# Atmospheric correction of satellite images using a neural network

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Atmospheric correction of Earth remote sensing data is one of the most important stages of their preliminary processing. The differences between the solar radiation reflected from the surface and the true one detected on board the spacecraft depend on many factors: the angle of declination of the sun, the position and angle of the survey of the spacecraft, the composition and humidity of the atmosphere, etc.

Often space images are processed without atmospheric correction. The implementation of such a correction makes it possible to obtain more reliable results, especially those based on the calculation of vegetation indices, since the influence of the atmosphere distorts the spectral ranges used to calculate the indices. In addition, atmospheric correction also improves the spatial definition of objects and boundaries.

Currently, data from most satellites are in the public domain, but only a small part of them represent data with previous atmospheric correction. As a rule, users who have access to the data of one or another satellite can perform atmospheric correction of the necessary data using the appropriate application programs. However, this processing is carried out interactively for each image of a specific area.

Data from most satellites are multispectral images of the earth's surface. In this work, multispectral survey data from the Sentinel-2 satellites are used. These satellites provide images in 13 spectral bands from optical to far infrared. This data is freely available on the Copernicus Open Access Hub. Access to this data is carried out through one or another service of access hubs.

Sentinel-2 images are available in several processing options. In this work, images of two processing levels are used - L1C and L2A.

The result of the L1C processing level is raw satellite images that provide maximum reflectivity without atmospheric influences. At this level, geometric correction of the observed scene is also carried out.

L2A processing level images are the result of atmospheric correction, taking into account the parameters of the imaging system and solar radiation at the time of shooting.

As a rule, users who have access only to the L1C level data of one or another satellite can carry out atmospheric correction of the necessary data using the appropriate application programs. For Sentinel-2 satellites, the correction is carried out using the Sen2Cor program. However, this processing is carried out interactively for each image of a specific area.

Images without atmospheric correction - level L1C and with atmospheric correction - level L2A

