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A Review on Image Processing Based Billing System for Electric Meter using Raspberry Pi 4

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ABSTRACT: In India's energy industry, the widespread use of edge computing-powered image processing-based billing devices offers a revolutionary way to overcome the drawbacks of manual billing procedures. Compared to manual billing procedures, this solution has several advantages: it is more accurate, has less errors, and is less vulnerable to fraud and manipulation. By incorporating image processing technology and character recognition technology (OCR) into billing devices, the danger of human error is minimized, and proper billing calculations are secured by automatic and precise data extraction from power meter readings. Advanced picture processing and meter variety are significant infrastructure trade-off considerations. Further study will focus on Data Privacy, Advanced Image Processing and Recognition, and a novel dimensional method for edge-based image processing-based billing devices. Leveraging edge computing capabilities reduces the need for manual intervention by facilitating real-time data processing and analysis, which approves for instantaneous invoice creation.

KEYWORDS: Image processing, Edge computing, Minimized susceptibility, Automated data extraction, data processing and analysis.

I. INTRODUCTION

The paper suggests an Image Detection based billing device for electric meters which employs edge computing. The project focuses on the development of an intelligent billing device of electric meters in homes and industries. We need to develop a solution using an ML model that could easily detect text from the image with proper details. Unlike the older method of billing by manually [1]. This method is a ML based solution which provides a better billing system by identifying from image. Many industries with limited technological resources or financial budgets, rely on manual billing processes. This can lead to errors and inefficiencies. To address this , the study proposes a novel solution: an image-based billing device. This standalone device would utilize a simple camera and processor to capture and analyze images, enabling quick and accurate billing without the need for complex technology like Optical Character Recognition (OCR). The device contains a GUI which helps in easy interaction with the programs. It also includes database updates, multiple modes of data entries and a paper free system.

In India, traditional energy meters are getting replaced by more sophisticated and accurate digital and electronic meters. Power companies face a significant financial burden due to lost revenue. This loss stems from a combination of factors: theft of electricity, inaccurate meter readings leading to incorrect billing, and customer delays in settling their bills. Prepaid energy meters offer a promising solution to dramatically reduce this revenue loss [2]. Modern smart meters are essentially advanced reading units (ARU) capable of calculating energy consumption and cost based on time and day of the week. In contrast, Advanced Metering Infrastructure (AMI) is a system of utility meters that measure consumption and provide data to utility companies and energy-conscious consumers looking to reduce their energy costs or feed power back into the grid. The way we track energy consumption is undergoing a transformation. Traditional one-way meter reading systems, known as Automated Meter Reading (AMR), are replacing by Advanced Metering Infrastructure (AMI) in power grids around the world. This shift brings a key advantage: two-way communication. Smart meters, the core of AMI, are electronic devices that not only capture energy usage data but can also transmit it back to the utility company in real-time. It empowers customers to track their own consumption and costs, and provides utilities with valuable data for monitoring and managing the electric grid more efficiently. AMI represents a significant evolution from the limitations of one-way AMR systems [3]. This paper proposes the use of smart meters in distributed

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generation, which is even more advanced than current methods, enabling efficient transmission and distribution of energy. Traditional manual meter reading and billing systems in India are plagued by complexity, time consumption, and human error. Researchers have proposed prepaid energy meters with GSM technology as a solution. This system allows users to verify their energy consumption status, promotes transparency through access to continuous monitoring, and enables prepayment for a cashless economy. Additionally, a relay ensures automatic power shutoff for low balance [4]. Arduino Uno manages the system securely and is a cost-effective to conventional meters, making it ideal for developing countries. The process, involving meter reading, costing, billing, and distribution, is prone to errors and delays. Prepaid energy meters offer an automated solution by automatically collecting meter readings, sending information to both authorities and consumers, reducing human effort, simplifying billing, and facilitating collection even in remote areas [5].

