iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** VI **Month of publication:** June 2023

DOI: https://doi.org/10.22214/ijraset.2023.54438

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VI Jun 2023- Available at www.ijraset.com

Automatic Meter Detection and Recognition: A Robust Approach Based on Image Processing Techniques

Unnati Maheshwari[1], Kundan Kumar Singh[2]
Computer Engineering Department, NMIMS University

Abstract: To address the issue of manual reading, Automatic Meter Reading (AMR) is introduced, which is a combination of detection and recognition that is efficiently applied to identify the meter and accurately read the digits on electric meters. The initial step in meter detection is the collection of the dataset, after which the annotation process generates XML files that are converted to CSV files and the label map is generated. Using a pre-trained classifier SSD ResNet, the model is trained and evaluated. The identified photos are used as input meter images in meter recognition, where a sequence of pre-processing techniques is performed. After which, using tesseract and leptonica, a model is generated from source, and digit recognition is conducted. The accuracy of 95.45% is then generated after training and evaluating on 2000 images of different kinds of electric meters in various surroundings.

Keywords: Automatic Meter Reading, Meter detection, Meter recognition, Image processing

I. INTRODUCTION

The impact of electricity on our lives cannot be overstated. As the demand for electrical power continues to rise, we have become increasingly reliant on technology for a wide range of purposes. The transition from traditional meters to automatic meters has been made possible by advancements in digital technology, wireless connectivity, and computer systems.

Electric meters are currently installed in all homes, offices, and other structures to monitor electricity usage. However, the current method of manually reading these meters by a representative of the Electricity Board has led to various problems for consumers, such as incorrect or missed readings. These errors are often the result of human operator error or difficulties in accessing the meter. Traditional manual meter reading is also inefficient, as it consumes both labour and energy, resulting in high costs and low productivity. In light of the rising population and industrialization in countries like India, this proposal suggests a more efficient method for meter reading to ensure reliable service with minimal operational costs. By addressing the issues associated with traditional manual meter reading, this proposal aims to improve the accuracy and punctuality of electricity billing and make it more convenient for the consumers. A meter recognition system that can identify the meters and, as a result, recognize the digits in the face of several challenges, such as the uncontrolled outside environment in which the images are obtained and the cluster of alphanumeric data surrounding the meter reading. This project proposes to build an image processing-based solution for acquiring reliable and accurate readings of various kinds of electricity meter in different environments. This helps to reduce labor and energy consumption, increasing productivity and minimizing costs. This work contributes by assisting in the reading of the precise consumption of electricity from the meters in kilowatt hour (kWh) of the Indian electric meters. As a result, this will aid in the development of a meter detection and recognition system that adds value while meeting the client's requirements.

This research paper proposes a more unique approach to Automatic Meter Reading. This project is divided into two parts: meter detection and meter digit recognition. Meter detection will first check for the presence of a meter before proceeding to the second stage. The method of meter digit recognition involves identifying the digits displayed on the meter, after which the result is given. Utilizing the existing image processing techniques, this strategy proves to be advantageous.

In [1], an application is developed with the aid of MATLAB that allows a customer to take the meter reading at their home without the requirement for a human to manually take the reading. The suggested approach in [2] by Abdullah Azeem et al., Mask RCNN successfully recognises all digits in all images and achieves the highest accuracy on the UFPR-AMR benchmark. [3] presented a unique approach based on SVM, an effective classifier utilised for both digit detection and recognition. In order to reduce the mean absolute error, [4] proposes a method that combines a detection model with a new regression technique to allow error correction among the most relevant dials.

II. LITERATURE REVIEW

This portion (Table 1) gives us the summaries of the papers which were reviewed.

