CHAPTER 8

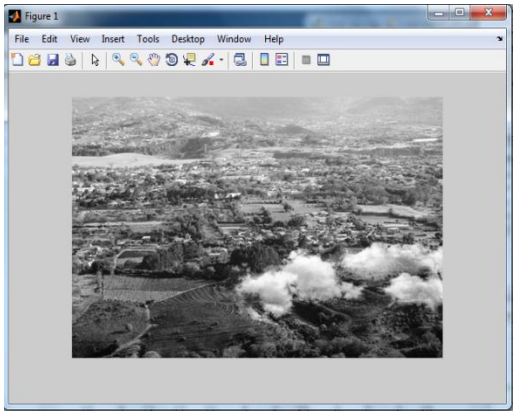
Result, Conclusion, Limitations and Future Scope

8.1 Result

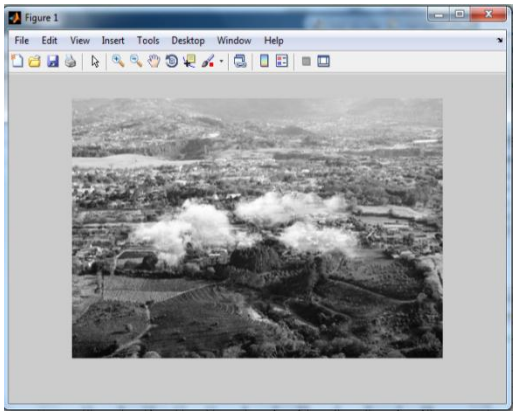
The proposed algorithm was tested on more than ten target image and their corresponding reference image. The dataset of satellite image taken from San-Jose-Costa-Rica-Latin-America. The cloudy pixels are detected & removed correctly in the target image from the reference image using the proposed automated cloud detection and removal algorithm. Figure1 (a) shows the reference image & Figure1 (b) shows the cloudy subject image which is to be corrected with respect to the reference image.

(a)

(b)



(c)



(d)

Fig 8.1(a)Subject Image; (b) Reference Image (c) Grayscale image of Subject image

