Water meter Bill generation through Image processing using CNN

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***Abstract* — Most important and need of the hour issue is water conservation and water pollution. As the whole world is suffering from its population growth and worst water pollution problem due to its industrial growth. So to tame the over usage of the water, water meters are playing the vital role and maintain the streaming of the process. Many studies show that the water usage can be controlled by charging the money for the water usage. Many advanced countries setup the water meters on almost 90% of their usage taps, due to this there is a drastic saving of water can be seen. In most of the model water readings are collected manually and then water meter bills are generated. So to automatize this process, proposed model uses the technique of automatically collecting the meter reading for the given stipulated period using the cameras on mechanical water meters. Then by using the Deep convolution neural network and correlation process to identify the reading numbers in proper way and thereby to generate the water meter bills automatically. This generated water bill is then delivered to the respective consumer via text message.**

Keywords - Convolution Neural Network, Image Normalization, Pixel correlation ratio., Bill generation.

I. INTRODUCTION

Water is one of the most essential elements for the survival of not only humans but also a lot of other mammals and most of the living creatures. Water is the elixir of life and is also a necessity for economic development of a particular area. This is evident from the fact that most of the early civilizations were formed around the banks of rivers, such as the Indus Valley Civilisation and the great Egyptian Empire, all of which were formed and thrived due to being very close to a source of fresh water.

About 70% of the Earth is covered with water which is quite good for the collective species that require the water, but out of this only 2% of the world's water reserves account for Fresh or potable water. This is an exponentially small number for a whole planet worth of species, but it will be enough if we use it sustainably. Most of the fresh water resides in the rivers, lakes and the glaciers. This uneven distribution of water has led to humans constructing dams and other reservoirs for the purpose of storing and transporting water to the settlements.

The ability of humans to effectively transfer water over long distances has led to the dispersion of the human race from the banks of the river to the corners of the planet, a man was not bound to the river for the source of water, it could be transported across to various corner with the help of pipes. This was really helpful until there was an immense increase in the demand for fresh water due to the rising population, this also led to an increase in the pollution and a decrease in the amount of available water.

Water is a highly precious resource that is intangible and needs to be preserved, but while transferring the water from the water sources, the pipelines are prone to pollution and leakages that can reduce the amount of water and cause excessive water wastage, which can quickly deplete the water resources. Therefore, there is an utmost need for the conservation of water at a global scale and reduce the water wastage to ensure a sustainable solution is found for the rising water epidemic.

Loss of water through the pipeline can be gauged through installing a water meter and analyzing the flow of water and also the volume that is being reduced throughout the journey. It is a very simple yet effective method to keep track of the wastage of water through a water meter that can calculate the water being released on one end and the water being received on one end, the difference is capable of providing the water lost during transit.

Water meters are extremely useful and can help identify the leaks in the transport system. This can help plug the leaks to ensure very less percentage of the freshwater salvaged gets wasted. This is highly useful and as the citizens of this planet, it is our responsibility to use water cautiously and conserve this natural resource. It is pretty simple and straightforward to maintain a water system leak proof with the help of a water meter as it can indicate if there is a disparity or a loss of

volume very easily. But, a water meter cannot be monitored continuously by a person, therefore there is a need for a system that can achieve this level of monitoring.

Optical Character Recognition also usually abbreviated as OCR. Optical Character Recognition defines the act of recognizing a character optically and also the technology that enables this kind of process. therefore, Optical Character Recognition is one of the most ingenious inventions, which can be used to identify the characters from a handwritten or printed image of physical or scanned documents. The Optical Character Recognition is responsible for the translation of the physical characters present in the image to meaningful, actual characters the computer can understand and work with.

This process of translation requires the combination of both hardware and software as the physical contents of the document need to be captured with the help of an Optical scanner or a camera and the software part that is used for the accurate recognition of the text and translation. This is a quite difficult process and can be implemented with higher accuracy if combined with capabilities of better computation, such as Artificial intelligence.

Convolutional Neural Networks are a subset of Neural Networks or Artificial Neural Networks. They are derived from the ANN's and are basically a type of Neural Network, which is a network that is designed to mimic the workings of a human brain. As the human brain is one of the most useful organs in the body, the seat of knowledge and our conscience, the Artificial neural networkutilizes the most basic unit cell of the brain, the neuron, and medals a network based on layers upon layers of neurons.

These layers are modeled in a fashion that the output of one layer of complex and numerous neurons is the input for the next layer. Convolutional Neural Networks are a class of artificial neural networks that are highly useful and have been extensively used in the field of image processing, due to the convolutional part of the neural network, they are excellent for the purpose of image classification and processing.

