Detailed study of Pearson Correlation and Cross-Correlation for Face Recognition

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Abstract – In the last decade face recognition has increasingly proliferated into various sectors such as health care , bio-metric based attendance system, maintaining low and order etc., In this work we have analyzed the most important algorithm that perform face recognition.

Keywords: Face recognition, Correlation, Cross correlation

I. Introduction – In the last few years face recognition has been gaining exponentially increasing demand due to its use across sectors. It can be used for bio -metric authentication, social-media space tagging etc., For a very long time face recognition has been performed by the robust correlation parameter based algorithms.

There are multiple type of correlation such as Karl Pearson correlation, Cross correlation , Kendal's Correlation, Spearman's Correlation etc. The most suitable correlation for face recognition is Pearson's Correlation as it can work on raw data. Cross correlation is primarily used for time and space variant signals. Hence it can be slightly modified to perform the face recognition.

II. Review of Literature

Correlation parameter has been used in multiple ways to accomplish face recognition.Annan Li*et.al.,* have maximised intra individual features that will increase correlation values in presence of pose variations[1]. A special variant of correlation called spherical correlation has been used for detecting curved correlation [2].Yung-hui Li*et.al.,* have used advanced correlation filters to recognise faces in the presence of illumination variations [3]. Michael Preetam, Jeffry *et.al.*,[4] discussed about the process for classifying cancer data sets .Further Boopidi, V.J Louis *et.al.*,[5] explained about the Implementing fast ICA using memristor crossbar arrays for blind image source separation. Recent works have designed more advanced filters based on correlation for recognising faces[6-7].

In this work, we have used the Pearson's correlation and Cross correlation to recognize face from the Yale face data base. We haveincluded variations in emotions such as happiness and sadness and included occlusions such as sunglasses to verify the robustness of the algorithms.

In the next section we describe Pearson's Correlation and Cross Correlation in detail. In the methodology and discuss Section we have explained our results. Finally in concluding section we have concluded our work

Correlation Parameter –

The correlation coefficient, denoted by r, is a measure of the strength of the straight-line or linear relationship between two variables. The correlation coefficient takes on values ranging between +1 and -1. There are many types of correlation such as Pearson Correlation, Cross-correlation, etc.,

Pearson Correlation (ρ): This is the most basic and most widely used correlation. Its formula is given by Equation (1):

$$\rho = \frac{cov(X,Y)}{\sigma_X \sigma_Y} \quad (1)$$

$$= \frac{\sum_{i=1}^{N}(x_i - x_{avg})(y_i - y_{avg})}{\left(\sqrt{\sum_{i=1}^{N}(x_i - x_{avg})^2}\right)\left(\sqrt{\sum_{i=1}^{N}(y_i - y_{avg})^2}\right)} \quad (2)$$

Cross-correlation Parameter:

Cross-correlation is a measure of similarity of two series as a function of the displacement of one relative to the other. This is also known as a sliding dot product or sliding inner product. It is commonly used for searching a long signal for a shorter, known feature. The cross-correlation between two sequences *f* and *g* is given by

$$(f * g)[n] = \sum_{m=-\infty}^{\infty} f[m]^* g[m+n] \quad (3)$$

III. Results & Discussion –

Fig 1 Sample image and image with occlusion(glasses)

Table 1 Pearson Correlation values

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0.94	0.7	0.7	0.78	0.74	0.11	0.69	0.69	0.6	0.78	0.7	0.46	0.74	0.39	0.67
2	0.82	0.9	0.57	0.85	0.82	0.03	0.6	0.58	0.51	0.68	0.72	0.62	0.77	0.24	0.56
3	0.71	0.59	0.87	0.68	0.72	0.2	0.85	0.81	0.69	0.8	0.6	0.41	0.81	0.51	0.8
4	0.78	0.87	0.57	0.97	0.78	0.04	0.63	0.56	0.51	0.67	0.71	0.64	0.75	0.28	0.56

