Artificial Intelligence in Blockchain for Coastal Area Calamity Property Insurance

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1.0 General Introduction

1.0 Introduction

As a natural pattern in the creation and growth mechanism of earth's civilizations, human settlements tend to be concentrated in coastal areas, owing to the economic benefits that are inherent due to the abundance of niche resources such as coastal fisheries, ocean navigation, tourism and recreation. The rapidly improving connectivity and transportation facility is a factor which has further enhanced the population of coastal areas.

Even though the exact coastline length cannot be measured, the approximate total length of coastlines in the world is roughly 312,000 kilometers, which goes to show the huge amount of resources and population that coastal areas can sustain. Currently, about 40% of the world's population lives within 100 kilometers of the coast **[1]**. At present about 1.2 billion people live in coastal areas globally. Also, this number is predicted to increase to 1.8–5.2 billion by the 2080s due to a combination of population growth and coastal migration **[2].**

However, with close proximity to the sea and ever-changing surface-pressure, tidal and wind conditions, a natural calamity- be it cyclones, hurricanes, tropical storms, tsunamis or floods is fairly common. The most common out of these are tropical cyclones, which are a huge threat to lives and property because of their turbulent winds, associated storm surge, incessant rain and flooding, and the tendency to fuel tornadoes. Tropical cyclones pose a major risk to societies worldwide with about 22 million directly-affected people and damages of $29 billion on average per year over the last 20 years **[3].** Cyclones are amongst the most destructive and rampaging natural disasters that can possibly occur. They have been responsible for about 1.9 million deaths worldwide over the last two centuries, and it is estimated that 10,000 people are killed each year by these storms **[4].** Usually, cyclones tend to do the most damage in coastal areas, thereby perpetually putting its people and their property at risk.

The frequent destruction of property and incurred financial losses due to the same, calls for a mechanism to reclaim the lost money from an insurance provider i.e. there is a strong need to have a safe, reliable, time-efficient and user-friendly coastal calamity property insurance system. Most traditional property insurance policies, however, do not provide for swift and practically time-efficient claim settlement in cases of loss due to natural calamities, i.e. such policies typically only cover damage or loss of personal possessions due to named perils like fire or theft. Homes and other property in coastal areas need a different coverage unlike those which most homeowners' policies provide. This can be solved by purchasing insurance which is specific to a particular calamity such as cyclone-insurance or flood-insurance and the likes. But, there are several problems associated with conventional insurance.

1.1 Statement of the Problem with Traditional property Insurance policy purchase and Claim settlement

1. Large number of Insurance companies dominate the market and reap the benefits
2. Common man does not understand the rules, clauses and technicalities of policies
3. Due to different reasons, Insurance companies do not pay the claims
4. During calamity, FIR should be lodged at a Police Station for claim settlement
5. There is lack of trust and transparency with Insurance companies
6. Delay in application for claim settlement due to accident, injury, state of shock etc..
7. Conflict of information between Insurance company and proposer
8. Lot of paper work and documents are needed to be submitted which may be misused
9. The cost of Property calamity Insurance premium is very high due the involvement of many parties such as Managers, Service Providers, Police Verification, Engineers for damaged cost estimation, Weather Data providers, Media Reports etc.

1.2 Aim and Objectives of the Study

This cost can be reduced dramatically with the right use of technology – **Integration of Blockchain with Artificial Intelligence**. This technology helps automated real-time data collection and analysis, and can help process the claims at faster and cheaper rates than at present. This can reduce confusion and increase transparency. As per Don and Alex Tapscott, the authors of the book "Blockchain Revolution", Blockchain is *"an incorruptible digital ledger of economic transactions that can be programmed to record not just financial transactions but virtually everything of value".* This technology, when combined with Artificial Intelligence, can significantly improve the speed and efficiency with which the coastal area calamity property insurance claim settlement system works and simultaneously enable decentralization of the system.

1.3 Background of the study

Use of Blockchain in Coastal Calamity Property Insurance

Blockchain is a distributed digital ledger in which transactions and records can be verified, signed and exchanged without the control of a central authority. Due to its immutable nature, in this system, the recorded information is very secure, transparent, difficult to alter, hack or cheat. As Blockchain utilizes advanced cryptographic techniques to produce a secure ledger of information, it prevents the unauthorized modification, addition or removal of data. Application of distributed ledger also provides a choice for secure collaboration between competitors by eliminating the requirement of faith between third party organizations. This allows parties to share documents, contracts and records without having physical possession of copies or relying on paper or intermediaries. One can store the documents on the blockchain by storing document's hash on-chain while keeping the whole document elsewhere. The document could be stored on a distributed file storage system or in a centralized database. One would put the document through a secure hash algorithm like SHA-256 and then store the hash in a block so that huge amount of space and cost can be saved. It also helps to know whether someone tampers with the original document. The change in input would result in a completely new hash value, different from original document.

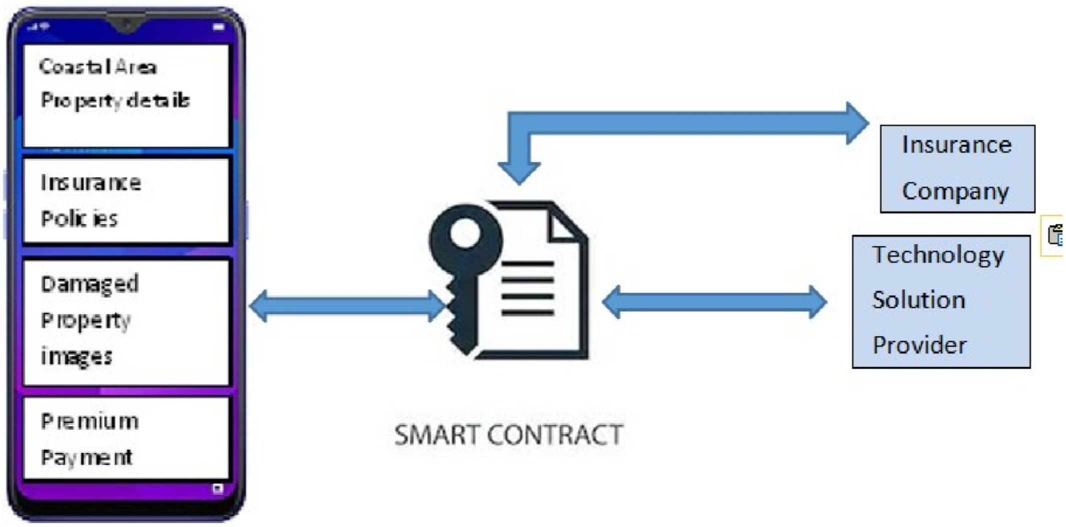
Use of Artificial Intelligence in Coastal Calamity Property Insurance

Artificial intelligence (AI) is a technology which entitles computer systems to achieve tasks that typically require a human's intelligent behavior. In the insurance industry, AI is can rebuild the areas such as underwriting, customer service, claim settlement, fraud detection , marketing transactions, chat bots, predictions using neural networks and to provide better, faster and cheaper services to customers. AI can make insurers more efficient. Customers can be serviced and contacted at a higher volume and higher speed, saving insurers money and creating happier customers. There will be no hassle of filing out claim forms or speaking to a service assistant during calamity. The claim processing speed can be improved by automating decision making processes and getting customers the money they need.

1.4 Methodology of Study

1. Provide a secured and an easy to use interface for coastal calamity property insurance through a mobile app or through a website
2. Using integration of Blockchain and Artificial Intelligence technology for secured and fast and cost effective claim settlement
3. The stakeholders involved in the coastal calamity property insurance are: Coastal Area people, Insurance Companies & Weather Data Providers, Technology solution providers-Blockchain and Artificial Intelligence.

