DOI: 10.24996/ijs.2022.63.12.40

ISSN: 0067-2904

Automatic Number Extraction from Fixed Imaging Distance

Haider Hameed R. al-Mahmood [1],Ghadah K. AL-Khafaji[2], Sarab M. Hameed[3], Anwar H. Al-Saleh[1], Ali A. Al-Zuky[1]

[1]*Department of Computer Science , College of Science, University of Mustansiriyah , Baghdad, IRAQ*
[2]*Department of Computer Science, College of Science, University of Baghdad, IRAQ*

Received: 20/1/2021 Accepted: 18/3/2021 Published: 30/12/2022

Abstract

Developed countries are facing many challenges to convert large areas of existing services to electronic modes, reflecting the current nature of workflow and the equipment utilized for achieving such services. For instance, electricity bill collection still tend to be based on traditional approaches (paper-based and relying on human interaction) making them comparatively time-consuming and prone to human error.

This research aims to recognize numbers in mechanical electricity meters and convert them to digital figures utilizing Optical Character Recognition (OCR) in Matlab. The research utilized the location of red region in color electricity meters image to determine the crop region that contain the meters numbers, then extracts this numbers region and convert it into binary image and extract the numbers as a text using OCR technique.

A camera for the Iphone 6 (8-megapixel) is used to take a snapshot of the meter screen. The red box in the meter is used to calculate the window coordinates (vertical and horizontal length) that contain the numbers in the original image. The results show a high level of accuracy, reaching 100% due to the effort done on pre-processing the digital images before feeding the part that contains the numbers into the OCR engine. Compared to the maximum accuracy obtained in other previous research of less than 100% in most of related works, the suggested method provide better approach to obtain the optimum results .

Despite the strong results, some challenges still need to be investigated further to find the best solutions, for example the issue of scratched or unclear meter screen, also the meter type 2 (the type that do not have the red box)

Keywords: Mechanical meter reading; Electrical meter reading; Number recognition; Numbers isolation; Numbers detection

استخلاص الارقام من الصور المثبتة بمسافات محددة

حيدر حميد رزاق المحمود[1]، غادة كاظم طعمة الخفاجي[2]، سراب مجيد حميد[3]، انوار حسين صالح[1]، علي عبد داود[1]

[1] قسم علوم اللحاسوب، كلية العلوم، الجامعة المستنصرية، بغداد، العراق

[2] قسم علوم الحاسوب، كلية العلوم، جامعة بغداد، بغداد، العراق

الخلاصه

*Email: hgkta2012@yahoo.com

تواجه الدول النامية العديد من التحديات لتحويل الكثير من الخدمات الموجودة حاليا الى خدمات ذات طابع الكتروني لتعكس الطبيعة الحالية لسير الاعمال والاجهزة المستخدمة لتحقيق وانجاز هذه الخدمات. وكمثال على ذلك خدمة استيفاء اجور تعرفة الكهرباء المستخدمة في المنازل والمؤسسات الكهرباء مازالت لحد الان تعتمد الطرق التقليدية في الجباية والمعتمدة على العمل الورقي الذي ينجز من قبل الموظف (قارئ المقاييس) والتي بدورها تعتبر عرضة للاخطاء البشرية اضافة الى الوقت الكبير لانجاز العمل مقارنة بالعمل الالكتروني.
هذا البحث يهدف الى تمييز الارقام في مقاييس الكهرباء ذات الطابع الميكانيكي وتحويلها الى ارقام الكترونية باستخدام تكنولوجيا (التمييز الضوئي للرموز) المتوفر بلغة البرمجة ماتلاب. في هذا البحث تم استخدام موقع المنطقة الحمراء في الصورة الملونة لعداد الكهرباء لتحديد المنطقة التي سيتم استقطاعها والتي تحتوي على الارقام، بعد ذلك يتم استخلاص هذه المنطقة التي تحتوي على الارقام وتحويلها الى صورة ثنائية الالوان (ابيض واسود) واستخراج الارقام كنص باستخدام تقنية التمييز البصري للحروف (OCR).
تم استخدام كاميرا مثبته بهاتف من نوع ايفون 6 (دقتها 8 ميكا بكسل) لتصوير شاشة المقياس الكهربائي، المربع الأحمر في واجهة العداد تم استخدامه لتحديد احداثيات النافذة (الطول والعرض للنافذة التي تحتوي على الارقام) في صورة واجهة العداد. النتائج أظهرت دقة عالية وبنسبة تصل الى 100% كنتيجة للجهد المبذول في معالجة الصورة قبل ادخال جزء الصورة الى الجزء الخاص بتمييز الارقام (اداة التمييز الضوئي للرموز).
مقارنة مع اعلى دقة تم الحصول عليها في البحوث السابقة
بالرغم من قوة النتائج المتحصلة الا انه ما زالت هنالك بعض التحديات بحاجة الى مزيد من الاختبارات وإيجاد الحلول المثلى لها، وكمثال على ذلك هي حالة الارقام في العدادات الميكانيكية ذات الواجهات التي تحتوي على خدوش تؤثر على وضوح صورة الارقام مشكلة شاشة العداد الغير واضحة او التي فيها شخوط.

