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Potential of Interpretation-Support System for Liver CT Images

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SUMMARY

For rapidly increasing amount of medical images, it is difficult for radiologist to interpretate the medical images fastly and for sufficient time. We investigated whether liver CT image has good features to be analyzed by computer algorithm. We examed the CT images of liver tumors (Hepatocellular carcinomas; HCCs) and searched any potential morphologic characteristics to be analyzed by computer algorithms. On unenhanced CT, HCCs appeared hypodense After enhancement, most HCCs were hyperdense, and then, as a consequence of rapid washout, HCCs became hypodense compared with the liver parenchyma. Most CT images of HCCs showed synchronous phase-specific morphologic features. We applied various edge detection filters to these images and some filters showed favorable performance in the detection of the edge of liver and HCC. Therefore, theses features seems to be analyzed by computer algorithms effectively.Further studies may be warranted.

Kev Words : Liver, CT, Computer Algorithm, Edge detection filter

1. INTRODUCTION

Hepatocellular carcinoma (HCC) ranks fifth in cancer frequency in the world with an estimated 0.5 to 1 million new cases occurring per year[1] and third as the cause of cancer death in Korea[2]. The number of patients with HCCs is increasing worldwide[3]. Thus, patients in high-risk groups consisting of those with liver cirrhosis and hepatitis B and C undergo routine screening[4]. Although ultrasonography (US) is widely used in screening for HCCs, it has limitations in the detection of small tumors[5]. Computed tomography (CT) is the most commonly used imaging modality in diagnosing liver malignancy (mainly HCC; hepatocellular carcinoma), but it is difficult for radiologists to distinguish true HCCs from small nodular AP shunts in patients with liver cirrhosis[6]. Owing to the development of multidetector CT (MDCT), capability in the imaging diagnosis of liver disease has increased surprisingly[6].

Therefore, the development of interpretation-support system for liver CT is required to help radiologists to avoid overlooking small nodular HCCs and reduce false diagnosis.

In this paper, we present common image features of HCC on CT images and investigate whether the edge detection filters are useful in detecting liver and HCC edges.

2. Diagnosis of HCC

2.1 Characteristics of HCC

The development of HCC from premalignant lesions is reported to occur in stages. The regenerative nodules evolve into dysplastic nodules (low and high grade). These may subsequently develop into early HCCs. The gross appearance of HCC is a direct reflection of the imaging findings. Macroscopically, HCCs are divided into two types; a distinctly nodular type and an indistinctly nodular type[7]. The classic HCC or the distinctly nodular type is seen as a clear nodule with a fibrous capsule and/or fibrous septa. Tumors of the indistinctly nodular type show only a vaguely nodular appearance with indistinct margin[7]. The tumor is usually paler than normal liver parenchyma. In well-differentiated HCCs containing less-differentiated cancerous tissues, a "nodule-in-nodule" appearance is observed. This appearance is not only regarded as a morphological marker but also the radiological marker[7].

2.2 Imaging Diagnosis of HCC

US has been utilized as a screening imaging modality for HCC, but it has some limitations such as operator-dependency, variable resolution, areas of difficult visualization, missing small tumors, etc. Thus, CT has been the most commonly used imaging modality in diagnosing HCC[8-10]]. On unenhanced CT, HCC appears hypodense where it may appear denser relative to the liver parenchyma[11,12]. It may be due to hemorrhage or calcifications. CT evaluation of the liver in a patient with a clinical suspicion of HCC shoud be performed by contrast enhancement. It shows three stages of enhancement; early arterial, late arterial and portal venous phases[13,14].

1) Early Arterial Phase (13-25 s)