This research paper dedicates section 2 for analysis of past work as literature survey, section 3 deeply elaborates the proposed technique and whereas section 4 evaluates the performance of the system and finally section 5 concludes the paper with traces of future enhancement.

II. LITERATURE SURVEY

This section of the literature survey eventually reveals some facts based on thoughtful analysis of many authors work as follows.

S. Kashid states that the lack and misuse of fresh water are detrimental to the fast development of the city. Thegrowth in population and unbalanced supply of the water resources are facing problems of water scarcity and this scarcity can be increased day by day. To improve this management the government has taken some strict action regarding this and their taken help of technical sophistication of meters for measuring water flows[1]. In the proposed methodology image processing techniques are used to capture the images reading using DSP processor.

J. A. Hernandez explains that the most important things to be done immediately before a disaster occurs is the deployment of devices enabled by IoT (Internet of Things).There are several national disasters that flood is one of the most dangerous since they have enough destructive power to change the course of rivers, sweep away and destroy whatever is in their path. A sensor is located at Riverside which transfers information from a water level sensor which is transmitted via Wi-Fi to a laptop, then this information is also seen in smartphones, where users can see the water level in rivers

R. Ortega-Palacios[3] elaborates on the information regarding the blood flow meter. The flow of meter is completely based on the traveling time from port to port or from one end to another end by using the two ultrasound transducers or the reflector; due to this, we can measure the flow of blood. This measuring is completely done with the upstream and the downstream ultrasound in transit time. Thus, the Authentication is based on the norm ANSI Std. N42.17A-2003 of blood flow protocol. The blow meter is one of the important researches because of blood flow the heart works.

A.Riano explains that the annular pipe flow or core annular flow are two immiscible liquids with a very different thickness which has very low cause for mass production and it is efficient. In proposed methodology oil holdup is resolved by using the image processing and it is later compared with the results calculated by the correlation available in the literature. [4]The result of the proposed methodology is later compared with the data and the prediction which are available. The best method for hold calculation is a mathematicalmorphology in a segmentation.

Wenhong Wu develops a long range andcentralized automatic metering for a water meter as a system, the function of GPRS is network-based it is not USB connector it has the signal chip C8051F340 single chip microcontroller.[5] This system requires administering the computer data collector, concentrator and the water meter to measure the water level. The water flowing through water meter will be connected it gives the value in pulse format is collected by the water meter.

B. Shakmak[6] Water scarcity is one of the emerging problems around the globe and intensified by population growth, pollution, severe droughts, over-exploitation of groundwater, and uneven distribution of water resources across the globe. A significant amount of water is lost on a daily basis through broken and leaking pipes. This paper investigates and detects water leakage in remote countries by using the infrared system's resolution by giving low and high values. Thus, the aim of the author is used to detect the leakage in pipes remotely. Water leakage detection problems can be solved by using the water meter process.

O.Masia expresses the growing problem of water scarcity and also there is growth in demand for providing the good quality of water to the public it is hard to deliver essentialutilities to urban areas.There is an application technique to obtain water from the river in Gauteng municipalities. Water Conservation and Water Demand Management (WC/WDM) in municipalities help to focus on the work. [7] Prepaid metering, AMR and some smart metering are already deployed in Gauteng and it indicates a potential for growth in the use of smart metering technology. Smart metering technology and metering technology, in

general, can and have reduced water scarcity that also reduces apparent or commercial losses.

S.Kashid introduces that the misuse of fresh water and scarcity of water creates a threat in sustainable development. Uneven Distribution of water, severe droughts, and the growing population are some of the main reasons for water scarcity. [8] In the proposed paper the author explains simple image processing techniques for anintelligent metering system.DSP processor and simple image processing algorithms are used in this system for reading the meter. At the very first stage, the image is captured from the water then it sends to the proposed algorithm for detection and for a meter reading. In this way, they reduce the consumption of water.

A. Manoharan expresses that water is one of the basic needs of human life. For daily usage, the water is supplied from dams or from the water tanks which used to store the water for the future. Water gets polluted due topollution from the environment. [9] The proposed methodology continuously monitors the water from all the tank and this distribution of the water can be done from a single place. For motoring and distributing the water for a different place can be done only by using the smart meters.

E. Mudaheranwa states the importance of solar water by using the smart energy management solution increases because self-consumption reduces electricity bills. Consuming and saving energy day by day is one of the major issues these days.[10] The main objective of the proposed methodology is to save energy and reduce power consumption.The energy meter is used to measure the cold and hot water temperature, andenergy usedis calculated by the meter and it sends the bill to the consumer and prepares the bill.

