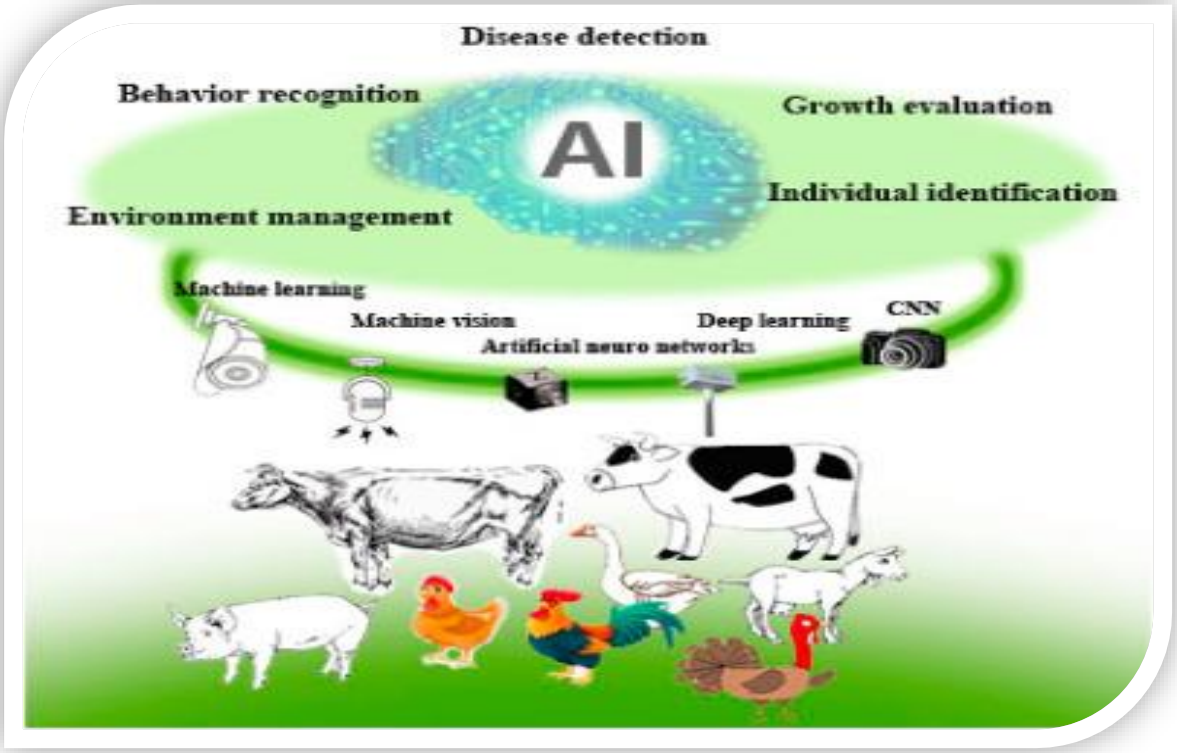
Livestock Health Monitoring Using Artificial Intelligence



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Abstract :

Monitoring the livestock with the Artificial Intelligence technology provides great scope for livestock health and also in animal husbandry. Traditional methods for livestock health monitoring typically involve regular observation and inspection of the animals by trained personnel. This can include checking the animals' behaviour and appearance, taking their temperature, listening to their heart and lung sounds, and examining them for any signs of illness or injury. Livestock health monitoring is an important aspect of modern farming, as it ensures the well-being of the animals and the quality of the products derived from them.

In this paper we explained the methodology for using AI in livestock health monitoring involves first installing the necessary sensors and cameras in the animals' living environments. Using such equipment data is collected on the animals such as their behaviour, body temperature, and heart rate. This data is then fed into machine learning algorithms, which can analyze it to detect potential signs of illness or other health issues.
The real time problem, market value for AI in livestock, and the importance of AI inlivestock health has been discussed. Comparison between all the existing Artificial Intelligence technologies has been discussed. With the help of comparison, a best fit product is proposed for the usage in livestock to monitor the health and also for other purposes. Usingvarious machine learning algorithms, an efficient model is made for the project. Concept generation with the deployment and real time potential business opportunity has been proposed with the limitations.

1.0 Problem Statement :

Cattle plays a vital role in the agriculture industry and especially in dairy based products worldwide. Nowadays, cattle are suffering from various health problems, diseases, unpredictable killings and being surplus for maintaining a breeding stock. This can result in significant economic losses for farmers, as well as negative impacts on animal welfare.

Current methods of livestock health monitoring can be time-consuming, labor-intensive, and reliant on subjective assessments by human experts, leading to delays in detecting health issues and potential misdiagnoses. So, it is important for farmers to adopt different and efficient methods for efficiency of cattle and their health monitoring which increases milk production supply.

As a country with an enormous population, livestock is indeed an important domain as it produces a large number of foods. Using Artificial Intelligence Technology, various diseases of cattle can be regularly monitored on daily basis. This would enable prompt diagnosis and treatment, reduce the spread of diseases, and improve animal welfare, while also minimizing economic losses for farmers.

2.0 Market/Customer/Business Need Assessment :

The livestock monitoring market is estimated to grow higher in future. It is estimated to be worth USD 1.6 billion in 2022 and it is projected to reach up to USD 3.7 billion by 2030, at a CAGR (Compound Annual Growth Rate) at 11.0% during the forecast period. AI is much useful in detecting early diseases, increased focus on real-time monitoring, rising demand for global meat consumption and cost-saving achieved through the adoption of livestock monitoring solutions, etc. These are some of the major factors driving the market growt

And also, the countries like India and China where the population is rapidly growing are the major market demand regions. The increase in the demand for dairy and meat products are expected to fuel the adoption of livestock monitoring solutions.

