2021 12th International Conference on Computing Communication and Networking Technologies (ICCCNT) | 978-1-7281-8595-8/21/$31.00 ©2021 IEEE | DOI: 10.1109/ICCCNT51525.2021.9579674

How to tackle Climate Change using Artificial Intelligence

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***Abstract*— In this era of the modern and fast-paced world, Climate Change and pollution are the kind of challenges that we need to tackle in a more efficient and smart way. It's imperative to use more technology to build solutions to solve these environmental problems. We believe that Artificial Intelligence is one of those technologies that can play a crucial role in contributing to those challenges we face today. This survey includes causes of environmental problems along with what specific solution in AI, we can build. Here we explain how Artificial Intelligence can help to reduce greenhouse gas emissions and help society to adapt to Climate Change. This survey concludes by discussing various pitfalls, advantages, and future scopes of different aspects of how we can integrate Artificial Intelligence with environmental challenges with technology, as humans always dreamed of.**

Keywords—Global warming, Artificial intelligence, Machine learning, Supervised learning, Neural networks, Modelling, Pollution

I. INTRODUCTION

Human life is increasingly getting influenced by Machine learning (ML) and artificial intelligence (AI), enabled by significant rises in processor availability, speed, connectivity, and cheap data storage. AI is contributing and advancing in so many aspects of life like medical and health provision, transport delivery, interaction with the internet, food supply systems and supporting security in changing geopolitical structures etc. World is approaching the cutting edge of technology which includes the era of self-driving cars, helping medical practitioners avoid misdiagnosis, accurate speech recognition, and receiving tailored purchase suggestions. Most applications are beneficial, although ethical issues such as climate change still exist. Evolving lifestyles must interact safely with climate change [1]. Climate change impact and causes are not considered as isolated threats, it's a multifaceted issue with a complex scientific base supporting it. Many Artificial Intelligence and Machine Learning algorithms are available like neural networks, Support Vector Machine, Random Forest etc. to tackle current climate change issues with ground accuracy. Recently constraints of computational architecture have restricted the implementation, especially for data-intensive issues like climate change. Due to emerging concerns of carbon emission and climate change, most of the companies are implementing "Carbon Footprinting" projects to estimate their own contributions to global climate change [2]. Also, the Paris Agreement marked a historic turning point for global climate action. In 2015 nearly every nation adopted the Paris Agreement as an international standard to address climate change and its impacts on ecosystems. Motivation behind this agreement is to reduce GHG emission and its negative impacts such as global temperature increase on ecosystems. This agreement was proposed at the United Nations Framework Convention on Climate Change's 21st Conference of Paris and accepted in December 2015, the Paris Agreement marked as an important historic step for global climate act [3].

Ice as well as glacier ice sheets about 10 % of the world's average region and also possess 26 million cubic kilometers of ice. Himalayas have among the biggest plethora's of ice as well as glaciers apart from the Polar Regions within the majority of the core Asia, thus conferring it with the name' third pole' of the planet. Its positive globally balanced area heat has grown after the late 19th century.

Many of the previous three years are successively hotter at the Planet's surface area than any the previous years, as well as the decade of 2000's was still the warmest, we believe. Also, the continuous upward trend in the globally averaged temperature shows that more areas are warming than cooling. Previous three decades were successively hotter on earth, and the decade of 2000's was the warmest. According to NOAA's annual climate report, the overall temperature of earth including land and sea has increased at an average rate of 0.13 degrees Fahrenheit almost per decade since 1880; but it has been observed that, the average rate of increasing in temperature has become twice than previous one. Decade 2011-2020 was the warmest decade recorded in the era with temperature being reached to 1.1°C which is above pre-industrial levels in 2019 with average global temperature rise. Human caused effects of Climate Change are presently increasing at a rate of 0.2°C per decade. An increase of 2°C compared to the temperature in pre-industrial times is linked with negative implications on an environment and overall human health [4].

