Natural numerical network - forward-backward PDE on directed graph

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The main objective of the presentation is to introduce a novel method for PDE-based data classification, in our case, for the classification of Natura 2000 protected habitats using Sentinel-2 satellite optical data. The natural numerical network is based on the numerical solution of the nonlinear forward-backward diffusion equation on a semi-complete directed graph. The forward diffusion averages the values of a diffused quantity, which causes the clustering of graph vertices together. The inverse process of averaging values of diffused quantity is induced by including backward diffusion into the model, which in our case, gives a repulsion of the graph vertices. The forward-backward model is considered on the semi-complete directed graph, which indicates that the diffusion occurs between each vertex, and the direction of diffusion influence depends on the directed edge. The choice of the diffusion coefficient in the partial differential equation leads to the nonlinearity of the model representing a generalisation of the Perona-Malik model from image processing. Partial differential equations on the directed graph are solved by a finite volume approach considering the balance of diffusion fluxes in the vertices of the graph. The presented natural numerical network is applied to classify Natura 2000 habitats from satellite imagery. The areas of protected habitats are semi-automatically or automatically segmented from satellite images, and the statistical characteristics of pixel values in optical bands of the satellite data are calculated and represent the feature space. The vertices of the graph are represented by spatial coordinates of points in the feature space. The natural numerical network controls the classification of the vertices in the directed graph by forward-backward diffusion evolutionary process, and its numerical discretisation represents a novel PDE-based supervised deep learning classification algorithm.