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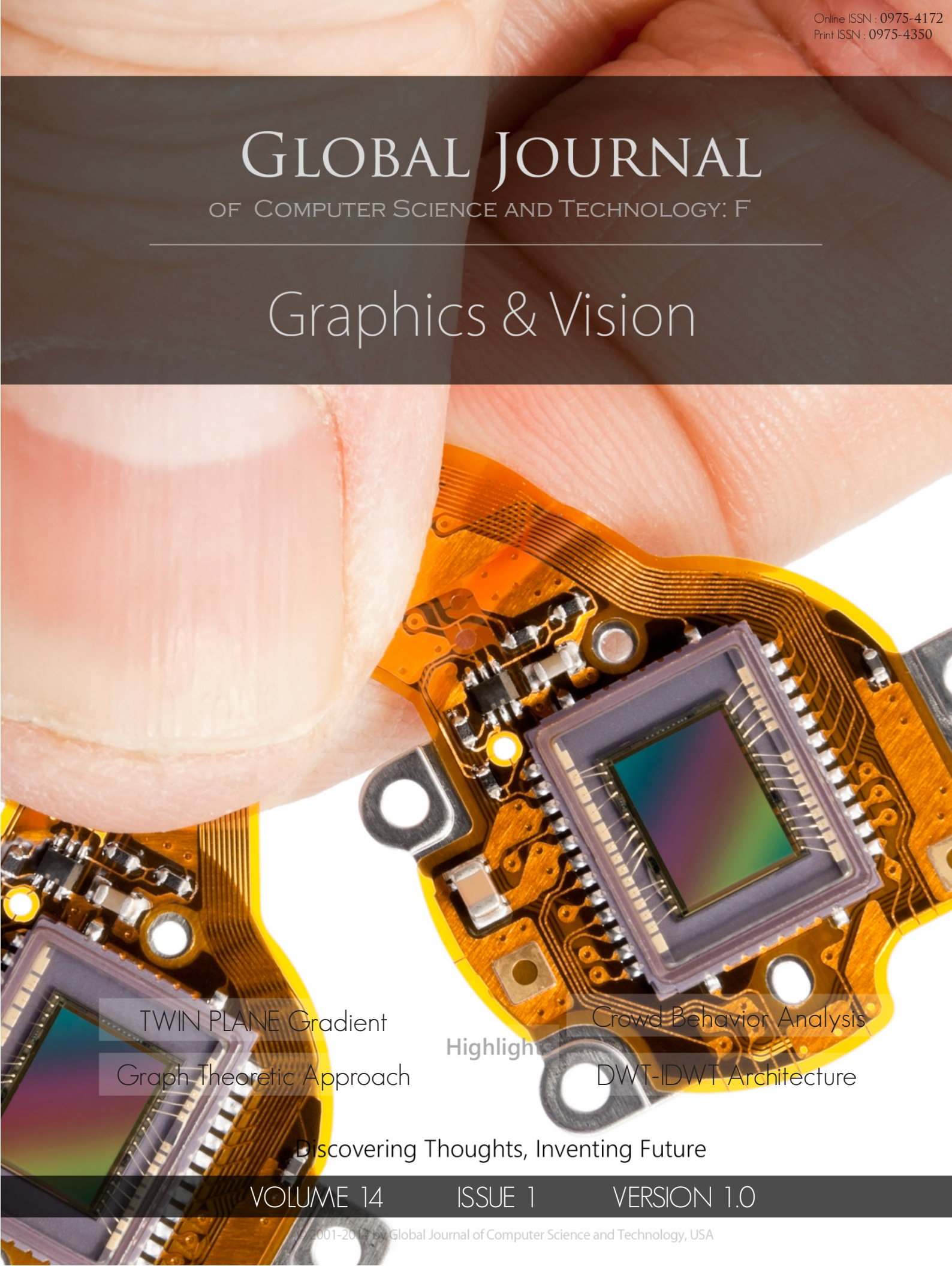

TWIN PLANE Gradient

Graph Theoretic Approach

Highlights

Crowd Behavior Analysis

DWT-IDWT Architecture

Discovering Thoughts, Inventing Future

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Classification of Facial Expressions based on Transitions Derived from Third Order Neighborhood LBP

By Dr. Vakulabharanam Vijaya Kumar, Gorti Satyanaraya Murty & Pullela S V V S R Kumar

Anurag Group of Institutions, India

Abstract- The present paper extended the LBP transitions derived from second-order neighbourhood on to third order neighbourhood LBP (TN-LBP) and derived transitions on Trapezoid patterns for facial expression classification. The TN-LBP forms four Trapezoid Patterns (TP) i.e. top left, bottom right and top right, bottom left. So far no researcher carried out work on classification problem based on transitions on third-order neighborhood LBP. The present paper derived transitions on the two reciprocal "Trapezoids of TN-LBP (T-TN-LBP) i.e. top left vs. bottom right. Each of these Trapezoids on TN-LBP will have five pixies and each of them will have 25 i.e 32 patterns. The present paper derived transitions on two symmetric T-TN-LBP. Based on this, facial expression recognition algorithm is built. The proposed approach is compared with the existing methods.

Keywords : *classification, facial expression recognition, lbp transitions, third order neighborhood lbp, trapezoid patterns.*

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Classification of Facial Expressions based on Transitions Derived from Third Order Neighborhood LBP

Dr. Vakulabharanam Vijaya Kumar [α], Gorti Satyanaraya Murty [σ] & Pullela S V V S R Kumar [ρ]

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Keywords: classification, facial expression recognition, lbp transitions, third order neighborhood lbp, trapezoid patterns.

I. Introduction

Imaging understanding is one of the most important tasks involving a classification system. Its primary purpose is to extract information from the images to allow the discrimination among different objects of interest. The classification process is usually based on grey level intensity, color, shape or texture. Image classification is of great interest in a variety of applications.

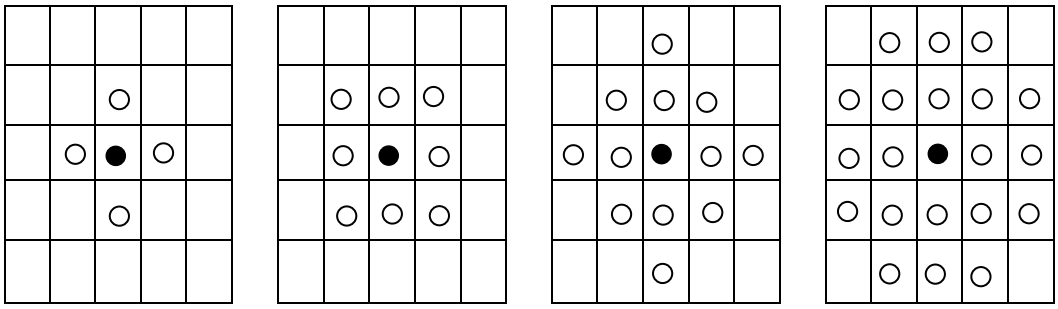

Figure 1 : Neighborhood for a central pixel: (a) First Order (b) Second Order (c) Third Order (d) Fourth Order

Most of the image analysis problems are related to the neighborhood properties. Each pixel in a neighborhood or image is considered as a random variable, x_r, which can assume values $x_r \in \{0, 1 \ldots G-1\}$, where G is the number of grey levels of the image. The probability $P(x_r = x_r \mid r)$, where r is the neighbor set for the element x_r. The Fig.1 illustrates different orders of neighborhood for a central pixel. Most of the research involved in image processing is mostly revolved around second order neighborhood only. This is because all the 8- neighboring pixels are well connected with central pixels and the methods based on second order neighborhood are given extraordinary results in various issues. The present paper considering the difficulties and complexities involved in the third order neighborhood and derived a new, simple and efficient model for image analysis.

II. Derivations of Transitions on Trapezoids of TN-LBP

The proposed method evaluated transitions on "Trapezoids of Third Order Neighborhood of LBP (T-TN-LBP)" and based on this, derived various algorithms for the recognition of facial expressions. The proposed transition based T-TN-LBP consists of 7 steps as described below.

Step 1: Take facial image as Input Image (Img).

Step 2: Convert the RGB image into Grey scale Image by using HSV color model.

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Step 3 : Crop the grey scale image.

Step 4: The present research evaluated TN-LBP on each 5 x 5 sub image. The TN contains only 13 pixels of 25 pixels of 5x5 neighborhood as shown in Fig.1. The TN-LBP grey level sub image is converted into binary sub image by comparing the each pixel of TN grey level sub image with the mean value of TN grey sub image. The following Equation.1 is used for grey level to binary conversion.

$$\text{TN-Pi} = \begin{cases} 0 & \text{if} \quad P_i < V_0 \\ 1 & \text{if} \quad P_i \geq V_0 \end{cases} \quad \text{for i} = 1,2,3 \qquad (1)$$

Where V_0 is the mean of the TN sub matrix

Step 5: The present research for classification purpose considered the two reciprocal trapezoids i.e. Top Left (TL) and Bottom Right (BR) trapezoids of TN-LBP. The Fig.2 shows TL and BR trapezoids of TN-LBP. The each trapezoid pattern consists of 5 pixels. The pixels P_1, P_2, P_5, P_6 and P_3 form the TL trapezoid. The Pixels P_8, P_{11}, P_{13}, P_{12} and P_9 form the BR trapezoid.

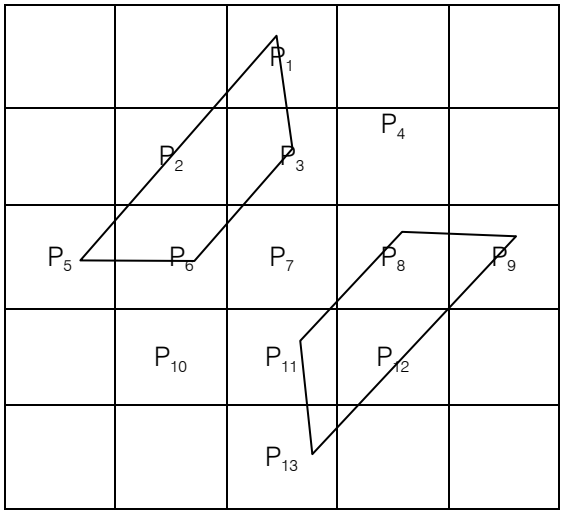

Figure 2 : The TL and BR trapezoids of TN-LBP

Step 6 : Each trapezoid of TN-LBP consists of five bit patterns. The present research computed the transitions from 0 to 1 and 1 to 0. Generally in 5 bit patterns, 3 types of 0 to 1 and 1 to 0 transitions occur i.e. zero, two and four transitions. The proposed method, considers two and four transitions only, which accounts for 87.5% of patterns.

Step 7 : Based on frequency occurrences of two and four transitions, the facial image is classified as one of the category (Neutral, Happiness, Sadness, Surprise, Anger, Disgust and Fear).

III. Results and Discussions

The proposed transition based T-TN-LBP method is experimented on a database contains 213 images of female facial expressions collected by Kamachi and Gyoba at Kyushu University, Japan [1]. A few of them are shown in Fig. 3.

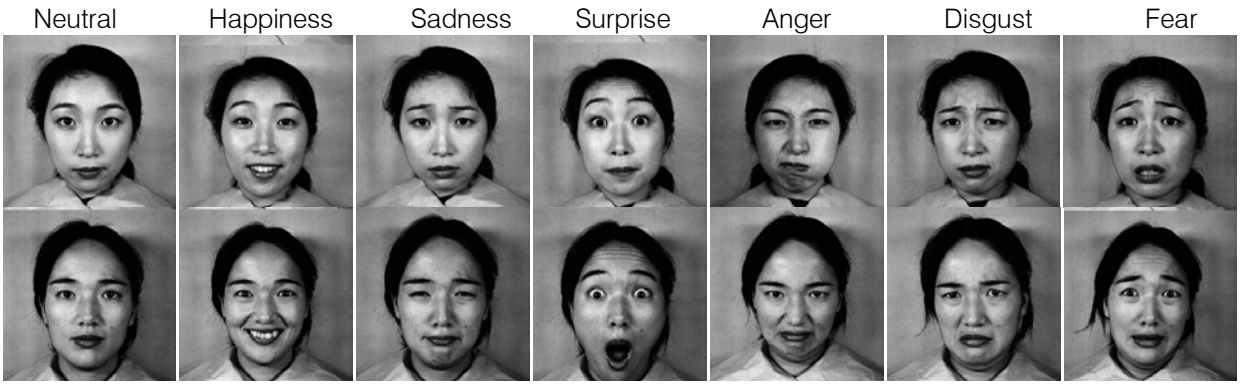

Figure 3 : Facial expression database (Kamachi and Gyoba at Kyushu University, Japan).

In the proposed "Transitions based on T-TN-LBP method", the sample images are grouped into seven categories of expression (neutral, happiness, sadness, surprise, anger, disgust and fear). Each T-TN-LBP consists of 5 bit pattern. It results a total of 32 bit patterns. This forms two-zero transitions i.e. the decimal value 0 and 31. The decimal values 5,9,10,11,13,18,20,21,22,26 results for 0 to 1 or 1 to 0 four transitions.The rest of the binary equivalent decimal values1,2,3,4,6,7,8,12,14,15,16,17,19,23,24,25,27,28,29, 30 results two transitions. The beauty of the proposed transitions on T-TN-LBP method is it evaluated the frequency occurrences of 2 and 4 transitions. This accounts a total of 87.5% of transitions.

The proposed method not considered the zero transitions which accounts for 12.5% of patterns. Further the proposed method evaluated the frequency occurrence of 2 and 4 transitions separately. The proposed method further evaluated sum of frequency occurrences two and four transitions of both TL and BR T-TN-LBP for the different facial expressions separately and listed in tables 1, 2, 3, 4, 5, 6 and 7 respectively. In the tables, STLT denotes sum of transitions (both 2 and 4) of Top Left Trapezoid and SBRT denotes sum of transitions (both 2 and 4) of Bottom Right Trapezoid. Further, the table also gives Total number of (2 and 4) transitions of both Trapezoids denoted as TBT in the above tables.

Table 1 : Frequency occurrence of transitions of T-TN-LBP method on Anger expression database.

		Transitions on Top- Left T-TN-LBP			Transitions on Bottom-Right T-TN- LBP			
S.No	Image Name	2	4	STLT	2	4	SBRT	TBT
1	KA.AN1.39	737	137	874	741	152	893	1767
2	KA.AN2.40	723	170	893	708	189	897	1790
3	KA.AN3.41	711	177	888	709	183	892	1780
4	KL.AN1.167	723	170	893	699	179	878	1771
5	KL.AN2.168	729	182	911	726	187	913	1824
6	KL.AN3.169	748	159	907	716	187	903	1810
7	KM.AN1.17	727	152	879	721	153	874	1753
8	KM.AN2.18	696	167	863	698	169	867	1730
9	KM.AN3.19	699	167	866	732	159	891	1757
10	KR.AN1.83	727	158	885	693	193	886	1771
11	KR.AN2.84	759	160	919	723	169	892	1811
12	KR.AN3.85	730	161	891	730	161	891	1782
13	MK.AN1.125	708	173	881	742	162	904	1785
14	MK.AN2.126	678	184	862	733	162	895	1757
15	MK.AN3.127	704	153	857	738	151	889	1746

16	NA.AN1.211	716	141	857	735	128	863	1720
17	NA.AN2.212	770	136	906	739	161	900	1806
18	NA.AN3.213	695	171	866	722	198	920	1786
19	NM.AN1.104	734	158	892	750	154	904	1796
20	NM.AN2.105	730	149	879	762	144	906	1785
21	NM.AN3.106	769	123	892	755	141	896	1788
22	TM.AN1.190	704	189	893	711	208	919	1812
23	TM.AN2.191	740	172	912	742	178	920	1832
24	TM.AN3.192	678	192	870	711	164	875	1745
25	UY.AN1.146	721	192	913	679	214	893	1806
26	UY.AN2.147	713	202	915	688	222	910	1825
27	UY.AN3.148	754	166	920	722	180	902	1822
28	YM.AN1.61	725	171	896	796	122	918	1814
29	YM.AN2.62	698	182	880	727	183	910	1790
30	YM.AN3.63	698	191	889	709	196	905	1794

Table 2 : Frequency occurrences of transitions of T-TN-LBP method on Disgust expression database.

		Transitions on Top- Left T-TN-LBP			Transitions on Bottom-Right T-TN- LBP			
S.No	Image Name	2	4	STLT	2	4	SBRT	TBT
1	KA.DI1.42	831	158	989	770	163	933	1922
2	KA.DI2.43	788	186	974	784	175	959	1933
3	KA.DI3.44	795	150	945	795	175	970	1915
4	KL.DI1.170	820	167	987	749	203	952	1939
5	KL.DI2.171	807	184	991	735	192	927	1918
6	KL.DI3.172	742	178	920	785	173	958	1878
7	KL.DI4.173	758	148	906	775	186	961	1867
8	KM.DI1.20	822	169	991	756	171	927	1918
9	KM.DI3.22	820	150	970	745	184	929	1899
10	KR.DI1.86	819	171	990	763	145	908	1898
11	KR.DI2.87	843	166	1009	726	172	898	1907
12	KR.DI3.88	792	156	948	778	179	957	1905
13	MK.DI1.128	833	144	977	794	151	945	1922
14	MK.DI2.129	837	132	969	789	163	952	1921
15	MK.DI3.130	806	160	966	764	183	947	1913
16	NA.DI1.214	798	182	980	767	186	953	1933
17	NA.DI2.215	834	168	1002	765	160	925	1927
18	NA.DI3.216	834	164	998	773	167	940	1938
19	NM.DI1.107	818	180	998	726	170	896	1894
20	NM.DI3.109	821	177	998	737	189	926	1924
21	TM.DI1.193	754	215	969	753	212	965	1934

22	TM.DI2.194	766	163	929	783	211	994	1923
23	TM.DI3.195	759	204	963	811	170	981	1944
24	UY.DI1.149	809	177	986	733	194	927	1913
25	UY.DI2.150	741	183	924	795	180	975	1899
26	UY.DI3.151	807	188	995	751	181	932	1927
27	YM.DI1.64	800	193	993	751	191	942	1935
28	YM.DI2.65	779	185	964	748	200	948	1912
29	YM.DI3.66	814	201	1015	758	155	913	1928
30	YM.DI4.67	847	195	1042	734	145	879	1921

Table 3 : Frequency occurrences of transitions of T-TN-LBP method on Fear expression database.

		Transitions on Top- Left T-TN-LBP			Transitions on Bottom-Right T-TN- LBP			
S.No	Image Name	2	4	STLT	2	4	SBRT	TBT
1	KA.FE1.45	796	195	991	844	194	1038	2029
2	KA.FE2.46	811	178	989	820	183	1003	1992
3	KA.FE3.47	783	192	975	815	189	1004	1979
4	KA.FE4.48	778	206	984	826	210	1036	2020
5	KL.FE1.174	778	197	975	832	192	1024	1999
6	KL.FE2.175	784	205	989	851	173	1024	2013
7	KL.FE3.176	796	197	993	843	199	1042	2035
8	KM.FE1.23	778	198	976	782	201	983	1959
9	KM.FE2.24	783	195	978	774	201	975	1953
10	KM.FE3.25	787	181	968	809	185	994	1962
11	KR.FE1.89	769	196	965	832	186	1018	1983
12	KR.FE2.90	792	186	978	818	183	1001	1979
13	KR.FE3.91	801	200	1001	830	197	1027	2028
14	MK.FE2.131	795	184	979	844	165	1009	1988
15	MK.FE3.132	802	180	982	832	174	1006	1988
16	MK.FE4.133	793	165	958	812	193	1005	1963
17	NA.FE1.217	793	188	981	801	190	991	1972
18	NA.FE2.218	783	188	971	824	181	1005	1976
19	NA.FE3.219	797	209	1006	856	173	1029	2035
20	NM.FE1.110	773	200	973	867	162	1029	2002
21	NM.FE2.111	783	186	969	820	177	997	1966
22	NM.FE3.112	798	184	982	825	164	989	1971
23	TM.FE1.196	796	208	1004	833	186	1019	2023
24	TM.FE2.197	814	199	1013	807	208	1015	2028
25	TM.FE3.198	793	189	982	823	200	1023	2005
26	UY.FE1.152	792	199	991	842	172	1014	2005

27	UY.FE2.153	819	194	1013	818	172	990	2003
28	UY.FE3.154	807	185	992	861	173	1034	2026
29	YM.FE1.67	803	196	999	826	177	1003	2002
30	YM.FE2.68	805	192	997	814	201	1015	2012

Table 4 : Frequency occurrences of transitions of T-TN-LBP method on Happiness expression database.

		Transitions on Top- Left T-TN-LBP			Transitions on Bottom-Right T-TN -LBP			
S.No	Image Name	2	4	STLT	2	4	SBRT	TBT
1	KA.HA1.29	847	207	1054	865	220	1085	2139
2	KA.HA2.30	847	193	1040	857	204	1061	2101
3	KA.HA3.31	823	210	1033	887	193	1080	2113
4	KA.HA4.32	832	221	1053	874	211	1085	2138
5	KL.HA1.158	809	251	1060	878	208	1086	2146
6	KL.HA2.159	844	208	1052	864	209	1073	2125
7	KL.HA3.160	839	204	1043	859	209	1068	2111
8	KM.HA1.4	839	217	1056	829	201	1030	2086
9	KM.HA2.5	849	185	1034	865	177	1042	2076
10	KM.HA3.6	782	238	1020	810	232	1042	2062
11	KM.HA4.7	831	215	1046	842	198	1040	2086
12	KR.HA1.74	823	217	1040	893	211	1104	2144
13	KR.HA2.75	831	204	1035	879	210	1089	2124
14	KR.HA3.76	819	199	1018	864	203	1067	2085
15	MK.HA2.117	827	211	1038	855	200	1055	2093
16	MK.HA3.118	831	185	1016	847	188	1035	2051
17	NA.HA1.202	835	208	1043	835	199	1034	2077
18	NA.HA2.203	833	205	1038	859	208	1067	2105
19	NA.HA3.204	863	196	1059	832	186	1018	2077
20	NM.HA1.95	836	211	1047	851	215	1066	2113
21	NM.HA2.96	842	202	1044	869	197	1066	2110
22	NM.HA3.97	857	186	1043	858	201	1059	2102
23	TM.HA1.180	826	208	1034	852	232	1084	2118
24	TM.HA2.181	817	236	1053	826	262	1088	2141
25	TM.HA3.182	823	223	1046	848	238	1086	2132
26	UY.HA1.137	846	222	1068	860	213	1073	2141
27	UY.HA2.138	861	212	1073	840	228	1068	2141
28	UY.HA3.139	824	213	1037	871	200	1071	2108
29	YM.HA1.52	833	220	1053	864	206	1070	2123
30	YM.HA2.53	826	214	1040	845	216	1061	2101

Table 5 : Frequency occurrences of transitions of T-TN-LBP method on Neutral expression database.

		Transitions on Top- Left T-TN-LBP			Transitions on Bottom-Right T-TN- LBP			
S.No	Image Name	2	4	STLT	2	4	SBRT	TBT
1	KA.NE1.26	871	214	1085	876	227	1103	2188
2	KA.NE2.27	868	195	1063	898	211	1109	2172
3	KA.NE3.28	863	199	1062	892	223	1115	2177
4	KL.NE1.155	861	227	1088	864	222	1086	2174
5	KL.NE2.156	871	220	1091	857	233	1090	2181
6	KL.NE3.157	873	226	1099	887	220	1107	2206
7	KM.NE1.1	844	221	1065	898	195	1093	2158
8	KM.NE2.2	843	242	1085	861	215	1076	2161
9	KM.NE3.3	877	208	1085	866	225	1091	2176
10	KR.NE1.71	858	207	1065	872	223	1095	2160
11	KR.NE2.72	862	224	1086	876	217	1093	2179
12	KR.NE3.73	871	233	1104	878	211	1089	2193
13	MK.NE1.113	894	185	1079	854	219	1073	2152
14	MK.NE2.114	886	203	1089	870	221	1091	2180
15	MK.NE3.115	861	201	1062	926	173	1099	2161
16	NA.NE1.199	888	214	1102	856	202	1058	2160
17	NA.NE2.200	873	237	1110	857	233	1090	2200
18	NA.NE3.201	900	188	1088	886	204	1090	2178
19	NM.NE1.92	860	191	1051	878	230	1108	2159
20	NM.NE2.93	876	202	1078	878	213	1091	2169
21	NM.NE3.94	930	210	1140	856	205	1061	2201
22	TM.NE1.177	855	228	1083	865	237	1102	2185
23	TM.NE2.178	849	245	1094	833	289	1122	2216
24	TM.NE3.179	834	239	1073	882	240	1122	2195
25	UY.NE1.134	873	204	1077	879	213	1092	2169
26	UY.NE2.135	874	214	1088	854	231	1085	2173
27	UY.NE3.136	881	210	1091	873	212	1085	2176
28	YM.NE1.49	851	215	1066	904	194	1098	2164
29	YM.NE2.50	888	186	1074	872	212	1084	2158
30	YM.NE3.51	887	214	1101	863	223	1086	2187

Table 6 : Frequency occurrences of transitions of T-TN-LBP method on Sadness expression database.