5	0.71	0.76	0.59	0.78	0.99	0.1	0.63	0.6	0.59	0.66	0.65	0.66	0.82	0.31	0.55
6	0.07	0.23	0.12	0.09	0.05	0.8	0.16	0.16	0.19	0.1	0.07	0.29	0.01	0.44	0.15
7	0.61	0.45	0.88	0.55	0.6	0.36	0.93	0.88	0.87	0.84	0.51	0.27	0.62	0.68	0.91
8	0.63	0.46	0.89	0.55	0.6	0.31	0.88	1	0.8	0.85	0.49	0.28	0.64	0.62	0.88
9	0.76	0.68	0.75	0.72	0.81	0.14	0.76	0.78	0.67	0.8	0.61	0.49	0.78	0.4	0.73
10	0.86	0.75	0.73	0.81	0.82	0.13	0.75	0.72	0.63	0.82	0.72	0.51	0.81	0.4	0.71
11	0.73	0.66	0.63	0.74	0.68	0.13	0.65	0.58	0.53	0.66	0.94	0.52	0.68	0.38	0.59
12	0.67	0.87	0.47	0.85	0.84	0.03	0.52	0.47	0.47	0.56	0.72	0.78	0.72	0.18	0.45
13	0.68	0.68	0.72	0.75	0.79	0.14	0.74	0.68	0.57	0.68	0.63	0.53	0.98	0.41	0.64
14	0.28	0.07	0.56	0.23	0.26	0.7	0.57	0.57	0.6	0.48	0.26	0.02	0.32	0.96	0.56
15	0.74	0.57	0.71	0.64	0.61	0.24	0.77	0.74	0.7	0.86	0.53	0.34	0.56	0.48	0.74
Max	0.94	0.9	0.89	0.97	0.99	0.8	0.93	1	0.87	0.86	0.94	0.78	0.98	0.96	0.91

Table 2Cross Correlation values

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1	721	645	690	652	698	545	661	673	681	652	626	625	694	639	686
2	660	625	626	622	655	478	605	613	619	600	590	593	657	568	625
3	678	613	692	626	673	524	668	671	668	646	600	593	685	628	682
4	654	622	623	639	649	478	609	608	616	598	588	594	655	568	622
5	696	646	673	648	714	537	650	659	674	634	616	639	696	625	669
6	531	446	530	460	523	552	510	522	542	488	445	445	510	557	537
7	661	590	688	604	653	542	676	675	686	646	581	570	654	645	692
8	670	597	693	608	661	541	671	693	681	650	584	579	661	642	692
9	698	638	688	642	696	534	666	678	680	653	612	618	694	629	686
10	677	620	659	630	668	500	640	644	646	633	604	592	672	597	655
11	626	576	609	588	615	469	592	590	596	577	605	559	616	560	603
12	644	619	612	618	655	475	593	599	613	582	588	611	641	561	610
13	699	647	691	655	700	536	669	671	674	647	620	626	724	634	682
14	625	543	643	556	615	585	620	631	649	591	544	533	611	680	644
15	659	592	659	602	641	517	641	646	649	632	574	567	641	604	664
Max	721	647	693	655	714	585	676	693	686	653	626	639	724	680	692

A sample image and its matching occlusion-present image is shown in Fig 1. In Table 1, we have computed the Pearson correlation for all 15 images against all 15 occlusion-present images. In this case, the occlusion was Sunglasses. Each row represents one image while each column represents the images with occlusion. The correlation is represented in the table. The highest correlation for each occlusion-image is in the last row. The correlation value of the correct matching images is shown inside darkened borders. If the maximum correlation value is obtained for the correct match then the image is recognised accurately. In this table 11 out of 15 images have been correctly recognised.

In Table 2, we have the cross-correlation parameter. All values inside are in the order of 10^5. We can see that 6 out of 15 images have been correctly recognised.

IV.Conclusion:

Pearson correlation has a recognition accuracy of 73% (i.e., 11 out of 15) while cross correlation has a recognition accuracy of 40% (i.e., 6 out of 15). Hence, we conclude that Pearson correlation captures features better than cross-correlation and is more suitable for face recognition systems.

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