Face Recognition for Cattle

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***Abstract* - Global standards for cattle recognition, registration and traceability are being developed. However missed or swapped cattle, false insurance claims and reallocation of cattle at slaughter houses are global problems throughout the world. Previous cattle recognition approaches have their own boundaries and they are not able to provide required level of security to cattle livestock. In this paper, an attempt has been made to minimize the above mentioned problems by descriptors automatic face recognition of cattle. The proposed multi-resolution algorithm extracts feature through Speeded Up Robust Feature (SURF) and Local Binary Patterns (LBP) from different Gaussian pyramid levels. The feature descriptors obtained at every Gaussian level area unit combined using weighted sum rule fusion techniques. The proposed algorithm yields rank-1 identification accuracy of 92.5 % on a cattle face database of 1200 cattle face image (120 subjects × 10 face image of each subject). Thus, in this paper, we have tried to demonstrate that identification of cattle based on their cattle face can be used to recognize the cattle and negate the notion that all cattle look alike.**

Keywords: Cattle, face recognition, animal identification, RFID, RANSAC.

I. Introduction

Recognition of cattle's face has received major attention during the past few years under the widespread and successful use of biometrics applications. The cattle recognition has a major role for their registration and traceability purposes. The correct registration technique would stop efforts for cattle manipulation and chase their movement. In general, the benefits of cattle traceability area unit to recognize the possession and parentage of every cattle to identify the unfold of unwellness therefore on guarantee food safety and validate sources, productions, exports and processes [1]. However, traditional approach of cattle identification has been a long faced problem for identification, registration, traceability, missed or swapped cattle and breeding association in different countries [2]. Wagyu Registry Association conducted registration of cattle's age of 4 months and over 14 months for breeding and marketing purpose [3]. Traditional cattle identification based on ear notching, microchip, freeze branding, RFID (Radio frequency Identification), ear tagging, ear tattooing and sketching (paint or dye) were used to provide required level of security to the cattle. Moreover body marker system of animal such as tattooing, ear notching can be easily identified by the owner or animal insured organizations and as such are not enough to provide reliability to cattle recognition. These approaches are not able to provide promising solutions to missing, swapping, theft, duplication and fraudulence activities of animal by imposters. Therefore it is still an open research problem in computer vision community as how to design and develop frameworks for automatic and robust animal identification.

According to available literature survey of cattle today online (www.cattletodayonline.com), 1.3 billion cattle population of the world is distributed as - 30% of total in Asia, 20% in South America, 15% in Africa, 14% in North Central America and 10% in Europe [4]. Also, a survey of cattle population states that every year around 14.121 million cattle are slaughtered for feeding in USA (January 1, 2012) [5]. All these facts emphasize the requirement of an automatic and robust identification scheme.

Animal biometrics system utilizes both the variability and uniqueness of vocalizations, coat patterns, body dynamics and their morphologies as biometrics traits [6]. Coat pattern of zebra, tiger, penguin and muzzle point of cattle are the equivalent to the fingerprints of humans.

The motivation of this work is to embark on a comprehensive research study on livestock for cattle identification, traceability and tracking, thus providing a mechanism for preventing livestock raiding and theft related violent conflicts in different countries. In addition, cattle identification system plays significant role in controlling vaccination management, disease outbreak and production management assignment of ownership. The uses of animal biometrics provide an identity of an individual based on their physical, chemical and behavioral characteristics. Biometric technologies are expected to provide better results over traditional animal identification methodologies and can be used to solve the discussed animal problems of being missing, swapped, forgotten, duplicated, border transfer, being falsely claimed for insurance and relocation at slaughter houses.

It is an emerging research analysis of animal detection and identification that is predicated on animal biometrics attribute referred to as composition. Animal biometrics offers a natural and reliable resolution to bound aspects of animal identity and livestock management by utilizing totally automated or semi-automated schemes to recognize human or animal supported their inherent physical and behavioral characteristics or animal's phenotypic appearance [7]. A phenotype is a combination of an organism's observation characteristics or traits such as their morphology, biochemical and physiological behavior. It has repeatedly been recognized as an intellectual frontier in different

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applications for animal security whose boundaries of applicability are yet to be determined. One of such novel applications is known as visual animal biometrics [6].