(d) Grayscale image of Reference image

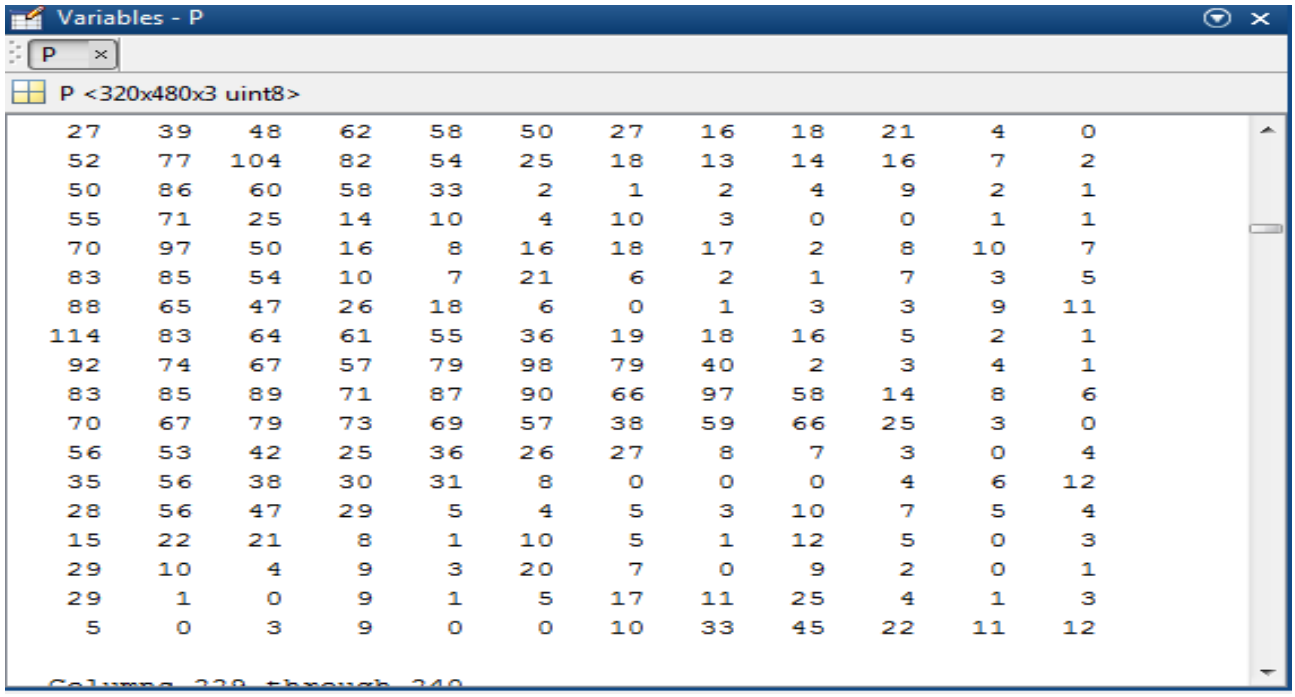


Fig 8.2: Pixel intensity value of Subject Image

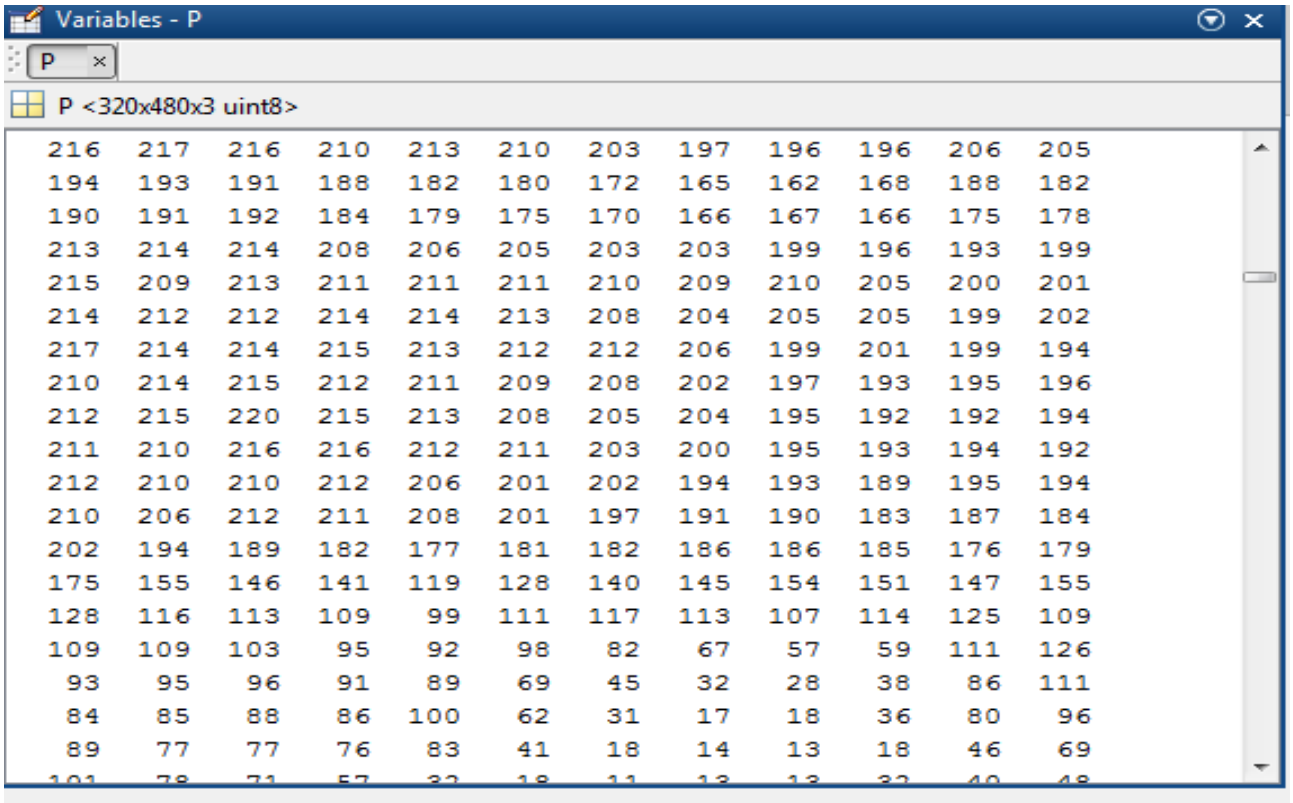


Fig 8.3: Pixel intensity of reference Image

The detected cloud is removed & replaced with data from the image acquired at different time