TABLE I: Literature Review for Meter Detection and Recognition

Citations	Description	Results	Future scope
[1]	An image acquisition device, such as a camera is installed, and captures real-time images of the meter readings. The image is first analysed, segmented, and the recognized digits are identified using the learning technique called Support Vector Machine (SVM).	As the number of features increase, the accuracy increases too	Usage of highly advanced image processing methods and feature learning algorithms will help achieve greater performance than this system.
[2]	A conventional meter, ZigBee modules, and a serial camera unit are all integral units required to make a prototype for an AMR system. The camera takes images of the meter reading and sends it to the server with the help of Zig-Bee module. The image further goes through the following stages such as segmenting of the digits, recognition of individual digits, and finally the reading process, which will be required to make the bill.	No results were mentioned, only the extracted picture of the digits was shown	Not mentioned
[3]	In this technique, mobile phones are used to capture the images of the electric meter. A series of image processing methods are applied to the system to accurately extract and recognize the numbers from meter.	Accuracy rating of 96.49% (per number digit) and accuracy rate of 85.71% for the readings taken from the electricity meters.	In order to improve the system to recognize the reading of a variety of meters in Saudi Arabia, to improve the accuracy, and develop an application for the employees of the company who use the system to support the reading process are all goals that need to be accomplished.
[4]	The paper proposes AMR modelled using a convolutional network multi-box model.	In addition to training more efficiently and using lesser epochs than the methods used as a baseline, the suggested method demonstrates an accuracy of 96%.	After the text that has been discovered has been segmented, character recognition methods are applied.
[5]	An algorithm is described for extracting and determining numbers from Qatari license plates and issuing appropriate tickets.	Using the difference between the four quadrants, the digit is determined. (No specific metric is employed)	Future objectives include the development of an algorithm that can deal with both forms of Qatari license plates, the research of the influence of noisy data in which license plate photos are hazy, and the evaluation of the system's efficiency.
[6]	This study provides a technique for segmenting series numbers from an electric meter using the VEDA method and compares its accuracy to that of the Sobel operator.	Displays accurate edge recognition capabilities with a success rate of 95% and increased efficiency than Sobel by a factor of five to nine times.	The proposed system has been fine-tuned to identify images in a various lighting background and with relatively lower resolution and blurry photos taken in different surroundings.
[7]	The images are binarized using thresholding, a projection approach is utilized to find the target areas, features are retrieved, and a backpropagation neural network is used to automatically read the numbers, all of which contribute to a high recognition accuracy rate.	The recognition accuracy can surpass 94%.	Challenges: The discriminating accuracy rate will decrease if the quality of the target image can hardly be assured. Since real-time control is not a concern in this system, model training speed has not been improved.
[8]	The technique of reading the values of an electrical meter begins with the use of a camera that captures an image of the meter, then MATLAB is used to recognize the numbers, and finally, the output of the digits recognized are saved in a text file.	Results are not mentioned in the paper	In the long term, the app could allow the user to monitor their consumption. Additionally, the application might be used to generate an amount based on the differences in the consumption units between two consecutive months.

[9]	The ideal solution is a combination of YOLOv4 and a unique regression methodology (AngReg) which investigates various post-processing strategies.	A meter recognition rate (MRR) of accuracy 98.90% — with a 1 Kilowatt-hour error tolerance (kWh).	Overall, the goal is to create a rejection system that will automatically request new image samples if the ones submitted were badly captured. Use Generative Adversarial Networks (GANs) to create more diversified training samples, preferably with pointers pointing in a balanced distribution across all possible directions, which will help in decreasing bias by restoring a more even distribution of labels to each class.
[10]	It has been presented in this work how to implement an independent watt meter reading system. Image segmentation and character recognition to read the numbers displayed on the watt meter in real time, with significant efficiency and low error rates will be the main goals to be accomplished.	No metric as such is used	Future software updates will allow the system to be utilized with other data-gathering devices, such as smart water meters and gas meters.
[11]	The impact of various digital screen appearances, different camera angles, and environmental intrusion can be counteracted by using a meter-reading technique that uses deep learning image improvement.	Meter with LCD Display: Accuracy- 86.90% Meter with Counter Display: Accuracy- 90.32%	The results of research can be used to recognize electric meter numbers on the phone in real time, in addition to executing image-based automatic meter reading operations reliably and consistently.
[12]	Mask RCNN (AMR) is an automatic number recognition system that uses mask region convolutional neural networks (Mask-RCNN) to detect counters, segment digits, and recognize numbers.	Mask-RCNN (AMR) F-Measure: 100% Recognition Accuracy: Counter Detection- 100% Digit Detection- 99.86%	Not mentioned
[13]	The research describes how data from a dispersed substation's local meter readings can be sent to the hub via an electronic data highway. Further, other operations including preprocessing, segmentation of the digits, and pattern matching are performed, yielding in the digits getting recognized.	(No accurate number mentioned in the paper)	In the long term, electric parameters can be estimated by meter images. The situation's status, such as security issues, HV equipment complications, and fire emerging can also be diagnosed by examining the image.
[14]	A new framework for digital electric meter reading recognition is provided in this paper. The technique is Horizontal and Vertical, in which the pattern is calculated from single digits.	Correctly detected reading region - 96.3% Correctly segmented individual digits - 94.1% Correctly meter reading recognition - 94.1%	(Not mentioned)

