# UNIVERSITI TEKNOLOGI MARA

# DETECTION OF BUILDING FEATURES IN INTERFEROMETRIC SYNTHETIC APERTURE RADAR DATASETS

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# ABSTRACT

Building features are the main components of geospatial data which are constantly required for many applications in this ever changing world. Producing and consistently updating building layers have been the functions of many mapping organisations in the world including Malaysia. In this regard, The Department of Survey and Mapping Malaysia (JUPEM) has faced an uphill task to frequently establish the building layers throughout the country where persistence cloud cover has always been the big issue. An alternative solution would be to utilize Synthetic Aperture Radar Interferometry (InSAR) technology which is widely known to have the penetration capabilities through cloud cover to perform such task. This study investigates the potential of using interferometric SAR datasets products namely unwrapped phase images and digital surface models (DSM) as the main input for building features detection strategy of built up area in Tanjung Malim district, State of Perak in Peninsular Malaysia. The objectives of the research are to improve the method of building features extraction from InSAR dataset by using shape and size of structure elements and to combine the extracted building features with the generated DSM height models to create 3D building model. The last objective is to make an assessment of 3D building features model which are derived from interferometric products with Photogrammetric-based DSM (PhotoDSM) and the digitised vector map data from JUPEM. In the first part, the study adopted commercial off the shelf (COTS) software Erdas Imagine 2011 and Fast Fourier Transformation-based IDL program to obtain digital surface model without the availability of ground control points (GCP) and secondly for building footprint detection, image filtering technique of ENVI and IDL involving convolution and morphological operation were used. Both models were finally combined to form a 3D building model of the study area. It has been found that the generation of DSM is possible with InSAR technique even when the temporal resolution of repeat-pass datasets is large (99 days apart). More importantly, it was found that the baseline distance factor is highly significant in order to produce desirable DSM results and must strictly adhere to ESA guidelines. High level of coherence values between two images that constitute interferometric pairs was found to be insignificant when generating interferometric SAR products. For the 2$^{nd}$ objective, building features detection method using unwrapped phase image has been proposed and tested based on image processing technique of IDL and ENVI. It was found that the detectable buildings masks of different threshold values and the reference digitised vector map from JUPEM have correlation values of more than 0.6 for five tested files. This shows that there is a strong relationship between the size of kernel and shapes with the success rate of detecting building features in unwrapped phase image datasets which needs further analysis in the future. The accuracies of InSAR-based DSM were found to be between 5 to 10 meters for built-up areas and in the region of 10 to 20 meters for areas covered by vegetation and forest. The values were found to be consistent with the values of 1.41 meters for 32 transect locations of buildings in the whole study area. This shows that InSAR-based DSM produces comparatively better building heights than vegetation or forest features heights. Although the results have shown that the potential of detecting buildings by the proposed method is very high and can be further improved with more research on structure elements development, the 3D model was found to be still insufficient to characterize small buildings in built-up areas of urban township like Tanjung Malim.

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# CHAPTER ONE
# INTRODUCTION

## 1.1 BACKGROUND OF STUDY

Building feature elements constitute the major elements in geospatial data and urban maps. Being the dominant features in urban maps presents the biggest challenge due to the rapid change of societal needs and the ever-increasing importance of planning and management. The ability to consistently update building features has therefore become the key indicator on the currentness of urban map.

Even though the usage of building maps today is almost effortless with the state of the art technology such as hand phones or tablets or mobile application devices, the task of acquiring building layer information is apparently not. Prior to gathering attributes on the ground, building information is captured with airborne or satellite-based optical technology for targeted urban area. Aerial photogrammetric technique enables surveyors to perform three dimensional data capture through stereoscopic and monoscopic digitising method. In this regard, building feature elements updating depends on the frequency of aerial photography. Satellite technology offers flexible approaches in acquiring imageries from archive image library or in new planning for data acquisition. Active sensor technology such as Light Detection and Ranging (LiDAR) and Interferometric Synthetic Aperture Radar (InSAR) utilise automated digital signal processing technique to obtain height information but require manual digitising to capture building features.

In short, building layers can only be maintained by acquiring new photographs of the area or by having a ground survey on any particular building in the target area as previously mentioned; or alternatively by using LIDAR technology. Both photogrammetry and LIDAR methods are widely considered up until now as the two most preferred methods to create and update building layers. This is proven by many researches conducted in recent years to produce automation in building digitising, namely by Weidner et al. [54], Weidner [55-56], Niederost [57-59], Baillard [60], Matikainen et al. [61], Champion et al. [62], Eidenbenz et al. [63], Gerke et al. [64], Baltsavias et al. [65], Olsen [66], Vozikis [67-68], Henricsson et al. [69], Koc San et al. [70] and Tao et al. [71]. The listed research that has successfully utilised digital photogrammetric method in the research were very popular due to the increasing ability of digital photogrammetric systems in generating high-resolution Digital Surface Model (DSM).