ROI based Automated Meter Reading System using Python

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Abstract– *The AMR system reduces the circuit complexity that is required for measuring the meter reading for individual meter, by taking the image of each meter and then processing the data for that respective meter. instead the image of the meter panel can be analyzed once and the meter reading for each meter can be extracted. This data can be stored on the server and can be used to analyze or calculate the billing of the customer. This system will reduce the visit required by the service provider to measure the meter reading monthly, and provide remote access to the meters.*

Key Words – **Automated Meter Reading(AMR), Image processing, Region of Interest, extraction, server, ThingSpeak, IoT.**

1. INTRODUCTION

The Automated Meter reading system is an Embedded system that calculates the meter reading data depending upon the input taken from the meter which can be in any analog or digital form and depending upon the input the algorithm can be used to deduce the meter reading by processing the data, many smart meters are available in the market which uses a closed loop system to calculate the meter reading data and various hardware setup for taking the input as various voltage and current input are taken to calibrate the consumption and also identify the theft of the current, and alert the service provider or the customer[1]. The service provider can control the meter and disable the supply for the customer whose bill is pending. The AMR system provides the service provider with access to the meters remotely and meter reading data. Image processing can be a great tool for extracting the meter reading data, as there would be less complex hardware as compared to that of the smart meters. In this project Raspberry Pi 3 B+ board is used as base hardware for performing all image processing related operations as Python has various inbuilt libraries that provide API(Appliation Programming Interface) for Image processing. In this project OpenCV and Tensorflow these two libraries are used to perform the various image processing operations and extract the meter reading data[2]. The PIL(Python Imaging Library) can also be used to perform basic operations like creating thumbnails, resize, rotation, convert between different file formats etc. The IDE(Integrated development Environment) that is used in this project is IDLE which uses tkinter GUI toolkit.

2. IMAGE PROCESSING

In the field of Digital Signal Processing the subcategory Digital Image processing overcomes the limitations of Analog Image processing. Various types of algorithms can be applied on the image and the desired data can be extracted from the image, also various image enhancement can be implied for clear image view. The image contains mainly three colors RGB (red-green-blue) these combine to form the different colors in an image. The percentage of colors varies in the image, the Python Imaging Library is used to perform basic operations on the image like thumbnails, rotate, resize, rotate and converting the file format[3]. The various image processing techniques are mentioned below:

2.1 Morphological Image Processing

It is useful in extracting the image components that are useful in particular size or type of shape. The two basic morphological operations include Erosion and Dilation. Morphological operation is performed on an image with small shape or pixel area called 'Structuring Element'. [4]

2.1.1 Erosion: The erosion of a binary image f by a structuring element s (denoted $f \ominus s$) produces a new binary image

$g = f \ominus s$

with ones in all locations (x,y) of a structuring element's origin at which that structuring element s fits the input image f, i.e. $g(x,y) = 1$ is s fits f and 0 otherwise, repeating for all pixel coordinates (x,y).
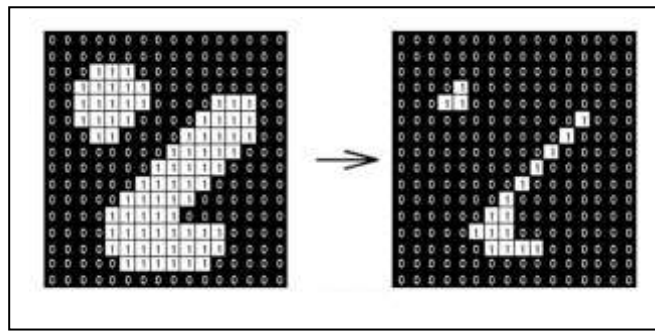

Fig. – 1: Erosion on Image

2.1.2 Dilation: The dilation of an image *f* by a structuring element *s* (denoted $f \oplus s$) produces a new binary image