III.METHODOLOGY

The paper consists of the following steps listed below:

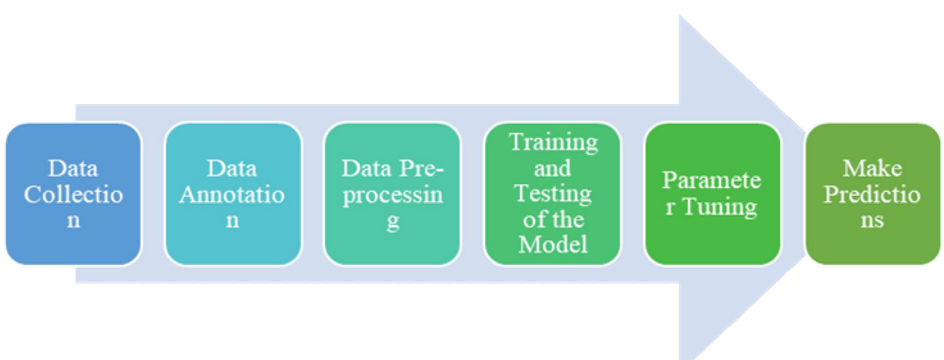

Fig. 1: Proposed meter detection and recognition framework

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VI Jun 2023- Available at www.ijraset.com

The proposed framework for meter detection and meter recognition is shown below:

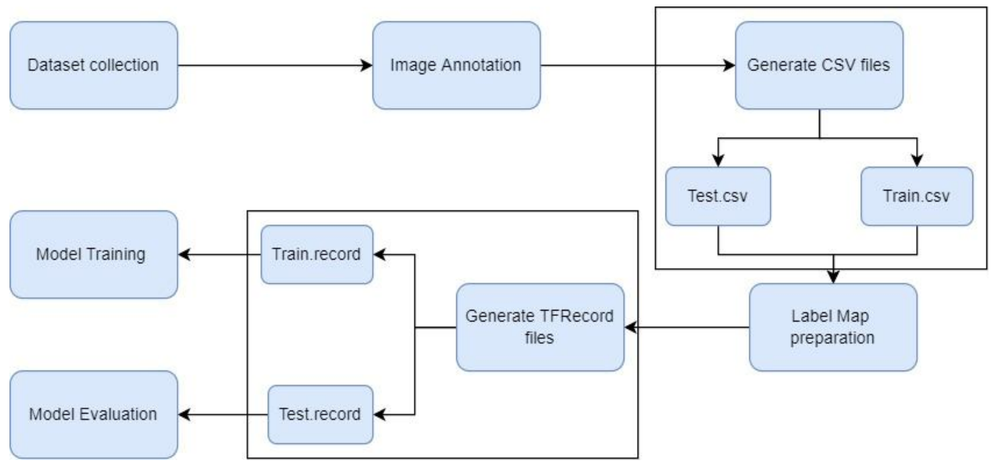

Fig. 2: Proposed block diagram for meter detection

The workflow of the meter detection model can be given as:

1) After gathering the dataset received from the client themselves, the images are compressed and resized for storage, thus degrading the overall performance.
2) The target area is labelled in the training dataset and given the desired label name and thus generating XML files.
3) The CSV files are generated from the XML files.
4) The same label name is then used in the label map preparation.
5) The TFRecords are generated using the CSV files.
6) The train.record file is used in training the model which is done on a pre-trained classifier and the test.record file is used in evaluating the model on the same classifier.

