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Reading of Energy Meter based on Image Processing Technology

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***Abstract* – The digital technology, the wireless communication, and the computer systems have drastically changed the Electric meter generation from Traditional Meter to Automatic Meter. The differences is in how to collect and process information, and traditional meter reading has been long used, and it is still one of the most common ways for meter reading. This method, however, has their disadvantages which are the result of human basis reading method that uses. If the reading problem is solved by adding a simple equipment which makes it automatic it will be still useful method of reading. In this paper it is described a prototype for Automatic Meter Reading (AMR) system that uses a Traditional meter, ZigBee modules, and a serial camera unit. This camera will take the photo of meter reading and transmit it to the server PC through Zig-Bee, where that image undergoes segmentation, recognition process and reading is get separated which is further used for preparing bill.**

***Keywords* – Zig-Bee, AMR, Image Segmentation, Extraction, Recognition.**

I. Introduction

Everybody must have faced problem with energy meter reading. After getting faulty bill, it is problem of user to get it corrected from the MSEB. Person has to visit the office, stand in a queue and get it corrected. The problem is just because of human intervention. Presently, person from EB [electricity board], comes and will take photograph of energy meter. This way he will collect database of at least 100 consumers. After database collection, next step is to download all the images, and SCAN all the photographs to find out consumer number and Meter reading. While doing this there is 100% manual error, which will create problem for normal consumer. To avoid human intervention in the billing process, NOW new generation, energy meter will be equipped with camera module with wireless transmission. After every month the image of energy meter will be transmitted wirelessly to main super computer (server). On server side, all the images will be processed and consumer id with electricity meter reading will be extracted. This information will be stored in database.

In our country consumers are not satisfied with the services of power distribution companies like APEPDCL; because of traditional meter billing methods adopted which requires huge number of labor and long working hours to collect complete data and billing. Human operator billing method is prone to erroneous. Sometimes the energy meter is placed in a location where it is not easily accessible. Manual billing is sometimes restricted and slowed down by various reasons. Printed billing has the tendency of losing in the mailbox. The increased population and industrialization in the countries like India, to facilitate easy and trusted service with minimum operating cost, a better method of billing procedure is proposed in this project.

II. Communication Technology

The AMR [1] [2] [3] [4] [5] system requires means of communication for transmitting and receiving their data. The information collected from each meter, must arrive reliably and securely to the utility provider, for billing and analyzing. In another way any command from provider office that addresses each node and each meter must arrive reliably and securely to its destination. In the network of node- meters each node and meter are identified by their unique id (Node-Id and Meter-Id).

The selection of which communication technology [8] to use depends on a complex set of engineering analysis that requires significant expertise and experience in communications, together with an in-depth knowledge of the application and its requirements. No single technology is the best price and performance solution for every application. From the broadest list of communication technology such as PLC, GSM, Wi-Fi, ZigBee and others, the ones that more are used in AMR are the GSM and ZigBee. GSM (Global System for Mobile Communication) is a development from cellular telephony. GSM adopts digital modulation and the key technology is time division multiple access (TDMA).

ZigBee [9] is a two-way wireless communication technology featuring short distance, low complexity, low power consumption, low data speed, and low cost. It is used mainly in data exchange between low power electronic devices within a short range. There can be as many as 65,000 wireless communication modules in a ZigBee network, which is very similar to telecommunication networks like CDMA or GSM. Each ZigBee module is like a telecommunication station, and the modules can communicate with each other within the whole network. The communication distances between the nodes can range from the standard 75 meters to hundreds of meters and even several kilometres. The ZigBee network can also be connected to other networks.

ZigBee is the most popular industry wireless mesh networking standard for connecting sensors, actuators, and instrumentation and control systems.

The main advantages of ZigBee are:

- Power saving, as a result of the short working period, low power consumption of communication, and standby mode.
- Reliability: Collision avoidance is adopted, with a special time slot allocated for those communications that need fixed bandwidth so that competition and conflict are avoided when transmitting data. The MAC layer adopts completely confirmed data transmission, that is, every data packet sent must wait for the confirmation from the receiver.
- Low cost of the modules and the ZigBee protocol.
- Short time delay, typically 30 ms for device searching, 15 ms for standby to activation, and 15 ms for channel access of active devices.
- Large network capacity: One ZigBee network contains one master device and maximum 65,000 slave devices. There can be as many as 100 ZigBee networks within one area.
- Safety: ZigBee provides a data integrity check and authentication function. AES-128 is adopted and at the same time each application can flexibly determine its safety property.

