Improved Smart Reading System for the Electrical Energy Meters

Swetha K. B.
Assistant Professor,
Department of ISE,
R. R. Institute of Technology,
Bengaluru, Karnataka, India

Ranjitha V.
UG Student,
R. R. Institute of Technology,
Visvesvaraya Technological University,
Bangalore, India

ABSTRACT

This paper presents a novel design for smart electric energy meters without changing the traditional electricity meter. It collects these readings in a central unit using the Internet. This design is useful for the purpose of avoiding human errors and frequent visits specifically when the homeowner is not around as well as having difficult access to remote areas. Also to keep up with the developed countries that use AMR (Automatic Meter Reading). The distinguishing point of the proposed design is that no change has been made to the internal fitting of the currently available conventional counter. The point is to install a camera facing the meter that takes a picture of the meter reading. Then, this image is processed with a Raspberry Pi3 (as processing unit) and converted to text using the OCR (optical character recognition) algorithm while recording the reading history. After that, it will be sent to the cloud (represented by the google drive spreadsheet) via the Internet, and this information will be collected from all consumers and will be ready to monitor electrical loads, record bills, give loads and costs reports to consumers, and thus participate in rationalizing electrical energy consumption.

Keywords: AMR; Raspberry Pi3; OCR; Cloud.

INTRODUCTION:

The meter used to measure the power used by the electrical load is known as an energy meter. Energy is the total energy a load consumes and uses in a specific period of time. It is used in household and industrial AC circuit to measure power consumption. Where the electricity companies install these meters at every subscriber, such as homes, factories, administrative and government buildings, and others, after connecting the electrical network to their units to supply loads such as lighting systems, fans, air conditioners, office equipment, and any other equipment with electricity.

The electricity meter industry has gone through several basic stages: electromechanical meters, electronic meters, and smart energy meters. The increasing global demand for electricity [1] raises important issues about how to meet these energy needs in a sustainable manner. Where it is necessary to search for alternatives that allow the efficient use of energy, which considers electricity a basic resource for social and economic development and a basic asset for managing life in society [2] [3] [4].

Despite the increasing development, the idea of cognitive smart metering and its interface with supervisory and energy management systems may stimulate the development of new equipment and methodologies to improve energy system control, efficiency, reliability and safety. The modernization of the energy meter is a fundamental issue of the electricity market and modern society. The problems related to the traditional electric meter reading system started to increase day by day for several reasons [5], including: population growth, human errors, remote areas, environmental conditions, and frequent visits.

As a result of these problems, a device that reads the electricity meter automatically and called it AMR (Automatic Meter Reading) [6] [7] was designed. This device collects energy information and sends it to the main stations of the electrical office for the purpose of its analysis and bill calculation. This reading system will reduce AMR from human errors resulting from reading, as well as access to remote areas that cannot be visited. This system is not only used to calculate the electricity meter, but also to read water meters [8] and gas [9] meters in developed countries.

This research builds a new system that reads the meter automatically without changing the traditional power meter using a camera and a single-board computer (Raspberry Pi) with conventional energy meters that will take a picture to read the meter when a consumer bill is needed then convert that image into text and send it to the central station withthe meter number (User ID [ID]) for each consumer. This data will be processed and an invoice generated automatically. After issuing the invoice, it will be sent to each consumer via SMS.

RELATED WORK:

In [10] authors introduced a Bluetooth meter design for wireless power meter reading. Two features are suggested, they can retrieve meter reading with minimal human intervention, and apply them to targeted applications. The interface between the meter reader, the computer, and the power meter can be classified, via the Bluetooth connector, into three main distinct parts. The first part consists of the interface between the computer and the Bluetooth radio unit.

