A Novel Framework Using Generative Adversarial Networks (GANs) to Create Land Resource Management Strategy Through Economic-Environmental Payoff Optimization

Banerjee, Sanchali (School: Thomas Jefferson High School for Science and Technology)

This study proposes a generative AI procedure for managing land resources to optimize the payoff between economic and environmental benefit. Randomly selected land usage images in the northeastern United States were obtained from the Multi-Resolution Land Characteristics (MRLC) Consortium, classifying pixels into 16 land classes. Economic and environmental attributes, including GDP, employment, and air quality index, were acquired from the Bureau of Economic Analysis and Environmental Protection Agency. A conditional generative adversarial network (cGAN) performing picture translation (Pix2Pix) was trained to generate land layout images in the following procedure: (1) The generator model produced layout images that were sent to the discriminator model. (2) The economic-environmental payoff was balanced via a custom loss function in the discriminator using a deep neural network. (3) After training, a user-provided aerial image of land was passed to the model; the image was segmented by land type using a U-Net trained on MRLC land maps and Landsat satellite imagery. (4) The model output an optimal land usage layout aligning with geographic constraints of the user's area of interest (ex. water bodies, urbanized regions). The neural network yields an average R^2 of 80.2% across the economic/environmental characteristics, and the U-Net has a pixel classification accuracy of 88.1%. The GAN achieves a Frechet Inception Distance of 10.4, indicating that it successfully generates realistic land layouts comparable to real-world standards. The findings demonstrate a robust framework that recommends the optimal allocation of land resources to sustain economic growth without compromising environmental sustainability.

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