series for same location. To remove the cloudy pixel from the subject image the new automated cloud detection and cloud removal (ACDCR) algorithm is applied. The final cloud-free image is shown in Figure below.

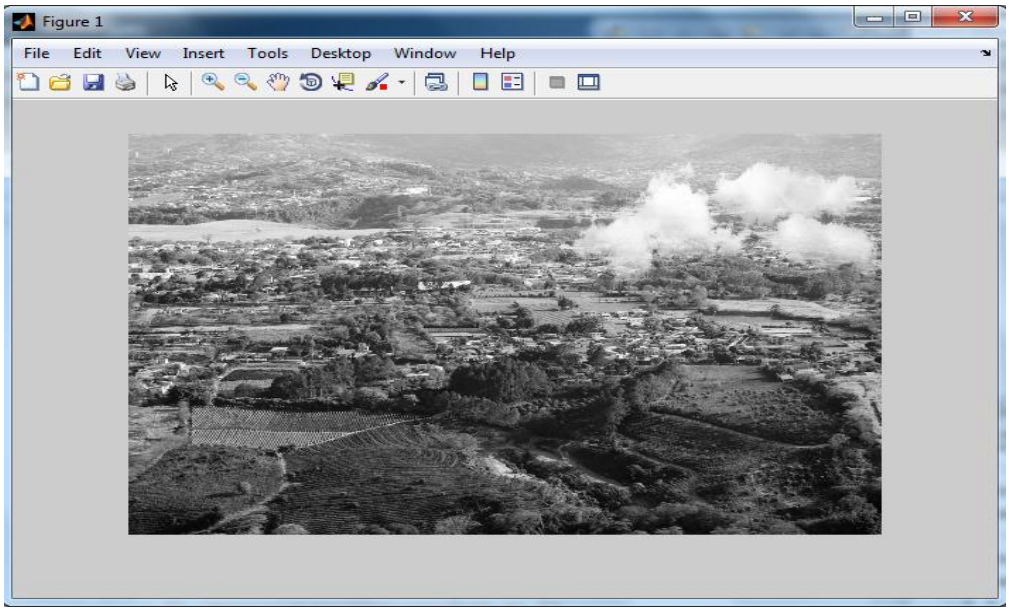
(a)

(b)

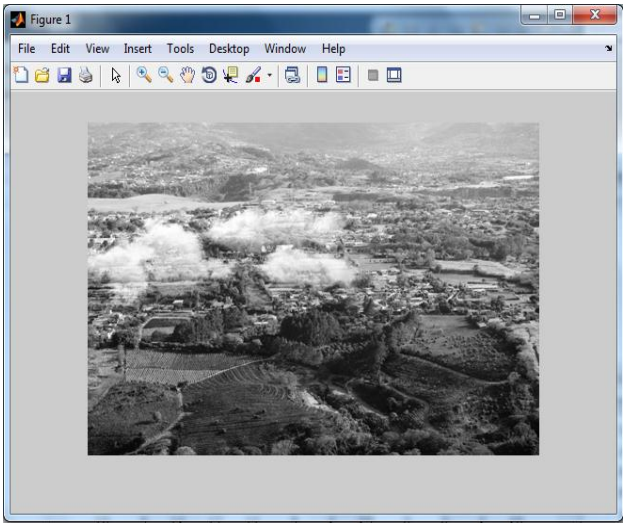
(c)