3.0 Target Specification and Characterization :

The product which will be used for livestock health monitoring should be a user-friendly interface since farmers and livestock keepers are going to use the product. The monitoring system should be accurate in detecting any health issues or abnormalities in the livestock. It should be low maintenance and cost-effective.

The monitoring system should be able to analyse the behaviour and patterns of livestock to detect any signs of health issues. It also should be able to monitor the reproductive and pregnancy conditions. It also should determine the temperature of the livestock and involving early detection of infectious diseases such as foot-and-mouth disease, brucellosis and tuberculosis, etc. A report should be generated by the system from the collected data for further decisions which can be made by the farmers and livestock keepers.

4.0 External Search :

The real time analysis of livestock health monitoring which involves movements, early detection of diseases and behavioral patterns as mentioned in the problem statement are gathered from the number of sources where the detailed analysis, study and experimentation has been done. Mentioned below are the sources:

https://nexocode.com/blog/posts/ai-based-smart-farming-machine-learning-in-livestock-farming/

https://ietresearch.onlinelibrary.wiley.com/doi/10.1049/iet-wss.2017.0060

https://www.ijert.org/iot-based-cattle-health-monitoring-system

https://www.iotforall.com/use-case/livestock-management

https://www.marketsandmarkets.com/Market-Reports/livestock-monitoring-market-72634532.html

https://www.marketsandmarkets.com/Market-Reports/livestock-monitoring-market-72634532.html

https://www.pashudhanpraharee.com/application-of-artificial-intelligence-ai-for-livestock-poultry-farm-monitoring/

https://www.pashudhanpraharee.com/artificial-intelligenceai-future-of-livestock-farming-in-india/

5.0 Benchmarking :

The farmers are adopting smarter techniques that can aid in adjusting the water usage, proper use of land and energy to feed the planet and eradicate the global food crisis especially considering the enormous growth in the world population. As AI technology became a successful method which had been adopted by several industries. Now, it is starting to revolutionise the future of farming with drones, intelligent monitoring systems, livestock health monitoring and robots. With this, a lot of AI products are used by many industries as well as farmers as of now. Below are the products which are already available in the market.

Feature	Drone	Robot	Sensor	Computer Vision	Wearable
Size	Medium sized, but small enough to be maneuvered	High, depending upon the specific model and intended usage.	Small	High	Small
Weight	Medium	High, depending upon the specific model and intended usage.	Light	High, depending upon the model and the software used	Light
User Interface	Vary depends on specific model and software used	High	Medium, depending upon the specific model and software used.	High, depending upon the model and the software used	High to Medium

Cost	High	High	Low to Medium	High	Low to Medium
Functionality	High	High	High	High	Medium
Durability	High	High	High	High	Medium
Energy Efficiency	High	Medium	High	High	High
Material Quality	High	High	High	High	High
Performance	High	High	High	High	Medium

6.0 Applicable Patents :

As the advancement of AI in monitoring livestock, new technologies, patents are increasing. Below are the few important patents used in the livestock

6.1 US20100030036A1 :

A patent titled 'System and Method for Wireless Health Monitoring for Livestock", describes the wireless health monitoring system for livestock which includes one or more sensors attached to the animals for collecting data on their heath, behaviour, and activity. The collected data is transmitted to the base system or base station where the data is analysed to detect the health problems like diseases, distress, behavioural patterns. It can also have a user interface to access the collected data.

6.2 US8149125B2 :

The patents describe the system for tracking and managing the animals such as livestock or cattle, using Radio Frequency Identification (RFID) tags and transceivers. Tags are attached to the animals and it transmits identification and location with other information to transceivers to the system. Transceivers can be used to track the battles movements, manage their feeding and care and also monitor their health.

6.3 US9538729B2 :

This patent involved the usage of a system and method for monitoring the health of animals, especially cattle, using sensors and machine learning algorithms. The system provides real time data about animal's behaviour, movement and other physiological parameters. The data is then analysed using machine learning algorithms. The system even alerts farmers or veterinarians about the animal's condition. This patent has helped farmers and veterinarians detect and treat illness early and also improving economic losses and animal health.

6.4 EP3188648B1 :

It's a European patent, describes a. Method and system for monitoring the behaviour and activity of livestock using a combination of sensors, cameras, and machine learning algorithms. The system collects data on the animal's posture, feeding habits, movements and social interactions using cameras and sensors which are placed in the animal's environment.

After analysing the collected data using machine learning algorithms, detection of animal's behaviour and potential health problems or distress can be identified.

6.5 KR101712633B1 :

It's a Korean patent, describing the involvement of a system and a method for monitoring the health and welfare of livestock using wireless sensors and the collected data is transmitted to the base station where it is analyzed to detect health problems. Along with this, the drones are used to identify animals and track their movements and behaviour over time.

7.0 Applicable Regulations :

With AI technology, we can detect health problems and other problems related to livestock. But it comes with some regulations.

7.1 Animal Welfare Regulations :

The welfare of animals is important and it should be ensured that any monitoring system does not cause undue harm or stress to the animals.

7.2 Environmental Regulations :

These regulations include waste disposal, air quality, and water quality. AI products should be sustainable and help the farmers to protect the environment by reducing harmful contamination.

7.3 Product Safety Regulations :

The products which are used for livestock health monitoring such as wearables, sensors, drones, have to undergo testing, certification and labelling.

7.4 Data Privacy Regulations :

Data which are collected, stored and used for livestock health monitoring subjected to data privacy regulations. It requires the consent from individuals as the data is being used for further processing, restricting the data usage for commercial purposes and making sure that the data is being secured.

7.5 Government Regulations :

Each country's government has different regulations as a whole when it comes to AI in livestock health monitoring. Especially regulations regarding import/export, biosecurity, food safety, animal welfare and environment.

