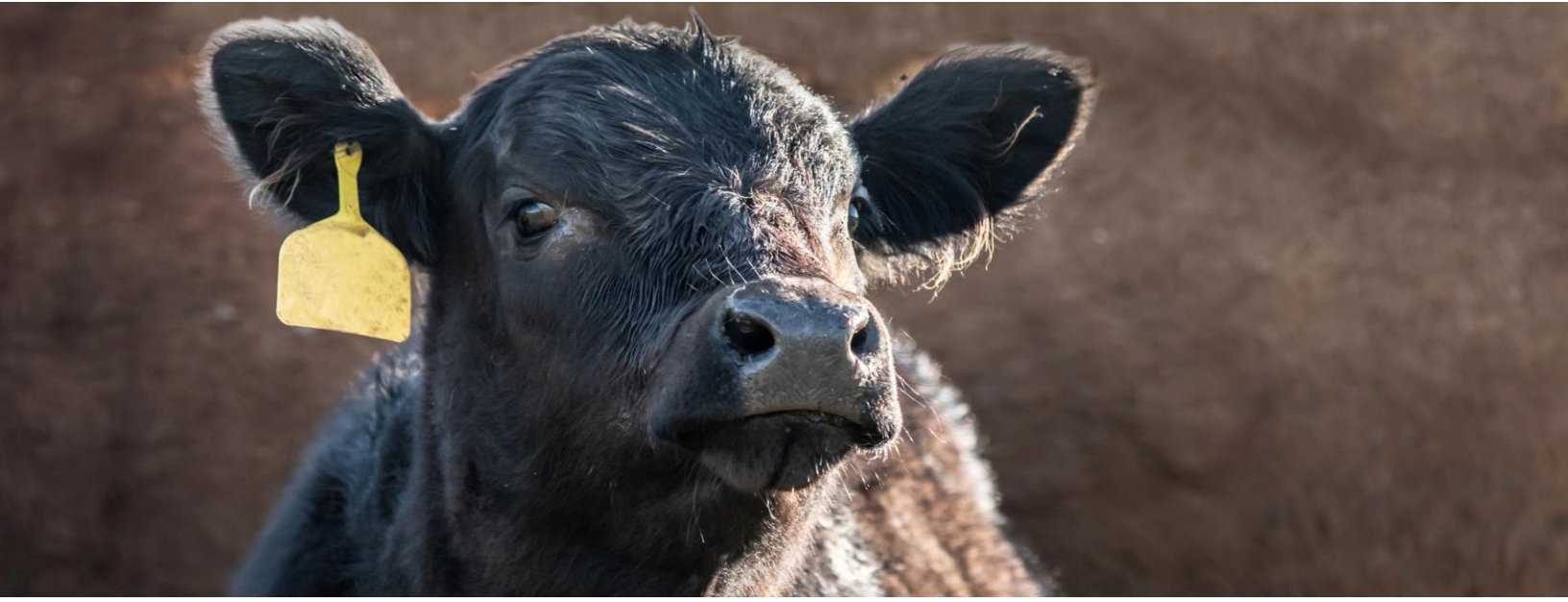
ARTIFICIAL INTELLIGENCE FACIAL RECOGNITION FOR EARLY DISEASE PREDICTION IN CATTLE

MAY 2023 | HTTPS://MYANIML.COM



Cattle diseases have a widespread impact. They jeopardize the sustainability of the beef and dairy industries, reduce animal welfare and risk food security and global supply chains. Cattle diseases even pose a threat to human health.

However, technological advances in artificial intelligence (AI), deep learning and biometrics give the cattle industry powerful new tools for predicting, preventing and containing disease outbreaks.

MyAnIML™, an AI startup for animal agriculture, has invented and commercialized the first-of-its-kind platform for early disease prediction in cattle using facial recognition technology to identify unique features inherent to a cow's muzzle. MyAnIML's technology stack reliably predicts disease and health incidents two to three days before symptoms are typically observed, alerting producers within hours of detecting a likely disease infection in one of their cows.

This paper presents data on the overwhelming need for early disease prediction in cattle and the processes used in developing MyAnIML's patent-pending predictive technology.