		Transitions on Top- Left T-TN-LBP			Transitions on Bottom-Right T-TN-LBP			
S.No	Image Name	2	4	STLT	2	4	SBRT	TBT
1	KA.SA1.33	846	236	1082	972	255	1227	2309

2	KA.SA2.34	882	213	1095	970	243	1213	2308
3	KA.SA3.35	886	205	1091	982	195	1177	2268
4	KL.SA1.161	883	210	1093	959	232	1191	2284
5	KL.SA2.162	878	222	1100	967	239	1206	2306
6	KL.SA3.163	873	224	1097	987	221	1208	2305
7	KM.SA1.9	949	203	1152	993	165	1158	2310
8	KM.SA2.10	873	213	1086	962	206	1168	2254
9	KM.SA3.11	920	197	1117	948	223	1171	2288
10	KM.SA5.13	847	221	1068	975	217	1192	2260
11	KR.SA1.77	866	203	1069	992	213	1205	2274
12	KR.SA2.78	851	230	1081	978	217	1195	2276
13	KR.SA3.79	867	213	1080	986	205	1191	2271
14	MK.SA1.119	829	222	1051	993	231	1224	2275
15	MK.SA2.120	882	171	1053	1021	188	1209	2262
16	MK.SA3.121	867	212	1079	982	206	1188	2267
17	NA.SA1.205	871	231	1102	983	201	1184	2286
18	NA.SA2.206	848	243	1091	974	251	1225	2316
19	NA.SA3.207	869	220	1089	980	215	1195	2284
20	NM.SA1.98	872	207	1079	973	209	1182	2261
21	NM.SA2.99	873	206	1079	955	226	1181	2260
22	NM.SA3.100	861	205	1066	980	217	1197	2263
23	TM.SA1.184	846	221	1067	980	225	1205	2272
24	TM.SA2.185	849	250	1099	995	224	1219	2318
25	TM.SA3.186	874	235	1109	959	253	1212	2321
26	UY.SA1.140	873	229	1102	975	232	1207	2309
27	UY.SA2.141	882	221	1103	1006	197	1203	2306
28	UY.SA3.142	885	232	1117	988	217	1205	2322
29	YM.SA1.55	846	225	1071	981	217	1198	2269
30	YM.SA2.56	871	232	1103	962	228	1190	2293

Table 7: Frequency occurrences of transitions of T-TN-LBP method on Surprise expression database.

		Transitions on Top- Left T-TN-LBP			Transitions on Bottom-Right T-TN-LBP			
S.No	Image Name	2	4	STLT	2	4	SBRT	TBT
1	KA.SU1.36	1005	231	1236	981	235	1216	2452
2	KA.SU2.37	973	234	1207	974	233	1207	2414
3	KA.SU3.38	1006	225	1231	983	237	1220	2451
4	KL.SU1.164	946	265	1211	988	238	1226	2437
5	KL.SU2.165	975	236	1211	991	226	1217	2428

6	KL.SU3.166	1007	227	1234	963	252	1215	2449
7	KM.SU1.14	967	211	1178	963	235	1198	2376
8	KM.SU2.15	928	241	1169	988	201	1189	2358
9	KM.SU3.16	957	216	1173	923	258	1181	2354
10	KR.SU1.80	956	233	1189	965	236	1201	2390
11	KR.SU2.81	949	262	1211	952	255	1207	2418
12	KR.SU3.82	959	228	1187	960	232	1192	2379
13	MK.SU1.122	977	215	1192	988	211	1199	2391
14	MK.SU2.123	963	214	1177	993	195	1188	2365
15	MK.SU3.124	964	220	1184	995	202	1197	2381
16	NA.SU1.208	962	228	1190	951	228	1179	2369
17	NA.SU2.209	956	250	1206	985	252	1237	2443
18	NA.SU3.210	1003	225	1228	989	228	1217	2445
19	NM.SU1.101	989	212	1201	963	221	1184	2385
20	NM.SU2.102	974	215	1189	997	216	1213	2402
21	NM.SU3.103	978	217	1195	941	228	1169	2364
22	TM.SU1.187	989	225	1214	990	240	1230	2444
23	TM.SU2.188	961	247	1208	950	256	1206	2414
24	TM.SU3.189	935	267	1202	976	235	1211	2413
25	UY.SU1.143	976	246	1222	954	270	1224	2446
26	UY.SU2.144	1004	238	1242	991	231	1222	2464
27	UY.SU3.145	979	246	1225	1001	234	1235	2460
28	YM.SU1.58	953	265	1218	996	216	1212	2430
29	YM.SU2.59	983	264	1247	986	210	1196	2443
30	YM.SU3.60	967	287	1254	974	235	1209	2463

Based on the above tables, classification algorithms for facial expressions are derived. The Algorithms 1, 2 derives facial expression classification based on frequency occurrences of 2, 4 transitions on STLT, SBRT respectively. The Algorithm 3 is derived based on the

TBT i.e Total number of transitions on both trapezoids of TN-LBP.

Algorithm 1: Facial Expression Recognition algorithm based on Frequency occurrences of STLT.
(STLT denotes Sum of Transitions on Top Left Trapezoid of TN-LBP includes sum of 2T and 4T)

```
Begin
if (STLT <= 920 )
print (“Facial Image is Anger Expression”)
else if ((STLT > 920) and (STLT<= 1045 ))
print (“Facial Image is Disgust Expression”)
else if ((STLT > 1045) and (STLT<= 1050))
print (“Facial Image is Fear Expression”)
else if ((STLT > 1050) and (STLT <=1075))
print (“Facial Image is Happy Expression”)
else if ((STLT > 1075) and (STLT <= 1110))
print (“Facial Image is Neutral Expression”)
else if ((STLT > 1110) and (STLT <=1170))
print (“Facial Image is Sadness Expression”)
else if (STLT> 1170)
print (“Facial Image is Surprise Expression”)
End.
```

Algorithm 2: Facial Expression Recognition algorithm based on Frequency occurrences of SBRT.
(SBRT denotes sum of transitions of Bottom Right Trapezoid of TN-LBP includes 2T and 4T)

```
Begin
        if (SBRT <= 920)
print ("Facial Image is Anger Expression")
else if ((SBRT > 920) and (SBRT <= 995))
print ("Facial Image is Disgust Expression")
else if ((SBRT > 995) and (SBRT < =1035))
print ("Facial Image is Fear Expression")
else if ((SBRT > 1035) and (SBRT <= 1105))
print ("Facial Image is Happiness Expression")
else if ((SBRT> 1105) and (SBRT <= 1125))
print ("Facial Image is Neutral Expression")
else if ((SBRT > 1125)  and (SBRT< =1230))
print ("Facial Image is Sadness Expression")
else if (SBRT > 1230)
print ("Facial Image is Surprise Expression")
End.
```

Algorithm 3: Facial Expression Recognition algorithm based on Frequency occurrences of TBT.
(TBT denotes the total number of Transitions on Both Trapezoids of TN-LBP)

```
Begin
if (TBT < 1835)
print ("Facial Image is Anger Expression")
else if ((TBT > 1835) and (TBT <= 1945 ))
print ("Facial Image is Disgust Expression")
else if ((TBT > 1945) and (TBT <= 2035))
print ("Facial Image is Fear Expression")
else if ((TBT > 2035) and (TBT <= 2150))
print ("Facial Image is Happiness Expression")
else if ((TBT> 2150) and (TBT <= 2220))
print ("Facial Image is Neutral Expression")
else if ((TBT > 2220) and (TBT<= 2325 ))
print ("Facial Image is Sadness Expression")
else if (TBT > 2325)
print ("Facial Image is Surprise Expression")
End.
```

Based on the above algorithms 1, 2 and 3, the present study evaluated success rate of classification of the facial expressions and results are shown in table 8 and corresponding graph is shown in Fig.4. From table 8, it is clearly evident that algorithm based on TBT has high classification rate than other two algorithms. The table 8 clearly indicates the algorithm based on STLT has low classification rate in recognizing the expressions like fear, happy and sadness. And also the algorithm based on SBRT failed in recognizing neutral and surprise facial expressions. The TBT has given high classification rate because where ever the STLT has failed; the SBRT performed well and vice versa is also true.

Table 8 : % of Facial Expression Classification based on proposed algorithms.

Facial Expression	STLT	SBRT	TBT
Anger	100	100	100
Disgust	96	83	100
Fear	0	70	100
Happy	33	86	100
Neutral	73	20	100
Sadness	10	93	100
Surprise	96	10	100

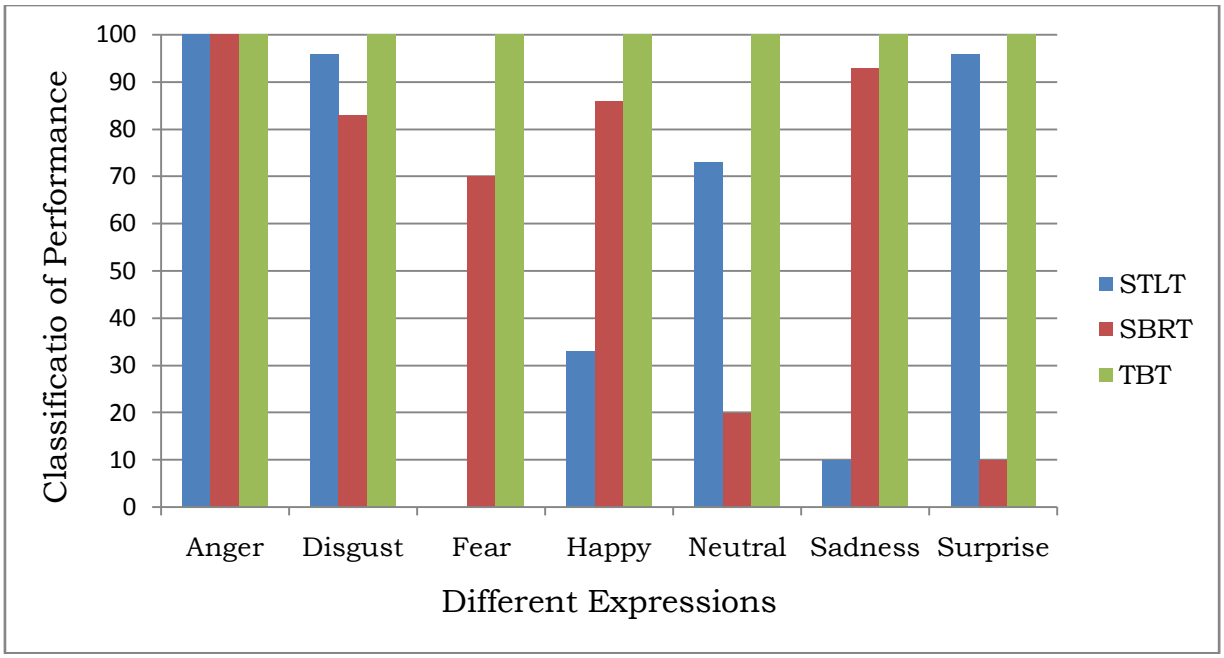

Figure 4 : Classification Performance of various algorithms.

IV. Comparison of The Proposed T-TN-LBP with Other Existing Methods

Table 9 shows the classification rate for various groups of facial expression by the proposed T-TN-LBP method with other existing methods like feature-based facial expression recognition within an architecture based on a two-layer perception of Zhengyou Zhang [2], Facial expression analysis by Dela Torre et.al [3] and Facial Expression Recognition Based on Distinct LBP and GLCM by Gorti SatyanarayanaMurthy et.al [4]. These methods are implemented on Kamachi and Gyoba[5] at Kyushu University-data set and compared with the proposed method. From table 9, it is clearly evident that, the proposed method exhibits a high classification rate than the existing methods. The graphical representation of this is also shown in Fig.5.

Table 9 : Classification rate of the proposed T-TN-LBP method with other existing methods

Image Dataset	Architecture based on a two-layer perception	Facial expression analysis	GLCM on DLBP of FCI Method	Proposed Method (T-TN-LBP)
Kamachi and Gyoba at Kyushu University, Japan-data set	80.29	91.79	96.67	100

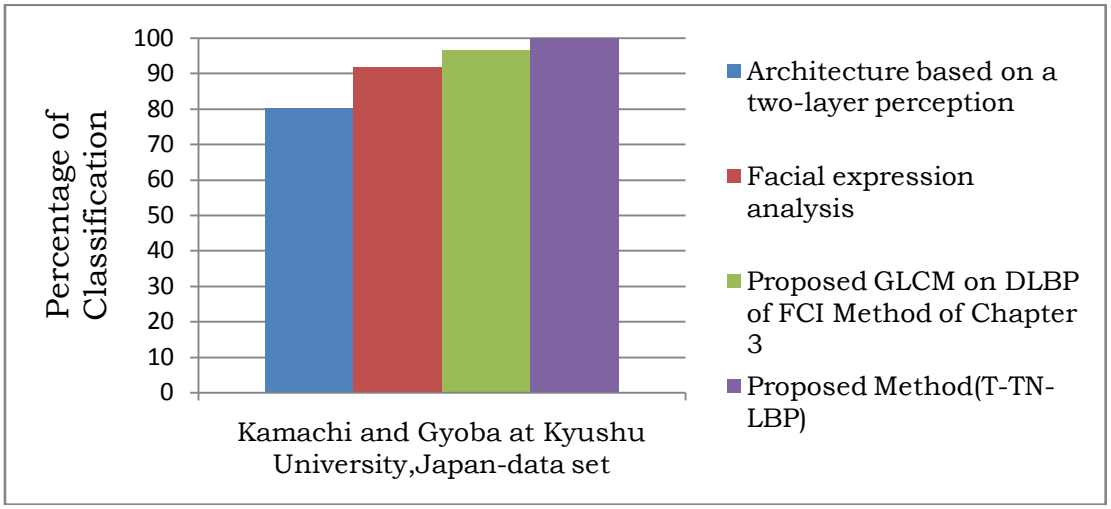

Figure 5 : Classification chart of proposed T-TN-LBP method with other existing methods.

V. Conclusions

The present paper derived new direction for various problems of image processing by deriving LBP on the third order neighborhood. The third order neighborhood consists of 12 pixels excluding centre pixel. This may lead to huge number of patters i.e. 2^{12}. The U-LBP on third order neighborhood leads to a negligible percentage of patterns. To overcome this, the present paper proposed transitions on T-TN-LBP. The T-TN-LBP considered 87.5% of transitions thus overcoming the disadvantage of U-LBP of third order neighborhood. The STLT, SBRT and TBT results of Table 8 clearly indicates an average facial expression classification result of 58%, 66% and 100% respectively.

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Fingerprint Recognition in Biometric Security - A Sate of the Art

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Abstract - Today, because of the vulnerability of standard authentication system, law-breaking has accumulated within the past few years. Identity authentication that relies on biometric feature like face, iris, voice, hand pure mathematics, handwriting, retina, fingerprints will considerably decrease the fraud. so that they square measure being replaced by identity verification mechanisms. Among bioscience, fingerprint systems are one amongst most generally researched and used. it\'s fashionable due to their easy accessibility. during this paper we tend to discuss the elaborated study of various gift implementation define strategies together with their comparative measures and result analysis thus as realize a brand new constructive technique for fingerprint recognition.

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I. Introduction

Humans have used body characteristics like face, voce, finger prints, Iris, etc. to acknowledge one another. Automatic recognition of those characteristics referred to as a biometrics; currently days it\'s become a full of life analysis space in pattern recognition. Over a decade\'s fingerprint is one amongst the oldest style of identification due to their individuality, consistency,the in trinsic ease in acquisition, distinctiveness,persistence and highmatching accuracy rate. As we know, No 2 folks have an equivalent set of fingerprints even identical twins fingerprints. Finger ridge patterns don\'t amendment throughout the lifetime of a personal. This property makes fingerprint a wonderful biometric symbol and can also be used as rhetorical proof. it\'s received a lot of and a lot of attention throughout the last amount because of the necessity for society in a very big selection of applications. Among the biometric options, the fingerprint is taken into account one amongst the foremost sensible ones. Fingerprint recognition needs a lowest effort from the user and provides comparatively sensible performance. Fingerprint recognition refers to the machine-controlled technique of corroborative a match between 2 human fingerprints. Fingerprints square measureone amongst several kinds of bioscience accustomed establish people and verify their identity.

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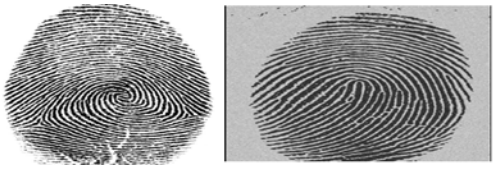

Figure 1.1 : Sample Finger Prints

Basically Skin of human fingertips consists of ridges and valleys and that they compounding along type the distinctive patterns. A fingerprint is that the composition of the many ridges and furrows. Fingerprints largely aren't distinguished by their ridges and furrows however square measure distinguished by point that square measure some abnormal points on the ridges. point is split in to 2 elements such as: termination and bifurcation. Termination is additionally referred to as ending and bifurcation is additionally referred to as branch. There are more point consists of ridges and furrows natural depression is additionally referred as follows.

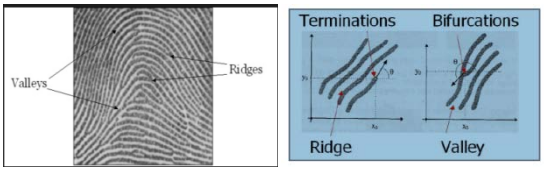

Figure 1.2 : pictures Showing Ridges and Valleys with Termination and Bifurcations

The human fingerprint is comprised of varied varieties of ridge patterns, historically classified in step with The decades-old Henry system: left loop, right loop, arch, whorl, and tented arch.

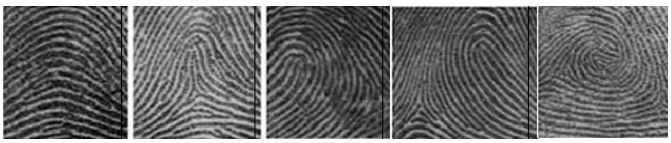

Fig.1.3 : left loop, right loop, arch, whorl, and tented arch of a Fingerprint

Fingerprint recognition system has been triple-crown for several application areas like laptop login, checking account recovery and cheque process. however the fingerprint recognition system still faces with defect in accuracy rate. the first objectives of the projected system can perform a lot of accuracy rate.

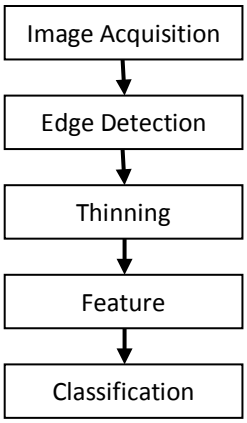

Figure 1.4 : Gender Classification Process

a) Image Acquisition

In any vision system the primary stage is that the image acquisition stage that is hardware dependent. variety of strategies square measure accustomed acquire fingerprints. Among them, the inked impression technique remains the foremost fashionable one. Inkless fingerprint scanners also are gift eliminating the intermediate digitization method. During this method we tend to usually use trivia extraction algorithmic program achieved by Binarization technique.

b) Edge Detection

An edge is that the boundary between 2 regions with comparatively distinct grey level properties. The set of pixels obtained from the sting detection algorithmic program rarely characterizes a boundary fully due to noise, breaks within the boundary and alternative effects that introduce spurious intensity discontinuities. Thus, edge detection algorithms usually square measure followed by linking and alternative boundary detection procedures designed to assemble edge pixels into meaning boundaries.

c) Thinning

Generally this technique is employed to neutralize all the constituent by examining the neighborhood of every constituent within the binary image and supported a specific set of pixel-deletion criteria. It conjointly checks whether or not the constituent is deleted or not. These sub-iterations continue till no a lot of pixels is deleted. the applying of the cutting algorithmic program to a fingerprint image preserves the property of the ridge structures whereas forming the binary image skeleton. This skeleton image is then utilized in the following extraction of trivia. Specially the cutting algorithmic program is employed to represent the structural form of a plane region is to scale back it to a graph. This reduction could also be accomplished by getting the skeleton of the region via cutting algorithmic program. However in broad spectrum the cutting algorithmic program is employed for edge detection. The cutting algorithmic program whereas deleting unwanted edge points ought to not:

- take away finish points.
- Break connectedness
- Cause excessive erosion of the region

d) Feature Extraction

Extraction of applicable options is one amongst the foremost necessary tasks for a recognition system. we tend to square measure exploitation back propagation algorithmic program to try to to this feature extraction. Feature Extraction is performed by following techniques.

1. Gauss Network technique.
2. Gradient technique.
3. Numerical technique.
4. Directive adaptive strategies.

Feature extraction cares with the quantification of texture characteristics in terms of a set of descriptors or quantitative feature measurements typically stated as a feature vector. it\'s fascinating to get representations for fingerprints that square measure scale, translation, and rotation invariant. Scale unchangingness isn't a major drawback since most fingerprint pictures may be scaled as per the dpi specification of the sensors. the current implementation of feature extraction assumes that the fingerprints square measure vertically bound. In reality, the fingerprints in our info aren't precisely vertically bound; the fingerprints could also be oriented up to removed from the assumed vertical orientation. This image rotation is part handled by a cyclic rotation of the feature values within the Finger Code within the matching stage.

e) Classification

RBF Neural Network classifier have a capability to be told from their expertise is that the key part within the drawback finding strategy of a pattern recognition task. A neural networks system is seen as Associate in nursing {information process information science |informatics| IP |science| scientific discipline} system composed of an outsized range of interconnected processing components. Every process part conjointly referred to as node, vegetative cell calculates its activity domestically on the idea of the activities of the cells to that it\'s connected. The strengths of its connections square measure modified in step with some transfer perform that expressly determines the cell's output, given its input. the educational algorithmic program determines the performance of the neural networks system. It ought to be noted that this network configuration is meant to just accept the load values that square measure obtained by protruding a take a look at pictures into image-space.

II. Literature Survey

Jain et.al. (2005) discussed in this paper about the attacks designed to extract information about the original biometric data of an individual from the stored template. These attacks are intended to either circumvent the security afforded by the system or to deter the normal functioning of the system. The different types of attacks discussed are; a fake biometric trait, Illegally intercepted data may be resubmitted to the system, The feature extractor may be replaced by a Trojan horse program that produces pre-determined feature sets, Legitimate feature sets may be replaced with synthetic feature sets, The matcher may be replaced by a Trojan horse program that always outputs high scores thereby defying system security, The templates stored in the database may be modified or removed, or new templates may be introduced in the database. The data in the communication channel between various modules of the system may be altered. The final decision output by the biometric system may be overridden. After discussing these attacks they suggested watermarking and steganography principles to enhance the integrity of biometric templates.

Ratha et.al. (2001) in this paper fingerprint authentication and the detail the stages of the fingerprint authentication process. Mostly they focused on vulnerable points of a biometric system for which they use a pattern recognition framework for a generic biometric system to help identify the possible attack points. As well they discussed the "Brute force attack directed at matching fingerprint minutiae" analyzes the resilience of a minutiae-based fingerprint authentication system in terms of the probability of a successful brute force attack. Even they tried "WSQ-based data hiding" and "Image-based challenge/response method," and "cancelable biometrics" to alleviate some of security threats.