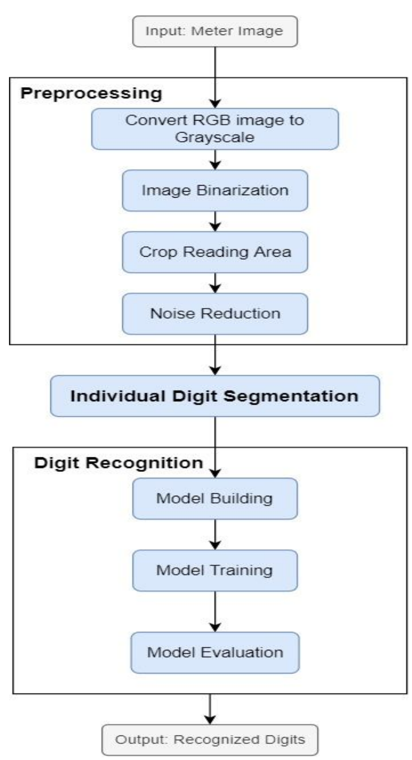

Fig. 3: Proposed block diagram for meter recognition

The workflow of the meter recognition model can be given as:

1) The meter image is used as an input and converted to grayscale image.
2) In the next step, the image is converted into a binary image, for this a threshold function is used.
3) Later, the binary image is processed to crop the metre reading portion.
4) Because noise could arise on the image after binarization, a noise reduction method must be implemented after trimming the reading region to reduce the noise.
5) The digits are segmented using the findcontour and minarearect function.
6) The segmented digits then undergo the process of digit recognition.
7) The model is built from source using tesseract and leptonica.
8) The model is then trained and evaluated and the parameters are tuned accordingly.

IV. RESULTS AND ANALYSIS

A. Proposed Method for Meter Detection

For meter detection, the steps are discussed in detail below:

1) Data Collection

The images are received and are compressed and resized for storage, thus reducing their overall quality.

2) Image Annotation

To boost efficiency, photos are manually annotated using the LabelImg software. The annotated files are saved as XML files in the PASCAL VOC format.

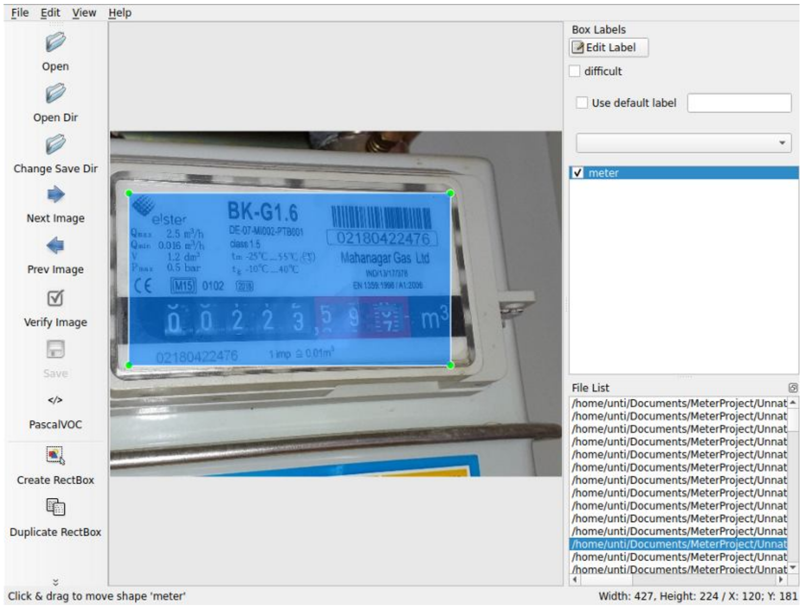

Fig. 4: Image Annotation

3) Generate CSV Files

Since the model is unable to process XML files as input, the files are then converted to CSV files, this is done to make sure the labelling is done correctly to avoid faults later.