III. System Design

The prototype design consists of three elements: Electromechanical or Traditional meter, Interface circuit, and ZigBee modules. The essential work is: the design of economic interface circuit and the programming of ZigBee modules. The modules will be programmed to act according to the standards of the ZigBee wireless network the same as End-Device, Router, and Coordinator, also as Concentrator, and Range extender[7].

A. Meter

The electromechanical induction meter operates by counting the revolutions of an aluminum disc which is made to rotate at a speed proportional to the power. The number of revolutions is thus proportional to the energy usage. The aluminum disc is supported by a spindle which has a worm gear which drives the register. The register is a series of dials which record the amount of energy used. Most domestic electricity meters must be read manually, whether by a representative of the power company or by the customer. This prototype aims to free the tedious job of reading by making it automatic. First: Convert the power usage into digital data; which is accomplished by interface circuit. Second: transmit the read data via ZigBee networks that ZigBee modules will be in charge. Third: received data will be processed according their use at office. For this project Electronic meter is used on which direct digital display of energy consumed in KWh is present.

B. Interface Circuit Design

The meter interface normally consists of a backup power supply, together with meter sensors, controlling electronics, memory for storing data and a communication interface that allows data to be transmitted from this remote device to a central location. This communication interface is normally bidirectional and allows central computer signals to be received by the remote unit as well. The data concentrator is used for the transmission of data and controls the sending of signals between the meter interface units and the central office. In this particular system the communication link takes the form of power line carrier technology, which is explained in the following section. The central computer system generally is made up from the host computer and the communication devices used for receiving and sending data to the data concentrators that exists the system.

Here camera is attached in front of energy meter to take the photo of reading display. Which is further transferred to server for billing purpose. LPC 2148 is used as a controlling element.

C. Zig-Bee

The main characteristics of ZigBee network are simple implementation, low power consumption, low cost interface, redundancy of devices, high node density per physical layer (PHY) and medium access control layer (MAC). Besides, they allow the network to work with a great number of active devices. ZigBee is based on IEEE 802.15.4 standard in terms of the PHY and MAC layers. IEEE 802.15.4 defines two kinds of devices: the Full Function Device (FFD) and the Reduced Function Device (RFD). The FFD has the function to coordinate the network and consequently has access to all other devices. The RFD is limited to a star topology configuration, not being able to work as a network coordinator, so it does not have all the protocol services. The FFD and RFD devices can operate in three different ways at the ZigBee standard as the ZigBee coordinator (ZC), ZigBee Router (ZR), or ZigBee End Device (ZED). The network layer supports three topologies: star, cluster tree and mesh as shown in Fig. 3. A star topology consists of a coordinating node and of one or more FFD or RFD which communicates with the ZC. At the cluster tree, the final devices can be associated to the network by the ZC and the ZR helping the increasing of number of nodes and the network scope. At the mesh topology, the FFD can distribute messages directly to other FFD. To enter the network, each device receives an address given by ZC or a ZR.

The meter reading system adopts a distributed structure according to its characters. The system consists of data collector, wireless communication networks and the server system. Digital meter data is transmitted through two separate boards i.e. ZigBee transmission module to the data collector module. The ZigBee true System-on-Chip

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CC2430 is suitable for the purpose. It combines the excellent performance of the leading CC2420 RF transceiver with an industry-standard enhanced 8051 MCU, 32/64/128 KB flash memory, 8 KB RAM and many other powerful features. It has low noise, low power consumption.

