Chapter 9
Computer-Aided Detection of Polyps in CT Colonography by Means of Feature Selection and Massive-Training Support Vector Regression

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ABSTRACT

One of the major challenges in current Computer-Aided Detection (CADe) of polyps in CT Colonography (CTC) is to improve the specificity without sacrificing the sensitivity. If a large number of False Positive (FP) detections of polyps are produced by the scheme, radiologists might lose their confidence in the use of CADe. In this chapter, the authors used a nonlinear regression model operating on image voxels and a nonlinear classification model with extracted image features based on Support Vector Machines (SVMs). They investigated the feasibility of a Support Vector Regression (SVR) in the massive-training framework, and the authors developed a Massive-Training SVR (MTSVR) in order to reduce the long training time associated with the Massive-Training Artificial Neural Network (MTANN) for reduction of FPs in CADe of polyps in CTC. In addition, the authors proposed a feature selection method directly coupled with an SVM classifier to maximize the CADe system performance. They compared the proposed feature selection method with the conventional stepwise feature selection based on Wilks' lambda with a linear discriminant analysis classifier. The FP reduction system based on the proposed feature selection method was able to achieve a 96.0% by-polyp sensitivity with an FP rate of 4.1 per patient. The performance is better than that of the stepwise feature selection based on Wilks' lambda (which yielded the same sensitivity with 18.0 FPs/patient). To test the performance of the proposed MTSVR, the authors compared it with the original MTANN in the distinction between actual polyps and various types of FPs

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in terms of the training time reduction and FP reduction performance. The authors' CTC database consisted of 240 CTC datasets obtained from 120 patients in the supine and prone positions. With MTSVR, they reduced the training time by a factor of 190, while achieving a performance (by-polyp sensitivity of 94.7% with 2.5 FPs/patient) comparable to that of the original MTANN (which has the same sensitivity with 2.6 FPs/patient).

INTRODUCTION

Colorectal cancer is the second leading cause of mortality due to cancer in the United States (Jemal, et al., 2009). Evidence has shown that the risk of colon cancer death could be reduced with early detection and removal of colonic polyps (Winawer, et al., 1997). Fiberoptic (or optical) colonoscopy is considered the gold-standard diagnostic test as it offers direct biopsy or removal of suspicious colonic polyps (Winawer, et al., 1997). However, optical colonoscopy is invasive (i.e., it has risks of complications such as perforation); it is expensive, and it requires a long examination time and creates high patient discomfort. Therefore, medical centers are seeking alternative techniques as population screening tools. CT colonography (CTC), also known as virtual colonoscopy, has been proposed as an alternative, less invasive technique for detecting colorectal neoplasms (Chaoui, Blake, Barish, & Fenlon, 2000; Coin, et al., 1983; Johnson & Dachman, 2000; D. J. Vining, 1997), which requires a lesser examination time and causes less patient discomfort. However, the sensitivity of CTC can be lower for inexperienced readers because there is a long learning curve for CTC reading. This limitation begs for a CADe approach as a "second reader" to assist radiologists in detecting polyps from CTC images (Yoshida & Dachman, 2005).

There has been great interest in the development of automated or semi-automated CADe schemes for the detection of polyps in CTC in the past decade (Gokturk, et al., 2001; Summers, et al., 2001; Summers, et al., 1998; D.J. Vining, Ge, Ahn, & Stelts, 1999; Yoshida & Nappi, 2001). A CADe scheme for polyp detection is typically composed of candidate detection followed by supervised classification. The task of candidate detection is to achieve a high sensitivity in detecting polyps by including as many suspicious lesions as possible. After the polyp candidate detection stage, feature extraction and analysis are performed on the objects detected in CTC. Based on these features, various classifiers have been applied that classify the candidates into polyps and non-polyps so that FP detections can be reduced while a high level of sensitivity is maintained. Linear and quadratic discriminant analysis were used by Yoshida *et al.* (Yoshida & Nappi, 2001), as well as by Jerobko *et al.* (A. Jerebko, Lakare, Cathier, Periaswamy, & Bogoni, 2006), as simple and effective classifiers. Acar *et al.* also applied a linear classifier based on edge-displacement field features (Acar, et al., 2002). Gokturk *et al.* employed a Support Vector Machine (SVM) to distinguish between polyps and normal tissue (Gokturk, et al., 2001). To improve the discriminant ability of SVMs, a committee of SVMs has been proposed to take advantage of combining multiple classifiers (A. K. Jerebko, Malley, Franaszek, & Summers, 2005). Another popular classifier is the Artificial Neural Network (ANN) (A. K. Jerebko, Summers, Malley, Franaszek, & Johnson, 2003). Logistic regression has also been employed for reducing FP detections where features were ordered according to their relevance (van Ravesteijn, et al., 2010). Yao *et al.* employed a topologic height map for FP reduction (Yao, Li, & Summers, 2009). Zhu *et al.* developed two-dimensional projection features for distinction between FP and true-positive (TP) detections (Zhu, et al., 2010). In summary, all of these proposed classifiers operated on extracted geometric, texture, morphologic, and other fea-

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