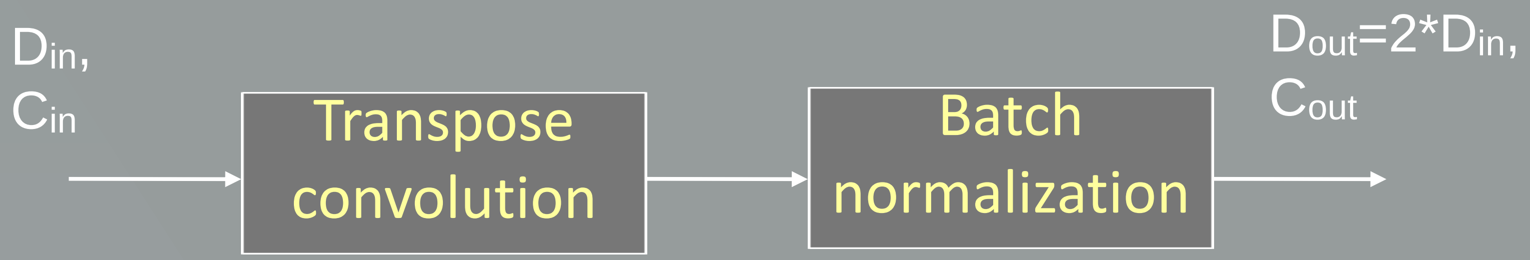
Level L1C

Level L2A

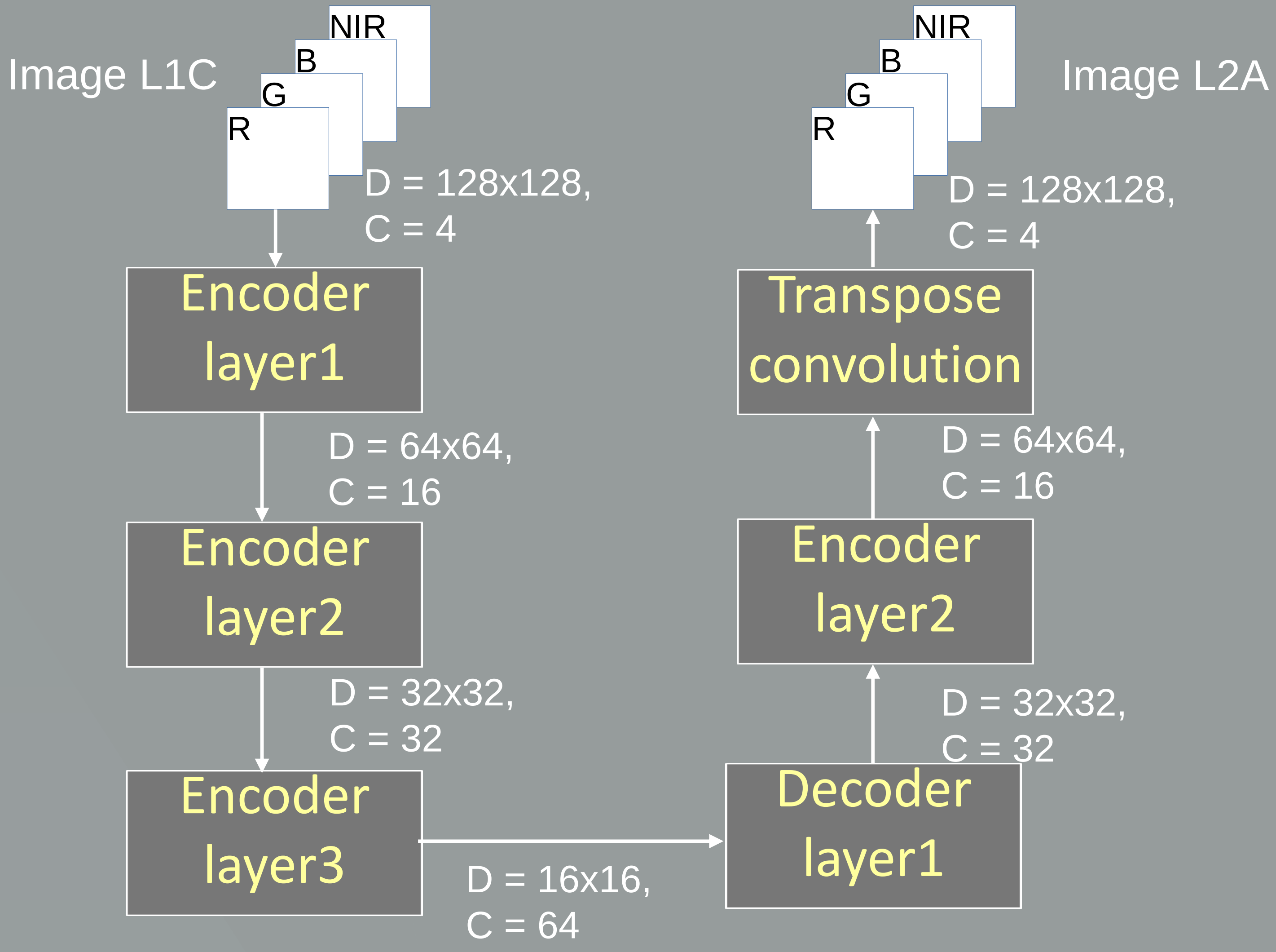
All application programs for atmospheric correction are based on models of the passage of light through the atmosphere and its reflection from the earth's surface and calculate the so-called spectral radiance factor. Such a calculation requires many parameters depending on the shooting conditions, as well as atmospheric parameters. Direct access to these parameters for "raw" images received from satellites, as a rule, is not provided.

We propose to use a fairly simple convolutional neural network for atmospheric correction. The input of this network receives images without atmospheric correction, and the result of its work will be images with atmospheric correction.
The most appropriate network architecture for such a transformation is the encoder - decoder architecture.


