Computer Aided Diagnosis System for Wireless Capsule Endoscopy Video

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Abstract

Along with the advancing of technology in wireless and miniature camera, Wireless Capsule Endoscopy (WCE), the combination of both, enables a physician to diagnose patient's digestive system without actually perform a surgical procedure. Although WCE is a technical breakthrough that allows physicians to visualize the entire small bowel noninvasively, the video viewing time takes 1 - 2 hours. Not only it sets a limit on the wide application of this technology but also it incurs considerable amount of cost. Therefore, it is important to automate such process so that the medical clinicians only focus on interested events. As an extension from our previous work that characterizes the motility of digestive tract in WCE videos, we propose a new assessment system for energy based events detection (EG-EBD) to classify the events in WCE videos. For the system, we first extract general features of a WCE video that can characterize the intestinal contractions in digestive organs. Then, the event boundaries are identified by using High Frequency Content (HFC) function. The segments are classified into WCE event by special features. In this system, we focus on entering duodenum, entering cecum, and active bleeding. This assessment system can be easily extended to discover more WCE events, such as detailed organ segmentation and more diseases, by using new special features. In addition, the system provides a score for every WCE image for each event. Using the event scores, the system helps a specialist to speedup the diagnosis process.

Event Detection

Energy Function

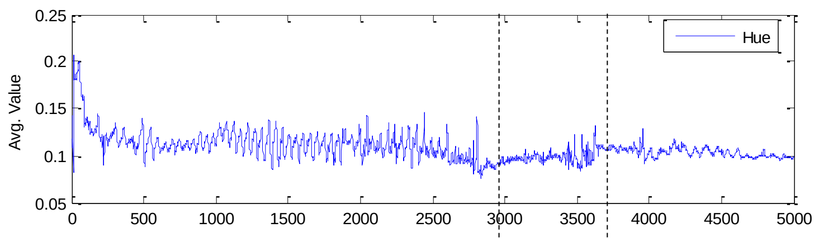
$$E_i = \sum_{k=2}^{\frac{N}{2}+1} \left| X_i(k)^2 \right|$$

High Frequency Content Function

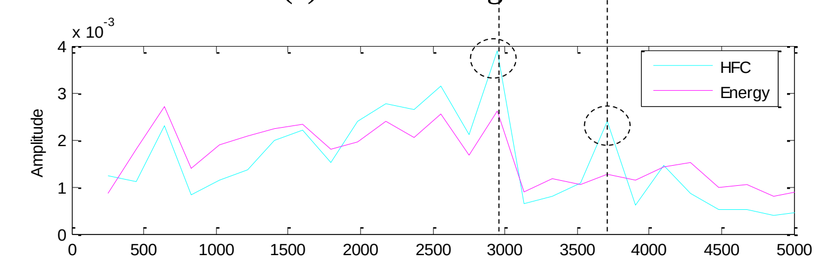
$$HFC_i = \sum_{k=2}^{\frac{N}{2}+1} \left| X_i(k)^2 \right| \times k$$

Condition for Event Detection

$$CEB_i = \frac{HFC_i}{HFC_{i-1}} \times \frac{HFC_i}{E_i}$$

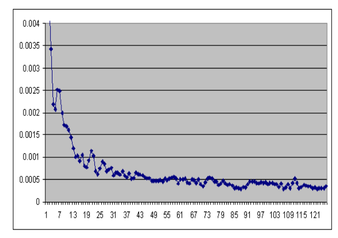


(a) Hue color signal

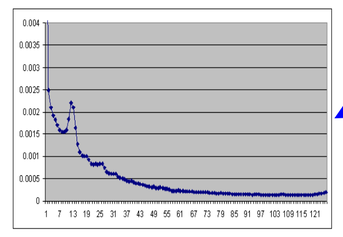


(b) Energy an HFC functions

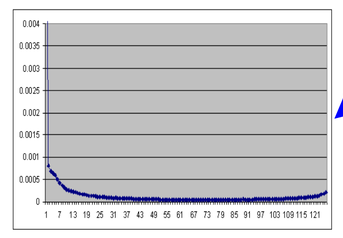
Event 3: Entering Colon



Stomach



Small intestine



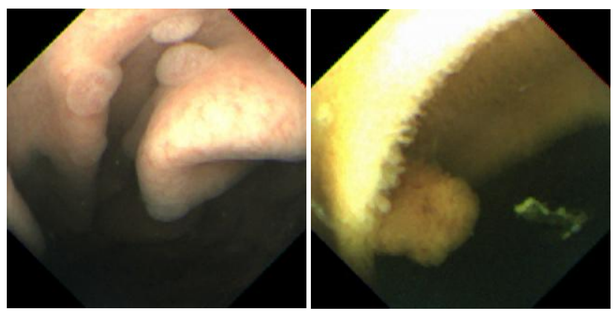
Colon ➔ Just like "*white noise*" in spectrum analysis!!

$$CE_i = \sqrt{\frac{N \times \sum_{i=m}^{m+N-1} x_i^2 - (\sum_{i=m}^{m+N-1} x_i)^2}{N \times (N-1)}}$$

