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Images Fusion Based On Fuzzy Clustering

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Abstract— Image change detection is a process that analyzes images of the same scene taken at different times in order to identify changes that may have occurred between the considered acquisition dates. With the development of remote sensing technology, change detection in remote sensing images becomes more and more important. Among them, change detection in synthetic aperture radar (SAR) images exhibits some more difficulties than optical ones due to the fact that SAR images suffer from the presence of the speckle noise, so that's why we proposed an unsupervised distribution-free change detection approach for synthetic aperture radar (SAR) images based on an image fusion strategy and a novel fuzzy clustering algorithm. The image fusion technique is introduced to generate a difference image by using complementary information from a mean-ratio image and a log-ratio image. In order to restrain the background information and enhance the information of changed regions in the fused difference image, wavelet fusion rules based on an average operator and minimum local area energy are chosen to fuse the wavelet coefficients for a low-frequency band and a high-frequency band, respectively. A reformulated fuzzy local-information C-means clustering algorithm is proposed for classifying changed and unchanged regions in the fused difference image. It incorporates the information about spatial context in a novel fuzzy way for the purpose of enhancing the changed information and of reducing the effect of speckle noise. Experiments on real SAR images show that the image fusion strategy integrates the advantages of the log-ratio operator and the mean-ratio operator and gains a better performance. The change detection results obtained by the improved fuzzy clustering algorithm exhibited lower error than its preexistences.

Index Terms— RFLICM, MATLAB, KAPPA.

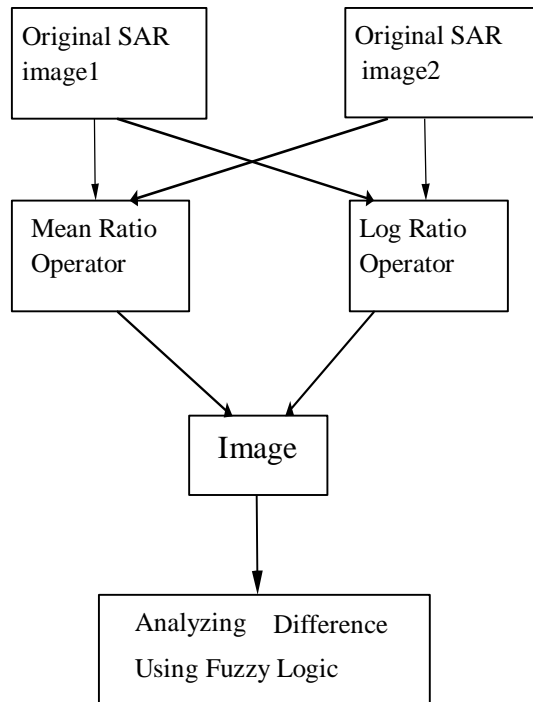
I. INTRODUCTION

In this project first we perform mean ratio and log ratio on two original images and performing DWT based fusion image using fusion rules and apply RFLCM and FLICM techniques on DWT based fusion image and finally compare the results of PCC and kappa values of both techniques. Image change detection is a process that analyzes images of the same scene taken at different times in order to identify changes that may have occurred between the considered acquisition dates. In the last decades, it has attracted widespread interest due to a large number of applications in diverse disciplines such as remote sensing, medical diagnosis and video surveillance. With the development of remote sensing technology, change detection in remote sensing images becomes more and more important. Among them, change detection in synthetic aperture radar (SAR) images exhibits some more difficulties than optical ones due to the fact that SAR images suffer from the presence of the speckle noise. However, SAR sensors are independent of atmospheric and sunlight conditions, which make the change detection in SAR images still attractive.

II. BLOCK DIAGRAM FOR OUR PROJECT

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RFLICM Algorithm Steps:

Step 1) Set the number of the cluster prototypes, fuzzification Parameter m and the stopping condition ϵ .

Step 2) Initialize randomly the fuzzy partition matrix.

Step 3) Set the loop counter $b=0$.

Step 4) Compute the cluster prototypes using (equation 6 in module2).

