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# Advancing for a better tomorrow

## NIRS Technique for Online Sugar Content Monitoring of Sugarcane on the Elevator Conveyor

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#### PA in Sugarcane

#### Precision Agriculture

A management strategy that uses information technologies to bring data from multiple sources to bear on decisions associated with crop production. (National Research Council, 1997)

Soil Mapping

Crop as a function of land and environment. Spatial and temporal variation considering. Farmers could make better decisions and actions based on information and situations ... and enjoy farming.



https://sydney.edu.au/agriculture/pal/about/what\_is\_precision\_agriculture.shtml





#### **Yield Monitoring**

- PROFIT = (Yield Map AsApplied Map) Other Costs
- Techniques
  - Chopper & elevator power measurement
  - Volumetric measurement
  - Machine Vision
  - Mass measurement







### Yield Map: Enough?

# PROFIT = $\int (Yield Map - AsApplied Map) - Other Cost$ Mass CCS Harvest Scheduling based on

- Yield & maturity
- Yield & CCS





#### **NIRs Concept: What is NIR?**



Source: https://www.khanacademy.org/science/physics/light-waves/introduction-to-light-waves/a/light-and-the-electromagnetic-spectrum





#### **NIR Spectroscopy**











#### Sucrose's NIR Spectrum



- Golic et al. 2003
- http://www.impublications.com/content/introduction-near-infrared-nir-spectroscopy





wavelength, nm

#### **NIRs Applications in Sugarcane**

Wavelength, nm	Measurement mode	Sample form	Prediction accuracy		
NIR (1445 - 2348)			°Brix (R <sup>2</sup> = 0.91)		
	Reflectance	Fibrated	$CCS(R^2 = 0.91)$		
			Fiber content ( $R^2 = 0.89$ )		
			Pol (R <sup>2</sup> = 0.96)		
NIR (1445 - 2348)	Transflectance	Clarified juice	°Brix (R <sup>2</sup> = 0.97)		
			$CCS (R^2 = 0.97)$		
			Pol ( $R^2 = 0.98$ )		
MIR (8000 - 12500)	Reflectance	Raw juice	Pol (R <sup>2</sup> = 0.98)		
NIR (1111 - 2222)	Transmittance	Raw juice	Pol (R <sup>2</sup> = 0.96)		
NIR (1111 - 2500)	Reflectance	Fibrated	Pol ( $R^2$ for the calibration model = 0.93)		
NIR (1100-2500)	Pofloctanco	Fibrated	Pol (R <sup>2</sup> = 0.96)		
	Reflectance		°Brix (R <sup>2</sup> = 0.97)		
			Fiber content ( $R^2 = 0.90$ )		
NIR (1100 - 2500)	Transmittance	Clarified juice	°Brix (R <sup>2</sup> = 0.99)		
			Pol ( $\dot{R}^2 = 0.99$ )		
NIR (1100 - 2498)	Reflectance	Fibrated	Pol (SEP = 0.21%)		
VNIR (600 – 1100)	Transmittance	Stalk	Pol (RMSEP = 1.1% Pol)		

Source: Nawi, et al. (2014). "In-field measurement and sampling technologies for monitoring quality in the sugarcane industry: a review." Precision Agriculture, 15(6), 684–703)





#### **NIRs Applications in Sugarcane**



#### CCS, Pol, °Brix, %Fiber

CCS, Pol, °Brix

Source: Nawi, N.M. (2014). "Development of new measurement methods to determine sugarcane quality from stalk samples." PhD dissertation, University of Southern Queensland





#### **NIRs Applications in Sugarcane**





CCS, Pol, °Brix, %Fiber

(only in full-range NIR)

Pol

Nawi, N.M. (2014)







#### **Our Project**

Motorized Fertilizer Applicator for VRT

Tobse New Holland

1 1

Variation Maps ?





Source: http://manuals.deere.com/omview/OMNW00271\_19/OU92976\_00000A5\_19\_16MAY06\_1.htm





#### The Setup



Schematic of the online measurement system











#### **Experiments**







#### **Results**



Pro Processing	Calibration		Prediction			
Fie-Fiocessing	LVs	R <sup>2</sup>	RMSECV	R <sup>2</sup>	RMSEP	RPD
MA + SNV	4	0.807	0.3	0.785	0.3	2.16

Note: LVs is Latent variables, MA is moving average method, SNV is Standard normal variate.





#### Conclusion

- The NIRS concept could be applied for sensing the sugar content of sugarcane billets on a running elevator conveyor (KK-3 variety).
- More sugarcane varieties and wider range of sugar contents must be covered for a better predictability power.





#### **Future Work**

- Improve acquisition rate and quality
  - Narrower / smaller FOV
  - Smaller gap between probe and samples
  - High efficient filtering techniques
- Include trashes
- Integrate with the yield monitoring system
- Integrate with GNSS for the field variation map
- Introduce CCS (after prototyping)
- Study for simpler indexes (CCS Signature)















