Preface

The advancements in the field of Information Technology generates a massive amount of data. This vast data serves as an input to knowledge discovery and machine learning producing unprecedented results leading to trend analysis, classification, prediction, fraud & fault detection, drug discovery, artificial intelligence and many more. One such cutting-edge technology is capsule endoscopy (CE). CE was introduced in the year 2000 by Given Imaging Inc, Israel and it was approved by U.S. food and drug administration (FDA) in the year 2010. CE is a non-invasive, non-sedative, patient-friendly and painless alternative to conventional endoscopy procedure. It provides a comfortable and efficient way to visualize the entire gastrointestinal (GI) tract. The capsule is a swallowable endoscopic device with 11 × 26 mm dimensions and 3.7 g weight that is ingested and propelled by natural peristalsis through the GI tract. The images are captured and transmitted by the capsule on to an external receiver tied on patients' waist. The received video is then analyzed by experts to detect abnormalities of the GI tract. With upper endoscopy and colonoscopy, it is not possible to visualize the entire small intestine. Gradually its wide application in hospitals is seen in the last few years because it can be used to view the entire GI tract without invasiveness, sedation, radiation or air-inflation.

However, CE videos length ranges from 6 to 8 hours, generating 55000 to 60000 frames which makes the analysis time-consuming. Depending on the expertise of the examiner, the examination would take 45 minutes to 2 hours. In addition to a huge number of frames, GI tract appearance, intestinal dynamics and, the need for constant concentration further complicates the diagnostic procedure. Thus, using selective automated features extraction and classification algorithms together formulated as a computer-aided diagnosis (CAD) system and artificial intelligence in health care can be an excellent help for experts and physicians in diagnosing the

abnormalities. A CAD system capable of analyzing and understanding the visual scene will undoubtedly assist the doctor with a precise, fast and accurate diagnosis. After the manual analysis of the CE video, CAD can also provide a second opinion to a gastroenterologist. This study addresses the design and development of various approaches for the CAD system for CE images.

Firstly this thesis summarizes the entire idea of CE since its inception in the year 1964 till now. It shows the origin of the idea, current advancements and future challenges in computer vision and machine learning concerning CE.

Secondly, the study proposes a framework for the restoration and enhancement of CE images while retaining a few important lost components.

Thirdly, the thesis shows a generalized approach for the segmentation of CE images. This technique is generic as it can be used for any normal or abnormal image of CE. Further, the efficacy of the proposed segmentation approach is put to test in the post-processing part where we proposes a feature selection, a fusion of feature method and a classifier to classify amongst four different classes of CE images.

Fourthly, this thesis presents a data reduction and feature selection approach designed for CAD systems for CE. This approach can also be used independently for data reduction and feature selection in any other application.

Finally, this thesis presents a multi-class classification system for automatic abnormality detection in CE using a hybrid model of conventional machine learning and deep learning. The proposed system outperforms both the conventional machine learning system as well as the deep learning-based systems.

The above aspects contribute to the design and development of a generalized framework and they can also be used independently. The study ends with the conclusion of the research and potential future work.