S. Botha expresses that till 2020 South Africa may experience a serious problem regarding the shortage of water as the demand for water is increasing day by day. Measurements from flow meters allow the water utility to make day-to-day decisions and long-term planning for the future.[11]The designed module can be implemented on a standard water pipe at residential areas. The developed system harvests energy using a solar panel.

M.Jha[12] introduces Smart Water Monitoring System (SWMS) for real-time water quality and usage monitoring. It consists of two parts: Smart Water Quantity meter and Smart Water Quality Meter. 70% of Earth's surface is covered with water, fresh water is less than 2% of the total volume. With population growth increasing at a tremendous rate, the human community has begun to face the wrath of water scarcity. This method can also be used to assume the water usage for individual users, based on their past data.

Z.Zi-Han proposes Bluetooth and GPRS technology for reading the power meter. This system is not only used in the electricity sector but also provides a technical solution for the water meter reading, gas meter reading, smart home and security [13]. With the rapid development of the power industry, the traditional manual meter reading technique is more and more unsuited to the development of society. in order to avoid the failure of automatic meter reading because of the communication line fault, the system can also use a hand-held device with the manual meter reading.

III PROPOSED METHODOLOGY

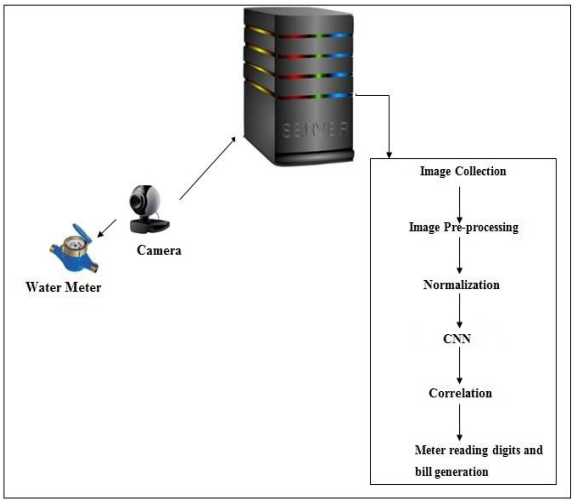

Figure 1: System Overview

The Overview of the proposed methodology for water meter bill generation can be seen in the figure 1. The steps involve in this process are deeply narrated in the below mentioned steps.

Step 1: Setup and Image collection - The proposed model of water bill generation is set up using a mechanical water meter of Global brand. Then this water meter is fixed on strong platform to make it run as needed by the experiment. An external web camera is setup in front of the water meter to view the reading in clear visibility of the light. This external web camera is connected to a laptop so that the image of the water meter can be taken at the said time.

To capture the image from the camera Java media File API is being used, This trigger the camera to grab a frame using the Frame grabbing control mechanism to extract the image and store into a desired format of JPEG.

Step 2: Image Normalization - The collected image is subjected to normalization process where every collected image is set to normalization process by comparing with a one selected model image that had given best reading of water meter.

To normalize the current image according to the model image firstly mean of RGB color channel is estimated for the model image and the current image. Then a difference in the mean for Model image and the current collected image is being estimated. The obtained difference of RGB is then applied to the current image to normalize it according to the model image. This process eventfully enhances the current reading image in brightness according to the model image, which helps the model to learn the system more accurately using the Convolution neural network in the coming steps. These steps can be shown in the equation of 1 and 2.

$$\mu = \frac{(\sum_{i=1}^{n} RGBi)}{n} \qquad \text{_____(1)}$$

Where
μ - Mean of the RGB
RGB_i - RGB of instance pixel

n - Number of pixels in the image

$$\int_{i=0}^{n} RGBi + (\mu m - \mu f) \quad \text{_____(2)}$$

Where

μ_m - Mean of the RGB of model image
μ_f - Mean of the RGB of current image
RGB_i - RGB of instance pixel
n - Number of pixels in the image

Step 2: Convolution Neural Network - First Layer- The normalized image is considered to perform the first layer of the Convolution neural network. In this step the collected image is set to estimate the red color pixel positions from the TOP and from the left. This is because the reading of the water meter contains in the red pixels.

This step is performed by traversing the image from the top and from the left to identify the pixel reading position and then mark them as the region of interest. This can be shown in the algorithm 1.The figure 2 shows the water that was used in the experiment.

