ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

BEEF CATTLE IDENTIFICATION USING PCA AND OTHER CATTLE IDENTIFICATION METHODS

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DOI: 10.5281/zenodo.1042110

ABSTRACT
Various Cattle identification methods are discussed in this paper. Cattle identification methods can be classified into 3, viz. Mechanical methods, Electronic methods and Biometric methods. Tagging, branding and tattoos are most commonly used mechanical methods. Three main electronic identifiers are ear tags, ruminal boluses and injectable transponders. DNA profiling, Iris imaging, Retinal imaging and Muzzle pattern imaging are biometric methods. All these are discussed in this paper with their merits and demerits. Finally beef cattle identification using eigen muzzle approach is studied and implemented.

KEYWORDS: Biometrics, PCA, Euclidean distance, tagging, branding, ruminal boluses, injectable transponders DNA profiling, Iris imaging, Retinal imaging, Muzzle pattern imaging

I.INTRODUCTION
Individual animal identification can be achieved through ear notching, ear tagging (metal, plastic, electronic), branding, tattooing or biometric methods such as nose prints, iris scanning, retinal imaging and DNA profiling. Non-biometric methods are already widely used, with ear tagging as common one. Implantable chips have not been accepted by some countries because of the risk that the device might migrate and enter the food chain and hot-iron branding is prohibited on animal welfare grounds. All non-biometric methods are invasive. Biometric methods provide certain advantages over mechanical and electronic devices.

Identifying people or cattle based on their behavioral (gait) and distinctive anatomical (Iris, Retina) characteristics is called biometrics [1]. Biometric identifiers cannot be shared or misplaced and represents bodily identity. The main three functionalities provided by biometrics are positive identification, large scale identification and screening. Biometric identification consists of 3 processes. First, image of an attribute is obtained. Features are extracted in second step and finally matching is done for recognition.

Uneven features of skin surface of cattle are called Muzzle (viz. snout or nose) patterns [2]. The distribution and arrangement of valleys and ridges are responsible for the formation of pattern on the muzzle. The asymmetry between muzzle halves is significant and the pattern of cattle muzzle is highly hereditable [3]. Due to its uniqueness, the muzzle pattern can be considered as a biometric identifier. Because the muzzle pattern is consistent over time and individualistic like human fingerprints, it is used as a form of permanent identification. The pattern structure of cattle muzzle patterns is complex than that of human fingerprints, and since the structure features are changed or deformed during the growing stage, these pattern structures cannot be skillfully recognized by using a technique like the one used for conventional fingerprint comparison. A robust method is required to identify cattle using their muzzle prints.

Muzzle recognition has been an active area of research with numerous applications. Eigen muzzle approach is one of the appearance based face recognition method which was developed by M. Turk and A. Pentland [4] in 1991. This method uses principal component analysis (PCA) and decomposes muzzle images into small set of characteristic feature images called eigen muzzles. When a new muzzle image is given, it is projected to feature space. Feature classification is done using Euclidean distance measure. This paper ends with muzzle print recognition using PCA with accuracy measurement.

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II.MECHANICAL METHODS

Traditionally, tagging, branding and tattoos have been commonly used to identify animals for trace back programs.

II.1 PLASTIC AND BAR CODED EAR TAGS

Ear tags are common form of animal identification. The tags are pierced through the cattle's ear, and allow for an animal to be identified from the front and the back. Tags are normally installed between the second and third cartilage rib of ears, using an applicator gun that corresponds to the type of ear tag being used. Ear tags are inexpensive, easy to use, flexible in all types of weather and usually easy to read. The main drawbacks of ear tags are that their possibility of tearing injuries, they can be easily ripped from the ear or become lost and potential fraudulent identification. A flexible plastic tag is shown in Figure 1

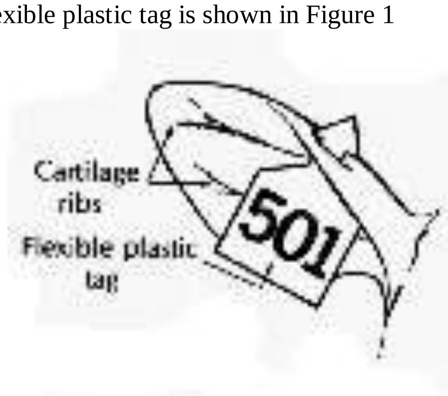

Figure 1. Proper attachment of ear tag

II.2 TATTOOING

Tattooing is commonly used in all animals and involves imprinting an identification number / letter combination into the skin of the animal using indelible ink. To avoid the interference of Tattooing with the use of ear tags the tattoo is placed above the first rib of the ear. Swine can be tattooed on the shoulder for carcass identification during slaughter and horses are often tattooed on the inside of their flank. One disadvantage of tattooing is that the animal must be restrained to apply and read the identification number [5]. A poor job of tattooing will produce tattoos that are hard to read. Figure 2 shows an ear with a tattoo and an ear tag.