II. LITERATURE REVIEW

Jay Dilipbhai Thanki, Priyank Dineshbhai Davda, Dr. Priya Swaminarayan [6] proposed a Optical Character Recognition (OCR) technology that converts scanned or photographed images of text into machine-readable text. Optical Character Recognition (OCR) acts as a powerful bridge, transforming scanned documents or photographed text into a format that machines can understand. This technology streamlines the process of extracting text, saving significant time and effort. As an active research field, OCR boasts a range of algorithms, like Tesseract and OpenCV, that continuously improve accuracy. The OCR process itself unfolds in several stages: First, a digital image of the text is captured (image acquisition). Then, the image undergoes pre-processing to prepare it for further analysis. Pre-processing involves enhancing the quality of the image, such as removing noise and skewing the image. Segmentation involves dividing the image into individual characters. Feature extraction involves identifying unique features of each character. Neural network training involves teaching the computer to recognize different characters based on their features. Post-processing involves improving the accuracy of the OCR results, such as using contextual analysis to reduce the chance of errors.

Karez Abdulwahhab Hamad and Mehmet Kaya authored a paper detailing Optical Character Recognition (OCR), a technology that converts text from images into a format machines can understand. OCR is a constantly evolving field with challenges like deciphering cursive and handwritten text [7]. With various OCR software options available, the authors highlight the need for regular, comprehensive reviews to stay updated on advancements. Their paper offers a thorough analysis of OCR research, exploring the key challenges and the core stages involved, including preprocessing, segmentation, normalization, feature extraction, classification, and post-processing. Optical Character Recognition (OCR) bridges the gap between visual text and machine understanding. It achieves this through a series of steps. The first phase, preprocessing, tackles image imperfections to prepare it for further processing. This might involve converting the image to black and white (binarization), removing unwanted specks (noise reduction), straightening any tilts (skew correction), and applying filters to enhance specific features. Finally, segmentation separates the text from the background, isolating the characters for recognition.

Senka Drobac, Krister Lindén et.al proposes a method on OCR , a challenging task for historical Finnish newspapers due to the diversity of languages, fonts, and spelling variations. Previous attempts to OCR the corpus have focused on specific language or font combinations, resulting in suboptimal performance [8]. This paper presents a novel approach using the Calamari2 training tool, which supports custom-made deep neural networks (DNNs). The authors trained a single mixed model for the entire corpus, achieving significant improvements in character error rates compared to previous methods. The use of DNNs and additional training data led to a 3.3% reduction in character error rates for Finnish and a 4.4% reduction for Swedish. Additionally, the Calamari tool allows for GPU-accelerated recognition, further enhancing efficiency. The authors also experimented with voting between multiple OCR models and evaluated the effectiveness of a post-processing method used in previous work. Overall, the proposed method demonstrates the feasibility of training a single mixed model for the entire corpus of historical Finnish newspapers, achieving substantial improvements in OCR accuracy and efficiency.

Ranjan Jana, Amrita Roy Chowdhury, Mazharul Islam proposed on how OCR enables the conversion of various document formats into editable and searchable data [9]. OCR streamlines processes in banking by automating cheque processing and transferring funds OCR facilitates document digitization in the legal industry, enhancing document management and retrieval is also employed in education, finance, and government agencies for efficient document handling. Automated document processing, reducing manual labor and errors. Enhances document accessibility and searchability. Saves storage space and simplifies document management. Improves efficiency and productivity in

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various industries. Overall, OCR plays a significant role in transforming paper-based documents into digital formats, streamlining processes and enhancing document accessibility.

Akanksha Mate , Megha Gurav , Kajal Babar , Gauri Raskar and Prof. Prakash Kshirsagar et.al propose text extraction is a crucial technique with numerous applications in computer vision, image processing, and document processing [10]. It enables the extraction of text from various sources, including images, videos, and scanned documents. This extracted text can then be utilized for various purposes, such as text search, content-based indexing, and license plate recognition. The effectiveness of text extraction depends on various factors, including the properties of the text, such as size, alignment, color, motion, and compression. Understanding these properties is essential for developing robust text extraction algorithms.

Deepali S Hirolikar, Ezhilarasan, Kuldeep Sharma, Badria Sulaiman Alfurhood et.al proposed the method of how traditional power departments still use manual billing systems. A smart framework with automation and strong security is needed. Paid-ahead meters help customers in understanding energy consumption and reduce errors in billing [11]. The proposed meter uses a Device 3B+, a traditional energy meter, a GSM device, a current measurement device, and a hand-off. The proposal includes two key innovations: GSM technology and overcurrent security. GSM technology is used for both transmission and storage functions.