4) Generate TFRecord:

The CSV files are converted to TFRecord files since in this format it is easier and faster to process and load during the training phase.

5) Labelmap Preparation:

The output labelmap.pbtxt file which is generated at the end translates each object class label to an integer value and is used in both the training and detection stages.

```
item {
    id: 1
    name: 'meter'
}
```

Fig. 5: Labelmap Preparation

6) Training the Model

The pre-trained model chosen is SSD ResNet model, since it provides a relatively good trade-off between performance and speed. After every iteration, the checkpoint files are generated periodically to evaluate the performance of the model. In each iteration, the classification loss, regularization loss, localization loss, total loss and learning rate is calculated after 100 per-step time and the total loss is calculated in the end.

7) Evaluation the Model

The model is evaluated on the same pre-trained model as the training model and the results are obtained. The evaluation process uses the checkpoint files created by the training model and evaluates how well the model performs in detecting objects in the test dataset.

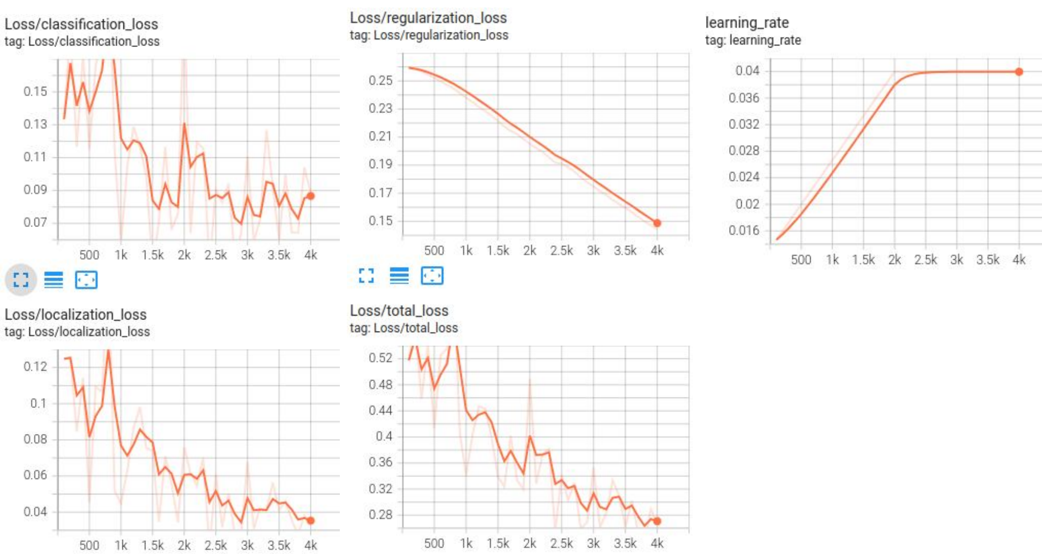

Fig. 6: Loss Metrics

B. Proposed Method for Meter Recognition:

For meter detection, the steps are discussed in detail below:

1) Pre-processing:

After the meter is detected successfully, meter recognition takes place to recognize the digits on the detected meter images, the steps for the same are discussed in detail below-

Fig. 7: Original Meter Image

2) Convert RGB image to Grayscale:

In this technique, RGB to grayscale conversion is used to simplify meter extraction and boost processing performance. The RGB to grayscale conversion technique is used to convert a colour image (RGB) captured by a digital camera to a grayscale image.

The following equation depicts an optimal strategy for converting RGB to grayscale:

Lu = 0.299 * R + 0.587 * G + 0.114 *B

Here, Lu stands for luminance.