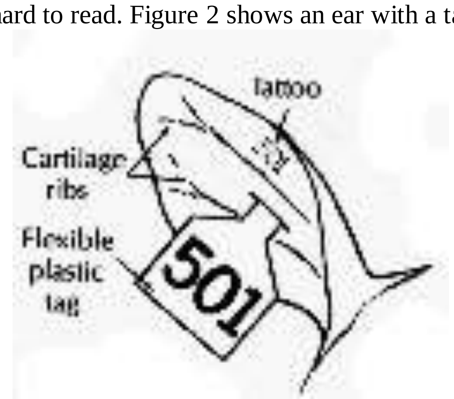

Figure 2. A good tattoo and ear tag in the same ear

II.3 FREEZE BRANDING

Freeze branding allows for animals to be identified from a greater distance than with ear tags. This method involves the use of branding irons, with letters and numbers, being chilled in liquid nitrogen or dry ice and alcohol. Upon application to the animal's hide, the chilled branding iron kills the cells that produce color pigment in the hair follicles. After freeze branding, white or colorless follicles are produced and this results in a permanent brand. Freeze branding causes less pain to the animal than that of hot branding. However, the freeze branding can only be applied on animals with dark hair.

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II.4 EAR NOTCHING

Ear notching is widely used in swine industry as a system of animal identification [5]. It involves removing V-shaped portions of the pig's ear that correspond to a specific litter number and also an individual pig number from that litter. The litter number is notched in the pig's right ear, and the individual pig number is notched in the pig's left ear (Figure 2.3). This system does not provide unique identification, due to the reduced distinct positions for ear notching. Another disadvantage is the discomfort and bleed caused to the pigs.

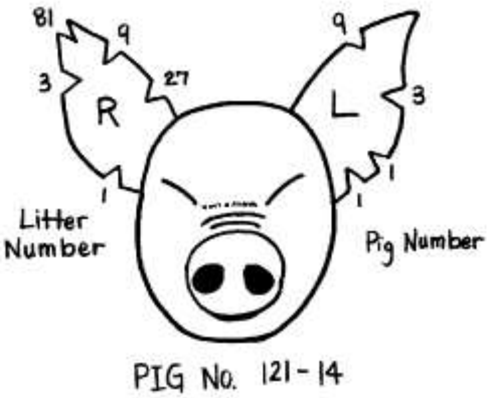

Figure 3 Ear notching system used by the purebred swine

III ELECTRONIC IDENTIFIERS

There are mainly 3 types of electronic identifiers, viz. ear tags, ruminal boluses and injectable transponders. Electronic identifiers are required due to ear tags and tattoos require manual and visible inspection.

III.1 RUMINAL BOLUS

An antenna and microchip are placed inside a small glass ampoule with high specific gravity ceramic capsule (bolus). It is then inserted into the ruminant's fore-stomach, usually the reticulum. According to Caja *et al*.[6], nontoxic ceramic material (alumina) of high specific weight is used to produce a bolus for enclosing different types of transponders. There are two types of readers, viz. static or portable. Static readers are used with large number of cattle. Static reader would read the electronic tag as the animal passed through the reading field and the information is downloaded and compared. The portable reader is used where the electronic identity is used for veterinary inspection or other management procedures [7].

The advantages of electronic rumen bolus are

1. It offers higher level of security.
2. Lack of physical damage or pain to the animal.
3. Minimal stress to the animal.

The main disadvantages of the rumen bolus are

1. High cost.
2. For routine management of the animals, it requires an external method of identification.

III.2 ELECTRONIC EAR TAG

Electronics ear tag was first introduced by Allflex USA, Inc. in 1993. It uses RFID technology. A coiled copper antenna and a microchip are encapsulated in a small plastic ear tag. Electronic ear tag is stationary and does not harm animal. Ear tags are unreliable because they are not tamper-proof as they can be easily ripped from the animal's ear or become lost.

III.3 INJECTABLE TRANSPONDER

Transponders have been injected in a variety of body locations like knee fold, armpit, forehead, ear, etc of the cattle [8]. The key concerns are breakage, loss or failure of transponders, migration of transponders and recovery of transponders after slaughter. The superior sites for implantation are base of the ear and axilla. Nehring *et al*. [9] found the axilla to have the higher retention, reading success and lower migration, compared to the base of the ear.

