

# Chapter 8

## Research Publications

- **Santosh Kumar** and Sanjay Kumar Singh, “Biometric Recognition for Pet animal”, *Journal of Software Engineering and Applications*, 7 (5), pp 470–484, 2014, [Google Scholar based Impact Factor : 1.16].
- **Santosh Kumar**, Shrikant Tiwari and Sanjay Kumar Singh, “ Face Recognition of Cattle: Can it be Done? ”, *Proceedings of the National Academy of Sciences, India Section A: Physical Sciences*, 86 (2), pp.137–148, 2016, [Impact Factor : 0.390].
- **Santosh Kumar**, Sanjay Kumar Singh, Ravi Shankar Singh, Amit Kumar Singh and Shrikant Tiwari, “Real-time recognition of cattle using animal biometrics ”, *Journal of Real-Time Image Processing*, pp. 1–12, 2016, [Impact Factor : 1.564].
- **Santosh Kumar** , Sanjay Kumar Singh and Amit Kumar Singh, “A Muzzle Point Pattern based Techniques for Individual Cattle Identification ” , *IET Image Processing*, 2016, [Impact Factor : 1.048].
- **Santosh Kumar** and Sanjay Kumar Singh, “Visual Animal Biometrics: Survey ”, *IET Biometrics*, pp. 1–38, 2016, doi: 10.1049/iet-bmt.2016.0017, [Impact Factor : 0.875].
- **Santosh Kumar** and Sanjay Kumar Singh, “Automatic identification of cattle using muzzle point pattern: a hybrid feature extraction and classification paradigm” , *Multimedia Tools and Applications*, pp. 1–38, 2016, doi:10.1007/s11042-016-4181-9, [Impact Factor : 1.34].

- **Santosh Kumar** and Sanjay Kumar Singh, “Monitoring of Pet Animal in Smart Cities using Animal Biometrics” , *Future Generation Computer Systems*, 2016, doi: 10.1016/j.future.2016.12.006, [Impact factor : 2.335].
- **Santosh Kumar**, and Sanjay Kumar Singh, “Cattle Recognition: A New Frontier in Visual Animal Biometrics Research ” , *Proceedings of the National Academy of Sciences, India Section A: Physical Sciences*, [under review].
- **Santosh Kumar**, and Sanjay Kumar Singh, “Deep Learning Framework for Recognition of Cattle using Muzzle Point Image Pattern ” , *Measurement, Elsevier*, [under review].
- **Santosh Kumar** and Sanjay Kumar Singh, “ Face recognition for cattle ”, *2015 Third International Conference on Image Information Processing (ICIIP)*, Jaypee University, Solan, Himachal Pradesh, Wagnaghat, 2015, pp. 65–72.
- **Santosh Kumar** and Sanjay Kumar Singh, T. Dutta and H.P Gupta, “Poster: a real-time cattle recognition system using wireless multimedia networks”, *In Proceedings of the 14th Annual International Conference on Mobile Systems, Applications, and Services (Mobisys–2016)*, Singapore, 2016, pp.48–48.
- **Santosh Kumar** and Sanjay Kumar Singh, T. Dutta and H.P Gupta, “A Fast Cattle Recognition System using Smart devices”, *In Proceedings of the 2016 ACM on Multimedia Conference (ACM MM–2016)*, Amsterdam, The Netherlands, 15—19 October, 2016, pp.742–743.
- **Santosh Kumar**, Sanjay K. Singh, “Feature Selection and Recognition of Muzzle Pattern of Cattle by using Hybrid Chaos BFO and PSO Algorithms”, *Advances in Chaos Theory and Intelligent Control*, edited by Ahmad Taher Azar and Sundarapandian Vaidyanathan, 2015.

# Bibliography

- [1] E. H. ADELSON, C. H. ANDERSON, J. R. BERGEN, P. J. BURT, AND J. M. OGDEN, *Pyramid methods in image processing*, RCA engineer, 29 (1984), pp. 33–41.
- [2] S. AHMED, T. GABER, A. THARWAT, A. E. HASSANIEN, AND V. SNÁEL, *Muzzle-based cattle identification using speed up robust feature approach*, in International Conference on Intelligent Networking and Collaborative Systems (IN-COS),, 2015, pp. 99–104.
- [3] T. AHONEN, A. HADID, AND M. PIETIKAINEN, *Face description with local binary patterns: Application to face recognition*, IEEE transactions on pattern analysis and machine intelligence, 28 (2006), pp. 2037–2041.
- [4] A. AIT-SAIDI, G. CAJA, A. SALAMA, AND S. CARNÉ, *Implementing electronic identification for performance recording in sheep: I. manual versus semiautomatic and automatic recording systems in dairy and meat farms*, Journal of dairy science, 97 (2014), pp. 7505–7514.
- [5] A. ALLEN, B. GOLDEN, M. TAYLOR, D. PATTERSON, D. HENRIKSEN, AND R. SKUCE, *Evaluation of retinal imaging technology for the biometric identification of bovine animals in northern ireland*, Livestock science, 116 (2008), pp. 42–52.
- [6] S.-I. AMARI, A. CICHOCKI, H. H. YANG, ET AL., *A new learning algorithm for blind signal separation*, Advances in neural information processing systems, (1996), pp. 757–763.
- [7] V. M. ANU, M. DEEPIKA, AND L. M. GLADANCE, *Animal identification and data management using rfid technology*, in In Proceedings of IEEE International