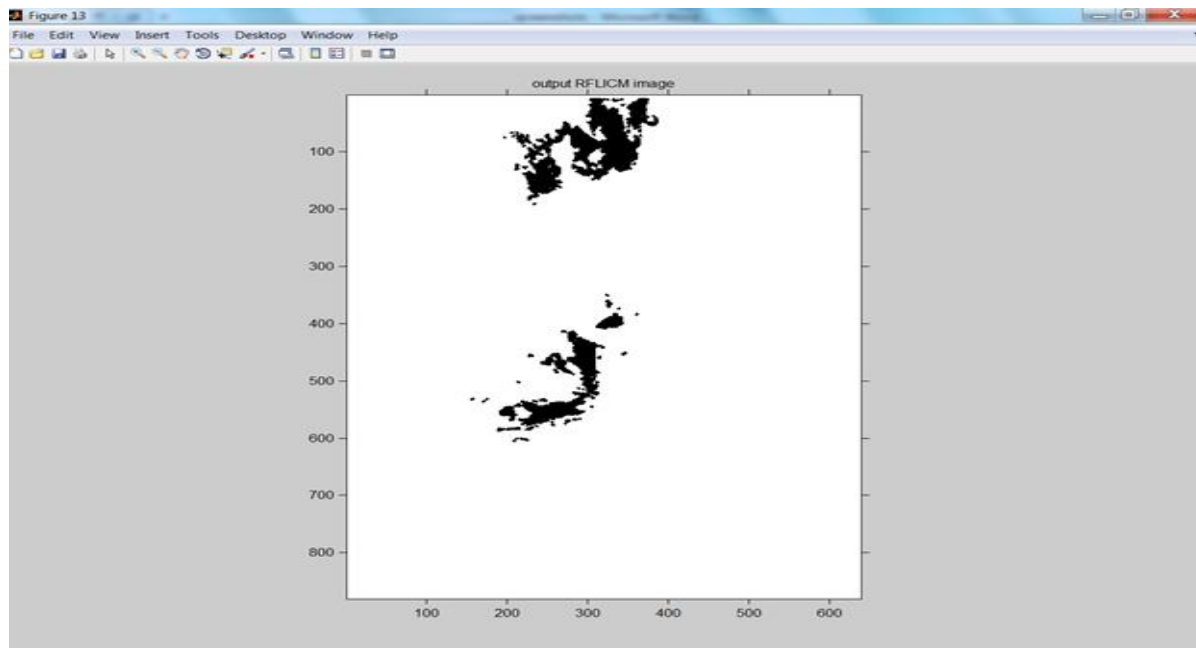
Step 5) Calculate the fuzzy partition matrix using (equation 5 in module2).

Step 6) $\text{Max}(U^{(b)} - U^{(b-1)}) < \epsilon$ stop; **Step 7)** otherwise, set $b=b+1$, and go to step 4.