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IV ANIMAL BIOMETRIC IDENTIFIERS

A non invasive solution to individual animal identification is provided by biometric methods. Any measurable, robust and distinctive physical characteristic that is used to identify or verify the claimed identity of an animal is called animal biometric identifier [10]. Measurable means the characteristics that can be represented in quantifiable, digital format in real time. Robustness is the measure of extent to which the characteristic is subject to significant changes over time. The variation of differences in the biometric pattern among the general population is measured by distinctiveness. The uniqueness of the identifier increases with increase in distinctiveness. Cost, ease of implementation, reliability and ease of use are the factors for the selection of any biometric identification system.

Biometric Identification systems are using biological data that cannot be altered, faked or appropriated. Biometric methods include nose printing, retinal imaging, iris imaging and DNA profiling. These biometric methods are covering the life history of animal, permanent and less prone to errors or fraud. Thus the transfer of identity from one animal to another by removing ear tag is completely blocked [11]. Thus the use of biometric methods enables reduction is substitution and confidence in transaction. Illegal killing, selling, buying and transporting of animals could be monitored and controlled. Fraud and confusion are minimized by permanent, positive and unalterable biometric animal identification methods [11]. Further cost of identification is reduced by the reduction in expense of digital imaging machines. The main drawback of biometric identifier is that they are not visible and requires specialized technology to read [12].

IV.1 DNA PATTERN

Except in the cases of identical twins, each individual has a unique complement of antibodies and a unique DNA pattern. This is the most effective method for animal identification. DNA pattern based identification greatly reduce identification errors due to its positive, accurate, quick, unalterable and easy means of recognition. A project on Electronic identification and molecular markers for the traceability of live stock (EID +DNA) was conducted in Spain during 2001-2003[13]. In this project, real time tagging and tracing back was given by Electronic Identification (EID). DNA was used for auditing the tracing back of animals.
Biopsy tagging was an easy and tampers proof method of sampling DNA in animals. These biopsies are effective for the analysis of DNA single nucleotide polymorphism (SND) and microsatellites in cattle. This EID and DNA profiling were coded and stored in database with data comparison and retrieval tools.

IV.1.1 DNA IDENTIFICATION TECHNIQUES FOR LIVE ANIMALS

DNA technology can be used for identification of animals in following ways [14].

1 Identification of an animal by comparison with the DNA sample already taken from the same animal. For the purpose of animal disease control and eradication, biological samples are often taken from live stock. These samples are used for authenticating the identity.
2 Young animal's systematic sampling and archiving of samples. If samples are taken during first tagging, gives a powerful tool. For example, if hair or tissue samples were collected along with ear tag, it will provide powerful tool for the confirmation during the secondary sampling.
3 Animal's systematic sampling and DNA profiling. Each of samples is tested and its DNA information is stored in database. This is used for the verification of ear tag.

Figure 4 DNA Tag and hair samples collector from Allflex, Australia

Cunnigham et al. [14] opined that universal use of DNA alone is not justified, but DNA along with tag can be used for powerful means of identification. In 2003, 'DNA Tag' was launched by a company named Allllflex in Australia. This 'DNA Tag' combines DNA sample collector with Electronic Ear Tag (Figure 4). The Tag and sample collector are preprinted with unique code. When tag is inserted into animal, hair samples are collected and sent to laboratory. A computer database links the archived DNA sample and ear tag in field that can be used for genetic testing. Even after the animal is killed, the meat samples can be taken and traced back with already collected hair sample.

V RETINA IMAGING

The thickness of retina varies from $100 - 500\ \mu m$. The retina is composed of synaptic and cellular layers, which can be broadly divided into outer epithelial layer (referred as sensory retinal epithelium or retinal pigment epithelium) and inner sensory layer (referred as sensory retina or neuroretina). One of most metabolically active tissue in the body is retina [15]. The main function of retina is to convert light energy into chemical and electrical energy for vision.

The animal retinal patterns will not change after death up to six hours. Retinal images are not affected by injuries on eye's cornea. Thus retinal imaging is preferable to retinal scanning as it allows more powerful and flexible analysis of retinal data [17]. In 1998 an Optireader device has been developed by Optibrand for retinal imaging, shown in figure 5.

Figure 5 OptiReader device

Using a handheld computer in combination with ocular fundus infrared digital camera, retinal images are acquired without any contact with the animal.