1.5 Conceptual Model



1.6 Scope of Study

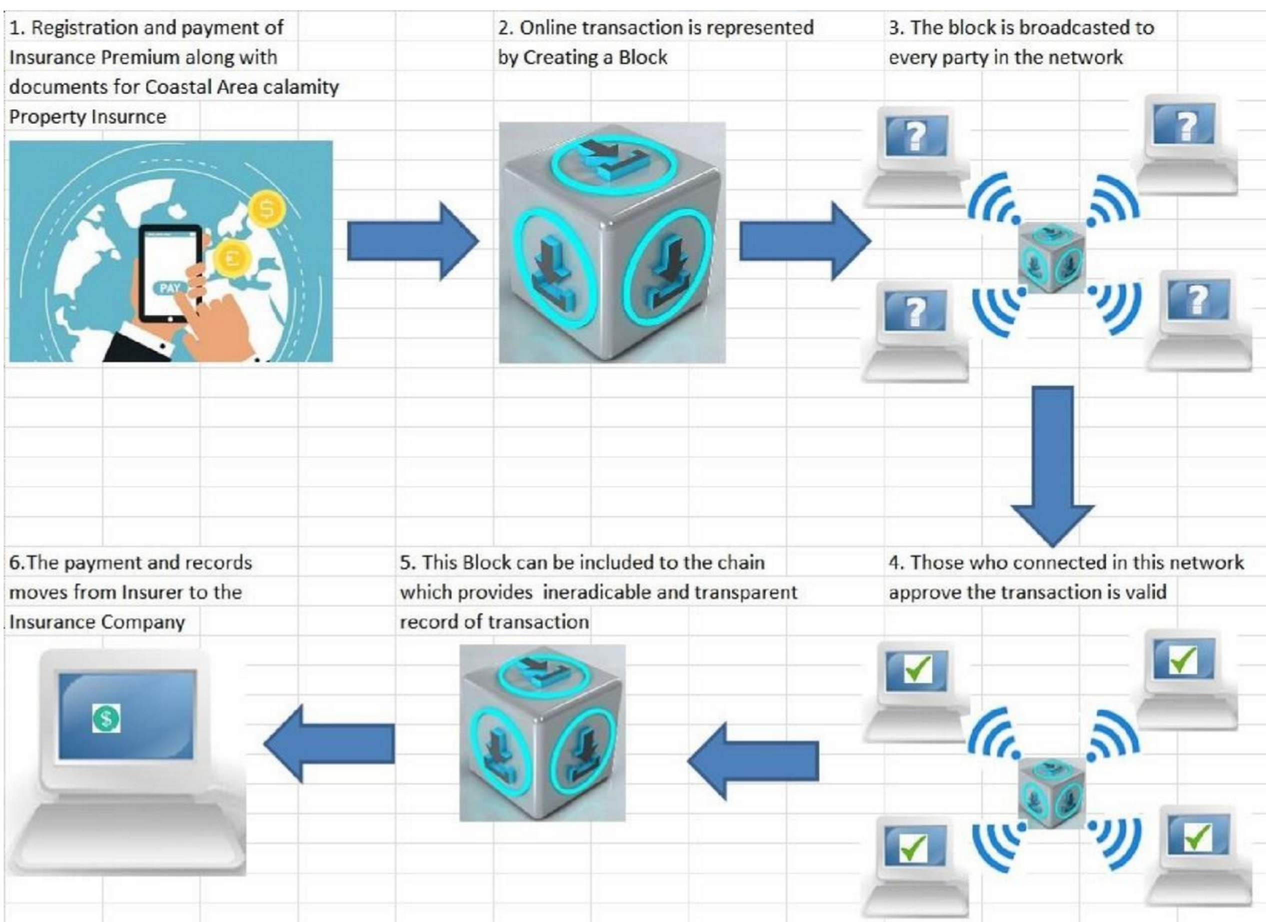
The main purpose of the study is to shield coastal area property losses from cyclones, hurricanes and floods during natural calamities and to provide a highly secure, cost-effective and quick liability protection to people through a decentralized process. This can be achieved by the integration of Artificial Intelligence with Blockchain technology. The solution uses the best features of both the technologies to provide ease-of-use while maintaining the security of the environment of the interface. The deployment of blockchain helps in effectively minimizing bugs and fraudulent datasets. Different classifiers and patterns generated by AI can be authenticated using decentralized blockchain infrastructure.

Blockchain-AI integration helps to deal with data and value. Blockchain ensures secure storage and sharing of valuable data. AI can explore and produce insights from data to generate value. Blockchain helps encrypted storage of data on a distributed ledger. Organizations can build better models by integrating Blockchainbased AI algorithms and smart contracts. Since Smart contracts provide speed, accuracy, transparency, security, and efficiency, they can be implemented in the insurance Industry. Insurers will be able to reduce administrative and claims processing costs, automate their policies and services, increase transparency, prevent fraud and can increase claim processing speed. Artificial intelligence can create computer programs that can solve problems and achieve goals like humans would. The most important benefit AI brings to insurance is better coverage. AI will be able to analyze emerging and existing risks in a more efficient fashion, compute damaged property cost, reduce processing time and cost and quick tracking of claims.

The fraudulent claims in the process can be identified by capturing patterns and traits that are almost invisible to human eyes. Fast and efficient customer service can be achieved through AI powered chatbots. Hence, there is a huge scope of integration of AI and blockchain in coastal area calamity property insurance.

1.7 Mathematical Methodology

A Blockchain is a distributed ledger holding information about transactions. Each transaction generates a hash. A hash is a function that converts an input of letters and numbers into a fixed length of encrypted output. Every block take reference from the previous block and together make the Blockchain. A Blockchain is very effective as it is scatter over many computers, each of which have a copy of the Blockchain. Through the mining process, miners create new blocks on the chain. By taking has reference of previous block in the chain every block has its own unique nonce and hash. On large chains, mining a block isn't easy. Any new transaction or record within the blockchain inferred the building of a new block. Each transaction is then proven and digitally signed to ensure its authenticity. It should be verified by the majority of nodes in the system before this block is added to the network. This has been illustrated as below.



The main blockchain architecture components are Node, Transaction, Block, Chain, Miners and Consensus Protocol. Each block consists of certain data, the hash of the block and the hash from the previous block.) Every block hash is generated through a cryptographic hash algorithm (SHA 256). A hash contains some letters and digits and works like a fingerprint. The instant a block is created, it automatically attaches a hash, and any changes made in a block affect the change of a hash too. Hashes help to detect any changes in blocks.

Every new user (node) joining the peer-to-peer network of blockchain receives a full copy of the system. A block is sent to each node once a new block is created within the blockchain system. Then, each node scrutinize the block and verifies whether the information stated there is correct. If everything is correct, the block is added to the local blockchain in each node.

A consensus protocol is created at all the nodes inside the blockchain. A consensus is fault to lerant mechanism which has set of network rules, and if everyone abides by them, it would get enforced itself inside the blockchain.

Generation of hash [6]

The processes and implementation of this secure hash algorithm are highlighted here.

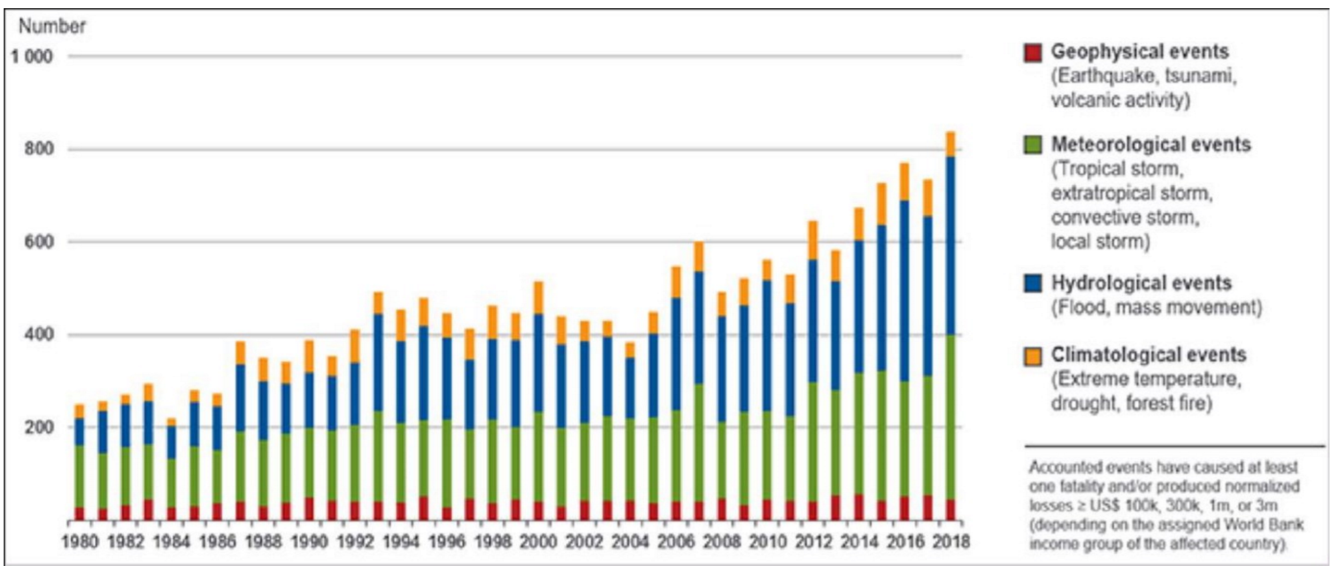
1: Takes input text and splits it into an array of the characters' ASCII codes.
2: Converts ASCII codes to binary.
3: Pad zeros to the front of each bit until they are 8 bits long.
4: Join them together and append them to one (1).
5: Pad the binary message with zeros until its length is 512 mod 448.
6: Take binary 8-bit ASCII code array from step 3 and get its length in binary.
7: Pad with zeros until it is 64 characters.
8: Append to your previously created binary message from step 5.
9: Break the message into an array of chunks of 512 characters.
10: Break each chunk into subarray of sixteen 32-bit words.
11: Loop through each chunk array of sixteen 32-bit words and extend each array to 80 words using bitwise operations.
12: Initialize some variables.
13: Looping through each chunk: bitwise operations and variable reassignment.
14: Convert each of the five resulting variables to hexadecimal.
15: Append them together and the result is your hash value or message digest.

1.8 Significance of Study

Currently, about 40% of the world's population lives within 100 kilometers of the coast **[1].** At present about 1.2 billion people live in coastal areas globally. Also, this number is predicted to increase to 1.8–5.2 billion by the 2080s due to a combination of population growth and coastal migration **[2]**. The threats to coastal communities include extreme natural disasters such as cyclones, tsunamis, hurricanes, coastal storms, and landslides, and longer-term risks of coastal erosion and sea level rise. The most frequent natural disaster are floods. As per Munich Re **[5]** the overall losses from world-wide natural catastrophes are stated below.

