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VEFS: focus-aware dual-spectrum vegetation isolation for rangeland monitoring across rangelands

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Abstract

We present VEFS, a focus-aware framework for isolating the main plant visible in dryland rangeland images. The aim is to extract the individual vegetation specimens which are most clearly in focus from field RGB photographs, even when the scene is visually complex. This remains difficult in rangelands because when plants are often proximally photographed against bright sandy backgrounds, parts of the image may be blurred, and vegetation may include both green, living material and dry components such as stems, litter, and thorns. In such conditions, standard vegetation extraction methods often fail, especially due to spectral overlap and overexposure of sunlight. This lead to the dry plant material looking similar to bare soil.

Our approach combines prompt-based YOLOE instance segmentation with both text and visual guidance and introduces a new scoring system called the Vegetation Ecological Focus Score (VEFS) to identify the main vegetation target in each image. VEFS is defined as $VEFS = \alpha C + \beta S + \gamma T + \delta D$, where C describes how centrally the object appears, S captures whether its shape and structure resemble a shrub, T measures how well green and dry plant parts are grouped together as one coherent object, and D estimates how strongly the object is in focus using image sharpness information. Rather than selecting vegetation only by colour or size, VEFS is designed to choose the plant that is both visually dominant and ecologically meaningful.

The dataset consists of rangeland images collected from Marsabit County, Kenya, and the Kavango region, Namibia, including varied shrub forms, different focus conditions, and diverse dryland backgrounds. Performance will be assessed against largest-object, centre-bias, green-threshold, and default YOLOE baselines using IoU, mIoU, precision, recall, VEFS agreement with expert interpretation, and species-agnostic focus-selection accuracy. We expect VEFS to better preserve dry woody structures, reduce background leakage, and produce more ecologically meaningful masks for applications such as rangeland monitoring, biomass-related assessment, and smart agricultural decision support.

Keywords: Focus-aware segmentation, open-vocabulary AI, photosynthetic and non-photosynthetic heterogeneity, shrub isolation