Chapter IV

Support Vector Machine for Recognition of White Blood Cells of Leukaemia

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Abstract

This chapter presents an automatic system for white blood cell recognition in myelogenous leukaemia on the basis of the image of a bone-marrow smear. It addresses the following fundamental problems of this task: the extraction of the individual cell image of the smear; generation of different features of the cell, selection of the best features, and final recognition using an efficient classifier network based on support vector machines. The chapter proposes the complete system solving all these problems, beginning from cell extraction using the watershed algorithm; the generation of different features based on texture, geometry, morphology, and the statistical description of the intensity of the image; feature selection using linear support vector machines; and finally classification by applying Gaussian kernel support vector machines. The results of numerical experiments on the recognition of up to 17 classes of blood cells of myelogenous leukaemia have shown that the proposed system is quite accurate and may find practical application in hospitals in the diagnosis of patients suffering from leukaemia.
Acute myelogenous leukaemia (AML) is a very serious illness caused by the abnormal growth and development of early nongranular white blood cells. It begins with abnormalities in the bone-marrow blast cells that develop to form granulocytes, the white blood cells that contain small particles, or granules. The ML cells do not mature, and they become too numerous in the blood and bone marrow. As the cells build up, they hamper the body’s ability to fight infection and prevent bleeding. Therefore, it is necessary to treat this disease within a short time after making a diagnosis.

The recognition of the cells in the bone marrow of patients suffering from AML, and especially the relative counts of different classes of blood cells in bone marrow, is a very important step in the recognition of the development stage of the illness and proper treatment of the patients (Bennett et al., 1976; Lewandowski & Hellmann, 2001). The percentage contribution of different cells (the so-called myelogram) is a fundamental factor in defining various subtypes of ML (Bennet et al.) and the proper treatment of patients.

Specialists recognize different cell-lines developments in the bone marrow: the erythrocyte, monocyte, lymphocyte, plasma, and granulocytic series (Bennet et al., 1976; Lewandowski & Hellmann, 2001). A lot of different blood-cell types belonging to these lines have been defined up to now by specialists. They differ by the size, texture, shape, density, color, size of the nucleus and cytoplasm, and so forth. The difficulty of cell recognition follows from the fact that there are also large variations among the cells belonging to the same family.

In the numerical experiments concerning feature selection, we have considered up to 17 classes of white blood cells. The considered classes include (a) proerythroblast, (b) basophilic erythroblast, (c) polychromatic erythroblast, (d) ortochromatic (pyknotic) erythroblast, (e) megal erythroblast, (f) myeloblast/monoblast, (g) promyelocyte, (h) neutrophilic myelocyte, (i) neutrophilic metamyelocyte, (j) neutrophilic band, (k) neutrophilic segmented, (l) eosinophils, (m) prolymphocyte, (n) lymphocyte, (o) proplasmocyte, and (p) plasmocyte. To cope with the cells not classified to any of the mentioned above classes, for example, the red blood corpuscles, the scarce cells not belonging to any already defined class, the so-called shadows of the cells deprived of the nucleus, parts of the cut blasts, and so forth, we have created the heterogeneous class denoted as the 17th.

The classes presented above represent different cell lines in the bone marrow as well as different stages of development within the same line. The cell types from 1 to 4 represent the erythrocyte development line. The classes from 6 to 11 form the succeeding stages of the granulocytic line. The classes 13 and 14 are members of the lymphocyte line, while 15 and 16 belong to the plasma line of development.

Table 1 presents four samples of these 17 blood-cell types extracted from the bone marrow. The considered classes represent different cell lines in the bone marrow as well as different stages of development within the same line. There is visible a well-defined nucleus in each cell, and the brighter irregular shape of the cytoplasm. All these images have been obtained as the result of an automatic extraction of the cells from the images of the bone marrow. Observe that the differences among classes are not well defined and it is not easy to recognize between them. Moreover, if we consider the representatives of separate classes, we can observe large differences with regard to the shape, size, and granulites (see, for example, the neutrophilic segmented or neutrophilic band).
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