Synthesizing Forestry Images Conditioned on Plant Phenotype Using a Generative Adversarial Network

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October 18, 2023

Abstract

Plant phenology and phenotype prediction using remote sensing data is increasingly gaining attention in order to enhance agricultural productivity. This work aims to generate synthetic forestry images that satisfy a specific phenotypic attribute, viz. canopy greenness. We harness a Generative Adversarial Network (GAN) to generate biologically plausible and phenotypically stable forestry images conditioned on the greenness of vegetation over a specific region of interest (describing a particular vegetation type in a mixed forest). The training data is based on the automated digital camera imagery captured by the National Ecological Observatory Network (NEON) and processed by the PhenoCam Network. This method helps render the appearance of forest sites specific to a greenness value. Further, synthetic images are utilized to predict another phenotypic attribute, viz., redness of plants. The Structural SIMilarity (SSIM) index is used to assess the quality of the synthetic images and their greenness and redness indices are compared against that of the original images using Root Mean Squared Error (RMSE) to evaluate the accuracy and integrity. The generalizability and scalability of our proposed GAN model is determined by effectively transforming it to generate synthetic images for other forest sites and vegetation types. From a broader perspective, this technique could be used to visualize forestry based on different phenotypic attributes in the context of various environmental parameters. This work provides a useful step in leveraging generative AI principles from pattern recognition and computer vision for plant phenological research.

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Keywords: Generative Adversarial Network (GAN), synthetic forestry imagery, plant phenology prediction, plant phenotype, canopy greenness (GCC), redness of plants (RCC)