The primary cause of anthropogenic climate change is net emissions of GHG. Excessive GHG emission creates an imbalance in the atmosphere which results in more energy being entering into the Earth's atmosphere than it's emitted, resulting in various forms of Climate Change. The atmosphere, which is rapidly getting warmed, changes its behavior significantly and continuously with changes in weather patterns - this is collectively called as 'Climate Change'. As of 2018, human activities have already caused approximately 1ºC temperature increase above pre-industrial levels. At current warming rates, and assuming business as usual continues, it is 2 estimated that warming will reach 1.5ºC by 2030-2052 [1]. Even a 1ºC rise in average temperature is observed and its consequences are very dangerous. We have witnessed increased frequency and severity of extreme weather events, rising sea levels and species extinction, as well as a rise in societal harms including increased displacement, deaths, damages and costs. These physical changes are occurring at high speed, and impact on humanity significantly.

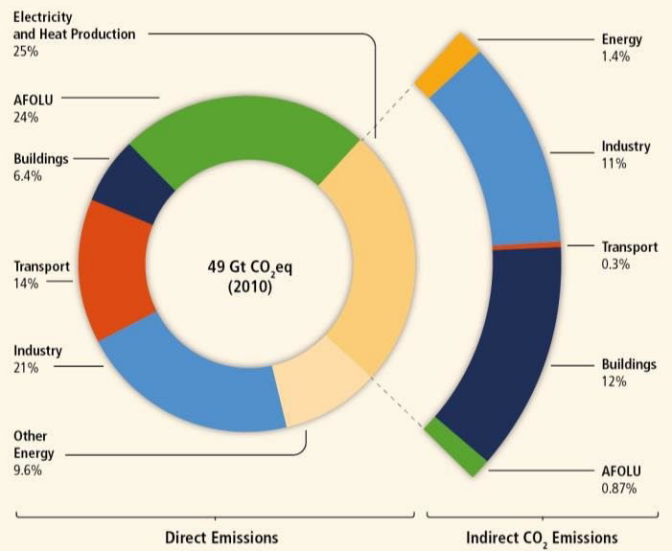

Fig. 1. Greenhouse Gas Emission by Economic Sectors [32]

Figure 1. shows total anthropogenic emissions GHG by economic sectors. Inner circle shows direct GHG emission shares of five economic sectors in 2010. Pull-out shows how indirect CO2 emission shares from electricity and heat production are attributed to sectors of final energy use. 'Other Energy' refers to all GHG emission sources in the energy factors.

II. Related Work

In 2018, an expert system was developed by P. Gentine, M. Pritchard, S. Rasp et al. [5]. In this system they demonstrated that machine learning, and neural networks in particular, can skillfully represent many of the effects of unresolved clouds and convection, including their vertical transport of heat and moisture. The concept wIn 2018, an expert system was developed by P. Gentine, M. Pritchard, S. Rasp et al. [5]. In this system they demonstrated that machine learning, and neural networks in particular, can skillfully represent many of the effects of unresolved clouds and convection, including their vertical transport of heat and moisture. The concept was proven in an idealized test bed using SPCAM over an aqua planet. In this research fundamental finding and development was Improvement of convection parameterizations using machine learning emulatorsas proven in an idealized test bed using SPCAM over an aqua planet. In this research fundamental finding and development was Improvement of convection parameterizations using machine learning emulators

Another work was published in 2012 by V.F.Rodriguez-Galiano, J.Rogan et al. on assessment of the effectiveness of a random forest classifier for land-cover classification [6]. In this research fundamental finding and development was Classify land cover from earth observation data (satellites).

In 2017, Work was published by Amy McGovern, Christopher D. et al. to propose use of artificial intelligence to improve real-time decision making for high impact weather [7]. Research demonstrated use of Random Forests, Gradient Boosted Regression Trees in several of the high-impact weather domains. In this research fundamental finding and development was the use of AI for post-processing of weather forecasts to aid human forecasters.