After stabilizing animal movement, the operator moves the Optireader towards the eye. Using the LCD screen on reader, the operator can adjust the position of reader to get the image of pupil of eye. After pressing the trigger, the algorithm starts running, which looks for retinal structure in the eye. When the structure is found, green lamp glows, and three to five images are displayed to operator via LCD screen. When the operator releases the trigger, the reader will choose one of the images with best characteristic. The operator can also select according to own decision. After selecting the image, the green light is turned off and reader is ready for next animal. After the image capture, date, time and location information are entered into the computer plus any other information if required. The details are then transmitted to a central data bank.

The images are stored as jpeg grayscale image with the following information, viz. GPS, location ID, ear tag number, reader's serial number and operators ID [16]. The templates of the retinal veins are extracted and stored, during retinal image capture. For recognition, template matching algorithm is used with a matching score.

VI DRAWBACKS IN THE EXISTING PRODUCTS/PROCESS/TECHNOLOGY

The existing methods such as branding, tattooing, ear tagging, and ear notching were flawed in that the identifier could be replicated, replaced, or modified. Electronic Ear tags pose a problem for permanent animal identification because they can be lost or moved from one animal to another. DNA is a reliable form of identification, but it can be costly and can require days or weeks to get results. Iris recognition and retinal imaging are two examples of biometrics that are applicable to animals, and each is present from birth. Iris recognition use in animal identification will be limited by the fact that the iris pattern does not stabilize until the animal is several months old and can undergo alteration following injury or infection. Retinal imaging is most effiecient method but not cost effective. Therefore a new method is required which is rapid, inexpensive and tamper proof.

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

VII MUZZLE PATTERN IMAGING

Due to the uniqueness of muzzle (viz. snout or nose) pattern, it can be considered as a powerful biometric.

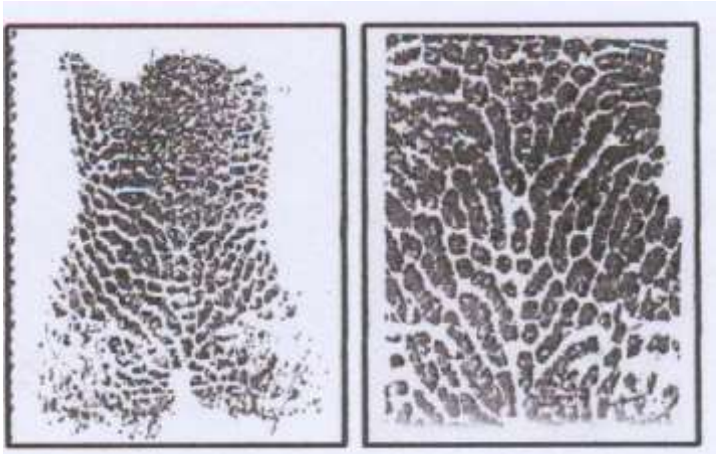

Figure 6 Examples of muzzle patterns of an animal at the age of 2 months (left) and the same animal at the age of 14 months (right)

Muzzle pattern of cattle are uneven features of their skin surface. It is a permanent way of identification. Examples of muzzle pattern of a cow taken on paper using black ink with in an age of 4 months and 14 months are shown in Figure 6. Muzzle patterns are consistent over time and individualistic like human finger prints. Disadvantages associated with ink & paper nose printing is long time and difficulty in obtaining print. These difficulties with ink and paper muzzle printing can be easily overcome with the use of digital imaging (Figure 7).

Figure 7 Digital image of muzzle pattern of cattle

VIII. MUZZLE PRINT RECOGNITION USING EUCLIDEAN DISTANCE AS CLASSIFIER

Muzzle print recognition using PCA and Euclidean classifier is summarized below.

1.Collect a set of 'M' muzzle images and perform following. ($M = 40,\ \ \tau_1, \tau_2, \tau_3, \dots, \tau_M$) The average muzzle of the set is defined by

$$\psi = \frac{1}{M} \sum_{n=1}^{M} \tau_n \qquad (1)$$

Calculate the difference image between each input image and average muzzle image.

$$\Phi_i = \Gamma_i - \psi \qquad (2)$$

These Φ_i are then used for principal component analysis, in which the data is best described by using eigen vector u_k and eigen values λ_k.