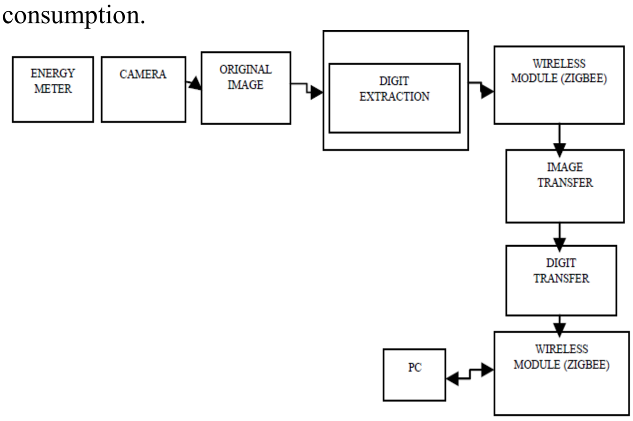

Fig.1. System block diagram

IV. Image Processing

A. Binarization Step

The binary of gray scale images is to use proper threshold to transform the 256 grey scale images into the binary images, that is, to set the white pixel bigger than the threshold, in the grey scale images, and set black the pixels smaller than the threshold, to form the binary images with only black and white. Binary images can be stored in matrix, a, M×N binary imagecan be expressed by the formula(1), in which i is the line number, j is the column number, xij is the pixel in line I and column j of I, the binary image , i=1,2,….N.

$$I = \begin{bmatrix} x_{11} & x_{12} & x_{1N} \\ x_{21} & x_{22} & x_{2N} \\ ..... & .... & .... \\ x_{M1} & x_{M2} & x_{MN} \end{bmatrix} \quad (1)$$

The threshold is divided into the whole threshold and partial threshold. Here whole threshold is used by means of iterative. First the 256 gray scale image is counted by means of grey scale histogram, choose the median of the grey scale image as the beginning threshold V0, and then perform iterative arithmetic as shown in formula (2) according to h1, the number of pixels with the grey scale value 1 in I, to obtain the final threshold value V. As shown in the experiments, when K=0.46, the binary will have the best results. Hence choose K=0.46 to obtain the binary image (1224 ×1632), Fig 2.

$$\sum\sum V_{m+1} = K\left[\sum_{l=0}^{V_m} h_l \times l \Big/ \sum_{l=0}^{V_m} h_l + \sum_{l=V_m+1}^{255} h_l \times l \Big/ \sum_{l=V_m+1}^{255} h_l\right] \quad (2)$$

Fig.2. Binary image

B. Cropping Numerical Area

If we count the number of white pixel dots of the binary image following the horizontal line, we will get the horizontal projection in which the abscissa stands for line number and the ordinate stands for the number of white pixel dots in response to each of the lines. As the digital area is rectangle, the digits are white, the frame is black, and the size is fixed, it can be decided that the line number in the digital area is between 400- 600. If the lines of the image outside the area are cutoff , the horizontal location of the area can be realized.

$$h\_sum(i) = \sum_{j=1}^{N} x_{ij} \quad (3)$$

If we count the number of white pixel dots of the binary image following the vertical line, we will get a vertical projection, in which the abscissa stands for column number and the ordinate stands for number of the white pixel dots in response to each of the column. As the digital area, with fixed sizes, has the least number of white pixel dots in the binary image after the horizontal location, it can be decided that the column number in the digital area is between 250-1380. If the lines of the image outside the area are cut off, the vertical location of the digital area can be realized and the image of the digital area can be obtained (Fig. 3).

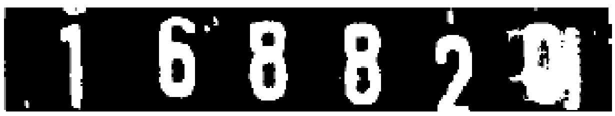

Fig.3. Image of digital area

C. Character segmentation

After the digital area has been obtained, it is still necessary to segment the digits in the black frame of the digital area in order to identify the digits next. In the rectangle black frame of the digital area there are 7 parts from the left to right i.e. 6 digits and narrow scale division area, with each part in a horizontal line, in response to the areas a,b,c,d,e,,f and g of the vertical projection. As the scale division does not need recognition, it can be cut off when the digits are segmented. As the characters of the digits have black frame as the background, the minimum value in a partial area will be obtained in the vertical projection and meet the conditions like the distance

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between the characters of the digits. The digital segmentation is performed by means of projection, the background column between the digits characters , combined with the fixed sizes of the digital characters[6].

Before projection the image has to go through invert dispose. Then the image with reversed color will have vertical projection so that dots of each column of the black pixels in the digital area will be counted and saved in array H[j], in which j is the value of columns in the image. For VH=E-D, in which VH is the threshold value, E is the math expectation and D is the variance in the vertical projection, When H[j]<VH and H[j+1]>0.,then j is the possible beginning position of the digital characters. When H[j]<VH and H[j-1]>0, then j is the possible ending position of the digital characters. According to the characteristics of the digital characters the adjacent area after the beginning position and the adjacent area before the ending position will be checked, adjusted and finally each of the digits will be segmented according to the adjusted beginning and ending positions.