- Conference on Innovation Information in Computing Technologies, IEEE, 2015, pp. 1–6.
- [8] W. R. ASSOCIATION ET AL., *The handbook for wagyu registration*, Kyoto: Wagyu Registry Association, (2009).
- [9] A. I. AWAD, *From classical methods to animal biometrics: A review on cattle identification and tracking*, *Computers and Electronics in Agriculture*, 123 (2016), pp. 423–435.
- [10] A. I. AWAD, H. M. ZAWBAA, H. A. MAHMOUD, E. H. H. A. NABI, R. H. FAYED, AND A. E. HASSANIEN, *A robust cattle identification scheme using muzzle print images*, in *In Proceedings of the IEEE Federated Conference on Computer Science and Information Systems (FedCSIS, 2013)*, pp. 529–534.
- [11] A. BARANOV, R. GRAML, F. PIRCHNER, AND D. SCHMID, *Breed differences and intra-breed genetic variability of dermatoglyphic pattern of cattle*, *Journal of Animal Breeding and Genetics*, 110 (1993), pp. 385–392.
- [12] U. BARRON, F. BUTLER, K. MCDONNELL, S. WARD, ET AL., *The end of the identity crisis? advances in biometric markers for animal identification.*, *Irish Veterinary Journal*, 62 (2009), pp. 204–208.
- [13] U. G. BARRON, G. CORKERY, B. BARRY, F. BUTLER, K. MCDONNELL, AND S. WARD, *Assessment of retinal recognition technology as a biometric method for sheep identification*, *Computers and electronics in agriculture*, 60 (2008), pp. 156–166.
- [14] B. BARRY, G. CORKERY, U. GONZALES-BARRON, K. MC DONNELL, F. BUTLER, AND S. WARD, *A longitudinal study of the effect of time on the matching performance of a retinal recognition system for lambs*, *Computers and electronics in agriculture*, 64 (2008), pp. 202–211.
- [15] B. BARRY, U. GONZALES-BARRON, K. MCDONNELL, F. BUTLER, AND S. WARD, *Using muzzle pattern recognition as a biometric approach for cattle identification*, *Transactions of the ASABE*, 50 (2007), pp. 1073–1080.

- [16] B. J. BARRY, *An Examination of Retinal Vascular and Muzzle Patterns as a Biometric Method of Identification and Verification of Livestock Identity*, PhD thesis, University College Dublin, 2008.
- [17] C. G. B. U. W. S. BARRY, B., *The use of muzzle pattern and face recognition as novel biometric methods for livestock identification*, in In Proceedings of the IUFOST 13th World Congress of Food Science and Technology “Food is Life, 2006.
- [18] M. S. BARTLETT, J. R. MOVELLAN, AND T. J. SEJNOWSKI, *Face recognition by independent component analysis*, IEEE Transactions on neural networks, 13 (2002), pp. 1450–1464.
- [19] H. BAY, A. ESS, T. TUYTELAARS, AND L. VAN GOOL, *Speeded-up robust features (surf)*, Computer vision and image understanding, 110 (2008), pp. 346–359.
- [20] B. C. BECKER AND E. G. ORTIZ, *Evaluation of face recognition techniques for application to facebook*, in In Processing of 8th IEEE International Conference on Automatic Face & Gesture Recognition, IEEE, 2008, pp. 1–6.
- [21] P. N. BELHUMEUR, J. P. HESPANHA, AND D. J. KRIEGMAN, *Eigenfaces vs. fisherfaces: Recognition using class specific linear projection*, IEEE Transactions on pattern analysis and machine intelligence, 19 (1997), pp. 711–720.
- [22] Y. BENGIO, A. COURVILLE, AND P. VINCENT, *Representation learning: A review and new perspectives*, IEEE transactions on pattern analysis and machine intelligence, 35 (2013), pp. 1798–1828.
- [23] H. S. BHATT, R. SINGH, AND M. VATSA, *Covariates of face recognition*, (2015).
- [24] R. M. BOLLE, J. H. CONNELL, S. PANKANTI, N. K. RATHA, AND A. W. SENIOR, *The relation between the roc curve and the cmc*, in Fourth IEEE Workshop on Automatic Identification Advanced Technologies (AutoID’05), IEEE, 2005, pp. 15–20.
- [25] M. BOWLING, D. PENDELL, D. MORRIS, Y. YOON, K. KATOH, K. BELK, AND G. SMITH, *Review: Identification and traceability of cattle in selected countries outside of north america*, Professional Animal Scientist, 24 (2008), pp. 287–294.

- [26] T. BURGHARDT, *Visual animal biometrics*, PhD thesis, PhD thesis, University of Bristol, United Kingdom.
- [27] T. BURGHARDT AND J. CALIC, *Real-time face detection and tracking of animals*, in 8th IEEE Seminar on Neural Network Applications in Electrical Engineering, 2006, pp. 27–32.
- [28] P. BURT AND E. ADELSON, *The laplacian pyramid as a compact image code*, IEEE Transactions on communications, 31 (1983), pp. 532–540.
- [29] G. BYRD, *Tracking cows wirelessly*, Computer, 48 (2015), pp. 60–63.
- [30] C. CAI AND J. LI, *Cattle face recognition using local binary pattern descriptor*, in 2013 Asia-Pacific Signal and Information Processing Association Annual Summit and Conference (APSIPA), 2013, pp. 1–4.
- [31] G. CAJA, E. DÍAZ-MEDINA, A. SALAMA, O. SALAMA, M. EL-SHAFIE, H. EL-METWALY, M. AYADI, R. ALJUMAAH, M. ALSHAIKH, M. YAHYAHOU, ET AL., *Comparison of visual and electronic devices for individual identification of dromedary camels under different farming conditions*, Journal of Animal Science, 94 (2016), pp. 3561–3571.
- [32] G. CAJA, M. HERNANDEZ-JOVER, C. CONILL, D. GARIN, X. ALABERN, B. FARRIOL, AND J. GHIRARDI, *Use of ear tags and injectable transponders for the identification and traceability of pigs from birth to the end of the slaughter line*, Journal of animal science, 83 (2005), pp. 2215–2224.
- [33] J. L. CAMBIER, *System and method for animal identification using iris images*, May 29 2012. US Patent 8,189,879.
- [34] S. CARNÉ, G. CAJA, J. GHIRARDI, AND A. SALAMA, *Long-term performance of visual and electronic identification devices in dairy goats*, Journal of dairy Science, 92 (2009), pp. 1500–1511.
- [35] C.-C. CHANG AND C.-J. LIN, *Libsvm: a library for support vector machines*, ACM Transactions on Intelligent Systems and Technology (TIST), 2 (2011), p. 27.
- [36] S. CHEN, C. F. COWAN, AND P. M. GRANT, *Orthogonal least squares learning algorithm for radial basis function networks*, IEEE Transactions on neural networks, 2 (1991), pp. 302–309.