Fig 8.4: (a) Subject Image; (b) Reference Image-1; (c) Reference Image-2

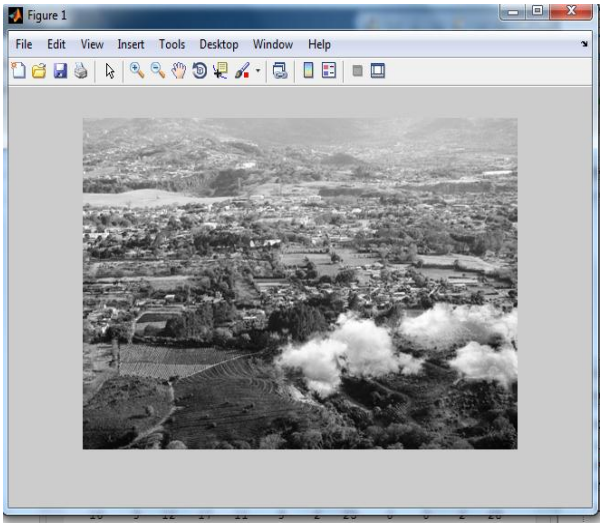
Gray scale image of (a) Subject Image; (b) Reference Image-1; (c) Reference Image-2 is as follows:



(a)

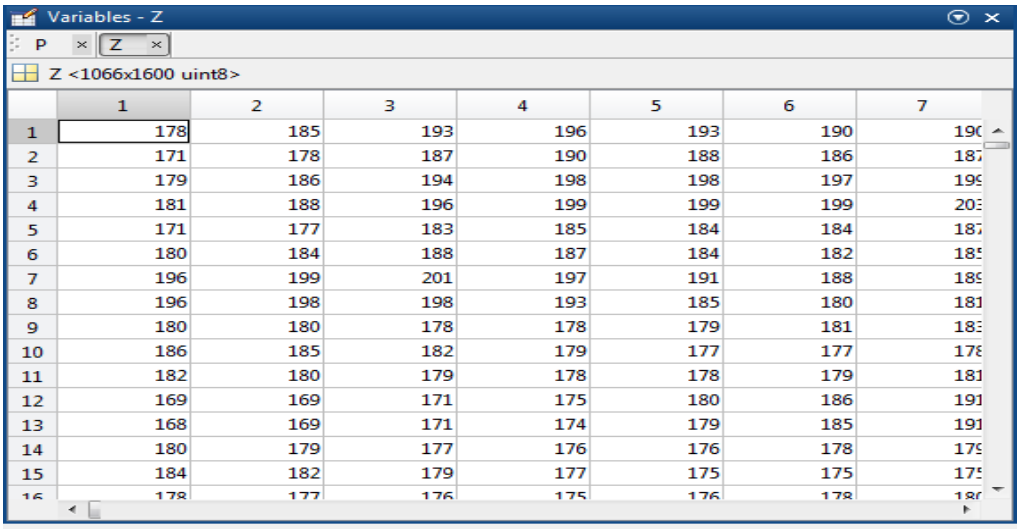


(b)