1. INTRODUCTION

Many developed countries have begun to convert most of the services that are provided to their citizen and businesses from traditional methods to digital services, for instance electricity, water and sewerage billing. According to [1], the Iraq government is lagging behind in utilizing Information and Communications Technologies (ICT) in these roles, meaning the electronic billing services provided to business (Government to Business) and the public (Government to Consumers) are still poor.

Obviously, replacing traditional services with digital alternatives brings a lot of benefits to people, businesses and governments (or corporations that provide the billing services on behalf of the government) in terms of cutting administrative costs and reducing errors. However, it is not an easy process when technology is implemented to automate a manual process. There are a lot of obstacles facing corporations when providing such services [2]. Example of such challenges include business online integration, managerial challenges, business processes challenges, in addition to the legal and technological challenges [3]

Manual meter reading requires an employee to read the data in person, write them down at the consumer's home, and only later will these data be fed into the corporation's system [4].

The current problem is that the figure entered into the information system can easily differ from the actual reading, leading to wrongly issued bills. This mistake can happen when either the staff member who read the meter recorded different values, or the employee reading the handwritten figures makes errors when inputting them to the electronic system (at the corporation office). In both cases, incorrect bill values will be issued to the consumer. This problem is considered as an opportunity to convert the task management from manual data entry to electronic data entry [5].

The best way to overcome this problem is by replacing the analog meter by a digital meter with an interface to export data to external devices [6]. This is the best solution available in the market, but it costs a lot for corporations, especially when it would involve millions of these new devices for a whole country. So, the alternative solution is to keep the traditional manual equipment and replace the reading phase with an automated task.
This research is concerned with solving the problem of converting the reading of electricity meters from the traditional way to an automated process, using Computer Aided Software, for instance Image Processing.

Image Processing tools and Statistic Pattern Recognition models include three major phases (preprocessing, feature extraction and learning classification) [7] that are employed to extract the digital information, Figure 1.