- [37] S. CHEN, J. LIU, AND Z.-H. ZHOU, *Making flda applicable to face recognition with one sample per person*, *Pattern recognition*, 37 (2004), pp. 1553–1555.
- [38] W. CHEN, K. WANG, H. JIANG, AND M. LI, *Skin color modeling for face detection and segmentation: a review and a new approach*, *Multimedia Tools and Applications*, 75 (2016), pp. 839–862.
- [39] W.-K. CHEN, J.-C. LEE, W.-Y. HAN, C.-K. SHIH, AND K.-C. CHANG, *Iris recognition based on bidimensional empirical mode decomposition and fractal dimension*, *Information Sciences*, 221 (2013), pp. 439–451.
- [40] C. J. COHEN, D. HAANPAA, AND J. P. ZOTT, *Machine vision algorithms for robust animal species identification*, in *In Proceedings of IEEE Applied Imagery Pattern Recognition Workshop (AIPR)*, IEEE, 2015, pp. 1–7.
- [41] G. CORKERY, U. A. GONZALES-BARRON, F. BUTLER, K. MC DONNELL, AND S. WARD, *A preliminary investigation on face recognition as a biometric identifier of sheep*, *Transactions of the ASABE*, 50 (2007), pp. 313–320.
- [42] T. COVER AND P. HART, *Nearest neighbor pattern classification*, *IEEE transactions on information theory*, 13 (1967), pp. 21–27.
- [43] N. DALAL AND B. TRIGGS, *Histograms of oriented gradients for human detection*, in *In Proceedings of IEEE Computer Vision and Pattern Recognition (CVPR'05)*, vol. 1, IEEE, 2005, pp. 886–893.
- [44] J. G. DAUGMAN, *High confidence visual recognition of persons by a test of statistical independence*, *IEEE transaction on pattern analysis and machine intelligence*, 15 (1993), pp. 1148–1161.
- [45] L. S. DAVIS, S. A. JOHNS, AND J. AGGARWAL, *Texture analysis using generalized co-occurrence matrices*, *IEEE Transactions on pattern analysis and machine intelligence*, (1979), pp. 251–259.
- [46] P. DE CHAZAL, M. O'DWYER, AND R. B. REILLY, *Automatic classification of heartbeats using ecg morphology and heartbeat interval features*, *IEEE Transactions on Biomedical Engineering*, 51 (2004), pp. 1196–1206.

- [47] B. DECANN AND A. ROSS, *Relating roc and cmc curves via the biometric menagerie*, in In proceedings of 6th IEEE International Conference on Biometrics: Theory, Applications and Systems (BTAS, IEEE, 2013, pp. 1–8.
- [48] T. DENOEU, *A k-nearest neighbor classification rule based on dempster-shafer theory*, IEEE Transactions on Systems, Man, and Cybernetics, 25 (1995), pp. 804–813.
- [49] M. L. DOMEIER AND N. NASBY-LUCAS, *Annual re-sightings of photographically identified white sharks (carcharodon carcharias) at an eastern pacific aggregation site (guadalupe island, mexico)*, Marine Biology, 150 (2007), pp. 977–984.
- [50] C. DOMENICONI AND D. GUNOPULOS, *Incremental support vector machine construction*, in In Proceedings of IEEE International Conference on Data Mining (ICDM), 2001, pp. 589–592.
- [51] J. DUNN, *A graph theoretic analysis of pattern classification via tamura's fuzzy relation*, IEEE Transactions on Systems, Man, and Cybernetics, (1974), pp. 310–313.
- [52] O. J. DUNN, V. A. CLARK, ET AL., *Applied statistics: analysis of variance and regression*, (1974).
- [53] J. DUYCK, C. FINN, A. HUTCHEON, P. VERA, J. SALAS, AND S. RAVELA, *Sloop: A pattern retrieval engine for individual animal identification*, Pattern Recognition, 48 (2015), pp. 1059–1073.
- [54] P. DZIUK, *Positive, accurate animal identification*, Animal reproduction science, 79 (2003), pp. 319–323.
- [55] W. B. EBERT, B., *Identification of beef animals*, Tech. Rep. YANR-0170, (2006).
- [56] A. EDWIN AND M. GEORGE, *Fuzzy mathematical approach for cattle identification*.
- [57] H. M. EL-BAKRY, I. EL-HENNAWY, AND H. M. EL HADAD, *Bovines muzzle identification using box-counting*, International Journal of Computer Science and Information Security, 12 (2014), p. 29.



- [58] E. B. H. EL-HENAWY, I. AND H. EL HADAD, *Cattle identification using segmentation-based fractal texture analysis and artificial neural networks*, Int. J. of Electronics and Information Engineering, 4 (2016), pp. 82–93.
- [59] A. ERNST AND C. KÜBLBECK, *Fast face detection and species classification of african great apes*, in In Proceedings of 8th IEEE International Conference on Advanced Video and Signal-Based Surveillance (AVSS), 2011, pp. 279–284.
- [60] K. ETEMAD AND R. CHELLAPPA, *Discriminant analysis for recognition of human face images*, JOSA A, 14 (1997), pp. 1724–1733.
- [61] C. FARABET, C. COUPRIE, L. NAJMAN, AND Y. LECUN, *Learning hierarchical features for scene labeling*, IEEE transactions on pattern analysis and machine intelligence, 35 (2013), pp. 1915–1929.
- [62] L. FLOM AND A. SAFIR, *Iris recognition system*, Feb. 3 1987. US Patent 4,641,349.
- [63] S. FOSSO WAMBA AND A. WICKS, *Rfid deployment and use in the dairy value chain: applications, current issues and future research directions*, in In Proceedings of IEEE International Symposium on Technology and Society (ISTAS), 2010, pp. 172–179.
- [64] A. FROST, C. SCHOFIELD, S. BEAULAH, T. MOTTRAM, J. LINES, AND C. WATHES, *A review of livestock monitoring and the need for integrated systems*, Computers and Electronics in Agriculture, 17 (1997), pp. 139–159.
- [65] M. FRUCCI, M. NAPPI, D. RICCIO, AND G. S. DI BAJA, *Wire: Watershed based iris recognition*, Pattern Recognition, 52 (2016), pp. 148–159.
- [66] T. GABER, A. THARWAT, A. E. HASSANIEN, AND V. SNASEL, *Biometric cattle identification approach based on weber’s local descriptor and adaboost classifier*, Computers and Electronics in Agriculture, 122 (2016), pp. 55–66.
- [67] D. GABOR, *Theory of communication. part 1: The analysis of information*, Journal of the Institution of Electrical Engineers-Part III: Radio and Communication Engineering, 93 (1946), pp. 429–441.