Fig. 8: Grayscale Image

3) Image Binarization

A binary image is created from the grayscale image produced by the previous stage (Black & White). In all the stages of the model, this conversion is the most crucial. However, the grey intensities in the input images to the model system are frequently distributed unevenly, or all of the intensity values may fall within a narrow range. Therefore, it is essential to employ a successful binarization methodology; otherwise, the method would fail to accurately extract the digits in the meter.

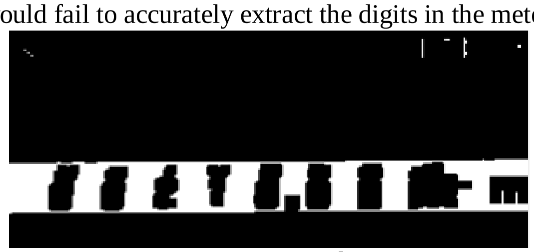

Fig. 9: Binarized Image

4) Crop Reading Area

In this step, the binarized image is processed to crop the part that has the meter reading only. The findcontours and boundingrect function are used to detect the region of interest, in our case it is the digit region in the meter. In this procedure, the image is scanned for locations with a dense concentration of white pixels. This region is identified, a green pixel border is placed around it, and the image is then cropped.

Fig. 10: Cropped Reading Area

5) Noise Reduction

After binarization, noise may still show on the image, so a noise reduction method must be used to remove the noise. Morphological operations including dilatation, erosion, closing, and opening are used on the cropped meter image.

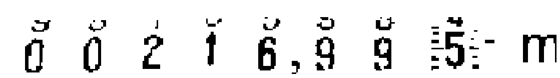

Fig. 11: Image After Noise Removal

6) Individual Digit Segmentation

In order to process each digit for identification, this step entails separating the digits. The cropped binarized image is provided as the input for this phase, where dilation which is a morphological operation is applied on the image to make the digits thick which will make it easy to find the appropriate contours. After which the digits are found using findcontour function and lastly the detected contours are segmented using minarearect which gives the minimum rectangular region. Finally, the digits are segmented and stored for the next step.


Fig. 12: Segmentation Process


Fig. 13: Segmented Digit

7) Digit Recognition

OCR (Optical Character Recognition) transforms a two-dimensional image of text, that could contain machine printed or handwritten text from its image representation into machine-readable text. Pytesseract, sometimes known as Python-tesseract, is a Python-based OCR application that wraps the Tesseract-OCR Engine. It can read and recognise text in photos and is utilised frequently in Python OCR image to text use cases.

8) Building the Model

The model is built from source, for this we make use of leptonica which helps build the tesseract model and gives the result for training of the model. In order to train the tesseract model, certain dependencies need to be installed. Here, we use the segmented images as input and convert them into .tiff files and create their respective .txt files, since the tesseract model does not accept jpeg files. We divide the .tiff and .txt files in the ratio of 80:20 for training and testing.

9) Training the Model

After this, the training of the tesseract model will begin and the checkpoint files for every 100 epochs will get generated and saved in the directory. At every iteration, the mean rms, delta, skip ratio will get generated. Lastly, the collective error rate and accuracy for every iteration in the training data will get generated in the end. The dataset gave an accuracy of 95.45%.

10) Evaluation of the Model

The model is then later evaluated with the help of the checkpoint files created in the training model and evaluate the test images.

V. CONCLUSION

This research paper proposes a novel digital recognition of electricity meter based on machine learning. For a variety of electric meter types, the proposed technique can yield satisfactory recognition accuracy. (1) A meter detection and recognition approach based on machine learning is used to apply to different types of electric meters in various surroundings; (2) an image enhancement and digital recognition method is utilised to detect the digits of electric meters while minimising environmental interference. Since the meter recognition system uses a computer vision technology, accuracy has increased which is 95.45%, as the system is robust to operator weariness or lack of knowledge, and costs have decreased as a result of both these factors. An easy way to comply with IJRASET paper formatting requirements is to use this document as a template and simply type your text into it.