Ross et.al. (2001) proposed a hybrid approach to fingerprint matching that combines a minutiae-based representation of the fingerprint with a Gabor-filter (texture-based) representation for matching purposes. The proposed algorithm first aligns the two fingerprints using the minutiae points extracted from both the images, andthen uses texture information to perform detailed matching.As a result, more information than minutiae points is being used to match fingerprints. The resultant matching score is combined with that obtained using the minutiaebased matching algorithm. Verification results suggest that the proposed hybrid approach is better suited for images acquired using compact solid-state sensors.
detection of center purpose within the fingerprint image. Otherwise, the algorithmic program is found to be terribly effective.

Mohamed et.al. (2002) proposed a fingerprint classification system and its performance in an identification system. The classification scheme is based on fingerprint feature extraction, which involves encoding the singular points (Core and Delta) together with their relative positions and directions obtained from a binarised fingerprint image. Image analysis is carried in four stages, namely, segmentation, directional image estimation, singular-point extraction and feature encoding. A fuzzy-neural network classifier is used to implement the classification of input feature codes according to the well known Henry system.

Hsieh et.al. (2003) proposed an effective wavelet-based method for enhancement of fingerprint image, which uses both the global texture and local orientation characteristic as well the wavelet transform can improve the clarity and continuity of ridge structures based on the multi resolution analysis of global texture and local orientation. Based on the hierarchical relationship of 2D wavelet transform, all the detail sub-images are reconditioned by reference to the related location of the approximation sub-image. This mechanism not only saves the computational time but also effectively improves the quality of fingerprint image like blur region and broken ridge.

Park et.al. (2004) proposed a novel approach for fingerprint classification based on Discrete Fourier Transform and nonlinear discriminant analysis. The directional images are constructed from fingerprint images utilizing DFT. Applying directional filters in the frequency domain after the transformation by the DFT achieves effective low frequency filtering, reducing the noise effects in fingerprint images.

The constructed directional images contain the essential directional structure which is common within each class and discriminates between classes. Kernel-based nonlinear discriminant analysis performs dramatic dimension reduction giving high quality discriminant information for classification by capturing global difference among classes. The fast algorithm FFT for DFT speeds up the preprocessing to construct directional images. Once the transformation matrix by KDA/GSVD is computed, the classification in the reduced dimensional space saves computational complexities further.

Sai et.al. (2005) proposed an approach that uses localized secondary features derived from relative minutiae information. A flow network-based matching technique is introduced to obtain one-to-one correspondence of secondary features. This method balances the tradeoffs between maximizing the number of matches and minimizing total feature distance between query and reference fingerprints. A two-hidden-layer fully connected neural network is trained to generate the final similarity score based on minutiae matched in the overlapping areas. The secondary features and matching algorithm have the following advantages: (i) can be easily adapted to existing applications; (ii) Are invariant to orientations,

overcoming one of the biggest challenges in partial fingerprint matching and (iii) localized features and dynamic tolerance areas provide the power to handle the spatial distortions. Solving the minutia matching problem by converting it into a minimum cost flow problem gives us an efficient way to find the optimal one-to-one correspondence between minutiae when the number of minutiae is not large.

Chikkerur et.al. (2006) proposed representation of localized texture features and also outline dimensionality reduction and also algorithm for identification. They used a multi-resolution representation using Gabor expansion to represent the minutiae neighborhood. The bases are derived using self similar Gabor elementary functions computed at multiple scales and orientations. They are biorthogonal bases. This approach tries to minimize the squared difference between the reconstructed and the original image.The performances are measured using the Cumulative Match Curve.

Fernandez et.al. (2007) in this work reviewed existing approaches for fingerprint image-quality estimation, including the rationale behind the published measures and visual examples showing their behavior under different quality conditions. Existing approaches have been divided into: 1) those that use local features of the image; 2) those that use global features of the image; and 3) those that address the problem of quality assessment as a classification problem. Local and global image features are extracted using different sources: direction field, Gabor filter responses, power spectrum, and pixel intensity values. In this paper, they also studied the effect of rejecting low-quality samples using a selection of quality estimation algorithms that includes approaches based on the three classes,

Yang et.al. (2008) proposed a a fingerprint verification system based on invariant moment features and nonlinear BPNN . A preprocessing enhancement with the STFT analysis makes the algorithm highly robust to poor-quality fingerprint images and improves the matching accuracy. Under the help of the enhancement, the reference point can be reliably and accurately determined with the complex filtering methods and LMS orientation estimation algorithm. Using the invariant moment analysis on sub-images, the extracted features have bound the effects of noise and non-linear distortions, while utilizing the invariant ability to the affine transformations of features to handle various input conditions. Matching the fingerprints is implemented by two measures: absolute distance and BPNN. The maximum, minimum and average elements of the vectors of input fingerprint, template fingerprint and the difference vectors of them are used as the BPNN inputs. As an excellent nonlinear classifier, the BPNN can improve the whole matching performance. But this system nee to improve robustness and reliability of proposed method.

Taok et.al. (2009) proposed a AFR system based on use of neural networks in an underground radio-localization system. In a highly aggressive environment such as mines, reliability and robustness are essential to any operational system. Using UWB as the physical wireless propagation medium and combined with fingerprinting-geolocation and neural networks, this work tends to overcome many of the problems encountered in indoor environments. Moreover a comparison between MLP and RBF performance is presented, providing a clear evidence of the role and importance of the neural networks in offering good accuracy and precision to the final system.

Hou et.al. (2010) in this review paper they summarized the progress on fingerprint orientation estimation, which can be categorized into local estimation and global modeling. The former is easy to code and advantageous in preserving true singularities. By contrast, the latter is able to yield more reliable solution in the presence of perturbations. Despite the numerous efforts in this field, the issue of fingerprint orientation estimation is far from being adequately addressed and further exploration is still necessary, in particular, to investigate orientation modeling with ability to preserve singularity and to develop advanced methods for local structure inference using global information.

Bansal et.al. (2011) in their review paper they broadly classified the fingerprint classification techniques as those working on binarized images and those that work on gray scale images directly. The approaches are distinguished on the basis of several factors like: the kind of input images they handle i.e. whether binary or gray scale, techniques of binarization and segmentation involved, whether thinning is required or not and the amount of effort required in the post processing stage, if exists. But low quality fingerprint images need preprocessing to increase contrast, and reduce different types of noises as noisy pixels also generate a lot of spurious minutiae as they also get enhanced during the preprocessing steps

Zhang et.al. (2012) in this paper studies image local features induced by the phase congruency model, which is supported by strong psychophysical and neurophysiological evidences, for FKP recognition. So they developed a new effective feature extraction and matching method for FKP recognition. For this they analyzed three commonly used local features, the local orientation, the local phase, and the phase congruency systematically and presented a method for computing them efficiently using the phase congruency computation framework. Codingand matching algorithm for each local feature was presented.

Yoon et.al. (2012) proposed a algorithm based on the features extracted from the orientation field and minutiae satisfies the three essential requirements for

alteration detection algorithm:1) fast operational time, 2) high true positive rate at low false positive rate, and 3) ease of integration into AFIS. The proposed algorithm and the NFIQ criterion were tested on a large public domain fingerprint database (NIST SD14) as natural fingerprints and an altered fingerprint database provided by a law enforcement agency.

Subrat Kumar Sahu et al. (2012) projected a brand new technique for fingerprint image improvement yet as matching algorithmic program supported directional curvature technique (DCT) of native ridges and a changed Tree primarily based matching approach. during this technique in preprocessing stage, the Fingerprint is De-noised, Binarized, cut and also the approximate core points square measure calculated by DCT algorithmic program. The trivia points square measure extracted by guide filtering over the image. characteristic all the trivia accurately yet as rejecting false trivia. Here they focused on the cutting and matching algorithmic program for the identification method wherever cutting method uses a changed approach of reiterative Rotation Invariant cutting algorithmic program (RITA) that is ensures the properly characteristic the trivia purpose

Madhuri et al.(2012) printed a SURF (Speeded up strong Features) primarily based technique during which they used native strong options for fingerprint illustration and matching as SURF (Speeded up strong Features) are reported to be strong and distinctive in representing native image info and located to be rotation-invariant interest purpose detector and descriptor. This approach perform person recognition in presence of revolved and partial fingerprint pictures and would be expeditiously able to differentiate between real and shammer matches of accuracy and speed. however fails once we image with the less quality is taken.

Ritu Kaur et.al.(2012) proposed a a novel method to estimate gender by analyzing fingerprints using fast Fourier transform (FFT), discrete cosine transform (DCT) and power spectral density (PSD).

Gender identification results using frequency domain analysis showed that this method could be considered as a prime candidate for use in forensic anthropology in order to minimize the suspects search list and give a likelihood probability value of the gender of a suspect. This method uses a optimal thresholding for each transform is chosen for better results. But when this method is tested on low quality images , it has issues of accuracy. Hence to enhance the performance a good quality fingerprint images must be used. Hence to improve the performance in real time scenarios with low quality patterns, it need be preprocessed and represented (SSS) properly .In future, more work

Gnanasivam P et.al.(2012) proposed a novel method wavelet transform (DWT) and singular value decomposition (SVD). The classification is achieved by extracting the energy computed from all the sub-bands of DWT combined with of gender Classification from fingerprint is proposed based on discrete the spatial features of non-zero singular values obtained from the SVD of fingerprint images. K nearest neighbor (KNN) used as a classifier.The SVD approach is selected for the gender discrimination because of its good information packing characteristics and potential strengths in demonstrating results. The SVD method is considered as an information oriented technique since it uses principal components analysis procedures (PCA), a form of factor analysis, to concentrate information before examining the primary analytic issues of interest K-nearest neighbors (KNN), gives very strong consistent results. It uses the database which was generated in the learning stage of the proposed system and it classifies genders of the fingerprints.

But singular values are not with lower magnitude are not visible hence the perfornacce may get affected on low quality inputs. Hence there should be some method which will help in increasing the magnitude of the invisible pixels.

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Detection of Optic Disc and Hard Exudates using TWIN PLANE Gradient Windowing Technique

By G. Ferdic Mashak Ponnaiah & Capt. Dr. S. Santhosh Baboo
Bharathiar University, India

Abstract - Detection of Optic disc (OD) in a fundus image is a foremost important step in the process of screening the diabetic retinopathy [1,4,18]. Hard Exudates detection algorithms usually find lot of false positives since the intensity and color distribution of OD will much resemble that of a Hard Exudates region [15,16]. So, most of the Exudates detection algorithms will miss classify the pixels at the OD region as Hard Exudates [2].

In our previous works, we used Genetic Algorithm(GA)[23,24] to find the OD location and size and reduced overall time, even doing the search on the entire problem space and also removed false hard exudates. In this work we are improving Hard Exudates detection accuracy using gradient index mapping technique applied on two similar planes of the RGB. The new algorithm is termed as TWINGRAB use the two planes of the RGB after proper gradient projection. The database used for this preprocessing is DIARETDB1[10].

Index terms: diabetic retinopathy, hard exudates, optic disc detection.

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Strictly as per the compliance and regulations of:

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G. Ferdic Mashak Ponnaiah [α] & Capt. Dr. S. Santhosh Baboo [σ]

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I. Introduction

Detecting hard exudates is a challenging process; hence there is research gap in fine tuning the process by introducing hybrid algorithms in finding the exudates which is a significant milestone to identify the diabetic retinopathy. The primary goal to achieve is a proper detection of Optic Disc which got similar pixel intensity and gradient like hard exudates. In the previous work based on the threshold value we have considered either the green plane or blue plane to detect the Optic Disc based on the colour intensity. In these work two similar planes of RGB plane is used to detect the feature candidates. A new algorithm called TWINGRAWB (TWIN PLANE INTENSITY GRADIENT WINDOWING BOUNDARY TECHNIQUE) is applied on two similar planes to find the Optic Disc and Hard Exudates.

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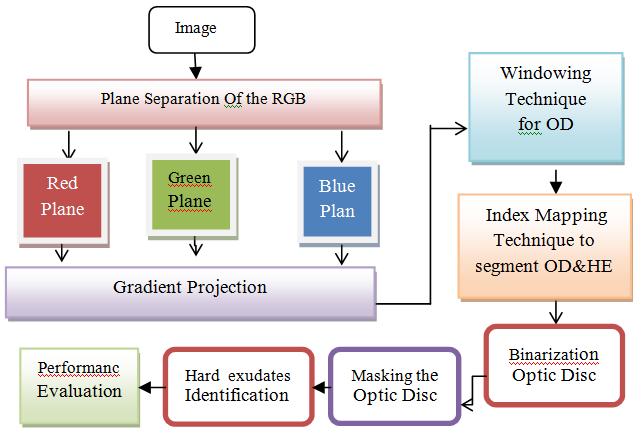
II. Future Method

a) TWINGRAB Algorithm

The steps involved in the proposed method is as follows:

Step1. Input the Red, Green and Blue plane.
Step2. Enhance the gradient of each plane.
Step3. Compare the two similar planes showing the optic disc location.
Step4. Identify the optic disc using pixel gradient and Index mapping to detect the hard exudates.
Step5. Find the optic disc boundary using binarization technique.
Step6. Mask the Optic Disk region since the hard exudates also have the same pixel.
Step7. After masking the Optic Disk Identify the feature hard exudate candidates.

b) Flow Diagram



c) Gradient Projection & Windowing Technique

The gradient is a generalization of the usual concept of derivation to find the function of many variables. Consider the function f(x1, ..., xn) which is a differentiate function of several variables called scalar field. The gradient of the scalar field is the vector of the *n* partial derivate of the function *f*. By this a vector value function is termed as vector field.

The function of the graph is represented by the slope of and the tangent of the image. More exactly, the gradient points in the direction of the greatest rate of increase of the function and the slope of the graph is the

magnitude in that direction. The tangent space equation of the graph is the non-constant coefficient of the component of the graph.

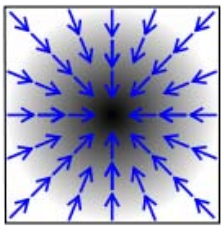


Figure 1

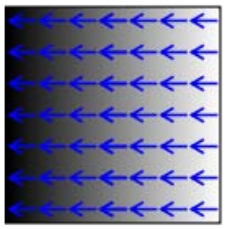


Figure 2

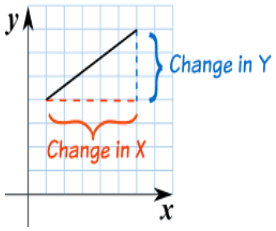
In the above Figure.1 and Fgure.2 , the values of the function are represented in black and white, black representing higher values, and its corresponding gradient is represented by blue arrows.

Consider a surface whose height above sea level at a point (x, y) is H(x, y). The gradient of H at a point is a vector pointing in the direction of the steepest grade or slope at that point. The steepness of the slope at that point is given by the magnitude of the gradient vector. The gradient may also use to measure how a scalar field changes in other directions, than just the direction of greatest change, by making a dot product.

The gradient is a vector operator denoted by . It is more often applied to a real function of three variables and may be denoted as,

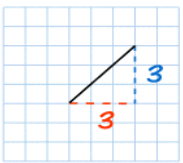
$$\nabla f = grad(f)$$

The method to calculate the Gradient is: Divide the change in height by the change in horizontal distance. It is denoted as,



Gradient=Change in vertical axis(Y)/Change in horizontal axis(X)

For example,



The gradient for this line=3/3=1. So the gradient is equal to 1.

Gradient can be applied to the histogram equalized image. After equalization of the image, the gradient of the image is to be found to analyze the image edge strengths. In general gradient of the image returns gradient values with respect to both axis Gx and Gy respectively.

The final magnitude of the gradient is obtained by,

$$|G| = |Gx| + |Gy|$$

Gradient for each plane as shown in Figure.3, Figure.4 and Figure.5 is obtained with the help of above algorithm in which magnitude and direction can be calculated to identify edge strength.

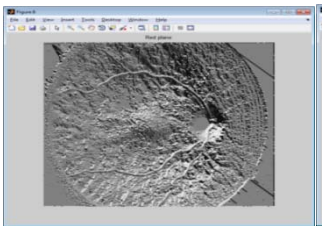


Figure 3 : Red Plane

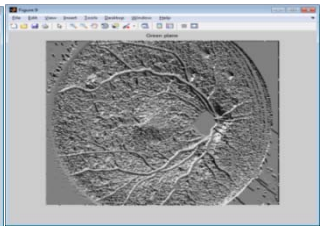


Figure 4 : Green Plane

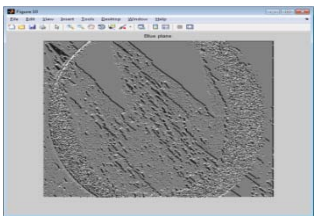


Figure 5 : Blue Plane

d) Advantage Of Twin Plane

The above gradient output image of blue plane shows no sign of Optic disk and Hard exudates when compare with the Red plane and Green plane. The Red plane and Green plane shows the feature extraction candidates clearly and considered as twin plane for the detection of Optic disc and Hard exudates. The twin plane technology helps to confirms the area of segmentation as there are more than one plane shows the same area of feature candidates for segmentation and provides a strong base for the further detection of true positive hard exudates.

e) Index Mapping Technique

The index mapping is a kind of technique to manage the digital images colors in a limited fashion, in order to save computer resource such as memory and storage of files when doing certain operations such as speeding up display refresh and file transfers. This is a kind of vector quantization compression.

Index mapping technique is used in which depends on pixel value arrangement index value to be assigned. The color index is a simple numerical expression that determines the color of an object, Index maps are a type of seeking tool that allow users find a set of maps covering their regions of interest along with the name or number of the relevant map sheet. In this segmentation for each index value, color to be assigned according to the value assigned for individual color.

It is limited to 256 colors, which can be any 256 from the set of 16.7 million 24 bit colors. Each color used is a 24 bit RGB value. Each such image file contains its own color palette, which is a list of the selected 256 colors (or 16 colors in a smaller palette). Images are called indexed color because the actual

image color data for each pixel is the index into this palette as color space. When an image is processed in this way, color information is not directly carried by the image pixel data, but is stored in a separate piece of data called palette array of color elements, in which every element, a color, is indexed by its position within the array. The image pixels do not contain the full specification of its color, but only its index in the palette. It also is done in two methods:

1. *Dithering* - Dithering means representing a color by combinations of dots of other colors. Dots is pretty much the definition. If the one exact shade of pink is not in the palette, then dots of other palette colors are mixed to simulate the color. Dithering often causes a visible and objectionable dotted or speckled image. But that simulated color may be much closer than a nearest color approximation.
2. *Nearest color* - This selection is the same as disabling dithering, or no dots. If the exact shade of pink is not in the palette, then the closest color in the palette is used, which might not be very pink at all. Sometimes exact color is not important. No dithering means no visible dots.

Indexation of images is a way of compressing the image without any data loss. Indexing an image will keep the resolution and color space intact, but the structure of the image will change. When an image is indexed an index table will be created. This is a list of the different colors that are used. The image itself will contain reference numbers to this index table as shown in fig 6. Especially when the image uses a lot the same colors, this can save a lot of space. Indexing an image won't change the way an image looks or will be printed. Each pixel will keep its original color.

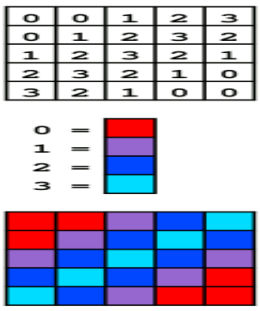


Figure 6 : color Index mapping

The above example represents the index mapping technique carried out for each image. Depends on the pixel value index value like 0,1, 2, 3 are to be assigned for each segmentation as shhown in Figure.6. If an image uses a lot of different colors, indexing this image will not make decrease the file size. In this case the image will not be indexed.

f) Binarization

Binarization is used for segmentation process in which required portion can be separated from the object. Here threshold value to be fixed for the image in which value below the threshold level then it will be assigned to binary '0' and above threshold level assigned to binary '1'. Depends on this process, image to be segmented in which optical disk portion can be detected from the iris image. This process is to be performed on the index mapped image from which threshold value to be labeled to corresponding pixel value in the image. Based on labeled pixel each are grouped to segment an image as shown in Figure.7. The output of the binarization fundus image is shown below in Figure.8 and the detetection of Optic Disc is shown in Figure.9.

g) Hard Exudates Detection

Masking is the process of removing unwanted portion from an image. In this process, threshold value to be assigned for an image for removal of unwanted portion in the iris image in which masking is applied. It can do so by taking the minimum and maximum value in the image in which average one as taken as threshold value for segmentation. This masking method masks the image contains the value below threshold level and hard exudates are recovered from the image as shown in Figure.10.

Screen Shorts of The Output Image

Index Mapping

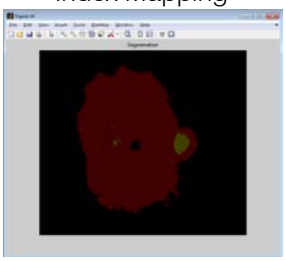


Figure 7

Binarization OD&HE

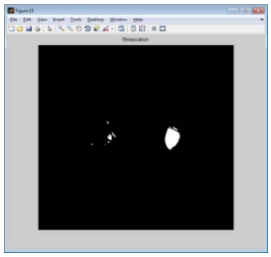


Figure 8

Optic Disc Detection

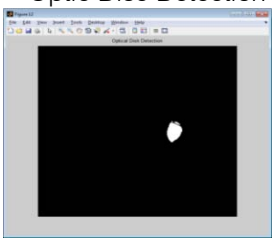


Figure 9

HE by masking OD

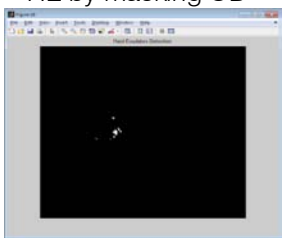
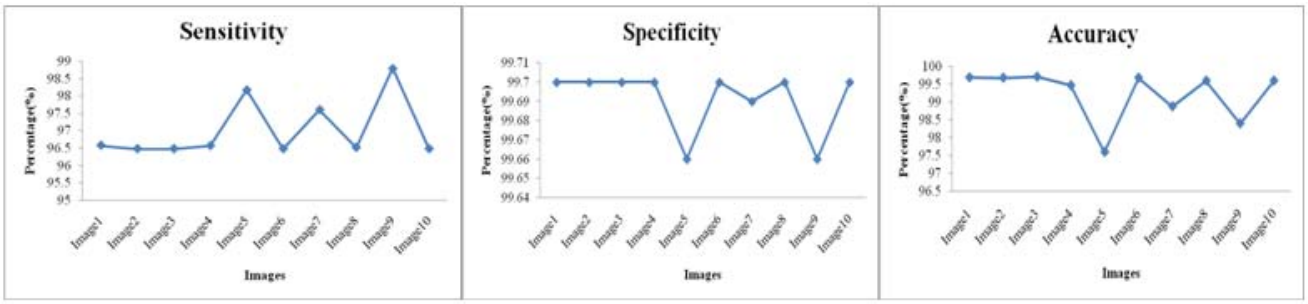
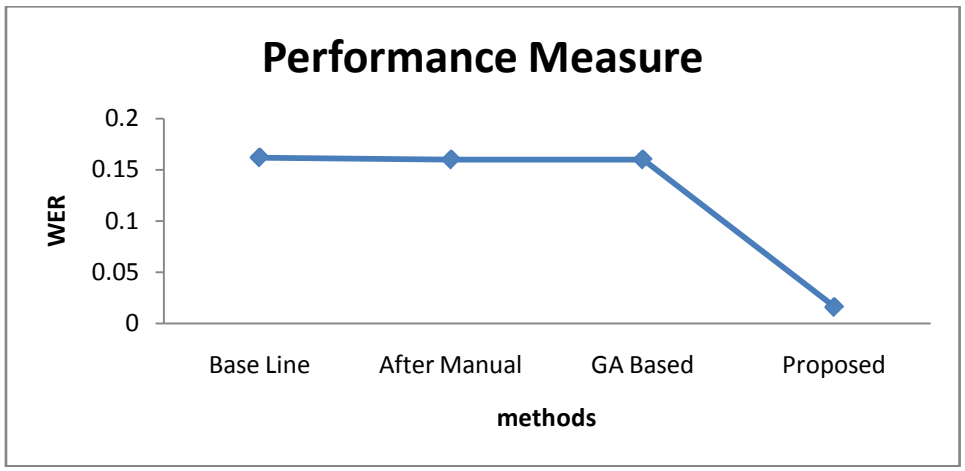


Figure 10

III. Result and Analysis

Images	TP	TN	FP	FN	Sensitivity(%)	Specificity(%)	Accuracy(%)
Image 1	1223	259404	781	43	96.58	99.69	99.69
Image 2	1223	259380	780	44	96.48	99.28	99.68
Image 3	1224	259466	781	45	96.48	99.73	99.71
Image 4	1221	258842	780	43	96.57	99.64	99.47
Image 5	1198	253962	870	22	98.18	99.66	97.6
Image 6	1224	259390	781	45	96.48	99.82	99.68
Image 7	1214	257307	807	30	97.61	99.69	98.88
Image 8	1223	259168	780	44	96.52	99.42	99.6
Image 9	1208	256048	867	15	98.8	99.66	98.4
Image10	1223	259181	780	45	96.48	99.55	99.6





performance	specificity	sensitivity	WER
Base line	0.927	0.75	0.162
manual	0.78	0.9	0.160
GA Based	0.78	0.9	0.160
Proposed	0.997	0.965	0.016

IV. Conclusion

The TWINGRAB algorithm is simple and efficient method to detect the Optic Disc and Hard exudates in the fundus image. A proper detection of Optic Disc and Hard Exudates will help in the diagnosis of the DIABETIC RETINOPATHY eye disease in the fundus image of the eye retina which is the main cause of the vision loss in the diabetic society. This TWINGRAB algorithm may used as a diagnostic tool where the large volume of the patients to be screened and thus reduce the pain of the eye examiners in the eye hospital and eventually useful in generating accurate results of the patients and lead to proper treatment to prevent the vision loss of the diabetic eye. The Weighted Error Rate (WER) of the proposed TWINGRAB is low compare with the baseline, manual and GA based method. This can be used in health care service to prevent the vision loss by early detecting the diabetic retinopathy. Similarly this can be further enhanced to detect various symptoms in the eye fundus image.