Support Vector Machines have also been used to detect and predict tornadoes [8]. SVM learns a linear model in different dimensional non-linear space by transforming the data using kernels. For the ANN, it is not easy to interpret the weights through the nonlinear functions as easy as SVM. For the SVM, the data transformation makes it difficult to identify the most important features of the data or what the model has identified.

Decision Tree based methods are popular in AI[9]. They train the models and learn based on most relevant variables, thus providing users many different predictive features which are possible. This works without giving less leverage to other extra attributes in the data which overwhelms the overall training process. Decision Tree gives insight to different relationships which are formed between attributes which are related to the event being predicted or modelled. In weather prediction or any kind of Climate Change prediction use cases Decision Tree is very powerful method.

An expert system was developed in January 2008 by Subimal Gosh and P.P. Mujumdar to demonstrate statistical downscaling of General Circulation Model simulations to streamflow using relevance vector machine [10]. Principal Components Analysis and fuzzy clustering. Relevance Vector

Machine was used to assess the impact of future climate change on hydrology in India, and including for river flow. Gradient boosted regression trees construct an ensemble of decision trees trained using boosting [11]. Whereas each tree in an RF is equally weighted and trained on equally weighted examples, a Gradient Boosted Regression Trees trains on differently weighted subsets of data, where the weights are determined by previous learning step.

As some limitations have been observed from above mentioned previous work for implementing AI enabled solutions for Climate Change, some of these are as follows-As ANN can't preserve and retain energy and moisture this can significantly impact climate prediction as accurate and efficient prediction requires a prediction model with energy and moisture conservation. Also, ANN are more deterministic and difficult to interpret the weights through the nonlinear functions which results in variable outcomes in prediction especially in the lower levels of the atmosphere [5]. The split rules for implementing Random Forest classifiers for land-cover classification are unknown which results in substantial differences in ESM simulations impacting the accuracy of the system therefore RF can be considered to be black box type classifier [6]. A significant problem in applying RF to diagnose aviation turbulence is that the observation platforms and NWP models that supply prediction attributes vary over time, and weather phenomena themselves may vary based on climate change which impacts on accuracy of the system [9]. A major limitation in the system is for standardization it considers the bias in only variance and mean. There is a possibility of deviation of data and GSM output from normal distribution values, which may further create bias in other statistical parameters [10].

III. ARTIFICIAL INTELLIGENCE AND ALGORITHMS FOR CLIMATE CHANGE

The term Artificial Intelligence is a state-of-the-art technique for solving different intelligence problems or AI-Hard problems which cannot be solved by conventional programming or conventional computer-science techniques. As we see today, AI has been part of solutions to many of the technical problems including Social Causes also. That's why we thought - Why not to use AI for Climate Change also extensively and to leverage the power of it. AI term was first coined in 1955 when 10 scientists submitted a research paper on the study of the conjecture that how we can describe a problem tor data so precisely so machines can simulate it and how machines can be used to form concepts, abstractions, and how they be can used to solve problems related with humans [12]. There are different types of AI - Reactive, Limited Memory, Theory of Mind and Self-Aware. Reactive has no or little memory to be used. Limited Memory means it uses some kind of memory to learn and generate responses. Theory of Mind is related with understanding of other external intelligent entities and Self-Aware is human-like self-awareness and intelligence. Machine Learning as we know is a technique for how to solve AI problems and then again, we have subtypes of ML, which we call different algorithms to solve actual technical problems. Today ML is largely related with Neural Networks - a sub-type of ML technique or we can say a way through which ML was first coined. ML evidently includes all mathematical theories and it's not completely a new invention if we go back to history. Since 1943, there has been an attempt to research Neurons, how they work and how they can be simulated. In 1950, Alan Turing did the world-famous Turing Test and showed the world that machines can indeed learn. Little breakthrough happened in 1962, when Widrow and Hoff proposed a rule in which a learning procedure examines the value before the weight adjusts it (0 or 1) according to the rule: Change in Weight = (Pre-Weight line value) * (Error / (Number of Inputs)). It is based on the idea that one perceptron can adjust the values of neighboring Perceptrons and thus can maintain balance [13]. Then in 1986, came the idea of backpropagation that how to extend Widrow-Hoff rule to multiple layers which distributes pattern-recognition through the whole network and adjusts the weights continuously to lower the difference between actual and desired output of Neural Networks [14]. This was major breakthrough for Neural research and encouraged researchers across world to use ML to solve problems. There are basically three types of ML - Supervised Learning, Unsupervised Learning and Reinforcement Learning. We'll explore each-type and how these can be used to solve Climate Change problem.