8.0 Applicable Constraints :

There are some applicable constraints for livestock health monitoring using AI. Some of them include:

8.1 Budget :

The cost for setting up an Artificial Intelligence based system for livestock health monitoring is expensive and the cost will increase if high-end sensors and equipment are

needed. This is a significant constraint for farmers with small farms especially when they are on an inadequate budget.

8.2 Connectivity :

Internet connection in rural areas can be a challenge with poor internet connectivity. Since AI-based livestock health monitoring systems require well-grounded and steady internet connection.

8.3 Need for Space :

A dedicated space should be required for servers, sensors and other important equipment since AI based systems require a certain amount of space. To be set up would be a constraint, especially in smaller farms.

8.4 Expertise :

Another significant constraint is that this AI based setup requires personnel who has specialised knowledge in AI and also a good expertise in both artificial intelligence and agriculture. Finding and hiring them would be a constraint for remote farms.

8.5 Data Security :

Smaller farms which don't have resources to invest in advanced security measures would be a constraint since the system uses sensitive data which must be designed with data security in mind.

9.0 Business Opportunity :

Considering the fact that Artificial Intelligence based products play a vital role in livestock health monitoring, it can be used extensively in livestock health by providing services to medium and smaller farms (farmers who don't have much resources). Based on the benchmarking of AI products which are being used in livestock, wearables are the preferred one for small and medium farms. This can be done by providing wearables to farmers and also livestock producers as a subscription-based service. This subscription-based model can be done by utilising already existing AI-based service providers with the help of an application, which can be downloaded in the mobile, or a dashboard is used to monitor the livestock as per farmers need. AI-based wearables are given to farmers once they subscribed to the service. Wearables can be attached to the livestock, here Ear tag is used as a wearable. The Ear tag with built-in sensors can be used to monitor various parameters such as behavioural patterns, psychological effects, body temperature, heart rate and respiratory rate. They are easy to install, lightweight and cost-effective, especially if they are affordable.

10.0 Concept Generation and Deployment :

The concept generation involves the step-by-step procedures for implementing the ideas formulated for the livestock health monitoring using AI. Below are the steps involved:

10.1 Identify the problem :

Each farm has their own unique problem. Identifying the problem would be the first step which involves the brainstorm for improving the livestock health monitoring process. This usually involves evaluation of different AI-based technologies and selecting the appropriate for the business problem.

10.2 Using Algorithms :

An important part of machine learning is implementing machine learning algorithms. A wide number of algorithms are being used such as decision tree, random forest, logistic regression, linear regression, clustering algorithms, Support vector machine, and K-neighbours. The model is prepared for training and tests to get the best results.

10.3 Develop the prototype :

The selected idea can be further developed into a prototype. This prototype can be further tested and checked for quality. This usually involves the development of hardware, software or a combination of both.

10.4 Commercialisation :

Once the prototype got checked for other metrics, it is commercialised to reach a wider audience. This can be done by promoting the product through advertisement, collaboration with promoters, technology companies and partnerships with livestock producers, farmers.

10.5 Hardware and Software Setup :

Installing sensors, cameras, wearables and other monitoring devices on the livestock which are AI-based health monitoring systems.

10.6 Data Collection :

After setting up the necessary hardware and software at the livestock, data is being collected through the products. The collected data has detailed information about each livestock regarding their vital signs, behaviour and other metrics. The collected data is then stored in a centralized database for analysis.

10.7 Data Analysis:

The collected data is being analysed using AI algorithms to identify patterns and anomalies that may indicate potential health issues. The AI system would be trained to recognize different health conditions and diseases. If something is not good, alerts can be sent to farmers, livestock producers or veterinarians if any such problems are detected. The alerts can be sent via SMS, email or through a dedicated mobile app.

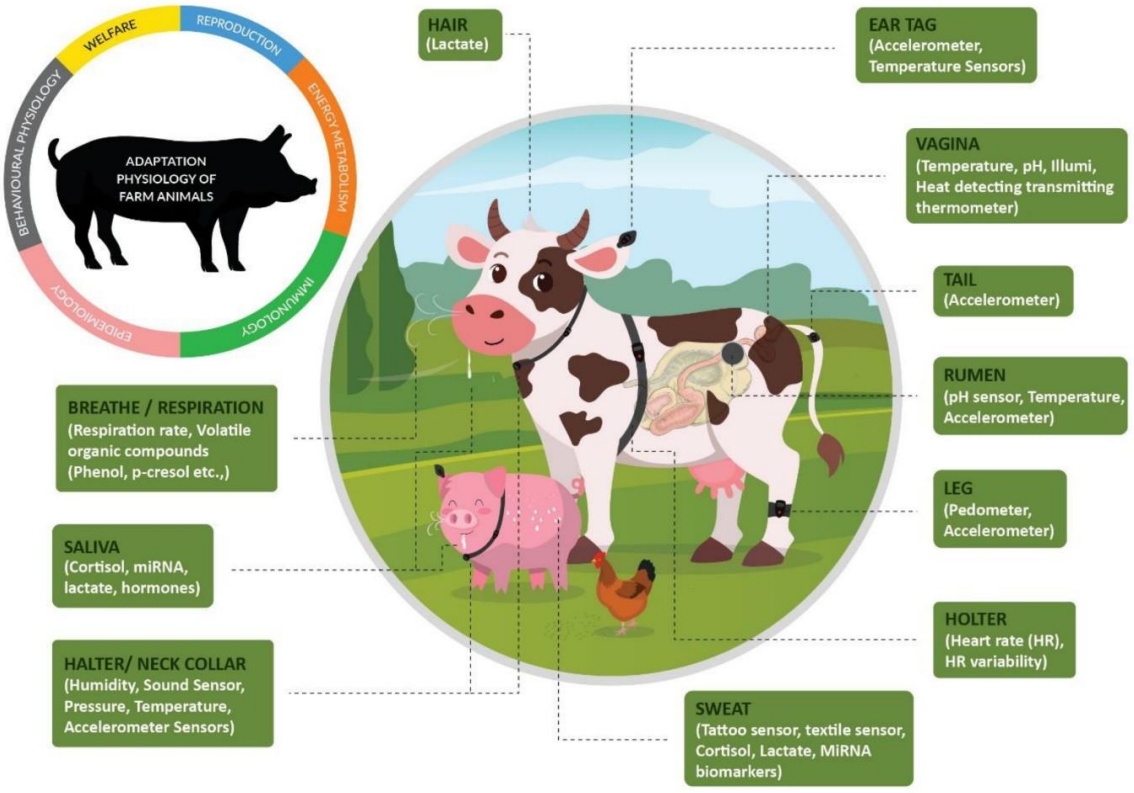
10.8 Monitoring, Treatment and Feedback :