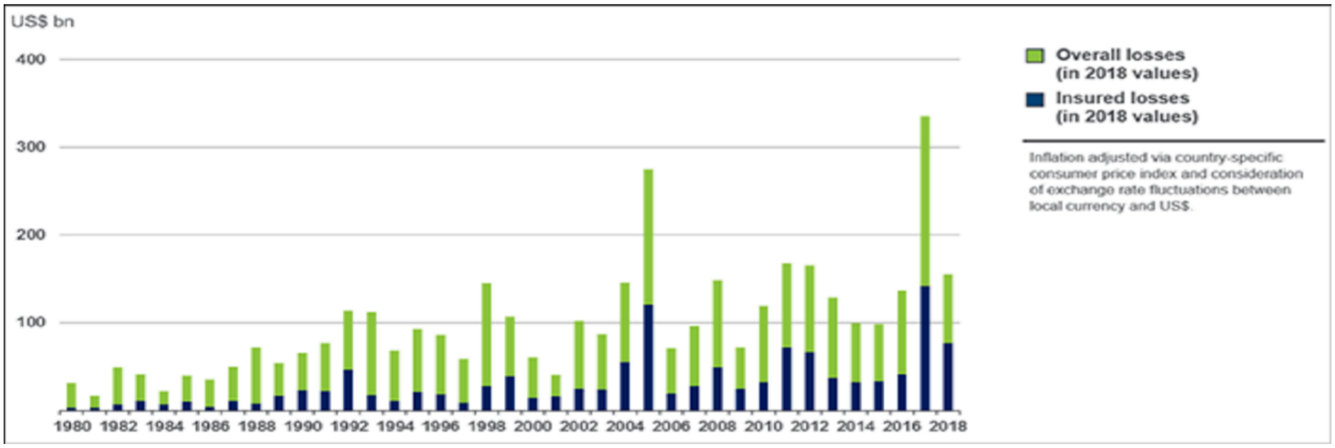
Number of World Natural Catastrophes, 1980-2018[5]

(Number of relevant events by peril)



Source: © 2019 Munich Re, Geo Risks Research, NatCatSERVICE. As of March 2019.

World Weather-Related Natural Catastrophes By Overall And Insured Losses, 1980-2018 [5]



Source: © 2019 Munich Re, Geo Risks Research, NatCatSERVICE. As of March 2019.

After studying the above statistics, the role of insurance becomes ever more important to the residents of coastal areas to protect their financial losses. The role of blockchain insurance is significant as it reduces the administrative cost through automated verification of claims/payments. Insurance companies can quickly view past claims and transactions registered on blockchain for easy reference. This encourages higher degrees of trust and loyalty between the insurer and customer.

1.9 Definition of Terms

AI –Artificial Intelligence

ASCII - American Standard Code for Information Interchange.

Blockchain: A distributed database and shared ledger that maintains continuous growing list of records (blocks) in a chronological order" (The Institutes, 2017)

Ethereum – A blockchain platform that allows different protocols to be merged together and improve its functionalities using programming and thus creating consensus-based applications that offer more possibilities of storing and using the blockchain technology (Buterin, 2014, p. 13).

Hashing - Hashing is the process by which a grouping of digital data is converted into a single number, called a hash (Norton Rose Fulbright, 2016).

Mining –“the act of contributing computing power to the network” (Benton & Radziwill, 2017, p. 39)

Smart contract –“an agreement in digital form that is self-executing and selfenforcing” (Werbach & Cornell, 2017, p.320), “A computer program which verifies and executes its terms upon the occurrence of predetermined events” (Giancaspro, 2017). “Uses the blockchain publishing platform to run computations which determine how financial assets are managed” (Davis, 2014).

Node – Devices like servers or computers connected to each other within the blockchain architecture.

Block – It is like a page of a ledger or record used for keeping a set of transactions which is distributed to all nodes in the network.

Transaction - A transaction is a transfer of value that is broadcast to the network and collected into blocks.

Chain - a sequence of blocks in a specific order

Miners – Who solve a cryptographic puzzle through a guess-and-check method in order to find the proper cryptographic hash for the block. Miners typically need large rigs of reliable, application-specific hardware to actually have a decent chance at being the first to verify and secure the block.

Consensus (consensus protocol) - a set of rules and arrangements to carry out blockchain operations

2.0 Literature Review

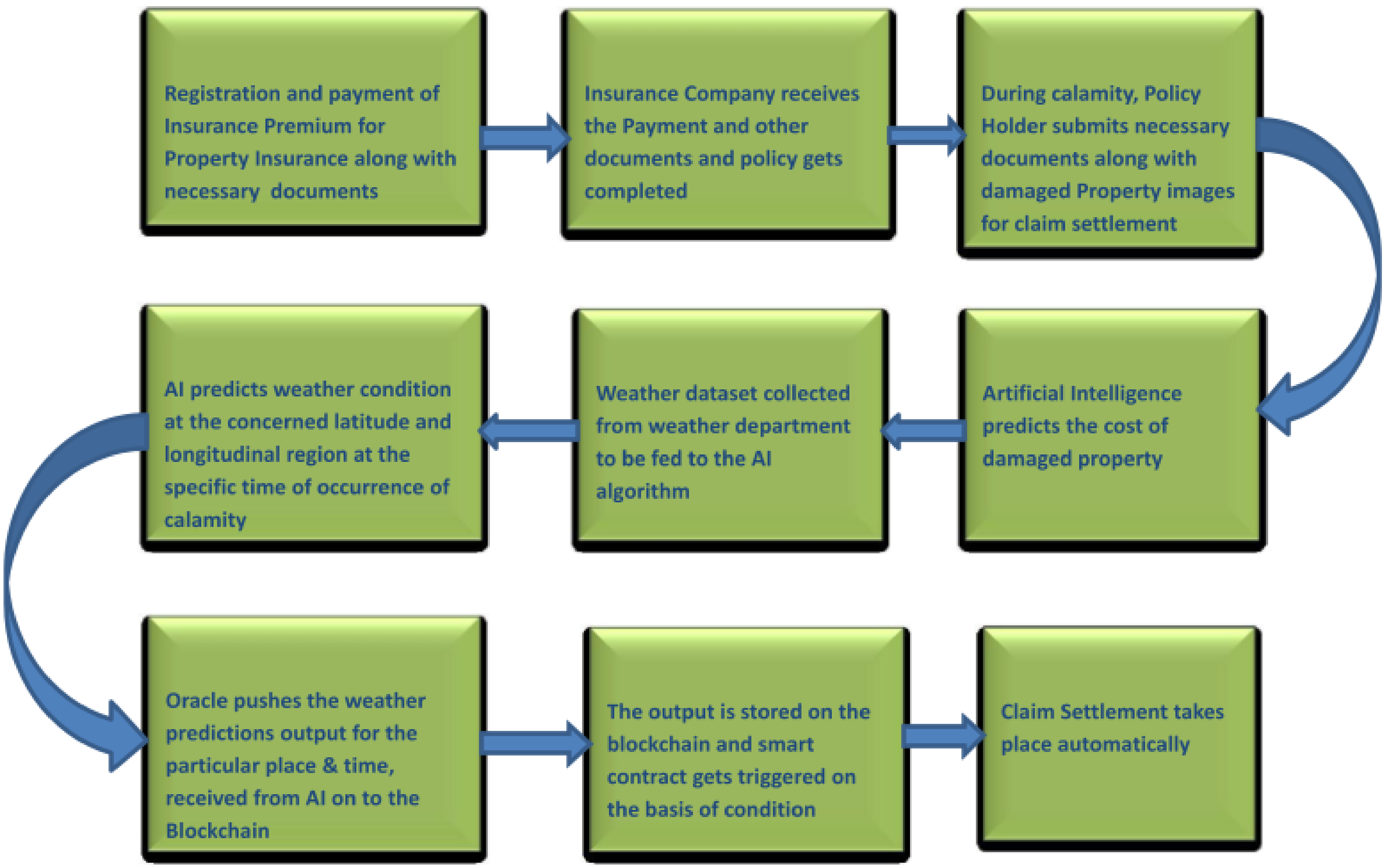
2.1 Related work

In contrast to my work, pertaining to the specific use case of the integration of Blockchain and AI in the domain of coastal-area calamity property insurance, prior research papers on Blockchain address only either technical issues such as security, consensus protocols or stick to either AI or blockchain.

3.0 Methodology and Model

3.1 Methodology and System-Architecture

Conceptual Working Model Design



3.2 Detailed Analysis of the model

Registration and payment of premium for property insurance with documents– Data concerning the individual and their property procured during registration and policy data is set up with a smart contract of a blockchain network, in effect making it immutable and enabling a secure mode of data storage. All the data fed is securely stored using hash encryption, characteristic of a blockchain setup, with minimal interference by the insurance provider. Payment of premium dues are completed through the blockchain network since it provides for a safe gateway for transfer of money.