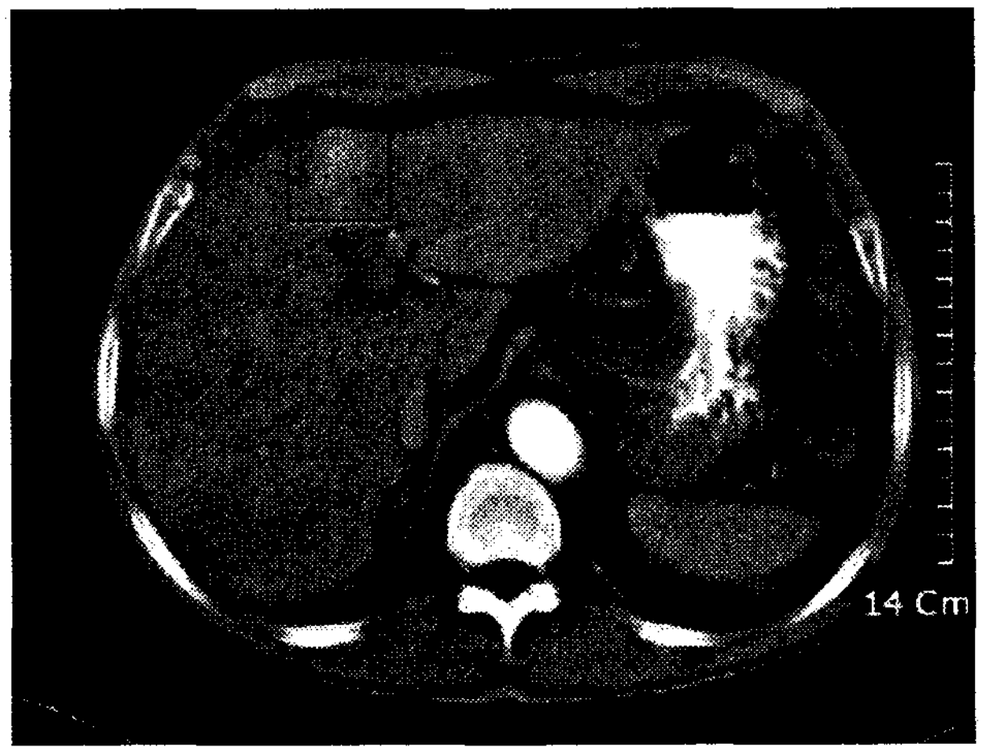
Most HCCs are hyperdense, some may be isodense or hypodense compared with the liver.

2) Late Arterial Phase (30-40 s)

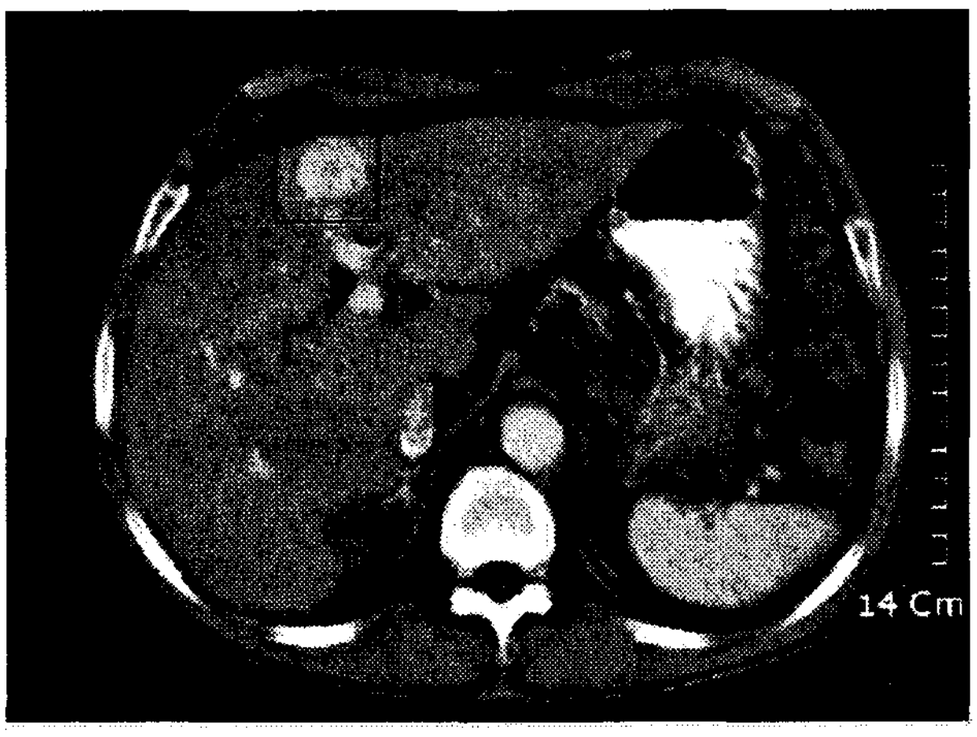
Most HCCs shows progressive enhancement.

