Animal Biometrics

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Preface

Animal biometrics is an emerging research field for representation and detection of visual animal biometric characteristics. It provides quantified methodologies for design and development of efficient animal biometrics-based recognition systems for different species or individual animal. The animal biometrics-based recognition refers to the use of discriminatory morphological characteristics, physiological and behavioral characteristics (face images, body structure, iris, movement pattern, and gait), phenotypic appearance-based features, and visual features (coat pattern of zebra, spot point on penguin's chest, skin patterning behind the gills of each whale shark and muzzle point image pattern of cattle). The phenotype appearance-based features of species or individual depict the major composite of observable and discriminatory feature characteristics of an organism. Further, it includes the morphological characteristics (image pattern), biochemical traits, phenology, behavior and biometric characteristics for detection and representation of species or individual animal, called animal biometrics identifiers or simply animal biometrics, for automatically detecting, representing, and recognizing a species or individual animal. The research field of animal biometrics uses formal methods to represent and detect biometric features, and morphological image pattern, and phenotypic appearances of animals. It can be utilized to recognize and classify species, identify individuals, detects the occurrence of, or variation in, a distinct behavior, as well as to estimate morphological characteristics and their inter-individual variation or intra-individual differences over time. The formal feature representation based methodologies which have been applied to identify and classify the massive classes of different species for identification of individual animal in the given class. Hence, it performs the detection of animal occurrence or variation in the huge inter-individual and intra-individual classes of species.

In the available literature on animal biometrics, the classical animal recognition methodologies are mainly ear-tagging-based animal identification, freeze branding, ear tattoos, ear-tips, or ear-notches, embedding of microchips and hot iron, embedding of transponders in the animal's body for identification, monitoring, and tracking of animals. These classical animal identification methodologies are invasive approaches for the recognition, and verification of individual cattle. Moreover, the classical animal recognition-based approaches are more susceptible to massive

vulnerability of loss and illegibility. It always leads to more security issues for the protection of cattle or other animals, as reported in various surveys.

Therefore, classical animal recognition methodology is unable to cater a competent level of security to individual cattle. Moreover, this methodology also fails to provide a required level of registration, identification of missed and swapped cattle, reallocation of livestock, and verification of false insurance claims. Furthermore, the classical animal recognition systems are limited in public domain due to the enormous amount of manpower requirements, high cost, and vulnerability of loss. This loss occurs due to duplication, fraudulent, and forging of embedded standard ear tags. However in the state-of-the-art-based animal recognition approaches, different governmental organizations and private animal insurance providers identify and then verify the animals to solve the biggest problem of the false insurance claims by cutting their ear or snatching the embedded label of ear tags or notches from the animal's ear. The duplication, forgery, and fraudulent processes are responsible for the falsification of the labeled ear tags. Therefore, it is tough to recognize and verify the registered insurance animals (owner of cattle) or impostor (non-insurance) animals.

Thus to provide better solutions for identification and verification of false insurance claims, monitoring of livestock, assistance during health management of animals, efficient recognition is required. The efficient recognition also prevents critical diseases and distribution of cattle in the livestock framework. These are thus the major issues of identification and monitoring of animals in the classical animal recognition approaches and traditional livestock framework-based systems. Further, these issues cannot be ignored by various scientists, veterinary professionals, animal experts, and different research communities before contributing their valuable efforts for the design and development of robust, noninvasive, and real-time animal biometrics-based recognition systems.

Therefore, it is strongly required to develop a real-time animal biometrics-based recognition system for identifying and monitoring different species or individual animal.

The animal biometrics is the emerging field and considered more reliable, like robust biometrics characteristics for verification and identification of species or individual animal than traditional animal identification-based methodologies. The animal biometrics-based recognition system can provide better security, higher efficiency, accuracy, cost-effectiveness and increased user convenience for modern livestock monitoring and frameworks. Therefore, the animal biometrics-based recognition system is used and deployed or evaluated in the livestock frameworks of private or government organizations (e.g., national Aadhar card for animals, verification of false insurance claims, analysis and study of the total species populations, monitoring of animal's health, diagnosis of widespread critical diseases) applications. Each animal biometrics identifier has its strength and weakness, and selection of particular biometric characteristics generally depends on the requirements of the applications. Any chosen biometric characteristics can also be compared on the well-defined factors such as universality, distinctiveness, permanence, collectability, performance, acceptability, and circumvention. Due to well-known distinctiveness and immutable properties of animal biometric identifiers over time,

these are the most widely used identifiers for recognition and verification of animals.

In view of addressing the above challenges, this book emphasizes the progress made in the classical animal identification methodologies for species or individual animal recognition over the past few decades. The authors believe that this book would provide a sound platform for understanding not only the fundamental coherent set of ideas or concept but also the intricate details of this proliferation and a wide range of technologies of animal biometrics, computer vision, and pattern recognition. In addition, the book is also helpful for the senior undergraduate and graduate students, researcher and industry professional working in this area, and other emerging applications demanding recognition and verification of animals.

The eight chapters of the book are organized as follows:

Chapter 1 presents a brief introduction of the animal biometrics followed by the major characteristics, advantages, potential applications, and interdisciplinary relevance of animal biometrics recognition system in the field of ecology. This chapter further includes the general framework of animal biometrics recognition systems along with major components for detection and identification of species or individual animal along with some state-of-the-art animal biometrics recognition systems. Furthermore, the chapter introduces the population distribution of different species, with opportunities, technological challenges, and recommendations for animal biometrics. Finally, the community, communication, data, and tool sharing are also included to provide the better collaboration to encourage the multidisciplinary researches in the field of animal biometrics.

