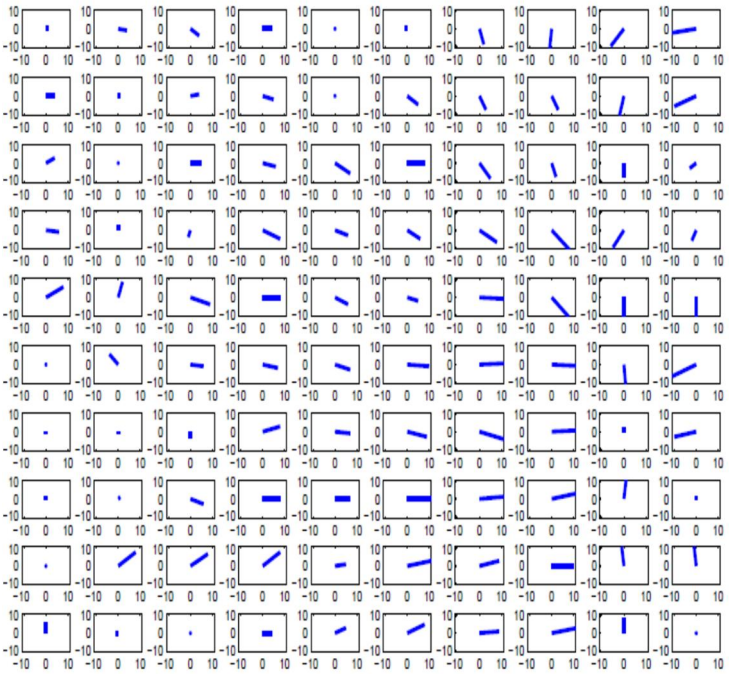

Figure 2: An example of a grid of motion vectors.

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It can be seen that most of the vectors point to the right.

1. sum of motion vectors

$$F_1 = \sum_{i=1}^{N} x_i \quad \text{Eqn. (6)}$$

2. sum of vector lengths

$$F_2 = \sum_{i=1}^{N} |x_i| \quad \text{Eqn. (7)}$$

3. sum of the following dot products

$$F_3 = \sum_{i=1}^{N} (x_i u_i) \quad \text{Eqn. (8)}$$

3 PRINCIPAL COMPONENT ANALYSIS

A distribution's PCA (Pratt, 2001; Gonzalez et al., 2004) [10] is also known as the Hostelling transform or the (discrete) Karhunen-Loève transform (KLT). For retaining the subspace with the highest variance, it is the only linear change that is truly optimal. PCA's computational complexity, however (O (M2N2)), is higher than other algorithms, such as the DCT (O(MN log 2MN)) described above. The principal components (PCs), which is the term that will be used throughout the rest of this the dissertation, are the fundamental functions. It is worth noting that unlike other linear transforms (including DCT), PCA does not have a fixed set of basis vectors. It computes the mean vector m_x and forms the covariance matrix, C_x for a distribution x, of size K:

$$M_x = \frac{1}{k} \sum_{k=1}^{k} x_k \quad \text{Eqn. (9)}$$

Having calculated m_x and C_x, the PCA of a distribution x is given by:

$$Y = A (x - m_x) \quad \text{Eqn. (10)}$$

Where the rows of matrix A are the normalised eigenvectors of C_x, ordered according to the decreasing corresponding Eigenvalues. The covariance matrix of y is a diagonal matrix C_y, whose diagonal elements are the Eigenvalues of C_x. The inverse transformation (since A is orthonormal, its inverse equals its transpose) produces the reconstructed x:

$$x = A^T y + m_x \quad \text{Eqn. (11)}$$

With regard to compression, the usefulness of PCA becomes clear when only some subset of q eigenvectors is used, in which case A becomes a q × n matrix Aq. Hence, the approximated reconstruction can be given as follows:

$$X = A_q^T + m_x \quad \text{Eqn. (12)}$$

There is an alternative way of calculating PCA which utilises singular value decomposition(Golub and van Loan, 1983) [12] and was used in this work. Here, x denotes the distribution with the subtracted mean, where each column contains a different subject, and each row different variable. Then we can write PCA as:

$$y = u^t x = SV^T \quad \text{Eqn. (13)}$$

where U,S,V& T is the singular value decomposition of x.

4 RESULT

Fig 3 shows a relation between efficiency vs S_0 where S_0 is the enclosed area of each coils. From graph it is clear that efficiency increases exponentially as the area of coils increases. But at higher values of S_0 it is almost gets linear it means after this value 6×10^{-4}if enclosed areas increase slightly, you get bigger change in efficiency.

Fig 4 shows a change between received average power vs S_0, from plot it is clear that as enclosed area increases received power also increases because you get more signals from follower resources as expected mathematically.