3) Portal Venous Phase (45-60 s)

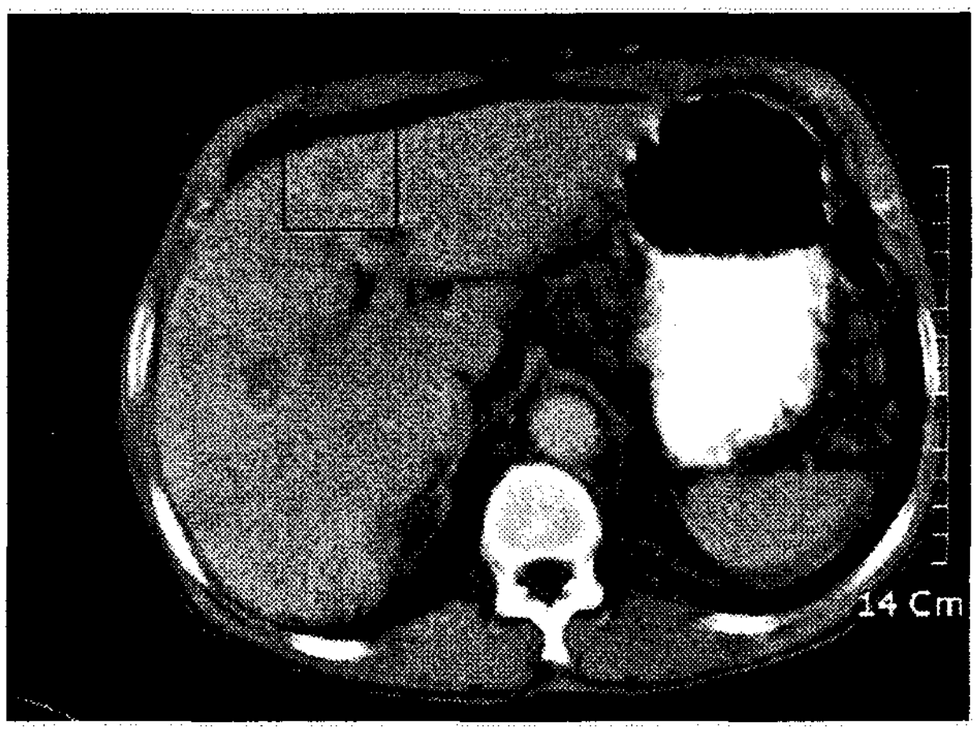
As a consequence of rapid washout, HCCs become hypodense compared with the liver parenchyma.



a) Early Arterial Phase



b) Late Arterial Phase



c) Portal Venous Phase

Fig. 1. Typical CT images of HCC with 3 phases of

3. METHODOLOGY

3.1. Enhanced CT

Triple phase CT was performed on a subsecond helical CT scanner(Somatom plus 4, Siemens, Erlangen, Germany). We reviewed enhanced CT images of 7 patients with HCCs and evaluate enhancement pattern of the images visually.

3.2. Application of Edge-Detection Filters

We applied five edge-detection filters to the liver CT images (Visual C++ 6.0) - Sobel, Prewitt, Robert, Laplacian and Canny filters. Processed images were evaluated visually.

4. RESULTS

4.1 CT Image Analysis

Five of 7 CT images of HCCs demonstrated typical enhancement pattern of 3 phases. Two of 7 CT images of HCCs showed delayed enhancement pattern in the early arterial and late arterial phases.

contrast enhancement

4.2 Edge-Detection Filters

From the results of CT images with enhancement, we decided to apply edge-detection filters to the5 CT images of early arterial phase showing typical arterial enhancing pattern of HCC. CT imafes after filtering process were showed as followings.