$g = f \oplus s$

with ones in all locations (*x,y*) of a structuring element's orogin at which that structuring element *s* hits the input image *f*, i.e. *g(x,y)* = 1 if *s* hits *f* and 0 otherwise, repeating for all pixel coordinates (*x,y*). Dilation has the opposite effect to erosion -- it adds a layer of pixels to both the inner and outer boundaries of regions.
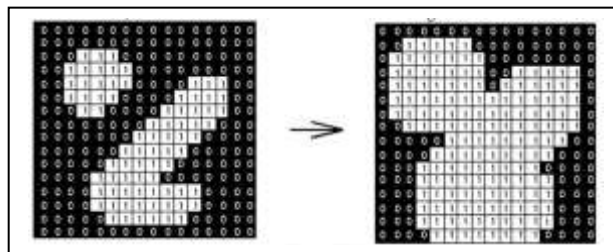
Fig – 2: Dilation on Image

2.1.3 Numpy: NumPy is the fundamental package for scientific computing with Python. It contains among other things:

- a powerful N-dimensional array object
- sophisticated (broadcasting) functions
- tools for integrating C/C++ and Fortran code
- useful linear algebra, Fourier transform, and random number capabilities

Besides its obvious scientific uses, NumPy can also be used as an efficient multi-dimensional container of generic data. Arbitrary data-types can be defined. This allows NumPy to seamlessly and speedily integrate with a wide variety of databases.

2.1.4 Image Thresholding: Thresholding is the simplest method of image segmentation. From a grayscale image, thresholding can be used to create binary images. The simplest thresholding methods replace each pixel in an image with a black pixel if the image intensity $I_{i,j}$ is less than some fixed constant T (that is, $I_{i,j}$ < T), or a white pixel if the image intensity is greater than that constant. The Fig 3 shows the original image of the meter and the thresholding of the image with value 255.

Fig. – 3: Thresholding of Meter Image

3. LITERATURE SURVEY

The smart meters that are available in the market vary depending upon the data that has to be monitored and the communication system that is used to send the data to a central station. GSM based communication system provides a global approach for the meter and efficient way of transmitting the data, it also provides other services like SMS (Short Message Service) and GPRS (General Packet Radio Service) for requesting and retrieving reading from individual houses back to the energy provider wirelessly. The low cost, simple setup, wide operating distance, less human intervention are some of the other salient features of this GSM based system[5]. Another system is Zigbee based system, ZigBee is a collection of communication protocols used to build small personal networks using low power digital radios. and is based on IEEE 802.15.4 standard. ZigBee based device is restricted to 10 - 100 meters and can be further extended using a mesh network of ZigBee devices. The rate of ZigBee is definite with 250 Kbit/s, best suited for intermittent data transmissions from a sensor or input device. The ZigBee digital power meter is a single phase digital kWh power meter with embedded ZigBee modem which sends the power usage reading using information back to the energy provider wirelessly[6]. SCADA (Supervisory Control and Data Acquisition) is a system operating with coded signals over communication channels so as to provide control of remote equipment. It is a category of software application program for process control, the gathering of data in real time from remote locations in order to control equipments. SCADA refers to the combination of telemetry and data acquisition. SCADA includes the collecting of the information via a RTU (remote terminal unit), PLCs (programmable logic controllers) and IEDs (intelligent electronic devices), transferring it back to the central site, carrying out any necessary analysis and control and then displaying that information on a number of operator screens or displays.

A system using SCADA isolates and precisely locates faults and optimize for energy saving. Centralized monitoring and control to manage multiple facilities from a single location and remote software administration for better control is possible. Systems using SCADA are prone to network attacks

4. PROPOSED SYSTEM

The Existing System that are available are mainly closed loop based systems that take input of Analog or digital format and then compute the meter reading data. In this project a raspberry Pi module with camera mounted on it is placed in front of the meter panel and the camera will take images of the panel, the individual meter reading will be extracted from each meter in the panel depending upon the customer. The Block diagram of the system is shown in the Fig. 4.
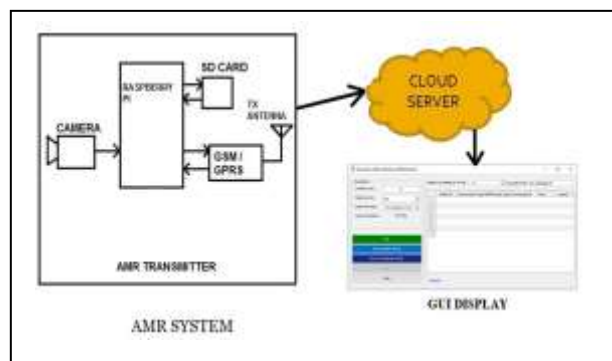