- [68] L. GAMBLE, S. RAVELA, AND K. MCGARIGAL, *Multi-scale features for identifying individuals in large biological databases: an application of pattern recognition technology to the marbled salamander *ambystoma opacum**, *Journal of Applied Ecology*, 45 (2008), pp. 170–180.
- [69] K. J. GASTON AND M. A. O’NEILL, *Automated species identification: why not?*, *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, 359 (2004), pp. 655–667.
- [70] R. K. GEISSLER, *Radio frequency animal tracking system*, June 21 2011. US Patent 7,965,188.
- [71] G. GOUDELIS, S. ZAFEIRIOU, A. TEFAS, AND I. PITAS, *Class-specific kernel-discriminant analysis for face verification*, *IEEE Transactions on Information Forensics and Security*, 2 (2007), pp. 570–587.
- [72] G. GUO, S. Z. LI, AND K. CHAN, *Face recognition by support vector machines*, in *In Proceedings of 4th IEEE International Conference on Automatic Face and Gesture Recognition*, IEEE, 2000, pp. 196–201.
- [73] R. N. HANDCOCK, D. L. SWAIN, G. J. BISHOP-HURLEY, K. P. PATISON, T. WARK, P. VALENCIA, P. CORKE, AND C. J. O’NEILL, *Monitoring animal behaviour and environmental interactions using wireless sensor networks, gps collars and satellite remote sensing*, *Sensors*, 9 (2009), pp. 3586–3603.
- [74] S. L. HANNUNA, N. W. CAMPBELL, AND D. P. GIBSON, *Identifying quadruped gait in wildlife video*, in *IEEE International Conference on Image Processing 2005*, vol. 1, 2005, pp. I–713.
- [75] R. M. HARALICK, *Statistical and structural approaches to texture*, *Proceedings of the IEEE*, 67 (1979), pp. 786–804.
- [76] R. M. HARALICK, K. SHANMUGAM, ET AL., *Textural features for image classification*, *IEEE Transactions on systems, man, and cybernetics*, (1973), pp. 610–621.
- [77] K. HE, X. ZHANG, S. REN, AND J. SUN, *Delving deep into rectifiers: Surpassing human-level performance on imagenet classification*, in *In Proceedings of the IEEE International Conference on Computer Vision*, 2015, pp. 1026–1034.

- [78] X. HE, S. YAN, Y. HU, P. NIYOGI, AND H.-J. ZHANG, *Face recognition using laplacianfaces*, IEEE transactions on pattern analysis and machine intelligence, 27 (2005), pp. 328–340.
- [79] L. HIBY, P. LOVELL, N. PATIL, N. S. KUMAR, A. M. GOPALASWAMY, AND K. U. KARANTH, *A tiger cannot change its stripes: using a three-dimensional model to match images of living tigers and tiger skins*, Biology Letters, (2009), pp. rsbl–2009.
- [80] J.-J. HILPERT, *Animal ear tag*, Dec. 23 2003. US Patent 6,666,170.
- [81] G. E. HINTON, S. OSINDERO, AND Y.-W. TEH, *A fast learning algorithm for deep belief nets*, Neural computation, 18 (2006), pp. 1527–1554.
- [82] H. HOSSEINI, *Animal muzzle pattern scanning device*, Dec. 15 2015. US Patent App. 14/969,511.
- [83] G. B. HUANG, H. LEE, AND E. LEARNED-MILLER, *Learning hierarchical representations for face verification with convolutional deep belief networks*, in In Proceedings of IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2012, pp. 2518–2525.
- [84] B. HUGHES AND T. BURGHARDT, *Automated visual fin identification of individual great white sharks*, International Journal of Computer Vision, (2016), pp. 1–16.
- [85] A. HUHTALA, K. SUHONEN, P. MÄKELÄ, M. HAKOJÄRVI, AND J. AHOKAS, *Evaluation of instrumentation for cow positioning and tracking indoors*, Biosystems Engineering, 96 (2007), pp. 399–405.
- [86] D. K. IAKOVIDIS, E. G. KERAMIDAS, AND D. MAROULIS, *Fuzzy local binary patterns for ultrasound texture characterization*, in International Conference Image Analysis and Recognition, Springer, 2008, pp. 750–759.
- [87] R. ISMAIL AND I. ISMAIL, *Development of graphical user interface (gui) for livestock management system*, in In Proceedings of 4th IEEE International Conference on Control and System Graduate Research Colloquium (ICSGRC), 2013, pp. 43–47.

- [88] A. JAIN, P. FLYNN, AND A. A. ROSS, *Handbook of biometrics*, Springer Science & Business Media, 2007.
- [89] A. JAIN, K. NANDAKUMAR, AND A. ROSS, *Score normalization in multimodal biometric systems*, *Pattern recognition*, 38 (2005), pp. 2270–2285.
- [90] A. K. JAIN, M. N. MURTY, AND P. J. FLYNN, *Data clustering: a review*, *ACM computing surveys (CSUR)*, 31 (1999), pp. 264–323.
- [91] J.-S. JANG, *Anfis: adaptive-network-based fuzzy inference system*, *IEEE transactions on systems, man, and cybernetics*, 23 (1993), pp. 665–685.
- [92] J.-S. JANG AND C.-T. SUN, *Functional equivalence between radial basis function networks and fuzzy inference systems*, *IEEE Transactions on Neural Networks*, 4 (1993), pp. 156–159.
- [93] H. JÉGOU, M. DOUZE, C. SCHMID, AND P. PÉREZ, *Aggregating local descriptors into a compact image representation*, in *In proceedings of IEEE international conference on computer vision and pattern recognition (CVPR)*, IEEE, 2010, pp. 3304–3311.
- [94] I. JIMÉNEZ-GAMERO, G. DORADO, A. MUÑOZ-SERRANO, M. ANALLA, AND A. ALONSO-MORAGA, *Dna microsatellites to ascertain pedigree-recorded information in a selecting nucleus of murciano-granadina dairy goats*, *Small Ruminant Research*, 65 (2006), pp. 266–273.
- [95] A. M. JOHNSTON AND D. S. EDWARDS, *Welfare implications of identification of cattle by ear tags*, *The Veterinary Record*, 138 (1996), pp. 612–614.
- [96] A. JORDAN, *On discriminative vs. generative classifiers: A comparison of logistic regression and naive bayes*, *Advances in neural information processing systems*, 14 (2002), p. 841.
- [97] J. M. KELLER, M. R. GRAY, AND J. A. GIVENS, *A fuzzy k-nearest neighbor algorithm*, *IEEE transactions on systems, man, and cybernetics*, (1985), pp. 580–585.
- [98] M. J. KELLY, *Computer-aided photograph matching in studies using individual identification: an example from serengeti cheetahs*, *Journal of Mammalogy*, 82 (2001), pp. 440–449.

