Localization of u-serrated patterns in direct immunofluorescence images by inhibition-augmented COSFIRE filters

Chenyu Shi[1], Joost M. Meijer[2], Jiapan Guo[1], George Azzopardi[3], Marcel F. Jonkman[2], Nicolai[1] Petkov

[1] Johann Bernoulli Institute for Mathematics and Computer Science, University of Groningen, The Netherlands
[2] Center for Blistering Diseases, Department of Dermatology, University Medical Center Groningen, University of Groningen, Groningen - The Netherlands
[3] Intelligent Computer Systems, University of Malta - Malta

Direct immunofluorescence (DIF) microscopy images are used by clinical doctors and pathologists to differentiate between subtypes of subepidermal autoimmune blistering diseases (sAIBD), such as the most common sAIBD bullous pemphigoid and epidermolysis bullosa acquisita (EBA). It is the reference standard for diagnosis of sAIBD and is used worldwide in medical laboratories. Two types of serrated patterns can be recognized in DIF images, namely n and u-serrated. DIF images that only contain n-serrated patterns indicate common sAIBD while the presence of u-serrated patterns is an indication for EBA. The manual identification of serrated patterns is challenging and experience is needed. We propose an automatic technique that localizes u-serrated patterns to assist and train doctors to diagnose EBA. The proposed method extends the existing trainable COSFIRE approach by adding an inhibition mechanism. A COSFIRE filter with inhibition that we propose is configured by two types of prototype patterns called positive and negative. The resulting filter is exclusively selective for patterns that are similar to the positive prototype used for configuration. In practice, we use a ridge-ending as a positive prototype and various curvatures as negative prototype patterns. We evaluate our approach by applying the configured COSFIRE filter with inhibition to a new data set called NversusU2016. This data set, which we made publicly available, is designed for the serration pattern analysis in DIF images in a variety of samples. Finally, we use the density of the responses of ridge-ending COSFIRE operators as a feature to localize u-serrated patterns. We then provide a reliability score that indicates the reliability of the resulting locations . We achieve an average recognition rate of 82.2% on the eleven subsets of NversusU2016 data set, which is exceeding the manual recognition rate of medical doctors.