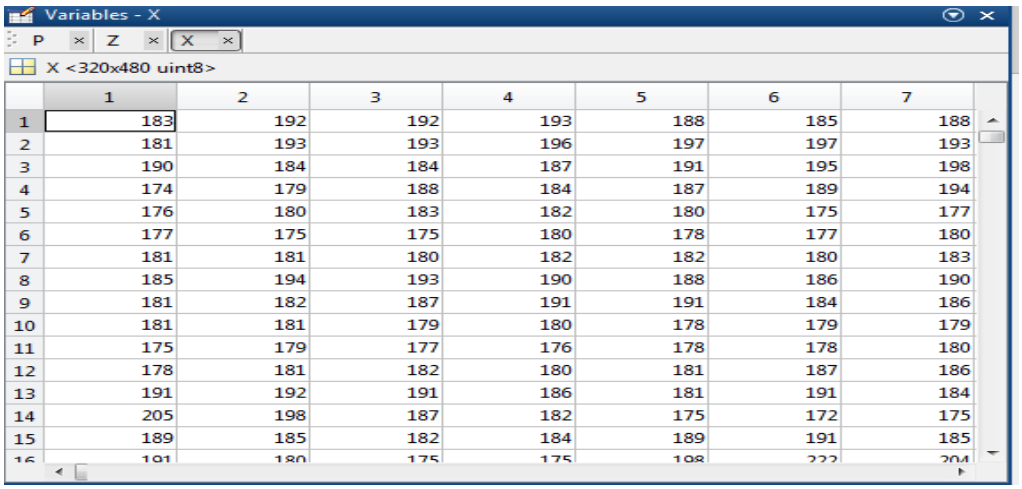
(c)

Fig 8.5: Gray scale image of (a) Subject Image; (b) Reference Image-1; (c) Reference Image-2



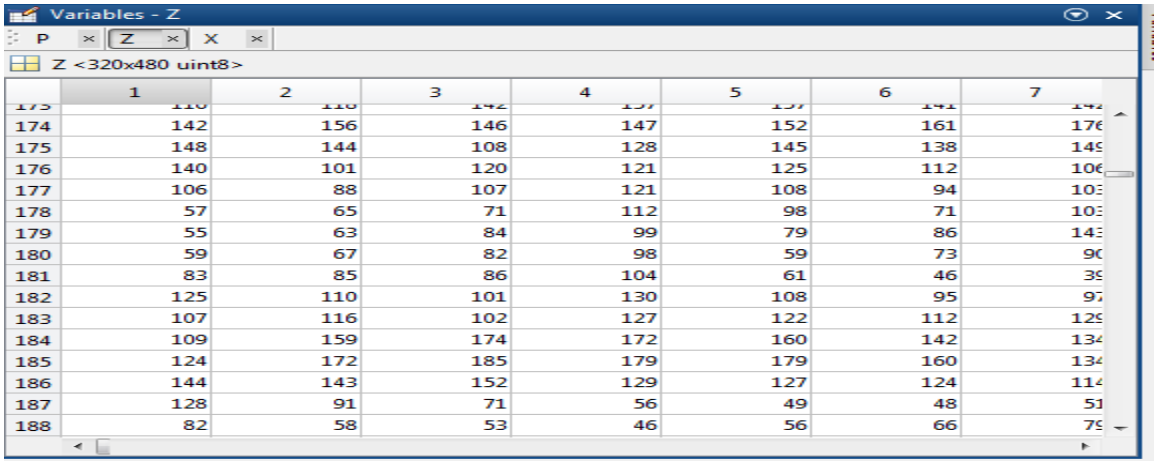
	1	2	3	4	5	6	7
1	178	185	193	196	193	190	190
2	171	178	187	190	188	186	187
3	179	186	194	198	198	197	199
4	181	188	196	199	199	199	203
5	171	177	183	185	184	184	187
6	180	184	188	187	184	182	185
7	196	199	201	197	191	188	189
8	196	198	198	193	185	180	181
9	180	180	178	178	179	181	183
10	186	185	182	179	177	177	178
11	182	180	179	178	178	179	181
12	169	169	171	175	180	186	191
13	168	169	171	174	179	185	191
14	180	179	177	176	176	178	179
15	184	182	179	177	175	175	175
16	178	177	176	175	176	178	180

(a)