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THE PROBLEM WITH CURRENT CATTLE DISEASE MANAGEMENT PROTOCOLS

The problems inherent in cattle disease management are multi-faceted. Treating and preventing disease, cattle death and productivity loss add up to significant economic impacts. Cattle diseases also risk public health.

LARGE-SCALE, FOREIGN ANIMAL DISEASE OUTBREAKS

Modern-day veterinary medicine, herd management techniques and mandated rapid response protocols have helped to prevent economically devastating disease outbreaks like those that plagued early 20th century U.S. cattle and livestock producers.

However, the threat of a significant disease outbreak in cattle is far from gone. Indeed, many epidemiologists believe rapid changes in climate and land use is facilitating more opportunities for viral sharing between wild animal species and facilitating the potential of future zoonotic events (viruses that cross between animal and humans). **A 2022 study published by the USA Center for Global Health Science and Security** predicts the "cross-species transmission of their associated viruses an estimated 4,000 times" by the year 2070.

Aside from newly emerged diseases, a more aggressive strain of a known illness, the re-emergence of an old, eradicated disease or the transmission of a disease that doesn't currently exist into North America are all possible foreign animal disease outbreaks that could potentially cripple the U.S. cattle sector.

A CASE STUDY:
THREE FOREIGN ANIMAL DISEASES OF RISK TO THE U.S. CATTLE INDUSTRY

Foreign animal diseases are defined as transmissible livestock or poultry diseases with the potential for significant economic or health impacts that are currently unknown in the U.S.. However, there have been several significant foreign animal disease outbreaks in U.S. history. While not currently a threat, these three diseases are watched closely as possible risks to the U.S. cattle sector.

Foot and Mouth Disease

Foot and mouth disease (FMD) is a low-mortality but highly contagious, multi-species disease. Cattle, sheep and swine are susceptible to FMD.

Though a significant FMD outbreak hasn't occurred since the 1920s, FMD is still considered a potential risk as it remains endemic in some areas of the world, costing **an estimated USD $6.5 to $21 billion annually** in global production losses and vaccination efforts. Because of how contagious it is, with the potential to impact multiple livestock sectors, a U.S. FMD outbreak would likely halt exports of all livestock products, **according to the U.S. Governmental Accountability Office**.

Bovine Tuberculosis

Although primarily eradicated in the U.S. due to vaccine programs and the pasteurization of milk, bovine Tuberculosis (bTB), **caused more losses in early 20th century U.S. livestock production** than all other infectious diseases combined.

Because bTB is a zoonotic disease, crossing between animal species (primarily cattle and swine) and contagious to humans, killing approximately 15,000 Americans in a 1917 outbreak. Because of the high risk of bTB to humans and because it remains endemic in some areas of the world, bTB is **designated a human public health risk.** In the U.S., **recent reports** of the virus existing in wild animal populations have raised concerns about a potential domestic bTB outbreak.

Bovine Spongiform Encephalopathy

Bovine Spongiform Encephalopathy (BSE), commonly known as "Mad Cow Disease," is a neurological disorder of cattle first recognized in the 1970s. Although BSE is not contagious to humans, consuming BSE-contaminated foods has been strongly linked to a fatal human neurological disease, variant Creutzfeldt-Jakob Disease (vCJD). Globally, 232 people have died from vCJD.

Between 2003 and 2018, there were **six reported cases** of U.S. cows infected with BSE. Multiple countries banned U.S. beef products after the 2003 incident, resulting in the loss of 90% of U.S. beef exports and billions of dollars in revenue. Even though the export bans were eventually lifted, BSE remains a significant threat to U.S. beef and dairy industries.

THE CURRENT AND ONGOING IMPACT OF ENDEMIC DISEASE MANAGEMENT

While foreign animal diseases often capture all the headlines simply because of their high risk and large profile, endemic (constantly present) diseases cause the biggest, day-to-day headaches for cattle producers already under the constraints of extremely thin profit margins.

A single disease outbreak can mean the difference in profitability for ranchers, depending on the severity and impact to the herd.

But it's not just the treatment costs that impact a producer's bottom line. Endemic disease management costs producers in multiple ways.