Chapter 2 presents a comprehensive survey on the state of the art in the field of animal biometrics. This chapter provides a brief introduction to the discipline of animal biometrics followed by the classification and identification techniques of species or individual animal. Furthermore, the potential challenges of existing techniques and research communities, tools, and data sharing are also discussed in brief.

Chapter 3 contains an overview of several reported cattle recognition frameworks based on face biometric features of cattle. Further, the authors in this chapter have developed a biometrics-based cattle recognition system for the validation of prepared face image database of cattle for recognition of individual cattle. The proposed recognition system also has been utilized to evaluate the experimental results of cattle face image by applying the existing handcrafted feature descriptor technique and appearance-based feature extraction and representation techniques.

Chapter 4 presents an automatic recognition algorithm of muzzle point image pattern of cattle for the identification of individual cattle, verification of false insurance claims, registration, and its traceability process. The proposed algorithm uses the texture feature descriptors acquired at each Gaussian smoothed level that are combined using fusion weighted sum rule method. With a muzzle point image pattern database of 500 cattle, the proposed algorithm yields the desired level of identification accuracy. In this chapter, the experimental results demonstrate that the identification accuracy performance of the proposed method is found superior to other appearance-based face recognition algorithms.

Chapter 5 presents a novel framework using hybrid texture feature extraction and classification approaches to identify cattle based on muzzle point image features. Further, the methods characterize the extracted pattern of muzzle point image for better recognition and classification of cattle, and it examines the discriminatory features of muzzle images using texture feature extraction technique and supervised machine learning-based multiclassifier techniques. Furthermore, the proposed approach is validated in this chapter by achieving the state-of-the-art accuracy on muzzle point image database of cattle with standard identification settings.

Chapter 6 presents deep learning-based cattle recognition system. It is proposed to identify the individual cattle using muzzle point image pattern. The deep learning-based feature extraction and representation approaches are applied in this chapter to learn the discriminatory texture feature representation of muzzle point images with limited training dataset. The proposed approach consists of two steps: (1) a deep mixture model to find accurate patch correspondence between muzzle point image patterns and (2) convolution neural network, deep belief network, and stacked denoising auto-encoder-based fusion network to extract the features from muzzle point image pattern. Extensive experimental results illustrate that the proposed deep learning approach outperforms state-of-the-art methods for recognition of cattle on muzzle point image database.

Chapter 7 presents a novel Fisher locality preserving projection-based cattle recognition framework for extraction and representation of cattle identification in real time. In this chapter, the efficacy of proposed muzzle point-based recognition approach for cattle is evaluated under identification settings which yields excellent recognition rate for identifying individual cattle. Further, the approach is also evaluated for the optimum recognition time for enrollment and recognition of cattle on different sizes of cattle image database.

Finally, Chap. 8 explores the emerging trends and future challenges of state-of-the-art animal recognition techniques in brief. It concludes with the findings of this book and draws potential suggestions for the future research.

This book is an extension of Ph.D. thesis of Dr. Santosh Kumar submitted to the Department of Computer Science & Engineering, IIT (B.H.U.), Varanasi January 2017, under the supervision of Prof. S. K. Singh.

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Abbreviations

AFR	Affordability requirement
Batch-CCIPCA	Batch-candid covariance-free incremental-PCA
CLAHE	Contrast limited adaptive histogram equalization
CMC	Cumulative match characteristic
CNN	Convolutional neural network
CRS	Cattle recognition system
DBN	Deep belief network
DT	Decision tree
DTM	Data transfer and management
EAD	Ease to access database
EER	Equal error rate
EN	Ear notching
EOAS	Ease of application system
FAR	False acceptance rate
FLDA	Fisher linear discriminant analysis
FLLP	Fisher locality preserving projection
FMR	False matching rate
FNMR	False non-matching rate
FRR	False rejection rate
GAR	Genuine accept rate
GMM	Gaussian mixture model
HOOG	Haar of oriented gradient
ICA	Independent component analysis
ILDA	Incremental linear discriminant analysis
IND-CCIPCA	Independent-candid covariance-free incremental-PCA
INT	Intermediate
K-NN	K-nearest neighbor
LBP	Local binary pattern
LDA	Linear discriminant analysis
LO	Low

LP	Lack of pain
LTE	Law's texture energy
MLP	Multilayer perceptron
MO	Moderate
MPI	Muzzle point images
NA	Not available
OSS	One-shot similarity
PCA	Principal component analysis
PFFD	Protection from fraud and duplication
PIM	Permanent identification methodology
PNN	Probabilistic neural network
PSDFC	Protection and security during food chain
RBM	Restricted Boltzmann machine
RFID	Radio frequency identification
RIFT	Rotation-invariant feature transformation
RPCA	Robust principal component analysis
RVP	Retinal vascular pattern
SDAE	Stacked denoising auto-encoder
SFTA	Segmentation-based fractal texture analysis
SIFT	Scale-invariant feature transform
SIM	Semi-permanent identification methodology
SOS	Scalability of system
SRORD	Success rate of reading database
SURF	Speeded-up robust feature
SVM	Support vector machine
TDL	Tucker tensor decomposition
TIM	Temporary identification methodology
UID	Unique identification number
VLAD	Vector of locally aggregated descriptors

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