Introduction

Hyperspectral images are three-dimensional data arrays that include spatial information about an object, supplemented with spectral information for each spatial coordinate. Currently, processing and analysis of hyperspectral images are popular research topics in the field of image processing and computer vision. Within the framework of this article, the technology of applying the method of searching for informative features of a hyperspectral image for the clustering problem, on the example of a separate area, is considered.

Formulation of the problem

The entire course of work can be conditionally divided into sequentially performed stages. At the first stage, using the preprocessing module, a small area, which is used for research and processing, is allocated. Further, a set of all two-dimensional sections by planes is selected from the hypercube of the researched area. This stage is necessary because in advance it is not possible to say which layers are significant, and also because the use of existing methods and means of features calculating is difficult for the considered hyperspectral images.

To study and process the sections obtained above, it was decided to use the well-established MaZda software, which allows calculating various groups of features, as well as the high-level Python programming language. As a result of the work of this software product, we obtain a set of texture and brightness features, which will be used in the future.

The studied images may contain a significant amount of noise components, and it is necessary to perform processing to smooth them out. Further, by explicitly setting the number of clusters, it is possible to separate the data under study, thus obtaining data sets (features) for training, grouped according to certain criteria.

The resulting feature sets are large in size and contain data that may not carry meaningful information that is important in classification. Due to this, it is necessary to reduce the dimension and search for signs that are informative.

Various algorithms can be used to search for informative features. In this framework of the work, the method of sequential addition of features was used. Further, using various classification algorithms (LDA, SVM), it is possible to classify the received data.

Practical research and software implementation

As initial data, a set of hyperspectral images of plant leaves was considered, with the number of spectral channels 242 and wavelengths from 436 nm to 965 nm. This set contained images of various classes of crops, such as: tomato, pepper, cabbage, carrot and others.

To research the algorithm described above, small areas of 10 × 10 pixels in size were cut out from the original image using a preprocessing module implemented in Python. The resulting new set of images is divided into training and test sets used in further research.

Next, using the same module, the resulting image hypercube - an array of brightnesses - was divided into two-dimensional ones for each pair of coordinates, and the resulting hypercube sections were used to further obtain a set of features, both brightness and texture, extracted using the MaZda software. Aggregating together the obtained features, we receive a set of aggregate features that characterize each image under consideration.

For the studied small areas of the image, the number of total brightness and texture features is 86878 features (24200 brightness features + 62678 texture features) for each image.

After this stage, it is necessary to reduce the dimension of the feature space due to the fact that calculations for all available features can take a lot of time and consume significant computing resources. To reduce the dimension in this work, we used the method which consists of the joint use of linear discriminant and correlation analysis. To search for informative features, the method of sequential addition of features was used.

As a result of using this approach, it was possible to reduce the dimension of the feature space under consideration from 86878 to 39, that is, by more than 2000 times.

Further, various classification algorithms were applied to the obtained data: LDA, SVM Logistic Regression, K-Nearest Neighbors - in order to select the algorithm with the highest classification accuracy. To assess the quality of classification, this paper proposes to use a measure equal to the ratio of the number of incorrectly classified objects to the total number of classified objects.

As a result, we obtain a hyperspectral image processing pattern that has lower resource requirements compared to classical methods. It can also be assumed that the use of this pattern may allow it to be used for various purposes in the field of image analysis, for example, when analyzing on mobile devices or unmanned aerial vehicles or drones.

Conclusion

Finding features that uniquely determine whether objects (image areas) belong to a certain class is one of the most important tasks of image classification and processing. Existing methods of image processing, determination of their features and classification algorithms work well with relatively small amounts of initial data. The calculations described in this paper were relatively small and were performed on a personal computer. Processing large arrays of source images takes considerable time and computational resources.

Currently, work is underway to study the possibility of constructing an algorithm that can much more efficiently cope with the task of searching for informative features of areas of hyperspectral images and their classification, while maintaining the accuracy of these processes.

The results obtained in this work can be used to develop tools for the intellectual analysis of hyperspectral images of various areas of human life and activity. For example, in agriculture, examining images taken from fields occupied by certain crops, one can find those that are weedy or that are different from those growing originally. Also, when compiling forest maps, it is possible to determine the composition of forests by hyperspectral images of their surface.