SmartInsure: Blockchain and CNN Leveraged Secure and Efficient Cattle Insurance

Presenter: Sukrutha L. T. Vangipuram

Anand Kumar Bapatla[1], Aishani Gupta[2], S. P. Mohanty[3], E. Kougianos[4]

University of North Texas, Denton, TX, USA.[1,2,3,4]

Email: ab0841@unt.edu[1], aishanigupta@my.unt.edu[2], saraju.mohanty@unt.edu[3], elias.kougianos@unt.edu[4]

Outline

- Introduction
- Significance of Cattle Insurance
- Centralized Insurance Management System
- Problems with Current IMS
- Novel Contributions
- Architectural Overview
- Implementation Details
- Results and Analysis
- Conclusion

Agriculture and Role of Insurance

- Agriculture: Crop cultivation + Livestock farming.
- Serves as the backbone for several country's economies.
- Depends on unpredictable weather and climatic events, making mitigation techniques futile.
- Livestock Farming is heavily damaged by viral diseases like Bovine Respiratory Diseases (BVD), and Foot and Mouth Diseases (FMD).
- Livestock Insurance: A special type of insurance within agriculture for cattle to ensure farmers are financially protected.

Cattle Insurance

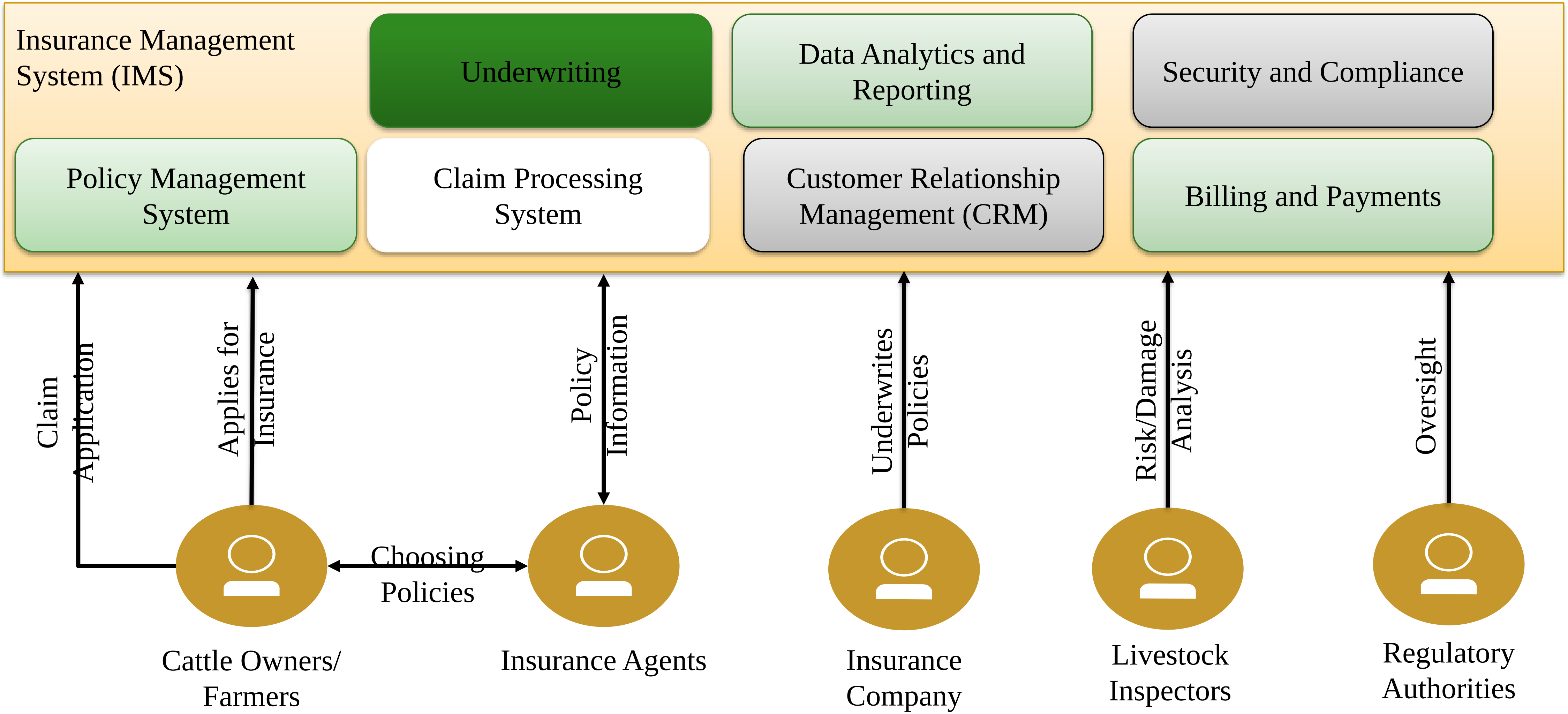
- Some viral diseases and symptoms:
  - Bovine Respiratory Diseases (BRD)
    - Coughing
    - Lack of appetite
    - Rapid and shallow breathing
    - Fever
  - Foot and Mouth Diseases (FMD)
    - Fever
    - Depression
    - Weight loss
    - Appetite loss
- Measures: Quarantine and Trade restrictions