Encoder Layer

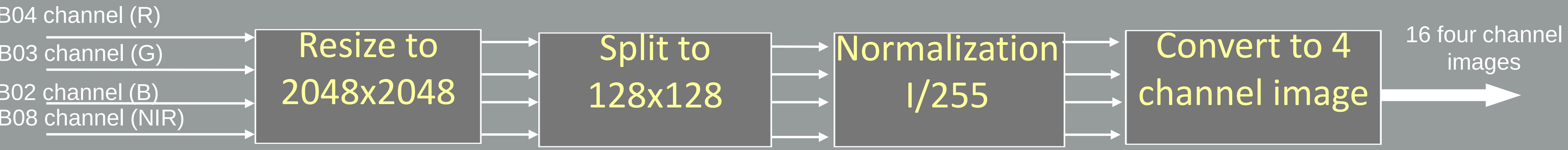



Decoder Layer




The proposed architecture consists of only 3 encoder layers and 3 decoder layers. To reduce the computational complexity, the source images are divided into parts of 128x128.

# Pre-processing




Network training:

Data obtained from Sentinel Hub for several regions of Central Asia over 3 years

Number of single-band images – 710 for each cannels (710 * 4 channels)

Number of traning 4 channel images - 9088 (568 * 16) for input and output

Number of validation 4 channel images - 1136 (71 *16) for input and output

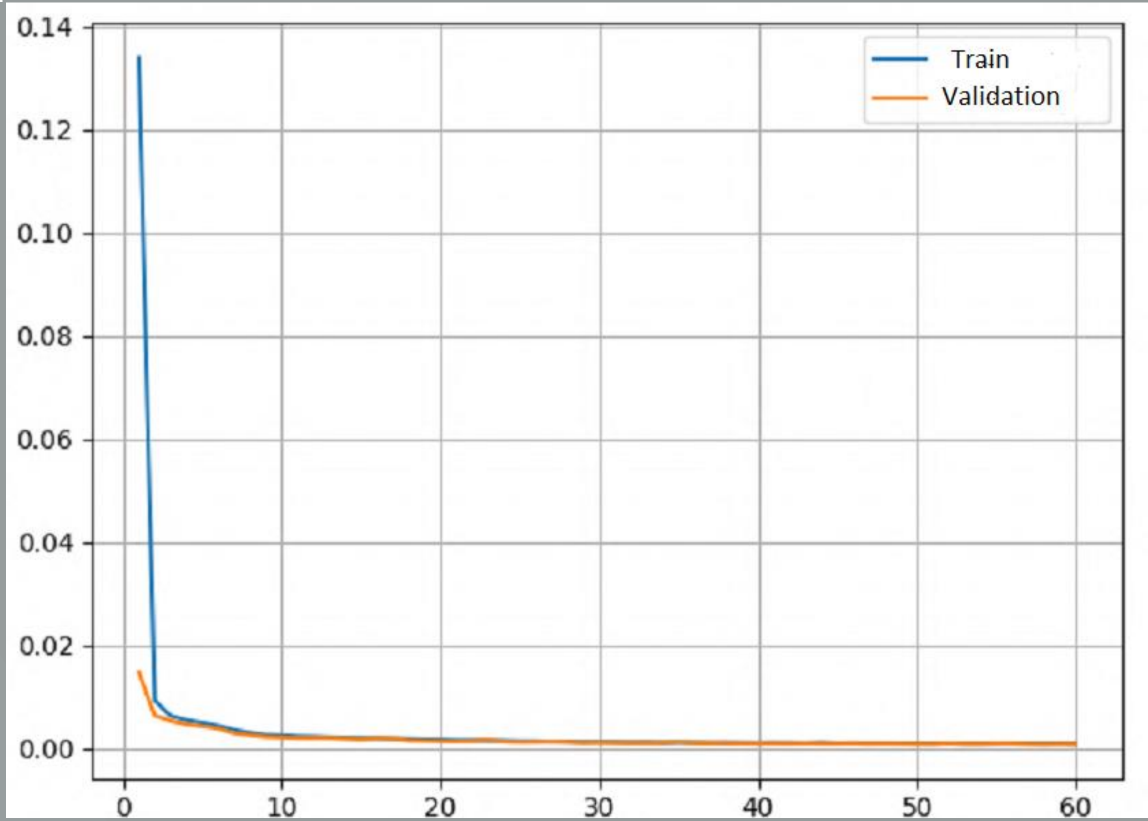
Number of test 4 channel images - 1136 (71*16) for input and output