Supervised Learning is a part of the Limited Memory type of AI where an algorithm learns on an existing data set which acts as a memory. In supervised learning, again there are different algorithms used - Linear Regression, Support Vector Machines, Naive Bayes, Decision Trees, Neural Networks. Prediction is the technique in AI or ML, we use to predict future values in outcome. Input dataset contains different attributes or features which contribute to expected output

Linear Regression is basically a statistical process to find out the relation between dependent variables which are actual output variables and independent variables which are input attributes in a dataset. Regression term was first evolved in 19th century when Francis Galton was describing a biological phenomenon which later called as "regression towards mean" [15]. Linear Regression we use for predicting estimated power to be generated from power plants, for predicting amount of GHG in air, for rise in temperature. Here, we use Multiple Linear Regression as we've multiple input variables. LR is actually a linear model where we try to create a linear relationship between these multiple input variables to output variable(s). There Are different techniques used for training the LR models, most common is Ordinary Least Squares. The distance of each data point from regression line, we have to square it and then addition of squared errors is what Ordinary Least Squares try to minimize. Then comes Gradient Descent. Gradient Descent minimizes error in the training model by iteratively optimizing the values of coefficients. First this takes random values for these coefficient values and then goes on for optimizing. In this approach, the learning rate known as 'alpha value' is important which decides the size of an

improvement step performed after each iteration. Then after this, we should apply regularization methods to our model, because these reduces the overall complexity also improves the no. of coefficients and values of coefficients required in your predictive model.

Support Vector Machine is used for the Carbon Foot printing problem where the goal is to predict the final carbon value or carbon score based on multiple inputs. SVM is also a Supervised Learning ML model but used for both Regression and Classification problems, which was developed by Vapnik in 1995 [16]. SVM when used for Regression is called Support Vector Regression or SVR. SVM maps input attribute vectors in some other high-dimensional space through a non-linear mapping. This is called a hyperplane. The most important factor here in SVM is margin. Margin is nothing but distance between two different support vectors which are close to this hyperplane, and SVM tries to maximize this margin to get excellent output. SVR is used for non-linear regression problems where it shows accurate output; this mapping into hyperplanes occurs using nonlinear functions. The kernel function selection is also an integral step while performing SVR on a dataset on which generally performance is dependent.

Artificial Neural Network - is a fundamental approach or algorithm in Neural Network which is part of ML. Deep Learning term is also coined by Hinton where there are multiple layers of ANN used to process the problem. The perception is actually a mathematical model based upon or developed on biological neurons. Neurons have axioms through which they send electrical signals to other Neurons. In the same way one Perceptron is connected to other Perceptrons through mathematical values instead of electrical signals. Each Neuron has its weight in numerical value. The output signals are calculated by multiplying the weight of Neuron and incoming numerical signal. A Neuron only sends signal output when input signals towards that Neuron gets exceeded beyond threshold. Activation functions in Neural Networks are integral because they are the decision-making units and which calculates the net output of Perceptron. These Neural Networks are made up of tons of Perceptrons, non-linear problems also can be solved using multiple layers of Neural Networks i.e., DL, but activation functions have to be used carefully which is the heart of Neural Networks. Convolutional Neural Networks is a key technique used for image-processing. In climate change problems, especially in forest fire use cases as we discussed, CNN is used effectively. Also, the processing of satellite-imagery needs visualization processing which mainly we tackle using CNN.