- Farmers cannot sell produce
  - Struggle to make a profit
  - Struggle to sustain

Cattle Insurance Management System

- Entities in cattle insurance management system
  - Owners/Farmers who own the cattle and seek to insure their livestock
  - Insurance companies responsible for underwriting the policies, setting the premiums, and processing the insurance claims.
  - Insurance agents act as intermediaries who help the farmer with choosing appropriate policy.
  - Regulatory agencies to overlook operations and ensure regulations.
  - Re-insurance providers where the insurance companies insure part of their cattle insurance portfolio.

Cattle Insurance Management System



Problems with Centralized Cattle IMS

- Centralized architectures are more prone to security threats.
- Unauthorized modification of insurance records and falsified claims.
- Significant delay in claim processing affecting the cattle owners/farmers.
- Identification of cattle using RFID tags which can be detached for falsifying information.
- Overhead costs for coordinating distributed stakeholders.
- More prone to disputes due to cumbersome paperwork involved.

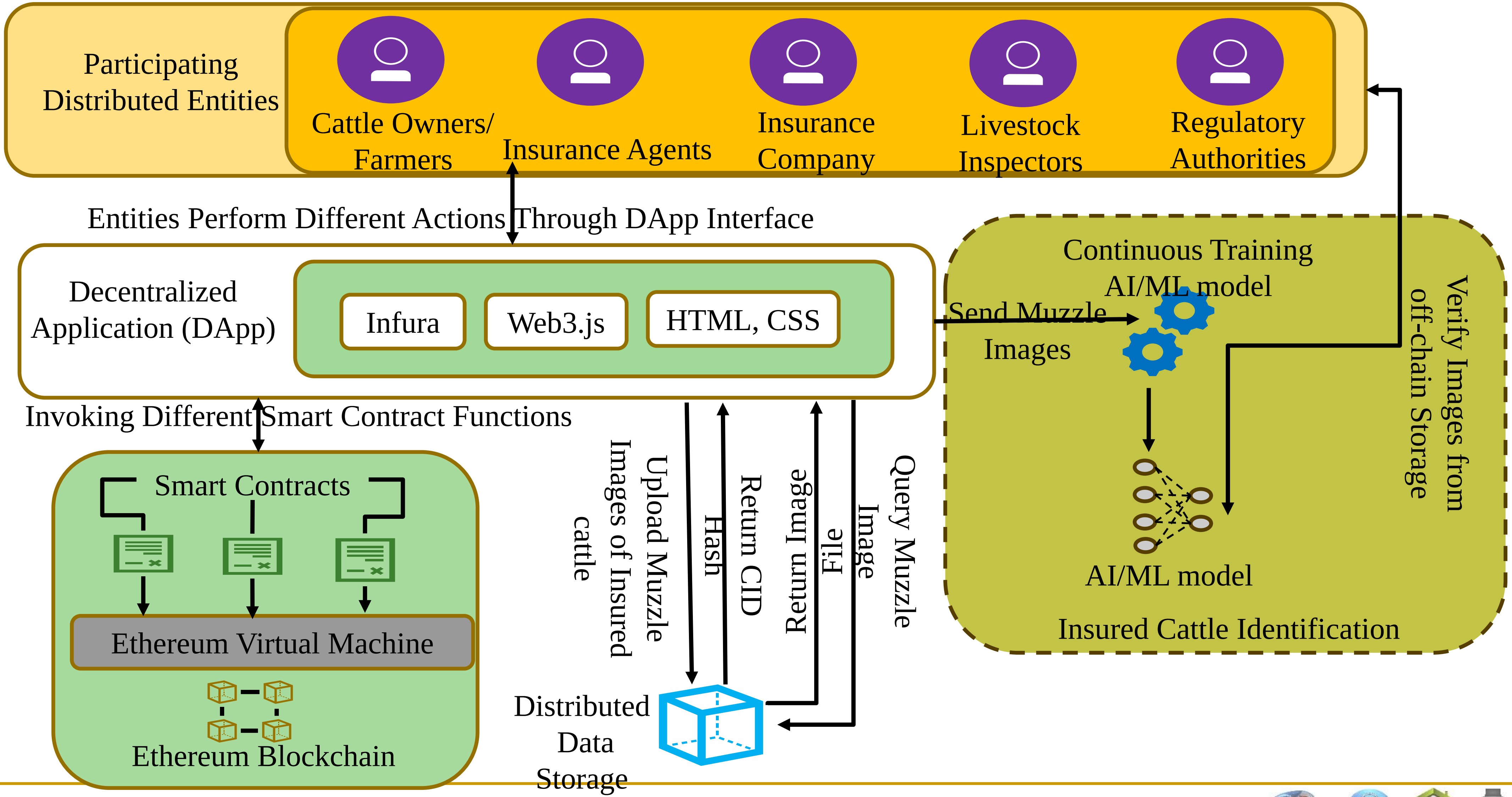
Novel Solutions Proposed

- Blockchain features in the proposed SmartInsure help prevent many of the security threats faced by the centralized architecture.
- The Immutability nature of the distributed ledger ensures no modifications can be done to the transactions once they are confirmed.
- The proposed blockchain-based architecture helps create a transparent environment to increase the efficiency of insurance management functions.
- Muzzle images are used to identify the insured cattle, preventing falsified claims.
- Proposed SmartInsure reduces paperwork, which can be cumbersome and lead to many disputes, and overhead costs.