- [99] H. KÜHL AND T. BURGHARDT, *Animal biometrics: quantifying and detecting phenotypic appearance*, Trends in ecology & evolution, 28 (2013), pp. 432–441.
- [100] B. C. KIM AND J. J. CHAE, *Iris recognition system*, July 15 2003. US Patent 6,594,377.
- [101] H. T. KIM, Y. IKEDA, AND H. L. CHOI, *The identification of japanese black cattle by their faces*, Asian-Australasian Journal of Animal Sciences, 18 (2005), pp. 868–872.
- [102] T.-K. KIM, S.-F. WONG, B. STENGER, J. KITTLER, AND R. CIPOLLA, *Incremental linear discriminant analysis using sufficient spanning set approximations*, in In Proceedings of IEEE Conference on Computer Vision and Pattern Recognition, IEEE, 2007, pp. 1–8.
- [103] B. F. KLARE AND A. K. JAIN, *Heterogeneous face recognition using kernel prototype similarities*, IEEE transactions on pattern analysis and machine intelligence, 35 (2013), pp. 1410–1422.
- [104] M. KLINDTWORTH, G. WENDL, K. KLINDTWORTH, AND H. PIRKELMANN, *Electronic identification of cattle with injectable transponders*, Computers and electronics in agriculture, 24 (1999), pp. 65–79.
- [105] M. M. R. KRISHNAN, V. VENKATRAGHAVAN, U. R. ACHARYA, M. PAL, R. R. PAUL, L. C. MIN, A. K. RAY, J. CHATTERJEE, AND C. CHAKRABORTY, *Automated oral cancer identification using histopathological images: a hybrid feature extraction paradigm*, Micron, 43 (2012), pp. 352–364.
- [106] A. KRIZHEVSKY, I. SUTSKEVER, AND G. E. HINTON, *Imagenet classification with deep convolutional neural networks*, in Advances in neural information processing systems, 2012, pp. 1097–1105.
- [107] S. KUMAR AND S. K. SINGH, *Biometric recognition for pet animal*, Journal of Software Engineering and Applications, 7 (2014), p. 470.
- [108] S. KUMAR, S. K. SINGH, T. DATTA, AND H. P. GUPTA, *A fast cattle recognition system using smart devices*, in Proceedings of the 2016 ACM on Multimedia Conference, ACM, 2016, pp. 742–743.

- [109] S. KUMAR, S. TIWARI, AND S. K. SINGH, *Face recognition for cattle*, in 2015 3rd IEEE International Conference on Image Information Processing (ICIIP), 2015, pp. 65–72.
- [110] K.-C. KWAK AND W. PEDRYCZ, *Face recognition using an enhanced independent component analysis approach*, IEEE Transactions on Neural Networks, 18 (2007), pp. 530–541.
- [111] M. LAHIRI, C. TANTIPATHANANANDH, R. WARUNGU, D. I. RUBENSTEIN, AND T. Y. BERGER-WOLF, *Biometric animal databases from field photographs: Identification of individual zebra in the wild*, in In Proceedings of the 1st ACM international conference on multimedia retrieval, ACM, 2011, p. 6.
- [112] H. LAROCHELLE, M. MANDEL, R. PASCANU, AND Y. BENGIO, *Learning algorithms for the classification restricted boltzmann machine*, Journal of Machine Learning Research, 13 (2012), pp. 643–669.
- [113] Y. LECUN, Y. BENGIO, AND G. HINTON, *Deep learning*, Nature, 521 (2015), pp. 436–444.
- [114] H. LEE, R. GROSSE, R. RANGANATH, AND A. Y. NG, *Convolutional deep belief networks for scalable unsupervised learning of hierarchical representations*, in In Proceedings of the 26th annual international conference on machine learning, ACM, 2009, pp. 609–616.
- [115] E. LESLIE, M. HERNÁNDEZ-JOVER, R. NEWMAN, AND P. HOLYOAKE, *Assessment of acute pain experienced by piglets from ear tagging, ear notching and intraperitoneal injectable transponders*, Applied Animal Behaviour Science, 127 (2010), pp. 86–95.
- [116] M. LETTINK AND K. M. HARE, *Sampling techniques for new zealand lizards*, in New Zealand Lizards, 2016, pp. 269–291.
- [117] C. LIU AND H. WECHSLER, *Comparative assessment of independent component analysis (ica) for face recognition*, in International conference on audio and video based biometric person authentication, Citeseer, 1999.