Shakshi Neha, Ishika Raj, Amanpreet Singh, Saveta Kumari, Devendra Kumar Mishra et.al [12] explored using computer vision for grocery detection, highlighting the potential of neural networks for accurate product identification despite challenges. While cloud computing offers widespread access, it can be a barrier for stores with limited technical resources. Edge computing bridges this gap by processing data locally, eliminating reliance on the cloud. This paper builds on existing research by examining current billing system issues and proposing an image detection-based billing system powered by edge computing. The proposal is a novel methodology for image processing-based billing systems using edge computing. A cloud-based image processing tool classifies products and calculate the bill. This system is designed to be cost-effective and easy to use. Edge computing allows us to avoid the need for a centralized data server, which can save time and money. In conclusion, our proposed methodology is a feasible and effective solution for image processing-based billing systems.

S.Thiyagarajan, Dr.G.Saravana Kumar, E.Praveen Kumar, G.Sakana et.al proposes how an intelligent system utilizes a camera-based assistive device that captures printed text and converts it into a machine-encoded format using optical character recognition (OCR). The text is then output through an earphone or speaker, allowing visually challenged individuals to access the content [13]. The system employs a Raspberry Pi board and OpenCV libraries for image processing and character recognition. Pytesseract technology is used to identify characters and lines of text. The system's output can be tailored to the user's preference, either through an earphone or speaker. Enables visually challenged individuals to independently access printed content. Facilitates easier storage, retrieval, and analysis of printed materials. Reduces the need for physical manipulation of printed documents. Overall, this system demonstrates the potential of technology to enhance accessibility and empower individuals with visual impairments.

Wydyantoab , Norshita Mat Nayan, and Riza Sulaiman et.al proposed the above paper how the process of extracting text from printed documents involves a series of steps, including grayscale conversion, noise removal, thresholding, segmentation, region selection, morphology, blob extraction, and output to an Arduino microcontroller [14]. These steps utilize OCR (Optical Character Recognition) techniques, primarily using OpenCV and Google's Tesseract, to transform images containing text into machine-readable text. The final outcome is the generation of printed text. The text recognition system accepts input from different sources, including camera feeds, stored image files, and internet browsing. The system processes the input images to extract and recognize text using a combination of image processing techniques and OCR tools like OpenCV and Tesseract. The extracted text is then saved and written using Drawbot under Arduino control on a Raspberry Pi system.

Dr Murugan R, Sindhu S, S R Likitha et.al proposes a billing system for small retail shops, leveraging object and image detection with edge computing to tackle manual billing challenges [15]. This system employs a camera to capture product images, then utilizes object detection algorithms for identification and classification. It even factors in product size for accurate pricing. Developed as a responsive web application, the system boasts a 90% object detection precision and eliminates the need for expensive hardware or software. This research presents a promising solution for small shops seeking to automate their billing processes. The system is accurate, easy to use, and cost-effective. The application continuously captures live video streams from a smartphone camera and processes the captured images using a machine learning model. Once a product is identified, it is added to the bill.

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K.Srilakshmi, K.Preethi, MD.Afsha ,N Poojashree , M.Venu et.al proposed how the conventional electricity meters are replacing with new digital meters for improved accuracy[16]. However, there are still challenges in the Indian power sector related to revenue collection and energy theft. Traditional billing systems are manual, slow, costly, and inflexible. In some cases, meter readings are taken manually by individuals, which is inefficient and time-consuming. To address these issues, a smart electricity meter using Arduino UNO is proposed. The system generates the power and sends a message to the customer's phone with the current usage and amount due. The goal is to reduce errors, manpower costs, and power theft. The system is implemented using an EEPROM for user-friendly billing.

Zameema Benazir.Z, Divya Prabha P, Noorul Hamitha.B, Rajeshbabu.S et.al proposed how the conventional methods of electricity bill management involve the use of various programming languages such as Java, PHP, Python, C#, and MS Access servers [17]. The project proposed in the paper is providing an innovative approach using Java Swing and MySQL to streamline the electricity bill payment process. This system is designed to maintain comprehensive records of customer bills, enabling administrators to manage all accounts. Registered users, including individual and commercial customers, can manage their own accounts but are restricted to information pertaining to other customers. The system facilitates efficient bill management and payment processing. It comprises four key modules: registration, login, admin, and billing screen.