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Crowd Behavior Analysis and Classification using Graph Theoretic Approach

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Abstract- Surveillance systems are commonly used for security and monitoring. The need to automate these systems is well understood. To address this issue we introduce the Graph theoretic approach based Crowd Behavior Analysis and Classification System (GCBACS). The crowd behavior is observed based on the motion trajectories of the personnel in the crowd. Optical flow methods are used to obtain the streak lines and path lines of the crowd personnel trajectories. The streak flow is constructed based on the path and streak lines. The personnel and their respective potential vectors obtained from the streak flows are used to represent each frame as a graph. The frames of the surveillance videos are analyzed using graph theoretic approaches.

Keywords: video surveillance, crowd motion, crowd behavior, optical flow, streak lines, path lines, streak line flow, graph theory, threshold, abnormal, normal, activity, classification.

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Crowd Behavior Analysis and Classification using Graph Theoretic Approach

Najmuzzama Zerdi [α], Dr. Subhash S Kulkarni [σ], Dr. V .D. Mytri [ρ] & Kashyap D Dhruve [ω]

Abstract- Surveillance systems are commonly used for security and monitoring. The need to automate these systems is well understood. To address this issue we introduce the Graph theoretic approach based Crowd Behavior Analysis and Classification System (***GCBACS***). The crowd behavior is observed based on the motion trajectories of the personnel in the crowd. Optical flow methods are used to obtain the streak lines and path lines of the crowd personnel trajectories. The streak flow is constructed based on the path and streak lines. The personnel and their respective potential vectors obtained from the streak flows are used to represent each frame as a graph. The frames of the surveillance videos are analyzed using graph theoretic approaches. The cumulative variation in all the frames is computed and a threshold based mechanism is used for classification and activity recognition. The experimental results discussed in the paper prove the efficiency and robustness of the proposed ***GCBACS*** for crowd behavior analysis and classification.

Keywords: video surveillance, crowd motion, crowd behavior, optical flow, streak lines, path lines, streak line flow, graph theory, threshold, abnormal, normal, activity, classification.

I. Introduction

Video surveillance systems fed by multiple high definition video streams have become a common feature in public and private spaces. The video surveillance systems are generally used to monitor activities and maintain vigil. The steady population growth observed in the past decade have resulted large crowd movements especially in public spaces like airports, train stations , bus stations, shopping malls, religious places, etc. The video surveillance feeds of such public spaces are currently monitored manually and are prone to human error. The number of crowd accidents observed have increased in the recent times [1].

The need for automated systems to classify the movements of crowds or detect abnormal activity can be considered as an open research issue. A crowd can be considered as a collection of people distributed over the region of interest. Tracking of human activity or personnel counting within video surveillance systems has been researched upon [2] [3] [4] for some time now. The open research issues that exist and require attention with respect to crowd analysis can be listed as modelling or knowledge extraction from crowd patterns [5][6][7][8] and crowd behavior analysis [9] [10] [11]. Limited work is carried out to classify the behavior of crowds in surveillance systems. The research work presented in this paper introduces the Graph theoretic approach based Crowd Behavior Analysis and Classification System (***GCBACS***). To achieve accurate classification results the behavior of the personnel in the crowd needs to be analyzed first. The behavior of the personnel in the crowd can be analyzed based on the motion or trajectory activities observed. Based on the behavior of the personnel analyzed, it can be classified into normal or abnormal activity. Abnormal activity detection is achieved by observing unusual behavior of personnel or group of personnel within a crowd. Activities like instantaneous disbursement, sudden convergence or fighting are classified as abnormal activities.

To study the behavior of personnel in the crowd, tracking methodologies are generally used. The commonly used tracking methodologies [2] [3] [4] fail when large crowds are considered. To overcome this drawback, researchers proposed the consideration of fixed cell sizes to identify local trajectories and later map it together to obtain the personnel trajectory patterns [8] [10] [12]. The frames are split into uniform cells in these approaches. The use of optical flow techniques within each cell is considered to obtain the trajectory patterns of personnel within a cell. The optical flow techniques exhibited better results when compared to traditional tracking methodologies [13]. The drawback of the optical flow is that only two consecutive frames are considered to obtain personnel trajectory patterns. The optical flow method are not able to capture long term does temporal dependencies [14]. To overcome this drawback the concept of particle flow was introduced in [14]. The particle flow computation is achieved by displacing a grid of particles with optical flow through numerical integration techniques, providing trajectories that relate a particles original position to its position at a later time. The particle flow mechanisms proved to be computationally very heavy and minute personnel

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motion details were ignored. The introduction of streaklines flows to obtain the trajectories of personnel in the crowd proved to provide accurate analysis results [15]. For crowd behavior classification in [16] an unsupervised machine learning technique based framework was proposed. The framework in [16] considered hierarchical Bayesian models to connect the visual features, "atomic" activities and the interactions for classification. In [15] streaklines coupled with social force models were used to detect abnormal activities.

The work carried out so far by researchers, primarily concentrates on analysis of activities amongst a few personnel present in the crowd only, and do not take into account the inter personnel activities for classification. To overcome this drawback the $GCBACS$ presented in this paper considers inter personnel activities for analysis. The inter personnel activities are monitored through the motion vectors observed. To obtain the behavioral vectors of personnel in the crowd video an optical flow is initially computed. Based on the optical flow the path lines and streak lines are obtained. The path lines, streak lines are used to derive the streak flow vectors which define the potential and personnel flow. Every frame of the video is analyzed using graph theoretic approaches. The $GCBACS$ considers each frame as a graph with sub graphs. All the frames are analyzed and the cumulative variance is computed. If the $GCBACS$ observes that the cumulative variance is greater than a threshold the activity of the personnel in the crowd is classified as an abnormal activity.

The remaining manuscript is organized as follows. Section two discusses the literature review. The $GCBACS$ is discussed in section three of the paper. The experimental study conducted to evaluate the performance of the $GCBACS$ is discussed in the penultimate section of the paper. The conclusion and future work is discussed in last section of this paper.

II. Literature Review

In this section of the paper a brief of the literature review conducted during the course of the research work presented here is discussed.

Hang Su et al. [17] propose a novel spatio-temporal viscous fluid field to recognize the large-scale crowd behavior from both the appearance and driven factor perspectives and present a spatio-temporal variation matrix to capture crowd motion characteristics and model the motion pattern as a spatio-temporal variation fluid field. They construct a codebook by clustering neighboring pixels with similar spatio-temporal features, and consequently, crowd behaviors are recognized using the latent Dirichlet allocation model. The drawbacks of this paper, when the interaction among pedestrian and estimate the interaction force between the pedestrians with sheering force in viscous fluid, which is referred to as spatiotemporal force field.

Si Wu et al. [18] proposed approach which is based on optical flow. For low quality videos, the resulting optical flow fields become unstable. To reduce the impact of noise, we use a regular grid to partition the flow field into a set of patches and focus on the average optical flow vector of each patch. The drawback of the proposed approach is limited by the accuracy of optical flow estimation.

BerkanSolmaz et al [19] proposed a framework to identify multiple crowd behaviors (bottlenecks, fountainheads, lanes, arches, and blocking) through stability analysis for dynamical systems, without the need for object detection, tracking, or training. The proposed method is deterministic and cannot capture the randomness inherent in the problem without a stochastic component.

Duan-Yu Chen et al. [20] proposed a real time constraint, each isolated region is considered a vertex and a human crowd is thus modeled by a graph. To regularly construct a graph, Delaunay triangulation is used to systematically connect vertices and therefore the problem of event detection of human crowds is formulated as measuring the topology variation of consecutive graphs in temporal order.

NuriaPelechano et al. [21] have shown a significant improvement in evacuation rates when using inter-agent communication. We can also observe the grouping behavior that emerges when there are a high percentage of dependent agents in the crowd. Only a relatively small percentage of trained leaders yield the best evacuation rates. We can visualize these results in real time with either our simple 2D or 3D viewer. Areas where there is room for improvement include adding individualism into Helbing's model so that agents would have different local motions depending on their roles.

III. Graph Theoretic Approach Based Crowd Behavior Analysis and Classification System (GCBACS)

a) System Modeling

Let us consider a surveillance video $F \times n$. The video represents a set of F frames and the dimension of each image n is $a \times b$ pixels. Let us consider a frame P at the t^{th} time instance and $P \in F$. Similarly the frame at the $(t+1)^{th}$ time instance is represented as Q .The frame $F^1 \in F$ is split into a number of blocks and a mesh based structure is created for computational ease. Let the set $\mathrm{I} \subset \mathrm{J}^2$ represent the crowd personnel to be observed in the surveillance video spaceJ^2. The set I consists of M personnel. The trajectory of the m^{th} personnel i.e. $m \in M$ at the time instance $\dot{t}$can be represented as $m\,(t{:}\,t_{\dot{t}}, m_{\dot{t}})$. At the initial instance i.e. $\dot{t} = 0$ the trajectory is represented as $m\,(t{:}\,t_0, m_0)$. The trajectories is utilized for optical

flow $\bar{J}$ computations. From the optical flows the streak lines Λ and path lines K of the personnel in the crowd are computed frame wise. The streak flow Γ is then derived which is used for analysis. For analysis a graph theoretic approach is adopted in the $GCBACS$. Each frame is considered as a graph $\mathbb{G}$ and analysis is carried out on the similarity and deviations are observed. Cumulative variance $\overline{\mathbb{F}_{\mathbb{V}}}$ is computed considering all the previous frames and the current frame. If the variance is greater than the threshold φ then abnormal activity is said to be detected. The $GCBACS$ proposed in this paper can be understood based on the model shown in Figure 1 of this paper.

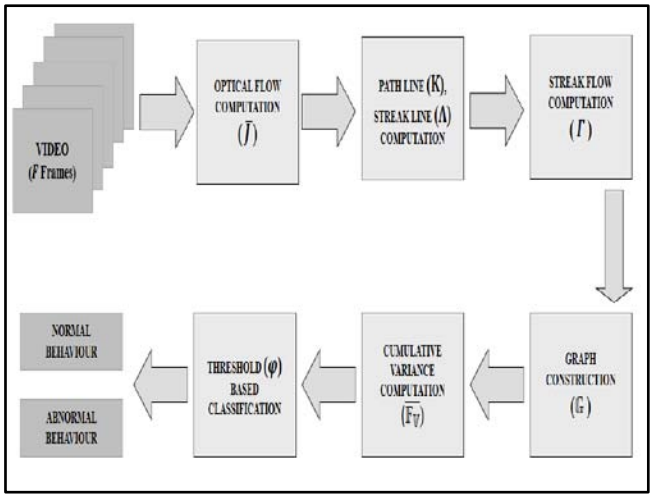

Figure 1 : GCBACS model overview

b) Optical Flow Computation

In $GCBACS$ the Lucas &Kanade based methodology is used to compute the differential optical flow of the crowd vectors. The optical flow enables trajectory detection of personnel in the crowd. Let the velocity field defined over the set I be represented as $v\,(M,t)$. The velocity satisfy the continuity in time C^0 and continuity in space C^2 domain to obtain smooth optical flows. To achieve optical flow computation a hierarchical graph structure is considered to represent the video $F \times n$. Let the levels L of the graph be defined as $L = 1,2,3 \ldots L_{max}$. If e represents the velocity then the optical flow residual vector e^{L-1} is used to minimizes the function vector $\epsilon^{L-1}(e^{L-1})$. Similarly the matching function ε^L can be minimized using the residual vector e^L. The primary guess for the L^{th} level of the optical flow is denoted as $g^L = [g_a^L g_b^L]$. The value of g^L is obtained by optical flow computations from L_{max} to $L-1$. The frame P and Q can be represented on the basis of the optical flows computed at all the levels and is represented as

$$\forall(a,b)\,\epsilon\,([p_a-\omega_a-1, p_a+\omega_a+1] \times [p_b-\omega_b-1, p_b+\omega_b+1]), P(a,b) = U^L(a,b) \quad (1)$$

$$\forall(a,b)\epsilon([p_a-\omega_a, p_a+\omega_a] \times [p_b-\omega_b, p_b+\omega_b]), Q(a,b) = V^L(a+g_a^L, b+g_b^L) \quad (2)$$

Where ω_a, ω_b are two integer values and U and V represent the previous two frames.

Based on the above equations it can be observed that there exist a domain definition difference between $Q(a,b)$ and $P(a,b)$. The optical flow representation of the frame $Q(a,b)$ is defined over the window size $(2\omega_a+3) \times (2\omega_b+3)$ instead of using $(2\omega_a+1) \times (2\omega_b+1)$. Consider that the displacement vector is $\bar{J} = [J_a \;\; J_b]^T = e^L$ and image position vector is $N = [p_a \;\; p_b]^T$. The vector $\bar{J}$ minimizes the matching function $\varepsilon(\bar{J})$. The function $\varepsilon(\bar{J})$ is defined as

$$\varepsilon(\bar{J}) = \varepsilon(J_a\, J_b) = \sum_{a=p_a-\omega_a}^{p_a+\omega_a} \sum_{b=p_b-\omega_b}^{p_b+\omega_b} ((P(a,b) - Q(a + J_a, b + J_b))^2) \quad (3)$$

An iterative Lucas –Kanade method is adopted to solve the function $\varepsilon(\bar{J})$ and is represented as

$$\frac{\partial\varepsilon(\bar{J})}{\partial\bar{J}} = -2 \sum_{a=p_a-\omega_a}^{p_a+\omega_a} \sum_{b=p_b-\omega_b}^{p_b+\omega_b} (P(a,b) - Q(a+J_a, b+J_b)) \cdot \left[\frac{\partial R}{\partial s}\frac{\partial R}{\partial t}\right] \quad (4)$$

Using the first order first order expansion about the point $\bar{J} = [0\;0]^T$ instead of $Q(a+J_a, b+J_b)$ Equation 4 can approximated as

$$\frac{\partial\varepsilon(\bar{J})}{\partial\bar{J}} \approx -2 \sum_{a=p_a-\omega_a}^{p_a+\omega_a} \sum_{b=p_b-\omega_b}^{p_b+\omega_b} \left(P(a,b) - Q(a,b) - \left[\frac{\partial Q}{\partial a}\frac{\partial Q}{\partial b}\right]\bar{J}\right) \cdot \left[\frac{\partial R}{\partial s}\frac{\partial R}{\partial t}\right] \quad (5)$$

Note that $(P(a,b) - Q(a,b))$ is the temporal frame image derivative at the point $[a\;b]^T$. The point is defined as

$$[ab]^T : \forall(a,b)\epsilon[p_a-\omega_a, p_a+\omega_a] \times [p_b-\omega_b, p_b+\omega_b] \quad (6)$$

The derivative at $[a\;b]^T$ is defined as

$$\partial U(a,b) = P(a,b) - Q(a,b) \quad (7)$$

In Equation 5, $\left[\frac{\partial R}{\partial s}\frac{\partial R}{\partial t}\right]$ is the gradient vector and ∇U can be defined as

$$\nabla U = \begin{bmatrix} U_a \\ U_b \end{bmatrix} = \left[\frac{\partial Q}{\partial a}\frac{\partial Q}{\partial b}\right]^T \quad (8)$$

The derivatives U_a and U_b can be computed directly from the image $P(a,b)$ in the $(2\omega_a+1) \times (2\omega_b+1)$, which is a neighborhood of the point N independently from the next image $Q(a,b)$. The derivative images satisfy the expression $\forall(a,b)\epsilon[p_a -$

$\omega_b, p_a + \omega_a] \times [p_b - \omega_b, p_b + \omega_b]$ and can be defined as

$$U_a(a,b) = \left(\frac{\partial P(a,b)}{\partial a}\right) = \left(\frac{P(a+1,b) - P(a-1,b)}{2}\right) \quad (9)$$

$$U_b(a,b) = \left(\frac{\partial P(a,b)}{\partial a}\right) = \left(\frac{Q(a,b+1) - Q(a,b-1)}{2}\right) \quad (10)$$

Based on $U_a(a,b)$ and $U_b(a,b)$ defined above the computation of $\frac{\partial \varepsilon(\bar{J})}{\partial \bar{J}}$ is given as

$$\frac{1}{2}\frac{\partial \varepsilon(\bar{J})}{\partial \bar{J}} \approx \sum_{a=p_a-\omega_a}^{p_a+\omega_a} \sum_{b=p_b-\omega_b}^{p_b+\omega_b} (\nabla U^T \bar{J} - \partial U) \nabla U^T \quad (11)$$

$$\frac{1}{2}\frac{\partial \varepsilon(\bar{J})}{\partial \bar{J}} \approx \sum_{a=p_a-\omega_a}^{p_a+\omega_a} \sum_{b=p_b-\omega_b}^{p_b+\omega_b} \left(\begin{bmatrix} U_a^2 & U_a U_b \\ U_a U_b & U_b^2 \end{bmatrix} \bar{J} - \begin{bmatrix} \partial U & U_a \\ \partial U & U_b \end{bmatrix} \right) \quad (12)$$

Equation 12 can be further simplified and defined as

$$\frac{1}{2}\left[\frac{\partial \varepsilon(\bar{J})}{\partial \bar{J}}\right]^T \approx K\bar{J} - \bar{t} \quad (13)$$

Where

$$K = \sum_{a=p_a-\omega_a}^{p_a+\omega_a} \sum_{t=p_b-\omega_b}^{p_b+\omega_b} \begin{bmatrix} U_a^2 & U_a U_b \\ U_a U_b & U_b^2 \end{bmatrix}$$

$$\bar{t} = \sum_{a=p_a-\omega_a}^{p_a+\omega_a} \sum_{b=p_b-\omega_b}^{p_b+\omega_b} \begin{bmatrix} \partial U & U_a \\ \partial U & U_b \end{bmatrix}$$

As $\frac{\partial \varepsilon(J)}{\partial J}\Big|_{J=J_{opt}} = [0,0]$

and matrix K is invertible, then the optical flow vector $\bar{J}_{opt}$ is defined as

$$\bar{J}_{opt} = K^{-1}\bar{t} \quad (14)$$

Considering $\bar{J}_{opt}$, it is evident that $P(a,b)$ contains information of the gradients in the a and b direction of N. A large number of iterations have to be considered to obtain accurate optical flow of personnel in the crowd video frames. Let $\mathcal{W}$ represent the number of iterations required and $\mathcal{W} \geq 1$. Based on the optical flow computations from $1,2,3,\cdots(\mathcal{W}-1)$ the initial guess $\bar{J}^{\mathcal{W}-1}$ for pixel displacement $\bar{J}$ is obtained. The initial guess is given as $\bar{J}^{\mathcal{W}-1} = [J_a^{\mathcal{W}-1} J_a^{\mathcal{W}-1}]^T$. If $Q_{\mathcal{W}}$ represents the new image based on $\bar{J}^{\mathcal{W}-1}$, provided $\forall (a,b) \in [p_a - \omega_a, p_a + \omega_a] \times [p_b - \omega_b, p_b + \omega_b]$ then

$$Q_{\mathcal{W}}(a,b) = Q(a + J_a^{\mathcal{W}-1}, b + J_b^{\mathcal{W}-1}) \quad (15)$$

Using the optical flow methodology in $GCBACS$ the residual pixel trajectory vector and mismatch vectors are obtained. The residual vector $\mathcal{R}^{\mathcal{W}} = [\mathcal{R}_a^{\mathcal{W}} \mathcal{R}_b^{\mathcal{W}}]$ minimizes the error function $\varepsilon^{\mathcal{W}}(\bar{\mathcal{R}}^{\mathcal{W}})$, defined as

$$\varepsilon^{\mathcal{W}}(\bar{\mathcal{R}}^{\mathcal{W}}) = \varepsilon(\mathcal{R}_a^{\mathcal{W}} \mathcal{R}_b^{\mathcal{W}}) = \sum_{a=p_a-\omega_a}^{p_a+\omega_a} \sum_{b=p_b-\omega_b}^{p_b+\omega_b} \left((P(a,b) - Q_{\mathcal{W}}(a + \mathcal{R}_a^{\mathcal{W}}, b + \mathcal{R}_b^{\mathcal{W}}))^2 \right) \quad (16)$$

Using Equation 14 the solution of $\varepsilon^{\mathcal{W}}(\bar{\mathcal{R}}^{\mathcal{W}})$ can be obtained and is given as

$$\bar{\mathcal{R}}^{\mathcal{W}} = K^{-1}\overline{\bar{t}_{\mathcal{W}}} \quad (17)$$

Where the mismatch vector matrix $\overline{\bar{t}_{\mathcal{W}}}$ is given as

$$\overline{\bar{t}_{\mathcal{W}}} = \sum_{a=p_a-\omega_a}^{p_a+\omega_a} \sum_{b=p_b-\omega_b}^{p_b+\omega_b} \begin{bmatrix} \partial U_{\mathcal{W}}(a,b) & U_a(a,b) \\ \partial U_{\mathcal{W}}(a,b) & U_b(a,b) \end{bmatrix} \quad (18)$$

In Equation 16 $\partial U_{\mathcal{W}}$ represents the $\mathcal{W}^{th}$ frame difference and is defined as

$$\partial U_{\mathcal{W}}(a,b) = P(a,b) - Q_{\mathcal{W}}(a,b) \quad (19)$$

From Equation 18, we can observe that the spatial derivatives U_a and U_b are computed only once initially and K is constant for an entire iteration loop. The parameter vector $\overline{\bar{t}_{\mathcal{W}}}$ is iteratively computed at $\mathcal{W}$ steps. That vector $\overline{\bar{t}_{\mathcal{W}}}$ is the amount of residual difference between the video frames after translation by the vector $\bar{J}^{\mathcal{W}-1}$. Based on the matrix K and $\overline{\bar{t}_{\mathcal{W}}}$, $\bar{\mathcal{R}}^{\mathcal{W}}$ is computed. The new pixel displacement is $\bar{J}^{\mathcal{W}}$ that is computed in the step $\mathcal{W}+1$ and is defined as

$$\bar{J}^{\mathcal{W}} = \bar{J}^{\mathcal{W}-1} + \bar{\mathcal{R}}^{\mathcal{W}} \quad (20)$$

The iteration steps to achieve convergence are repeated till the value of $\bar{\mathcal{R}}^{\mathcal{W}}$ is below a preset threshold or the $\mathcal{W}$ number of maximum iterations are completed. If $\mathcal{S}$ represents the number of iterations required to reach convergence then the optical flow vector can be defined as

$$\bar{J} = e^L = \bar{J}^{\mathcal{W}} = \sum_{\mathcal{W}=1}^{\mathcal{S}} \bar{\mathcal{R}}^{\mathcal{W}} \quad (21)$$

The optical flow based on the velocities in the a and b direction at the t^{th} time instance can be represented as

$$\bar{J} = [J_a \quad J_b]^T \quad (22)$$

c) Streakline Flow Computation

The optical flow computed present gaps in the trajectories of personnel in the crowd. In $GCBACS$ the gaps in the optical flow of similar motion vectors are

filled using the streak lines [15] and new trajectory vectors are established prior to analysis using graph theoretic approaches.