Fig. – 4 AMR Block Diagram

An algorithm is to be developed for finding the ROI(Region of Interest) and then identifying the segment digits in the ROI, depending upon the pixel density of the segments and then defining the segment as ON or OFF. The extracted meter reading is to be uploaded on the server and this data can be downloaded from the server and displayed on the GUI. The Raspberry Pi 3 B+ module is used in the project with Raspberry Pi Camera V2.1. The Python language is to be used for performing various image processing techniques using the given inbuilt libraries that are available.

5. ALGORITHM

The Python Algorithm is developed for extracting the meter reading from the meter, the original image that is taken as input is converted into Grayscale so as to make the pixels of the image uniform so that the different image processing can be easily applied. A lookup table is created for writing the digits after detecting the segment value. The image is resized by changing the image height to 600, Gaussian blurring is applied to remove the Gaussian noise. Canny edge detection is applied by specifying the thresholding and edge values, the edge detection will output the image with edges in the image

visible the contours are formed in the image for the LCD display that is captured in the meter image. The number of contours are identified and saved in descending order so as to check them individually moving from outside to inside. The area of the contours is found out by looping over them, if the contour has four vertices then it is the LCD display of the meter. The contour is marked by applying the four point transform and the edges of the contour are marked and warped, thresholding is applied to the saved contour along with morphological operations. After thresholding the contours are found out again the contour are then taken and the digit area is calculated in width and height of the contours. If the width is greater than 11 and height in between 30 and 52 then it must be a digit, the contours are sorted from left to right the digit ROI is extracted and width and height of each of the seven segment digits is extracted. The seven segments of the digit are defined the total thresholding pixels are counted and area of the segment is computed if the total number of non-zero pixels is greater than 50% then the segment is marked as ON else OFF the segment digits are compared with the lookup table and the digit is drawn on the image, at the output the image is shown with the digits drawn on them and in digital format.
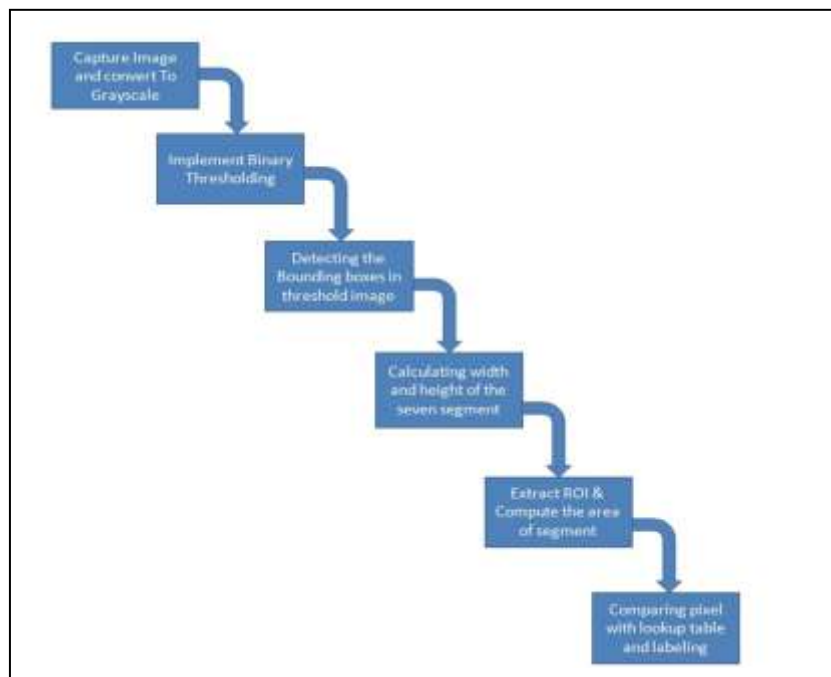

Fig. – 5 Flowchart of Algorithm

6. RESULTS

The image that is taken as input is shown in the Fig. 6 and the algorithm that is developed is implied on it.