The details filled in by the proposer like - duly filled in claim form, plan of the property, Bills/receipts, KYC documents, their account details in the blockchain network are taken into the blockchain and stored in a block by a smart contract. Nodes check if the message was actually sent by the proposer and if so, the transaction gets added to a block (which also contains other transactions occurred in the same time frame). The nodes have to resolve a complex mathematical problem (mining) in order to add the new block to the blockchain.

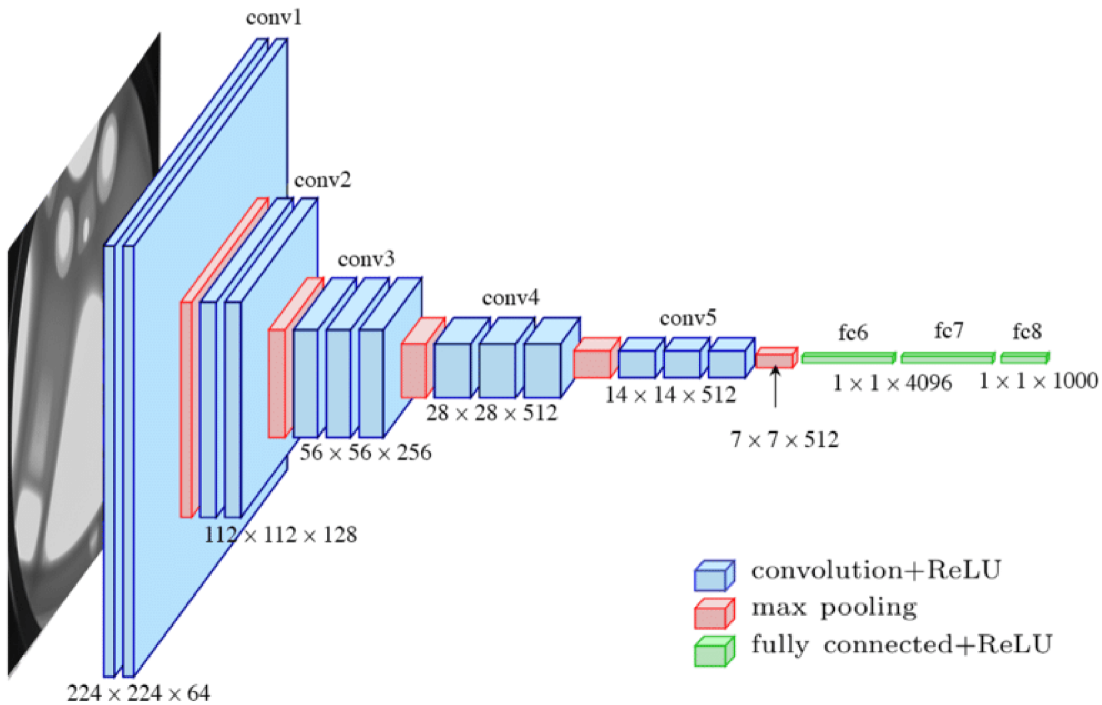
Insurance company receives the payment and the policy is completed –The policy bond along with proof of transaction of documents is stored on local copies of the blockchain network and cannot be tampered by any party. Also, the documents and policy details can be accessed during claim settlement or any stage of insurance claiming process by triggering a smart contract.

During calamity, Policy Holder submits necessary documents along with damaged Property images for claim settlement

Post-calamity, the policy holder can demand settlement of claim by providing minimal details of the calamity like the exact location of the damaged property, the time of occurrence of the calamity and a few images of the damaged property along with policy bond. The rest of the documents and information required for verifying the person demanding the claim settlement can be obtained from the data stored in the blockchain network during policy registration.

Artificial Intelligence predicts the cost of damaged property – During natural calamity, manual inspection of damaged property for claim processing is not scalable as it involves many parties such as engineers, police, media etc. which increase the cost of insurance. Damaged house roof inspection, taking measurement, estimating damage manually is time-consuming and dangerous task. Automatic assessment of the damages through image analysis is much faster, economical and accurate and it will become even better as they collect more & more data for each use case. The cost of the damaged property can be predicted by using Deep learning ML model. This would eliminate the role of additional parties for cost quotation and decentralize the process. The property images uploaded by the policyholder are preprocessed and it is ensured that the quality of images uploaded is sufficient for the ML model setup to work on. The damaged property (House, Cars etc.) prediction is done by AI using deep learning techniques. The deep learning model requires a supreme-quality dataset containing a large number of images. Deep learning models work more accurately and efficiently with larger and balanced datasets .The model performance can be improved further by applying data augmentation process. Once the image dataset is obtained after filtering and cleaning data to only retain non redundant and genuine image data, it must be preprocessed to ensure the ability to deploy the model smoothly. This can be achieved by using VGG16 – Convolutional Network for Classification and Detection.

Mathematical model of VGG 16 Convolutional Network for Classification and Detection [46]



The architecture of VGG-16 — Image from Researchgate.net [46]

1. **Input Layer:** As an input **i**t receives colourful images with the size 224 x 224 and 3 channels i.e. Red, Green, and Blue.
2. **Convolution Layer:** The images pass across a stack of convolution layers where each convolution filter contains a very small receptive field of 3 x 3 and stride of 1. In order to maintain the same resolution and the size of input and output feature of maps each convolution kernel uses row and column padding.
3. **Max pooling:** It is executed over a max-pool window which is a non-overlapping window of size 2 x 2 with stride equals to 2
4. Each convolution layer is not followed by a max pool layer. Sometimes a convolution layer is succeeding another convolution layer without the max-pool layer in between.
5. There are 4096 channels each in the first two fully connected layers and 1000 channels in the third fully connected layer(output layer), one for each category of images in the imagenet database.
6. The hidden layers contains ReLU as their activation function.

4.0 Cyclone, Rainfall, Flood, Weather Forecasting using Machine Learning

4.1.0 What is Machine Learning ?

Machine learning is implementation of artificial intelligence (AI) that enables a system to instinctively learn from experience without being precisely programmed. Machine learning concentrates on the development of computer programs that can access data and uses it for improvement.

The process of learning starts with observing the data which we provide such as examples, records, instructions, direct experiences etc., in order to glance patterns in data and make greater conclusions in the future, based on the specimen that we provide. The principal objective is to authorize the computers without any human intervention to study automatically and adjust actions accordingly.

The actual process of machine learning methods can be outlined as (i) Explains a statement to an unknown mapping f and set a hypothetical set H of the solving model. (ii) Assemble and arrange a training set K with a finite set. (iii) Define the loss function for the model. (iv) Choose the learning algorithm P. (v) Get the variables that make the loss function fetch the pole hour and select them as the optimal variables of the model. (vi) Store this trained model m with the optimal variables, and utilize it to make forecast and analysis of new data.

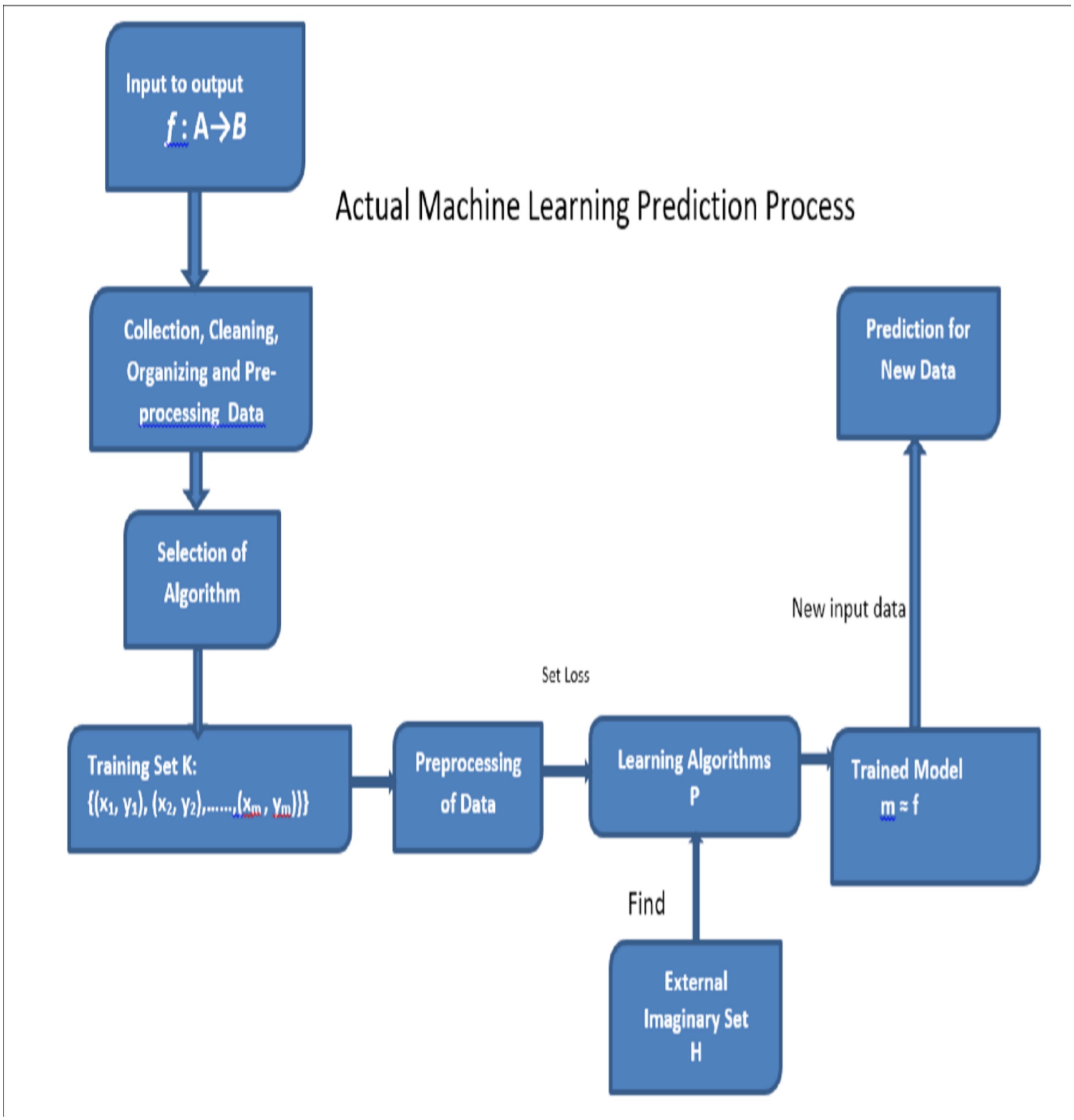
Machine learning algorithms can be classified into 3 broad categories — supervised learning, unsupervised learning, and reinforcement learning. It can also be divided into many categories according to the learning tasks, such as prediction, feature selection, and dimensionality reduction. Since this analysis focuses on Cyclone forecast modeling, only predictive algorithms will be narrated here. If the aim of the model is to predict discrete values, this kind of learning task is called “classification”; if it is to predict continuous values instead, this learning task is called “regression”.