Let us consider a particle at position N in the t^{th} time instance, present in the F frame and it is represented as $\left(a_F^N(t), b_F^N(t)\right)$. The advection of the particle is achieved by

$$a_F^N(t+1) = a_F^N(t) + J_a(a_F^N(t), b_F^N(t), t) \quad (23)$$

$$b_F^N(t+1) = b_F^N(t) + J_b(a_F^N(t), b_F^N(t), t) \quad (24)$$

Where J_a, J_b are obtained from the optical flow vectors. For all the frames F and time $t = 1,2,3 \ldots T$ using particle advection we can obtain a vector matrix. The columns of the matrix can be used to obtain the particle trajectory details from time t to the current time T and are called path lines. In this paper $\mathrm{K}^N(t,T)$ is used to represent the path lines. The row of the matrix can be used to obtain the streaklines that connect the particles from t video frames that originated from the position N. The streaklines is represented using $\Lambda^N(0,t)$ notation in this paper. Inconstancies are noticed in the streak lines obtained. To overcome this drawback in [15] the extended particle was introduced based on the position N and the optical flow velocities. The l^{th} extended particle can be defined as

$$\mathrm{E}_l = \left\{a_l^N(t), b_l^N(t), J_a^l, J_b^l\right\} \quad (25)$$

Where $J_a^l = J_a(a_l^N(l), b_l^N(l), l)$ and $J_b^l = J_b(a_l^N(l), b_l^N(l), l)$.

Based on the streak lines the behavior of the personnel in obtained. Using the streak lines, the streak flow is computed and is defined as

$$\Gamma_s = (J_a^s, J_b^s)^T \quad (26)$$

The streak line computation is realized by integrating the optical flows $\bar{J}$ computed and forming extended particles. To compute Γ_s, J_a^s and J_b^s have to be computed. The computation of J_a^s and J_b^s are similar in nature. If $J_a^l \in \mathrm{E}_l \forall_{l,\mathrm{E}}$ then let us consider a vector $\mathcal{J}_a = [J_a^l]$ to obtain the streak flow in the a direction. The extended particle E_l has three pixels as its neighbors which forms a triangle. J_a^s is considered as the interpolations of the neighboring pixels and is computed by

$$J_a^l = a_1 J_a^s(i_1) + a_2 J_a^s(i_2) + a_3 J_a^s(i_3) \quad (27)$$

In Equation 26 i_{indx} represents the index of the pixel, a_{fn} represents the basis function. Using the interpolation method the parameters $J_a^s(i_1), J_a^s(i_2)$ and $J_a^s(i_3)$ are obtained. For all the vectors in $\mathcal{J}_a$ and based on Equation 26 we can state

$$\mathfrak{L}\, J_a^s = J_a^l \quad (28)$$

Where a_{fn} are the elements of the matrix $\mathfrak{L}$. Based on Equation 25 and 26 similarly J_b^s can be computed. Using J_a^s and J_b^s the streak flow Γ_s is obtained. In $GCBACS$ the use of streak flow to observe the trajectory of the personnel in the crowd is considered as the streak flow methodology enables instantaneous change observation when compared to particle flows.

d) Graph Therotic Mechanism For Analysis And Classification

In $GCBACS$ the behavior of crowd personnel observed using the streak flow is analyzed using a graph structure adopted for all the F frames of the video. Let us consider a graph $\mathbb{G}(\mathbb{V}, \mathbb{E})$ obtained from the streak flow Γ_F. The vertices of the graph are the number of pixel vectors observed and is defined as

$$\mathbb{V} = \{v_1, v_2, \ldots v_n\} \quad (29)$$

The edges of the graph $\mathbb{G}$ can be represented as

$$\mathbb{E} = \{e_1, e_2, \ldots e_m\} \quad (30)$$

The streak flow Γ computed represents a planar field, and $\Gamma = \Gamma_c + \Gamma_r$ based on the decomposition defined by Helmholtz. Γ_c is the incompressible part and Γ_r is the irrotational part of the vector field. In [22] two functions are introduced such that, $\Gamma_c = \Delta\alpha$ and $\Gamma_r = \Delta\beta$. The stream function α and the velocity potential function β are computed using Fourier Transforms as described in [22]. The functions α and β are defined as

$$\alpha(a,b) = \alpha_0 + \left(\frac{1}{2} \times \int_0^b \left(J_a^c(a,s) + J_a^c(0,s)\right) ds\right) - \left(\frac{1}{2} \times \int_0^a \left(J_b^c(s,b) + J_b^c(s,0)\right) ds\right) \quad (31)$$

$$\beta(a,b) = \beta_0 + \left(\frac{1}{2} \times \int_0^a \left(J_a^r(s,b) + J_a^r(s,0)\right) ds\right) + \left(\frac{1}{2} \times \int_0^b \left(J_b^r(a,s) + J_b^r(0,s)\right) ds\right) \quad (32)$$

The function α provides details of the steady motion vectors and β provides the details of the random motion changes detected. By combining the α and β vectors the potential functions of the video frame is computed and the edge set $\mathbb{E}$ can be defined as

$$\mathbb{E} = \{\alpha, \beta\} \quad (33)$$

To detect abnormal behavior analysis of consecutive frames is considered i.e. graph $\mathbb{G}_{t-1}$ and graph $\mathbb{G}_t$. The relation amongst the graphs can also be considered as the relation amongst the sub sets of $\mathbb{G}_{t-1}$ and $\mathbb{G}_t$ and is defined as

$$\mathcal{R}_{\mathbb{G}} = \left(\frac{\mathcal{R}}{Min(\mathbb{V}_{t-1}, \mathbb{V}_t)}\right) \quad (34)$$

Where $\mathcal{R}$ represents the number of vectors common to the graphs $\mathbb{G}_{t-1}(\mathbb{V}, \mathbb{E})$ and $\mathbb{G}_t(\mathbb{V}, \mathbb{E})$.

$$A_{\mathbb{G}}^N = \left(1 - \left(\frac{\mathcal{M}}{Max(\mathbb{G}_{t-1}^{Sub}, \mathbb{G}_t^{Sub})}\right)\right) \quad (35)$$

Where $\mathcal{M}$ is the number of matched sub graphs observed in the graph frames $\mathbb{G}_{t-1}(\mathbb{V},\mathbb{E})$ and $\mathbb{G}_t(\mathbb{V},\mathbb{E})$. $\mathbb{G}_{t-1}^{Sub}$ represents the sub sets of $\mathbb{G}_{t-1}$ and $\mathbb{G}_t^{Sub}$ represents the sub sets of $\mathbb{G}_t$. The matching of the energy potential functions of the frames is given by

$$\mathbb{P}_{\mathbb{G}} = \left(\frac{\sum_{x=1}^{m} \left| \frac{e_x^{t-1} - e_x^t}{e_x^{t-1}} \right|}{m} \right) \tag{36}$$

The local differences in the sub sets are measured to analyze the finer movements in the graphs and is computed using

$$\mathfrak{D} = \left(\frac{f(\mathbb{G}_{t-1}^{Sub}, \mathbb{G}_t^{Sub})}{(f_{Max} - f_{Min})} \right) \tag{37}$$

Where $f(x)$ is a function that defines the matching between the sub sets $\mathbb{G}_{t-1}^{Sub}$ and $\mathbb{G}_t^{Sub}$. Combining all the above definitions the variance between two frames represented as graphs is measured as

$$\mathbb{F}_{\mathbb{V}} = \Big(\big(Max(1 - \mathcal{R}_{\mathbb{G}}, A_{\mathbb{G}}^{N}) \big) \times (\gamma \times \mathbb{P}_{\mathbb{G}} + (1-\gamma)\mathfrak{D}) \Big) \tag{38}$$

Where γ is a predefined integer. The cumulative variance observed till the F^{th} frame can be defined as

$$\overline{\mathbb{F}_{\mathbb{V}}} = \sum_{x=1}^{F} \mathbb{F}_{\mathbb{V}} \tag{39}$$

If the value of the cumulative variance is greater than a predefined threshold φ then abnormal event is detected in the video and it is assigned the class 1 else 0. The classification can be defined as

$$\begin{cases} F_{Class} = 0, & If\ \overline{\mathbb{F}_{\mathbb{V}}} < \varphi \\ F_{Class} = 1, & If\ \overline{\mathbb{F}_{\mathbb{V}}} \geq \varphi \end{cases} \tag{40}$$

Having discussed the $GCBACS$ proposed in this paper, its performance is evaluated in the next section of this paper.

IV. Performance Evaluation

To evaluate the performance of the $GCBACS$ the authors have considered the data set from University of Minnesota [23]. The dataset [23] consists of abnormal and normal crowd personnel videos. In this paper two scenarios are from the dataset are considered. They are referred as scenario 1 and scenario 2 in this section of the paper. The performance of the $GCBACS$ is compared with the Viscous Fluid Field (VFF) method proposed in [17]. Matlab is used to develop $GCBACS$. The performance presented here is based on the recognition results and the quantitative evaluations studied. In scenario 1 the outdoor crowd personnel activity is monitored. Indoor environments are characterized by lower lighting conditions and analyzing the personnel behavior can be achieved only if robust techniques are in place.

a) Recognition Results

The recognition results obtained on evaluating the performance of the $GCBACS$ and VFF on Scenario 1 and Scenario is shown in Figure 2.In the figure the use of bars is considered to represent the results where the green bars represent normal crowd activity and the red bars represent abnormal crowd activity. From the figure it is clear the proposed $GCBACS$ exhibits better accuracy when compared to the system proposed in [17] i.e. VFF. The $GCBACS$ nearly follows the ground truth bar shown in the figure. The misclassification ratio of the $GCBACS$ was found to be 0.05 and the miss classification ratio of VFF was found to be 0.14. From the figure it is noticed that the VFF has a few misclassified values which is also seen in the results shown in [17]. The misclassification is reduced as the $GCBACS$ adopts the streak line flow to capture the behavior of personnel in the scenario videos considered. Based on the results it can be concluded that the $GCBACS$ proposed in this paper can be efficiently adopted for crowd behavior study and analysis under varying conditions i.e. indoor and outside scenarios.

b) Quantitative Evaluations

To evaluate $GCBACS$ and VFF quantitatively, the red bars which represent abnormal activities detected are considered to be positive events. The results are evaluated using receiver operating characteristic curves (ROC) [24]. The ROC curve obtained for scenario 1, scenario 2 is shown in Figure 3 and Figure 4. From Figure 4 and Figure 5 it is clear that the $GCBACS$ exhibits a better crowd activity classification when compared to the VFF system. Considering Scenario 1 it is observed that the area under the ROC curve for $GCBACS$ is 0.89 and 0.68 for the VFF. The area under the ROC curve for $GCBACS$ and VFF is 0.97 and 0.79, considering scenario 2. Both $GCBACS$ and VFF exhibit better results when the indoor scenario 2 is considered as the motion of the personnel in this video is relatively uniform. The motion trajectories of personnel in scenario 1 is erratic and random. In both the scenarios the area under the ROC curve of $GCBACS$ is more than the area under the ROC curve for VFF.

The accuracy and efficiency plots for scenario 1 are shown in Figure 5 and Figure 6 of the paper. From Figure 5 it is observed that average activity classification accuracy of $GCBACS$ is 0.83. The average activity classification accuracy considering the VFF system is 0.71. In Figure 6 it is observed that the crowd activity classification efficiency of $GCBACS$ is 17.4% better than VFF. Considering scenario 2 the crowd activity classification accuracy and efficiency plots are shown in Figure 7 and Figure 8 of this paper. Considering Figure

7 it is observed that the average activity classification accuracy of $GCBACS$ is 0.88. The average activity classification accuracy of VFF is 0.76. $GCBACS$ exhibited a 13.8% greater crowd activity classification efficiency than the VFF system. The improvement in activity classification efficiency can be proved from Figure 8 of this paper.

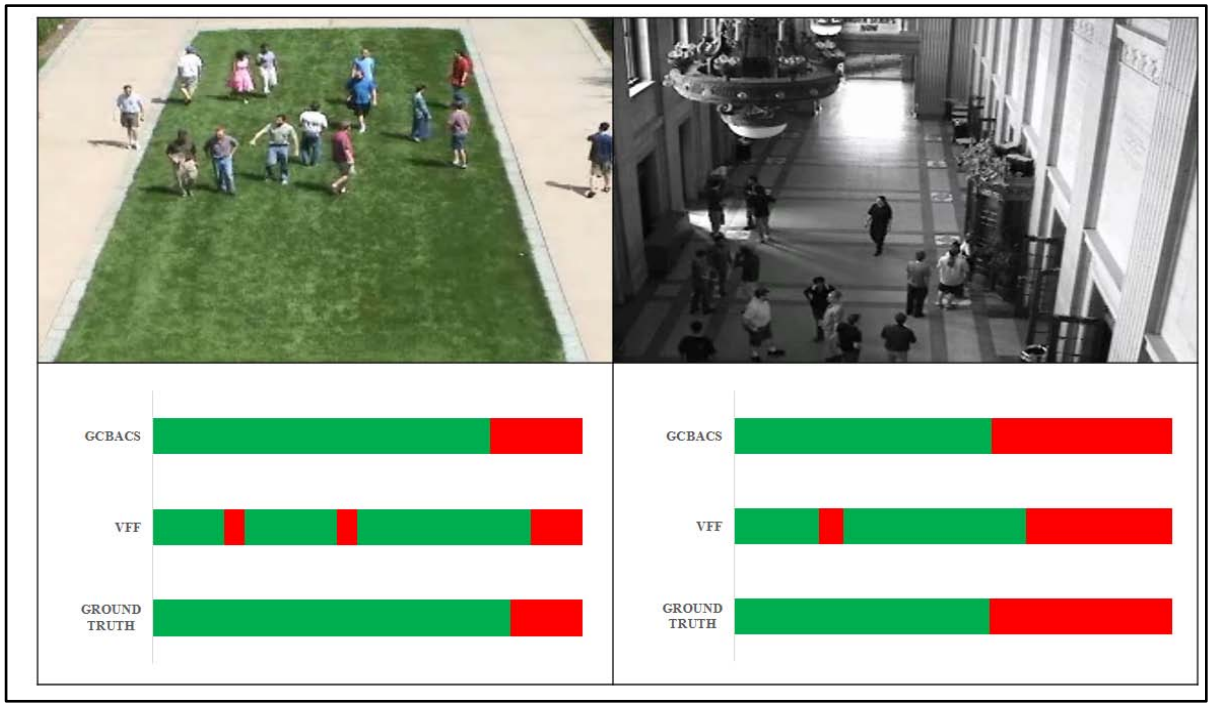

Figure 1 : Comparison results of crowd behavior recognition and classification for sample videos in Sequence 1 and Sequence 2 Using GCBACS and VFF. The ground Truth is also shown.

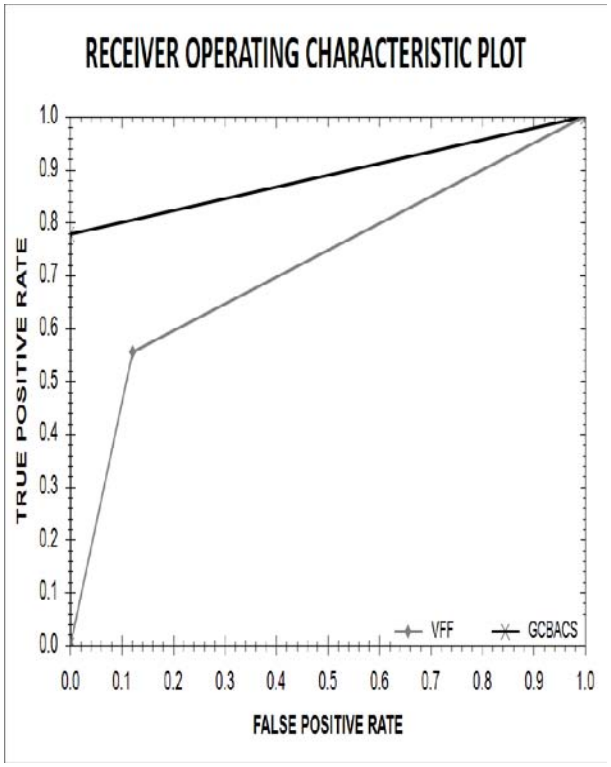

Figure2 : ROC Curves for Crowd Activity Classification based on GCBACS and VFF for Scenario 1

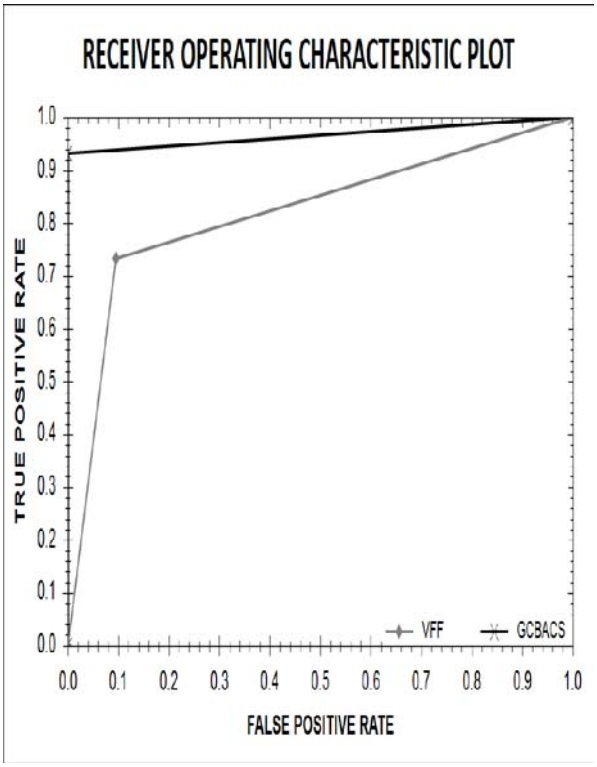

Figure 3 : ROC Curves for Crowd Activity Classification based on GCBACS and VFF for Scenario 2

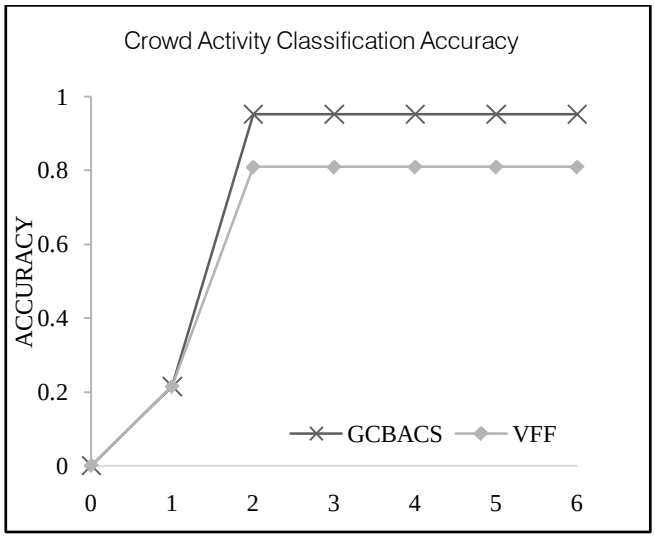

Figure 4 : Crowd Activity Classification Accuracy based on GCBACS and VFF for Scenario 1

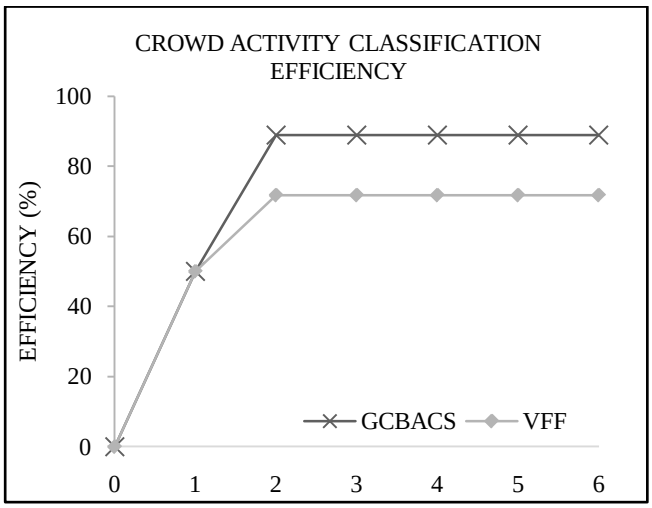

Figure 5 : Crowd Activity Classification Efficiency based on GCBACS and VFF for Scenario 1

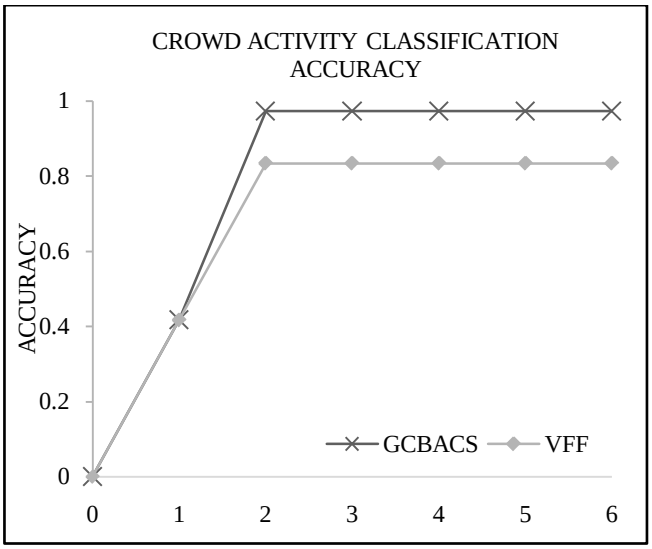

Figure 6 : Crowd Activity Classification Accuracy based on GCBACS and VFF for Scenario 2

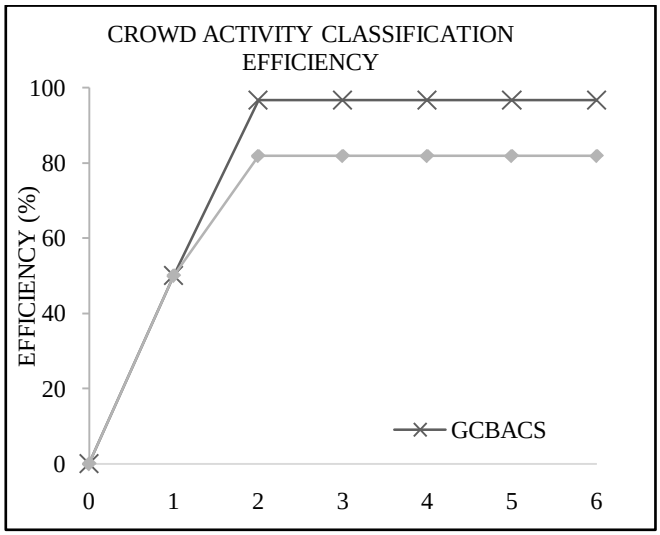

Figure 7 : Crowd Activity Classification Efficiency based on GCBACS and VFF for Scenario 2

The results presented in this paper prove that the proposed $GCBACS$ out performs the VFF algorithm proposed in [17] in terms of the classification accuracy, classification efficiency and the area under the ROC curve.

V. Conclusion and Future Work

This paper introduces the $GCBACS$ for surveillance video crowd behavior and analysis. The $GCBACS$ considers the use of streak flows to attain the crowd personnel behavior. The streak flows are obtained from the streak lines and path lines. Optical flow methods are used to obtain the streak lines. The potential field variations captured by the streak flows are analyzed using graph theoretic approaches. A threshold based scheme is adopted to classify the cumulative variation observed in all the frames of the video. The crowd activity is classified as normal and abnormal behavior based on the inter personnel activity. The experimental results presented in this paper validate that the proposed $GCBACS$ can be utilized for analysis of indoor and outdoor crowd surveillance videos. The results validate that the proposed $GCBACS$ outperforms the existing methods used for crowd behavior analysis and classification. The future of the research work presented in this paper is to validate the performance of $GCBACS$ in varied datasets.