If any issue is detected, the AI system would provide necessary guidance and also suggests some treatment or actions to be taken. The suggestions like changes in feeding, medication or suggesting that a veterinarian should be called for further examination. Finally, the AI system gives continuous suggestions to the farmers on a daily basis and also provides recommendations.

11.0 Final Product Prototype:

11.1 Wearable :

A final product consists of a wearable ear tag which has a sensor with it, monitors livestock health, movements, and other metrics. The ear tag is small in size, lightweight and can be easily attached to the livestock.



11.2 Cloud Computing:

A cloud interface is needed to store the collected data from the sensor for real-time data analysis. The stored data can be used for effectiveness and efficiency of livestock management.

11.3 Subscription:

Since the product depends on the AI based server for algorithms and further processes, a subscription-based service would be given to the users based on their needs (subscription packages). The service can be done by already existing AI service providers.

11.4 Dashboard/Application:

The status can be seen by a dashboard or a mobile application. The user interface is used by farmers or livestock producers. A notification is sent to the users by the dashboard if any abnormalities are detected. Recommendations for further treatments, suggestions and other features can be made as per farm needs.

12.0 Requirements:

The product requires a large number of sources for the entire process. Below as follows:

12.1 Team Requirement:

The requirement is based on the size of the project. It depends on each scenario.

- Machine Learning Engineers
- Cloud Architects
- Data Scientists
- Software Engineers
- Computer Vision Engineers
- Hardware Engineers

12.2 Algorithms/Frameworks:

As this product is completely based on the machine learning resources, it is necessary to use algorithms for predictive modelling. Below are the best algorithms for monitoring

- Linear Regression
- Random Forest
- Decision Tree
- Support Vector Machine
- K-Nearest Neighbours
- Naive Bayes
- Logistic Regression
- Clustering Algorithms

13.0 Code Implementation On Small Scale:

- **Github Link :**

  https://github.com/mayurpawar24/Livestock-Health-Monitoring

Livestock Health Monitoring:

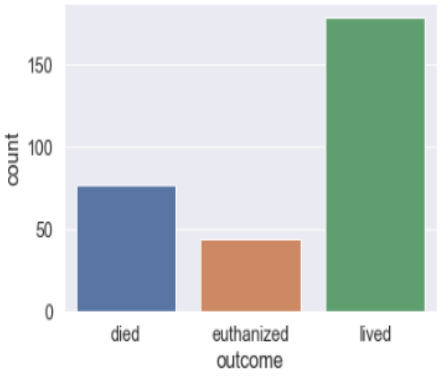
```
In [124]: df.head()
```

Out[124]:

	surgery	age	hospital_number	rectal_temp	pulse	respiratory_rate	temp_of_extremities	peripheral_pulse	mucous_membrane	capillary_refill_time	...	pacl
0	no	adult	530101	38.5	66.0	28.0	cool	reduced	NaN	more_3_sec	...	
1	yes	adult	534817	39.2	88.0	20.0	NaN	NaN	pale_cyanotic	less_3_sec	...	
2	no	adult	530334	38.3	40.0	24.0	normal	normal	pale_pink	less_3_sec	...	
3	yes	young	5290409	39.1	164.0	84.0	cold	normal	dark_cyanotic	more_3_sec	...	
4	no	adult	530255	37.3	104.0	35.0	NaN	NaN	dark_cyanotic	more_3_sec	...	

5 rows × 28 columns

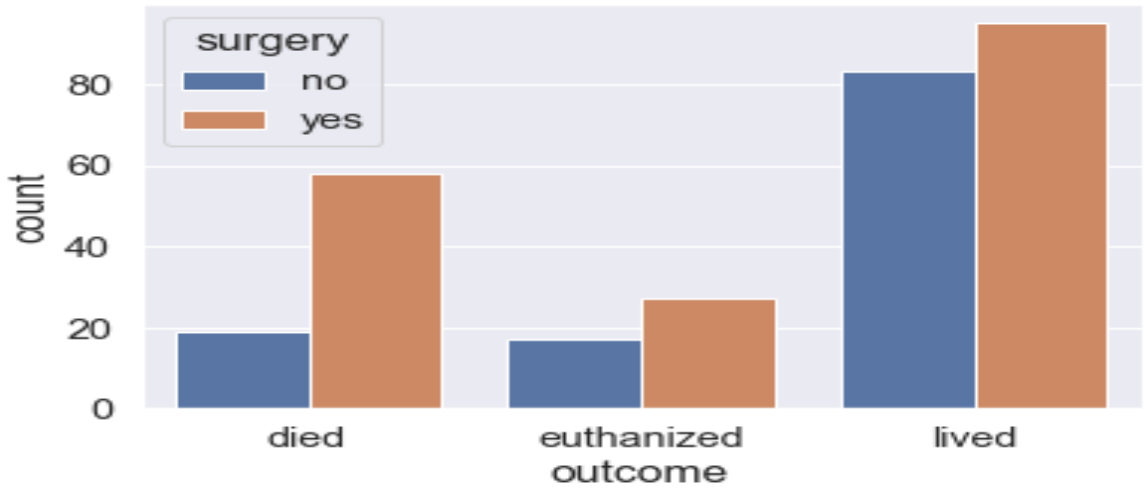
```
In [96]: sns.countplot(data=df, x='outcome');
```