D. Digital Recognition

The energy meter usues 6 digits. Four of the 5 integers usually show whole characters, except that some of the digital characters ae a little upward while others are a little downward. The last integer and the decimal point may show the whole characters in the shift of the digits, or show two half characters.

a. Characteristics of the strokes of the digital characters

The strokes for the digits 0-9 includes straight strokes and curve strokes. A straight stroke is a line segment including horizontal, vertical, up-left slanting and up—right slanting stroke. A curve stroke is a curve segment, including closed curve and non closed curve. Of the ten digits, the digit has double closed curves and digits 0,4,6,9 have single closed curves. The digits 1,2,3,5,7 have non closed curves. If the closed curve of the single closed curve digit is at the upper part, it is 9. If it is at lower part it is 6 or 4; or if it is in the middle it is 0. 4 and 6 can be discriminated by means of vertical stroke. The digit 1 has only a vertical stroke and the digits 2,3 and 7 have horizontal stroke. The horizontal stroke of 2 is at the bottom. 7 has up-left slanting strike besides a horizontal stroke. 5 has both horizontal and vertical strokes.

b. Digital Recognition Algorithm

This algorithm involves three steps,

Step 1: Determine datum line of the digits. For this make a horizontal projection of the digit and count the dots of the black pixels in each line. If there is a blank area at both ends of the projection, the datum line is fixed on the center of the bigger blank area in response to the whole character. If the blank area is only in the middle of the projection, the datum line is fixed on the center line of the blank area in response to the half character.

Step 2: Search for the closed curve area of the digital characters. For this choose a white pixel dot as A and search for an area connected to A and mark all the pixel dots in the connected area as background1. If all the white pixel dots in the image have been marked as background 1, this shows that that character is a non-closed curve character and the search can be stopped. If some white pixel dots in the image have not been marked as background 1, then choose one of the dots as B and continue the search for the area connected to B and mark all white pixel dots in the connected area as background 2. If all the white pixel dots of the image have been marked as background 1 and background 2, this shows that the character is a single closed curve digit. Otherwise , it is a double closed curve digit.

Step 3: According to the datum line, the digits are divided into 4×2=8 smaller areas. According to search result of the closed curve area, combined with the characteristics of the related digital strokes , search in each smaller area and finally determine the digital character.

V. Results

With the help of above image processing technology digits are extracted from the digital are of the image taken by camera and transferred to the server PC.

Fig.4. Image of the energy meter.

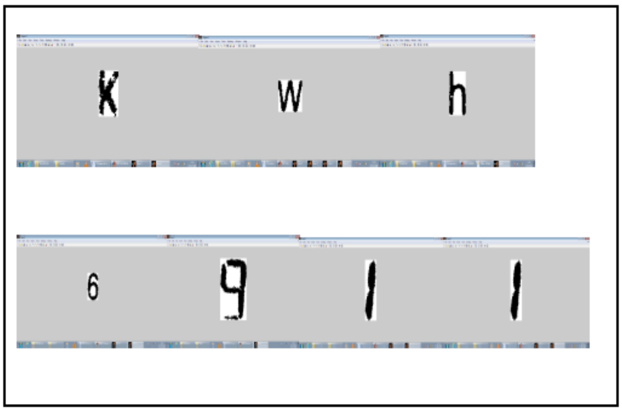

Fig.5. Extracted digits of the energy meter reading.

VI. Conclusion

The objective of developing this wireless energy meter reading system is not only to have high accuracy over a wide current dynamic range, better reliability and robustness but also to face the weakening competence in meter reading in localities such as increasingly over crowded big cities, overpopulated rural, sub urban regions and remote or snowy districts.

The tangible benefits of this system are in this system no meter reader is required, By using this system the real time meter reading is possible. This system reduces the cost of meter reading with low cost module, detect meter tempering, and no need to change existing meter, misuse of electricity will be decreased and reduces the corruptions hence reduces load shading. There will be no fake bills so the customers will be satisfied. With computer vision technique, the remote meter recognition system led to increased accuracy, since it is not sensitive to operator fatigue or lack of expertise, and cost reduction by decreasing the time and the operator skills that are required.

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