The second part includes the interface between the Bluetooth radio unit and precise control. Both Part 1 and Part 2 interfaces use the standard RS232 protocol. Finally, the last part will be the interface between the power controller and the power meter Communication link complies with Serial Peripheral Interface (SPI) standard. In [11] authors Design AMR smart device proposes using DSP and ZigBee connection, The basic unit of this system isthe reading (user station) unit with ZigBee connection. Multi stations can create a network of ZigBee that contains an Ethernet DC (Data Collection)tool . Data is collected From all substations by collector, That sends to the control centerthis data over the Internet. however it is necessary to establish the original images, the command can send by server to the Obsession Collector. A sensor of image CMOS is used to take meter reading image as a AMR system central unit, the processor DM643 has three interfaces of video that video capture mode configured or view video independently. The outputs of image sensor is analog signal using the standard PAL . The video signal output is composite in ITU- RBT.656 format is decoded by the decoder TVP5150 , that configured with a processor of DSP by communication I2C. In [12] authors Enhanced Power Meter that supports wireless data transmission, which designs prototype of the power meter by use current sensor and voltage sensor and ADC(Analog to Digital Converter), The digital value converted is delivered to Raspberry Pi via its pins GPIO and more calculations are done using the software updated , Raspberry Pi execute all basic functions of the microcontroller and provide features like sending SMS and emails with the help of GSM modem and Wi-Fi dongle. This system enables continuous energy consumption monitoring. In [13] authors Develops a system for reading electrical energy metrics for the Iraqi consumer, using Bluetooth technology that developed the old meter using a method that does not change the properties of the physical disk, which is the adoption of disk layout to dark and other reflective regions and the use of the infrared reflective type (CNY70) sensor, as it works to give a signal when a reflecting region passes and not when a dark area passes. The Bluetooth meter reader, which is a way to communicate with the surrounding device and add the microcontroller Arduino (MEGA) and Bluetooth to overcome human errors of reading the meter and shortening the manual data entry.In [14] authors Suggested cheap automatic measurement system and easy-to-install that it can take data usage using the LDR(light dependent resistor) and Raspberry Pi unit to transfer the data taken. The module of light sensor to sensethe intensity of the light incident on it uses a photo resistor , and the comparator powers of digital output .the Raspberry Pi via GPIO pins light sensor is connected to it . UART (Universal Asynchronous Receiver/Transmitter) is applied to the GSM unit. Communication between the Raspberry Pi and GSM unit depends on the UART that the serial data received from Raspberry Pi translates into parallel information and vice versa.

In [15] authorsDevelop real-time monitoring of the AMR power meter in smart city - IoT application describing the active energy measurement method recorded by conventional real-time meter by using EEPROM, Real Time Clock (RTC), Relay Circuit, IOT Server, current sensor and voltage sensor connect to Arduino ATMEGA328 .The basic reason for the E-meter based IOT design is to reduce energy consumption in the home and avoid intervention of human , cost reduces and saves human energy. It works manually and automatically. This metric sends bills direct to the mobile phone before the due date without human error. This computing reduces labor costs and also makes the framework more efficient and accurate.

In [16] authorssuggested a smart power monitoring using Raspberry Pi with Python Control Programmer. It is ableto monitor various parameters such as Current, Voltage, So that the energy can be calculated by the use of the voltage sensor and current sensor. In some cases, if the bill is not paid, then the power can be interrupted with the help of the relay circuit and the consumer can take appropriate precautions to reduce the electrical appliances used as well

THE PROPOSED METHODOLOGY:

The proposed system in Fig. 1. uses the position of the Raspberry camera in front of the electric meter to capture the image to extract the meter reading using an optical character recognition algorithm using Raspberry Pi3, a type of Linux OS and python language, and send it over the Internet to the cloud to build the database and calculate the consumer bill.

The proposed system in this paper differs from previous work. Where the automatic reading system of the electric energy meter was designed and implemented without changing the structure of the traditional meter in addition to its low cost and high accuracy, as well as the method used in image processing and not by connecting the voltage sensor and the current sensor or changing the internal structure of the meter as in previous works.