III. WORKING OPERATION

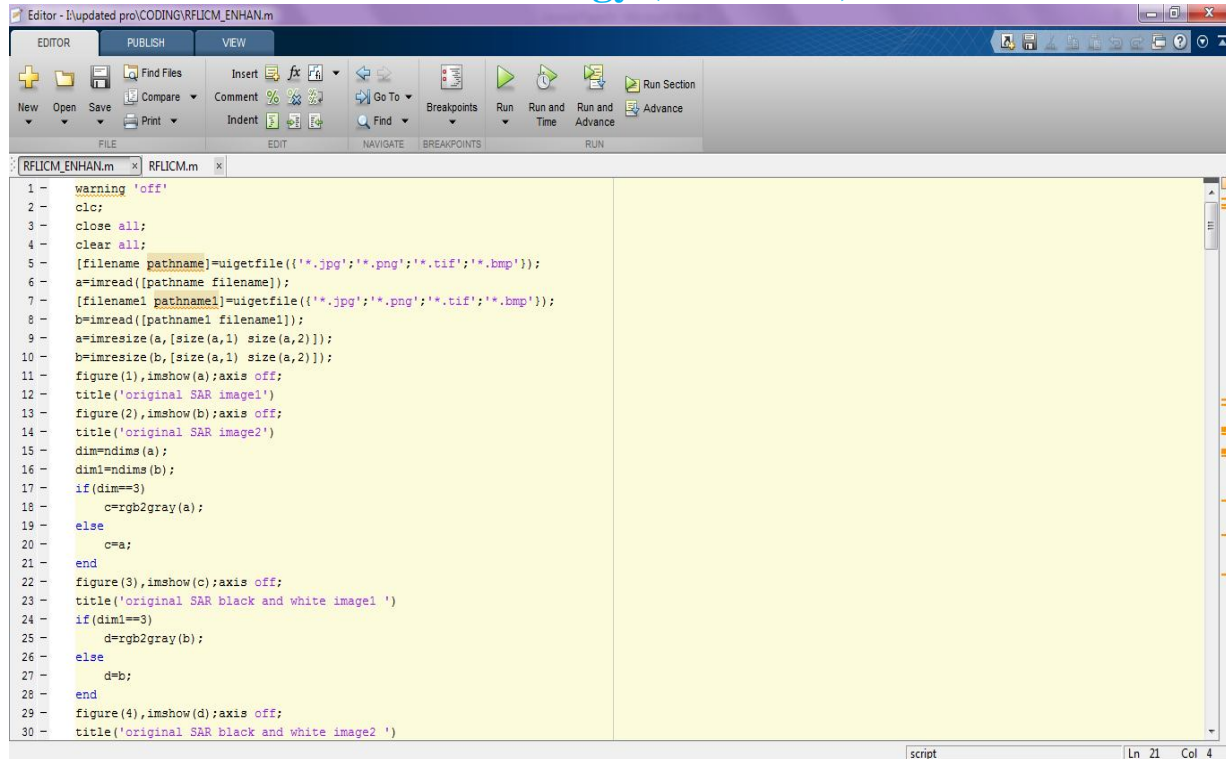
The working of our project is, by giving two satellite input images, our project generates gray scale images and then it find mean ratio operator and log ratio operator based on it. LFICM is algorithm is applied to generate difference between these two gray scale images. This output will be given as input for RFLICM algorithm, and it will generate more accuracy in output

