Abstract. This study evaluates the performance of a new generation algorithm designed to both increase detection sensitivity of cancers and to markedly reduce the false mark rate. In the advanced algorithm, several improvements were implemented. The algorithm for the initial detection of potential mass candidates was upgraded to ignore dense areas that do not represent masses. For the initial detection of potential clusters candidates, the advanced algorithm considers interdependence between various stages of the parametric clusterization process and implements automatic performance optimization. Moreover, the advanced algorithm includes a one-step global classification model, which assigns a score to each candidate lesion, instead of sequential multi-step filtration at various steps of the algorithm. Both the advanced and the previous algorithm were run on 83 malignant cases, with proven pathology, and on 523 normal screening cases that were consecutively culled from 4 clinical sites. The overall sensitivity of the advanced algorithm was 86%, compared to a sensitivity of 84% for the previous one. The false mark (FM) rate per case, decreased from 3.20 for the previous algorithm, to 1.39 for the advanced one. The advanced algorithm reduced both mass FMs and cluster FMs. In conclusion, the new algorithm outperforms the old one with a slight increase in sensitivity and with a substantial reduction in false mark rate for both masses and clusters.

1 Background

CAD algorithms for mammography are designed to detect suspicious findings with a high sensitivity [1]. However, the relatively high sensitivity does not guarantee improved cancer detection in clinical practice, because the radiologist does not accept all CAD prompts due to the relatively large number of false marks generated by the CAD algorithm. The purpose of this study was to investigate a new generation algorithm that was designed to optimize performance by both increasing the detection sensitivity of cancers and markedly reducing the false mark rate.
2 Methods

The advanced, new generation algorithm was designed both to increase the detection sensitivity of malignant findings and to reduce the rate of false marks, compared to the previous algorithm. Eighty-three malignant cases, with proven pathology, and 523 normal screening cases were consecutively culled from 4 clinical sites. A non-blinded radiologist demarcated the biopsy proven finding (Ground Truth) on each view of the 83 malignant cases, using the prospective radiology and pathology reports. The radiologist also recorded the BI-RADS category for all 523 normal cases. The normal cases included 391 (74.8%) negative cases (BI-RADS category 1) and 132 (25.2%) cases with a benign finding (BI-RADS category 2). Both the advanced and the previous algorithms were run on the malignant and the normal cases. The detection marks displayed by the algorithms on each view of the 83 malignant cases, were compared with the Ground Truth, to identify the true detection marks. All the detection marks displayed by the algorithms on the 523 normal cases, were considered false marks. The performance of the two algorithms was compared. The detection sensitivity was evaluated on the 83 malignant cases, while the false marks were analyzed on the 523 normal cases.

2.1 The Detection of Mass Lesions

In the Candidate Generation step, the algorithm performs a very sensitive initial detection process in order to detect the location of any potentially malignant mass, defined as a local density in the breast tissue. As a result, a large number of the generated candidates are actually false marks. In order to eliminate as many as possible candidates that do not represent real masses, most of the candidates need to be filtered out.

In the candidate generation step, the advanced algorithm searches directly for objects with characteristics of masses, while the previous algorithm searched for density peaks that are only possible indicators for the presence of a mass kernel. From the perspective of X-ray attenuation in body tissues, masses are relatively homogeneous objects and the contrast between a mass and its surrounding depends on the tissue type of the background. The advanced algorithm is, therefore, designed to detect homogeneous objects of relevant size and with an appropriate brightness, using a gradient based approach. This method assumes that the brightness of the masses in the mammogram has approximately a Gaussian shape. Such shapes are detected by convoluting the gradient of the image with kernels representing a Gaussian derivative. The process is one-dimensional and is performed in parallel for the X and the Y directions of the image. It has been established that the advanced algorithm for mass candidate generation results in far fewer false candidates. The CAD mark generated by the algorithm for a mass is an ellipse surrounding the mass (figure 1). The size of the mark varies according to the size of the mass.