Python is a heavily interpreted programming language derived from a natural English language that is used in this research because it is a strong and open source language, so Python can work on any system in the world. Python provides multi-threading technology that allows the program to be able to execute several commands at the same time, and it contains many libraries, and this work used some of these libraries to distinguish the number from the image, in addition to sending to the cloud. It also helps bind external parts to the Raspberry Pi [5].

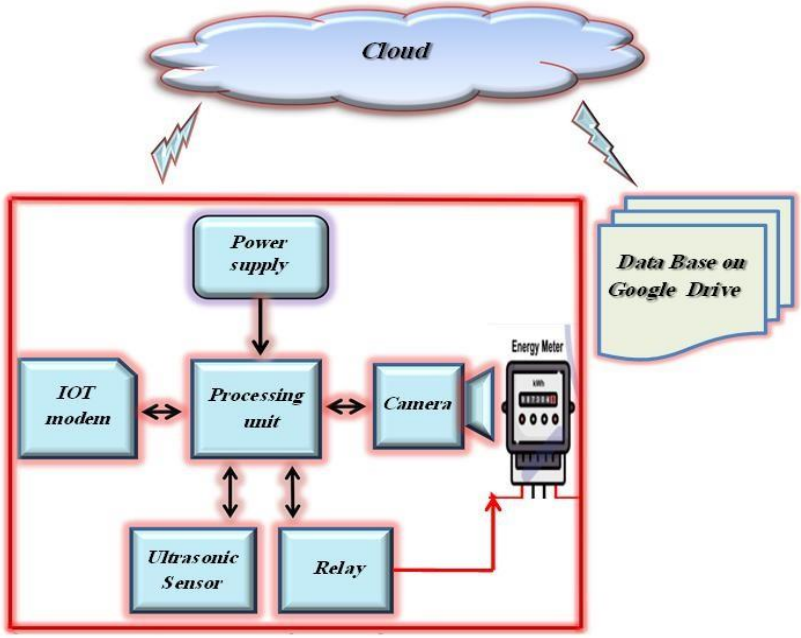


Fig.1 . The Block Diagram of the Proposed Electrical Energy Meter System

Raspberry Pi3 Camera:

The Raspberry Pi3 camera is capable of delivering 5 mega pixel clear picture, or recording 1080p HD video at 30 frame per second, the camera panel is specially designed from Raspberry Pi3 foundation in the UK. The unit is connected to Raspberry by 15 pin ribbon cable to CSI (Camera Serial Interface), which is specially designed to interact with the cameras. This bus is able to transfers high data rates of pixel to the processor. The panel is small in size, and weighs, making it ideal for portable and other applications in terms of weight and size.

Raspberry Pi3 module B:

The Raspberry Pi3 module B is an embedded computer or an SBC (single board computer). The processor of this Raspberry is a hybrid between a microprocessor and micro controller. It is actually a SoC (System on Chip), containingmultiple dies stacked on top of each other [17][18]. It contains 4x USB2 ports and 40 pins Extended GPIO (General Purpose Input/Output) ,Bluetooth, Wi-Fi and etc.