On average 5% of beef cattle end up dying due to various diseases and the situation is considered even worse in dairy cattle. But even if an animal survives, the loss of productivity during the infection period can significantly impact a producer or rancher's bottom line. A pregnant cow in a cow-calf operation may abort her calf after a disease infection, meaning the rancher lost an entire year in that animal's production cycle. Infected beef cattle don't efficiently gain weight during critical growth stages, resulting in animals that take longer to reach market weights, while consuming more feed. Dairy cows infected with mastitis may suffer complete loss of milk production or irreversible tissue damage to their mammary gland.

Based on a comprehensive analysis of cattle lost to diseases, cost of medical treatment and low productivity impacts, MyAnIML estimates that the U.S. cattle industry loses approximately $200 billion annually to common cattle diseases.

THE HUMAN HEALTH DANGER OF ANTIBIOTIC-USE FOR DISEASE MANAGEMENT IN CATTLE PRODUCTION

While antibiotics have been a powerful tool for treating and controlling cattle diseases, the heavy use of antibiotics in cattle has created an unanticipated negative impact on human health – the rise of deadly, antibiotic-resistant bacterial strains.

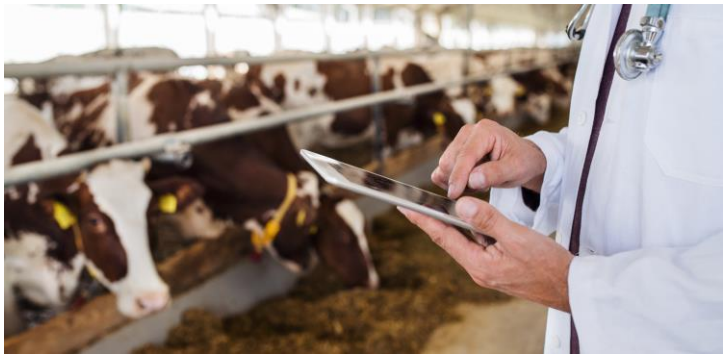
Antibiotic overuse has been directly linked to the rise of antibiotic-resistant bacteria like Methicillin-resistant Staphylococcus aureus (MRSA) in the U.S., contributing to 2.8 million infections and up to 162,044 deaths. While the human medical sector has been criticized for over-prescribing antibiotics, the livestock sector, which uses many of the same antibiotics as those used for human health, has been recognized as the biggest culprit in the development of antibiotic-resistant bacterial strains.

Indeed, **more than 70%** of all medically important antibiotics sold in the U.S. are used in livestock production, not human health. And out of all the livestock sectors, the cattle industry is the highest user of antibiotics, commanding 40% of all antibiotics sold to livestock producers.

THE MYANIML SOLUTION

For all these reasons, we need to invent better, more proactive tools for cattle disease management. Now however, for the first time in the history of livestock production, we have at hand high-tech solutions such as AI to innovate new solutions.

Using AI, biometrics, data analytics and facial recognition, MyAnIML is the first health platform to identify and use the cow's muzzle as a predictor of health-related stress.



CASE STUDY: THE ECONOMIC IMPACT OF TWO COMMON DISEASES IN U.S. CATTLE HERDS

Bovine Respiratory Disease (BRD) and Infectious bovine keratoconjunctivitis (IBK) are two of the most common diseases in the U.S. cattle herds. They each pose a huge economic risk to cattle producers.

Bovine Respiratory Disease

BRD, commonly called "shipping fever," is a highly contagious respiratory disease that primarily impacts calves. It is the most common disease in the U.S. beef industry, causing an estimated $800 to $900 million in costs annually. It is believed that approximately 16% of cattle in U.S. feedlots of 1000 animals or more are affected by BRD.

Calves infected with BRD are often treated multiple times, with decreasing returns for every treatment received. Therefore, regardless of the need, many feedlot producers choose to treat incoming calves with antibiotics preemptively. At approximately $50 per head treatment, an average 5000-head feedlot spends $250,000 annually avoiding BRD.

Infectious Bovine Keratoconjunctivitis

IBK, commonly known as cattle pinkeye, is a highly contagious disease of a cow's cornea that can result in mild to severe illness and significant reductions in cattle performance and value. IBK is not contagious to humans, a different viral source causes human pinkeye.