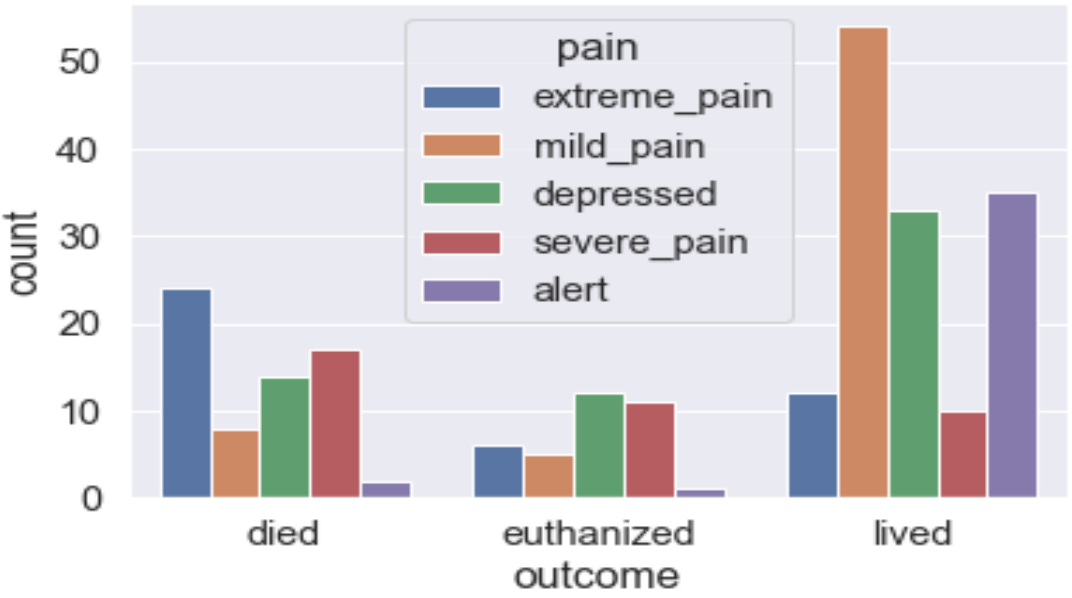


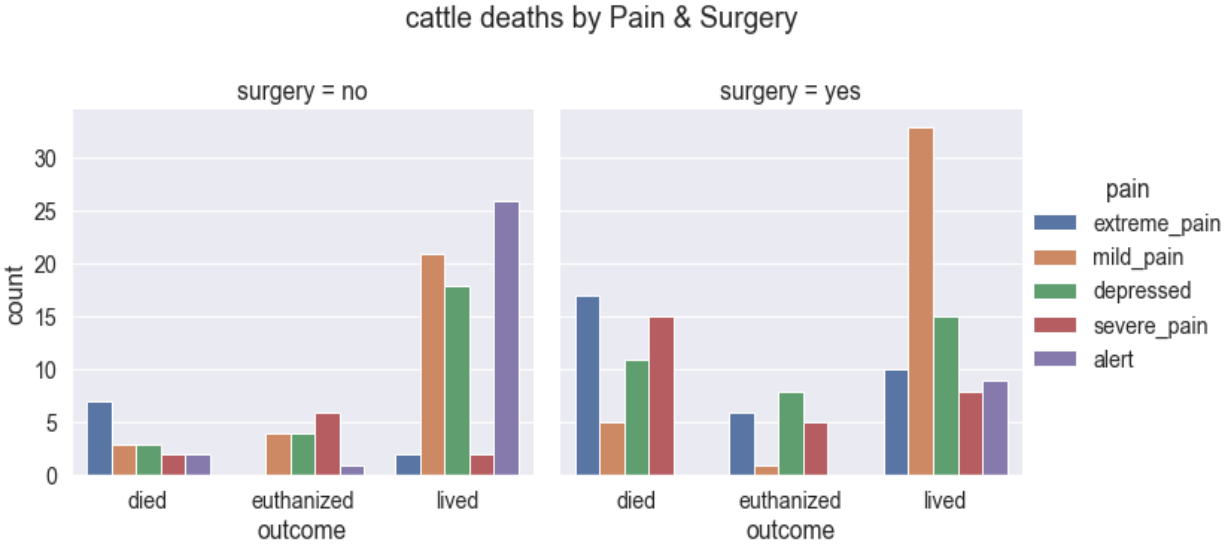
Among the 299 cases, about 75 cattles died and 40 were euthanized. We will study the condition of these cattles in this kernel.

1. Surgery & Pain:

We will study the effects of surgery and pain. How many of the cattle which died underwent surgery and what level of pain did they feel?


