



Artificial intelligence based muzzle recognition technology for individual identification of animals

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The increasing growth of the world trade and growing concerns of food safety by consumers needs cutting-edge animal identification and traceability systems (Tharwat *et al.* 2014). Identification of dairy animal(s) by unique identification number and maintaining information pertaining to corresponding animal(s) will help in varied ways including ownership ascertainment, scientific farm management, developing effective breeding strategy, achieving farm-to-fork traceability, and in implementing effective disease control programs, livestock insurance and subsidy schemes. Commonly followed methods for identification of bovine animals are ear tagging using different systems like visual tags, radio frequency identification devices (RFID) tags, bar coded ear tags and quick response (QR) coded tags. Retention of these tags over long period, especially over the years, during different handling, rearing and weather conditions often pose problem and compromises the effectiveness of identification (Girish *et al.* 2017). In addition, cases of tampering of the ear tags compromise the traceability system. In view of these issues, animal identification verification systems or the methods which can validate the identity of the animals are required. Commonly used methods for traceability verification are molecular techniques which are normally based on Microsatellite genotyping and/or SNP genotyping (Girish and Barbuddhe 2019). These techniques are cumbersome, laborious and costly. Also, their field applicability is challenging especially in Indian scenario wherein farms are spread over broad geographical area often in remote villages.

To address this issue, a simple and accurate animal identification verification technique based on bovine muzzle imaging using mobile camera and their analysis using Artificial Intelligence (AI) based software program ‘GoMukh’ is being reported in this work.

The ‘GoMukh’ recognition software uses Clonoid’s proprietary facial recognition algorithms based on deep

convolutional neural networks. A facial recognition system uses biometrics to map facial features from a photograph or video. We have applied the same concept to cattle facial recognition. The algorithm maps the key factors of muzzle nose print and created a unique facial signature for that muzzle. Next time when the same muzzle image is added for matching, the facial signature - a mathematical formula compares the information with a database of registered cattle images to find a match.

The cattle recognition process involves 4 steps in general

1. Muzzle detection - Locate muzzle in the image and mark with a bounding box;
2. Face alignment - Normalize the face to be consistent with the database, such as geometry and photometrics;
3. Feature extraction - Extract features from the muzzle that can be used for the recognition task and
4. Pattern recognition- Perform matching of the muzzle against one or more known faces in a prepared database.

The software uses a large training dataset to train a very deep CNN model for cattle muzzle recognition, which has resulted in a highly accurate recognition software. To facilitate easy collection and analysis, a mobile app ‘GoMukh’ was also designed which will act as user interface and enables easy and quick image processing, analysis and assignment. Effort was to provide cross-browser compatibility to the animal identification application to enable clean access across all major browser platforms including but not limited to Internet Explorer, Mozilla Firefox and Google Chrome. System was built with open source technologies available in the market to realize the benefits of easy code maintenance, short delivery timelines and easy modifications and/or enhancements which may arise in the future. We used PHP, Java, HTML, CSS, JavaScript and Apache server running in Linux environment. GoMukh was implemented with different types of PHP frameworks for different modules as needed and also used Java Server side modules for security purpose. GoMukh uses MySQL for database purpose. All the images are stored in the file system and the links are stored inside the MySQL Database. Community edition is being

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implemented initially which can be changed to enterprise edition as per the requirement. Mobile App was designed using Android packages under Java Framework. App functionality requires many approvals which it takes while installing the application. GoMukh App takes care of blurriness and lighting of image. App rejects the images if it is not as per the needs of the system. This saves the resources and bandwidth for the total system thus improving the performance of the system in total.

Images of the muzzle for identification purpose can be captured using the mobile camera of minimum 5 Megapixel resolution. This mobile camera based muzzle based animal identification method is applicable to only bovines above the age of 2 years. Brief procedure for collection of the muzzle images from bovines is as follows: Clean the muzzle of the animal with a clean cloth. Take photograph of the tag for identification. Restrain the head of the animal preferably by tying to a pole. Shaking of face or head will blur the image hence animal must be restrained properly. Put up a chin up pose for imaging. Hold the camera around 1 feet from the muzzle. Ensure that muzzle is in the middle of the screen with the nostrils as the side edges. Clearly visible beads and ridges without any blurring indicates good quality image. Camera must be focused on to the inter nostril region. Nostrils should be close to the edge of the photograph with little margins. Ensure good lighting on the face especially on muzzle with no shadows. Image should not be captured under direct sunlight. In case of outdoor photography use an umbrella to block the excess light. After capturing, images must be uploaded onto the app along with the corresponding identification number of the animal.