IV. TACKLING CLIMATE CHANGE USING AI

In this section we will explain different causes and issues which lead to significant amount of CO2 emission. We are trying to relate each issue with AI and creating use case around it. It is important to create problem statement like any other general AI problem, so we can think of using appropriate technique or algorithm to create the solution.

A. AI in Electricity

Electricity production and consumption plays a major role in climate change problems. We've different ways of producing energy which contributes to climate change and GHG emissions. We've thought about how we can improve the Electricity life-cycle in all production, transportation and in consumption. Rapidly transition to low-carbon sources is the foremost thing we expect. Not only Governments or big energy companies but society also has to play a major role in this transition. Today's world runs on data, and if we want to use AI then we need to record more data for building solutions which we see scarce in this sector. Encouraging use of clean technologies. There are two types of sources basically - Variable and Controllable. Variable sources include Wind Energy and Solar Energy which are based on external factors. Controllable includes Geothermal and Nuclear plants. Renewable energy sources or carbon-free energy sources are more important when we talk about Climate Change. ML and Neural Networks techniques should be used for prediction and training the data set collected from historical data. Electricity Companies need to start leveraging the historical data for building AI solutions.

Google's Deepmind project uses ML Algorithms and Neural Networks to predict how much energy can be harnessed based on weather forecasts Data prediction [18]. With that, it also recommends the optimal output to the Grid required for production. Governments should be self-encouraged to implement AI-based models in farms to harness and thus increase the value of wind energy. Likewise, another most valuable carbon-free source is Solar Energy generated using solar panels and solar cells. We can use the same Neural Networks techniques to predict power generation using historical data of Temperature, thus at which temperature and humidity level how much energy gets produced. In this way we can control the production of these energy components. In water rich-countries, Hydro-electric energy is another major way of producing electricity. How do we use AI here? Building water dams itself generates considerable GHG emissions. In the Amazon basin, a team of scientists had developed an AI-based solution, a computational model using ML which predicts appropriate sites for hydropower dams which will emit considerably less amount of GHG [19]. In our opinion, various factors or attributes like soil constituents of the site, carbon measure of soil can help to build ML models to predict the quality of site and energy quality value.

B. AI in Forest Fire

Deforestation, Wildfires and Climate Change all these are very much interlinked. According to Global Forest Watch, forests can provide 30% of the solution to keep global temperature below 2 degrees Celsius [20]. Forest fires around the world generate a tremendous amount of oxygen and thereby increase overall GHG emission. Greenpeace says, every year, around 8 billion tons of CO2 are released in the air by fire, which is actually more than CO2 emissions generated by burning coal [21]. Thus, forest fire is one of the topmost issues which contributes to climate change and global warming. One estimate suggests that one-third of global carbon emission will be reduced by better management of

land, forests and farming [22]. That's why we want to use more technology in this area. Use of AI with ML and Neural Networks becomes prevalent here. Topmost concern about how we'll use technology here is how'll collect appropriate data. Collecting data is a little tricky in this area. One of the ways we think and already being used is collecting Satellite images, so we can analyze those images using Neural Networks mostly using CNN. In this case historical data will be that were previously fires have occurred. Forest fire susceptibility is to find probable areas of forest where fire can catch, and thus providing early alerts to departments.

We can have attributes like moisture in the air, wind speed, wind direction, temperature these are one of the attributes we can use to feed our ML prediction systems or Neural Networks input. All these properties will help to predict the probability of a fire incident. In Neural Networks, spatial prediction models can be used and then we can apply oversampling to eliminate Class imbalance if any. In this way, we can use the most influential factors affecting the forest fire to predict the future fire. This research [23], has used both conventional image-processing algorithms and CNN in a combined manner and introduced a new adaptive pooling approach. Using these two things can be avoided which are general problems in CNN - traditional feature extraction process is avoided which takes time and a complex one and other is learning of invalid features which are redundant one.