surgery
no
yes
count
80
60
40
20
0
died
euthanized
lived
outcome

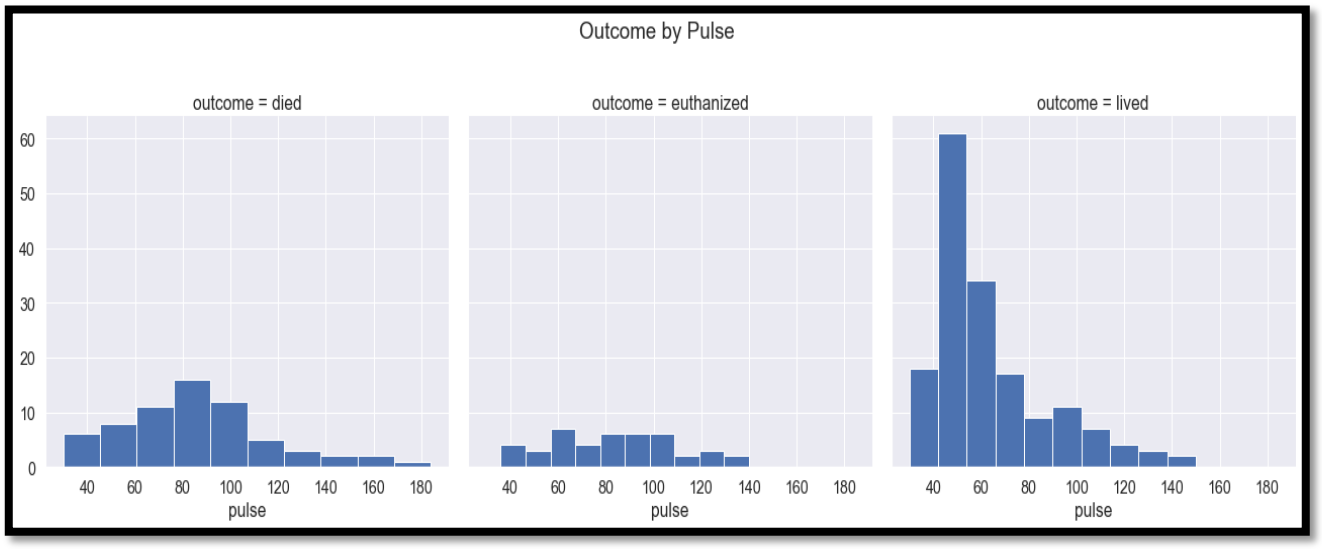

pain
extreme_pain
mild_pain
depressed
severe_pain
alert
count
50
40
30
20
10
0
died
euthanized
lived
outcome

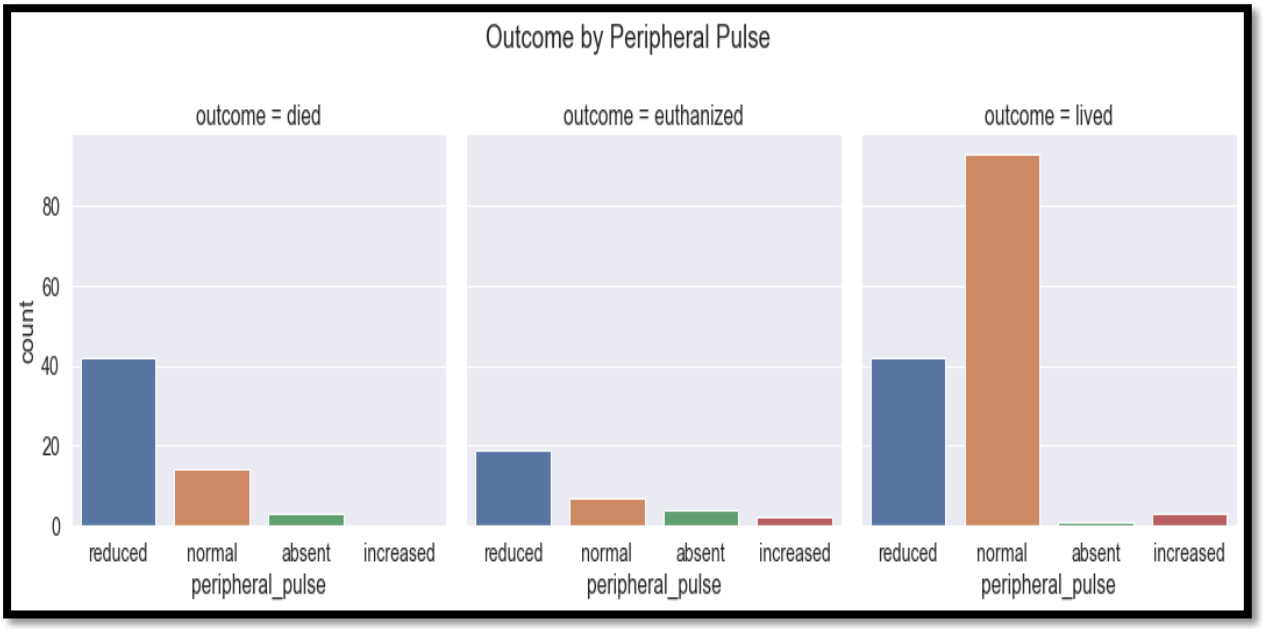

cattle deaths by Pain & Surgery
surgery = no
surgery = yes
count
30
25
20
15
10
5
0
died
euthanized
lived
outcome
pain
extreme_pain
mild_pain
depressed
severe_pain
alert

.