4.1.1 Actual Machine Learning Prediction Process

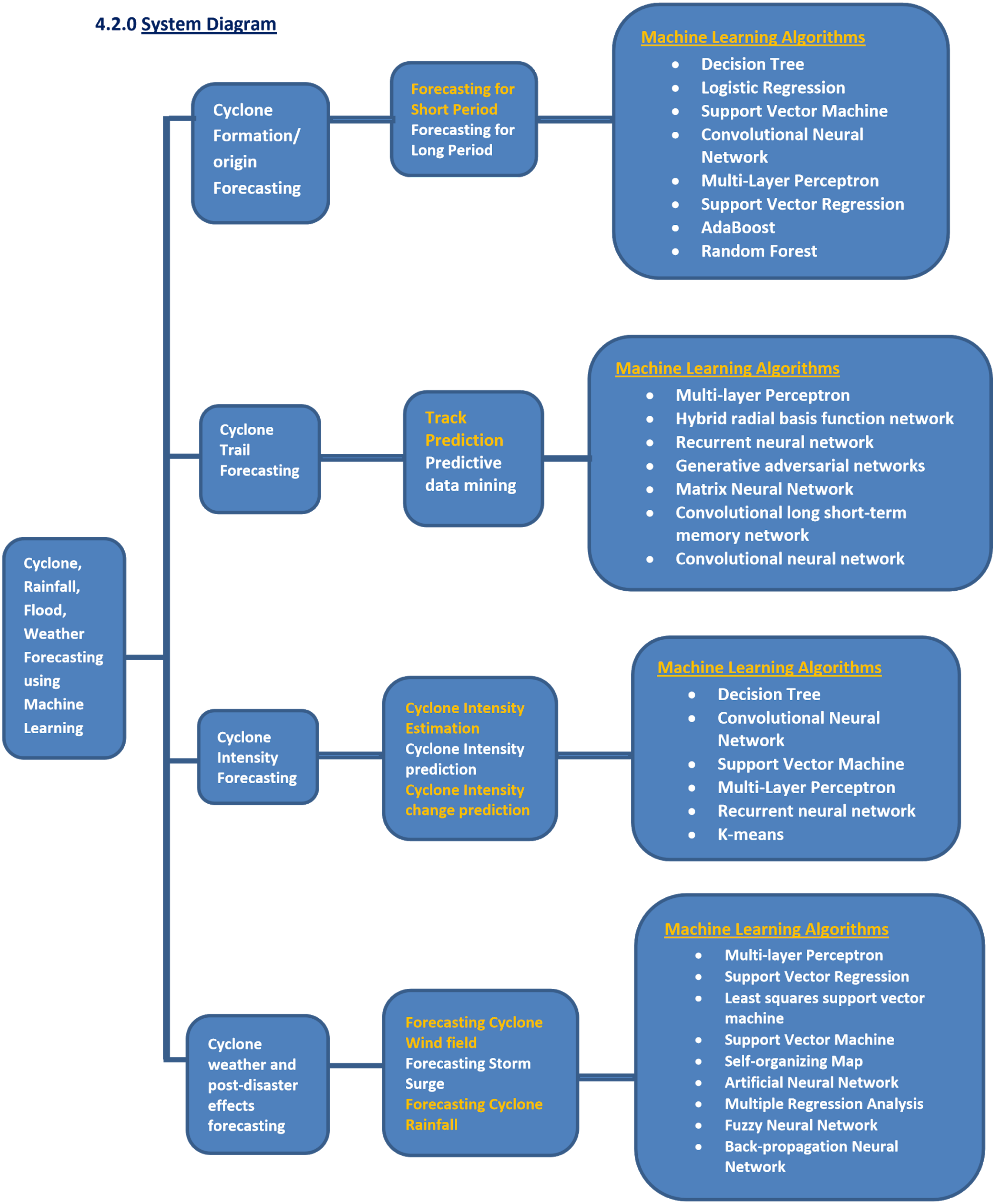
For predicting the cyclone, Machine Learning’s “Classification” and “Regression” methods are used to predict discrete values and continuous values respectively. The objective of the prediction task is to set up a mapping f from the input space A to the output space B, $f: A \rightarrow B$, and f depends on a vector of nonlinear parameters, c: $b=f(a, c)$. The parameters c are collected during training, which, for the classification or regression/mapping problem, is an optimization of the performance criterion (e.g., a minimization of the mean square error).

4.1.2. Input to Output Interface diagram

Problem Statement



4.2.0 System Diagram



4.2.1 Cyclone Formation/ Origin Forecasting

4.2.1a Cyclone/ Rainfall Formation Forecasting for Short Period

- Decision Tree - Future & cause of Cyclone, based on disturbance & Satellite Data, can be predicted **[7]**
- Logistic Regression- cyclonic circulation in the atmosphere based on tropical perturbation can be predicted **[7]**
- Support Vector Machine-Cyclone can be predicted from satellite image Data **[8]**
- Convolutional Neural Network- Cyclones can be detected on the basis of Simulation of Numerical Models **[9]**
- Random Forest- Thunderstorms can be predicted **[10]**

4.2.1b Cyclone/ Rainfall Formation Forecasting for Long Period

- Support Vector Regression - Produce Forecasts for upcoming season and Reduce errors in prediction **[11]**
- Multi-layer Perceptron- Seasonal Prediction **[12]**
- Self-organizing Map & Fuzzy neural network - Define Genesis potential index for Global Climate Models **[13]**

4.3.0 Cyclone Trail Forecasting

4.3.1a Cyclone Track Prediction

- Multi-layer Perceptron- Predict cyclone tracks **[14]**
- Hybrid radial basis function network- An integrated & automatic Cyclone identification and track mining system can be developed **[15]**
- Recurrent neural network- Trajectory prediction **[16]**
- Generative adversarial networks- Cyclone tracks with meteorological data & satellite images can be predicted**[17]**
- Matrix Neural Network - A predictive model that preserves spatial information from the cyclone tracks can be developed **[18]**
- Convolutional long short-term memory network- To track and predict Cyclone trajectories a spatio-temporal model can be proposed **[19]**
- Convolutional neural network- Cyclone tracks can be predicted **[20]**

4.3.1b Predictive Data Mining

- 🎬 Decision Tree - Discover predictors and rules governing cyclone landfall and re curvature **[21]**

4.4.0 Cyclone Intensity Forecasting

4.4.1a Cyclone Intensity Estimation

- Decision tree- Using microwave image data intensity can be estimated **[22]**
- Support vector machine- Cyclone intensity levels can be marked and network architecture can be esigned for categorizing Cyclone, based on intensity. Also cyclone intensity can be estimated from satellite images **[23]**
- Convolutional Neural Network- Cyclone intensity can be estimated as a regression task Employ 2D-CNN and 3D-CNN can be employed to analyze the relationship between cyclone intensity & satellite images obtained **[24]**

4.4.1b Cyclone Intensity prediction

- Multi-layer perceptron- Cyclone intensity values can be directly predicted and different network-based models to identify the best intensity forecasts model can be compared **[25]**
- Recurrent neural network- A pure data-driven intensity prediction model can be designed **[26]**
- Convolutional neural network-Long short-term memory neural network- A space-time model based on a hybrid network of 2D-CNN, 3D-CNN, and LSTM can be designed [27]
- Transfer learning- A robust prediction model with transfer learning and stacking can be developed **[28]**

