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Automatic detection of breast cancer mitotic cells based on the combination of textural, statistical and innovative mathematical features

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ABSTRACT

Automatic grading systems based on histopathological slide images are applied to various types of cancers. To date, cancer scientists and researchers have conducted many experiments to find and evaluate new and innovative automatic cancer grading systems to accelerate their therapeutic diagnoses and ultimately to enable more efficient prognoses. The previously proposed automatic or computer-aided systems for breast cancer grading, including specializing mitosis counting, suffer from various shortcomings. The most important one is their low efficiency along with high complexity due to the huge amount of features. In this paper, three types of features with more flexibility and less complexity are employed. These features are: completed local binary pattern (CLBP) as textural features, statistical moment entropy (SME) and stiffness matrix (SM) as a mathematical model which includes geometric, morphometric and shape-based features. In the proposed automatic mitosis detection method, these three types of features are fused with each other. The SM feature comprises of characteristics which are to be extracted for reliable discrimination of mitosis objects from non-mitosis ones. The evaluations are applied over histology datasets A and H provided by the Mitos-ICPR2012 contest sponsors. Employing both a nonlinear radial basis function (RBF) kernel for support vector machine (SVM) and also random forest classifiers, leads to the best efficiencies among the other competitive methods which have been proposed in the past. The results are in the form of F-measure criterion which is a basis for bioinformatics assessments and evaluation.

1. Introduction

Breast cancer (BC) is a pervasive cancers know to predominantly effect females. Its early diagnosis aids physicians to prescribe the necessary treatments or at least know the exact prognosis of the BC. In general, for patients suffering from malignant BC, there are three conventional criteria known as tubule formations, nuclear pleomorphism and the mitotic cells counting. Conventionally pathologists would grade the acquired histopathology slide images based on scores given to each

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of the three named criteria. As a matter of fact, to equalize and universalize such grading, the world health organization (W.H.O.) established a unique standard known as Elston and Ellis or the Nottingham for BC grading. Among the three scoring criteria in the Nottingham standard, the counting of mitotic cells is more difficult than the other two criteria even for professional pathologists. The only instrument which assists pathologists for mitosis counting is the conventional microscope. To count the number of mitotic cells for a BC patient, pathologists select at least 10 high power fields (HPFs) which is equal to 400 magnification ($40\times$) as a standard for mitotic counting. The average number of detected mitoses is used in the related scoring procedure determined in the Nottingham standard. However, one must be aware that mitotic activity is a four phase cell division procedure; there are many other cellular activities which can be mistaken as mitosis. The two most significant ones are apoptotic cells – cells having a normally programed cell death – and hyperchromatic cells – cells which are abnormally irritated and inflated. These types of cellular figures along with some other types like lymphocytes, cytoplasm, blood spots and fatty tissues not only mislead professional and skillful pathologists taking them as mitotic cells but also makes an artificial automatic detection system vulnerable to similar sources of errors. As can be seen from Fig. 1, the volume and in fact the number of non-mitosis candidates is greater than that of mitosis ones even in a determined HPF. On the other side, the mitosis and non-mitosis candidates have many similarities with one another. As has been highlighted earlier, mitotic counting is a tedious, time consuming and complicated activity, and can lead to inter- and intra-observation interferences. Therefore, there is currently an unmet medical need among the biomedical image processing research centers to establish an

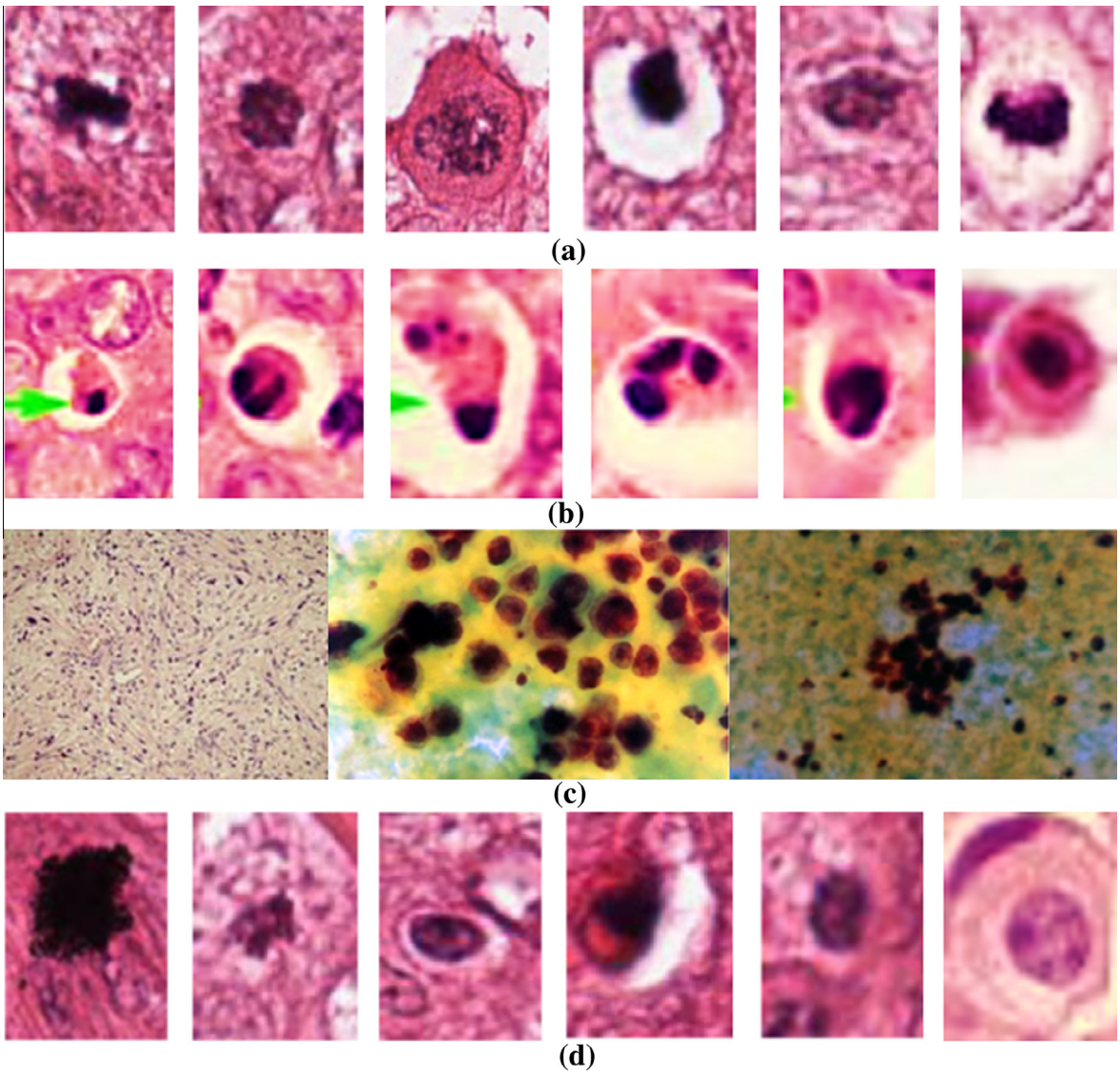

Fig. 1. Some samples of (a) mitosis and (b–d) non-mitosis objects mostly mistaken as mitosis ones and known as: (b) apoptotic cells and (c) hyperchromatic cells and (c) other types of cellular activities like lymphocytes, cytoplasm, etc.