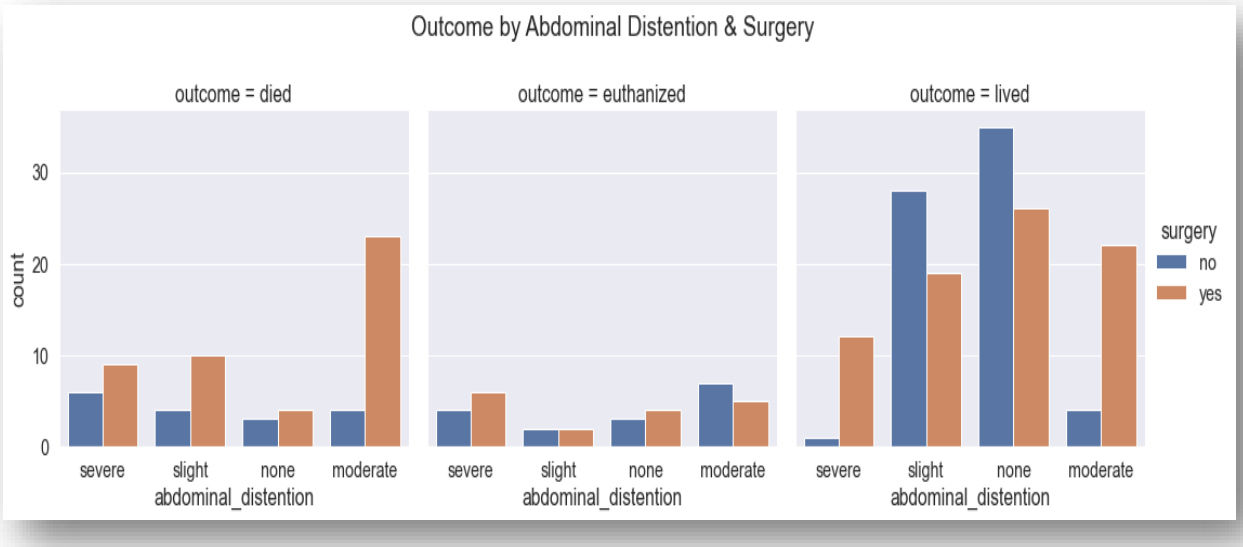
- Only 20 of the 77 cattles that died underwent surgery.
- About 18 cattle underwent surgery but were euthanized.
- A large majority of the cattle that died felt extreme or severe pain.
- While a majority of cattles that were euthanized experienced severe or depressed pain.

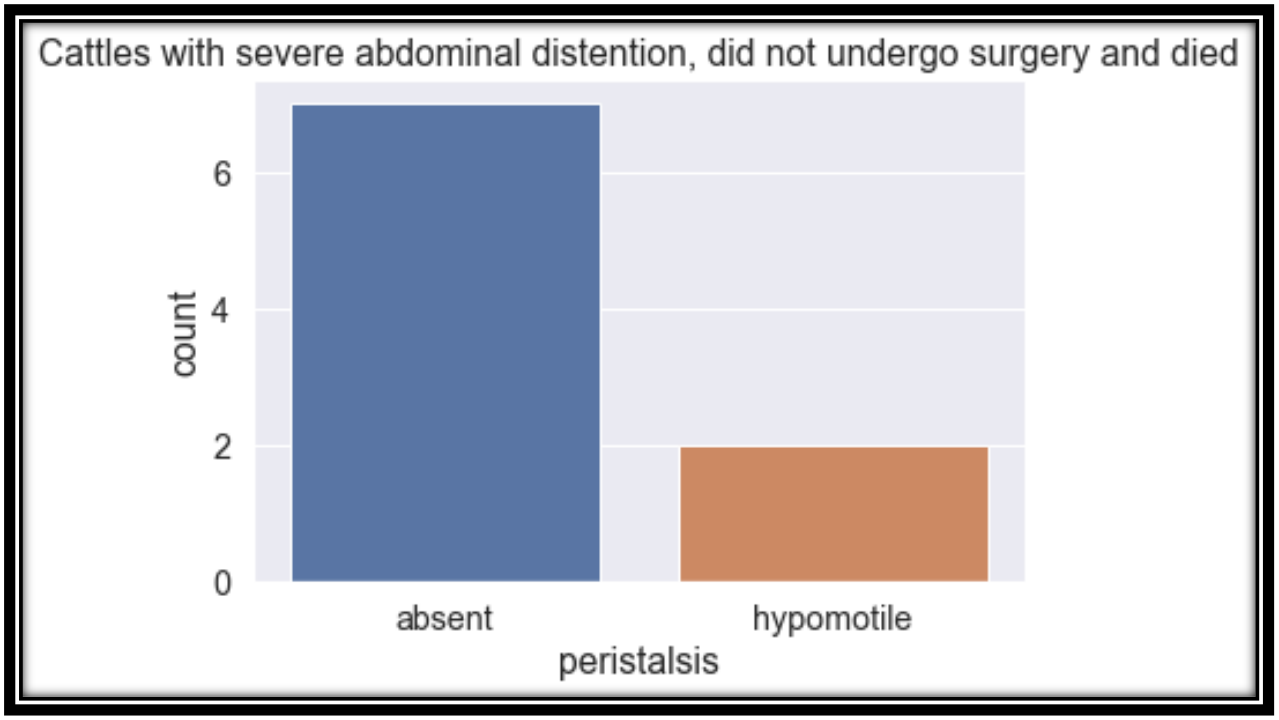
2. Circulation :





3. Gut Health:





- We were given the information that when there is Abdominal Distention, a surgery is necessary to alleviate the condition. A large proportion of Cattles with severe distention that died had not undergone surgery. Meanwhile, a large proportion of Cattles with severe distention that survived had undergone surgery.

- Of the 9 Cattle with severe distention that did not undergo surgery and died, 7 had an absent peristalsis. That was the sign of a compromised gut.

4. Analysis on Target variable:

In this dataset, target variable is outcome.