	1	2	3	4	5	6	7
1	183	192	192	193	188	185	188
2	181	193	193	196	197	197	193
3	190	184	184	187	191	195	198
4	174	179	188	184	187	189	194
5	176	180	183	182	180	175	177
6	177	175	175	180	178	177	180
7	181	181	180	182	182	180	183
8	185	194	193	190	188	186	190
9	181	182	187	191	191	184	186
10	181	181	179	180	178	179	179
11	175	179	177	176	178	178	180
12	178	181	182	180	181	187	186
13	191	192	191	186	181	191	184
14	205	198	187	182	175	172	175
15	189	185	182	184	189	191	185
16	191	180	175	175	198	222	204

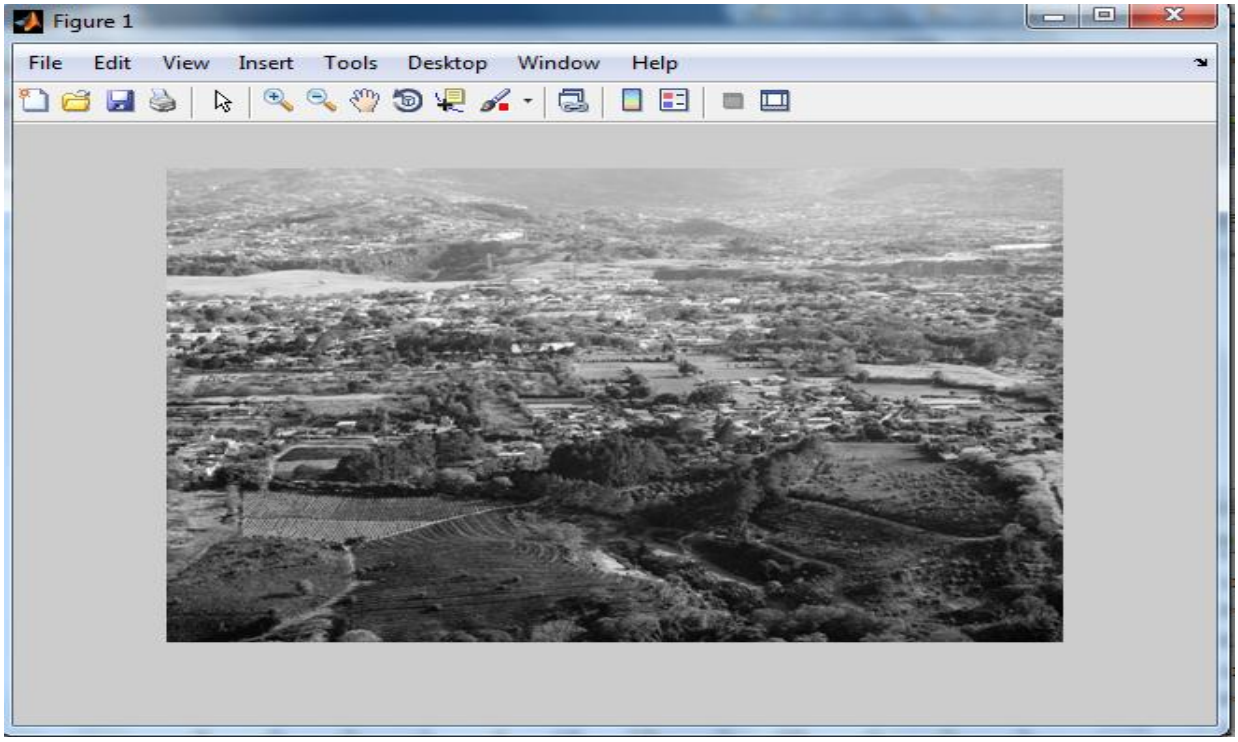
(b)