R.B Hiware, P.Bhaskar, Uttam Bombale, Nilesh Kumar propose how the conventional electricity billing systems in India are fraught with errors, delays, and inefficiencies. These issues arise due to inaccuracies in meter readings, human errors during data entry, and discrepancies in processing paid and unpaid bills [18]. A significant drawback of the postpaid system is the lack of control over consumption for consumers, leading to substantial power wastage. As power resources are limited, utilizing electricity responsibly is crucial. Prepaid systems have demonstrated significant reductions in power consumption in various countries. Additionally, prepaid systems minimize human errors associated with meter readings and bill processing. Wireless meters are suitable for residential apartments and industrial units with high energy consumption. Technological advancements have facilitated high-speed, secure, and reliable data exchange.This paper proposes a prepaid scratch card billing system for electricity, along with wireless metering technology.

Manisha V Shinde, Pradip W Kulkarni et.al proposed how the conventional methods of meter reading are crucial for accurate billing of vital resources like electricity, gas, and water. Traditionally, this process involved manual snapshots taken by energy provider employees. These photos were then submitted to a central office for interpretation and bill generation [19]. This human-dependent method was prone to inaccuracies and inefficiencies. To address these challenges, Automatic Meter Reading (AMR) technology was developed. AMR automates the entire meter reading and billing process, significantly improving efficiency, reliability, and cost-effectiveness. Imagine a camera fixed in front of every household's electricity meter. This camera automatically captures an image of the meter reading when instructed to do so. The image is then transmitted wirelessly to the energy provider's office. Using image recognition technology, the system pre-processes and extracts the digits from the meter image. These digits are then used to generate an accurate bill for each customer. Finally, the bill is sent directly to the customer's phone as a text message through a GSM module.

J Deny, A Bhargav Narasimha, R Guna Vardha Reddy S Sathish et.al. The project aims to develops a smart IoT-based energy meter equipped with a GSM module for real-time energy consumption tracking. The meter will offer several advantages over existing systems Remote Monitoring will track energy consumption remotely from your mobile phone, eliminating the need for manual meter checks [20]. Energy Alerts receive SMS alerts when exceeding pre-set energy consumption thresholds, promoting proactive energy management. Transparent Billing Gain transparency into unit charges and bill generation. Consumption History will give access to detailed past energy consumption data for informed decision-making. Remote Load Control: Switch appliances on/off remotely via SMS, optimizing energy usage and reducing costs. Automated Billing will Generate and receive bills automatically upon load turn-off, simplifying the billing process with DUAL SMS notification.

V Preethi, G Harish et.al prosed how electricity, a vital resource for domestic, industrial, and agricultural activities, faces power theft. This illegal practice results in substantial losses for electricity boards, particularly in countries like India. Thankfully, technological advancements offer a solution through Smart Energy Meters (SEMs) [21]. SEMs are intelligent devices equipped with an energy meter chip for accurate energy measurement and a wireless communication module for data transfer. This paper delves into a smart energy meter designed for automatic metering and billing. The meter continuously displays the energy consume and corresponding amount on an LCD screen while transmitting data to a central base station. This system offers numerous benefits. Theft Detection provides the feedback loop between

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users and the substation facilitates the identification of unauthorized energy usage, enabling swift action against power theft, Remote Monitoring is the energy providers can remotely access and monitor energy consumption patterns without physically visiting each household.

Eric Edem Dzeha, David Owusu, Godfrey A Mills, Ing Bernard Pi-Bansa et.al proposed how the electric utilities have relied on manual meter reading to obtain user energy consumption data for billing, a process that is time-consuming, prone to errors, and lacks real-time updates [22]. With the rise of smart digital meters and IoT solutions, remote data collection has become a reality. However, in many developing countries where most meters are still non-smart, manual reading persists. This paper proposes a mobile application solution that addresses this challenge. Users simply take pictures of their energy meters using the app, and the data is transmitted to a central server for processing using an AI engine. The app also allows users to enter details of the meter. At the server, Optical Character Recognition (OCR) technology extracts meter readings from the images. Trained on the open-source MNIST database, the OCR engine achieved an impressive 99.09% accuracy in extracting customer energy consumption data from image data. The system was tested using existing image databases and in real-world scenarios. This software solution offers significant benefits to utilities using post-paid meters and manual data recording.