Adopting the phenotypic appearance in animal biometrics provides the motivation to develop efficient and more robust face recognition of cattle. Cattle classifications, tracking their lifecycle, understanding animal disease trajectory and population analysis are some applications which have focused research areas in visual animal biometrics. On the other hand, using the animal biometrics system has big challenges with respect to accuracy and robustness since the animal's body dynamics and body morphological traits may be easily controlled [5].

The outline of this paper is as follows: Section II demonstrates the literature review. Section III explains cattle face database and proposed algorithm for recognizing cattle. Section IV illustrates the experimental result and performance analysis in detail. Section V concludes our work and suggests some future research directions.

II. Related work

Traditional identification methodologies are used to provide security to livestock/cattle throughout world. These cattle identification methodologies categorized as: (1) Permanent identification methodology, (2) Semi-permanent identification methodology, and (3) Temporary identification methodology. Permanent identification approaches are ear tattooing, microchip, ear tip/notch and freeze branding. Semi-permanent identification methods include tagging and sketching (paint/dye) of id collar and ear. Lastly, RFID based identification methods which are used to provide security to the cattle is categorized under temporary identification methodologies. Sketching pattern of cattle's fur based approach can be used to recognize the broken colour of breeds (e.g. Ayrshires, Guernseys and Holsteins). The sketching only depends on the individual drawing ability which may lack in standard quality of pattern thereby affecting identification accuracy. Sketching approaches cannot be applied to solid coloured breeds (e.g., Red Poll, Milking Shorthorn and Brown Swiss breed associations) as they require discriminative artificial marking methods such as tattooing and tagging on the cattle's ear. According to Johnston, Edwards and Wardrope, ear tagging approach was not a successful method for cattle identification because the label can be lost easily [8] [9]. Table 1 demonstrates the traditional methodology for cattle identification based on different attributes.

In Indonesia animal identification was conducted by the ear tagging and it became the most feasible method for the cattle identification. Other countries such as Great Britain, Australia and USA have deployed system based on Radio-frequency identification (RFID) embedded in ear tag. The ear tag based approach works well in some ways, but also has its own limitations. The ear tag produces defects in the cattle's ear label and it may also be eventually get damaged. As a result the ear will gradually get corrupted because of the long-term usage. Beside these activities, all of artificial marking basically can be duplicated.

The aim of cattle breeding traceability system based on RFID provide an integrated framework for cattle identification and monitoring. W. Zaiqiong et al. proposed a RFID-based traceability system for daily beef cattle management in order to obtain full track of information in the process of beef breeding [11]. In order to get better identification, RFID can easily be deployed at checkpoints. UHF-RFID technology is an alternative for designed approach to retrieve animal data from the embedded microchips. The benefit of RFID Technology for cattle identification is to give proof of origin, age verification, disease control, automatic handling at farm, fraudulent protection, storing and updating vaccination and movement data [12] [13]. The main drawback of RFID is that the cost of the RFID tag, that is higher as compared to barcode system and poses a good challenge to the cattle identification privacy. There is a requirement to develop a robust identification system for identifying individual cattle in order to achieve registration and traceability purposes, especially for beef cattle.

Traditional Identification Methods for Cattle Recognition for further improvement in animal detection and identification system, muzzleprint (nose print) of cattle was investigated as distinguished pattern for animals since 1921 [21]. Cattle identification approach based on muzzle point is a non-invasive, inexpensive and accurate biometric identifier analogous to human fingerprint. The registration and traceability process of cattle takes place in different countries (e.g. Japan, Canada, Australia and USA) for marketing and breeding purposes. In cattle identification, the muzzle patterns are lifted over white paper and marked with thin black ink from their age duration of 4 to 14 months. It is a manual cattle identification process and consumes a lot of time and dairy's staff assistance to get it.

The equipment and materials used in traditional approaches for cattle identification based on muzzle print are - A5- size white papers, stamp black ink, cottons and tissues. The procedure of muzzle data capturing are presented as - (1) The cattle's head has got to be kept still employing a rope, (2) Improvement the nose to eliminate snot victimisation tissues, (3) once cleared snot, apply a skinny ink layer victimisation cottons on the nose and so print on the paper with upward rolling movement, (4) Repeat steps 2 and 3 till the amount of information is adequate. The last step of data preparation is to convert muzzle printed data into digital image. The data lifted on paper were converted into digital images using a scanner with resolution 300 dpi.