REFERENCES

[1] S. Jaiswal, A. Prajapati, N. Shirodkar, P. Tanawade and C. Gala, “Electricity meter reading based on image processing,” International Journal of Engineering Science and Computing, vol. 7, no. 4, pp. 11189–11190, 2017.

[2] A. Azeem, W. Riaz, A. Siddique and U. A. K. Saifullah, "A Robust Automatic Meter Reading System based on Mask-RCNN," 2020 IEEE International Conference on Advances in Electrical Engineering and Computer Applications (AEECA), Dalian, China, 2020, pp. 209-213, doi: 10.1109/AEECA49918.2020.9213531.

[3] C. P. Edward V, "Support Vector Machine based automatic electric meter reading system," 2013 IEEE International Conference on Computational Intelligence and Computing Research, Enathi, India, 2013, pp. 1-5, doi: 10.1109/ICCIC.2013.6724185.

[4] Gabriel Salomon, Rayson Laroca, David Menotti, “Image-based Automatic Dial Meter Reading in Unconstrained Scenarios”, Measurement, Volume 204, 2022, 112025, ISSN 0263-2241, https://doi.org/10.1016/j.measurement.2022.112025.

[5] M. Shinde and P. Kulkarni, Reading of Energy Meter based on Image Processing Technology, International Journal of Electronics Communication and Computer Engineering, Volume 5, Issue (4) July, Technovision-2014, pp. 1-5.

[6] L. A. Elrefaei, A. Bajaber, S. Natheir, N. AbuSanab and M. Bazi, "Automatic electricity meter reading based on image processing," 2015 IEEE Jordan Conference on Applied Electrical Engineering and Computing Technologies (AEECT), Amman, Jordan, 2015, pp. 1-5, doi: 10.1109/AEECT.2015.7360571.

[7] Iqbal, Arif & Basit, Abdul & Ali, Imran & Baber, Junaid & Ullah, Ihsan. (2021). Automated Meter Reading Detection Using Inception with Single Shot Multi-Box Detector. Intelligent Automation and Soft Computing. 27. 299-309. 10.32604/iasc.2021.014250.

[8] Shuo, Hong & Yu, Ximing & Donghang, Lv & Shaoli, Li & Yu, Peng. (2019). Digital recognition of electric meter with deep learning. 600-607. 10.1109/ICEMI46757.2019.9101443.

[9] Granger, H., Chanchad, R., & Razak, S., License Plate Number Detection Algorithm for Qatari License Plates, 2012, pp.1-6.

[10] Parthiban, K. & Palanisamy, A.M.. (2013). Reading values in electrical meter using image processing techniques. 2013 International Conference on Intelligent Interactive Systems and Assistive Technologies, IISAT 2013 - Proceedings. 1-7. 10.1109/IISAT.2013.6606430.

[11] Bai, Qiushi & Zhao, Limeng & Zhang, Yunzhou & Qi, Zixin. (2010). Research of automatic recognition of digital meter reading based on intelligent image processing. 10.1109/ICCET.2010.5486243.

[12] Shutao Zhao, Baoshu Li, Jinsha Yuan and Guiyan Cui, "Research on Remote Meter Automatic Reading Based on Computer Vision," 2005 IEEE/PES Transmission & Distribution Conference & Exposition: Asia and Pacific, Dalian, China, 2005, pp. 1-4, doi: 10.1109/TDC.2005.1546972.

[13] D. Shu, S. Ma and C. Jing, "Study of the Automatic Reading of Watt Meter Based on Image Processing Technology," 2007 2nd IEEE Conference on Industrial Electronics and Applications, Harbin, China, 2007, pp. 2214-2217, doi: 10.1109/ICIEA.2007.4318804.

[14] A. Anis, M. Khaliluzzaman, M. Yakub, N. Chakraborty and K. Deb, "Digital electric meter reading recognition based on horizontal and vertical binary pattern," 2017 3rd International Conference on Electrical Information and Communication Technology (EICT), Khulna, Bangladesh, 2017, pp. 1-6, doi: 10.1109/EICT.2017.8275241.