C. AI in Transportation

Transportation equally takes part in climate change problems.Emissions from road, air, rail and water transport have been partly responsible for acid deposition, stratospheric ozone depletion. Road travel accounts for three-quarters of transport emissions. Most of this comes from passenger vehicles like cars and buses which mostly contribute 45.1%. The other 29.4% comes from trucks carrying things. So here AI comes in picture so that we can find a solution to lower the pollution. Though the prediction model and deep network a data was predicted of the increase pollution but in current scenario it is a little different. World have been hit with pandemic and reduction of CO2 emissions have occurred. Some companies are using fourth-generation technologies to cut GHG emissions on roads, the seas and in the air. We can use AI but it will be to integrate autonomous vehicles transport in all over the world. In a handful of US cities, ML is being deployed to improve vehicle flow. In Pittsburgh, this has reduced engine idling by 40%, delivering an estimated 20% cut in carbon emission [24]. The Scalable Urban Traffic Control system – developed by scientists at Carnegie Mellon University enables each junction to set traffic light sequencing according to real-time information on traffic volumes, collected from cameras and radar. Data is shared with systems at nearby intersections, to predict the flow of vehicles and thus of traffic.Auto manufacturers are working hard to bring smart amenities to their latest models, ensuring driver comfort and accessibility [25]. AI can help the world to track the current scenario and pollution baseline and handle the situation and advise people directly on avoiding exposure to dangerous levels of air pollution.AI can help model such differences by looking at the samples. There are researches at the University of Pittsburgh is a creating a new model for traffic intersections that reduces energy consumption and improves the flow of traffic. Texas A&M using Deep and neural network for Signal Controller [26].

The use of ML and AI in autonomous cars for having smooth traffic, reduced fuel consumption and improved air quality may sound like a science fiction, but two test projects conducted by the researchers of the Berkeley Laboratory are showing positive results. By using all these sensors and software, algorithms are able to identify a speed which consumes the least amount of fuel, emit lesser GHG, they are also able to identify the best path for a car to move ahead in consonance with other cars on the road. Most car accidents happen due to human error. When a software is controlling your car system, the possibility of an error is quite less. This software allows a car to be entirely controlled by AI, thus reducing the chances of an accident [24].

D. AI in tracking Carbon Footprinting

We understand that environmental protection is not just a step that should be taken by the government or organizations but it's an individual step also. This should focus on reducing individual Carbon Footprinting values. In this way, individuals can take meaningful action steps to contribute to solving climate change issues and thus helping to reduce GHG emissions. We intend to build an application which will track few attributes and will further use for predictions, modelling using ML or Neural Networks. These attributes will be basically user inputs like - Total Electricity consumption of a day (per day reading), transportation distance covered using personal vehicle, amount of gassed used per day for cooking, meat ate per week, how much plastic bags you've consumed from departmental store, paper-based products used per week. This report [27] suggests that streaming online videos streaming on smaller screens and online gaming activities produce significant carbon emissions. This also we can model using AI by tracking daily consumption of streaming applications and thus curbing at personal level. Other than personal level Carbon Footprinting tracking, we also suggest that industry level Carbon Footprinting measuring should be there. For this, the company should track each employee's individual Carbon Footprinting when they're in office. Also, how much electricity consumption is there daily, how much paper-based products are getting used, all this information will help to build the data required for running ML algorithms. We'll use simple linear regression and SVM here to accommodate this data.