4.4.1c Cyclone Intensity change prediction

- Evolutionary algorithm & Particle Swarm Optimization- One can predict whether the cyclone will intensify or weaken **[29]**
- Decision tree-Rapid intensification related predictors can be validated and intensity change can be predicted **[30]**
- Recurrent neural network- Rapid intensification prediction can be done **[31]**
- Support vector machine- Storms can be classified as Rapid intensification or Non rapidly intensifying by applying ML techniques **[32]**
- Support vector machine, Artificial neural network, Random forest- Rapid intensification predictability can be quantified using AI **[33]**
- K-means- Cyclone-troughs configurations that are favorable for R can be explored **[34]**

4.5.0 Cyclone weather and post-disaster effects forecasting

4.5.1a Cyclone Wind field Prediction

- Multi-layer Perceptron- Wind velocity simulation mode can be created and cyclone winds from satellite data can be optimized. **[35]**
- Least squares support vector machine - Cyclone's inner core 2D surface wind field structure can be estimated and the wind field inside the cyclone boundary layer can be reproduced. **[36]**

- Support Vector Regression - An authentic surface wind speed prediction technique can be evolved.[37]

4.5.1b Storm Surge Prediction

- Multi-layer Perceptron & Support Vector Regression - Develop a time-dependent storm surge model for quick prediction Predict the peak values of storm surge using the tropical storm parameters [38]
- Back-propagation Neural Network - Quantify the Rapid intensification predictability can be computed using AI [39]
- Artificial Neural Network – A storm surge forecast model and an objective selection procedure can be explained [40]

4.5.1c Cyclone Rainfall Prediction

- Support Vector Regression- Hourly cyclone rainfall and flood can be predicted [41]
- Multi-layer Perceptron - A hybrid neural network model to predict cyclone rainfall can be developed. [42]
- Artificial Neural Network - The total rainfall and the groundwater level can be predicted using ANN model [43]
- Fuzzy Neural Network- Cyclone precipitation prediction strategy can be designed. [44]

4.6.0 Oracle pushes the weather predictions output for the particular place & time, received from AI on to the Blockchain

4.6.1. Role of Oracle in smart contract

Smart contracts are often necessary to have appropriate information from the out-side world to execute the contract or agreement. Here, blockchain oracles play an important role as smart contracts by themselves cannot interact with external sources [45].

An oracle is an intermediate that generates a secure connection between smart contracts and various off-chain resources that they need to function. It behaves as the middle layer between Application Programming Interface (API) and blockchain that interpret information for the blockchain to read. Oracles retrieve and analyze external data for the blockchain and smart contracts through web APIs or market data feeds. So oracle is just an external service which has a smart contract for communicating with users' smart contracts and relaying the data. Oracles play an important role in the networking and execution of a smart contract. Through these oracles, information is screened, verified, and transmitted to the contract. Oracles allow smart contracts to facilitate and operate to their optimum potential. This data is received and sent by oracles in encrypted form. [45].

4.6.2. Work Flow

1) The contract sends a request to an oracle smart contract. For example the data output of the weather prediction for the time and place of the calamity is pushed onto the blockchain by Oracle which now provides easy access of the external AI-generated output to the smart contract.

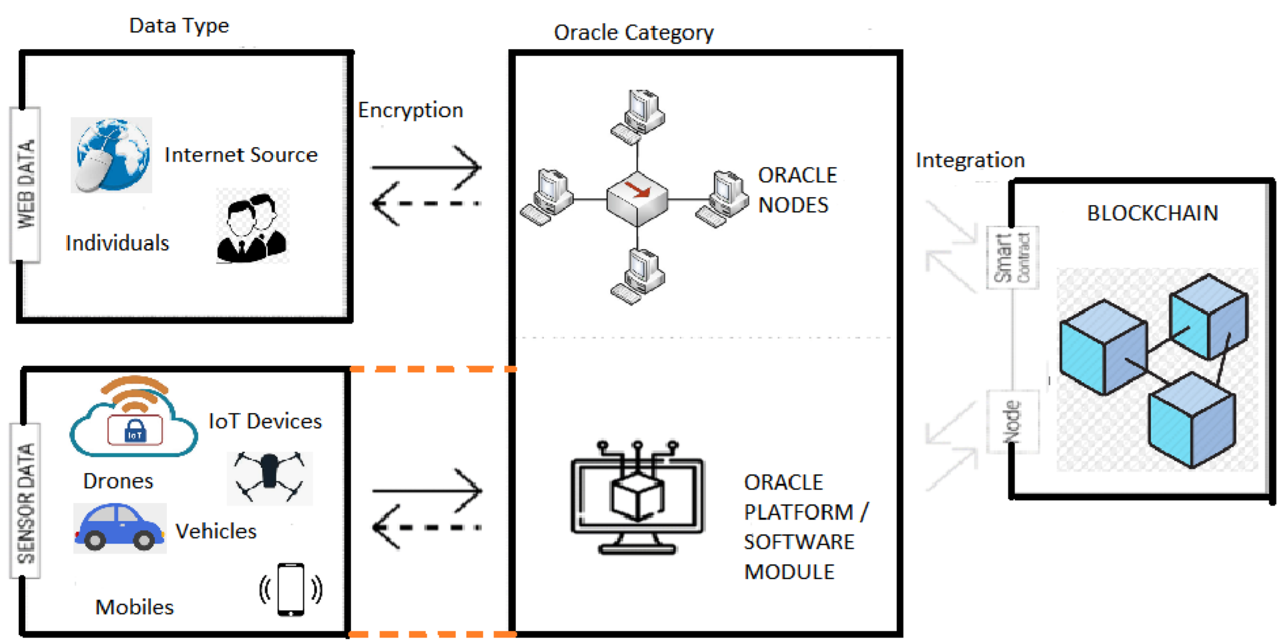
2) The oracle contract catches the attention of the oracle service provider by emitting an event.

3) When the new request for information in the oracle contract is generated, the oracle's backend system notices this.

4) Through Oracle's backend structure the transaction would be sent to the oracle contract with the requested information

5) The oracle contract collects the requested information in the transaction and it either forwards it directly to our contract or our contract has to pull the information from the oracle contract.

GRAPHICAL REPRESENTATION OF BLOCKCHAIN ORACLE FRAMEWORK



4.7.0 The output is stored on the blockchain and smart contract gets triggered on the basis of condition

Output is stored on the blockchain, if (type of calamity at the particular (latitude, longitude) and time == output from AI) {trigger claim settlement smart contract} where the cost of damaged property predicted by AI would be taken as the amount parameter in the smart contract. Smart contract is executed and Claim is settled.

4.8 Implementation

Implementation of Part 1: Uploading documents through blockchain

- As Insurance proposer needs to upload lot of documents on blockchain, an Interplanetary File System (IPFS) which is a peer-to-peer hypermedia protocol, where a collection of hashed files can be stored on each node could be used.
- The insurance company can retrieve any of those documents by simply calling the hash of the file it wants.
- IPFS then carefully searches through nodes and supplies the file.
- An asymmetric encryption platform called "GnuPG" can used to encrypt a file with the public key of the intended recipient so that only that party can decrypt it during retrieval through IPFS.
- Any fraudulent party who retrieves the file from IPFS can’t do anything with it as they can’t decrypt it.

Result for Part I: Visualization

Implementation of Part 2 : Artificial Intelligence predicts the severity of the damaged property so that the cost can be predicted.

1. Validates if the given image is of a house or not (uses VGG16 convolutional neural network models for image classification.)

Result:

```
pipe1('https://raw.githubusercontent.com/Ashreyagit/image/main/mobile.jpg', categ_list)

Ensuring entered picture is a house...

'The entered image is a not a house. Please try again. Consider a different angle or lighting.'
```

```
pipe1('https://raw.githubusercontent.com/Ashreyagit/image/main/65.jpg', categ_list)

Ensuring entered picture is a house...
('n02859443', 'boathouse')

'Successful. Proceeding to damage assessment...'
```

2. Validates that the house is damaged or not

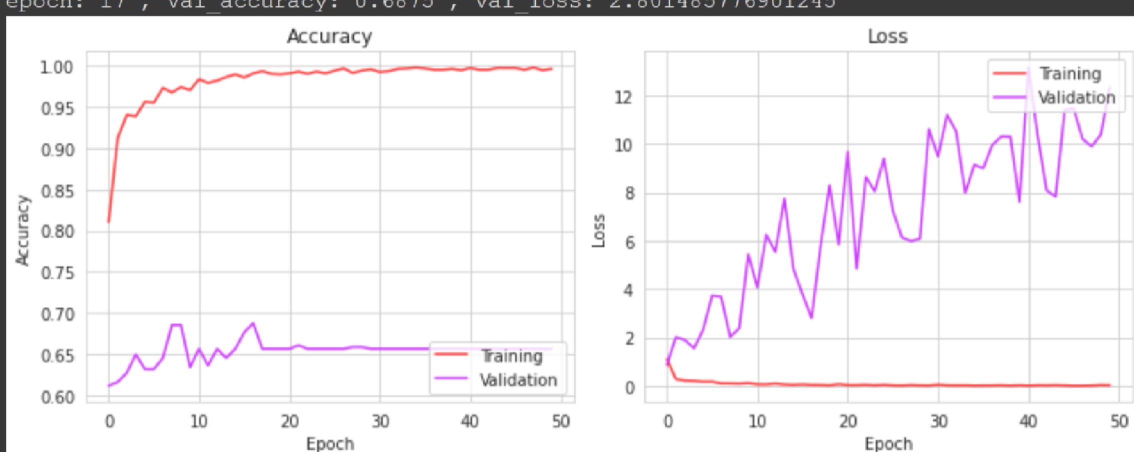
Accuracy of trained model-

```
Epoch 00049: val_accuracy did not improve from 0.68750
Epoch 50/50
114/114 [==============================] - 1s 6ms/step - loss: 0.0439 - accuracy: 0.9961 - val_loss: 12.3318 - val_accuracy: 0.6562

Epoch 00050: val_accuracy did not improve from 0.68750
```

```
plot_metrics(d2_history1)

Best Model:
epoch: 17 , val_accuracy: 0.6875 , val_loss: 2.801485776901245
```