Minagawa H. et al. proposed identification method of cattle based on their muzzle patterns lifted over paper. It does not need direct contact to the animal and it enables identification from a distance without getting too close [13]. However, it cannot be used in computerized analysis because inked print images do not have sufficient quality and there is no existing standard muzzle print benchmark. Kim et al. proposed a face recognition approach for Japanese black cattle which can easily be incorporated for their identification purposes [14]. Furthermore, Burghardt et al. evaluated the face recognition of individual animal or species based the appearance of their morphological characteristics (e.g. coat pattern) by video filmed in a widely unconstrained natural habitat.

Ali et al. have proposed that uses SIFT for detection the interesting points for image matching. For a strong identification scheme, a random sample consensus (RANSAC) algorithm program has been joined with the SIFT output to remove the outlier points and deliver the goods additional robustness. The identification accuracy of cattle in affordable interval is 90% [16]. But this approach takes additional processing time on large database size. It compensates some weaknesses of ear tagging and electrical based traditional identification techniques (RFID) in terms of accuracy and processing time.

Recently N. Ary et al. performed cattle identification based on muzzle point and compared with methods from the previous two research papers based on original SIFT approach, the value of the Equal Error Rate (EER) being equal to 0.0167. The proposed matching refinement technique has with success reduced the false matching in order that the value of the EER has been decreased to 0.0028. But in the proposed method acquisition of the muzzle point is a manual process since it is based on the image of the muzzle pattern lifted on paper. It does not have standard digital image which is captured by high resolution camera [17]. Gonzales Barron U. et al proposed approach for assessment of retina for biometric recognition of sheep [18].

Table 1 List of animal identification method

Identification method/ Attribute	Permanent Identification Method				Semi-Permanent Identification Method		Temporary Identification Method	
	Tattooing	**Microchip**	**Ear-Tip/Notch**	**Freeze Brand**	**ID Collar**	**Ear Tagging**	**Paint/Dye**	**RFID**
Reliability	Medium	Very high	High	Very high	Low	Low	Low	Very low
Cost	Medium	Very high	Low	Medium	Low	Low	Very low	Very low
Visibility	Very low	NA	Medium	High	Very high	Very high	Very high	NA
Longevity	High	Very High	Very High	High	Low	Low	Very low	Low
Risk of harm	Low	Very low	Medium	Low	High low	Very high	Very low	Very low
Accuracy	High	Very High	NA	Low	High	Low	Very low	High
Uniqueness	High	Very High	NA	Low	High	Medium	Very low	Very High
Database Required	High	Very High	NA	Low	Low	Medium	NA	Very High

1. Cattle Database Preparation and Description

To prepare the cattle's face database, a 12 megapixel digital camera has been used to capture cattle face images (indoor and outdoor background) from Institute of Agricultural, Department of Dairy and husbandry, BHU, Varanasi. The preparation of cattle database is taken in two different sessions. The size of cattle face image database is 1200 face images shown in figure 1.

Fig 1: Few cattle face image from Cattle face database

Data acquisition process faces problems due to non-cooperative and unconstrained environment of the cattle. If the cattle (cattle and calves) are uncomfortable due to hunger or health illness, they will not take a frontal position and ceaselessly move their head resulting in pose deformations over the whole body (shape and structure). The major issues in cattle database acquisition can be summed up as animals actively deforming their shape, animal body surface reflecting differently under different light luminance and animals getting partially hidden by vegetation. Cattle is supposed to exercise no voluntary control over their expressive behaviour, movement, dynamics and their body morphologies and thus are rendered as highly non-cooperative users of biometrics. Capturing their frontal face image with neutral face expression is a big challenge. It takes about 25–30 min in order to organize a good environment to capture the biometric data of single cattle.

A. Feature Extraction and Matching

The proposed feature extraction algorithm is galvanized by the observation that cattle have rich skin texture and distinct facial features. Further, it is troublesome to restrict pose variations of cattle, implying that holistic face recognition algorithms might not yields best results however local feature based algorithm might offer best results. The hypothesis created here is expresses as - information content present within the image changes with frontal face image pose and illumination condition variations in indoor and outdoor background. To expeditiously extract and encode this data local feature based algorithms should be utilized. The features used in this proposed research work are appearance based (PCA, LDA and ICA), texture based (Local Binary Patterns (LBP) and Speeded Up Robust Feature (SURF).