Future Research Direction

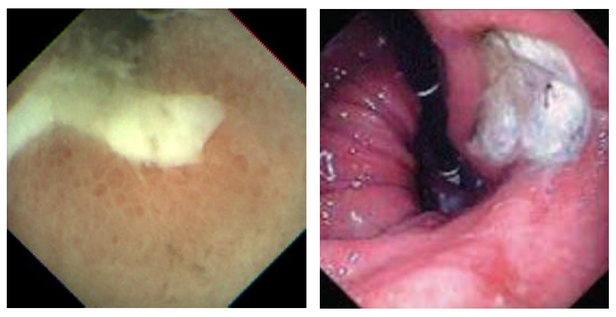
➔ **Polyp Detection**

(1) Shape feature
(2) Curvature feature

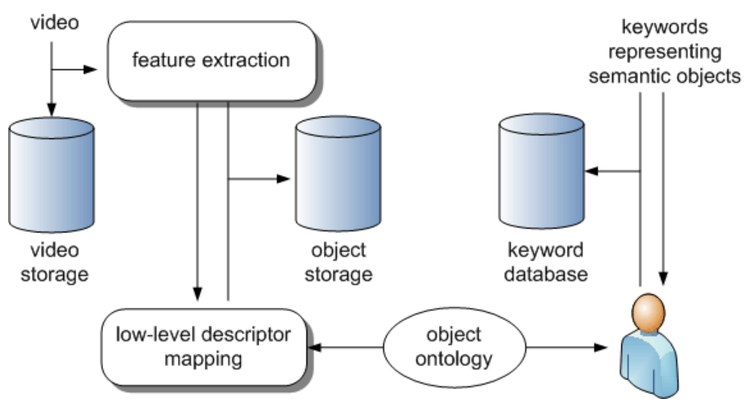


➔ **Ulcer Detection**

(1) Color feature
(2) Textural feature



➔**Semantic Model for WCE Video Indexing and Retrieval**



Approach

1. General Feature Extraction (Color Signal)
2. Event Boundary Detection (HFC)
3. Apply Special Features1
4. Event Classification

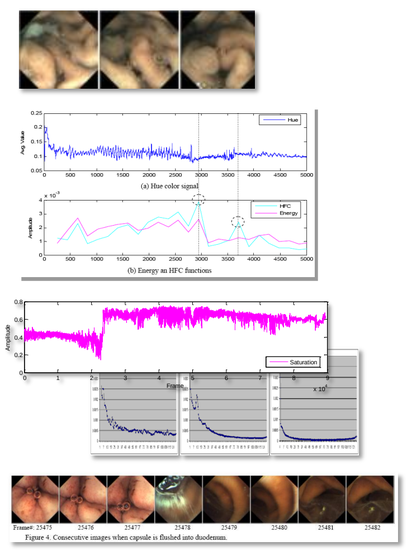
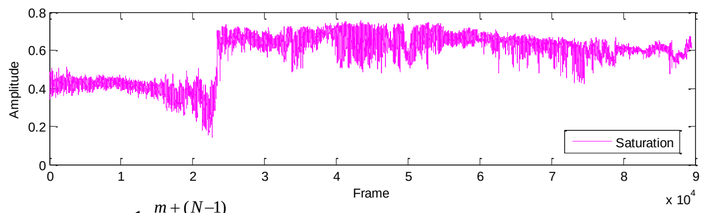


Figure 4. Consecutive images when capsule is flushed into duodenum.

Special Features

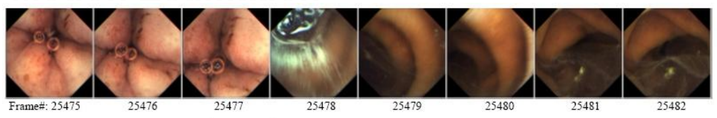
Event 1: Entering Small Intestine

(1) Raising of Average Saturation Values



$$MS_i = \frac{1}{N} \sum_{i=m}^{m+(N-1)} AvgSat_i$$

(2) Motion Estimation

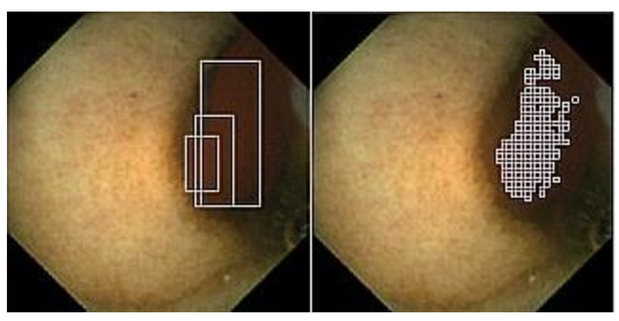


$$MAD(dx,dy) = \frac{1}{m \times n} \times \sum_{i=-\frac{n}{2}}^{\frac{n}{2}} \sum_{i=-\frac{m}{2}}^{\frac{m}{2}} \left| F(i,j) - G(i+dx, j+dy) \right|$$

$$Distance(P_1, P_2) = \sqrt{\left|P_1(x) - P_2(x)\right|^2 + \left|P_1(y) - P_2(y)\right|^2}$$

Event 2: Bleeding Detection

(1) Color-based Segmentation
(2) Cluster-based Approach in Pixel Domain

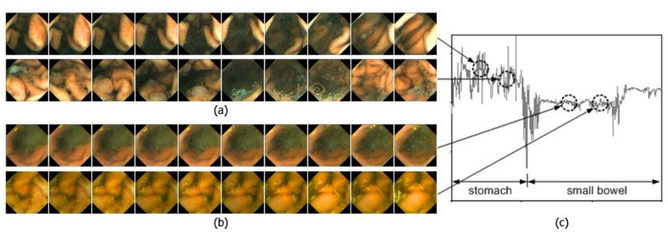


$$BL_i = macro(i) \times 50\% + micro(i) \times 50\%$$

General Feature

Intestinal Contractions

Color signal is used to characterize peristaltic patterns in the different digestive organs.



Multimedia Information Group