River mesohabitat classification from aerial photographs using deep learning

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Compartmentalizing rivers into mesohabitat units is an important part of a hierarchical quantification of river habitat across a range of spatial scales. Mapping mesohabitat via field sampling or hydraulic modelling is however time consuming, so high-resolution remote sensing data are being increasingly utilized. Here we present a system for automated classification of mesohabitat using a deep learning-based classification scheme applied to aerial photographs. We first present a method for automated extraction of the river channel, and also for automated filtering of areas under shadow from bankside trees. We then show how surface flow patterns (smooth / rippled versus standing waves) can be classified in imagery using a trained convolutional neural network created in TensorFlow with the Keras API. We then show how integration of these classified surface flow patterns with information on channel gradient, obtained through airborne NIR-LiDAR data, can be used to classify rivers into mesohabitat units such as deep glides / pools, runs / shallow glides, splashes / rills, and rapids / cascades. Using a regulated salmon river in Norway (the River Nidelva), we show how the mesohabitat classification changes according to flow conditions (dependent upon discharge downstream of a hydropower station), showing the temporally dynamic aspect of mesohabitat. The deep learning approach used here can be customized to provide more detailed information on flow features, such as delineating between broken and unbroken waves, to provide a more refined flow classification, and the classification approach can be further advanced by inclusion of additional remote sensing or hydraulic modelling approaches that provide further information on hydro-morphological features.