B. Proposed Algorithm for Recognizing Cattle

The steps involved in the proposed automatic cattle identification algorithm are illustrated in fig. 2. As mentioned previously, the pixel information in the Cattle face image changes with different body changes, pose variations and illumination condition. For example, in the cattle face images in figure 2, there are numerous poses and the illumination present in the face images of some cattle in the database is very low. The effect of such artefacts can be mitigated by using a Gaussian pyramid is called low pass filter process. Therefore, two levels of Gaussian pyramid are applied to ensure that excessive image information of pose and low illumination is sufficiently filtered while preserving discriminating texture information by using LBP and SURF feature extraction approaches. Four level of Gaussian images, SURF and LBP techniques are applied successfully to extract features from the original cattle face images contained in the cattle face database. LBP features are extracted from low frequency cattle face images while SURF features are extracted from the original cattle face image. Fig. 2 exemplifies the SURF and LBP features extracted from the original and Gaussian smoothed images. The details descriptions of the proposed recognition algorithm for cattle are described below:

For a given input cattle face image, the face region is detected, cropped and resized to 92×112 pixels. Cattle face images are convolved to get a set of low pass filtered images (Gaussian Pyramid). In low pass filter, If G_1 is the original image (e.g. the lowest level of the Gaussian Pyramid), then G_l, (the 1^{th} layer of the Gaussian pyramid) is given by:

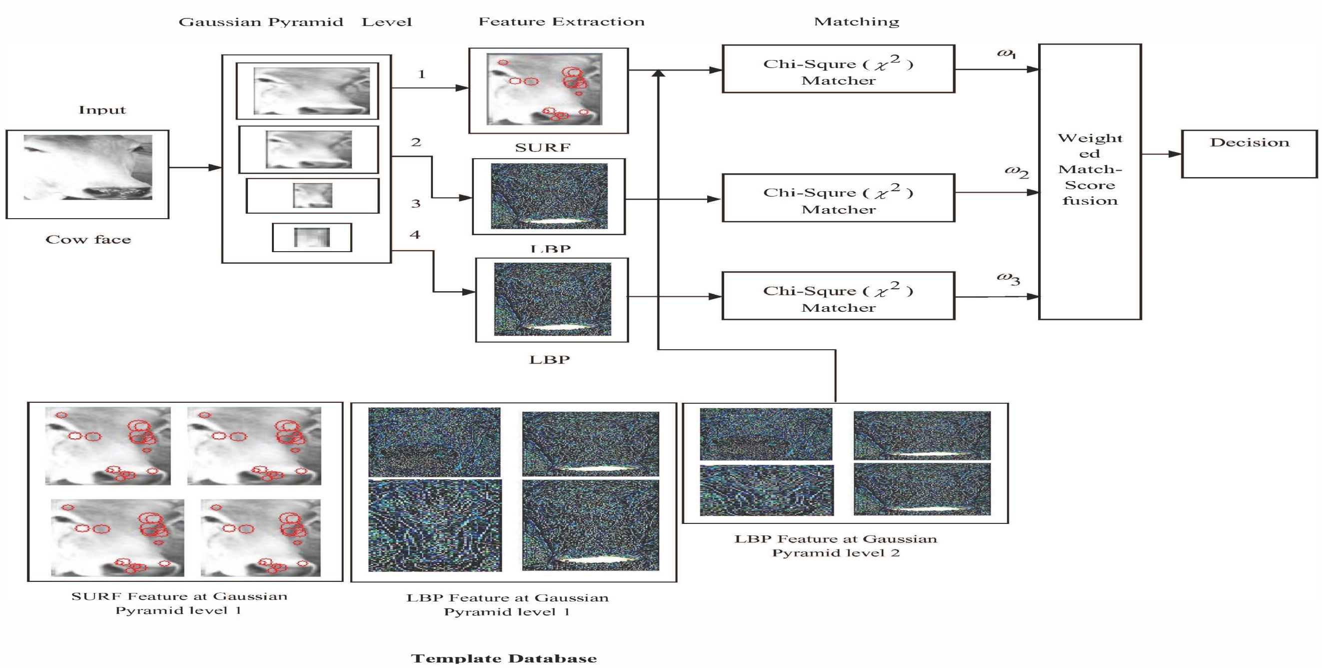

Fig 2: Demonstrating the steps involved in Cattle face recognition algorithm

$$G_l(i,j)=\sum_{m=-2}^{m=2}\sum_{n=2}^{n=-2} W(m,n)G_{l-1}(2i+m,2j+n) \quad \text{.......(3)}$$