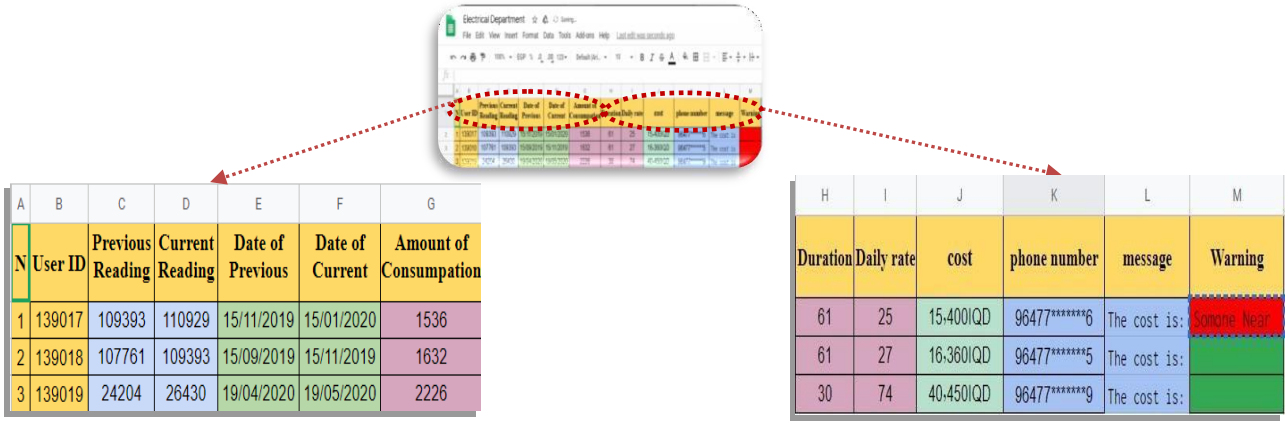
IoT Modem:

For the houses that have not internet, IoT modem is a device can be used to connect the Raspberry Pi3 in the proposed system to the Internet with 2.4 GHZ bandwidth using the Wi-Fi feature in Raspberry Pi3, where each device has its own unique IP address and port number. It is also can be used for the remote areas where the internet is not available. The Raspberry Pi3 connected directly to the Internet for the houses that already have. This is to reduce the cost of the proposed device, given that a large number of homes currently have internet service, as it has become a necessary requirement in every home.

Ultrasonic Sensor:
The ultrasonic sensor uses a transducer to transmit and receive ultrasonic pulses that transmit information about the proximity of the body [19]. This sensor was connecting to the Raspberry Pi3 in prosper system that used for the purpose of preventing or informing the Electricity Department that the owner of the house or others are trying to manipulate the electrical meter by sending a warning message to the cloud to take appropriate measures by the electrical department to protect the meter from tampering or disruption by the consumer. It is one of the protection methods for the proposed system.

Relay:
Relay "switch" was used to cut the electrical current from the load [20] in case the bill was not paid by the owner of the house, as it was connected with the Raspberry Pi3.

Cloud:



N	User ID	Previous Reading	Current Reading	Date of Previous	Date of Current	Amount of Consumpation
1	139017	109393	110929	15/11/2019	15/01/2020	1536
2	139018	107761	109393	15/09/2019	15/11/2019	1632
3	139019	24204	26430	19/04/2020	19/05/2020	2226

Duration	Daily rate	cost	phone number	message	Warning
61	25	15·400IQD	96477*******6	The cost is:	Somone Near
61	27	16·360IQD	96477*******5	The cost is:	
30	74	40·450IQD	96477*******9	The cost is:	

Fig.2: Cloud

The cloud refers to the servers as in fig.2. that are accessed over the Internet where the data collected from all the consumers' Raspberry Pi as database for analysis and make billing by equations of the Electricity Office for each consume, Google Drive Spreadsheet is used [21].

Remote IT:
It is a program that has been used to control a large number of Raspberry Pi3 in addition to the implementation of programs remotely via the internet as it is considered the main application in the Electricity Department to control the proposed system found in every home without the need to visit it, It is possible to enter every camera in the proposed system for life monitoring of the meter in addition to the possibility of taking instant reading of the meter and cut off the electrical current in case the bill is not paid by the customer

SIMULATION RESULTS:

The proposed system programming any picture is taken of the energy meter and (OCR) algorithm for isolating the number from the picture is applied where this process is done in eight stages:

- The first stage is resizing the image to avoid problems with larger-resolution images.
- The Second stage is to segment the numbers of meter out of the image by cropping it and saving it as a new image, then use this image to detect the character in it.
- The Third stage gray scaling that is common in all steps of processing image. This accelerate the next processing that no longer need to work with color details when processing an image. Each image will contain useful and not useful information, in this case the numbers for the energy meter are useful information the rest is largely unnecessary to our program. This unnecessary information is called hype.
- Fourth stage using a bilateral filter and unwanted details will remove from an image and erase more background information.
- The Fifth stage is an edge detection procedure. There are many ways to do this, the easiest and most common way is to use OpenCV 's canny edge detection method.
- The sixth stage is converted to a binary image in order to reduce background details.
- The seventh stage is erosion process to removes elements that are smaller than the structuring element and

perimeter pixels from larger image elements. The erosion operator takes two inputs of data, the first is the image to be eroded, the second is a set of coordinate points known as a structuring element (usually small), also known as a (kernel). The exact impact of erosion on the input image determines by these structuring elements. During erosion operation, every pixels elements that touches a background pixel are changed to a background pixels. The objects become smaller due to erosion and a single object can be divided into several objects.

- The eighth stage is to actually recognize the number of the energy meter in reading the number information from the segmented image using the tesseract, it is a tool recognizes and reads the text present in images. Through what has been mentioned it shows that the image of the meter goes through eight stages in order to distinguish the number by the library used to distinguish the number, where these stages are illustrated in the fig.3.

