Article

Assessment of Texture Features for Bermudagrass (*Cynodon dactylon*) Detection in Sugarcane Plantations

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Abstract: Sugarcane products contribute significantly to the Brazilian economy, generating U.S. $12.2 billion in revenue in 2018. Identifying and monitoring factors that induce yield reduction, such as weed occurrence, is thus imperative. The detection of Bermudagrass in sugarcane crops using remote sensing data, however, is a challenge consideringtheir spectral similarity. To overcome this limitation,this paper aims to explore the potential of texture features derived from images acquired by an optical sensor onboard anunmanned aerial vehicle (UAV) to detect Bermudagrass in sugarcane. Aerial images with a spatial resolution of 2cm were acquired from a sugarcane field in Brazil.The Green-Red Vegetation Index and several texture metrics derived from the gray-level co-occurrence matrix were calculated to perform an automatic classification using arandom forest algorithm. Adding texture metrics to the classification process improved the overall accuracy from 83.00% to 92.54%, and this improvement was greater considering larger window sizes, since they representeda texture transition between two targets. Production losses induced by Bermudagrass presence reached 12.1 tons × ha^{-1} in the study site. This study not only demonstrated the capacity of UAV images to overcome the well-known limitation of detecting Bermudagrass in sugarcane crops, but also highlighted the importance of texture for high-accuracy quantification of weed invasion in sugarcane crops.

Table S1. Error matrices for the experiments 1, without texture, and for experiments 2 to 8 (texture with windows ranging from 3x3 to 15x15).

	Reference – without texture						Reference – with texture (3x3 window size)				
	BG	ST	SC	BS	DO		BG	ST	SC	BS	DO
BG	466	0	2	0	291	BG	474	0	12	0	265
ST	0	500	0	4	0	ST	0	500	0	4	0
SC	19	0	498	0	27	SC	16	0	488	0	26
BS	15	0	0	496	67	BS	10	0	0	496	57
DO	0	0	0	0	115	DO	0	0	0	0	152

(Rows labeled "Classified as")

	Reference – with texture (5x5 window size)						Reference – with texture (7x7 window size)				
	BG	ST	SC	BS	DO		BG	ST	SC	BS	DO
BG	468	0	1	0	210	BG	461	0	6	0	192
ST	0	500	1	4	0	ST	0	500	0	4	0
SC	27	0	498	6	5	SC	37	0	494	8	2
BS	5	0	0	490	28	BS	2	0	0	488	35
DO	0	0	0	0	257	DO	0	0	0	0	271

(Rows labeled "Classified as")

	Reference – with texture (9x9 window size)						Reference – with texture (11x11 window size)				
	BG	ST	SC	BS	DO		BG	ST	SC	BS	DO
BG	471	0	1	0	163	BG	473	0	0	0	159
ST	0	500	0	4	0	ST	0	500	0	4	0
SC	28	0	499	8	1	SC	22	0	500	11	1
BS	1	0	0	488	29	BS	5	0	0	485	22
DO	0	0	0	0	307	DO	0	0	0	0	318

(Rows labeled "Classified as")

Reference – with texture	Reference – with texture

		(13x13 window size)							(15x15 window size)				
		BG	ST	SC	BS	DO			BG	ST	SC	BS	DO
Classified as	BG	462	0	3	0	125	Classified as	BG	462	0	3	0	106
	ST	0	500	0	4	0		ST	0	500	0	4	0
	SC	32	0	497	12	5		SC	27	0	497	12	8
	BS	6	0	0	484	18		BS	11	0	0	484	16
	DO	0	0	0	0	352		DO	0	0	0	0	370

BG – Bermudagrass; ST – Straw; SC – Sugarcane; BS – Bare Soil and DO – Dark Objects.