Architectural Overview

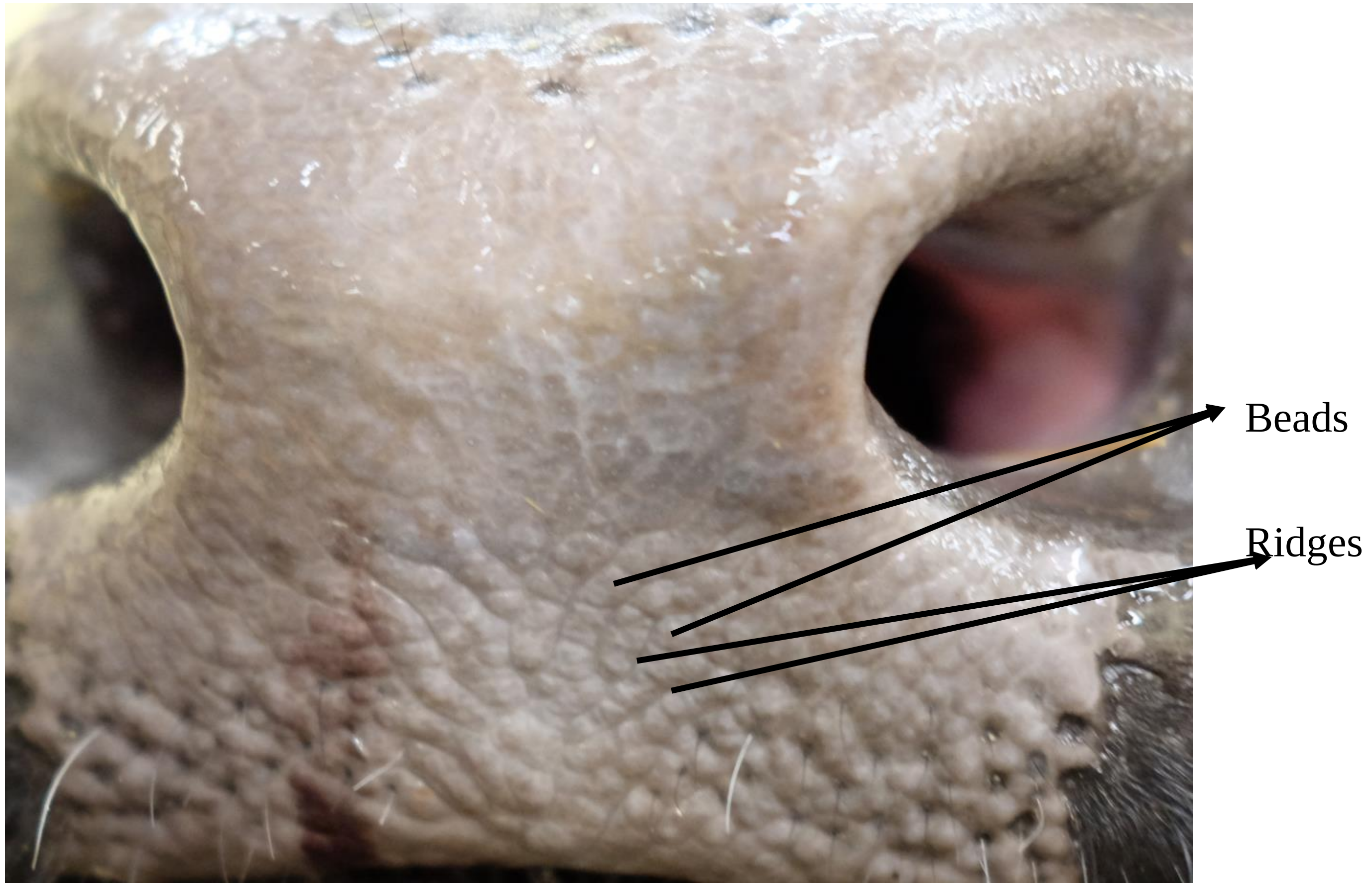
- Five Components of the proposed SmartInsure
  - Distributed entities: Includes stakeholders like Cattle owners/farmers, Insurance agents, Insurance companies, Livestock inspectors, regulatory agencies, etc.
  - On-chain component: Smart Contracts holding the business logic and access control mechanisms.
  - Off-chain component: Decentralized file storage system to store large muzzle image data of insured cattle.
  - Image verification service: AI-based image identification of insured cattle to prevent falsified claims.
  - User Interface: user-friendly interface for different stakeholders to perform insurance functions.

Architectural Overview



Implementation

- Dataset consists of 4923 images from 268 different feed yard breed cattle
- Cattle breeds:
  - Angus
  - Angus Hereford Cross
  - Continental British Cross
- Images taken with a 26MP camera
- Images resized to 180 * 180 pixels