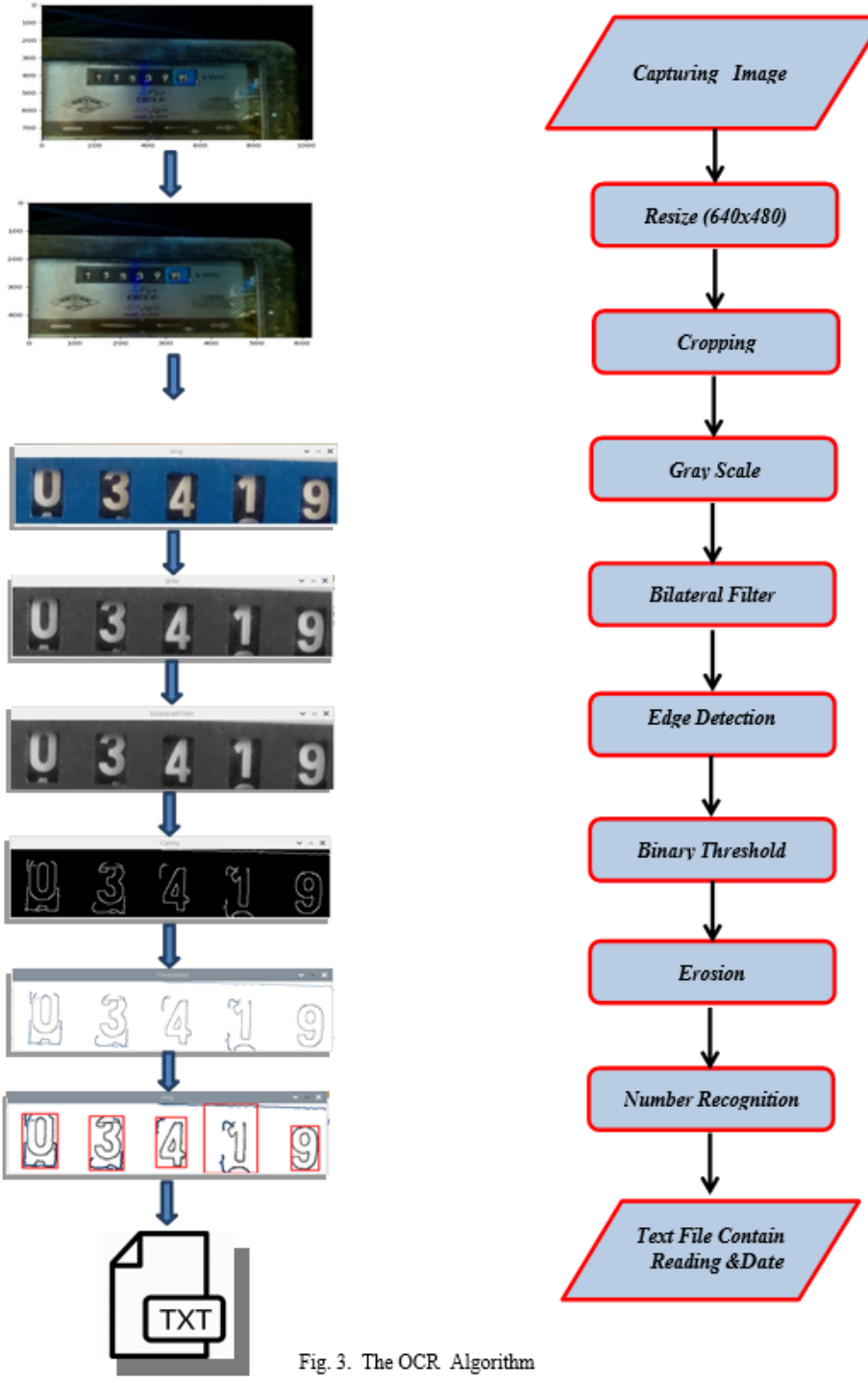


Fig. 3. The OCR Algorithm

Accuracy of the Proposed System:

The algorithm used was tested on 490 collected images of electric energy meters, and the algorithm proved successful (98.8%), according to the fig.4.

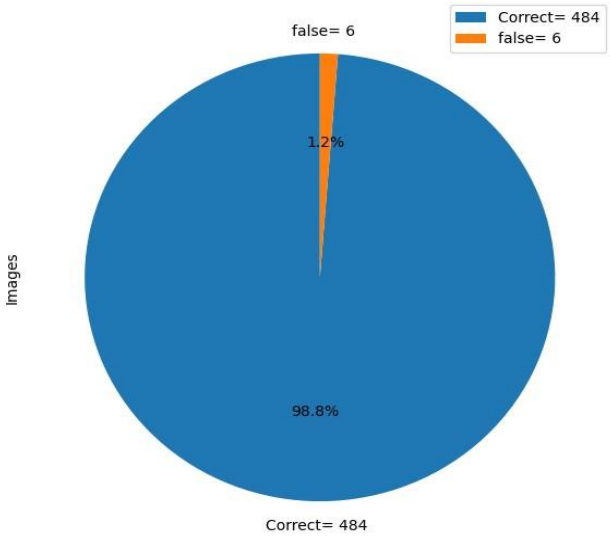


Fig.4 . The Proposed System Accuracy

CONCLUSION AND FUTURE WORK:

In this research, enhancement of automatic reading system for the electrical energy metershas been designed and implemented for all consumers using a new method that does not affect the basic structure of the meter at a low cost. The Raspberry Pi 3 model B was used because of its cheap price, open source and rich OpenCV library, as well as high performance in image processing operations. The algorithm used was tested on 490 real images of different meters, andthe accuracy of the algorithm was 98.8%. Full electricity control has been approved by adding really to the main wallof the house to cut off in case of the bill is not paid or for other reasons. A protection system has been adopted in terms of approaching or tampering with the device by adding the prepared Ultrasonic sensor at a specific distance to alert in the event of proximity or tampering with the device. What distinguishes the Raspberry Pi3 is the use of the Linux system, which is a system known for its high protection, because the Raspberry Pi3 is not contacted further. The used method is characterized by simplicity, speed and accuracy, as it provides all the necessary information about the subscribers, including the meter identification numbers and their reading values, which represent the amount of energy they consume. The continuous communication with customers is made, and it can be used to send invoices, guidance and awareness messages to rationalize electrical energy through SMS. The database associated with the proposed system provides reliable information to conduct integrated calculations of energy consumption and costs, and toanalyze it for every home and every residential neighborhood and can cover the entire country. This information is available at all possible times to facilitate monitoring of the electrical network.

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