Vivek Kumar Sehgal, Nitesh Panda, Nipun Rai Handa, Shubhrangshu Naval, Vipul Goel et.al proposed a paper of an automated billing system for energy meters, resembling a postpaid mobile connection. The user-friendly interface allows users with minimal computer knowledge to read the meter remotely from an office PC [23]. The system utilizes a GSM modem with a SIM card attached to the energy meter, enabling real-time communication and billing. A separate PC connected to another modem stores and manages the user data. The system provides complete usage details, including current consumption, units consumed, and due bill amount. Users can instantly access their bill information and even pay it electronically. The SIM card in the meter sends SMS alerts regarding the due bill, ensuring timely payments. Additionally, an LCD display on the hardware module shows current usage and total units consumed. Users can send a specific code to the meter's SIM card to retrieve their current bill amount and pay using a pre-programmed code.

Noman Mehmood, Zain Anwar Ali, Ali Akbar Sidiqui, M Asif, Sarwar Wasi proposed a paper of a system for transmitting local area meter readings to a centralized billing and control station. The system utilizes an analog electric meter interfaced with digital circuitry to provide real-time billing and readings to customers via an LCD display [24]. It offers the option of prepaid or postpaid usage, monitored and controlled by the server. Each user receives a PIN code for accessing the meter for recharging (prepaid) or checking balance. The core components are a microcontroller, GSM module for wireless data transmission, and an analog meter with an IR module. The system revolves around the GSM module and microcontroller, with the former handling data transmission and the latter controlling all operations.

Surabhi Naik, Shailaja Patil proposed a paper on the combat revenue loss and inefficiencies in the electricity sector, a smart electricity measuring system with an Android-based payment system is proposed [25]. This system comprises three modules: a microcontroller-based prepaid meter, an Android app for monitoring and recharging, and a GSM circuit for SMS alerts. This user-aware system promotes energy conservation and timely payments, reducing revenue losses and theft.

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III. METHODOLOGY

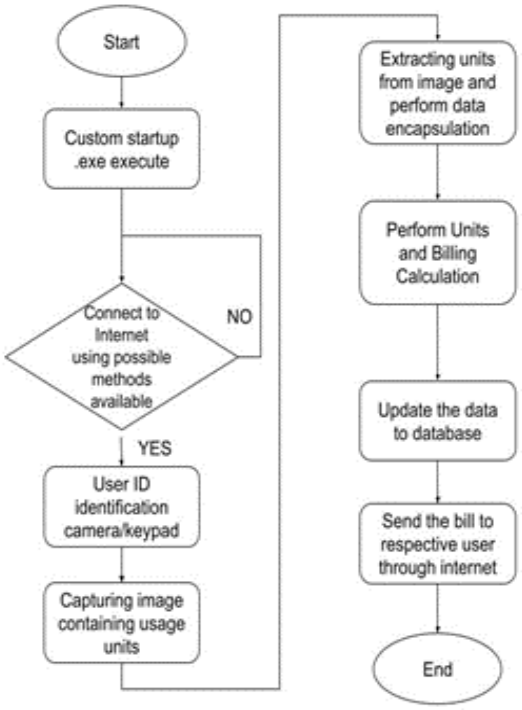

Figure 1: Flow chart of the methodology of image processing billing system

The custom software which is designed for billing system will be embedded in a custom startup file which is going to run whenever the device's powered on first priority basis. Internet connection will be accessed by either of the provided methods from the device like wifi or SIM services. The authentication of the user is done using user id identification either done through camera or keyboard. The main process of capturing the image containing units, extracting the units from the image and encapsulating the data will be the data the retrieving steps. The received data will be processed and the billing calculation will be done respectively. The bill amount and the user data will be updated to the database. The respective bill will be sent as a notification through internet either using email or message services.

IV. CONCLUSION

After reviewing the above papers it can be say that traditional method of energy meter billing systems in India rely on electromechanical and digital meters, leading to time-consuming and labor-intensive processes. Additionally, the current billing system is often inaccurate, slow, costly, and lacks flexibility and reliability. In response to these challenges, smart image processing billing devices for electric meters offer real-time data on unit consumption and accurate billing. The OCR technique from Pytesseract model is the heart for character recognition, to handle the data on unit usage SQL database will be used. One potential solution to increase the usability of the device is by using GSM for enabling messaging of bills. This literature review explores these techniques and communication systems for image processing based billing for electricity meters.

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