IBK is estimated to affect more than 10 million U.S. calves annually, causing losses of more than $150 million, and it is not uncommon during an IBK outbreak for a herd to experience 90% to 100% infection rates.

Over a three-month outbreak period, a 500-animal beef cattle ranch with a 90% infection rate will spend an estimated $15,000 in total treatment costs and experience approximately $41,000 in revenue loss due to reduced weight gains for a total loss of $65,000 per outbreak.

THE COW'S MUZZLE AS A LIVESTOCK BIOMETRIC MARKER

Each cow muzzle is unique, much like a human's fingerprint, with an individual pattern of beads, grooves and ridges. Even cattle of the same breed with identical colors and patterns can be uniquely identified using their muzzle.

Although muzzle identification is not yet widely known, or utilized, in cattle production, the concept has been extensively researched. The **first documented study** into cattle muzzles was in 1922, with researchers manually noticing differences of imprinted muzzle patterns. They even noted anomalies between muzzles of healthy and ill cattle. Since then, multiple studies across nations have confirmed the potential of a cow's muzzles as a reliable livestock biometric marker with the potential to replace other methods for identifying and tracking cattle, including electronic ear tags.

A **2022 study published by University of Nebraska-Lincoln (UNL)** assessed 59 deep-learning models using the images of cow's muzzle as a uniquely identifying characteristic. The highest accuracy achieved was 98.7%. The study concluded that there is "great potential of using deep learning techniques to identify individual cattle using muzzle images and to support precision beef cattle management."

CURRENT TECHNIQUES FOR CATTLE IDENTIFICATION AND TRACEABILITY

Identifying and keeping track of cattle has always been part and parcel of cattle production. Cattle identification is also a crucial tool in traceability initiatives to limit the impact of disease outbreaks.

But with more than one billion cattle estimated worldwide – 94 million in the U.S. herd alone, keeping track of those animals is complicated by the sheer number of cattle regularly transported across state, regional and even international lines.

The **USDA's animal disease traceability program** aims to prevent disease outbreaks by requiring all cattle and bison moved across state lines to be officially identified with an ear tag adhering to the National Uniform Eartagging System (NUES) and accompanied with a document of veterinary inspection. In 2023 the USDA proposed phasing out metal ear tags in favor of electronic identification tags (EID), previously known as RFID tags.

The proposed EID tags gather data from the cow they are installed on. The tag can be read using a wand (tag reader) waved within 30 inches of the tag. As cows are moved or subjected to medical events, such as given a vaccine, their data is updated.

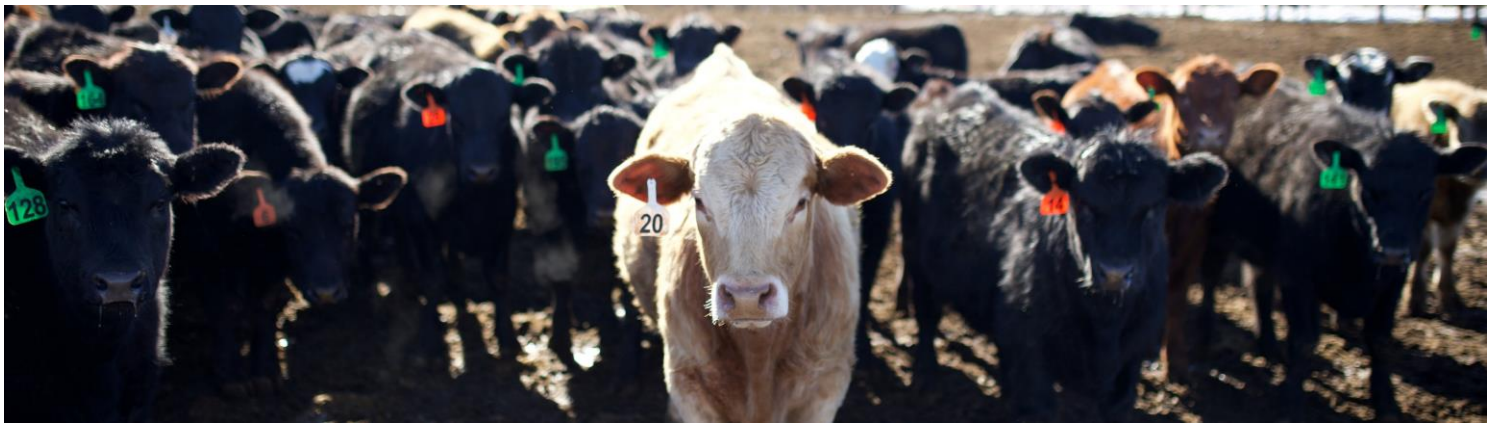
Many industry groups support EID ear tags, arguing that electronic traceability capabilities help strengthen consumer trust and protect U.S. herds from the threat of a foreign animal disease outbreak and keep better, more reliable health records for producers to assess. However, ranchers and farmers have criticized the cost and logistics of the EID ear tags. They complain that the tags are expensive to purchase and install and often go missing when cows are in transit between feedlots and sale barns. When the tag is lost, the data accompanying that cow is typically lost with it.

