Oil Palm Tree Height Estimation Using InSAR

Chong Khai Loong[1], Kasturi Devi Kanniah[1,2]and Christine Pohl[3]

1 Tropical Map Research Group, Faculty of Geoinformation and Real Estate, UniversitiTeknologi Malaysia.UTM Skudai, 81310 Johor, Malaysia.

2 Centre for Environmental Sustainability and Water Security, Research Institute for Sustainable Environment, UniversitiTeknologi Malaysia, 81310 Skudai, Johor DarulTakzim, Malaysia.

3 Representative Chair Remote Sensing, Institute for Computer Science, University of Osnabrueck. Barbarastr.22b, 49076 Osnabrueck, Germany.

ABSTRACT:

Oil palm is the main agricultural product of Malaysia in which it generates substantial national income. It is important to monitor the growth of oil palm to predict the national oil palm production and to plan for an optimal replanting schedule. Oil palm tree height is a vital parameter that can be related to the growth stage of oil palm. It also can be used in age and biomass estimation as well as crop condition monitoring. With the advent of remote sensing techniques, such important parameter can be effectively derived at large scale at low cost. In this study, we aim to extract oil palm tree height information using interferometric synthetic aperture radar (SAR) data. This technique utilized the phase information collected in two successive data acquisitions, co-registered at sub-pixel level to produce interferograms that show fringes wrapped in modulus two *pi*. These fringeswill then be unwrapped into meaningful height information.Vegetative structures like oil palm protruding from the Earth surface could be measured by using two pieces of height information: the digital surface model and bare earth model. By calculating their difference, an absolute tree height can be identified. In this study, open source SAR data from the European Sentinel-1 (Copernicus satellite mission) was used to derive a digital surface model. The study area is located in Kluang, Malaysia. The digital surface model was produced using a pair of images through a series of processing steps. These include sub-pixel co-registration, interferogram formation, noise filtering, phase unwrapping and phase to height derivation. The preliminary results show that InSARprocessing is not able to proceed due to inherent low coherency found in vegetation and also due to the temporal decorrelation which limits the application of DEM generation in tropical countries.

KEY WORDS: InSAR, Sentinel-1, oil palm, tree height, remote sensing

INTRODUCTION

Oil palm is an essential crop in Malaysia as it makes up major income of agricultural products in the country due to increasing demand for vegetable oil across the world (Corley, 2009). Monitoring of the oil palm is important as a part of efforts in yield prediction and environmental conservation. Oil palm tree height is one of the parameters that can be used to monitor oil palm for age estimation and biomass estimation (Tan et al., 2013).

Oil palm does not stop growing in height, unless limited by natural events, management flaws or human factors. Therefore this growth attribute is very valuable in estimating oil palm age. Corley and Tinker (2008) state that the height of oil palm grows 30 to 60 cm annually throughout its life cycle, depending on the physical condition and hereditary aspect. In practice, this parameter is often overlooked as it is not easy to measure from the ground level. Height information can be retrieved using various approaches of remote sensing, e.g. LiDAR and Interferometry Synthetic Aperture Radar (InSAR). In this research, we used InSAR data to derive oil palm heights.

As an application in remote sensing, InSAR can provide height information in large scale with high accuracy (Woodhouse, 2005).By comparing Digital Surface Model (DSM) against a reference Digital Terrain Model (DTM) which carries bare earth elevation, oil palm tree height can be derived.This technique utilized the phase information collected in two successive acquisitions, co-registered at sub-pixel level to produce interferogram that show fringes that wrapped in modulus two *pi*. These fringes can be unwrapped into meaningful height information. The main objective of this research is to derive oil palm tree height using InSAR technique.

METHODOLOGY

Sentinel-1A satellite provides open source C-band (wavelength: 3.75-7.5 cm) data with global coverage. The data are acquired on repeat-pass mode with a revisit interval of 12 days (6 September & 18 September 2015). The data has the resolution spacing of 2.3 meter (range) x 14.0 meter (azimuth). The data are processed using Sentinel-1 Toolbox (S1TBX) following the standard inteferometric processing procedures (Ferretti *et al*., 2007) as shown in diagram below:

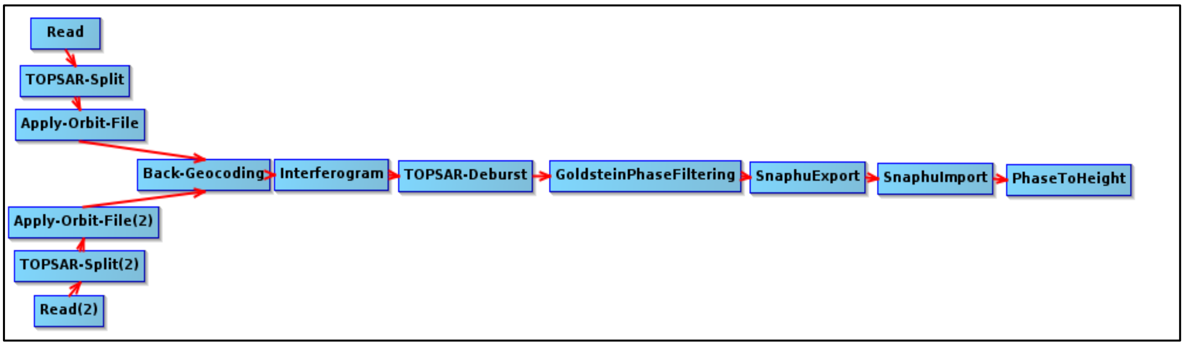

Figure 1: The processing steps of Sentinel-1 Inteferometric Synthetic Aperture Radar application

