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DETECTING LAND-COVER CHANGE USING MODIS TIME-SERIES DATA

By

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SUMMARY

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University:	University of Pretoria
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Anthropogenic changes to forests, agriculture and hydrology are being driven by a need to provide water, food and shelter to more than six billion people. Unfortunately, these changes have a major impact on hydrology, biodiversity, climate, socio-economic stability and food security. The most pervasive form of land-cover change in South Africa is human settlement expansion. In many cases, new human settlements and settlement expansion are informal and occur in areas that are typically covered by natural vegetation. Settlements are infrequently mapped on an ad-hoc basis in South Africa which makes information on when and where new settlements form very difficult. Determining where and when new informal settlements occur is beneficial from not only an ecological but also a social development standpoint. The objective of this thesis is to make use of coarse resolution satellite data to infer the location of new settlement developments in an automated manner by making use of machine learning methods. The specific sensor that is considered in this thesis is the MODIS sensor on-board the Terra and Aqua satellites. By using samples taken at regular intervals (8 days), a hyper-temporal time-series is constructed and consequently used to detect new human settlement formations in South Africa. Two change detection methods are proposed in this thesis to achieve the goal of automated new settlement development detection using this high-temporal coarse resolution satellite time-series data.

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OPSOMMING

BEPALING VAN LANDELIKE VERANDERING DEUR GEBRUIK TE MAAK VAN MODIS TYDREEKSDATA

deur

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Universiteit:	Universiteit van Pretoria
Graad:	Philosophiae Doctor (Elektronies)
Sleutelwoorde:	autokorrelasie funksie, verandering deteksie, extended Kalman filter, menslike nedersettings, hiper-temporaal, landelike verandering, MODIS, tyds-reeks

Menslike verandering wat ’n invloed het op die natuurlike toestand van woude, landbou en hidrologie word gedryf deur die noodsaakliheid om water, kos en behuising aan meer as 6 biljoen mense te verskaf. Hierdie verandering het ’n geweldige impak op hidrologie, biodiversiteid, klimaat, sosio-ekonomiese stabiliteit en voedselsekuriteit. Die mees algemene landelike verandering in Suid-Afrika is die uitbreiding van menslike nedersettings. Nuwe menslike nedersettings en die uitbreiding hiervan is dikwels informeel en kom voor in areas wat tipies bedek is met natuurlike plantegroei. In Suid-Afrika is dit baie moeilik om informasie te bekom oor waar en waneer nuwe nedersettings voorkom aangesien hierdie informasie nie gereeld opgedateer word nie. Die bepaling van waar en waneer nuwe nedersettings voorkom is voordelig vanuit beide ’n ekologiese sowel as ’n sosiale-ontwikkelings standpunt. Die doel van hierdie proefskrif is om te bepaal waar nuwe nedersettings ontwikkel deur gebruik te maak van medium resolusie sateliet data. Hierdie inligiting kan op ’n outomatiese manier bekom word deur gebruik te maak van masjien-leer metodes. Die data wat gebruik word om die navorsing vir hierdie proefskrif uit te voer is verkry van die MODIS sensor op die Terra en Aqua sateliete. Deur gebruik te maak van observasies wat elke 8 dae beskikbaar is, is ’n hiper-temporale tydreeks saamgestel. Hierdie tydreeks is gebruik om te bepaal waar nuwe menslike nedersettings in Suid-Afrika gevorm het. Twee metodes word voorgestel in hierdie proefskrif om te bepaal waar nuwe nedersettings vorm.

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This thesis is dedicated to:

God Almighty, for all the countless opportunities that He has given me;

My loving family and friends, for their support, encouragement and good advice

Fame and fortune is like the wind, here one day and gone the next;

what is man to do but this: love God and those around you;

this is man's most meaningful pursuit.

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LIST OF ABBREVIATIONS

Autocorrelation Function	ACF
Atmospheric Infrared Sounder	AIRS
Advanced Microwave Scanning Radiometer-EOS	AMSR-E
Advanced Microwave Sounding Unit	AMSU-A
Advanced Space borne Thermal Emission and Reflection Radiometer	ASTER
Algorithm Theoretical Basis Document	ATBD
Bidirectional Reflection Distribution Function	BRDF
Change Vector Analysis	CVA
Clouds and the Earth’s Radiant Energy System	CERES
Discrete Fourier Transform	DFT
Disturbance Index	DI
Extended Kalman Filter	EKF
Earth Resource Satellite	ERTS
European Remote Sensing	ERS
Enhanced Thematic Mapper Plus	ETM+
Enhanced Vegetation Index	EVI
Fast Fourier Transform	FFT
Fraction of Absorbed Photosynthetically Active Radiation	FAPAR
Geographical Information System	GIS
Global Earth Observation System of Systems	GEOSS
Group on Earth Observations	GEO
High-Resolution Visible	HRV
Humidity Sounder for Brazil	HSB
Indian Remote Sensing	IRS
Infrared	IR
Instantaneous Field of View	IFOV

Japanese Earth Resource Satellite	JERS
Low earth orbit	LEO
Multi-angle Imaging SpectroRadiometer	MISR
Measurements of Pollution in the Troposphere	MOPITT
National Land-Cover	NLC
Net Primary Productivity	NPP
Neural Network	NN
Normalized Difference Vegetation Index	NDVI
Photosynthetically Active Radiation	PAR
Point Spread Function	PSF
Principal Component Analysis	PCA
Probability Density Function	PDF
Radiative Transfer Model	RTM
Signal-to-noise Ratio	SNR
Satellite Pour l'Observation de la Terre	SPOT
Support Vector Machine	SVM
Synthetic Aperture Radar	SAR
Television and Infrared Observation Satellite	TIROS
Univariate Image Differencing	UID
United Nations	UN
Ultra Violet	UV
Vegetative Cover Conversion	VCC
Vegetation Index	VI

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