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Geometric Correction in High Resolution Satellite Imagery using Mathematical Methods: A Case Study in Kiliyar Sub Basin

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Abstract- The number of high resolution space imagery have great interest in the photogrammetric and remote sensing communities. This imagery is considered as a basic information source for mapping with various applications in geomantic. By this hybrid both the projection model and polynomial model in geometric correction of satellite imagery, it needs to control points and standardisation data. In the geometric correction of the IRS P-5 LISS III imagery is required whenever the image is to be compared with existing maps or with other imagery. In this paper execute the composition of correction function using Ground Control Points. The results show eligibility of geometric correction of these models for selected imagery. An accuracy analysis is performed, with emphasis being laid on the number and location of Ground Control Points.

Keywords: *remote sensing, GCP, polynomial, projection.*

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Strictly as per the compliance and regulations of:

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Capt. Dr. S. Santhosh Baboo [α] & Mr. S. Thirunavukkarasu [σ]

Abstract - The number of high resolution space imagery have great interest in the photogrammetric and remote sensing communities. This imagery is considered as a basic information source for mapping with various applications in geomantic. By this hybrid both the projection model and polynomial model in geometric correction of satellite imagery, it needs to control points and standardisation data. In the geometric correction of the IRS P-5 LISS III imagery is required whenever the image is to be compared with existing maps or with other imagery. In this paper execute the composition of correction function using Ground Control Points. The results show eligibility of geometric correction of these models for selected imagery. An accuracy analysis is performed, with emphasis being laid on the number and location of Ground Control Points.

Keywords: remote sensing, GCP, polynomial, projection.

I. Introduction

Preprocessing of satellite images consist of radiometric and geometric characteristics analysis. Preprocessing commonly comprises a series of sequential operations, including geometric correction, atmospheric correction or image registration, normalization, masking (e.g., for clouds, water, irrelevant features), Image Rectification, and Image Re sampling [6]. The geometric correction of high-resolution satellite imagery needs to take into account the instrument characteristics, the satellite motion, earth rotation, terrain effects, and the ground control points (GCP) simultaneously. This is much different with the traditional geometric correction algorithms, which conducts the correction sequentially and uses the ground control points in higher level processing [1].

In the geometric correction transformation the (High Resolution Satellite Image Geometric correction) transforms the imagery, as they are acquired by the sensors, to match certain cartographic projection, free of distortions, and each pixel is assigned with specific coordinates. While the imagery is to provide Earth Surface hyper spectral reflectance data with a wide range of different viewing configurations, and provide Bidirectional Reflectance Distribution Function (BRDF), for atmospheric, land and water studies [12].

Atmospheric analysis mainly to refers the atmosphere effect along with its corresponding territory (land) features reflection (while geometric analysis). While in the correction removes effects of the atmosphere on the radiation from the territory that arrives to the camera as well as other sensor; it also converts the physical values of the image from radiance to ground reflectance. But it needs accurate observation and illumination angles for each pixel [3]. Imagery registration itself is a general problem and arises in many applications such as depth perception, dynamic scene analysis, change detection and landscape classification. Geometric analysis refers to the image geometry with respect to sensor system with the launch of various commercial high-resolution earth observation satellites, such as Indian Remote Sensing Satellite IRS-P5 Liss-III, Digital Globe Quikbird system, the Space Imaging Ikonos system and Spot-5 precise digital maps generated by satellite imagery are expected in the spatial information industry [1].

The main goal of imagery rectification is to facilitate the overlay of supplementary imagery and other geographic data. A TopoSheet (Standard Map) position, with boundaries set with Universal Transverse Mercator (UTM), is recognized for each scene, thus all imagery is for the same region and once rectified will be available in the same map area. The UTM bounds for the scene are established according to the imagery size, the 28.5 x 28.5 m pixels, and the minimum/maximum northing and easting required containing the full scene area. These boundaries, the UTM zone-1 and the ellipsoid are established on each newly created empty file. Usually RS Imagery is being projected to UTM using WG84 datum for IRS [6].

Finally Geometric rectification of the imagery resample is to produce another copy of imagery data as you change either the pixel dimensions or the High resolution of Satellite image. When you compress the image the number of pixels, information is deleted from the image. When you enhance the number of pixels, new pixels are added, in the application [7].

In this paper Geometric corrections in CartoSat-1 IRS –P5 Liss III Imagery have been used in various

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non-rigorous mathematical models used for geometric corrections. Such as polynomial and DLT model that used different number of Ground control points (GCP).

II. Review of Papers

Due to this fact, an additional constrain is needed to define the point in 3D space. Collinearity equations are the rigorous models, which describe this projection relation between 2D image space and 3D object space. Unlike ordinary photogrammetric photography, high-resolution satellites are a line sensing imaging systems where every line is imaged at different time. That may help to understand the need of a special treatment of the sensor model (Makki, 1991). In general, the rigorous time dependent mathematical models are based on the collinearity equations, which relate image coordinates of a point to its corresponding ground coordinates. Published studies reported till date on IKONOS and other satellites focus on two main aspects, the accuracy attainable in ortho-image generation and DTM extraction concerning 3D positioning from stereo spatial intersection using rigorous and non-rigorous sensor orientation models. Due to some limitations, most of the new High Resolution Satellite Imagery (HRSI) vendors hide the satellite orbit information and calibration data from the customer's community such as for IKONOS and QUICKBIRD imagery. This means that other alternative models should be used to solve this problem and calculate the imagery parameters. Therefore, these empirical approaches can be applied to determine the ground point coordinates in either 2D or 3D.

III. Geometric Corrections

The use of standard pixel sizes and coordinates permit suitable layering of images from different sensors and maps into a GIS. The final level is ortho rectification. This level focuses on pixel by pixel correction of the image for topographic distortion. Every pixel in the resulting image appear as if the earth is viewed from directly above, the image is a strict orthographic projection.

Geometric correction is needed to preprocess remotely sensed data and to remove geometric distortion such as Internal and External distortion, so that individual image pixels are in their appropriate plan metric (*x, y*) map locations. This allows remote sensing derived information to be related to other thematic information in Geographical Information System. Geometrically corrected imagery can be used to extract exact direction, distance and polygon area information. Geometric corrections in IRS P6 Liss-III Imagery have been used in these steps of geometric correction in satellite imagery and used in different number of Ground control points[8].

Now a days, utilization of satellite images as a substitute for small scale airborne photograph to produce new maps and accurate old maps much faster than before eliminates shortage of geo information and need to update these information. Immediate access to information and needed geometry accuracy of photogrammetry for maps of different scales leads to a demand for accurate mathematical model from accuracy and speed point of examination. This paper presents a suitable solution to solve the two dimensional problem.

Generally, used mathematical model for geometrical correction of satellite images are divided in two types of physical or general models [5].

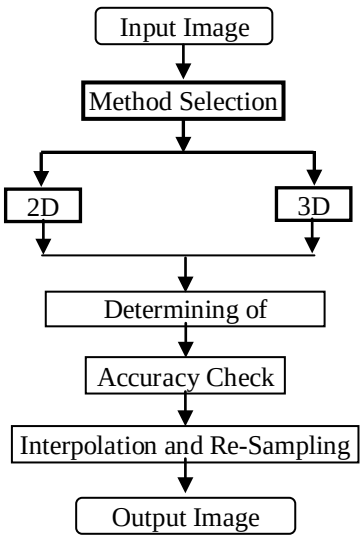


Figure 1 : Geometric correction

IV. Mathematical Moduls

Physical Model

This model explains the procedure of imagery physically and the parameters used show the position and angle of sensor in object space. This model such as co-linearity equation is suitable for adjustment of analytical aerial triangulation and has high accuracy.

General Models

In this model the type of sensor has no importance and parameters used in linking object space and image space are not associated to sensor physics. Rational Function Models, polynomials, affine model and so on are of this type.

Appropriate to photogrammetric operation such as image reconstruction, rectification and generation that is to be in real time practice of general models are appropriate and it is done in photogrammetric instruments without any attention to the sensor type and for new sensors it is sufficient to update only the coefficients of models. Substituting the sensor model by a general one should be done by selecting the best fitting physical sensor models.

The following modules are used in geometric Correction and discussed with our study area

a) Polynomial model

Polynomial models usually needed for the transformation between image and object coordinates. In the transformation it is expressed in different orders of the polynomials based on the distortion of the image, the number of Ground Control Points and terrain type. A linear transformation is the first order polynomial transformation, which can change the location, rotation, scale, and skew. In most cases, first order polynomial is used to project raw image to an object for data covering small areas and large areas. A non-linear transformation of higher order Polynomial or second order polynomial transformations that can be used to correct non-linear distortions that convert latitude/longitude to the image such as earth curvature and sensor distortion.

This polynomial equation can calculate new output pixel locations (x, y) and relate image location to the Ground Control Point location. The following 2D and 3D equations are used to commonly for the polynomial model[9].

$$\left.\begin{aligned} X &= a_0 + a_1 x + a_2 y \\ Y &= b_0 + b_1 x + b_2 y \end{aligned}\right\} \quad (1)$$

Given a coordinate (x, y) in the model parameter, the model coordinates of the corresponding (a,b) are given by the equations

b) Projective Transformation

A projective is an invertible mapping h from P2 to itself such that three points x1, x2, x3 lie on the same line if and only if h(x1),h(x2),h(x3)do. A mapping h:P2 → P2 is a projectivity if and only if there exist a non-singular matrix

H such that for any point in P2 represented by a vector x it is true that h(x)=Hx definition as.

$$Hx = X' or \begin{pmatrix} x_1' \\ x_2' \\ x_3' \end{pmatrix} = \begin{bmatrix} h_{11}h_{12}h_{13} \\ h_{21}h_{22}h_{23} \\ h_{31}h_{32}h_{33} \end{bmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix}$$

$$X = \frac{a_0 + a_1 X + a_2 Y}{1 + c_1 X + c_2 Y}$$

$$y = \frac{a_0 + a_1 X + a_2 Y}{1 + c_1 X + c_2 Y} \quad (2)$$

This model is useful because the linearity of the equations as a function of the coefficients permits least-squares procedure to be used for determining these coefficients. Affine, DLT, Quadratic, and Cubic are polynomials obtained from this model and include the number of coefficients that would be required to utilize the corresponding model. In the analysis of high resolution satellite imagery it is necessary to place these data into registration. To implement this operation the data are divided into sub imagery, and the miss registration between the data subsets is modeled by projection transformation. An Implementation of projection model as contrary to perspective affine model for satellite line scanner imagery is quite robust and stable for image orientation and triangulation. All of a Ground Control Point will give rise to a set of two Projective Transformation equations derived from the relationship between the GCP coordinates and the image coordinates in the geocentric system.

In programming 2D projective Transformation equation in direction and aerial triangulation of High Resolution satellite imagery, all coefficients and coordinates of ground control points synchronously is produced by bundle adjustment. Combining above function with additional parameter, we can model other effective non linear parameters. There are more 2D mathematical models, which has been described in Sadeghian & Valadan (2001).

V. Studied Area and Data Set

Palar is a south Indian river, originating from the Nandidurg hills of Karnataka, it flows through the states of Karnataka (93 km), Andhra Pradesh (33 km) and Tamil Nadu (222 km) before finally draining into the Bay of Bengal at Vayalur. This river is divided in to 8 sub basins. This mostly covers Thiruvannamalai and Kanchipuram districts an area of about 939.91km^2 of which about 92.43% of the total area.

The Kiliar Sub Basin area around the Palar Basin is located at Latitude (12°41'9"N and 12°22'32"N) and Longitude (79°53'26"E and 79°25'10"E). Studied images of Kiliyar Sub basin is a Pan and Liss III merged data panchromatic stereo pair of 5.86m pixel size and proper radiometric quality, a base to height ratio equal to taken on March-2013. Figure 2(a) Viewer#1 Shows the Study area Satellite Terrain data IRS-P6 Liss-III and Figure 2(b) Viewer#2 Shows the Georeferenced data (Toposheet) the above data are collected from Remote Sensing Institute, Taramani, Chennai.

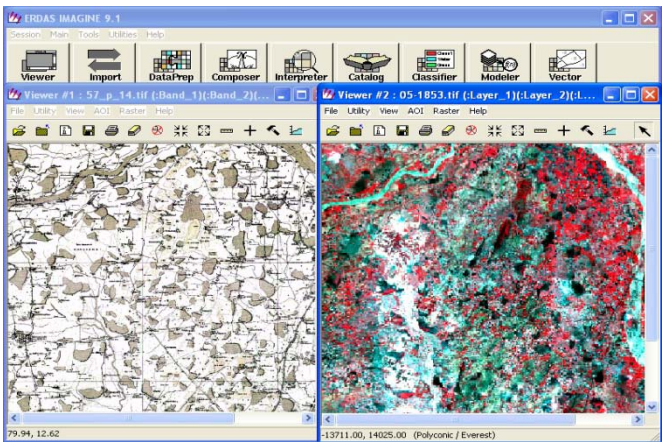


Figure 2 : (a) TopoSheet *Figure 2 : (b) Study Area*

ERAS Image software is used to correct the geometric correction by using the projection type and reference details shown in Table 1, which also presents the main characteristics of the acquired images.

Table 1 : Methodological Specification of IRS P6 Liss III Imagery

Image Type	Pan and Liss III Merged Data
File Format	Geo TIFF
Projection Type	UTM
Spheroid Name	WGS 84
Datum Name	WGS84
UTM Zone	1
North or South	North

a) Ground Control Point Selection

In Kiliyar sub basin areas Geo-reference Data (TopoSheet) 1:50000 Scales and 23.8 meter Satellite Imagery IRS P6 Liss III data date 12 march 2012 to provide by Remote Sensing Institute, Chennai of Tamilnadu. Ground Control point selection is done how as same sparseness in image space especially in corners of geo-referenced image. Control points are selected from crossings of roads, streets and railway stations and so on.

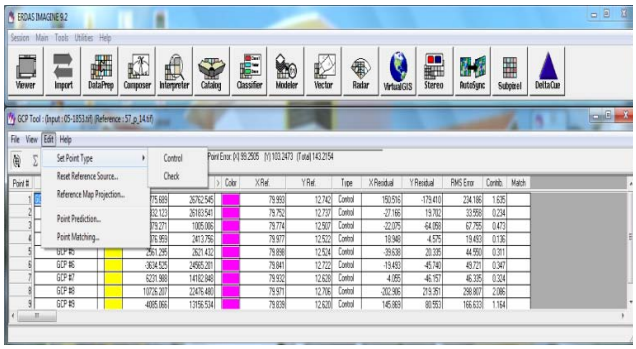


Figure 3 : Ground Control Points

The Figure 4 shows the correspondingly image with ground control and check points distribution, with using GCP Tool in ERDAS Software.

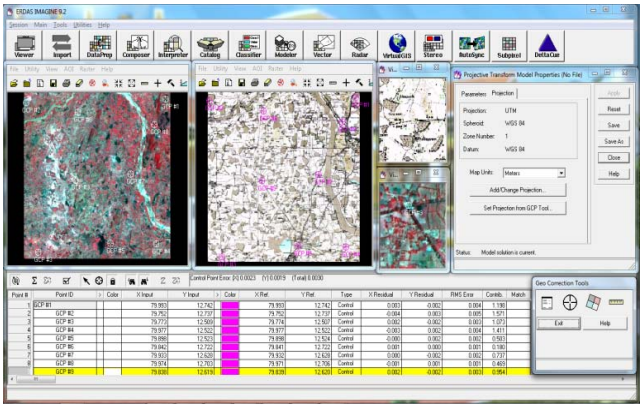
Figure 4 : GCP distribution

The check points and the ground control points (GCPs) in this study were derived from a digital 1:50000 Scale topographic map that produced by Remote Sensing Institute, Taramani in Chennai. It provides approximately planimetric (the word refers to 2D space) accuracy and 50cm vertical accuracy. When compared with the ground resolution of the IRS P6 Liss III image, this digital map provides sufficient control data. The following Practical Test (figure) is to prove the accuracy of the above mathematical model with hybrid model.

b) Experimental Result

The main objective of this approach is based on rectification of result of polynomial using such as polynomial mathematical mode. After geometric correction of satellite imagery using polynomial, the main residual errors are affected from relief displacement, which the polynomial has not been able to model. In order to model relief displacement, projective method is used. This method consists of two main stages. At the first stage, a global polynomial is used for geometric correction of Satellite imagery and the image coordinate of ground control points is recalculated using global polynomial. At the second stage, the calculated coordinates in step 1 and the real image coordinates are used in Projective model.

In order to remove outstanding errors efficiently we should locate a model that maps the calculated coordinates from polynomial to original coordinates. Therefore we can assume that results of polynomial are mapped to an intermediate space close to genuine space of image.



In order the coordinate of each ground control point, at the first, a polynomial is used and then the output of polynomial is overcorrected using Projective model. The above figure is used to calculate both models.

c) Accuracy Result

An IRS P6 Liss III satellite image from a region of Kiliyar Sub Basin is used as experiment area. This image is located near the Kanchipuram and Thiruvannamalai districts.

Result of Polynomial model

There were 9 GCP accessible that we used in three cases with control point. The result is shown in table.

Table 2 : Error Result using Polynomial model

Control Point Error (X)=9.4975 (Y)=4.0785 Total =10.3361					
GCP Point	Mean Residual		Result		
	X	Y	RMSE	Contrib.	Match
1	15.606	4.483	16.237	1.571	
2	-12.522	5.380	13.629	1.319	
3	12.835	-1.810	12.962	1.254	
4	-13.703	-1.571	13.793	1.334	0.000
5	-1.244	5.171	5.319	0.515	-0.069
6	0.503	-7.431	7.448	0.721	0.124
7	2.313	0.382	2.344	0.227	0.817
8	-6.618	-3.353	7.418	0.718	0.419
9	2.829	-1.252	3.094	0.299	0.279

After getting this final imagery and substitute appropriate polynomial model with same Ground control points and reference points are using Projective model by using the GIS ERDAS application software. The result is shown in the below table.

Result of Projective model

There were 9 GCP accessible that we used in three cases with control point. The result is shown in table.

Table 3 : Error Result using Projective model

Control Point Error (X)=56.4247 (Y)=49.1244 Total = 74.8128					
GCP Point	Mean Residual		Result		
	X	Y	RMSE	Contrib.	Match
1	106.751	-82.936	135.182	1.807	0.274
2	17.335	4.903	18.034	0.241	-0.489
3	24.529	-56.822	61.89	0.827	0.003
4	3.494	-3.277	4.79	0.064	0.571
5	-28.297	25.109	37.831	0.506	0.355
6	-82.566	-11.044	83.301	1.113	0.293
7	-26.111	-19.912	32.837	0.439	-0.083
8	-70.539	77.613	104.879	1.402	0.241
9	55.384	66.365	86.439	1.155	0.715

Result of Hybrid model

There were 9 GCP accessible that we used in all three cases with control point. The result is shown in the table

Table 4 : Error Result using Hybrid model

Control Point Error (X)=0.0023 (Y)= 0.0019 Total = 0.0030					
GCP Point	Mean Residual		Result		
	X	Y	RMSE	Contrib.	Match
1	0.003	-0.002	0.004	1.198	0.000
2	-0.004	0.003	0.005	1.571	-0.000
3	0.002	-0.002	0.003	1.073	0.000
4	-0.003	0.002	0.004	1.411	0.000
5	0.000	0.002	0.002	0.503	-0.000
6	0.001	0.000	0.001	0.180	0.000
7	0.000	-0.002	0.002	0.737	-0.000
8	-0.001	0.001	0.001	0.469	0.000
9	0.002	-0.002	0.003	0.954	0.000

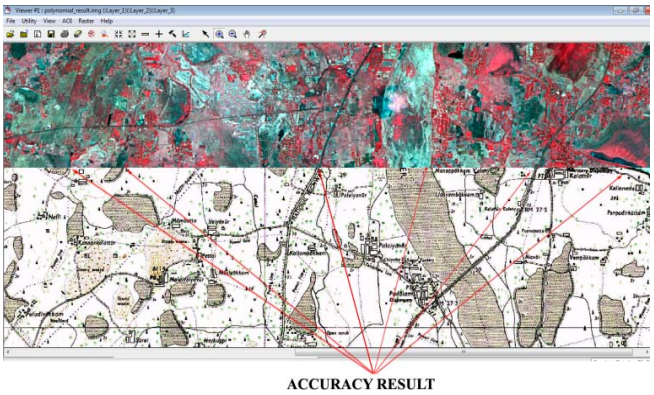


Figure 6 : Hybrid model accuracy result matching points

VI. Result

For examination of the results from the mathematical models in section 2, the unknown coefficients were determined using 9 control points for each model. Then with the determined coefficients, the corrected Image coordinates were calculated for 9 check points. RMS errors were calculated for each model base on the two types of coordinates for check points. Below table shows results for each model.

Table 5 : RMSE Value for IRS P6 LISS-III imagery in Different models

Model	No. of GCP	Control Point	RMS error
Polynomial	9	9	**10.3361**
Projection	9	9	**74.8128**
Hybrid	9	9	**0.0030**

VII. Conclusion

The preprocessing of remotely sensed image is very important to improve the quality and to remove errors. It consists of two types of correction geometric and radiometric correction. In this paper, the results of practical test conclude that above hybrid model gives the best results compared to the mathematical methods especially for high resolution satellite imageries such as IRS-P6 Liss III. The main advantages of this model are increased accuracy, simple calculations and lesser number of ground control points required. Future research work may be selecting effective ground control points in point wise polynomial functions utilizing projective transformation.

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Design and FPGA Implementation of High Speed DWT-IDWT Architecture with Pipelined SPIHT Architecture for Image Compression

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Abstract- Image compression demands high speed architectures for transformation and encoding process. Medical image compression demands lossless compression schemes and faster architectures. A trade-off between speed and area decides the complexity of image compression algorithms. In this work, a high speed DWT architecture and pipelined SPIHT architecture is designed, modeled and implemented on FPGA platform. DWT computation is performed using matrix multiplication operation and is implemented on Virtex-5 FPGA that consumes less than 1% of the hardware resource. The SPIHT algorithm that is performed using pipelined architecture and hence achieves higher throughput and latency. The SPIHT algorithm operates at a frequency of 260 MHz and occupies area less than 15% of the resources. The architecture designed is suitable for high speed image compression applications.

Keywords: *SPIHT, DWT, pipelined architecture, FPGA, High speed, image compress ion.*

GJCST-F Classification: *I.4.0*

Strictly as per the compliance and regulations of:

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T. Vijayakumar [α] & S. Ramachandran [σ]

Abstract- Image compression demands high speed architectures for transformation and encoding process. Medical image compression demands lossless compression schemes and faster architectures. A trade-off between speed and area decides the complexity of image compression algorithms. In this work, a high speed DWT architecture and pipelined SPIHT architecture is designed, modeled and implemented on FPGA platform. DWT computation is performed using matrix multiplication operation and is implemented on Virtex-5 FPGA that consumes less than 1% of the hardware resource. The SPIHT algorithm that is performed using pipelined architecture and hence achieves higher throughput and latency. The SPIHT algorithm operates at a frequency of 260 MHz and occupies area less than 15% of the resources. The architecture designed is suitable for high speed image compression applications.