2 sets of data are selected based on same orbit, incidence angle, polarization etc. but different position (baseline) and acquisition time. In this case they are obtained at 12 days apart. As the original sentinel-1 Single Look Complex (SLC) data comes with 3 subswath, the data were split into individual swath and polarization. Each dataset is registered to its own orbital path using Sentinel-1 precise orbit file before co-registration at sub-pixel level. Interferogram can be formed using phase difference derived from the coregistered images. The value shown consist of ambiguous phase value (unknown number of 2π) which could be solved by phase unwrapping.

As the sensor (Sentinel-1) use TOPSAR mode to retrieve data, the data contain overlapped strips which were removed using “TOPSAR deburst” function. As the process of phase unwrapping consumes a high amount of memories and processing power (especially when the coherence is low), the interferogram has to be subsetted to speed up the process. The interferogram was then unwrapped using Statistical-cost, Network-flow Algorithm for PHase Unwrapping (SNAPHU) by Chen and Zebker (2001). The unwrapped phase is then translated into meaningful height information using phase-to-height function.

<u>Test site</u>

The experiment was carried out in an oil palm research station of Malaysian Palm Oil Board (MPOB), in Kluang, Johor. The plantation covers an area of 486 ha. It consists of oil palms of different growth stages. There’s an urban area near the plantation. The area is relatively flat with slightly undulated terrains.

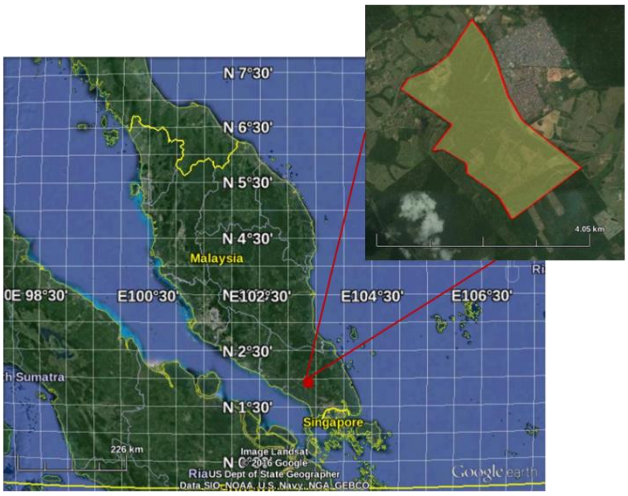

Figure 2: Test site located in Johor, Malaysia.

RESULT AND DISCUSSION

Using the Sentinel-1 data, several products were produced. It was found that the products are not able to produce the intended result. They are explained by comparing several products as shown in figure below (Figure 3).