Cow-calf producers have been especially reluctant to implement EID tag systems, **according to a Oklahoma State University Extension document.** Even though the net costs are relatively small per animal through its lifetime in the production process, most of the costs (but few of the benefits) fall on cow-calf producers in the early stages of the supply chain because they install the tag.

CURRENT TECHNIQUES FOR CATTLE IDENTIFICATION AND TRACEABILITY

In addition, the EID information can only be accessed if the cow is being run through a chute system or otherwise restrained so they can get close enough to use the wand. That means producers in large operations still rely on visual ear tags or other methods to identify a specific animal in a herd. Even with free tag programs promoted by the USDA, it is estimated that currently only 3% to 4% of U.S. cattle producers actually use EID tags, and many have come out in criticism of a mandated EID rule.

To enable more rapid and easy identification of sick animals tagged by the MyAnIML software system, MyAnIML has also developed an inexpensive Bluetooth-enabled ear tag with geolocation and tracking capabilities. The MyAnIML predictive disease platform can be used with or without the addition of the geolocation ear tag system.

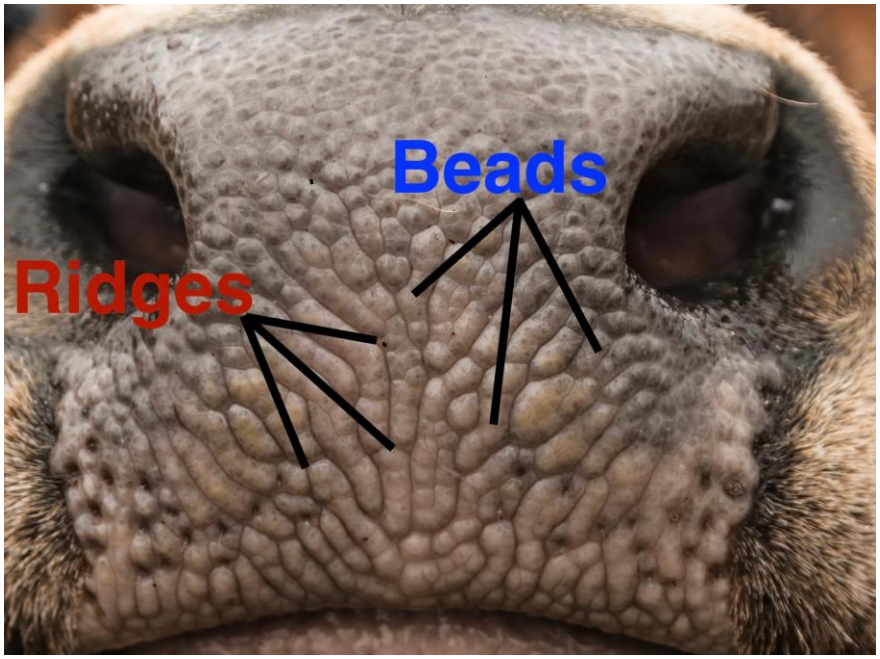


THE MUZZLE AS DISEASE INDICATOR

BUT A COW'S MUZZLE OFFERS MORE TO PRODUCERS THAN A WAY TO IDENTIFY THEIR ANIMALS. A COW'S MUZZLE CAN BE USED TO PREDICT DISEASE, AS MYANIML HAS PROVEN.