Fig. – 6 Meter RGB Image

The RGB image is converted into grayscale and canny edge is also applied to it as shown in Fig. 7.

Fig. – 7 Grayscale and Canny Edge detection

The detected segment digits are drawn on the meter ROI and also stored in a variable. The Fig. 8 shows the detected digits.

Fig. – 8 Detected Digits

Multiple meter image is also taken as input and the same algorithm is applied on the image by individually taking each meter.

Fig. – 9 Multiple Meter Image

The multiple meters are cropped and then the extraction algorithm is applied on each cropped meter image the cropped meters is shown in Fig. 10.

Fig. – 10 Four Meters Cropped

The output of each meter is drawn on the LCD display as shown in Fig. 11.

Fig. – 11 Multiple Meter Extraction.

The meter reading is uploaded on an open source platform called 'ThingSpeak' which provides the different fields to save the meter data of individual meter and the standard time can be set for checking when the data has been uploaded. The API is used for writing the meter data and added in the algorithm, HTTPS is used to upload the data and four fields are created for uploading the data.[7]
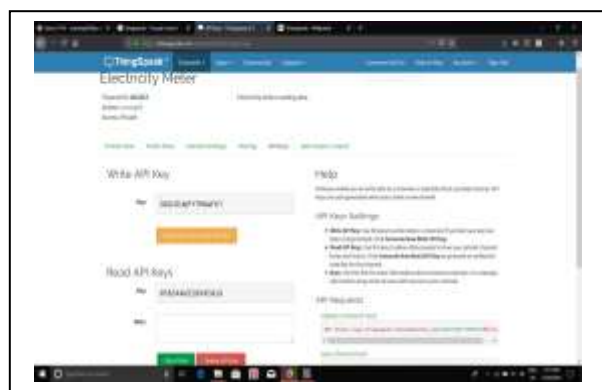
Fig. – 12 API key for ThingSpeak

The Four fields are shown in graphical format, and meter reading versus date and time data is plotted. The Fig. 13 shows the four different fields.

Fig. – 13 Four Meter Reading Data.

The uploaded data can also be downloaded in CSV(comma separated values) which contains entry id for each and every uploaded data, and the uploaded values.

Fig. – 14 Uploaded data in CSV format

The GUI display shows the meter reading data by reading the excel sheet after pressing the show reading the four fields and the date & time is also displayed. The entry id is taken as input.
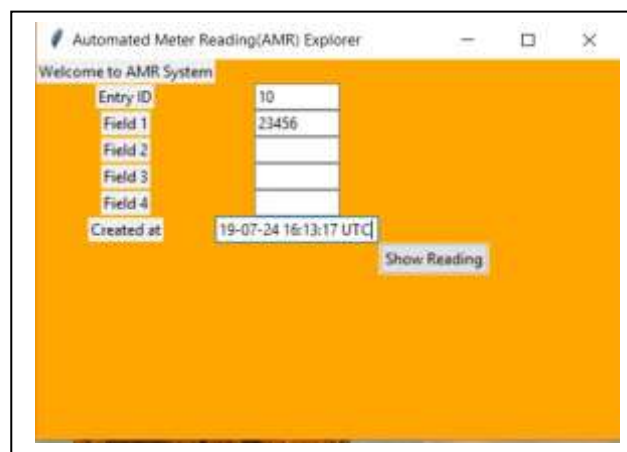

Fig. – 15 GUI display for showing meter readings.

7. CONCLUSION

Hence by avoiding the conventional method of tapping each and individual the meter reading can be extracted from the meter panel image, this data can be uploaded on the server using the Raspberry Pi. This is an open loop system and requires less hardware. Since this system can be fitted at the meter location so there is no need for operator to visit the site for meter collection data.

8. FUTURE SCOPE

The Dynamic image processing can be applied so as to capture the power data of meter since the new digital meters display show multiple data with changing screen. Various error or warning led on the meter display can also be checked and reported to the service provider.

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