GoMukh app follows simple protocol for individual assignment. App has complex algorithm which will compare the image with the available images by checking the patterns of ridges and beads, (Fig. 1) and confirm identity of the animals. This app helps to compare the muzzle image of the animal with the preloaded muzzle images to confirm identification or it verifies the correctness of the identification numbering. In other words, app will assist in confirming that the animal identification tags/ numbers are not tampered with. For this purpose, muzzle image of the

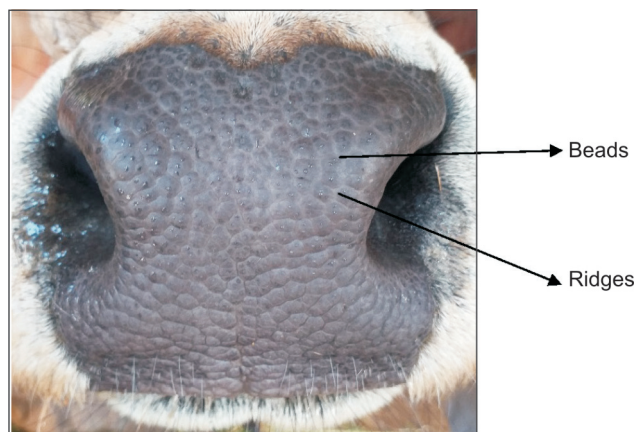


Fig. 1. Beads and ridges in the muzzle based on which GoMukh software identifies the individual.



Fig. 2. Some muzzle images collected from buffalo using the mobile camera—(a) Blurr image—This image will be automatically rejected by the GoMukh software (7.63% of the total images); (b) Image accepted by app but not assigned to particular individual (1.98% of the images). (c) Good image: Image which was accepted and assigned to particular individual (98.02%).

animal must be captured immediately after tagging of the animal. All the images collected from the animals have to be uploaded onto the app along with the identification number of the animal. To verify the identification number of the particular animal, image of the animal has to be captured and uploaded in the app along with the probable identification number. If the muzzle image of the animal in question matches the database images then the app will confirm the identity. In case, there is any mismatch, it indicates that the animal identification muzzle image is not matching with the identification number. If the collected image is blurred, app will not consider the image for uploading.

To validate the app for its performance, muzzle images of 198 cattle and buffaloes of age more than 2 years were collected from following three farms: (i) Instructional Livestock Farm Complex, Veterinary College, P.V. Narasimha Rao Telangana State Veterinary University (PVNRTSVU), Hyderabad, Telangana State; (ii) Livestock

Table 1. Details of the images collected, analyzed and the results of the muzzle images analyzed using GoMukh app

Image detail	Result
Total no. of animals imaged	198
Total no. of images	6119
Average no. of images/animal	31 (~30.90)
Total no. of blur images (which were not accepted by the app)	467
Average no. of blur images/animal	2 (C~2.358)
% of blur images	7.63%
Total number of app readable images	5,652
% of total readable images	92.36%
% readable images assigned correctly to individual	5,540
% of images assigned correctly (among the readable images)	98.02%
Total no. of readable images which could not be assigned to any individual	112
% of images not assigned to any individual (among readable images)	1.98%
Number of images assigned wrongly to another individual	0

Research Station, PVNRTSVU, Mamnoor, Warangal, Telangana State and (iii) Private Farm in Siddipet, Telangana State. Muzzle images were collected by a trained manpower using mobile camera by simple restraining of the animal by tying to a pole. Minimum thirty images were collected per animal. About 10% of the total images, i.e. about 20 animals which were not imaged in the previous activity were also imaged and tested in the app to ensure that there is no cross assignment of individuals by the app.