IV. OUTPUT

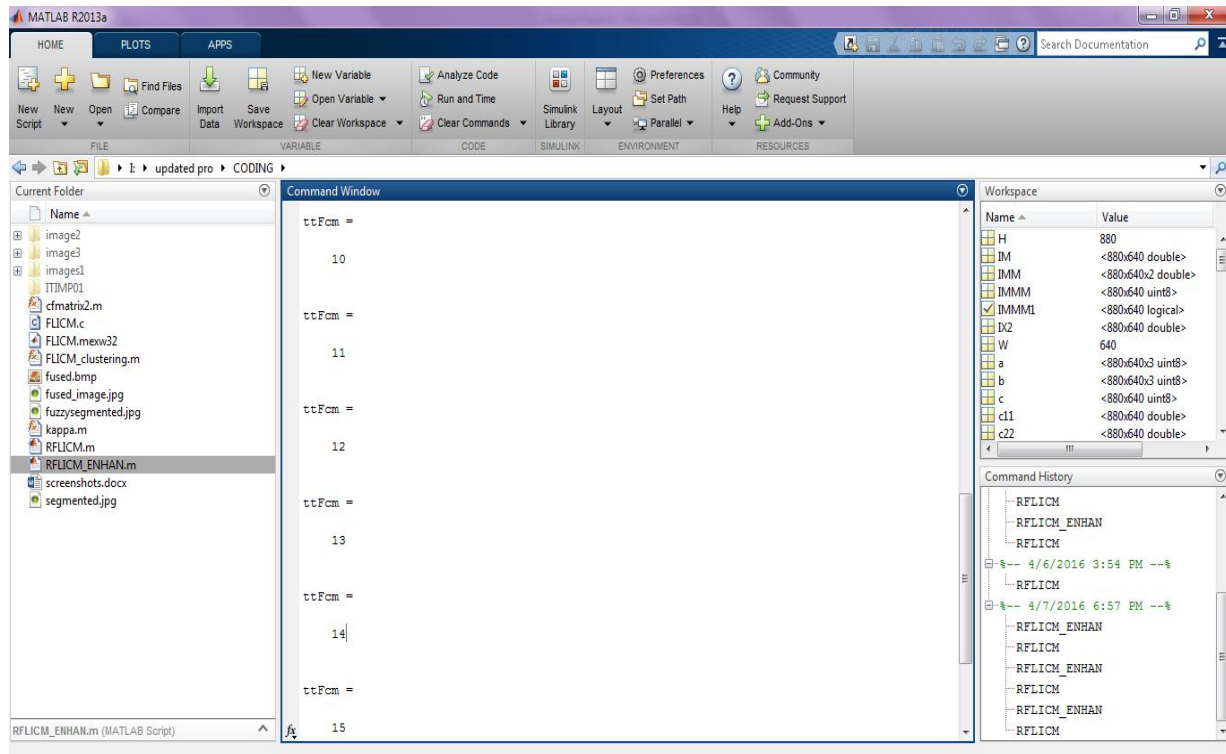


RFLICM Output Image

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```
1 - warning 'off'  
2 - clc;  
3 - close all;  
4 - clear all;  
5 - [filename pathname]=uigetfile({'*.jpg'; '*.png'; '*.tif'; '*.bmp'});  
6 - a=imread([pathname filename]);  
7 - [filename1 pathname1]=uigetfile({'*.jpg'; '*.png'; '*.tif'; '*.bmp'});  
8 - b=imread([pathname1 filename1]);  
9 - a=imresize(a,[size(a,1) size(a,2)]);  
10 - b=imresize(b,[size(a,1) size(a,2)]);  
11 - figure(1),imshow(a);axis off;  
12 - title('original SAR image1')  
13 - figure(2),imshow(b);axis off;  
14 - title('original SAR image2')  
15 - dim=ndims(a);  
16 - dim1=ndims(b);  
17 - if(dim==3)  
18 -     c=rgb2gray(a);  
19 - else  
20 -     c=a;  
21 - end  
22 - figure(3),imshow(c);axis off;  
23 - title('original SAR black and white image1')  
24 - if(dim1==3)  
25 -     d=rgb2gray(b);  
26 - else  
27 -     d=b;  
28 - end  
29 - figure(4),imshow(d);axis off;  
30 - title('original SAR black and white image2')
```



Current Folder: updated pro \ CODING

Command Window:

```
ttFcm =  
10  
ttFcm =  
11  
ttFcm =  
12  
ttFcm =  
13  
ttFcm =  
14  
ttFcm =  
15
```

Workspace:

Name	Value
H	880
IM	<880x640 double>
IMM	<880x640x2 double>
IMMM	<880x640 uint8>
IMMM1	<880x640 logical>
IX2	<880x640 double>
W	640
a	<880x640x3 uint8>
b	<880x640x3 uint8>
c	<880x640 uint8>
c11	<880x640 double>
c22	<880x640 double>

Command History:

```
RFLICM  
RFLICM_ENHAN  
RFLICM  
4/6/2016 3:54 PM --  
RFLICM  
4/7/2016 6:57 PM --  
RFLICM_ENHAN  
RFLICM  
RFLICM_ENHAN  
RFLICM  
RFLICM_ENHAN
```

V. CODING