- [118] C. LIU AND H. WECHSLER, *Gabor feature based classification using the enhanced fisher linear discriminant model for face recognition*, IEEE Transactions on Image processing, 11 (2002), pp. 467–476.
- [119] A. LOOS AND A. ERNST, *An automated chimpanzee identification system using face detection and recognition*, EURASIP Journal on Image and Video Processing, 2013 (2013), pp. 1–17.
- [120] D. G. LOWE, *Object recognition from local scale-invariant features*, in In proceedings of the 7th IEEE international conference on computer vision, vol. 2, Ieee, 1999, pp. 1150–1157.
- [121] J. LU, K. N. PLATANIOTIS, AND A. N. VENETSANOPOULOS, *Face recognition using lda-based algorithms*, IEEE Transactions on Neural networks, 14 (2003), pp. 195–200.
- [122] Y. LU, X. HE, Y. WEN, AND P. S. WANG, *A new cow identification system based on iris analysis and recognition*, International Journal of Biometrics, 6 (2014), pp. 18–32.
- [123] M. T. LUCAS, *Livestock inventory tracking system and methods*, Sept. 13 2011. US Patent 8,019,662.
- [124] L. LUCHESEYD AND S. MITRAY, *Color image segmentation: A state-of-the-art survey*, Proceedings of the Indian National Science Academy (INSA-A), 67 (2001), pp. 207–221.
- [125] H. A. MAHMOUD AND H. M. R. E. HADAD, *Automatic cattle muzzle print classification system using multiclass support vector machine*, International Journal of Image Mining, 1 (2015), pp. 126–140.
- [126] J. MARCHANT, *Secure animal identification and source verification*, JM Communications, UK. Copyright Optibrand Ltd., LLC, (2002).
- [127] A. MARSHALL AND S. PIERCE, *The use and abuse of photographic identification in sharks and rays*, Journal of fish biology, 80 (2012), pp. 1361–1379.
- [128] R. MEHTA AND K. E. EGUIAZARIAN, *Texture classification using dense micro-block difference*, IEEE Transactions on Image Processing, 25 (2016), pp. 1604–1616.

- [129] C. A. MERTLER AND R. A. VANNATTA, *Advanced and multivariate statistical methods*, Los Angeles, CA: Pyczak, (2002).
- [130] H. MINAGAWA, T. FUJIMURA, M. ICHIYANAGI, K. TANAKA, M. FANGQUAN, ET AL., *Identification of beef cattle by analyzing images of their muzzle patterns lifted on paper.*, in In Proceedings of the 3rd Asian Conference on Asian agricultural information technology & management (AFITA), China Agricultural Sciencetech Press, 2002, pp. 596–600.
- [131] S. MISHRA, O. TOMER, AND E. KALM, *Muzzle dermatoglyphics: a new method to identify bovines*, Asian Livestock (FAO), (1995), pp. 91—96.
- [132] F. C. MONTEIRO, *Automatic cattle identification using graph matching based on local invariant features*, in International Conference Image Analysis and Recognition, Springer, 2016, pp. 792–800.
- [133] T. K. MOON, *The expectation-maximization algorithm*, IEEE Signal processing magazine, 13 (1996), pp. 47–60.
- [134] C. MUSGRAVE AND J. L. CAMBIER, *System and method of animal identification and animal transaction authorization using iris patterns*, July 23 2002. US Patent 6,424,727.
- [135] V. NAIR AND G. HINTON, *Rectified linear units improve restricted boltzmann machines*, in In Proceedings of the 27th International Conference on Machine Learning (ICML), 2010, pp. 807–814.
- [136] V. NAIR AND G. E. HINTON, *Rectified linear units improve restricted boltzmann machines*, in In Proceedings of the 27th International Conference on Machine Learning (ICML-10), 2010, pp. 807–814.
- [137] M. NEARY AND A. YAGER, *Methods of livestock identification*, (2002).
- [138] M. NIXON, *Feature extraction & image processing*, Academic Press, 2008.
- [139] G. NOONAN, J. RAND, J. PRIEST, J. AINSCOW, AND J. BLACKSHAW, *Behavioural observations of piglets undergoing tail docking, teeth clipping and ear notching*, Applied Animal Behaviour Science, 39 (1994), pp. 203–213.



- [140] A. NOVIYANTO AND A. ARYMURTHY, *Beef cattle identification based on muzzle pattern using a matching refinement technique in the sift method*, Computers and electronics in agriculture, 99 (2013), pp. 77–84.
- [141] A. NOVIYANTO AND A. M. ARYMURTHY, *Automatic cattle identification based on muzzle photo using speed-up robust features approach*, in In Proceedings of the 3rd European Conference of Computer Science, ECCS, vol. 110, 2012, p. 114.
- [142] T. OJALA, M. PIETIKAINEN, AND T. MAENPAA, *Multiresolution gray-scale and rotation invariant texture classification with local binary patterns*, IEEE Transactions on pattern analysis and machine intelligence, 24 (2002), pp. 971–987.
- [143] S. OZAWA, S. L. TOH, S. ABE, S. PANG, AND N. KASABOV, *Incremental learning of feature space and classifier for face recognition*, Neural Networks, 18 (2005), pp. 575–584.
- [144] N. R. PAL AND S. K. PAL, *A review on image segmentation techniques*, Pattern recognition, 26 (1993), pp. 1277–1294.
- [145] Z. PAN, Y. WANG, AND W. KU, *A new k-harmonic nearest neighbor classifier based on the multi-local means*, Expert Systems with Applications, 67 (2017), pp. 115–125.
- [146] J. A. PENNINGTON, *Tattooing of Cattle and Goats*, Cooperative Extension Service, University of Arkansas Division of Agriculture, US Department of Agriculture, and county governments cooperating, 2007.
- [147] F. PERRONNIN, J. SÁNCHEZ, AND T. MENSINK, *Improving the fisher kernel for large-scale image classification*, in In Proceedings of European Conference on Computer Vision (ECCV), 2010, pp. 143–156.
- [148] W. PETERSEN, *The identification of the bovine by means of nose-prints*, Journal of dairy science, 5 (1922), pp. 249–258.
- [149] W. C. PRATT, *Cattle management method and system*, Sept. 11 2012. US Patent 8,261,694.
- [150] T. R. REED AND J. H. DUBUF, *A review of recent texture segmentation and feature extraction techniques*, CVGIP: Image understanding, 57 (1993), pp. 359–372.