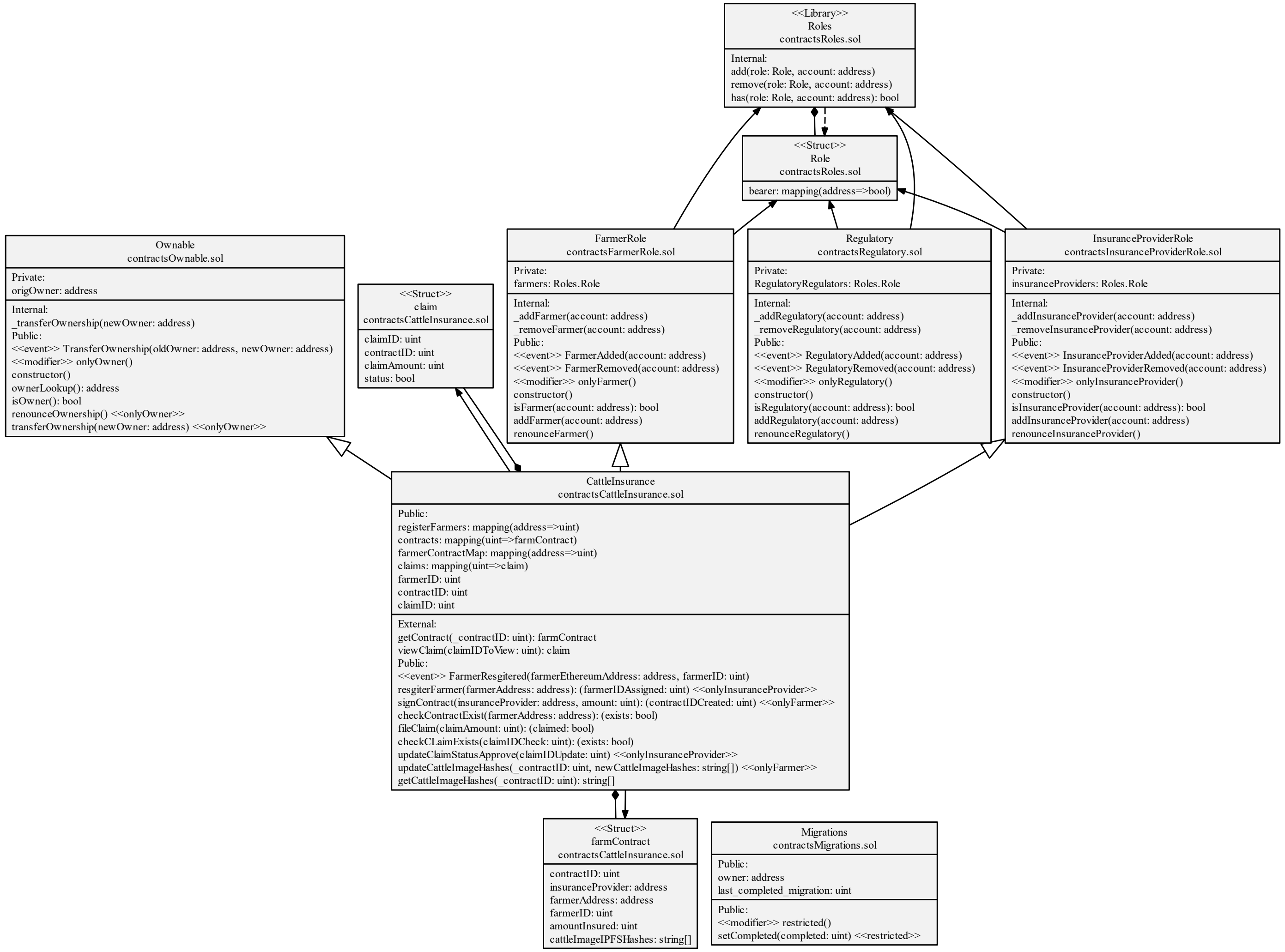


Dataset: Y. Xiong, G. Li, and G. Erickson. (2022) Beef cattle muzzle/noseprint database for individual identification. Last Accessed: 2023-08-10. [Online]. Available: https://zenodo.org/records/6324361

Implementation

- Smart contract design:
  - Solidity language used for implementing smart contracts in the Ethereum platform
  - Role Based Access Control (RBAC) Mechanism is employed using smart contracts.
  - Each stakeholder will be assigned to a role and modifiers are defined to control the access to different insurance functions
  - Factory contract design pattern is used for creating and deploying cattle insurance policy smart contracts.

Implementation



Implementation

- Blockchain Network:
  - Local development environment Ganache.
  - 10 free accounts with 100 test ETH.
  - Truffle development suite to design the decentralized App.
  - Testing is done using the node assertion library Chai.
- Distributed Data Storage:
  - Inter-Planetary File System (IPFS) I used for storage of cattle muzzle images.
  - Infura API to interact with the off-chain storage.

