41 Land-Based Cloud Classification

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41.1 Introduction

Classification of clouds has remained one of the few essential meteorological observations that have not yet been automatized. Typically, clouds have been detected by means of satellites; a recent study is reported by Visa et al. [1]. The scope in this study [2] was in *land-based* imaging of clouds, data being received by an all-sky imager. The research was initiated by Vaisala Oy, the company manufacturing detectors for weather observations. The emphasis was in developing recognition algorithms based on *visual appearance* of clouds. The hardware implementation was expected to apply visible and infrared domain. Another study involving land-based cloud classification is presented by Buch et al. [3].
In many problems of computer vision, the targets are distinct objects and the major challenge remains in optimizing image formation and in finding powerful features for classification. In our case, both the nature of the target (clouds) and the imaging method (land-based remote sensing) imply a challenging recognition task.

41.2 Basic idea

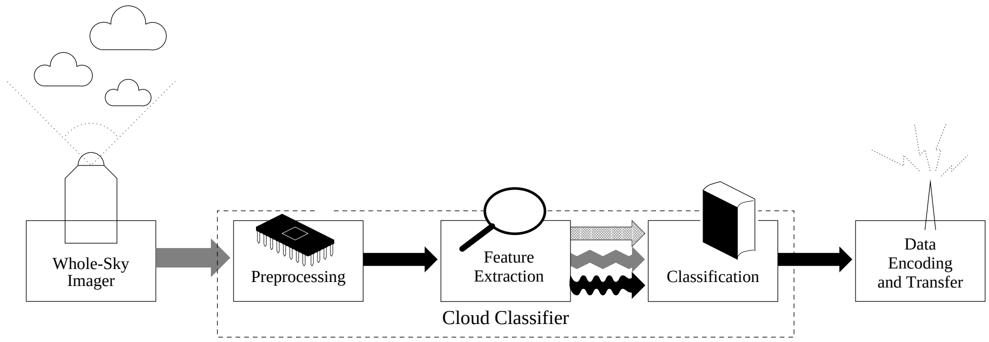

Figure 84: Proposed classification scheme

An outline of a device implementation is shown in Fig. 84. The aim for the classifier is to distinguish between thirteen target classes: ten cloud genera, fog, sun or clear sky. The elementary features are calculations between graylevels of neighboring pixels. These features are designed to indicate sharpness of cloud edges, fibrousness and specks of different size.
Typically, central parts of clouds belonging to different genera resemble each other by having similarly smooth appearance. In practice, this means that *classification at edges, being the most reliable, should be utilized in classifying the whole patch of a cloud*. That is, a cloud is seen as a fuzzy aggregate of segments containing some of the possible texture types of the respective genus. This principle was applied in the classification algorithm by propagating edge information to central areas of clouds.
In order to obtain a primary evaluation of the performance of the feature set, *Self-Organizing Map* [4] was applied. A small but comprehensive set of cloud images

was used as source data for the map shown in Fig. 85. The labels indicate classes of interest, cloud genera being subdivided to specks (S), edges (E), bulk (B) and gaps (G). The organization of the labels indicates some consistent clusters. The map verifies the intuitive assumption that different genera have visually similar details. Moreover, the intra-genus differences seem to be greater.
The smooth classes sun and sky occupy the center of the map, whereas specks, edges and other classes with pronounced graylevel variations are organized at the edges of the map. Precipitative clouds form an own cluster at the right edge of the map. The distinct cluster in the bottom refers to oddities in the applied imagery: branches of trees, street lamps etc.

41.3 Classification

For meteorological purposes, the required spatial resolution for the classification is much lower than the one of the source image. In addition, the subclasses of clouds (edges, specks, bulk, gaps) are of little interest and should be recombined to form integral specks of clouds. After pixelwise classification the image is divided to inner and outer areas in eight directions, resulting in total of 16 sectors. Each sector is labelled to the class having the largest amount of occurrences.
Two source images are shown in the top of Fig. 86. The final classification is shown in the bottom. Both images contain misclassified sectors. The errors are often logical: visual appearances of different cloud genera are known to be confusing in practice. According to the experience obtained in this study, clouds, despite their physically complex nature, seem to be interpretable by means of image processing. Of course, performance of classification would be improved if altitude measurements were available. Nevertheless, this study can and should be seen as an indication of classification power when applying *visual information only*. It must be kept in mind that cloud classification is problematic also to human observers because no exact definitions exist for a cloud or cloud genera. Consequently, the results of the study can be considered promising.

References

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[4] T. Kohonen. The Self-Organizing Map. *Proceedings of the IEEE*, 78(9):1464-1480, 1990.