Identification of individual by muzzle imaging technology: Details of the images taken and results obtained are given in Table 1. The total number of animals imaged were 198. The total number of images taken was 6,119, which gives an average number of images per animal as 31 ($C=30.90$). It is advised to take at least 30 images for enhancing specificity and accuracy of the individual assignment. More the images, better the performance of the app. The total number of blur images were 467 which was 7.63% of the total images. Average number of blur images per animal was 2 (~ 2.36). Blurr images are automatically rejected by the GoMukh app. Hence, the software ensures that only images ideal for app comparison are uploaded onto the app. Blurring of images is very common in livestock imagery as animals do not stay still for long in spite of best restraining method used. Out of 6,119 images, 467 were blurred and not considered by the app. Hence, 5,652 readable images were collected which means 92.36% of the images were app readable. Out of the 5,652 images about 5,540 images were accurately assigned to specific individual by ear tag number. They did not cross match with any other imaged animals, which gives the accuracy of above 98.02% correct assignment of the animals using the GoMukh app. The total number of images which were readable but was not correctly assigned to specific individual were 112 which was less than 2% ($C \approx 1.98\%$) of total images. This may be because of improper imaging due to movement of animal (eg. angle), water drops on the muzzle, improper lighting/focus and shaking of Camera/Phone handling. However, none of the images were wrongly assigned to another individual. As at least 30 images are collected per animal, problem with such images can be sorted out. Number of images wrongly assigned to another individual was NIL. That means there was no cross identification or wrong identification. of image by the app which makes GoMukh app a highly reliable app. All the animals in the field study were identified accurately without any cross identification.

This technique has several advantages over the existing traceability verification techniques. Microsatellite genotyping based method involves extraction of DNA, polymerase chain reaction amplification of the microsatellite targets using multiple markers and analyzing the amplification results using the genetic analyzer (Bheemashankar *et al.* 2017). This technique requires collection of the blood sample during the tagging and preserving them in freezer till the final disposal of animal. Whenever the traceability verification requirement arises,

DNA of the reference sample is extracted, microsatellite genotyped and the results are compared with that of the DNA extracted from the meat sample in question. This technique is expensive, laborious, time consuming and difficult to apply under field conditions. Biometric based methods for animal identification are gaining importance in recent years. Bovines muzzle classification can be used as a biometric classifier for identification of animals (Hagar *et al.* 2015). A method for animal identification based on muzzle print or nose print which was found to be unique and distinguishable pattern was reported by Petersen (1922). Subsequently, this method was used in different countries for identification. However, in this technique, muzzle patterns are recorded by inked muzzle print collection. Collecting the muzzle image imprint is inconvenient, lacks quality and the process is laborious (Minagawa *et al.* 2002). To overcome the inherent problems in muzzle imprint collection using ink, Santosh *et al.* (2018) reported a method for animal identification verification by muzzle imaging similar to this work. But the images were collected using the high end camera (20 MP) in the work. Whereas, the in the method reported in this work, image can be captured using the 5 MP mobile camera which makes the methodology simple and field friendly. The technique obviates the requirement of sample collection, preservation and laboratory analysis as in molecular techniques. This artificial intelligence based muzzle identification system can be integrated into different ongoing traceability programs of Central and State Governments like animal identification drive of Department of Animal Husbandry, Dairying and Fisheries (DAHD&F), Government of India, Maharashtra Animal Identification and Recording Authority (MAIRA), Information Network for Animal Productivity and Health (INAPH) of National Dairy Development Board, meat traceability (www.livestocktraceindia.in) system established by ICAR – National Research Centre on Meat, Hyderabad, traceability program of Agricultural and Processed Food Products Export Development Authority, New Delhi (Meat.Net) and different livestock insurance programs. Muzzle based identification will help in maintaining the sanctity of the tagging system and verify in cases of tampering or loss of the tags. Using muzzle based identification system exclusively is limited by the shortcoming of the technology that it can be used only after the animal reaches 2 years of age.

SUMMARY

India is witnessing raising interest in animal identification and traceability in recent years. Identification and tagging of productive bovines across India with the internationally accepted 12 digit unique animal identification number using bar coded ear tags under the national program of Department of Animal Husbandry and Dairying, Government of India has brought about visible change in the mindset of the stakeholders. Country is realizing the benefits of the system and steadily embracing it. But the animal identification verification system is

lacking in the country and this gap can be filled by the artificial intelligence based muzzle identification technique reported in this work. Field test indicated 98% successful identification of all accepted images and 100% successful identification of all test animals. None of the images were cross assigned to any other individual. Mobile based operations without requirement of any consumables and laboratory test makes the technique field-friendly. System can be handy to agencies involved in animal identification and traceability in India and abroad.

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