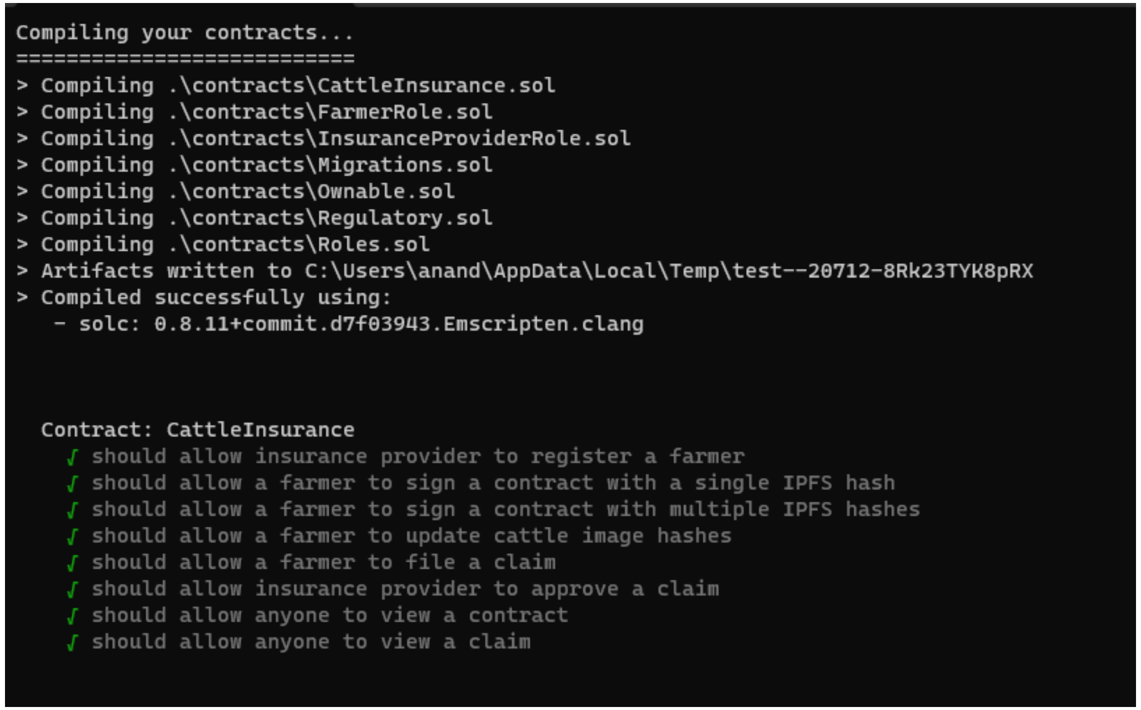
Implementation

- CNN Architectural details:

Layer	Type	Filters	Output Shape
1	Rescaling	-	(180,180,3)
2	Conv2D	16	(180,180,16)
3	MaxPooling2D	-	(90,90,16)
4	Conv2D	32	(90,90,32)
5	MaxPooling2D	-	(45,45,32)
6	Conv2D	64	(45,45,64)
7	MaxPooling2D	-	(22,22,64)
9	Dense	128	(128,)
10	Dense	268	(268,)

Results

- Functional Validation
  - Test cases are designed for maximum code coverage using chai assertions.
  - Along with insurance functions, access control is also tested.