	1	2	3	4	5	6	7
174	142	156	146	147	152	161	176
175	148	144	108	128	145	138	149
176	140	101	120	121	125	112	106
177	106	88	107	121	108	94	103
178	57	65	71	112	98	71	103
179	55	63	84	99	79	86	143
180	59	67	82	98	59	73	90
181	83	85	86	104	61	46	39
182	125	110	101	130	108	95	97
183	107	116	102	127	122	112	129
184	109	159	174	172	160	142	134
185	124	172	185	179	179	160	134
186	144	143	152	129	127	124	114
187	128	91	71	56	49	48	51
188	82	58	53	46	56	66	79

(c)

Fig 8.6: Pixel intensity of (a) Subject Image; (b) Reference Image-1; (c) Reference Image-2



(a)

Variables - A

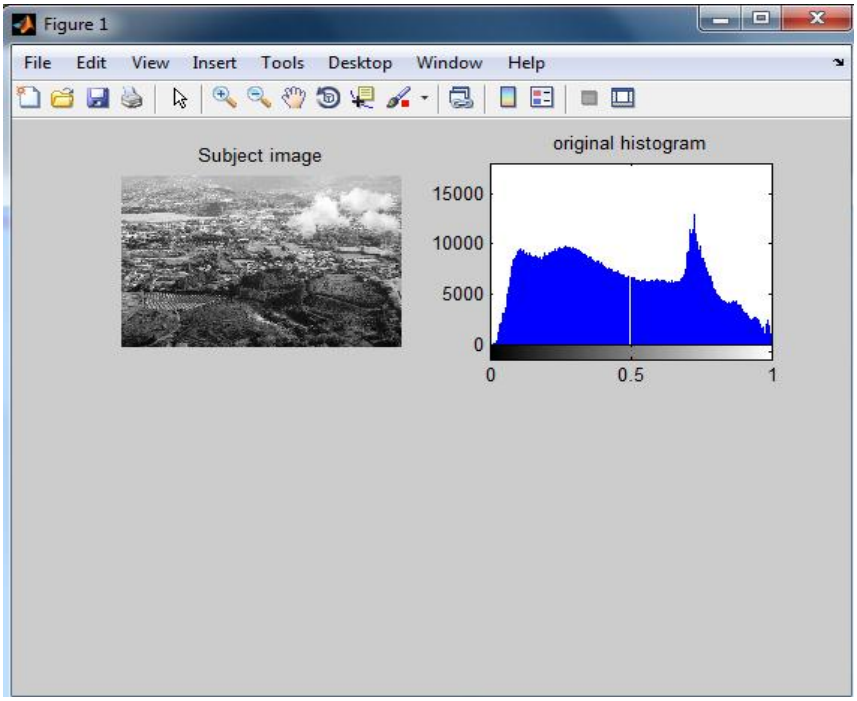
P Z X A

A <320x480 uint8>

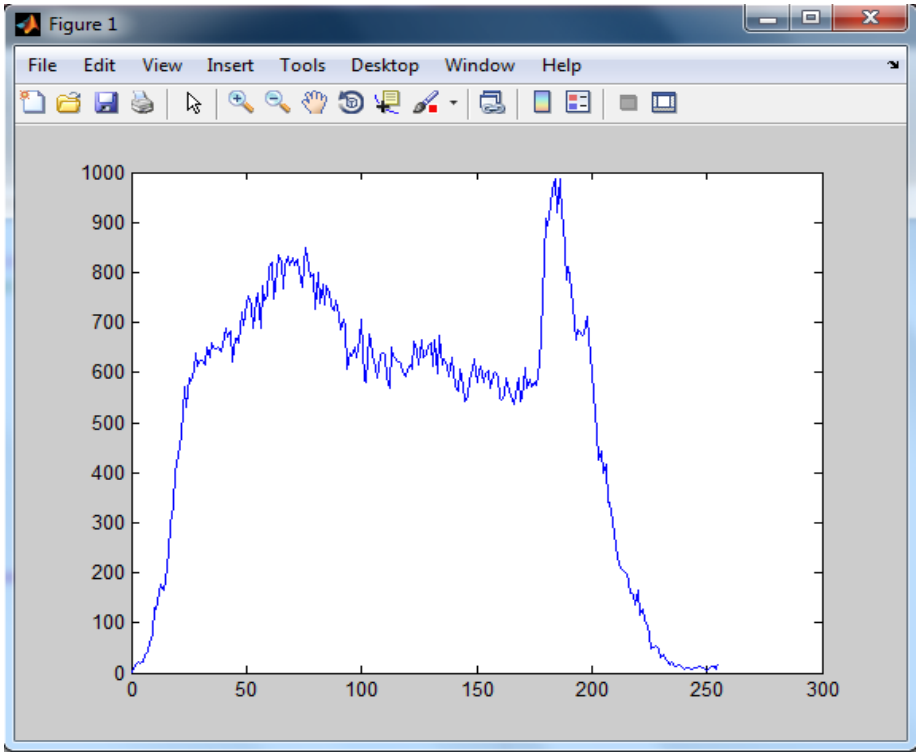
	1	2	3	4	5	6	7
1	183	192	192	193	188	185	188
2	181	193	193	196	197	197	193
3	190	184	184	187	191	195	198
4	174	179	188	184	187	189	194
5	176	180	183	182	180	175	177
6	177	175	175	180	178	177	180
7	181	181	180	182	182	180	183
8	185	194	193	190	188	186	190
9	181	182	187	191	191	184	186
10	181	181	179	180	178	179	179
11	175	179	177	176	178	178	180
12	178	181	182	180	181	187	186
13	191	192	191	186	181	191	184
14	205	198	187	182	175	172	175
15	189	185	182	184	189	191	185
16	191	180	175	175	198	222	204

(b)

Fig 8.7: (a) Cloud-free Image; (b) Pixel intensity of cloud-free image



(a)



(b)

Fig 8.8: (a) Histogram of Subject Image; (b) Histogram of Cloud_Free_Image

8.2 Accuracy Test

The quality of image can be assessed with the use of Root Mean Square Error (RMSE)

$$\text{RMSE} = \sqrt{\frac{\sum_{i=1}^{M}\sum_{j=1}^{N}\left[R(i,\,j)-S(i,\,j)\right]^2}{MXN}}$$

Where R represent the Reference Image, S represent Subject Image and (i,j) represent the image coordinates of Reference and subject image respectively.