Just like when a person's cheeks flush or the whites of their eyes take on a yellowish tint as they begin to get sick, the beads and ridges of a cow's muzzle start to change at the onset of a health event. However, those changes are too subtle to be observed by the human eye, especially in the context of a large herd and 1000s of animals.

MyAnIML solved that problem with a proprietary software system and algorithm that rapidly analyzes facial images to identify individual cattle and then takes the second step of noting subtle changes in muzzle characteristics that occur with the onset of disease or another health event.



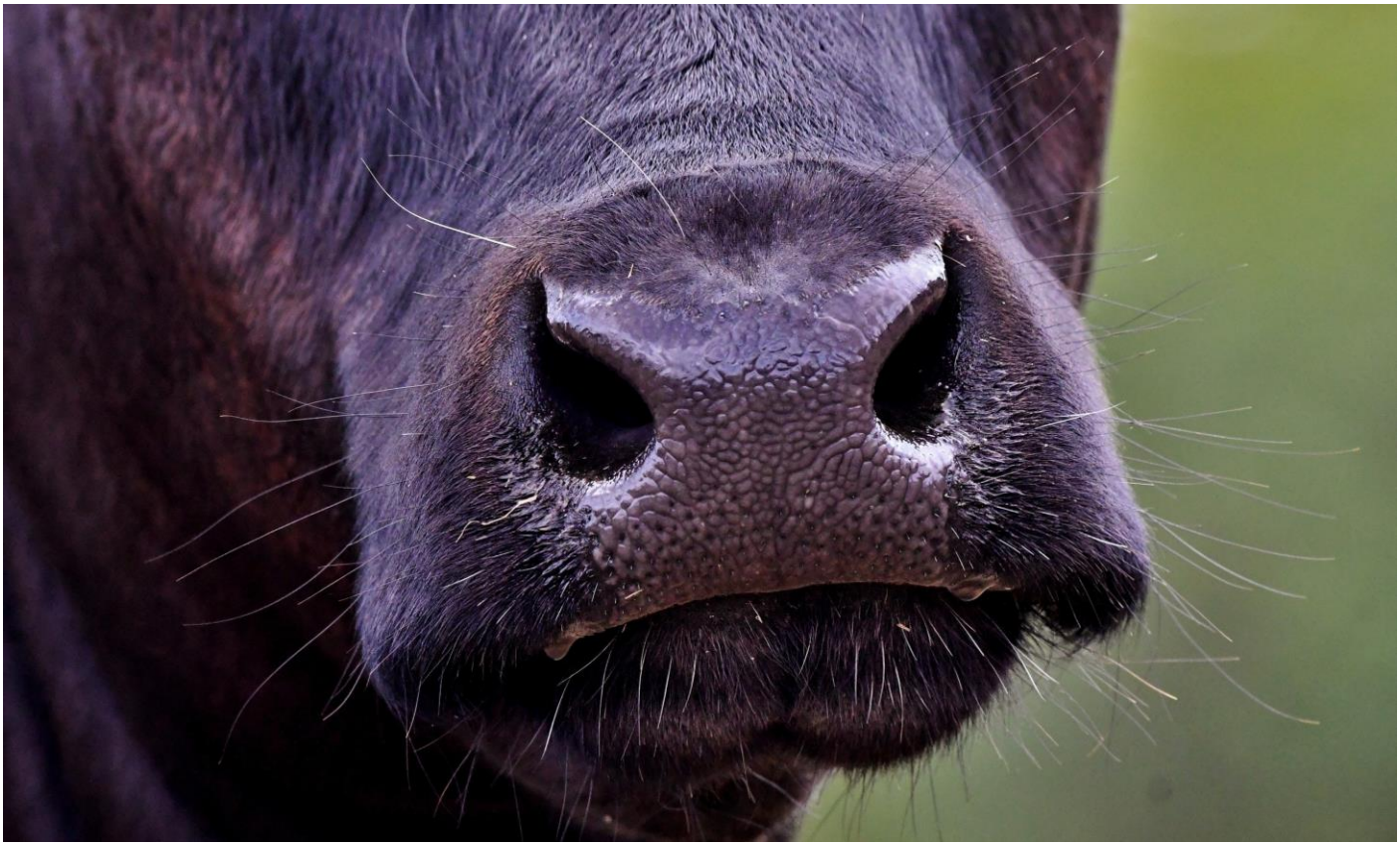
THE LOGISTICS OF THE MYANIML SOLUTION

The first step in the MyAnIML process is capturing multiple, high-quality images of a cow's face and muzzle.