Results

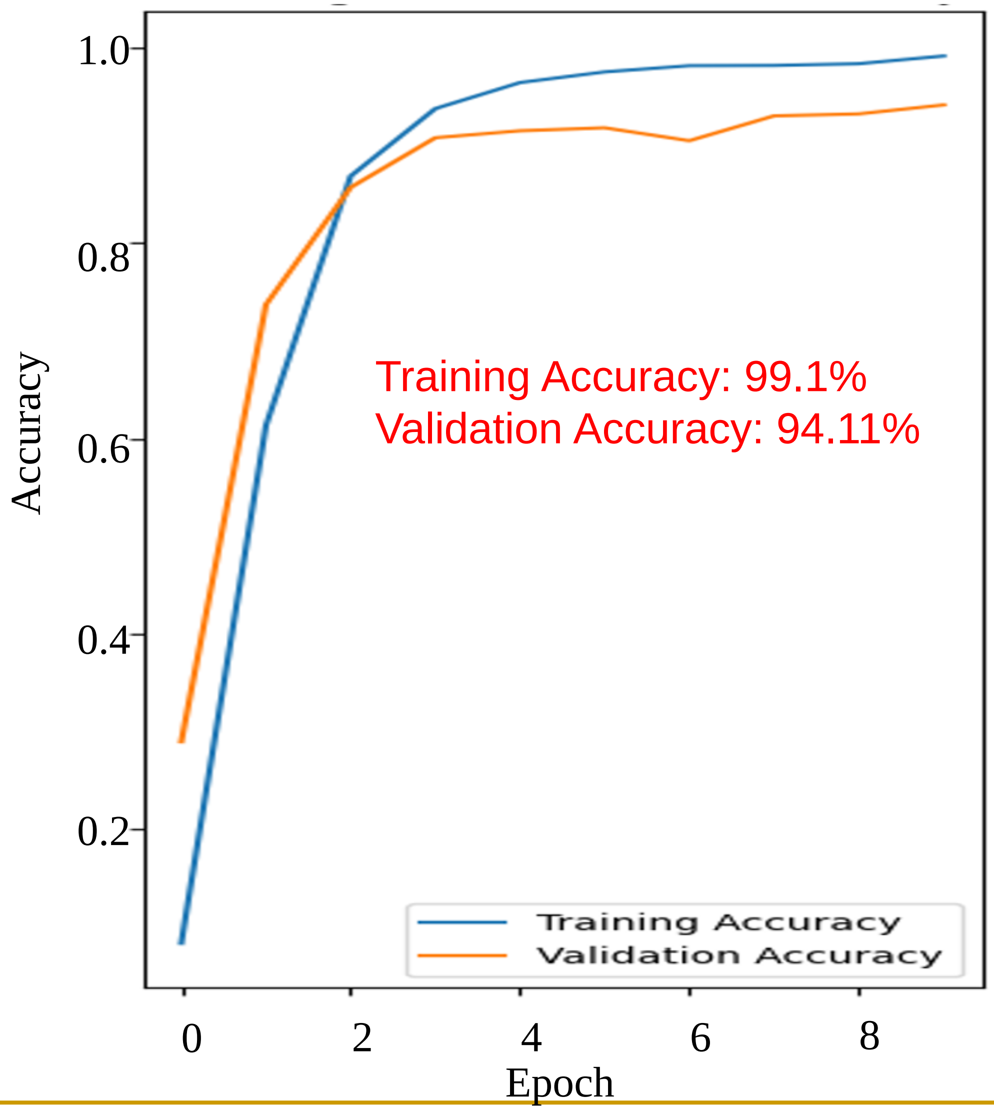
- CNN model performance is measured using validation accuracy and loss metrics.
- Let the number of validation samples be given as $N_{correct}$ and the total number of samples N_{val}. The Validation Accuracy can be calculated as follows:

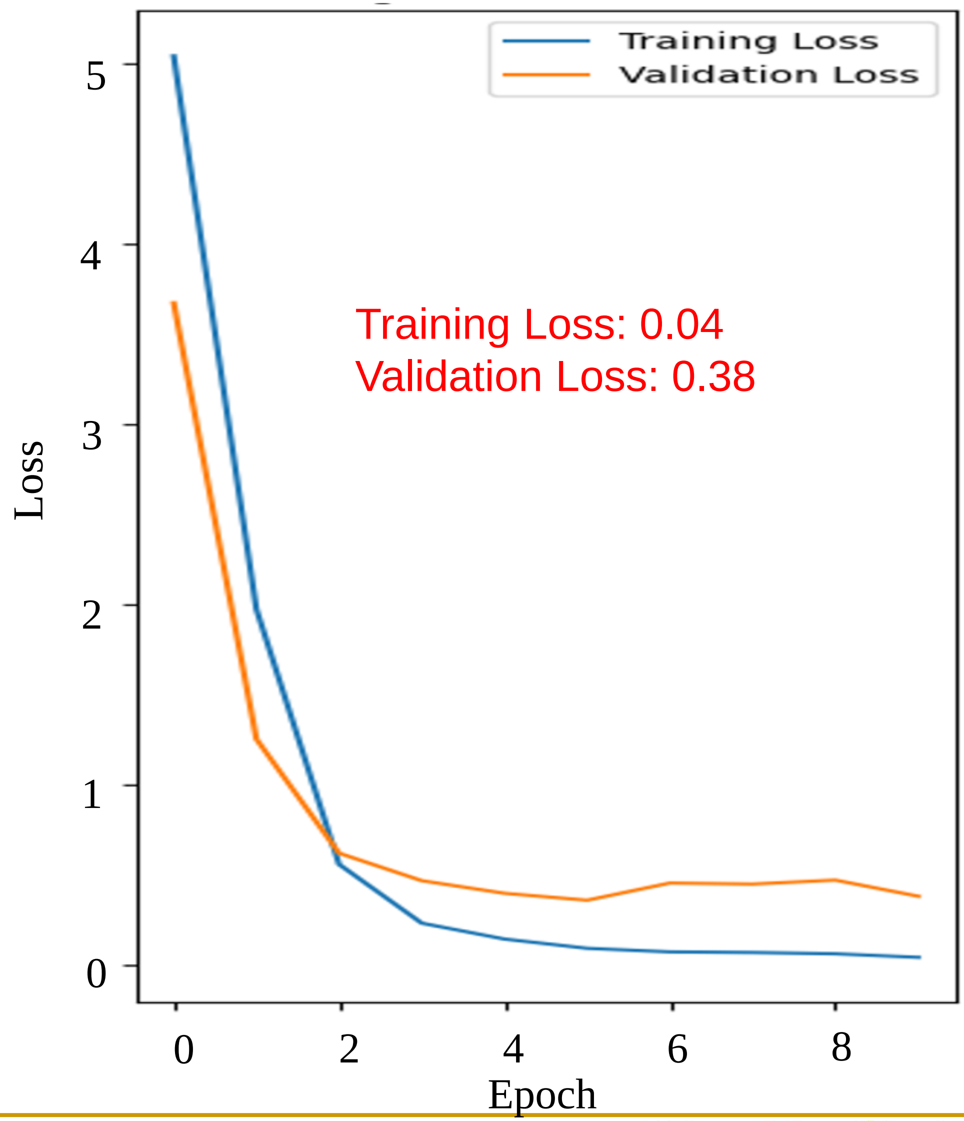
$$Validation\ Accuracy = \frac{N_{correct}}{N_{val}}$$

- For the validation dataset of size N_{val}, y_{true} represents the true target value, y_{pred} predicted the target value and $L(y_{true}, y_{pred})$ is the loss function computed as:

$$Validation\ Loss = \frac{\sum_{i=1}^{N_{val}} L(ytru_{ei}, yp_{redi})}{N_{val}}$$

Results


Training Accuracy: 99.1%
Validation Accuracy: 94.11%
Training Accuracy
Validation Accuracy
Accuracy
Epoch
1.0
0.8
0.6
0.4
0.2
0
2
4
6
8


Training Loss: 0.04
Validation Loss: 0.38
Training Loss
Validation Loss
Loss
Epoch
5
4
3
2
1
0
0
2
4
6
8

Conclusions

- A Novel cattle insurance management system SmartInsure is proposed to solve the security and latency of IMS.
- Deep learning-based approach for cattle identification using muzzle images to avoid falsified insurance claims.
- Role-Based Access Control Mechanism is implemented for manager role-specific functions.
- Implemented DApp is tested for functionality.
- The deep learning model is analyzed with validation accuracy and loss metrics.
- Performance of the implemented CNN model is measured using validation accuracy and loss with acceptable values of 94.11% and 0.38.

Future Work

- More complex interactions will be included in the designed Dapp.
- More tamper-proof identification mechanisms will be explored instead of muzzle images.
- A responsive user-friendly interface with multiple views with role-specific functions.

Thank You !!