- [151] V. REILLY, H. IDREES, AND M. SHAH, *Detection and tracking of large number of targets in wide area surveillance*, in European Conference on Computer Vision, Springer, 2010, pp. 186–199.
- [152] C. M. ROBERTS, *Radio frequency identification (rfid)*, computers & security, 25 (2006), pp. 18–26.
- [153] M. ROJAS-OLIVARES, G. CAJA, S. CARNÉ, A. SALAMA, N. ADELL, AND P. PUIG, *Retinal image recognition for verifying the identity of fattening and replacement lambs*, Journal of animal science, 89 (2011), pp. 2603–2613.
- [154] C. S. S. A. A. N. P. P. ROJAS-OLIVARES MA, CAJA G, *Determining the optimal age for recording the retinal vascular pattern image of lambs*, Journal of animal science, 90 (2012), pp. 1040–1046.
- [155] W. ROSSING, *Animal identification: introduction and history*, Computers and Electronics in Agriculture, 24 (1999), pp. 1–4.
- [156] J. ROY, L. VIGILANT, M. GRAY, E. WRIGHT, R. KATO, P. KABANO, A. BASA-BOSE, E. TIBENDA, H. S. KÜHL, AND M. M. ROBBINS, *Challenges in the use of genetic mark-recapture to estimate the population size of bwindi mountain gorillas (gorilla beringei beringei)*, Biological Conservation, 180 (2014), pp. 249–261.
- [157] D. W. RUCK, S. K. ROGERS, M. KABRISKY, M. E. OXLEY, AND B. W. SUTER, *The multilayer perceptron as an approximation to a bayes optimal discriminant function*, IEEE Transactions on Neural Networks, 1 (1990), pp. 296–298.
- [158] L. RUIZ-GARCIA AND L. LUNADEI, *The role of rfid in agriculture: Applications, limitations and challenges*, Computers and Electronics in Agriculture, 79 (2011), pp. 42–50.
- [159] C. P. RUSK, C. R. BLOMEKE, M. A. BALSCHWEID, S. ELLIOT, AND D. BAKER, *An evaluation of retinal imaging technology for 4-h beef and sheep identification*, Journal of Extension, 44 (2006), pp. 1–33.
- [160] S. R. SAFAVIAN AND D. LANDGREBE, *A survey of decision tree classifier methodology*, IEEE Transactions on Systems, Man, and Cybernetics, 21 (1990), pp. 660–674.

- [161] J. SÁNCHEZ, F. PERRONNIN, T. MENSINK, AND J. VERBEEK, *Image classification with the fisher vector: Theory and practice*, International journal of computer vision, 105 (2013), pp. 222–245.
- [162] D. SCHERER, A. MÜLLER, AND S. BEHNKE, *Evaluation of pooling operations in convolutional architectures for object recognition*, in International Conference on Artificial Neural Networks, Springer, 2010, pp. 92–101.
- [163] E. SEEMANN, B. LEIBE, K. MIKOLAJCZYK, AND B. SCHIELE, *An evaluation of local shape-based features for pedestrian detection.*, in In Processing of British Machine Vision Conference (BMVC), vol. 5, Citeseer, 2005, p. 10.
- [164] C. SHANAHAN, B. KERNAN, G. AYALEW, K. MCDONNELL, F. BUTLER, AND S. WARD, *A framework for beef traceability from farm to slaughter using global standards: An irish perspective*, Computers and electronics in agriculture, 66 (2009), pp. 62–69.
- [165] R. B. SHERLEY, T. BURGHARDT, P. J. BARHAM, N. CAMPBELL, AND I. C. CUTHILL, *Spotting the difference: towards fully-automated population monitoring of african penguins spheniscus demersus*, Endangered Species Research, 11 (2010), pp. 101–111.
- [166] S. K. SHRIKANT TIWARI AND S. K. SINGH, *Face recognition of cattle: Can it be done?*, Proceedings of the National Academy of Sciences, India Section A: Physical Sciences, 86 (2016), pp. 137–148.
- [167] R. SINGH, M. VATSA, H. S. BHATT, S. BHARADWAJ, A. NOORE, AND S. S. NOOREYEZDAN, *Plastic surgery: A new dimension to face recognition*, IEEE Transactions on Information Forensics and Security, 5 (2010), pp. 441–448.
- [168] J. SKLANSKY, *Image segmentation and feature extraction*, IEEE Transactions on Systems, Man, and Cybernetics, 8 (1978), pp. 237–247.
- [169] D. F. SPECHT, *Probabilistic neural networks*, Neural networks, 3 (1990), pp. 109–118.
- [170] C. W. SPEED, M. G. MEEKAN, AND C. J. BRADSHAW, *Spot the match—wildlife photo-identification using information theory*, Frontiers in zoology, 4 (2007), p. 1.

- [171] K. STANFORD, J. STITT, J. KELLAR, AND T. MCALLISTER, *Traceability in cattle and small ruminants in canada*, Revue Scientifique et Technique-Office International des Epizooties, 20 (2001), pp. 510–522.
- [172] M. SUGIYAMA, *Dimensionality reduction of multimodal labeled data by local fisher discriminant analysis*, Journal of Machine Learning Research, 8 (2007), pp. 1027–1061.
- [173] Y. SUN, H. JIA, Y. HU, AND B. YIN, *Color face recognition based on color image correlation similarity discriminant model*, Multimedia Tools and Applications, 73 (2014), pp. 2063–2079.
- [174] Y. SUN, X. WANG, AND X. TANG, *Deep convolutional network cascade for facial point detection*, in In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2013, pp. 3476–3483.
- [175] M. SUZAKI, *Animal identification based on irial granule analysis*, May 8 2001. US Patent 6,229,905.
- [176] M. SUZAKI AND Y. KUNO, *Method of extracting iris region and individual identification device*, Sept. 2 2003. US Patent 6,614,919.
- [177] A. THARWAT, T. GABER, A. E. HASSANIEN, H. A. HASSANIEN, AND M. F. TOLBA, *Cattle identification using muzzle print images based on texture features approach*, in In Proceedings of the 5th International Conference on Innovations in Bio-Inspired Computing and Applications (IBICA), 2014, pp. 217–227.
- [178] A. TREVARTHEN, *The national livestock identification system: the importance of traceability in e-business*, Journal of Theoretical and Applied Electronic Commerce Research, 2 (2007), p. 49.
- [179] M. A. TURK AND A. P. PENTLAND, *Face recognition using eigenfaces*, in In Proceedings of IEEE conference on Computer Vision and Pattern Recognition (CVPR'91), 1991, pp. 586–591.
- [180] L. TURNER, M. UDAL, B. LARSON, AND S. SHEARER, *Monitoring cattle behavior and pasture use with gps and gis*, Canadian Journal of Animal Science, 80 (2000), pp. 405–413.