The tendency is for magnetic field homogeneity to decrease with increasing magnetic field uniformity. By adding a plot, the uniformity of various TC structures has been examined. The outcome depicted in Figure shows that as the number of spins rises, the TC's magnetic field uniformity falls, resulting in a more uniform magnetic field. The magnetic field homogeneity of Helmholtz coils is superior to that of the double solenoid pair with the same number of turns, while the single solenoid pair performs the worst.

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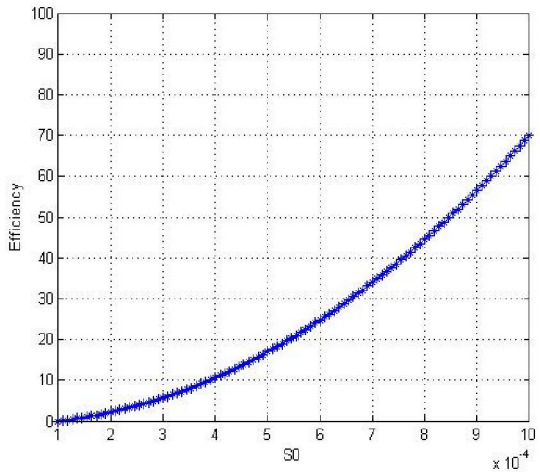

Figure3: S_0 Vs Efficiency

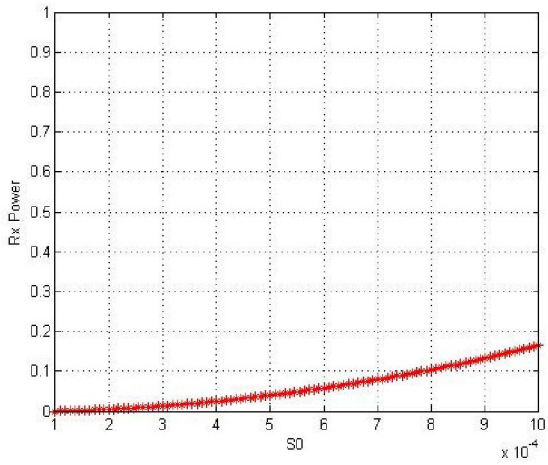

Figure4: S_0 Vs R_x power

Meanwhile, as the number of turns increases, the magnetic flux density coefficient of the TC magnetic field leads to a linear rise. The single and double solenoid coils' magnetic flux density coefficients are quite similar when they have the same number of turns, whereas the Helmholtz coils' is numerically smaller and gets wider as the number of turns rises.

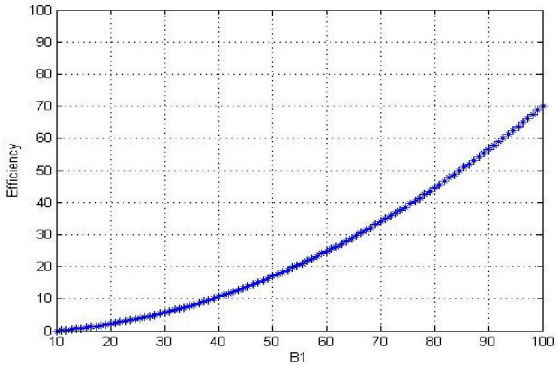

Figure 5 (a): Relation between Efficiency V/s Magnetic field densities

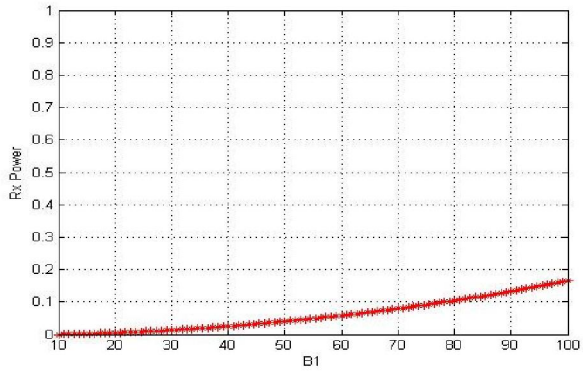

Figure 5 (b): Relation between R_xV/s Magnetic field density

5 CONCLUSION

In general, the discriminator trial results match those of the corresponding classifiers. The classification should use SVC with a radial basis kernel. HMM and sliding window segmentation techniques are the most effective. It can be seen that classifiers that combine features from the entire picture and sub-image regions, particularly for the SVC-based discriminator, work best. In fact, the error of the stomach/intestine discriminator is only 100 frames, taking up only 4 seconds of fast-forward watching, while the error of the intestine/colon discriminator is 500 frames, taking up 20 seconds of viewing time. These times would change with viewing speed, which is typically slower, and are based on the clinician observing the video at 25 frames per second. However, we have demonstrated that using such tools can cut down on the time needed to annotate GI transition spots, thereby reducing the amount of time needed to watch the video.

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