Build the matrix A of size $N^2 \times M$.

$$A = [\Phi_1, \Phi_2, \Phi_3, \dots, \Phi_M] \qquad (3)$$

2. Calculate the matrix L using eqn 4.

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$$L = A^T A \tag{4}$$

Find $M' = 8$, eigen vectors(v_i) of L with highest corresponding eigen values.
3.Calculate eigen muzzle U using equation 5

$$U = AV \tag{5}$$

4.Calculate weight vector Ω_i for each muzzle images (eqn 6). Calculate the threshold θ (eqn 7) that defines maximum allowable distance from any muzzle class.

$$\Omega_i = u^T \Phi_i \tag{6}$$

$$\theta = 0.46max\|\Omega_i - \Omega_j\| \tag{7}$$

$$\text{for } i = 1,2, \dots, M; j = 1,2, \dots M.$$

5. For a new muzzle image repeat 2 to 4 and classify according to eqn 8.

$$\begin{cases} \text{If } \theta \le \zeta \text{, not a muzzle image} \\ \text{If } \theta > \zeta, \theta > \varepsilon_{min}, \\ \text{it is a known muzzle corresponding } \varepsilon_{min} \\ \text{Otherwise, a new muzzle image} \end{cases} \tag{8}$$

IX. ACCURACY MEASUREMENT

The performance of the system can be measured by using accuracy [18]. Accuracy gives correctness of identification procedure. The accuracy of identification system is given by

$$Accuracy(\%) = \left(100 - \frac{(FAR(\%) + FRR(\%))}{2}\right) \tag{9}$$

where FRR is False Rejection Rate and FAR is False Acceptance Rate. FAR is the rate at which non-authorised muzzle is authorized as genuine. FRR is the rate at which genuine muzzle getting rejected. If FRR and FAR decreases, accuracy increases.

X. MATERIALS AND METHODS

Muzzle pattern can be digitized using two methods.

1. Ink and Paper method
2. Photo (Baranov et al 1993)

In our method muzzle photos are used. A previous research used PCA with Euclidean distance [16]. In this method, PCA is used for feature extraction and fuzzy distance measure for classification. The muzzle photos have been taken from Jersey kinds of beef cattle race. Special permission has been taken from Kerala Government for collecting muzzle photos from Kudappanakkunnu Farm, Trivandrum. The set of muzzle photos are standardized in orientation and scale manually. A rectangular region with minimum distance between nostrils is taken as Region of Interest (ROI). Example of ROI is shown in Figure 8. Each ROI is resized into 300×300 pixels. The blue rectangle region in Figure 8 is the ROI.

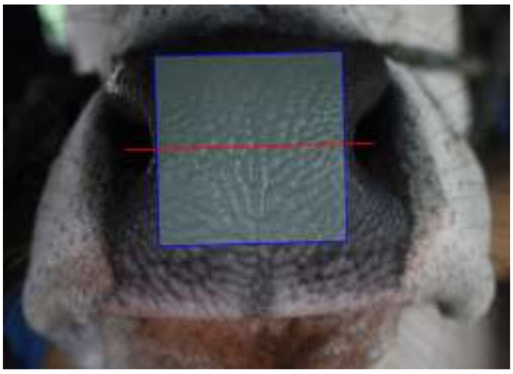

Figure 8 Region of Interest (ROI) of the muzzle photo

The experiments are done using a PC with intel core I5-4200M running at 2.5Ghz, and 4GB RAM. The PC is installed with MATLAB in windows R 64 bit. Programs in MATLAB are written for PCA and Fuzzy distance measure classification.

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Training Phase

Step 1. Collect and normalize the muzzle print image.
Step 2. Extract the features of the training image using PCA extraction method.
Step 3. Represent each image by one feature vector.
Step 4. Store the Database and find the distance measures among them.

Testing phase

Step 1. Collect and normalize the muzzle print image.
Step 2. Extract the features of the testing image using PCA.
Step 3. Compare feature vectors of testing image and training images using fuzzy distance measure.
Step 4. Matching to find muzzle or not and position as minimum distance value, if muzzle.

XI. ANALYSIS AND RESULTS

In our work the minimum image portion between muzzle nostrils is taken and normalized to 300×300 pixels. For each image, feature vectors are calculated using PCA. Using Euclidean distance measurement, classification is done and accuracy values (eqn.9) are noted. Muzzle images of 40 cows are collected and stored in database. Algorithm is tested for 5, 15, 25 and 35 with other images as unknown. Accuracy value is measured as per equation 9 and results are shown below.

Number of images	**5**	**15**	**25**	**35**
Accuracy (PCA with Euclidean)	**74**	**58**	**50**	**50**

The average accuracy of PCA with Euclidean is 58% and PCA. But PCA method is less resistant to geometric transformations.

XII. CONCLUSION AND FUTURE WORK

For the recognition of cattle, existing biometric and non biometric methods are studied in detail and cattle identification using PCA is implemented. In this method all the images are converted into PCA based feature vector. Classification is done using Euclidean distance measure. Results show that the method gives 58% accuracy. But PCA method is less resistant to geometric transformation. A rotation and scale invariant Speeded Up Robust Features (SURF) based muzzle print recognition method is available. This can be modified to produce better recognition with noise also, that will be the future work.

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