```
tic warning 'off' clc; close all; clear all;  
[filename pathname]=uigetfile({'*.jpg';  
 '*.png'; '*.tif'; '*.bmp'});  
a=imread([pathname filename]);
```

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```
[filename1 pathname1]=uigetfile({'*.jpg';  
 '*.png';*.tif;*.bmp'});  
b=imread([pathname1 filename1]);  
b=imresize(b,  
 [size(a,1) size(a,2)]); figure(1),  
imshow(a);axis off;  
title('original SAR image1')  
figure(2),imshow(b);  
axis off; title('original SAR image2')  
dim=ndims(a);  
dim1=ndims(b); if(dim==3)  
    c=rgb2gray(a);  
else  
    c=a; end figure(3),imshow(c);axis off; title('original SAR black and white image1 ') if(dim1==3) d=rgb2gray(b); else d=b;  
end figure(4),imshow(d);axis off; title('original SAR black and white image2 ') e1=mean2(c); f1=mean2(d); mean_ratio=1-  
min(e1/f1,f1/e1); log_ratio=log(f1)-log(e1); g1=im2bw(c,abs(mean_ratio)); h1=im2bw(d,abs(log_ratio));  
figure(5),imshow(g1);axis off; title('mean ratio operator') figure(6),imshow(h1);axis off; title('log ratio operator')  
[ca,ch,cv,cd]=dwt2(g1,'db1');  
[ca1,ch1,cv1,cd1]=dwt2(h1,'db1');  
dd=zeros(size(ca,1),size(ca,2));  
for i=1:size(ca,1)  
for j=1:size(ca,2) dd(i,j)=ca(i,j)+ca1(i,j)/2;  
endenddd5=zeros(size(ch,1),size(ch,2));  
dd6=zeros(size(ch1,1),size(ch1,2));  
  
dd7=zeros(size(cv,1),size(cv,2)); dd8=zeros(size(cv1,1),size(cv1,2)); dd9=zeros(size(cd,1),size(cd,2));  
dd10=zeros(size(cd1,1),size(cd1,2)); for i5=1:size(ch,1) for j5=1:size(ch,2) dd5(i5,j5)=(ch(i5,j5)).^2;  
dd6(i5,j5)=(ch1(i5,j5)).^2; dd7(i5,j5)=(cv(i5,j5)).^2; dd8(i5,j5)=(cv1(i5,j5)).^2; dd9(i5,j5)=(cd(i5,j5)).^2;  
dd10(i5,j5)=(cd1(i5,j5)).^2; end end dd11=zeros(size(ch,1),size(ch,2)); dd12=zeros(size(ch1,1),size(ch1,2));  
dd13=zeros(size(cv,1),size(cv,2));  
  
for i6=1:size(ch,1) for j6=1:size(ch,2) if (dd5(i6,j6)<dd6(i6,j6)) dd11(i6,j6)=ch(i6,j6); else  
dd11(i6,j6)=ch1(i6,j6); end end end for i7=1:size(cv,1) for j7=1:size(cv,2) if (dd7(i7,j7)<dd8(i7,j7))  
dd12(i7,j7)=cv(i7,j7); else dd12(i7,j7)=cv1(i7,j7); end end end for i8=1:size(cd,1)  
for j8=1:size(cd,2) if (dd9(i8,j8)<dd10(i8,j8)) dd13(i8,j8)=cd(i8,j8); else dd13(i8,j8)=cd1(i8,j8); end end  
end fused_image=idwt2(dd,dd11,dd12,dd13,'db1'); figure(7),imshow(fused_image);axis off; title('DWT based Fused Image')  
imwrite(fused_image,'fused.bmp')  
%%  
  
IM=double(fused_image); imwrite(IM,'fused_image.jpg'); [maxX,maxY]=size(IM);  
IMM=cat(3,IM,IM);  
  
%%%%%%%%  
cc1=8; cc2=250;  
tt=0; while(tt<15) tt=tt+1;  
c11=repmat(cc1,maxX,maxY); c22=repmat(cc2,maxX,maxY);  
if tt==1 test1=c11; test2=c22; end c333=cat(3,c11,c22);  
ree=repmat(0.000001,maxX,maxY); ree1=cat(3,ree,ree); distance=IMM-c333; distance=distance.*distance+ree1;
```