To do so, MyAnIML provides producers with cameras mounted at common gathering spots, like in a milking booth (in the case of dairy cows), or mounted on the side of a feeder truck (in the case of a feedlot). As the cow waits, the camera rapidly takes multiple images of its face and uploads the images to the cloud where they are analyzed by the MyAnIML software.

In more remote locations without easy internet access, edge computing cameras are mounted at spots like watering tanks or even on a semi-trailer that cattle are being loaded onto.

The images are automatically analyzed, and within hours, a report is delivered to the producer's email with the health status of every cow photographed. Each alert is linked to the cow's identifying ear tag and includes a photo of the specific animal.



CUSTOMER NOTIFICATION EMAIL

Tag	Status
CT1016	Healthy
CT10161	Healthy
CT1010	Healthy
CT910	Sick
CT101	Healthy
CT10	Healthy
CT1018	Healthy
CT1019	Healthy
CT672	Healthy

Email is sent out with an excel file that contains the health status of all cattle and link of the pictures of sick cattle.

At that point, the producer accesses data about the animal's general location (pen number, for instance) to locate the animal, isolate them from the herd and observe them for symptoms of disease or other health events.

If the producer has also installed MyAnIML's Bluetooth ear tag tracking tags, they can then use their mobile device to access an add-on app that automatically provides them with stored location information and helps them find that specific animal even if amongst hundreds of other cattle.

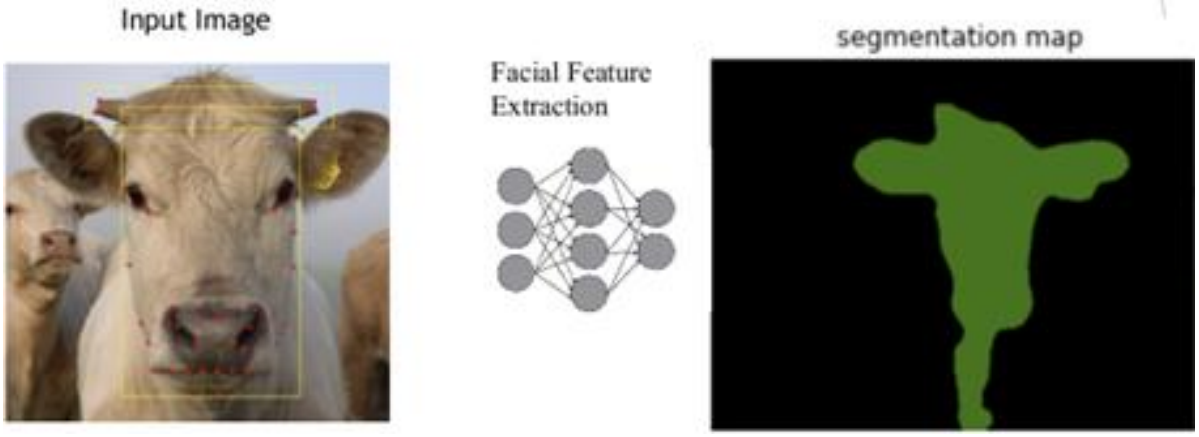
Once within 100 feet of that particular animal, the tag links via Bluetooth with their mobile device and activates a buzzing noise from the tag. In addition, a directional arrow appears on the app which the producer can use to point them to the animal's exact location.

THE MYANIML ALGORITHM AND SOFTWARE SYSTEM

The first step in developing the MyAnIML software system was designing a unique Regional Convolutional Neural Network (R-CNN), a machine learning model for computer vision and object detection. Then MyAnIML built proprietary Cattle Facial and Muzzle libraries. No such publicly-accessible libraries currently exist.

MyAnIML began first by building a facial (including the cow's entire face) to ensure we could accurately identify individual animals and could develop a model that would predict how a cow's face and muzzle would change over time. Reliably predicting what a young calf's face will look like when fully grown means we can track data specific to that animal starting at a young age.