A Neuro-Fuzzy interceptive system and Multi-Layer Perceptron ANN have been implemented to estimate such carbon footprint. These can solve CO2 prediction problems if used in your mobile or web application. We know about SVM - Support Vector Machine in ML and this solves these prediction problems more effectively. SVM actually can be used for both regression and classification problems of CO2 predictions. Many researches [28], [29] found out that SVM is more accurate than the semi-empirical equations approach in finding out solubility of solutes in CO2. It's more productive to predict the CO2 exchange rate. SVM is a constructive ML instrument that can be utilized for time-series prediction [30]. We'll use different attributes as a part of the data set as

input data. CO2 emission data will be generalized or approximate values we can put in a data set against different input attributes for historic data. Pre-processing on this data, that is for Normalization will be needed for SVM for performance improvement. Then cross-validation is an important step in SVM for input data classifying into testing and training data respectively. In this way we can use such algorithms like SVM for back-end processing of Carbon Footprinting calculators using these pre-trained models. For historical data we can use values like in 1 km how much CO2 emits approximately or 1kg meat is related with how much carbon emission or how much amount of paper-based product relates to which amount of CO2, because we cannot get real-time historic data individually at individual level.

V. CONCLUSION

AI like any other technology does not always make the world a better place, but sometimes it really can. AI can accelerate many things in climate change like - control in energy production thus by limiting CO2 emission, controlling consumption, individual carbon tracking, carbon capturing industry and many more.AI can also optimize the food industry including meat industry and thus by again managing carbon emission also in reducing different types of wastes which contributes to GHG emission. But AI or ML is part of the solution only, and we can leverage then to enable other tools to contribute to this solution. We know that, AI itself is evolving continuously, right from Turing Machine to today's conversational robots we're seeing increment in technology and this will only help to tackle challenges in Climate Change. We don't have to just solve different challenges but using AI will enhance the field of ML also, so more research would be carried out and generation of new ideas in this vast field will take place. All these have a great advantage to our society, by leveraging ML on such issues. Like prediction which turns into mitigation, adaptation helps in planning for disaster management for the disasters which have Climate Change as a cause many ML practitioners and researchers want to act on these issues with technology but they're uncertain how they can contribute. We need to see more effective engineering and kind of innovative research to contribute to solving these issues. This needs strategic planning from governments and researchers both to work on different issues and how they can use ML efficiently to mitigate those.

Using AI has its limitations also, extensive computation for ML also leads to Carbon emission. Thus, AI also has Carbon Footprinting. There's much considerable energy required to train ML models and algorithms to run on servers or cloud environments. We should think of how efficient algorithms we can build to run those on lower power, such efforts have been made at MIT University where they've developed a new AI system which has lower carbon foot printing and uses low power for computation [31]. They've eliminated retraining of Neural networks which reside on multiple hardware platforms and thus lower the overall use of energy which is getting used. Green AI - This is new field is emerging where research and scientists around the world are thinking on how to train Neural Networks low-energy mode, also redefining the algorithms and hence setting limits for data set size and boundaries for configurations used in ML algorithms. Computational efficiency has given little importance by AI research community. Another concern is that Climate Change related data faces challenges in gathering data.

In many cases we've seen data is mostly proprietary or personal data (in an individual Carbon Footprinting tracking) which contains sensitive information. Also, most of the data is not as per ML benchmark that we use to solve typical problems in AI. Data is heterogeneous sometimes and there's no global data available for some use cases, like we can have abundant data for some country or region but that same data can't be used for some other places for few use cases.

The purpose of the paper was to survey previous work done and explore many other ways also what can be done to use AI for solving Climate Change. This paper has not done implementation or demonstration of solutions that we've explored. We believe that this survey would be helpful to practitioners who're implementing solutions to tackle Climate Change.

ABBREVIATIONS

GHG – Greenhouse Gases, NLP – Natural Language Processing, ML – Machine Learning, DL – Deep Learning, MIT – Massachusetts Institute of Technology, LSTM – Long-Short Term Memory, ANN – Artificial Neural Network, CNN – Convolutional Neural Network, HMM – Hidden Markov Model, NB – Naïve Bayes, AI – Artificial Intelligence, ACM – Association for Computing Machinery. GCM – General Circulation Model, SVM – Support Vector Machine, GBRT – Gradient Boosted Regression Trees, RF – Random Forest.

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