The most appropriate loss function for network training in this problem is the mean square error MSE

Optimization algorithm - Adam

The learning rate was initially set to 0.001 and then halved when the loss on the validation set stopped decreasing. The training batch size was set to 50 and the number of epochs to 80. The early stopping principle was also used.

Loss

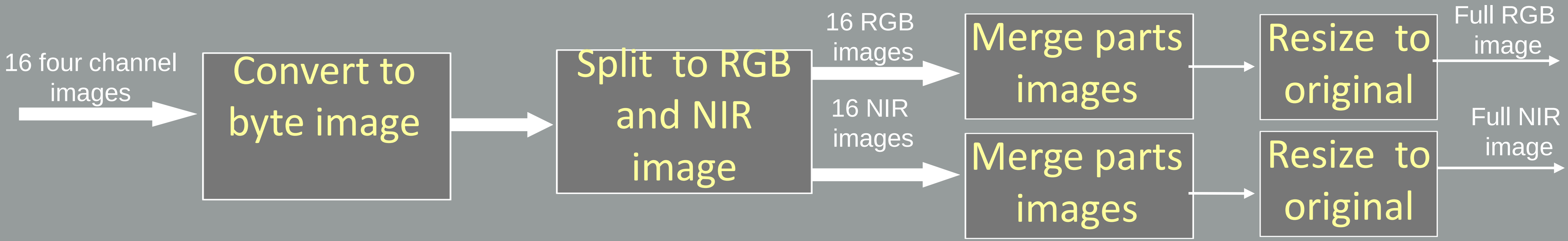


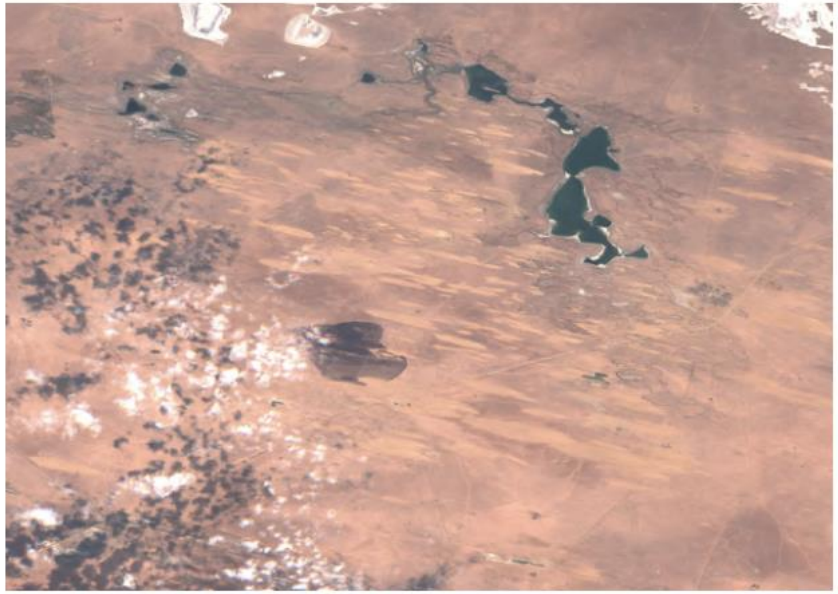

Epoch

The root-mean-square error of the atmospheric correction during training was about 0.1%, and during testing - 0.4%


Parts of the complete image
Part size = 128x128

# Post-processing



Full image L1C

Full image L2A - from network

# Thank you for your attention