Such that $(0 \le l \le N, 0 < i \le c_i, 0 < j \le R_l)$ where N is the number of Gaussian pyramid layers, c_i is the number of l^{th} layer, R_l is the l^{th} layer row number of Gaussian pyramid and W(m,n) presents at Gaussian kernel with dimensions of 5×5 window size and a reduction factor for Gaussian pyramid equal to 4. The steps are:

1. SURF descriptors area unit deployed to detect on the original image G_1. Descriptor provides scale and rotation

invariant data from the lowest level (G_1) of Gaussian pyramid.

2. Moving down the Gaussian pyramid, the size of image decreases and it cannot get sufficient number of interest points in the images at Gaussian pyramid level 1, level 2, level 3 and level 4. Therefore, CLBP is applied at only level 1 and level 2 and to confine the more discriminating texture Cattle face image information from these Gaussian pyramid levels.
3. In proposed face recognizing of Cattle face approach, Chi-Squre (χ^2) distance is employed to measure the unsimilarity between the corresponding levels of Gaussian pyramid. Suppose S_0, S_1 and S_2 be the min-max face image normalized scores for each Gaussian pyramid level.
4. Finally weighted sum rule [22] is applied for combine the 3 match scores,

$$S_{Fused}=W_0\times S_0+W_1\times S_1+W_2\times S_2 \quad\ldots\ldots(4)$$

5. In the above equation (4), w_0, w_1, and w_2 are the weights assigned to different levels of Gaussian pyramid and S_{Fused} is the fused score. In the proposed approach for

Cattle face recognition experiments, w_0 =0.9, w_1 =0.05 and w_2 = 0.05 yield the best recognition performance.

2. Automatic Segmentation

The experimental result of cattle face recognition is demonstrated in following parts: (A). Experimental performance evaluation. (B). Experimental Analysis.

2.1. Experimental Performance Evaluation

For experimental result based performance evaluation, the database of cattle face (images) was segmented into two parts: (i) Training (gallery). (ii) Testing (probe). Six images of every subject were at random selected for training (total of 40 subject ×10 images per subject) and remaining 160 images were used as testing. The training and testing partitioning were performed 5 times for cross validation and rank-1 identification accuracies were evaluated for cattle face recognition. The performance of the proposed algorithm is compared with SURF and LBP texture based algorithms along with three appearance based algorithms [24]. The three appearance based algorithms used for comparison are:

- Principal Component Analysis (PCA) [25]
- Linear Discriminative Analysis (LDA) [26]
- Independent Component Analysis (ICA) [27]

Following are cattle face identification accuracy of appearance and texture based face algorithms:

Table 2: Identification accuracy of appearance based cattle face recognition.

Gaussian Level	Identification Accuracy (%)		
	PCA	LDA	ICA
1	74.39	75.57	79.75
2	79.81	80.64	82.95
3	81.89	84.19	84.9
4	83.86	85.95	86.95

Table 3: Identification accuracy of Batch_CCIPCA, ICA, Ind-CCIPCA, ISVM, LDA, LDA_LiBSVM, PCA and PCA_LiBSVM

Gaussian Level	Identification Accuracy (%)							
	Batch-CCIPCA	ICA	Ind-CCIPCA	ISVM	LDA	LDA-LiBSVM	PCA	PCA-LiBSVM
1	78.39	78.75	46.95	82.48	77.29	70.33	75.95	78.57
2	83.9	80.29	47.32	88.68	80.95	75.79	83.5	85.67
3	85.9	86.34	50.95	93.87	85.59	84.9	86.7	92.75
4	93.37	89.75	52.25	96.87	92.87	93.91	90.38	95.62

Table 4: Identification accuracy of Batch-ILDA, CCIPCA-LiBSVM, ICA-LiBSVM, ILDA and ILDA-LiBSVM algorithms