Figure 2: Sample of Water meter used in the experiment

ALGORITHM 1: First Layer for region of interest estimation

// Input: Normalized Image N_{IMG}
// Output: Coordinates X,Y
function: getCordintes(N_{IMG})
1: Start
2: count=0
3: ***for*** i = 0 to size of Width of N_{IMG}
4: ***for*** j=0 to size of Height of N_{IMG}
5: $P_{SIGN} = N_{IMG(ij)}$ RGB
6: R= P_{SIGN} >> 16 & H_D
7: G= P_{SIGN} >> 8 & H_D
8: B= P_{SIGN} >> 0 & H_D
9 : ***IF*** (R>80 AND G<50 AND B<50)
10: count++
11: ***End for***
12: ***IF*** (count>0), ***THEN***
13 X=i
14 Y=j
15: ***BREAK***
16: ***End for***
17: **return** (X,Y)

Deep Layer CNN - Once the coordinates for the reading are identified, then these coordinates are used to extract a sub image that contains only readings. This sub image is again cropped for each of the digits of the analog reading. These cropped images are subject to estimate the ratio to its full length and width with respect to the number position. And this ratio is then stored in array to evaluate the correlation between the stored numerical images.

Step 3- Correlation - The ratio array evaluated in the last step is subject to correlate with the stored numerical images. For the stored images which contains the number is also set to estimate the ratio array. Then these two ratio array is used in the Pearson correlation estimation technique, where a correlation between the cropped numerical image and stored numerical image is evaluated to identify the reading of the water meter. This correlation estimation using Pearson equation is given in the equation 3.

$$r = \frac{\sum xy - \frac{\sum x \sum y}{n}}{\sqrt{(x^2 - \frac{\sum x^2}{n})}\sqrt{(y^2 - \frac{\sum y^2}{n})}} \quad \text{_____(3)}$$

Where
x is the ratio array of Cropped image
y is the ratio array of trained stored image
n is the array Size

Step 4- Bill generation - Once the current reading is extracted, then the past reading of the user is used to get the difference. Then a bill is generated to intimate the consumers via a text SMS.

IV RESULT AND DISCUSSIONS

The proposed methodology of water meter bill generation through water meter image is being set up using the window based laptop and an external web camera. The Laptop is equipped with a processor of Intel Core i5 Processor and 6GB of primary memory. For the development purpose model uses the Java programming language through Netbeans as the IDE and Mysql as the database server. The model uses to Java media files Plug-in and API for capturing the live images of water meter. The model is tested in some circumstances to measure its effectiveness as mentioned below.

To measure the error rate in the precision of the system, proposed model uses Mean absolute error (MAE). MAE is the difference between the two continues entities, in our experiment the two continue entities are proper detection of reading and improper detection of reading. To evaluate this the model conducts 5 experiments. Each of the experiments involves 10 trails. The recorded results can be shown in the table 1. The MAE can be estimate using the following equation 4.

$$\text{MAE} = \frac{(\sum_{i=1}^{n} | xi - yi |)}{n} \quad \text{_____(4)}$$

Where,
xi - Number of trails
yi - Number of proper reading
n- Number of Trails

Experiment No	No Trails in an Experiment (xi)	No of proper reading(yi)	xi-yi
1	10	8	2
2	10	6	4
3	10	4	6
4	10	7	3
5	10	7	3
		MAE	3.6

Table 1: Mean Absolute Error Reading (MAE)

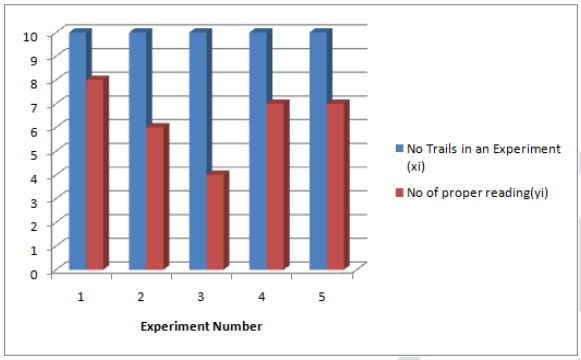

Figure 3: MAE performance

On observing the table 1, it clearly comes to know that the obtained MAE of 3.6 is low and this value denotes the accuracy of the proposed model is indeed a better results in the first trail of water meter bill generation through image processing.

V CONCLUSION AND FUTURESCOPE

To curb the time consuming process of water meter bill generation the proposed system involves a technique of reading the water meter through the web camera. And thereby capture the image of the water meter from the web camera on said interval of time and then use this image to get the current meter reading. Proposed model uses the Image normalization process to enhance the quality of the image to feed the image to Convolution neural network. The CNN yields the ratio array of the water meter reading that is utilized in the correlation estimation through the Pearson correlation scheme. Through this method current meter water reading is evaluated to compare that with the previous readings to generate the bill amount. This bill amount will messaged to the respective consumer via text SMS.

In the future this model can be implemented in real time for all kinds of water meters. And also a panel for the consumer can be provided using a mobile app to view all the past bill details along with the captured image.

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