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

```
da=1./distance;
da1=da(:,1)+da(:,2);      distance1=distance(:,1).*da1;      u1=1./distance1;      distance2=distance(:,2).*da1;
u2=1./distance2;      ccc1=sum(sum(u1.*u1.*IM))/sum(sum(u1.*u1));      ccc2=sum(sum(u2.*u2.*IM))/sum(sum(u2.*u2));
tmpMatrix=[abs(cc1-ccc1)/cc1,abs(cc2-ccc2)/cc2];      pp=cat(3,u1,u2);      for i9=1:maxX      for j9=1:maxY      if
max(pp(i9,j9,:))==u1(i9,j9)
IX2(i9,j9)=1; else
IX2(i9,j9)=2;
end
end
end
%%%%%%%%%%
if max(tmpMatrix)<0.0001
break; else      cc1=ccc1;      cc2=ccc2;      end for i10=1:maxX      for j10=1:maxY      if IX2(i10,j10)==2
IMMM(i10,j10)=254;

else
IMMM(i10,j10)=8;      end      end end
%%%%%%%%%%
%figure,imshow(uint8(IMMM)); output=uint8(IMMM); imwrite(output,'segmented.jpg'); end
for i11=1:maxX      for j11=1:maxY
if IX2(i11,j11)==2 IMMM(i11,j11)=200;
else
IMMM(i11,j11)=1;      end      end end
%%%%%%%%%%
IMMM=uint8(IMMM); IMMM1=im2bw(IMMM);
for JJ2=1:size(IMMM1,1) for KK2=1:size(IMMM1,2) if(IMMM1(JJ2,KK2)==1) IMMM1(JJ2,KK2)=0;
else
IMMM1(JJ2,KK2)=1; end end end figure(8),imshow(IMMM1);axis off; title('Ground truth image');
%% RFLICM

cNum = 3; m = 2; winSize = 3; maxIter = 500; thrE = 0.001;
[H,W] = size( fused_image ); imageFileName='fused.bmp';
[imOut,iter] = FLICM_clustering
( imageFileName, cNum, m, winSize, maxIter, thrE );
disp(sprintf('Total Iterations = %d',iter));
figure(9),
imshow(imOut,[]);axis off;
title('FLICM output image ');
U = rand( H, W, cNum-1 )*(
1/cNum); U(:,:,cNum) = 1 - sum(U,3);
ssum=zeros(length(3*size(U,1)
*size(U,2)),1); cc=zeros(length(3*size(U,1)
```