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I. Introduction

Technological growth of semiconductor industry has led to unprecedented demand for low power, high speed complex and reliable integrated circuits for medical, defence and consumer applications. Today's electronic equipment comes with user friendly interfaces such as keypads and graphical displays. As images convey more information to a user, many of the equipment today have image displays and interfaces. Image storage on these smaller, handled devices is a challenge as they occupy huge storage space; also image transmission requires higher bandwidth. Hence most of the signal processing technologies today has dedicated hardwares that act as co-processors to compress and decompress images. Discrete Wavelet Transforms have been widely used for image compression and decompression. Much architecture has been proposed for high-speed 2-D DWT computation. The architectures can be broadly classified as separable and non-separable architectures [1]. Vishwanath etal. [2] Have proposed a low-storage short-latency separable architecture in which the row-wise operations are performed by systolic filters and the column-wise operations by parallel filters. Liao et al. [3] Have introduced architecture in which each of the row- and column-wise filtering operations are decomposed using the so called lifting operations into a cascade of sub-filtering operations. Chakrabarti et al. [4] have proposed two non-separable architectures, one using parallel 2-D filters and the other an SIMD 2-D array. Cheng et al. [5] have proposed an architecture in which a number of parallel FIR filters with a polyphase structure are used to improve the processing speed at the expense of increased hardware. Hung et al. [6], in an effort to provide a reduced count of multipliers and to facilitate the processing of the boundary data, have proposed an architecture that is a pipeline of one stage of parallel multipliers and two stages of accumulators to perform the accumulation tasks of the filters in each of the two directions. Marino [7] has proposed a two-stage pipeline architecture in which the first stage performs the task of the first decomposition level and the second stage decomposes all the remaining levels and has aimed at providing a short computation time. These existing architectures have not exploited the computational parallelism inherent in the DWT operation to the extent possible in order to provide a high speed. The proposed architecture is modular and allows extension to any precision without much effect on the clock frequency. Simulation results have established that the proposed fast implementation scheme can produce high-quality reconstructed signals. The parallel DWT processor enhances throughput by producing two outputs in one clock cycle. The speed of the presented architecture does not depend on the number of filter taps and the number of bits per sample value. Since DWT was introduced, several codec algorithms were proposed to compress the transform coefficients as much as possible. Among them, Embedded Zerotree Wavelet (EZW), Set Partitioning In Hierarchical Trees (SPIHT) and Embedded Block Coding with Optimized Truncation (EBCOT) are the most famous ones [8-9]. In [9], if no entropy coding or arithmetic coding methods are incorporated coding tables are not required with slight loss in compression ratio. Moreover, SPIHT can be easily used for either fixed bit rate or variable bit rate applications and it is also very suitable for progressive transmission [8]. Furthermore, SPIHT has about 0.6 dB peak signal-to-noise-ratios (PSNR) gain over EZW [10] and is very close to EBCOT in many circumstances [9].

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In this work a pipelined SPIHT algorithm is designed for high speed applications. Section 2 discusses image compression and DWT algorithm, section 3 discusses DWT based image compression, Section 4 discusses design of DWT architectures and Section 5 discusses SPIHT encoder, Section 6 is conclusion.

II. Background Theory

An image (from Latin imago) is an artifact, for example a two-dimensional picture that has a similar appearance to some subject—usually a physical object or a person. Images may be two-dimensional, such as a photograph, screen display and as well as a three-dimensional, such as a statue. They may be captured by optical devices—such as cameras, mirrors, lenses, telescopes, microscopes, etc. and natural objects and phenomena, such as the human eye or water surfaces. A still image is a single static image, as distinguished from a moving image. This phrase is used in photography, visual media and the computer industry to emphasize that one is not talking about movies or in very precise or pedantic technical writing such as a standard. Image file size—expressed as the number of bytes—increases with the number of pixels composing an image and the color depth of the pixels. The greater the number of rows and columns, the greater the image resolution, and larger the file. Also, each pixel of an image increases in size when its color depth increases—an 8-bit pixel (1 byte) stores 256 colors, a 24-bit pixel (3 bytes) stores 16 million colors, the latter known as true color. The need for image compression becomes apparent when the number of bits per image resulting from typical sampling and quantization schemes is computed. Considering the amount of storage for the 'Lena' digital image, the monochrome (grayscale) version of this image with a resolution 512x512x8 bits/pixel requires a total of 2,097,152 bits, or 786,432 bytes. Such image should be compressed for efficient storage or transmission. Image compression refers to algorithms which reduce image data redundancy in order to store the image efficiently. Uncompressed multimedia data demands considerable storage capacity and bandwidth. Digital images can be compressed due to two factors which are [11]:

1. Spatial redundancy
2. Perceptual redundancy.

Spatial redundancy refers to intra frame redundancy that when the image are taken in dark back ground or when the background will be same colour most of the data required to represent the image will be same and are redundant which can be ignored to save storage space. This can also be defined as the correlation between the adjacent pixel values.

Figure 1 : Perceptual redundancy in images [2]

A pixel in an image will be represented as 8 bits. If we observe the two figures shown in Figure 1 above, the first one is represented with 6 bits and seems to be good in quality where as the other which is represented with 4 bits looks blurred. Human eye will not be able to distinguish even when the image is represented with 6 bits which is short of some information; this is called perceptual redundancy and is taken as advantage for compressing the images. Compression is of two types: Lossless compression and Lossy compression. Lossless compression is one where the information can be recovered after decompressing such that no loss of data occurs. For example 212 214 220 222 216 212 212 214 is the data in one line we can represent this as +212 +2 +6 +2 -6 -4 0 +2 and so on. This method is called predictive encoding. There is another way of lossless compression where for example k is the letter that repeats frequently in an image data so instead of representing k we replace all k's with '.' Simple dot as data represented for '.' is much less than a alphabet 'k'. In this way frequent symbols are represented with symbols which require less data to represent thus reducing the space required to store the image. This technique is called statistical encoding. In both the cases data can be recovered and no loss occurs. Lossy compression is one where the data compressed cannot be recovered. For example a 1024x1024 resolution image is transmitted as 512x512 pixels it is a lossy compression. There are different forms of lossy compression of which we are interested in transform

encoding based lossy compression. Transform encoding involves mathematical transformation separating image information based on gradual spatial variation of brightness from information with faster variation of brightness at edges of the image. In the next step, the information on slower changes is transmitted lossless, but information on faster local changes is transmitted with lower accuracy by quantizing the data. This results in loss of data which cannot be recovered.

III. Wavelet based Image Compression

Wavelet coding has become very popular due to its robustness under transmission and decoding errors at higher compression rates avoiding blocking artifacts. Wavelet based compression is based on sub-band coding. Sub band coding involves splitting the frequency band of the image into sub bands and then to code each sub band using a coder and bit rate accurately matched to the statistics of the band. Simple DWT consists of a low pass filter and high pass filter which splits the image into low frequency and high frequency sub bands.

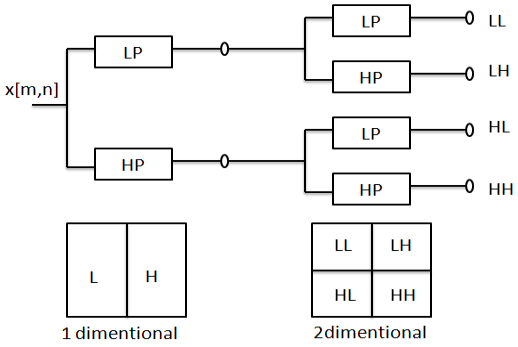

Figure 2 : 2-Dimensional DWT [2]

Figure 2 shows the two dimensional decomposition of image where the first one is row decomposition and the second stage is column decomposition.

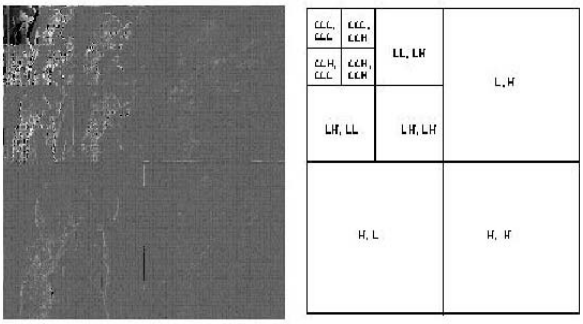

Figure 3 : Representation of decomposed image [2]

Decomposition is done till the image decomposes to 4x4 block. Figure 3 shows the decomposed image where the low frequencies are at the top left corner of the image and purely higher frequency at bottom right corner.

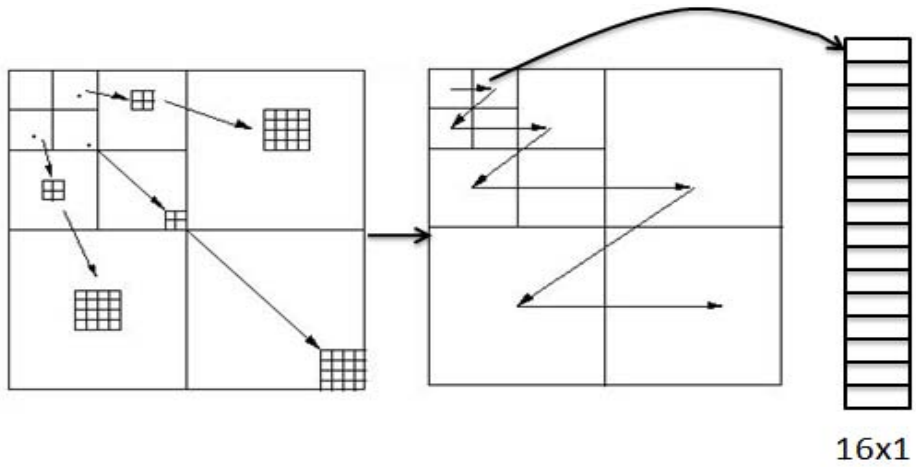

Figure 4 : Framing the decomposed blocks [2]

Once decomposed in to 4x4 blocks they are arranged in a 16x1 matrix in zigzag order as shown Figure 4, in this way all the blocks are arranged in the matrix finally it forms a 16xN matrix.

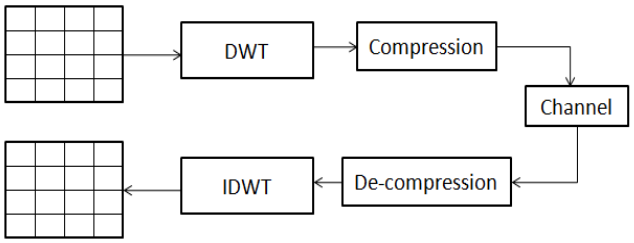

Figure 5 : Image compression block diagram

Finally after wavelet transformation image data is compressed and transmitted through channel and de-compressed at the receiver, after that IDWT will recover the image data that represents the image. In this work compression and de-compression algorithm have been developed as shown in Figure 5 using the existing wavelet transformation on FPGA hardware.

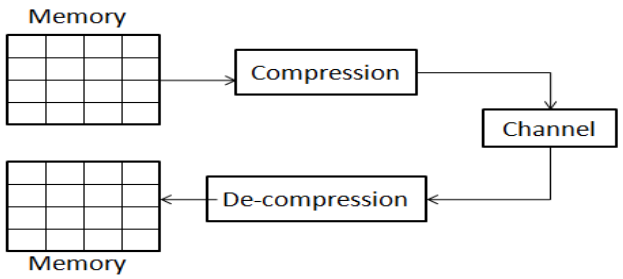

Figure 6 : Modified architecture

In order to demonstrate the working of the proposed hardware DWT values stored in a memory to compress and after de-compressing as shown in Figure 6.

IV. Design of dwt Architecture

In [12-15] DWT architectures have been discussed that use techniques like distributive arithmetic, lifting scheme and symmetric logic for hardware implementation to meet speed and power requirements. In [16-17] parallel processing algorithms are discussed for DWT implementation. In this work, high speed architectures for DWT and SPIHT encoding schemes are designed. Compressor involves converting a matrix of 16x64 elements into 4x64 elements by multiplying with fixed matrix of order4x64, this way memory required to store 16x64 elements is reduced and it is flexible to transmit 4x64 instead of 16x64 elements. Each column of 16x64 represents a 4x4 decomposed block and each element consists of 8 bits with sign-magnitude representation as shown in Figure 7.

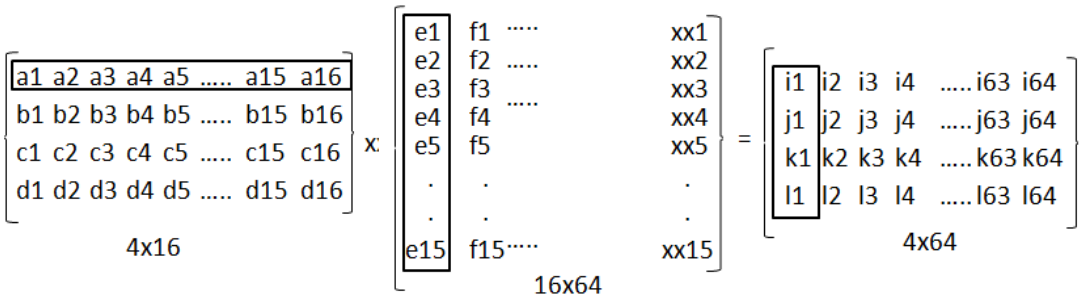

Figure 7 : Compressor concept

Compression basically done here is the multiplication of the input matrix with a fixed matrix to produce reduced number of elements for transmission and storage. Basic matrix multiplication involves multiplying and accumulating the row elements of one matrix with the other matrix. To perform this number of columns of first matrix should be equal to number of rows of the second matrix. One important consideration here as discussed in the previous step that 4x4 block is framed on to 16x1 matrix then input matrix is fed to the compressor as column by column. So that when the first column is received serially will be multiplied with 4 rows of the fixed matrix simultaneously as the input data is of real time nature, storing and processing input, would take much hardware hence we will proceed with 4-multipliers instead of one. So by the time when one complete column is received, it is processed and provides four outputs simultaneously. Output generation will require series of multiply and accumulate operations. If the input is in 2's complement one adder will be sufficient but as the input is signed format we need additional logic to decide whether addition or subtraction has to be performed. Since the last bit is sign bit we use only 7-bit multiplier instead of 8-bit thus balancing the hardware used for sign detection circuitry. Output will be stored in 8-bit, but after multiplication of two elements we get 15-bit including sign bit and if it is to be accumulated for 16 times which is the number of elements in the input column we get around 18 bits. So we will transmit only 8-MSB bits ignoring others, this is considered as quantization where certain information is lost. Another important aspect is storing the fixed matrix

elements in memory. If we store all the elements of matrix in a single memory, we can access only one element for one cycle. To perform 4 multiplications simultaneously and to access 4 row elements simultaneously, different row elements are stored in different memories of smaller size such that they can be accessed simultaneously. Another challenge occurs where output is available after every 16 cycles which is after receiving one complete column serially, 4 outputs will be available which cannot be sent serially in a single clock cycle. So we will transmit each output element for every 4 cycles because of a specific reason which we will discuss with de-compression section. After sending 4 elements for 16 cycles another set of outputs will be available to transmit. Since data is received serially we need to have a mechanism for synchronizing the data. An active high signal called 'vi' which is valid input is provided which is high if the input is valid, also a valid out signal is asserted when we transmit the data for each 4 cycles of the compressor. If this input is low data will not be received and no operation is performed.

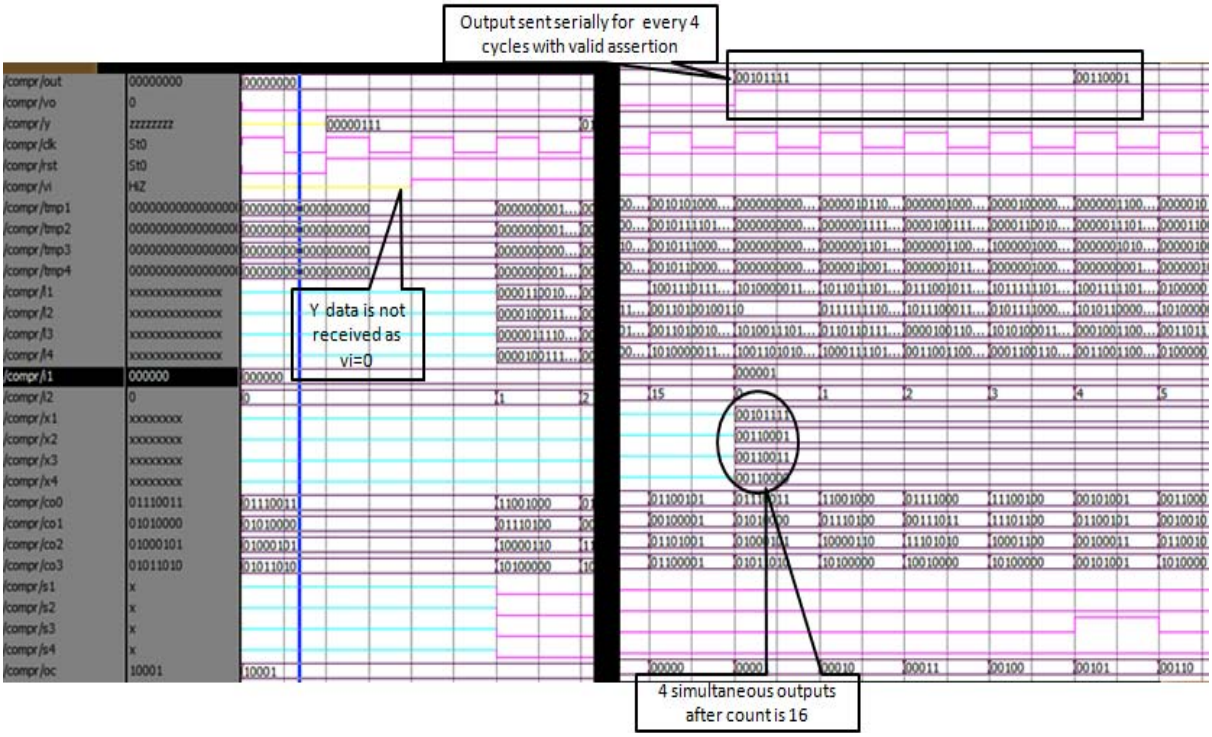

Figure 8 : Compression waveform

From the Figure 8 we can observe that when valid input is not asserted input y is not received and no operation is performed also, after 16 cycle 4 simultaneous outputs are available and are sent serially for each 4 cycles with 'vo' asserted which is marked in the waveform.

Device utilization for spartan3 and virtex2 FPGA are compared.Virtex2 has lesser utilization with 89 MHz frequency where as in spartan3 Maximum frequency is 83 MHz and Power consumed is 0.2W. It shows 4 multipliers one ROM and a total 4 adders and 8 subtractors were used, extra subtractors were required due to signed number representation.

Table 1 : Compressor device utilization for spartan3 xc3s200pq208-5

Number of Slices	300	1920	15%
Number of Slice Flip Flops	134	3840	3%
Number of 4 input LUTs	584	3840	15%
Number of bonded IOBs	20	173	11%
Number of MULT18X18s	4	12	33%

Table 2 : Compressor device utilization for virtex2 xc2v500fg256-5

Number of Slices	281	3072	9%
Number of Slice Flip Flops	134	6144	2%
Number of 4 input LUTs	549	6144	8%
Number of bonded IOBs	20	172	11%
Number of MULT18X18s	4	32	12%

SPARTAN3		Virtex2	
Macro Statistics		Macro Statistics	
# ROMs	: 1	# ROMs	: 1
16x32-bit ROM	: 1	16x32-bit ROM	: 1
# Multipliers	: 4	# Multipliers	: 4
7x7-bit multiplier	: 4	7x7-bit multiplier	: 4
# Adders/Subtractors	: 13	# Adders/Subtractors	: 13
18-bit adder carry out	: 4	18-bit adder carry out	: 4
19-bit subtractor	: 8	19-bit subtractor	: 8
5-bit adder	: 1	5-bit adder	: 1

a) De-Compressor

In de-compression compressed image is multiplied with the transpose of the fixed co-efficient matrix which was used for compression thus obtaining the actual 16x64 matrix is obtained.

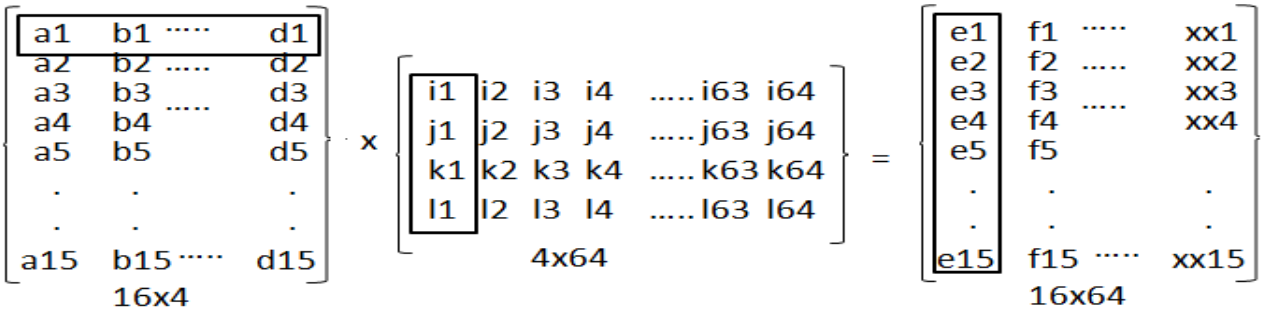

Figure 9 : De-compression

In De-compression we have 16 rows of fixed co-efficient as it is transposed so it infers that we need to use 16 multipliers to process real time input. This will consume more hardware so we will take advantage of the input property that input is available for every 4 cycles but not for every cycle which we intentionally designed for in the compressor section. Using this as advantage if we have the same 4 multipliers which multiplies an incoming element with 4 rows and before the next element comes that is after the next 4 cycles multiplication with all the sixteen rows will be completed thus with reduced hardware and same throughput is achieved by taking advantage of the input property. Using 16 multipliers has certain disadvantages which are when using 16 multipliers is input is not available for certain cycles for which no operation will be done causing reduced efficiency. Efficiency can be increased by operating de-compressor unit at 4 times faster than the previous block which is compressor, if it operates at high frequency 16 outputs will be available for each 4 cycles which have to be sent out serially in 4 cycles this imposes frequency constraints on the next computing block which is IDWT. So using 4 multipliers will have less hardware and high efficiency without latency and it is still capable of processing the real time compressed input. Output is again quantized to 8-bits to fit output register.

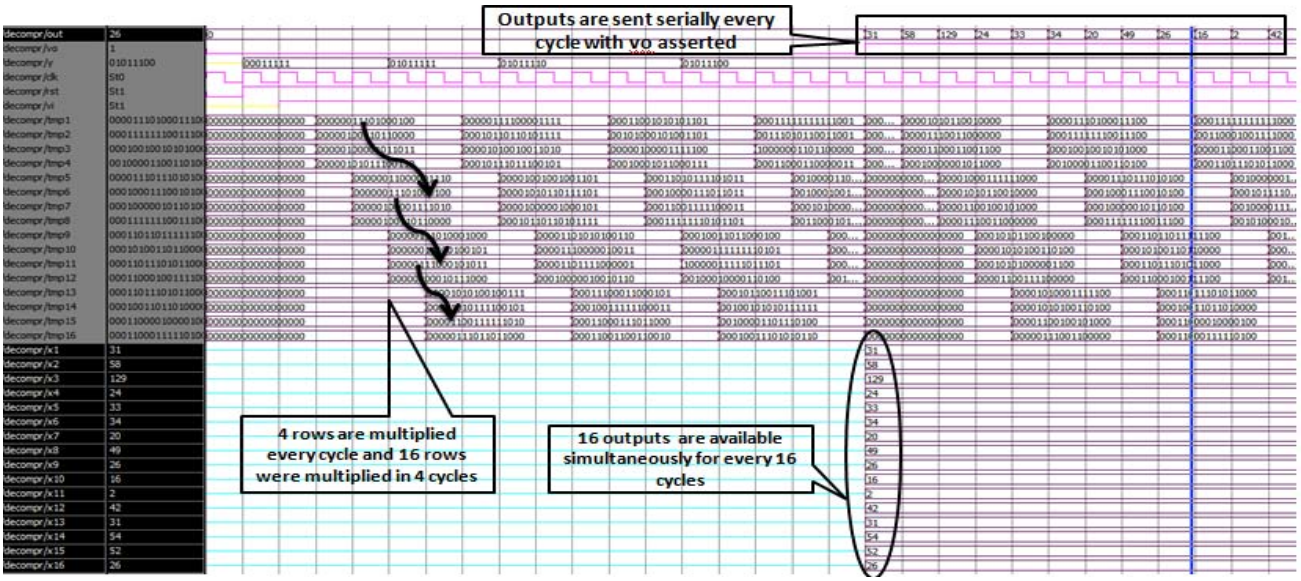

Figure 10 : De-compressor waveform

We can observe that 4 multipliers are used for four cycles to multiply 16 rows and after 4 cycles next input will be received and the process repeats. For every 16 cycles we will get 16 outputs simultaneously which will be stored in 16 registers and will be sent serially for every cycle and after 16 cycles we will obtain new set of outputs. Latency here is 16 but as the output is sent for every cycle throughput is 100%. This system can be called as a pipelined architecture.