Gaussian Level	Identification Accuracy (%)							
	Batch-CCIPCA	ICA	Ind-CCIPCA	ISVM	LDA	LDA-LiBSVM	PCA	PCA-LiBSVM
1	74.4	79.50	80.70	77.75	78.93	74.4	79.50	80.70
2	80.25	81.90	82.42	79.49	80.90	80.25	81.90	82.42
3	85.50	83.95	88.50	82.85	83.25	85.50	83.95	88.50
4	94.40	86.79	95.87	88.10	94.44	94.40	86.79	95.87

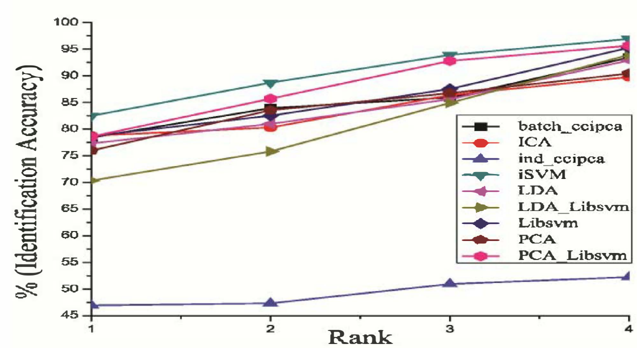

Fig.3. CMC to show identification accuracy of cattle's muzzle point (table.3).

Fig.4 demonstrates identification accuracy of Batch-ccipca, ICA, ind-ccipca, and isvm, LDA, LiBSVM, PCA and PCA-Libsvm for cattle's muzzle point. It illustrates that incremental support vector machine algorithm gives 95.87 % identification accuracy with respect to others. Accuracy of ind-ccipca increases slowly on increasing the Gaussian pyramid level because the number of selected Eigen-muzzles decreases at each Gaussian level. This accuracy is very low compared to others algorithms. However, when leaving the top 10 eigenfaces (Eigen muzzle) for each algorithm, PCA achieves better accuracy due to the top PCA Eigen-muzzle encode illumination variations. Identification accuracy of PCA-Libsvm is higher than PCA because it predicts the Eigen-values data of test cattle muzzle point dataset. Similarly, identification accuracy of LDA-Libsvm is comparatively higher LDA at every Gaussian pyramid level.

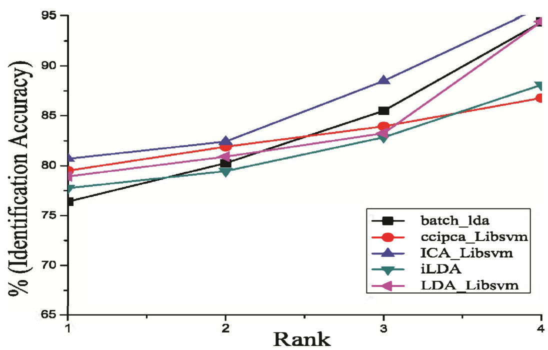

Fig. 4. CMC to show identification accuracy of cattle muzzle point (table.4)

Table 3: Identification accuracy of texture based and proposed cattle face recognition.

Gaussian Level	Identification Accuracy (%)		
	LBP	SURF	Proposed Algorithm
1	82.89	83.76	85.95
2	84.67	85.98	86.95
3	87.44	88.75	89.92
4	89.95	90.57	92.75

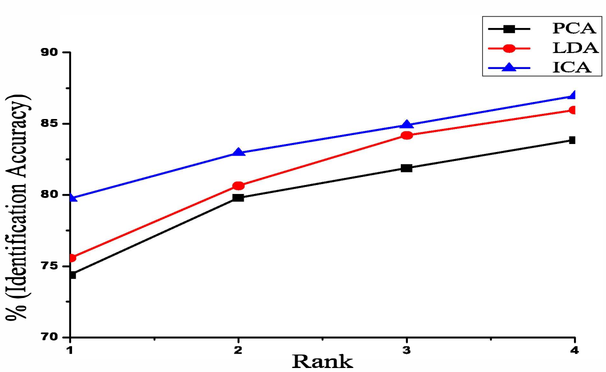

Fig. 5. CMC for appearance based algorithms (PCA, LDA and ICA).