Applying alogrithm

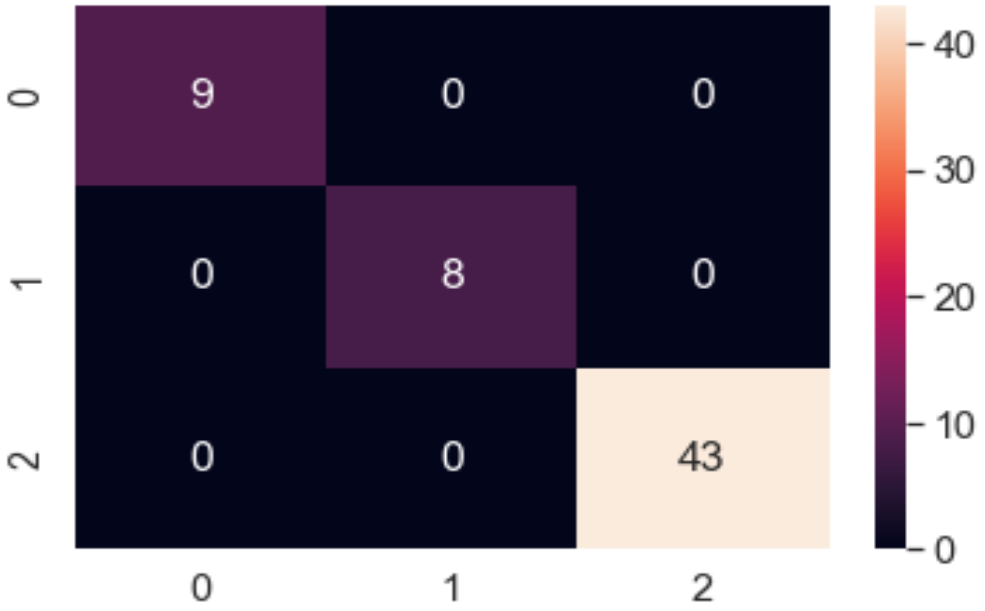
In [153]:
```
from sklearn.linear_model import LogisticRegression
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.svm import SVC
from sklearn.neighbors import KNeighborsClassifier
```

In [154]:
```
algo = {'LR':LogisticRegression(),
        'DT':DecisionTreeClassifier(),
        'RFC':RandomForestClassifier(n_estimators=100),
        'SVM':SVC(gamma=0.001),
        'KNN':KNeighborsClassifier(n_neighbors=10)}
```

In [155]:
```
for k, v in algo.items():
    model = v
    model.fit(X_train, y_train)
    print('Acurracy of ' + k + ' is {0:.2f}'.format(model.score(X_test, y_test)*100))
```

```
Acurracy of LR is 73.33
Acurracy of DT is 70.00
Acurracy of RFC is 78.33
Acurracy of SVM is 76.67
Acurracy of KNN is 75.00
```

Here, Maximum accuracy is Random Forest Classifier. So, we make confusion matrix of RFC.



14.0 Financial Modeling :

1. **Cost-benefit analysis equation:** A cost-benefit analysis can help determine the financial impact of implementing a new technology or method for monitoring cattle health. The equation can be represented as:

   Net Benefit = Total Benefits - Total Costs.

   where Total Benefits could include increased milk production, reduced mortality rates, and lower treatment costs, while Total Costs would include the initial investment in AI technology, maintenance costs, and any other related expenses.

2. **Revenue projection equation:** To estimate the potential revenue increase resulting from improved cattle health, the following equation could be used:

   Projected Revenue Increase = (Current Milk Production x Expected Increase in Milk Yield per Cow) x Number of Cows.

   where Current Milk Production represents the baseline milk production prior to implementing AI technology, Expected Increase in Milk Yield per Cow represents the expected increase in milk production due to improved cattle health, and Number of Cows represents the total number of cattle in the herd.

- The cost-benefit analysis equation can help determine the financial feasibility of implementing AI technology for monitoring cattle health. It considers the net benefit of implementing the technology by comparing the total benefits, including increased milk production, reduced mortality rates, and lower treatment costs, with the total costs, including the initial investment in AI technology, maintenance costs, and other related expenses.
- On the other hand, the revenue projection equation estimates the potential revenue increase resulting from improved cattle health. It considers the current milk production, the expected increase in milk yield per cow due to improved cattle health, and the total number of cattle in the herd.
- There are many ways to model the financial impact of Livestock Health Monitoring Using Artificial Intelligence (AI), but one possible approach is to use a basic cost-benefit analysis. Let us define the following variables:

  I: Initial Investment
  Y: Annual Yield or Revenue
  C: Annual Cost

  S: Savings per animal per year due to improved health monitoring (this includes mm reduced treatment costs, decreased mortality rates, and increased productivity)

  A: Additional AI-related costs (e.g. software, hardware, maintenance)

T: Time horizon of the analysis (in years)
r: Discount rate

The equation for the net present value (NPV) of the Livestock Health Monitoring Using AI project is:

$$NPV = -I + \Sigma[(Y - C - S - A) / (1+r)^t]$$

where Σ represents the sum of all years from 1 to T.

This equation calculates the present value of all the net cash flows that the project will generate over the analysis period. The net cash flow is the difference between the revenue generated by the project (Y) and its total cost (C + S + A), discounted back to the present day using the discount rate (r).If the NPV is positive, it means that the project is expected to generate a profit and is therefore potentially worthwhile to pursue. Conversely, if the NPV is negative, it suggests that the project may not be financially viable.

It's important to note that this is a simplified model, and other factors such as market demand, regulatory compliance, and operational efficiency should also be taken into account when evaluating the financial viability of a Livestock Health Monitoring Using AI project.

15.0 Conclusion :

Indian agriculture is on the verge of adopting modern technologies such as Internet of Things (IOT), Artificial Intelligence (AI)/Machine Learning (ML). Currently, the availability of AI in livestock is minimal since there are few players in the market that provide such services to the farmers and livestock producers at a higher rate. Catering to nearly 267 millionfarmers possess a huge opportunity in deploying AI used products at an affordable cost. One of the affordable AI-based products is Wearable (Ear Tag) for livestock health monitoring. Commercializing the AI products in animal husbandry is not an easy task since farmers don’t have awareness about how AI works and helps them in achieving the predictive results. Partnership between government, or with a private entity is a potential collaboration for implementing such technologies in animal husbandry. If implemented, the overall quality of livestock increases to a potential rate. The field of animal husbandry and also livestock will see tremendous growth with a number of potential business opportunities.

16.0 References :

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