Accuracy after fine-tuning the model-

```
Epoch 00049: val_accuracy did not improve from 0.90848
Epoch 50/50
114/114 [==============================] - 31s 268ms/step - loss: 0.7414 - accuracy: 0.8152 - val_loss: 0.3136 - val_accuracy: 0.9085

Epoch 00050: val_accuracy did not improve from 0.90848
```

Result:

```
Image('https://raw.githubusercontent.com/Ashreyagit/image/main/65.jpg')
```

```
pipe2('https://raw.githubusercontent.com/Ashreyagit/image/main/65.jpg', ft_model)
```

```
Validating that damage exists....
[[0.00721256]]
Validation complete - proceed to location and severity determination
```

3. Determines location and severity of damage as Entire, Roof, Roof along with wall and Severe, Minor and Moderate respectively

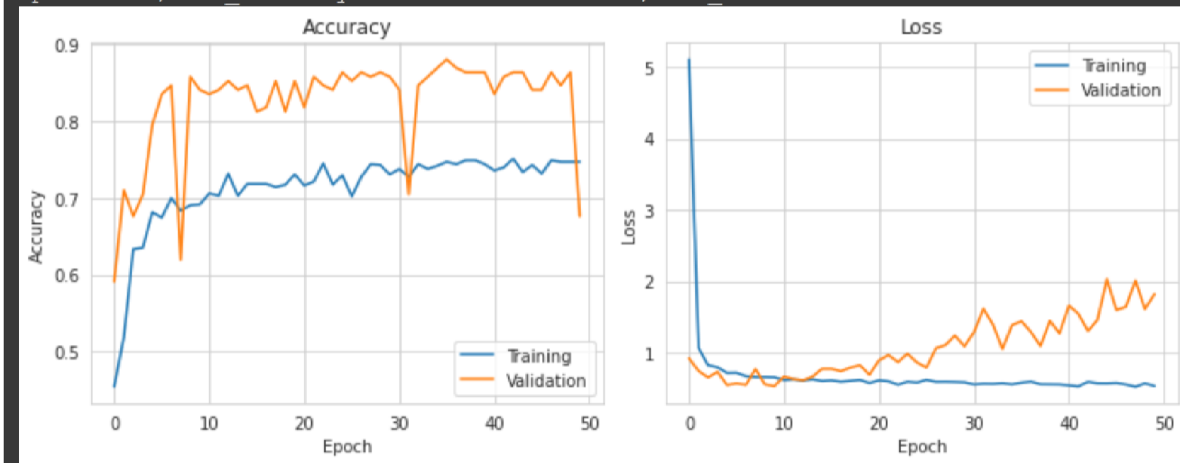
Accuracy of trained model-

```
Epoch 49/50
61/61 [==============================] - 0s 7ms/step - loss: 0.5661 - accuracy: 0.7168 - val_loss: 1.6083 - val_accuracy: 0.8636

Epoch 00049: val accuracy did not improve from 0.88068
```

```
plot_metrics3(d3_history3)
```

```
Best Model:
epoch: 36 , val_accuracy: 0.8806818127632141 , val_loss: 1.4372233152389526
```



Accuracy after fine-tuning the model-

```
Epoch 50/50
61/61 [==============================] - 16s 256ms/step - loss: 2.7655 - accuracy: 0.6725 - val_loss: 0.3580 - val_accuracy: 0.9773

Epoch 00050: val_accuracy did not improve from 0.97727
```

Result:

```
Image('https://raw.githubusercontent.com/Ashreyagit/image/main/bhola3.jpg')
```

```
pipe31('https://raw.githubusercontent.com/Ashreyagit/image/main/bhola3.jpg', ft_model3)
```

```
Validating location and extent of damage....Result: Location : Entire | Severity: Severe
Location and Severity assessment complete.
```

```
Image('https://raw.githubusercontent.com/Ashreyagit/image/main/bhola.jpg')
```

```
pipe31('https://raw.githubusercontent.com/Ashreyagit/image/main/bhola.jpg', ft_model3)
```

```
Validating location and extent of damage....Result: Location : Roof | Severity: Minor
Location and Severity assessment complete.
```

```
Image('https://raw.githubusercontent.com/Ashreyagit/image/main/65.jpg')
```

```
pipe31('https://raw.githubusercontent.com/Ashreyagit/image/main/65.jpg', ft_model3)
```

```
Validating location and extent of damage....Result: Location : Wall and Roof | Severity: Moderate
Location and Severity assessment complete.
```

Entire Workflow Predictions-

```
pipeline('https://raw.githubusercontent.com/Ashreyagit/image/main/roofless.jpg')
```

```
Ensuring entered picture is a house...
```

```
Successful. Proceeding to damage assessment...
Validating that damage exists....
Validation complete - proceed to location and severity determination
Determining location and extent of damage...
Validating location and extent of damage....Result: Location : Roof | Severity: Minor
Location and Severity assessment complete.
```

```
pipeline('https://raw.githubusercontent.com/Ashreyagit/image/main/b.jpg')
```

```
Ensuring entered picture is a house...
```

```
Successful. Proceeding to damage assessment...
Validating that damage exists....
Validation complete - proceed to location and severity determination
Determining location and extent of damage...
Validating location and extent of damage....Result: Location : Wall and Roof | Severity: Moderate
Location and Severity assessment complete.
```

```
pipeline('https://raw.githubusercontent.com/Ashreyagit/image/main/c.jpg')

Ensuring entered picture is a house...
```

```
Successful. Proceeding to damage assessment...
Validating that damage exists....
Validation complete - proceed to location and severity determination
Determining location and extent of damage...
Validating location and extent of damage....Result: Location : Entire | Severity: Severe
Location and Severity assessment complete.
```

Link to the complete code-
https://colab.research.google.com/drive/1EUs33zkp21tlnTiwwxcHgOvOC9IrLUvb?usp=sharing

4.9 Conclusion

Blockchain technology ensures quick, secured, and cost effective transaction processing services with the help of encrypted distributed ledgers which furnishes trusted real-time verification of transactions without any intermediaries such as banks, financial institutions, clearing agents etc. One of the main advantages of blockchain technology is data security.

One can store the documents on the blockchain by storing document's hash on-chain while keeping the whole document elsewhere. The document could be stored on a distributed file storage system or on a centralized database. One would put the document through a secure hash algorithm like SHA-256 and then store the hash in a block so that huge amount of space and cost can be saved. It also helps to know whether someone tampers with the original document. The change in input would result in a completely new hash value, different from original document.

During natural disaster like cyclone, AI can predict the weather condition at the concerned latitude and longitudinal region at the specific time of occurrence of calamity. Artificial intelligence can also automate the claims processing by predicting the cost of damaged property such as mobile phones, vehicles, house roofs, etc.

Through integration of blockchain and AI, the insurance claims can be settled easily which otherwise takes weeks and months to settle such payments after the catastrophe event.

References

[1] Center for International Earth Science Information Network (CIESIN) of Columbia University. 2006. CSD Coastal Population Indicator: Data and Methodology Page. http://sedac.ciesin.columbia.edu/es/csdcoastal.html

[2] (IPCC, 2007a) .M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden, C.E. Hanson (Eds.), Climate Change 2007: Contribution of the Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK (2007)

[3] Geiger, T., Frieler, K., and Bresch, D. N.: A global historical data set of tropical cyclone exposure (TCE-DAT), Earth Syst. Sci. Data, 10, 185–194, https://doi.org/10.5194/essd-10-1852018, 2018

[4] Nicholls, R.J.N., N. Mimura, and J.C. Topping. 1995. Climate change in south and south-east Asia: Some implications for coastal areas. Journal of Global Environmental Engineering 1:137– 154

[5] Source: © 2019 Munich Re, Geo Risks Research, NatCatSERVICE. As of March 2019. https://www.munichre.com/topics-online/en/climate-change-and-natural-disasters/naturaldisasters/overview-natural-catastrophe-2016.html

[6] Lukman Adewale Ajao, James Agajo, Emmanuel Adewale Adedokun and Loveth Karngong Crypto Hash Algorithm-Based BlockchainTechnology for Managing Decentralized LedgerDatabase in Oil and Gas Industry J2019,2, 300–325; doi:10.3390/j2030021

[7] Zhang, W.; Fu, B. Discriminating developing versus non developing tropical disturbances in the western North Pacific through decision tree analysis. Weather Forecast.2015, 30, 446–454. [CrossRef]

[8] Kim, M.; Park, M.S.; Im, J.; Park, S.; Lee, M.I. Machine Learning Approaches for Detecting Tropical Cyclone Formation Using Satellite Data. Remote Sens.2019,11, 1195

[9] Matsuoka, D.; Nakano, M.; Sugiyama, D.; Uchida, S. Deep learning approach for detecting tropical cyclones and their precursors in the simulation by a cloud-resolving global non hydrostatic atmospheric model. Prog. Earth Planet. Sci.2018,5, 80.

