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A novel convolutional neural network for digital soil mapping

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Abstract: Soil texture or particle size fractions (PSF) greatly influence many soil properties like soil hydraulic conductivity and the distribution of water and solutes in the soil profile. Therefore, the knowledge of the vertical and lateral variation in PSF is crucial for agricultural, environmental, and geo-engineering applications. In our current research, we proposed a synergistic use of state-of-the-art machine learning algorithm, namely convolutional neural network (CNN), with equal-area smoothing splines to map PSF lateral and vertical variations down to 2 m depth. Here, we test our approach with soil data from the arid region in Isfahan Province, Iran. We used the different equal-area intervals in one multi-task CNN model to predict the PSF's by using 164 ancillary data. The robustness of the proposed multi-task CNN was evaluated using the conventional layered prediction of a random forest (RF) algorithm. Our results indicated the RMSE values obtained by CNN and RF models increased with soil depth. It could be shown that soil-environmental interactions with ancillary data is strongest in the topsoil layer compared to the results in deeper horizons. Importantly, the results revealed the superiority of CNN relative to RF in all depths for predicting clay, silt, and sand contents and finding the relationships between target and ancillary data when the latter approach was insufficient. Beside this, CNN has the possibility in a multi-task model to address interaction effects of a given depth interval to the others. For instance, the CNN improved prediction accuracies of clay, silt, and sand contents in top soils (0–5 cm) about 22.2%, 13.3%, and 26.4%, respectively, compared to those of RF model. Therefore, the use of CNN as a new toolkit offers a high potential for future digital soil mapping.

Keywords: Convolutional neural networks, random forest, soil texture, digital soil mapping, Iran.

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