Table 3 : De-compressor device utilization for virtex2 xc2v500fg256-5

Logic Utilization	Used	Available	Utilization
Number of Slices	1217	3072	39%
Number of Slice Flip Flops	424	6144	6%
Number of 4 input LUTs	2305	6144	37%
Number of bonded IOBs	20	172	11%

VIRTEX2

Macro Statistics
Multipliers : 4
7x7-bit multiplier : 4
Adders/Subtractors : 49
16-bit adder carry out : 16
17-bit subtractor : 32
2-bit adder : 1

SPARTAN3

Macro Statistics
Multipliers : 4
7x7-bit multiplier : 4
Adders/Subtractors : 49
16-bit adder carry out : 16
17-bit subtractor : 32
2-bit adder : 1

Device utilization for de-compressor is more than compressor as number of adders and subtractors as well as registers are 4 times more than the compressor because number of rows are 16 for fixed matrix and we have reduced the multipliers from 16 to 4.

b) Integration of Compressor and De-Compressor

Now we will integrate compressor and de-compressor along with memory to arrive at Figure 11. Here we have a memory containing DWT output which has a memory controller that controls the addresses to be read or written after which image is compressed and de-compressed and finally stored in a memory.

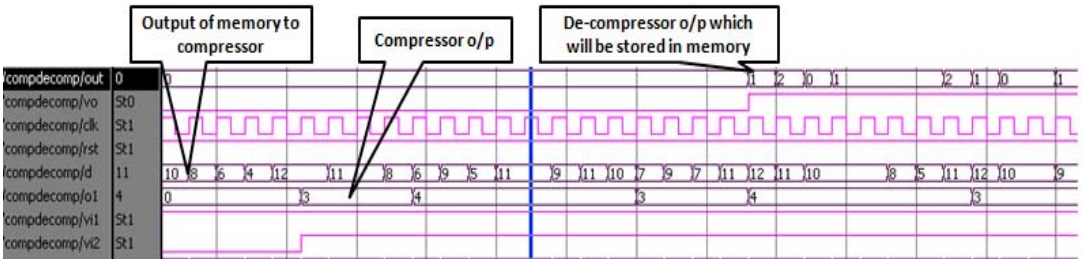

Figure 11 : Integrated waveform

D is the output of memory which is fed to compressor and o1 is the output of compressor fed to de-compressor and out is final de-compressed output which is again stored in the memory further to integrate with IDWT. Valid input and outputs used will provide synchronization between the multiple blocks and vo is asserted when data is available at out port.

Table 4 : Device utilization for Virtex-2 after integration

Logic Utilization	Used	Available	Utilization
Number of Slices	1500	3072	48%
Number of Slice Flip Flops	550	6144	8%
Number of 4 input LUTs	2853	6144	46%
Number of bonded IOBs	20	172	11%
Number of MULT18X18s	8	32	25%

Device utilization is combination of the utilization of compressor and de-compressor.

Table 5 : Device utilization for Virtex-5 after integration

Device Utilization Summary (estimated values)			[-]
Logic Utilization	**Used**	**Available**	**Utilization**
Number of Slice Registers	838	69120	1%
Number of Slice LUTs	942	69120	1%
Number of fully used LUT-FF pairs	396	1384	28%
Number of bonded IOBs	50	640	7%
Number of BUFG/BUFGCTRLs	5	32	15%

V. SPIHT Architecture

DWT decomposes input image into sub bands of various frequency components. The decomposed sub bands contain the low frequency components and higher frequency components. The low sub band component is further decomposed using 2D DWT into another four sets of sub bands, the higher sub bands are retained as it is after one level of decomposition. The lowest sub band which is low frequency component is considered as the parent, all other sub bands are considered as the child. In order to compress the decomposed image, SPIHT algorithm is used for compression. SPIHT makes use of three lists – the List of Significant Pixels (LSP), List of Insignificant Pixels (LIP) and List of Insignificant Sets (LIS). These are coefficient location lists that contain their coordinates. After the initialization, the algorithm takes two stages for each level of threshold – the sorting pass (in which lists are organized) and the refinement pass (which does the actual progressive coding transmission). The result is in the form of a bit stream. SPIHT keeps three lists: LIP, LSP and LIS. LIP stores insignificant pixels, LSP stores significant pixels and LIS stores insignificant sets. At the beginning, LSP is empty, LIP keeps all coefficients in the lowest sub band and LIS keeps all tree roots which are at the lowest sub band. SPIHT starts coding by running two passes. The first pass is the sorting pass browses the LIP and moves all significant coefficients to LSP and outputs its sign. Then it browses LIS executing the significance information and following the partitioning sorting algorithms. The second pass is the refining pass browses the coefficients in LSP and outputs a single bit alone based on the current threshold. After the two passes are finished, the threshold is divided by 2 and the encoder executes the two passes again. This procedure is recursively applied until the number of output bits reaches the desired number. An input of image size 16 x 16 is encoded using SPIHT algorithm, the input image after DWT decomposition and different pass of SPIHT is shown in Figure 12. For a 16 x 16 input image each of 8 bits, the total number of input bits before encoding is 768, after sixth pass encoding the compressed bits are 277 at the receiver, 277 bits are decoded to obtain 768 bits. For higher compression, it is required to stop SPIHT with lower number of pass.

108	50	-40	23	18	16	-20	28	33	18	17	-31	-1	0	7	9
95	-20	-80	44	4	56	17	6	24	-15	14	10	4	6	5	0
30	76	15	47	8	52	-25	70	15	-9	15	12	0	8	2	1
45	-30	14	17	38	12	1	-5	7	4	6	1	4	3	2	-1
32	13	39	10	5	28	2	0	50	8	5	6	25	0	-48	0
4	70	20	1	8	18	23	9	15	7	0	1	9	18	6	1
7	2	44	3	7	-60	38	10	0	6	5	4	5	4	13	0
4	80	55	18	-30	15	-10	8	3	0	-2	21	-1	0	7	9
34	17	18	-12	15	0	1	7	7	2	0	1	8	4	-1	0
4	45	13	-1	0	13	4	5	0	0	3	2	16	25	8	1
-1	3	7	-11	2	0	1	2	4	5	6	0	7	5	3	2
0	8	14	-20	7	2	8	0	0	7	8	-1	1	0	2	1
1	3	0	0	4	7	0	0	2	0	7	8	-10	1	2	1
20	0	1	-1	3	2	0	1	1	9	0	0	0	0	0	-5
2	8	3	6	2	4	1	0	0	0	2	1	0	0	2	1
1	4	0	-2	1	3	-1	0	1	0	3	0	1	0	-1	0

Fifth pass: N=2 Threshold = 4 Number of bits = 283

110	50	-42	22	18	18	-22	30	34	18	18	-30	0	0	6	10
94	-22	-82	46	6	58	18	6	26	-14	14	10	6	6	6	0
30	78	14	46	10	54	-30	70	14	-10	14	14	0	10	0	0
46	-30	14	18	38	14	0	6	6	6	6	0	6	0	0	0
34	14	38	10	6	30	0	0	50	10	6	6	26	0	-50	0
6	70	22	0	10	18	22	10	14	6	0	0	10	18	6	0
6	0	46	0	6	-62	38	10	0	6	6	6	6	6	14	0
6	82	54	18	-30	14	-10	10	0	0	0	22	0	0	6	10
34	18	18	-14	14	0	0	6	6	6	0	0	10	6	0	0
6	46	-14	0	0	14	6	6	0	0	0	0	18	26	10	0
0	0	6	-10	0	0	0	0	6	6	6	0	6	6	0	0
0	10	14	-22	6	0	10	0	0	6	10	0	0	0	0	0
0	0	0	0	6	6	0	0	0	0	6	10	-10	0	0	0
22	0	0	0	0	0	0	0	0	10	0	0	0	0	0	6
0	10	0	6	0	6	0	0	0	0	0	0	0	0	0	0
0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Sixth pass: N=1 Threshold = 2 Number of bits = 277

109	51	-41	21	19	17	-21	29	33	19	17	-31	0	0	7	9
95	-21	-81	45	5	57	17	7	25	-15	15	11	5	7	5	0
31	77	15	47	9	53	-29	71	15	-9	15	13	0	9	3	0
45	-31	15	17	39	13	0	5	7	5	7	0	5	3	3	0
33	13	39	9	5	29	3	0	51	9	5	7	25	0	-49	0
5	71	21	0	9	19	23	9	15	7	0	0	9	19	7	0
7	3	45	3	7	-61	39	11	0	7	5	5	5	5	13	0
5	81	53	19	-31	15	-11	9	3	0	-3	21	0	0	7	9
35	17	19	-13	13	0	0	7	7	3	0	0	9	5	7	0
5	45	-13	0	0	13	5	5	0	0	3	3	17	25	9	0
0	3	7	-11	3	0	0	3	5	5	5	0	7	5	3	3
0	9	15	-21	7	3	9	0	0	7	9	0	0	0	3	0
0	3	0	0	5	7	0	0	3	0	7	9	-9	0	3	0
21	0	0	0	3	3	0	0	0	9	0	0	0	0	0	-5
3	9	3	7	3	5	0	0	0	0	3	0	0	0	3	0
0	5	0	-3	0	3	0	0	0	0	3	0	0	0	0	0

Total number of bits required for decoding =47+123+169+248+283+277= 1147

Figure 12 : SPIHT encoder for 16 x 16 image

For compression of higher image sizes, the input image of size NxN is decomposed to three levels using three 2D DWT. Each 2D DWT consist of two 1D DWT that is performed along row and columns of input matrix. First level decomposition give rise to LL, LH, HL and HH sub band of size N/2xN/2. The LL sub band is decomposed to four more sub bands of N/4xN/4 size and in the third level LLL sub band is decomposed into N/8xN/8 sub band. Thus after three level decomposition there exist four sub bands of size N/8xN/8, three sub bands of size N/4xN/4 and three sub bands of N/2xN/2. SPIHT encoder algorithm encodes the ten sub bands into bit stream based on the compression ratio expressed in terms of bits per pixel (bpp). Input image is represented using 8 bit per pixel, the compressed image can be represented using bpp less than 8, thus leading to compression. Figure 13 shows the top level architecture of SPIHT encoder, the input image is stored in an input register, for each pass the SPIHT encoder algorithm is realized using logic gates and the output is stored in an intermediate register. The intermediate memory is further processed by the second stage SPIHT encoder and multiple stages of SPIHT encoder is designed for processing the inout data in pipeline. The master clock is used for synchronization of pipeline stages.

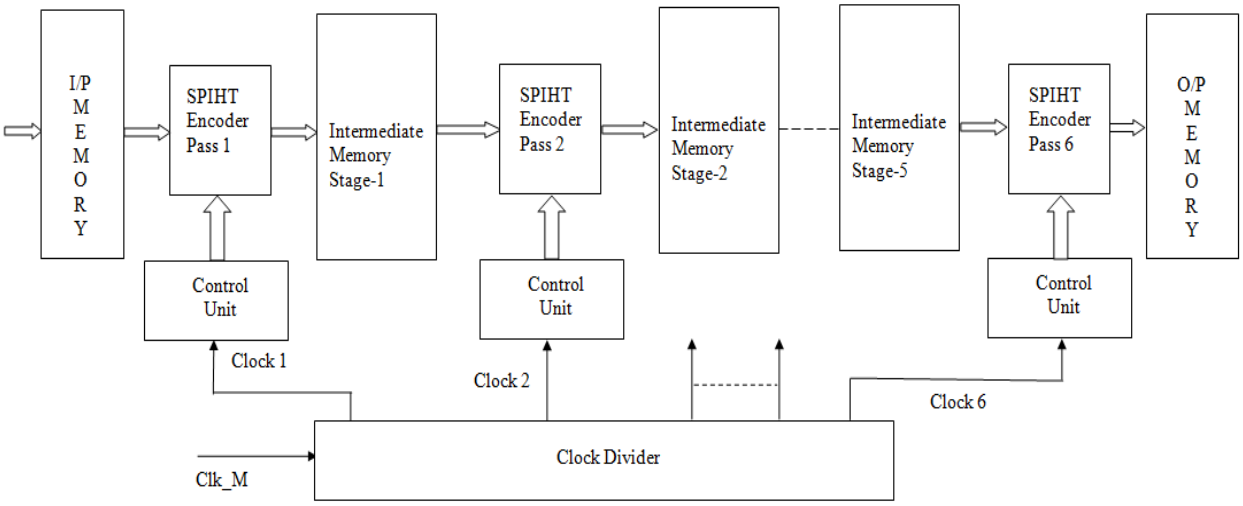

Figure 13 : Top level pipelined architecture for SPIHT encoder

Figure 14 shows the internal architecture of SPIHT encoder that consists of LIP memory for LL coefficients, LIS memory for higher sub bands. The LIP elements are compared for its significance and are transferred into LSP memory; similarly the LIS elements are partitioned and stored in sorted coefficients memory. Based on the LSP memory elements the bit stream is generated in the refinement pass. The pipelined architecture designed in this work achieves higher throughput and better latency. Independent memory modules used for every iteration increases area, however increases frequency of operation.

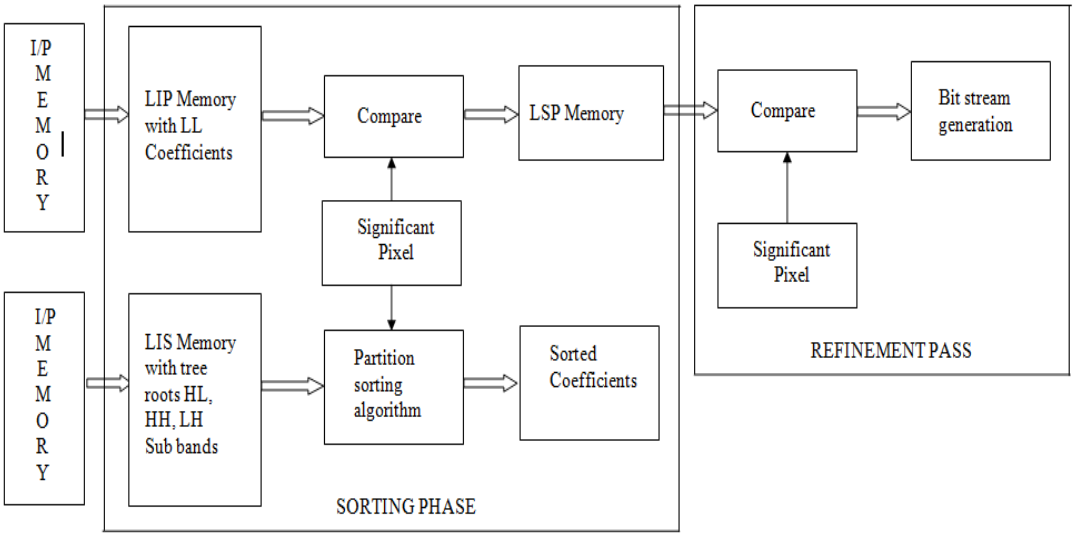

Figure 14 : Architecture of SPIHT encoder

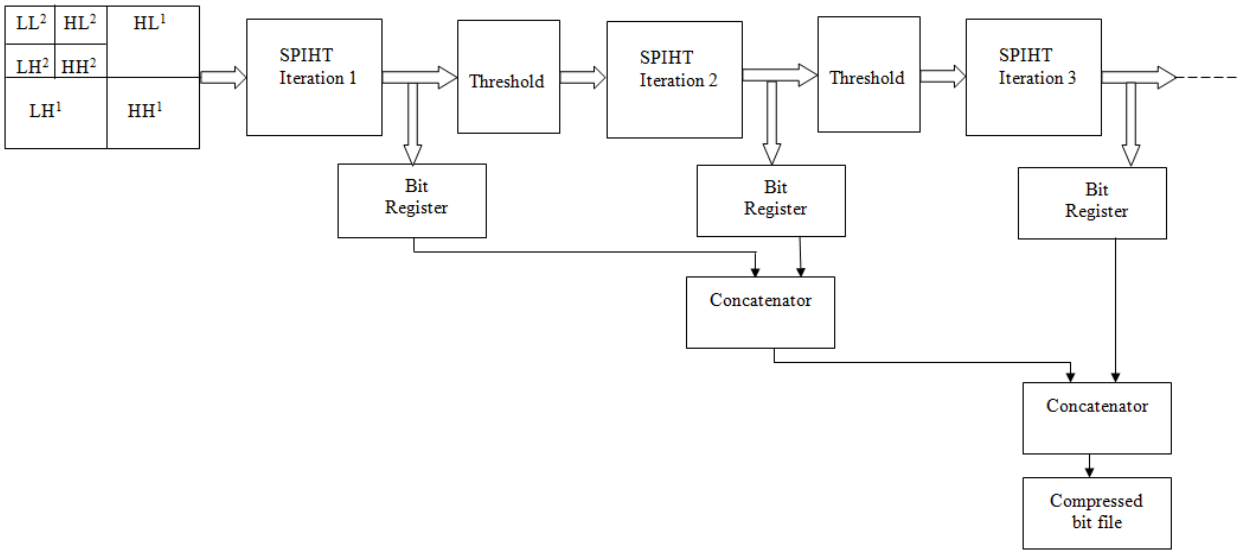

Figure 15 : Pipelined SPIHT encoder

The hierarchical sub bands obtained after two level 2-D DWT is stored in an input memory as shown in Figure 15. The SPIHT iteration 1 module generates the bit stream as discussed in Figure 14. The threshold module further scales the sub bands for generation of bit stream in the second iteration. The threshold levels are set according to the compression ratio required. In this work, variable threshold is set for LL and higher sub bands. The SPIHT encoder is repeatedly computes the bit stream until the sub bands in the input memory have elements greater than 10. The number 10 is fixed based on trial and error analysis carried out for achieving highest compression ratio of 120%. The final bit stream obtained after concatenation is regrouped and is transmitted over noisy channel. The SPIHT encoder is modeled using HDL and synthesized using Xilinx ISE targeting Virtex-5 FPGA. The synthesis results of first stage pipeline architecture for SPIHT encoder are shown in Figure 16.

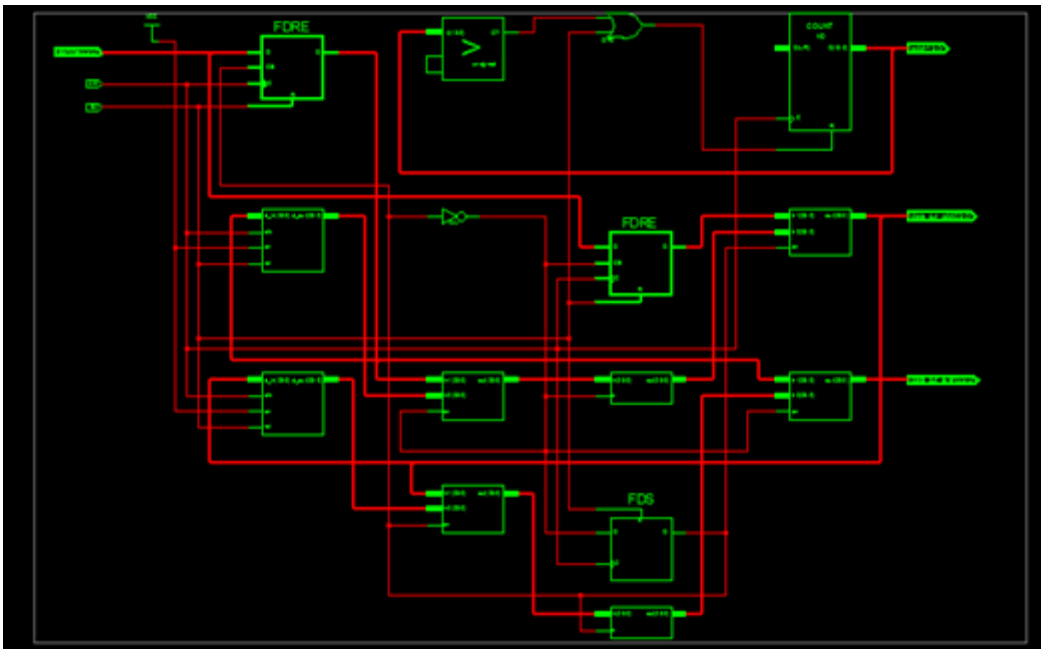

Figure 16 : First stage pipeline architecture for SPIHT encoder

Table 6 shows the synthesis results of SPIHT encoder on Virtex-5 FPGA. The HDL code is optimized for power and timing performances. From the simulation results and synthesis results obtained, it is demonstrated that the SPIHT algorithm developed functionally correct and is also optimized for high speed applications.

Table 6 : Synthesis results of SPIHT encoder

Parameters	Resource utilization
No. of slices	2389 out of 69120
No. of LUTs	3321 out of 69120
Max. Frequency	265 MHz
Power Dissipation	0.9mW

VI. Conclusion

Image compression technique with DWT is well understood and has been implemented on hardware. Entire architecture was split into individual blocks and developed for reduced hardware and higher throughput. De-compressor will take advantage of the input property that will be available for each 4 cycles and because of which 75% of the multipliers were reduced with 100% throughput and latency of 16. One important observation with XST toll is it will synthesize a block ROM when array is declared and used as memory where as if memory is defined in terms of look up tables XST will use CLB's. SPIHT encoder is designed using pipelined architecture and operates at maximum frequency of 265MHz. DWT combined with SPIHT occupy less than 5% of the resources on Virtex-5 FPGA.

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3. Submission of Manuscripts,

4. Manuscript's Category,

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14. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several and unnecessary diagrams will degrade the quality of your paper by creating "hotchpotch." So always, try to make and include those diagrams, which are made by your own to improve readability and understandability of your paper.

15. Use of direct quotes: When you do research relevant to literature, history or current affairs then use of quotes become essential but if study is relevant to science then use of quotes is not preferable.

16. Use proper verb tense: Use proper verb tenses in your paper. Use past tense, to present those events that happened. Use present tense to indicate events that are going on. Use future tense to indicate future happening events. Use of improper and wrong tenses will confuse the evaluator. Avoid the sentences that are incomplete.

17. Never use online paper: If you are getting any paper on Internet, then never use it as your research paper because it might be possible that evaluator has already seen it or maybe it is outdated version.

18. Pick a good study spot: To do your research studies always try to pick a spot, which is quiet. Every spot is not for studies. Spot that suits you choose it and proceed further.

19. Know what you know: Always try to know, what you know by making objectives. Else, you will be confused and cannot achieve your target.

20. Use good quality grammar: Always use a good quality grammar and use words that will throw positive impact on evaluator. Use of good quality grammar does not mean to use tough words, that for each word the evaluator has to go through dictionary. Do not start sentence with a conjunction. Do not fragment sentences. Eliminate one-word sentences. Ignore passive voice. Do not ever use a big word when a diminutive one would suffice. Verbs have to be in agreement with their subjects. Prepositions are not expressions to finish sentences with. It is incorrect to ever divide an infinitive. Avoid clichés like the disease. Also, always shun irritating alliteration. Use language that is simple and straight forward. put together a neat summary.

21. Arrangement of information: Each section of the main body should start with an opening sentence and there should be a changeover at the end of the section. Give only valid and powerful arguments to your topic. You may also maintain your arguments with records.

22. Never start in last minute: Always start at right time and give enough time to research work. Leaving everything to the last minute will degrade your paper and spoil your work.

23. Multitasking in research is not good: Doing several things at the same time proves bad habit in case of research activity. Research is an area, where everything has a particular time slot. Divide your research work in parts and do particular part in particular time slot.

24. Never copy others' work: Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

25. Take proper rest and food: No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

26. Go for seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. Think technically: Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

32. Never oversimplify everything: To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print to the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects in your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.

Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page
- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

Administration Rules Listed Before Submitting Your Research Paper to Global Journals Inc. (US)

Please carefully note down following rules and regulation before submitting your Research Paper to Global Journals Inc. (US):

Segment Draft and Final Research Paper: You have to strictly follow the template of research paper. If it is not done your paper may get rejected.

- The **major constraint** is that you must independently make all content, tables, graphs, and facts that are offered in the paper. You must write each part of the paper wholly on your own. The Peer-reviewers need to identify your own perceptive of the concepts in your own terms. NEVER extract straight from any foundation, and never rephrase someone else's analysis.

- Do not give permission to anyone else to "PROOFREAD" your manuscript.

- Methods to avoid Plagiarism is applied by us on every paper, if found guilty, you will be blacklisted by all of our collaborated research groups, your institution will be informed for this and strict legal actions will be taken immediately.)
- To guard yourself and others from possible illegal use please do not permit anyone right to use to your paper and files.

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Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

INDEX

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