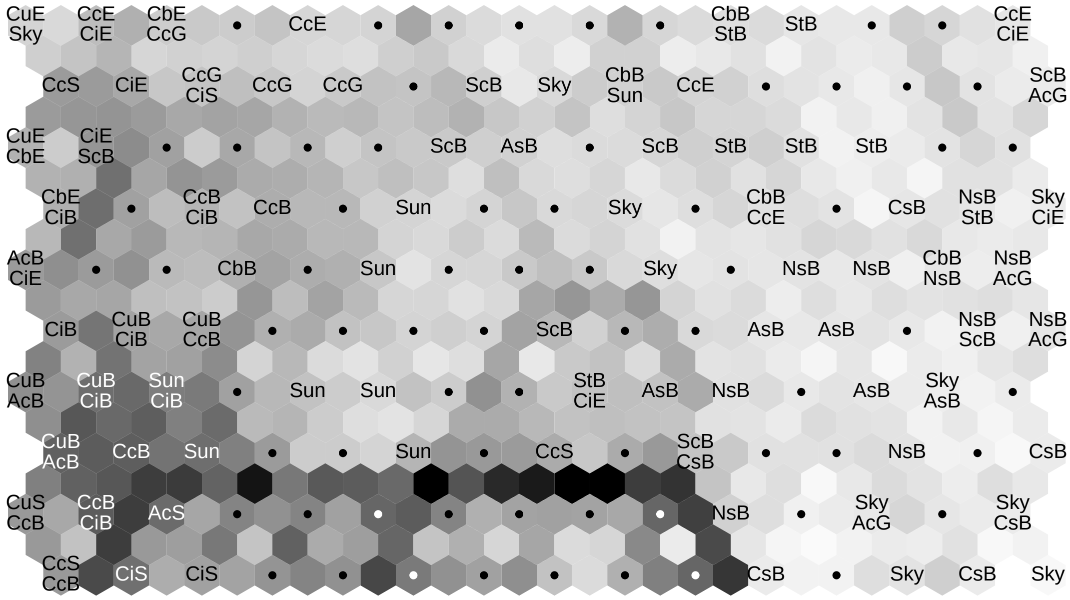

Figure 85: Class clusters on the Self-Organizing Map

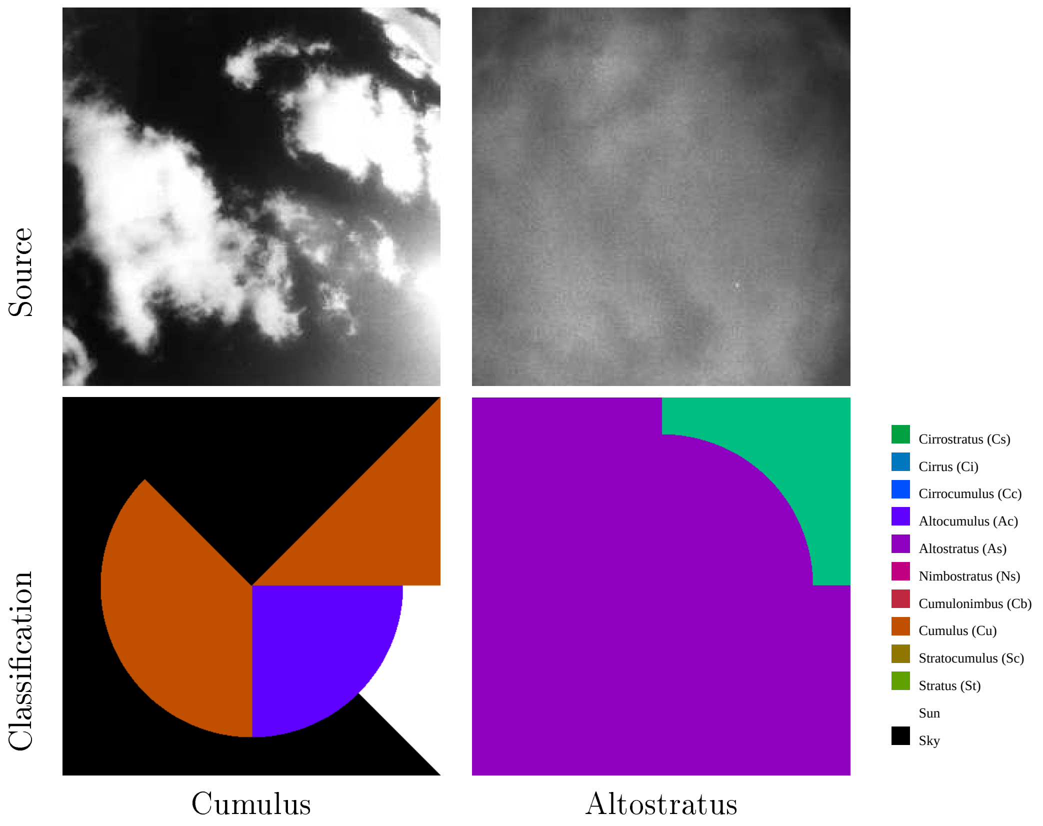

Figure 86: Raw all-sky images and classifications