[10] Ahijevych, D.; Pinto, J.O.; Williams, J.K.; Steiner, M. Probabilistic forecasts of mesoscale convective system initiation using the random forest data mining technique. Weather Forecast.2016,31, 581–599.

[11] Richman, M.B.; Leslie, L.M. Adaptive Machine Learning Approaches to Seasonal Prediction of Tropical Cyclones. Procedia Comput. Sci.2012,12, 276–281.

[12] Nath, S.; Kotal, S.; Kundu, P.J.M.; Physics, A. Seasonal prediction of tropical cyclone activity over the north Indian Ocean using three artificial neural networks. Meteorol. Atmos. Phys.2016,128, 751–762.

[13] Yip, Z.K.; Yau, M.K. Application of artificial neural networks on North Atlantic tropical cyclogenesis potential index in climate change. J. Atmos. Ocean. Technol.2012,29, 1202–1220.

[14] Ali, M.M.; Kishtawal, C.M.; Jain, S. Predicting cyclone tracks in the north Indian Ocean: An artificial neural network approach. Geophys. Res. Lett.2007,34.

[15] Lee, R.T.; Liu, J.K. Tropical cyclone identification and tracking system using integrated neural oscillatory elastic graph matching and hybrid RBF network track mining techniques. IEEE Trans. Neural Netw.2000,11, 680–689.

[16] Alemany, S.; Beltran, J.; Perez, A.; Ganzfried, S. Predicting hurricane trajectories using a recurrent neural network. In Proceedings of the 33rd AAAI Conference on Artificial Intelligence; AAAI Press: Honolulu, HI, USA,2019; Volume 33, pp. 468–475

[17] Rüttgers, M.; Lee, S.; You, D. Prediction of typhoon tracks using a generative adversarial network with observational and meteorological data.arXiv2018, arXiv:1812.01943.

[18] Zhang, Y.; Chandra, R.; Gao, J. Cyclone track prediction with matrix neural networks. In Proceedings of the 2018 International Joint Conference on Neural Networks (IJCNN), Rio de Janeiro, Brazil, 8–13 July 2018;IEEE: Piscataway, NJ, USA, 2018; pp. 1–8

[19] Kim, S.; Kim, H.; Lee, J.; Yoon, S.; Kahou, S.E.; Kashinath, K.; Prabhat, M. Deep-HurricaneTracker: Tracking and Forecasting Extreme Climate Events. In Proceedings of the 2019 IEEE Winter Conference on Applications of Computer Vision, Waikoloa Village, HI, USA, 7–11 January 2019; pp. 1761–17

[20] Giffard-Roisin, S.; Yang, M.; Charpiat, G.; Kumler Bonfanti, C.; Kégl, B.; Monteleoni, C. Tropical Cyclone Track Forecasting Using Fused Deep Learning From Aligned Reanalysis Data. Front. Big Data2020,3, 1

[21] Zhang, W.; Leung, Y.; Chan, J.C. The analysis of tropical cyclone tracks in the western North Pacific through data mining. Part I: Tropical cyclone re curvature. J. Appl. Meteorol. Climatol.2013,52, 1394–1416.

[22] Bankert, R.L.; Hadjimichael, M.; Kuciauskas, A.P.; Richardson, K.; Turk, F.J.; Hawkins, J.D. Automating the estimation of various meteorological parameters using satellite data and machine learning techniques. In Frontiers of Remote Sensing Information Processing; World Scientific: Singapore, 2003; pp. 227–252.

[23] Pradhan, R.; Aygun, R.S.; Maskey, M.; Ramachandran, R.; Cecil, D.J. Tropical Cyclone Intensity Estimation Using a Deep Convolutional Neural Network. IEEE Trans. Image Process.2018,27, 692–702.

[24] Lee, J.; Im, J.; Cha, D.H.; Park, H.; Sim, S. Tropical Cyclone Intensity Estimation Using MultiDimensional Convolutional Neural Networks from Geostationary Satellite Data. Remote Sens.2020,12, 108.

[25] Baik, J.J.; Paek, J.S. A Neural Network Model for Predicting Typhoon Intensity. J. Meteorol. Soc. Jpn. Ser. II2000,78, 857–869

[26] Pan, B.; Xu, X.; Shi, Z. Tropical cyclone intensity prediction based on recurrent neural networks. Electron. Lett.2019,55, 413–414.

[27] Lee, J.; Im, J.; Cha, D.H.; Park, H.; Sim, S. Tropical Cyclone Intensity Estimation Using MultiDimensional Convolutional Neural Networks from Geostationary Satellite Data. Remote Sens.2020,12, 108.

[28] Deo, R.V.; Chandra, R.; Sharma, A. Stacked transfer learning for tropical cyclone intensity prediction.arXiv2017, arXiv:1708.06539.

[29] Geng, H.-T.; Sun, J.-Q.; Zhang, W.; Wu, Z.-X. A novel classification method for tropical cyclone intensity change analysis based on hierarchical particle swarm optimization algorithm. J. Trop. Meteorol.2017,23, 113–120

[30] Zhang, W.; Gao, S.; Chen, B.; Cao, K. The application of decision tree to intensity change classification of tropical cyclones in western North Pacific. Geophys. Res. Lett.2013,40, 1883–1887.

[31] Chandra, R.; Dayal, K.S. Co evolutionary Recurrent Neural Networks for Prediction of Rapid Intensification in Wind Intensity of Tropical Cyclones in the South Pacific Region. In ICONIP 2015: Neural Information Processing; Springer: Cham, Switzerland, 2015.

[32] Mercer, A.; Grimes, A. Diagnosing Tropical Cyclone Rapid Intensification Using Kernel Methods and Reanalysis Datasets. Procedia Comput. Sci.2015,61, 422–427

[33] Mercer, A.; Grimes, A. Atlantic tropical cyclone rapid intensification probabilistic forecasts from an ensemble of machine learning methods. Procedia Comput. Sci.2017,114, 333–340.

[34] Fischer, M.S.; Tang, B.H.; Corbosiero, K.L.A Climatological Analysis of Tropical Cyclone Rapid Intensification in Environments of Upper-Tropospheric Troughs. Mon. Weather Rev.2019,147, 3693–3719

[35] Wei, C.C. Study on Wind Simulations Using Deep Learning Techniques during Typhoons: A Case Study of Northern Taiwan.Atmosphere2019,10, 684

[36] Zhang, C.; Dai, L.; Ma, L.; Qian, J.; Yang, B. Objective estimation of tropical cyclone inner core surface wind structure using infrared satellite images. J. Appl. Remote Sens.2017,11, 046030.

[37] Wei, C.C. Forecasting surface wind speeds over offshore islands near Taiwan during tropical cyclones: Comparisons of data-driven algorithms and parametric wind representations. J. Geophys. Res.-Atmos.2015,120, 1826–1847.

[38] Lee, T.L. Back-propagation neural network for the prediction of the short-term storm surge in Taichungharbor, Taiwan.Eng. Appl. Artif. Intell.2008,21, 63–72.

[39] Chen, W.B.; Liu, W.C.; Hsu, M.H. Predicting typhoon-induced storm surge tide with a twodimensional hydrodynamic model and artificial neural network model. Nat. Hazards Earth Syst. Sci.2012,12, 3799–3809.

[40] Kim, S.; Matsumi, Y.; Pan, S.; Mase, H. A real-time forecast model using artificial neural network for after-runner storm surges on the Tottori Coast, Japan .Ocean Eng.2016,122, 44–53.

[41] Lin, G.; Chen, G.; Wu, M.; Chou, Y.J. Effective forecasting of hourly typhoon rainfall using support vector machines. Water Resour. Res.2009,45.

[42] Lin, G.F.; Chen, L.H .Application of an artificial neural network to typhoon rainfall forecasting. Hydrol. Process.2005,19, 1825–1837

[43] Hsieh, P.C.; Tong, W.A.; Wang, Y.C. A hybrid approach of artificial neural network and multiple regression to forecast typhoon rainfall and groundwater-level change. Hydrol. Sci. J.2019,64, 1793–1802

[44] Huang, Y.; Jin, L.; Zhao, H.S.; Huang, X.Y. Fuzzy neural network and LLE Algorithm for forecasting precipitation in tropical cyclones: Comparisons with interpolation method by ECMWF and step wise regression method. Nat. Hazards2018,91, 201–220.

[45] Al-Breiki, H., Rehman, M.H.U., Salah, K., Svetinovic, D.: Trustworthy blockchainoracles: Review, comparison, and open research challenges. In: IEEE Access pp.85675–85685 (2020

[46] https://www.researchgate.net/figure/VGG16-architecture-16_fig2_321829624

[47] Google images have been used for creating dataset.