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Green Internet of Things for Enterprises

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***Abstract:** Today digital transformation is playing a key role in many intelligent enterprises. Due to this there is a tremendous data exchange between internet of things which results in higher demand of bandwidth over communication network. Hence there is a need to utilize the bandwidth effectively which aids in reducing the greenhouse gas emissions in internet of things. Reducing the data size is one aspect that can be considered, to wisely utilize the network bandwidth. In this paper, a novel GWOICT (Grey Wolf Optimizer for Information and Communication Technology) algorithm is developed using jpeg baseline compression algorithm and grey wolf optimizer to reduce the size of images that enables to reduce the CO2 emissions while transferring data over a network of objects. The proposed technique has shown better results in terms of compressing the images and reducing CO2 emissions over the network for driving towards green internet of things in an enterprise.*

***Keywords:** Green Internet of Things, Grey Wolf Optimization, Image Compression, CO2 Emissions*

I. INTRODUCTION

Today most of the organizations have undergone the era of digital transformation. To meet the expectations of next generations, organizations should step towards being intelligent by using emerging technologies such as augmented and virtual reality, artificial intelligence, machine learning and internet of things which acts as building blocks for their success. To drive an organization towards an intelligent enterprise, artificial intelligence in internet of things (AI in IoT) is an important factor that helps to intelligently process vast volumes of data generated by connected devices [1]. In most of the IoT applications there is a huge information exchange between the connected devices and this information must be intelligently processed by considering CO2 emissions that are being emitted during the process of data exchange. In [2] [3][4] internet of things with cloud computing is used to connect the devices and to transmit the information seamlessly and intelligently for decision making. is to reduce the size of the data before transmitting over the network. In this paper images are considered to reduce the size and emissions, as they are usually transmitted in large volumes over internet.

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II. REVIEW OF LITERATURE

With rapid digitalization across the globe the consumer expectations for the
services offered by enterprises is increasing exponentially. To meet these expectations there is need to unify all the intelligent technologies by ensuring that greenhouse gases and emission of carbon dioxide are in control. Efforts were done for binging intelligence to internet of things for ubiquitous healthcare systems in [5]and a proof of concept is illustrated for IoT based healthcare-based monitoring system to enhance overall performance, system energy efficiency, security and reliability that will help to reduce greenhouse gas emission up to some extent. Today there is lot of focus by enterprises to reduce the CO2 emissions. To govern the greenhouse gas emissions an international agreement – "Kyoto protocol" is made between the nations to bind for reducing the emissions [6] [7] [8]. Energy efficient metrics with respect to ICT were discussed in the field of photonic telecommunication engineering that suits for ICT information processing device or any network [9]. Global e-sustainability initiative [10] have assessed that ICT enabled solutions will help world to subsidize 16.5% of global output by 2020. An investigation using different methods is done in [11] on the effects of internet usage and economic growth on CO2 emissions. Here through variance composition analysis it is derived that if there is a continuous increase in the usage of internet then it is obvious that there will be an increase in electricity consumption in future. Hence it is important for OECD countries to maintain the existing measures of controlling CO2 emissions. In [12] green ICT principles are summarized and some key principles that talk about bandwidth and data exchange for reducing the ICT emissions are a) Sending data that is only needed which can save the energy consumption b) Minimizing the length of data path can help to be energy efficient c) Trade off processing for communications by combining data from multiple sources before transmitting and effective compressive sensing will enhance the energy efficiency. It is estimated that global greenhouse gas emissions for communication networks will be 24% by 2020 and the study in [13] also indicated that the footprint of smart phones would exceed the contribution of laptops and desktops.There were lot of compression methods that were explored in previous studies. In [14] a method for lossy image compression based on convolutional neural networks, recurrent neural networks are proposed which outperformed JPEG2000, WebP and BPG. Stop-code tolerant (SCT) approach is introduced in [15] for training recurrent convolutional neural networks for lossy image compression.

Various recurrent neural networks are considered like LSTM and associative LSTM were compared in [16] to introduce a new hybrid GRU showing improvements in AUC (area under the rate distortion curve). An optimized method that has been proposed in [17] has exhibited better rate distortion performance than JPEG and JPEG 2000 compression methods. An evaluation is carried out with different data sets for compressing sensor data based on constant models, linear, nonlinear models and correlation models [18]. These approaches had an additional burden of training the data when compared to JPEG and therefore optimizing the image size without any training is necessary.

Optimization is one aspect that can be considered for reducing the image sizes. There are several optimization methods such a swarm optimization, genetic optimization, cuckoo optimization and grey wolf optimization. A review is carried out on Cuckoo optimization [19] and it is used for game theory and multi-objective optimization problems. Later is it compared with genetic and colonial competitive algorithm [20]. But grey wolf optimization has shown better results when compared to other methods since last few years. Grey wolf optimization is used in various engineering applications such as the design of compression springs with minimum volume, design of castellated beams. These have shown successful results over other methods on using grey wolf optimizer [21] [22].The focus of this paper is to reduce the CO2 emissions by reducing the volume of data exchange over internet of things. The standard jpeg baseline compression algorithm is modified by incorporating grey wolf optimizer to reduce the size of the images and later reduction of greenhouse gas emissions is calculated based on the image compression ratio.