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```
*size(U,2),1); ssum1 = zeros(cNum,1);
G=zeros(length(3*size(U,1)
*size(U,2),1);
c1=var(fused_image)/(mean2(fused_image))^2;
for i3=1:size(U,1) for j3=1:size(U,2)
for k3=1:cNum          ssum(i3,j3,k3)=U(i3,j3,k3).^m;          cc(i3,j3,k3) = (U(i3,j3,k3).^m)*
(fused_image(i3,j3));          ssum1(k3)=cc(i3,j3,k3)/ssum(i3,j3,k3);          end end
end for i4=1:size(U,1)
for j4=1:size(U,2)
for k4=1:cNum
if (c1(1,j4)^(j4)>=mean2(c1))
G(i4,j4,k4)=          1/(2+min((c1.^(j4)/c1).
^2,(c1/c1.^(j4)).^2))*
(1U(i4,j4,k4)).
*norm(fused_image(i4,j4)-ssum1(k4)).^2;
else
G(i4,j4,k4)=
1/(2min((c1.^(j4)/c1).^2,(c1/c1.^(j4)).^2))
*(1U(i4,j4,k4)).*norm(fused_image(i4,j4)-ssum1(k4)).^2;          end
end
end
end
V=zeros(length(3*size(U,1)*size(U,2)),1);          for i5=1:size(U,1)          for j5=1:size(U,2)
for k5=1:cNum V(i5,j5,k5)=U(i5,j5,k5);          U(i5,j5,k5)=1/((norm(fused_image(i5,j5)ssum1(k5))
.^2+G(i5,j5,k5))/(norm(fused_image(i5,j5)-ssum1(k5))
.^2+G(i5,j5,k5))).^(1/(m-
1)); if (max(V(i5,j5,k5)-U(i5,j5,k5))<thrE)
break; end end end
end figure(10),imshow(U); title('RFLICM output in HSV') cmap2=hsv2rgb(U); dd21=rgb2gray(cmap2);
dd22=im2bw(dd21,graythresh(dd21)); for JJ1=1:size(U,1) for KK1=1:size(U,2) if(dd22(JJ1,KK1)==1) dd22(JJ1,KK1)=0;
else
dd22(JJ1,KK1)=1; end end end dd23=imerode(dd22,strel('diamond',1)); figure(11),imshow(dd23); title('RFLICM output')
[confmatrix] = cfmatrix2(IMMM1(:),dd23(:));
TP=(confmatrix(4))/(confmatrix(3)+confmatrix(4));
FP=(confmatrix(2))/(confmatrix(1)+confmatrix(2));
TN=(confmatrix(1))/(confmatrix(1)+confmatrix(2));
FN=(confmatrix(3))/(confmatrix(3)+confmatrix(4)); PCC=(TP+TN)/(TP+FP+TN+FN);
disp(['Percent correct classification of RFLICM =' num2str(PCC)]); ghh=im2bw(imOut,graythresh(imOut)); [confmatrix1] =
cfmatrix2(IMMM1(:),ghh(:));
TP1=(confmatrix1(4))/(confmatrix1(3)+confmatrix1(4));
FP1=(confmatrix1(2))/(confmatrix1(1)+confmatrix1(2));
```

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```
TN1=(confmatrix1(1))/(confmatrix1(1)+confmatrix1(2));  
FN1=(confmatrix1(3))/(confmatrix1(3)+confmatrix1(4)); PCC1=(TP1+TN1)/(TP1+FP1+TN1+FN1);  
disp(['Percent correct classification of FLICM =' num2str(PCC1)]; g2=imresize(g1,[size(U,1) size(U,2)]);  
[confmatrix2] = cfmatrix2(IMMM1(:),g2(:));  
TP2=(confmatrix2(4))/(confmatrix2(3)+confmatrix2(4));  
FP2=(confmatrix2(2))/(confmatrix2(1)+confmatrix2(2));  
TN2=(confmatrix2(1))/(confmatrix2(1)+confmatrix2(2));  
FN2=(confmatrix2(3))/(confmatrix2(3)+confmatrix2(4)); PCC2=(TP2+TN2)/(TP2+FP2+TN2+FN2);  
disp(['Percent correct classification of MEAN RATIO =' num2str(PCC2)]); h2=imresize(h1,[size(U,1) size(U,2)]); [confmatrix3]  
= cfmatrix2(IMMM1(:),h2(:));  
TP3=(confmatrix3(4))/(confmatrix3(3)+confmatrix3(4));  
FP3=(confmatrix3(2))/(confmatrix3(1)+confmatrix3(2));  
TN3=(confmatrix3(1))/(confmatrix3(1)+confmatrix3(2));  
FN3=(confmatrix3(3))/(confmatrix3(3)+confmatrix3(4)); PCC3=(TP3+TN3)/(TP3+FP3+TN3+FN3);  
disp(['Percent correct classification of LOG RATIO =' num2str(PCC3)]); disp('KAPPA for RFLICM') kappa(confmatrix);  
disp('KAPPA for FLICM') kappa(confmatrix1); toc
```

VI. CONCLUSION

In this project, we have presented a novel SAR-image change detection approach based on image fusion and an improved fuzzy clustering algorithm, which is quite different from the existing methods. First, for the wavelet fusion approach that we proposed, the key idea is to restrain the background (unchanged areas) information and to enhance the information of changed regions in the greatest extent. On the other hand, the information of background obtained by the log-ratio image is relatively flat on account of the logarithmic transformation. Hence, complementary information from the mean-ratio image and the log ratio image is utilized to fuse a new difference image. Compared with other existing methods (mean ratio and log ratio), the proposed approach can reflect the real change trend as well as restrain the background (unchanged areas). Second, in contrast with the log-ratio image and the mean-ratio image, the estimation of the probability statistics model for the histogram of the fused difference image may be complicated since it incorporates both the log-ratio and mean-ratio image information at different resolution levels. Here, the RFLICM algorithm that incorporates both local spatial and gray information is proposed, which is relatively insensitive to probability statistics model. The RFLICM algorithm introduces the reformulated factor as a local similarity measure to make a tradeoff between image detail and noise. Compared with the original algorithms, RFLICM is able to incorporate the local information more exactly. The experiment results show that the proposed wavelet fusion strategy can integrate the advantages of the log-ratio operator and the mean-ratio operator and gain a better performance. The change detection results obtained by the RFLICM exhibited less spots than its preexistence (i.e., FLICM) since it is able to incorporate the local information more exactly.

VII. ACKNOWLEDGEMENT

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)

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