- [181] G. VAN DE WOUWER, P. SCHEUNDERS, AND D. VAN DYCK, *Statistical texture characterization from discrete wavelet representations*, IEEE transactions on image processing, 8 (1999), pp. 592–598.
- [182] J. C. VAN GEMERT, J.-M. GEUSEBROEK, C. J. VEENMAN, AND A. W. SMEULDERS, *Kernel codebooks for scene categorization*, in European conference on computer vision, Springer, 2008, pp. 696–709.
- [183] I. R. VEGA AND S. SARKAR, *Statistical motion model based on the change of feature relationships: human gait-based recognition*, IEEE Transactions on Pattern Analysis and Machine Intelligence, 25 (2003), pp. 1323–1328.
- [184] L. VINCENT AND P. SOILLE, *Watersheds in digital spaces: an efficient algorithm based on immersion simulations*, IEEE transactions on pattern analysis and machine intelligence, 13 (1991), pp. 583–598.
- [185] L. VINCENT AND P. SOILLE, *Watersheds in digital spaces: an efficient algorithm based on immersion simulations*, IEEE transactions on pattern analysis and machine intelligence, 13 (1991), pp. 583–598.
- [186] ———, *Watersheds in digital spaces: an efficient algorithm based on immersion simulations*, IEEE transactions on pattern analysis and machine intelligence, 13 (1991), pp. 583–598.
- [187] P. VINCENT, H. LAROCHELLE, Y. BENGIO, AND P.-A. MANZAGOL, *Extracting and composing robust features with denoising autoencoders*, in In Proceedings of the 25th ACM international conference on Machine learning, ACM, 2008, pp. 1096–1103.
- [188] P. VINCENT, H. LAROCHELLE, I. LAJOIE, Y. BENGIO, AND P.-A. MANZAGOL, *Stacked denoising autoencoders: Learning useful representations in a deep network with a local denoising criterion*, Journal of Machine Learning Research, 11 (2010), pp. 3371–3408.
- [189] P. VIOLA AND M. JONES, *Rapid object detection using a boosted cascade of simple features*, in In Proceedings of the 2001 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR), vol. 1, IEEE, 2001, pp. I–511.

- [190] A. S. VOULODIMOS, C. Z. PATRIKAKIS, A. B. SIDERIDIS, V. A. NTAFIS, AND E. M. XYLOURI, *A complete farm management system based on animal identification using rfid technology*, *Computers and Electronics in Agriculture*, 70 (2010), pp. 380–388.
- [191] L. WALLACE, J. PATERSON, R. CLARK, M. HARBAC, AND A. KELLOM, *Readability of thirteen different radio frequency identification ear tags by three different multi-panel reader systems for use in beef cattle*, *The Professional Animal Scientist*, 24 (2008), pp. 384–391.
- [192] J.-G. WANG, J. LI, W.-Y. YAU, AND E. SUNG, *Boosting dense sift descriptors and shape contexts of face images for gender recognition*, in *In Proceedings of IEEE Computer Society Conference on Computer Vision and Pattern Recognition-Workshops*, IEEE, 2010, pp. 96–102.
- [193] D. WARDROPE, *Problems [suppurating wounds] with the use of ear tags in cattle.[correspondence]*, *Veterinary Record (United Kingdom)*, 137 (1995), p. 675.
- [194] J. WENG, Y. ZHANG, AND W.-S. HWANG, *Candid covariance-free incremental principal component analysis*, *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 25 (2003), pp. 1034–1040.
- [195] R. L. WILLHAM, R. J. WEBER, AND M. M. HASSOUN, *Livestock record system*, June 21 1994. US Patent 5,322,034.
- [196] L. WOLF, T. HASSNER, AND Y. TAIGMAN, *The one-shot similarity kernel*, in *In Proceedings of 12th IEEE International Conference on Computer Vision*, IEEE, 2009, pp. 897–902.
- [197] J. XU, G. SOLMAZ, R. RAHMATIZADEH, D. TURGUT, AND L. BOLONI, *Internet of things applications: Animal monitoring with unmanned aerial vehicle*, arXiv preprint arXiv:1610.05287, (2016).
- [198] J. YOSHIZAKI, K. H. POLLOCK, C. BROWNIE, AND R. A. WEBSTER, *Modeling misidentification errors in capture–recapture studies using photographic identification of evolving marks*, *Ecology*, 90 (2009), pp. 3–9.

- [199] X. YU, J. WANG, R. KAYS, P. A. JANSEN, T. WANG, AND T. HUANG, *Automated identification of animal species in camera trap images*, EURASIP Journal on Image and Video Processing, 2013 (2013), p. 1.
- [200] A. L. YUILLE, P. W. HALLINAN, AND D. S. COHEN, *Feature extraction from faces using deformable templates*, International journal of computer vision, 8 (1992), pp. 99–111.
- [201] L. ZAORÁLEK, M. PRILEPOK, AND V. SNÁŠEL, *Cattle identification using muzzle images*, in Proceedings of the Second International Afro-European Conference for Industrial Advancement AECIA 2015, Springer, 2016, pp. 105–115.
- [202] W. ZHAO, R. CHELLAPPA, P. J. PHILLIPS, AND A. ROSENFELD, *Face recognition: A literature survey*, ACM computing surveys (CSUR), 35 (2003), pp. 399–458.
- [203] W. ZHU, W. HUANG, Z. LIN, Y. YANG, S. HUANG, AND J. ZHOU, *Data and feature mixed ensemble based extreme learning machine for medical object detection and segmentation*, Multimedia Tools and Applications, 75 (2016), pp. 2815–2837.
- [204] Z. ZIVKOVIC, *Improved adaptive gaussian mixture model for background subtraction*, in In Proceedings of the 17th IEEE International Conference on Pattern Recognition (ICPR), vol. 2, IEEE, 2004, pp. 28–31.
- [205] S. S. K. ZIYABARI AND I. ARIS, *A critical review of sustainable radio frequency identification (rfid)-based livestock monitoring and management systems: towards quality products and practices*, Journal of New Sciences, 12 (2014), pp. 1–10.
- [206] K. ZUIDERVELD, *Contrast limited adaptive histogram equalization*, in Graphics gems IV, Academic Press Professional, Inc., 1994, pp. 474–485.