III. METHODOLOGY

The novel GWOICT (Grey Wolf Optimizer for Information and Communication Technology) is proposed by combining JPEG standard compression algorithm [23] and Grey Wolf Optimization [24] to reduce the size of the images while maintaining its quality. In the novel model, the given image is taken as an input and color transformations are applied. Later image is split into 8x8 blocks to perform an optimal calculation and to apply discrete cosine transforms (DCT). The output of DCT is used to perform quantization using grey wolf optimization and finally zig zag scanning is executed to realize an optimal compressed image for transferring it over the network.CO2 emissions are evaluated before and after the reduction of the size in image that aids towards an intelligent enterprise for driving towards sustainability factors. Block diagram shown in figure 1 is used to reduce the size of the images.The below is the novel GWOICT algorithm to reduce the size of images and to calculate CO2 emissions over internet of things.

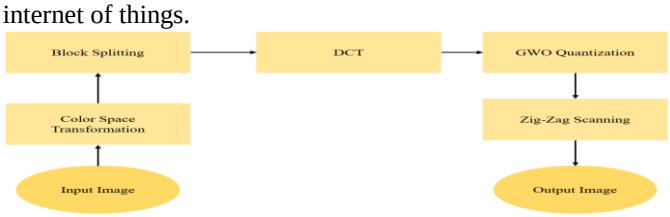

Fig 1: Block Diagram for novel GWOICT to reduce size of Images

// Pseudo Code to reduce size of images and CO2 emissions //

Step 1: Read the image

Step 2: Apply the color space transformation on input image

Step 3: Divide into blocks preferable 8x8 or 16x16

Sept 4: Apply DCT on the blocks obtained in step 3

Step 5: Apply the Gray-wolf optimizer on the quantization to obtain the adaptive quantization

Step 5.1: Set the random positions for the n wolfs in a given dimension

Step 5.2: Find the fitness values for each wolf with given function

Step 5.3: Set α, β, δ values and ω values according to the fitness values

Step 5.4: Update the α, β, δ values and ω values after each iteration

Step 5.5: After all iterations, set the optimized quantization

Step 6: Apply the zig-zag scanning to obtain the compressed image

Step 7: Generate the new compressed image

Step 8: Calculate the ghg emissions for the image obtained in step 7

Step 9: Calculate the percentage of ghg emissions reduced

Step 10: End of Program

IV. RESULTS AND DISCUSSIONS

The GWOICT algorithm that is developed based on jpeg baseline compression algorithtm and grey wolf optimizer is evaluated by providing various images as inputs to reduce the size and CO2 emissions under a constrained envirionment. Initially baboon image is provided as an input to standard jpeg algorithm and a compressed image is obtained with the generated CO2 emissions. Later the same image is provided as an input to GWOICT algorithm where several iterations are exectuted for quantization for α, β, δ and ω until optimized values are realized to have an optimal compressed image with the generated emissions.

CO2 Emissions: CO2 emissions for input and output image are calculated as represented in [25].Here an average of 1 MB data during the total lifecycle, emits 20 grams of CO2 which is equivalent to 0.02 grams of CO2 for 1 KB of data.

Table 1 below represents the average compression ratio that has been realized for jpeg standard compression and GWOICT. Here GWOICT have shown a better compression ratio when compared to standard jpeg compression. Table 2 represents the CO2 emissions generated by each method and there is a fifty percent reduction of CO2 emissions in novel method when compared to standard jpeg compression.

V. CONCLUSION

Due to the exponential growth of digitalization in enterprises, there is extreme need for focusing on sustainability aspects and Information Communication Technology (ICT) sector to reduce the greenhouse gas emissions.

Due to this digitalization there is a lot of data exchange in internet of things which results for higher demand of bandwidth over the network. In this paper an attempt is made to reduce the CO2 emissions over IoT by reducing the size of the image before the transmission over the network. From the above results, there is reduction in CO2 emissions over the IoT for achieving Green IoT. In future, security issues can be added for secure transmission of data in view of making enterprises to intelligent enterprises by addressing sustainability aspects.

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Table- I: Image Sizes and Compression ratio

Algorithm	Name of Standard Image	Input Image (original size)	Output Image (compressed size)	Compression Ratio
JPEG (Standard)	Baboon	258 kb	25 kb	10:1
GWOICT	Baboon	258 kb	13 kb	20:1

Table- II: CO2 Emissions reduction comparison

Algorithm	Name of Standard Image	Emission with original size	Emission with compressed size
JPEG (Standard)	Baboon	5.16	0.50
GWOICT	Baboon	5.16	0.26

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