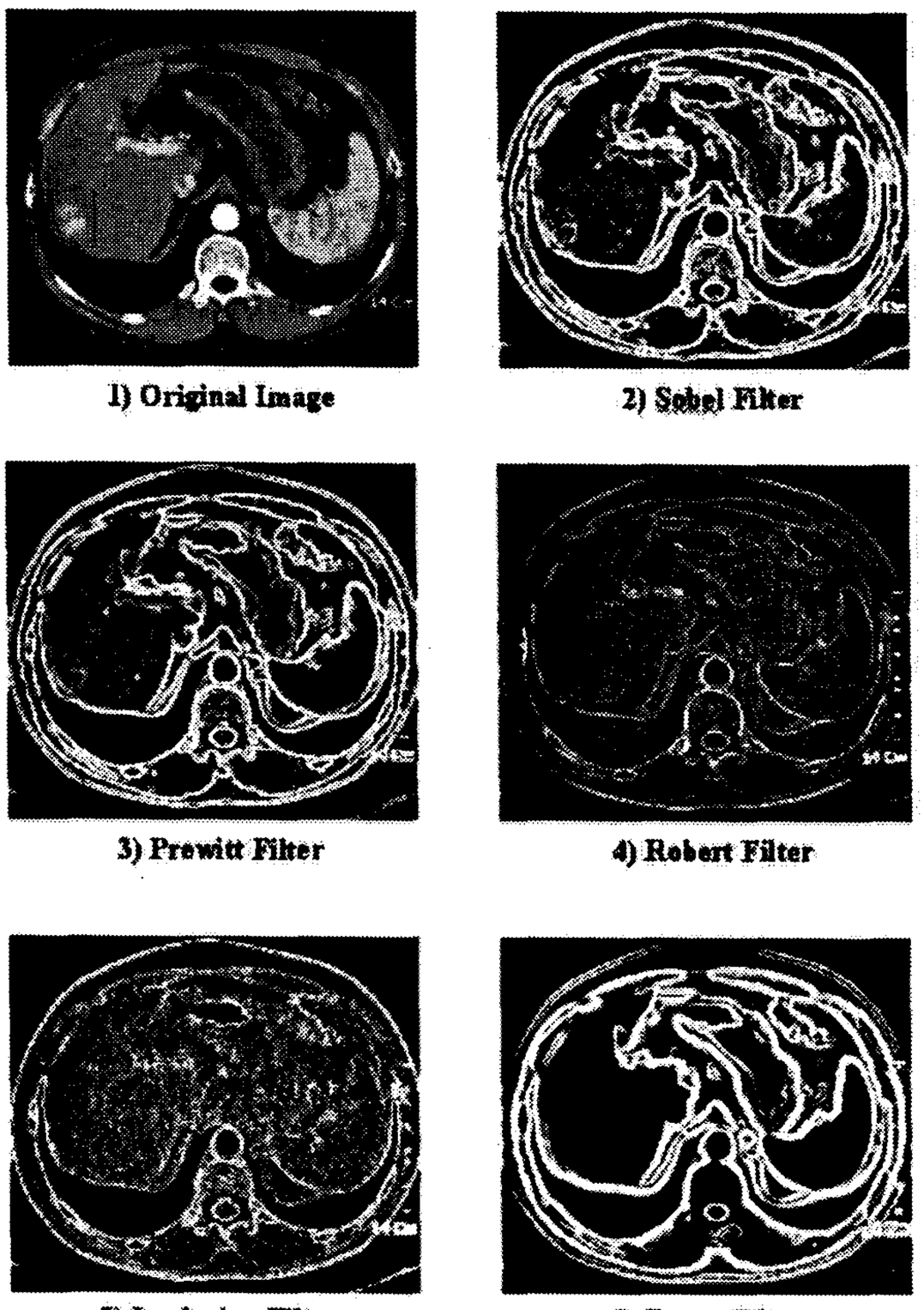


Fig. 2. The CT images of liver before and after applying various edge-detection filter

Sobel and Prewitt filters detected all edges of 5 CT images of HCCs, but Robert and Canny detected only one. Laplacian did not succeed in any cases. Therefore, Sobel and Prewitt showed better edge detection performance than other filters. Canny filter usually showed more definite liver edges.

5. Conclusion

Contrast-enhanced CT shows good performance in detecting HCCs. However, some HCCs are difficult to detect due to small size, etc. Some edge-detection filters showed favorable performance in the detection of the edge of liver and HCC. Therefore, computer-assisted tool is needed to raise detectability of HCCs on CT images.

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