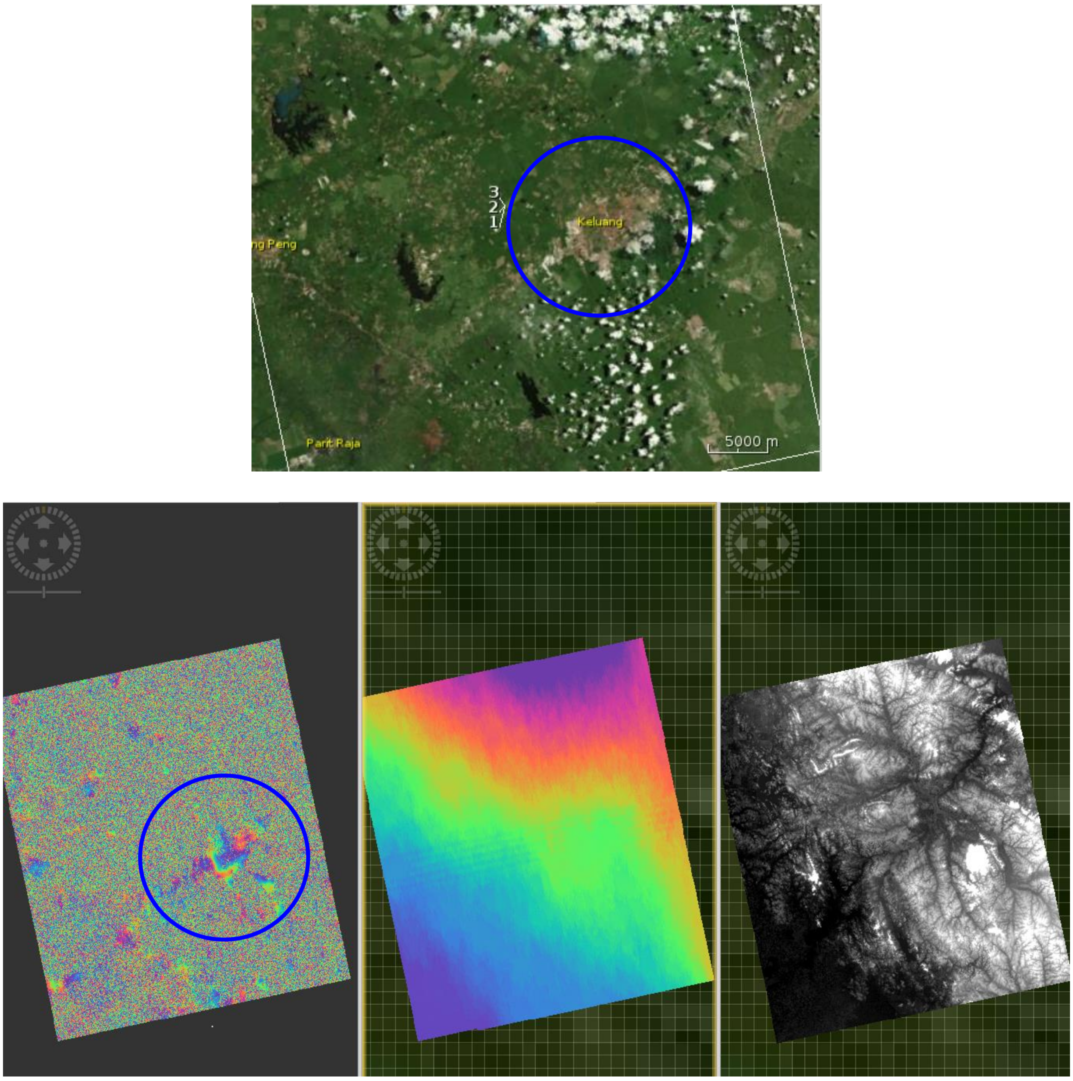

Figure 3: Comparison of different products with synchronized image view. Optical image of the test site from google map (top); Interferogram product (bottom left); Unwrapped phase product (bottom middle); and SRTM 1-arc second elevation product (bottom right).

From the interferogram, it was found that urban area or man-made structures shows some observable fringes due to relatively high coherency (see figure 3, circle in blue). While for vegetated area, no fringes are observed as they consists of signals with low coherence. It was found that the unwrapped phase product shows incomprehensible values, as compared to the SRTM 1-arc second product. Thus, the height value cannot be derived.

The analysis on the distribution of coherence show that low coherency were found throughout the image (<0.2) (see figure 4). This low coherence is mainly caused by temporal decorrelation especially in vegetated areas.

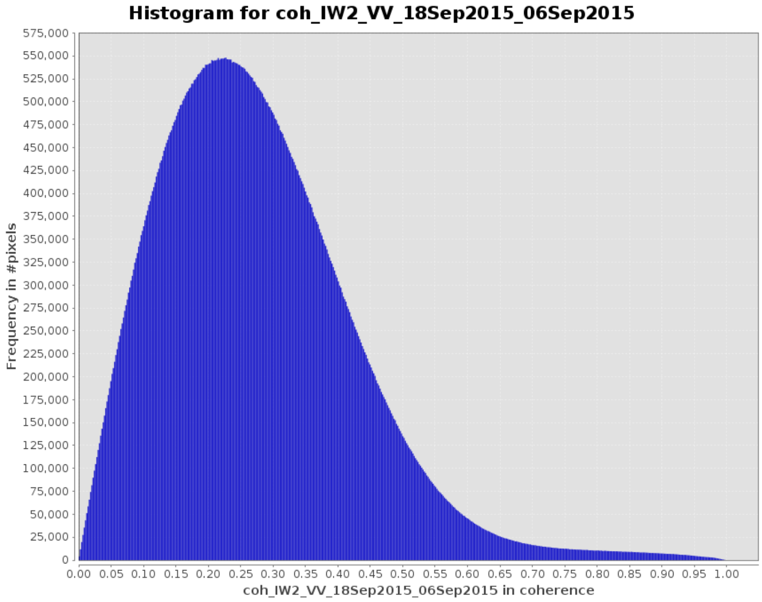

Figure 4: Histogram of the coherence between 2 phase products

The final image derived from Sentinel-1 data yielded poor result due to low coherence in the vegetated area of our test site. The reasons may be:

1. Sentinel-1 operates on C-band, which is highly fluctuated as it interferes strongly with changing vegetation of top layer.
2. Sentinel-1 has a relatively long temporal baseline (12 days minimum).
3. The inherent low coherence on vegetated area couldn't be solved unless applied with single-pass InSAR.

CONCLUSION AND RECOMMENDATION

The estimation of oil palm height using satellite InSAR application is feasible only if there are data with high coherence.Unless with lower temporal baseline, else it is unlikely that it will produce meaningful result. Sentinel-1B launched in April 2016 is undergoing calibration and testing and it will be operational in the mid of September 2016. With this launch, the constellation of Sentinel-1 satellites is complete and the temporal revisit of the image will be greatly shortened (reduced up to 6 days). This will probably be the solution for the current setback.

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