The value of RMSE is higher in corrupted image and is less in the uncorrupted images. This shows that, cloud-free image represents better information compared to subject image and reference image.

Comparative statement of existing algorithm with the proposed ACDCR

Sl No.	Algorithm	RMSE
1	Mean	11.1595
3	Radiometric Normalization	11.1038
2	Modified Maximum Averaging	10.8451
4	Automated cloud detection and cloud removal (ACDCR)	9.4516

Table 8.1: Accuracy Test

8.3 Conclusion

The ACDCR algorithm described is an automatic method to detect cloudy pixel in the satellite subject image and the detected cloudy region is removed & replaced by the reference image of same location. The missing information in the subject image is reconstructed from the reference image. As the approach is based on the pixel-to-pixel comparison, it produces a better image. This method was tested for various input images and their corresponding reference images.

8.4 Limitation

The major limitation of this research proposal is listed below:

- The live satellite images are not frequently available for a continuous time period.
- To work with large data set, a high-end machine is required.
- The variability of land, cloud is observed as the change in the general pattern. So it is difficult to set the threshold value for all the potential cases.

8.5 Future Work

- The proposed research is based on pixel-to-pixel evaluation on satellite imagery for the purpose of detection and correction of cloudy region in the images. The proposed approach works properly for large and thick cloud coverage area.
- The research may further be extended for identifying and removing thin and small cloud coverage area.
- The research may further be extended for identifying cloud shadow coverage area.
- The research may also be extended for classifying between clouds and the object on the earth whose appearance is same as cloud.