FUZZY-BASED FROST FILTER FOR SPECKLE NOISE REDUCTION OF SYNTHETIC APERTURE RADAR (SAR) IMAGE

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate regarding scope and quality for the award of the degree of Master of Science in Computer Science.

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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Thesis submitted in fulfillment of the requirements
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LIST OF SYMBOLS

$I_{(t)}$	noise-affected signal
$R_{(t)}$	original image
$v_{(t)}$	speckle noise
$\hat{I}_{(t)}$	mean value of $I_{(t)}$
$\hat{F}_{(t)}$	filtered image
$W_{(t)}$	weighting function
C_B	coefficient variation of noised image
C_B	coefficient variation of noise
k	normalization constant
var	variance
σ'	coefficient of variation
m	column size
n	row size
μ	mean of local neighbour

LIST OF ABBREVIATIONS

ALOS	Advance Land Observation System
ATMAV	Asymmetric Triangular Moving Average
ATMED	Asymmetric Triangular Median Center
AVNIR	Advanced Visible and Near Infrared Radiometer
DN	Digital Number
ENL	Equivalent Number of Looks
ESA	European Space Agency
GIS	Geographical Information System
JAXA	Japan Aerospace Exploration Agency
NRC	National Resource Canada
PALSAR	Phased Array type L-band Synthetic Aperture Radar
PRISM	Panchromatic Remote Sensing Instrument Stereo Mapping
RADAR	Radio Detection and Ranging
RAR	Real Aperture Radar
RS	Remote Sensing
SAR	Synthetic Aperture Radar
SI	Speckle Index
SIC	Satellite Imaging Corporation
TMAV	Symmetric Triangular Moving Average
TMED	Symmetric Triangular Median Center

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ABSTRAK

Imej radar apertur tiruan (SAR) adalah imej beresolusi tinggi dan kurang dipengaruhi oleh keadaan cuaca sama ada waktu siang atau malam berbanding imej optik. Imej SAR, disebabkan kelebihannya, menjadikan ia semakin popular berbanding imej optik dalam kajian cerapan bumi menggunakan teknik penderiaan jauh. Tetapi, hingar bintik yang berlaku dalam imej SAR mengakibatkan kesukaran dalam penafsiran imej dan proses pengurangan hingar bintik menjadi penting sebelum imej SAR digunakan. Penapis hingar bintik yang ideal mempunyai keupayaan dalam mengurangkan hingar bintik tanpa kehilangan maklumat dan memelihara tekstur imej. Kajian ini telah mencadangkan penapis hingar bintik yang hampir menyerupai kriteria-kriteria tersebut. Kajian ini menyiasat prestasi penapis sedia ada, iaitu Frost, Lee, Kuan, dan Median dalam mengurangkan hingar bintik dalam imej ALOS-PALSAR yang mempunyai kawasan-kawasan muka bumi homogen dan heterogen di Kuantan, Pahang, Malaysia. Selepas ditapis, imej keluaran akan diukur dan dinilai mengunakan parameter-parameter kualiti imej bagi memperlihatkan kekuatan penapis-penapis dalam mengurangkan hingar bintik dan memelilara tekstur. Parameter-parameter bagi penilaian prestasi penapis-penapis ialah *Equivalent Number of Looks* (ENL), Indeks Bintik (SI), Min, Sisihan Piawai dan Varian. Hasil kajian menunjukkan penapis Frost adalah yang terbaik dipilih sebagai penapis di dalam penyelidikan ini. Kemudian penapis ini telah diubah suai dengan menggunakan pendekatan kabur. Ia dicadangkan dengan tujuan menyingkirkan hingar bintik sambil memelihara tekstur. Terdapat empat gabungan penapis-penapis dicadangkan, iaitu Frost-ATMAV, Frost-ATMED, Frost-TMAV, dan Frost-TMED. Berdasarkan hasil perbandingan dan penilaian penapis-penapis ini, Frost-TMAV telah dipilih sebagai penapis cadangan terbaik. Ia memperbaiki prestasi penapis-penapis Frost bagi setiap ukuran parameter; dengan nilai pembaikan sebanyak 19.47% bagi ENL, 8.48% bagi SI, 2.56% bagi min, 6.15% bagi sisihan piawai, dan 2.00% bagi varian, apabila diuji dengan imej-imej kawasan homogen ALOS-PALSAR. Manakala apabila digunakannya ke atas kawasan heterogen, ia memperbaiki 9.54% bagi ENL, 4.41% bagi SI, 3.03% bagi min, 1.51% bagi sisihan piawai dan 2.96% bagi varians. Ini mengesahkan bahawa penapis Frost-TMAV boleh digunakan dalam prapemprosesan data ALOR-PALSAR. Ini bermakna penapis ini mempunyai keupayaan dalam menghasilkan imej-imej berkualiti baik berbanding penapis-penapis lain berdasarkan parameter-parameter yang telah dikaji.

ABSTRACT

The Synthetic Aperture Radar (SAR) image is a high-resolution image and is less influenced by weather conditions either day or night compared to the optical image. SAR image, because of its advantages, is becoming more popular than the optical image in the remote sensing area for earth observation study. However, the speckle noise that occurs in the SAR image causes difficulties in image interpretation, and speckle noise reduction process has become necessary before of the usage of SAR image. The ideal speckle filter has the capability of reducing speckle noise without losing the information and preserving its texture. This study proposes the use of speckle noise filter that as nearly possible to meet those criteria. This research has investigated the performance of existing filter, which was Frost, Lee, Kuan, and Median, and had applied it to ALOS-PALSAR images with homogeneous and heterogeneous earth area surfaces in Kuantan, Pahang, Malaysia. Filtered image is measured and evaluated using image quality parameters to show the performance of the filters in reducing speckle noise and preserving the texture. The parameter used for filters evaluation performances are Equivalent Number of Looks (ENL), Speckle Index (SI), Mean, Standard Deviation and Variance. The experiment results showed that Frost filter has better results compared to others and has been selected as the qualified existing filter. The Frost filter was modified by applying the fuzzy approach which was aimed at eliminating speckle noise while maintaining texture. There are four combinations of proposed filter, which are Frost-ATMAV, Frost-ATMED, Frost-TMAV, and Frost-TMED combination. Based on the results of comparison and evaluation of the filters, Frost-TMAV combination has been selected as the best-proposed filter. It had improved the performance of Frost filters for each parameter's measurement; it showed the improvement value of 19.47% for ENL, 8.48% for SI, 2.56% for mean, 6.15% for standard deviation and 2.00% for a variance, applied into homogeneous areas of ALOS-PALSAR images. While when used with heterogeneous areas, it improved 9.54% for ENL, 4.41% for SI, 3.03% for mean, 1.51% for standard deviation and 2.96% for the variance. It has been verified that the Frost-TMAV could be used for ALOS-PALSAR data pre-processing, which means that this filter can produce good-quality images based on parameters used when compared with other filters.

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