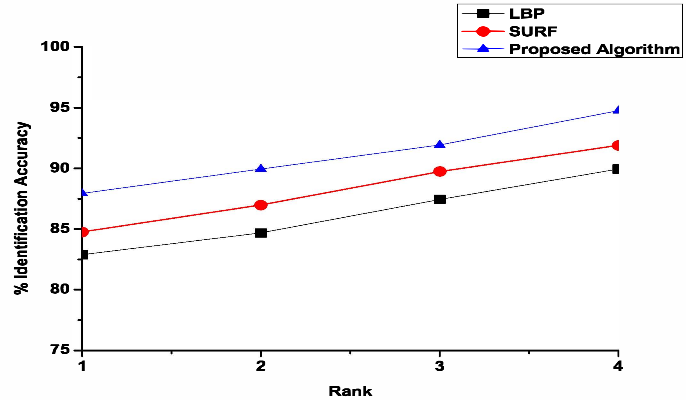

Fig 6. CMC to show identification accuracies of individual components of the proposed face recognition algorithm.

Fig. 3 shows identification accuracy of ICA-Libsvm is 95.87% higher than batch-iLDA, ccipca-Libsvm, incremental-LDA (iLDA) and iLDA-Libsvm. ICA and ICA-Libsvm improve the identification accuracy of PCA by removing the first and second order statistics by sheering the dataset.

4.2. Experimental Performance Evaluation

The identification accuracy of all the 6 face recognition algorithms (e.g. PCA, LDA, ICA, SURF, LBP and the proposed algorithm) are computed on the cattle face database. The results of above algorithm based experiment are demonstrated in table 2 (Fig. 4) and table 3 (Fig. 5) respectively. Some experimental points can be illustrated as follows:

- Table II demonstrates that among the appearance based algorithms, Independent Component Analysis (ICA) yields the best accuracy of 86.95%. It can account for more variation (size, shape and cattle face) in the input Cattle face image compared to PCA and LDA. Accuracy of PCA and LDA increases with increasing the levels of the Gaussian pyramid i.e., decreasing the resolution of the image.
- For local texture based algorithms for face recognition, SURF yields the maximum accuracy 90.57% at level 4 whereas for LBP, it had been noticed (with the help of table 3) that the performance of LBP will increases with increasing the levels of Gaussian pyramid. This demonstrates that LBP yields higher performance with images smoothed by applying Gaussian pyramid.
- Since the performance trend for higher level of Gaussian pyramids is comparable for appearance based algorithms and LBP, correlation analysis was performed to for feature extractor that may offer maximum complementary data. The correlation value of LBP and SURF at level-1 was very low and thus the appliance of SURF features at

level-0 and LBP features at levels-1 and level-2 within the proposed algorithm.

- The performance of the proposed algorithm is evaluated and average rank-1 identification accuracy is observed to be 92.75% with a standard deviation of 2.18.

III. Conclusion and Future Direction

Missing, swapping, reallocation and false insurance claims at slaughter homes area unit global problems throughout the world and use of biometrics and non-biometrics methodology not able to give them enough level of security to manage mentioned above issues. This research pioneers a new unconstrained cattle face database with different muzzle pattern, pose variation and expression. The objective of this research is to explore the possibility of using face of cattle for recognition. This research performs a preliminary study on using automatic face recognition for identifying face of cattle. Speeded Up Robust Feature (SURF) and Local Binary Pattern (LBP) texture based face recognition algorithm has been proposed to extracts local texture features from different levels of Gaussian filtered images of cattle face. Experimental results on a database of 1200 (120 subjects x10 images of each) cattle face demonstrate that automatic face recognition for cattle is feasible to mitigate above traditional animal identification problems and may give better identification accuracy.

In future, we plan to do further research keeping in view the following areas. Size of cattle face database is to be enhanced and different conditions may be considered while acquisition of cattle image for each subject: pose variation, distance variation and illumination variation and occlusion (covering, non covering) variation etc.

- Another relevant research study is to collect images of cattle after a couple of months and then analyze the efficiency of face recognition in cattle.
- Illumination variation could be a big challenge due to completely different light conditions indoors and outdoors, atmospheric condition etc. Hence new illumination invariant methodology should be developed for cattle recognition based on their face and muzzle point pattern.
- Covariates–based fusion techniques can be developed as cattle covariates are to be estimated from the pair of images being compared.
- Multimodal-biometric techniques can be developed to improve the recognition accuracy of cattle face by using muzzle point pattern and face as biometric identifiers.
- After performance evaluation of different face recognition algorithms with different covariates, we tend to here with conclude that algorithm developers, scientist and researchers have nonetheless to explore the depths of the method of cattle face recognition.

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