Using a facial feature extraction method, the algorithm classifies every pixel of the image as either pertaining to the cow's face or not so the computer could recognize what is the cow's face and what isn't.



MyAnIML followed the same technique to isolate the muzzle from the rest of the face and then created a 3D image to accurately identify changes in the muzzle's beads, ridges and grooves. Then photos were enhanced, so the computer could detect the difference between the muzzle and anything stuck to it, like grain, dirt or hay.

DEVELOPING THE MYANIML DISEASE CLASSIFIER

Once MyAnIML had a reliable system for extracting high-quality images the computer could analyze, the process of training the algorithm was started. The algorithm required 2500 pictures to reach 90% accuracy.

MyAnIML staff worked with ranchers and veterinarians to take 3,000 images of healthy cows. These cows were made up of three different breeds, Hereford, Angus and Charolais. Pictures were taken of each cow in a chute and standing independently outside of a chute. Based on veterinary inspections, these 3,000 cows were verified as healthy at the time the images were taken and remained healthy for the time immediately following when the images were taken.

MyAnIML also captured 1,500 photographs of cattle known to be sick at the time the images were taken. Running these two sets of images through the algorithm trained the software to recognize the difference between a healthy and a sick muzzle. At this time the system was also trained for cattle identification, achieving 98% accuracy in image recognition.

Out of the 1,500 images of sick and contagious cattle, 800 were diagnosed with IBK (pinkeye), 600 had BRD and the rest had various other health issues such as foot rot, uterus infection or frozen ears. This information was then used to train the system how to detect differences between diseases. For example, an IBK muzzle starts to show smoothness at the onset of infection, while a BRD muzzle develops lesions before it starts to get smooth.

Example of a healthy muzzle

A

Example of a sick muzzle

B

IMAGE A IS A HEALTHY MUZZLE. IMAGE B IS A SICK COW INFECTED WITH IBK (PINKEYE).

Once the computer had learned what a healthy versus sick muzzle looked like, MyAnIML also captured an additional 600 images of cattle that were not identified as sick at the time the images were taken. The algorithm flagged these animals as unhealthy. MyAnIML gave this information to the vet and cattle owners and these cattle were separated for observation. In two to three days visual symptoms of sickness were reported.

This result proved that the MyAnIML technology accurately identify healthy versus sick animals based on images of the cow's muzzle and that the system could then go one step further, identifying sick animals several days before visual symptoms were observed. The algorithm had achieved reliable predictive capabilities.

Specifically, out of these 600 pictures, we predicted pinkeye with 86% accuracy (and 9% false positives) and BRD with 70% accuracy (15% false positives and 15% false negative). As more images are added to the dataset, accuracy rates will improve.

SUMMARY

With MyAnIML's early predictive capabilities, cattle producers can reduce the spread of disease in their herd, support sick animals earlier for better outcomes and potentially eliminate expensive treatments and preemptive treatments, such as giving antibiotics to calves whether they are sick or not.

But the proven capabilities of the MyAnIML technology platform summarized in this white paper are just the beginning of what the MyAnIML data engineers and our research and commercial partners believe this technology will eventually accomplish.

MyAnIML is currently developing additional disease datasets and improving the accuracy of the ones we already have. In addition, from our producer partners, we know that the technology is capable of identifying health events outside of disease or infection. For instance, cows going into estrus or a pregnant cow days away from giving birth are being flagged as 'unhealthy.' With this information, a producer can more reliably ensure an animal is bred at the right time or has more accurate information about an impending birth, allowing them to separate or observe that animal more closely.

In addition, the MyAnIML technology means every farm or ranch hand is empowered with rapid, computer-enabled observation skills. Typically a producer relies on their employees to visually spot symptoms of a cow in distress. Especially in large herds, it can be easy to miss an unhealthy animal, even more so at the early stages of the health event. With MyAnIML producers save on the labor time needed for observation, they have a more accurate way of identifying sick animals that what even trained veterinarian professionals can do.

MyAnIML is also an easy and reliable way of identifying and tracking cattle, without all the logistical complications and problems experienced with current electronic (RFID and EID) ear tag systems.