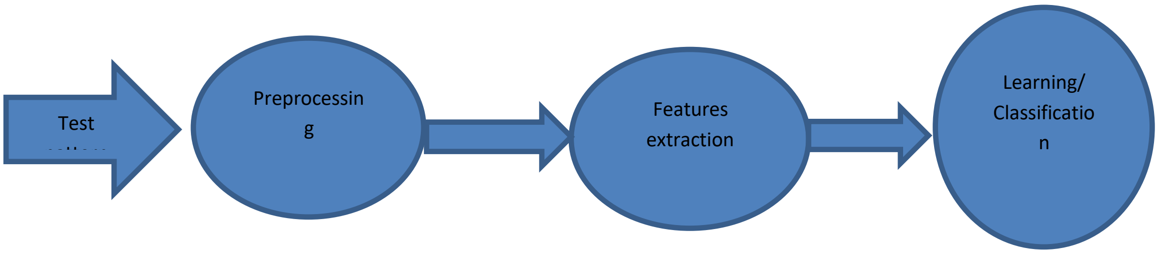


Figure 1: Statistical Method of Pattern Recognition

The outline of the suggested work is derived from a pattern recognition model, where the matching process involves comparing the produced numbers with a predefined number database to map them to the right numbers. The OCR engine in Matlab is used to do the matching process [8]. The next step is to confirm the resulting figures personally via the employee, before feeding the numbers into the information system. In addition, it is recommended to retain the image for future auditing.
This research attempts to solve the problem of converting the manual meter energy reading service provided by the four major utility companies in Iraq (Baghdad Electricity Distribution Co., North Electricity Distribution Co., Central Electricity Distribution Co., and South Electricity Distribution Co.) They all agreed on a unique design for a widely distributed energy meter and installed more than 6 million instruments around the country [9].

2. RELATED WORKS

As this work is based on Pattern Recognitions and Image Processing, it is worth investigating relevant previous work in these fields. The survey presented below is ordered by the year of publication, from the earliest to the newest dates.
[10] Proposed an algorithm for detecting enhanced Maximally Stable Extremal Regions (MSERs) as major character. For removing regions, these candidate characters are filtered by stroke width variation. For text region detection, some preprocessing is applied to the natural image and an intersection of canny edge and MSER area is produced to determine regions that are even more likely to belong to text. As final step, the selected text region is fed to novel Optical Character Recognition (OCR) technique to enable editable and usable text (not numbers). The results obtained were up to 77.47% on the ICDAR 2011 dataset which contains 229 training image and 255 testing images.

[11] used a camera to take snapshots of a Temperature Monitoring System LCD screen and feed the image to an OCR for detecting characters and converting them to digital numbers. The designed module segmented the display screen into seven segments for the measuring

instruments. The research achieved 95% accuracy in recognition ratio when the algorithm was applied to a data set of 110 images.
[12] Proposed chain code techniques to extract features such as the decimal numbers boundaries. 50 samples were prepared for each character to get the average data set. The Freeman Chain Code has eight neighborhood directions; all of them are applied to get extra detail that helps to build the decimal number shape. Mean error calculations were adopted as the measure for the closeness between numbers of the chain code belonging to the input image and the pre-calculated chain code, which was stored in a database. The lower difference was considered the best result of the recognition process. The results ranged from 60% (for digits 3, 4 and 5) to 90% for the digit (0), while digits 2, 7 and 8 gained 70% recognition and digits 1, 6 and 9 80%. None reached 100% accuracy
[13] Presented a multiple hypotheses framework that involved (OCR) and an integration module as an image operator set module. These operators detect multiple interest areas that contain characters. The OCR was applied to each area and returned multiple potential characters. The suggested method achieved characters recognition up to 95% under good detection circumstances.
[14] Utilized a Haar transform to convert the image into a frequency domain. The research replaced DWT filters with Haar DWT, and the results for detected edges became clearer, as well as less time consuming. A dynamic thresholding technique was employed to obtain the optimum threshold value, which helped to isolate the text region in the image.
[15] Proposed a new algorithm for number recognition from a manual meter called "Hausdorff distance for Meter Reading (HD_MR)". The suggested algorithm achieved 99.9% accuracy with a maximum processing time of 31 milliseconds when used with 150-600 image sample in the offline part of the research, while 11653 images were used in the online test. Hausdorff distance is a mathematical term used in image processing applications when needing to measure the dis-similarity between any two objects [16].
[17] Suggested vertical and horizontal scans for a cropped area that contains the digits (with white color pixels), from the beginning of the first numeric edge in the left to the far edge of the number on the right side. The whole window is then divided into similar boxes, number equal to the numbers of digits in the meter. The results achieved 85.71% accuracy for the whole meter read, compared with 96.49% for each individual digit.
[18] Suggested a new algorithm consisting of a 7-step process, involving 4 operations. It starts from Object Detection in the image, then Noise Removal, before the Image Segmentation phase and finally recognizing the numbers. The proposed method for feature extraction was based on pixel density. The recognition rate for the presented approach was 79%.
[19] Applied the technique of region growing to select the most relative area in the image after the initial seed point has been selected. The research was not implemented on a number and no data set size are mentioned.
[20] Suggested a special technique as a speed breaker in digital image processing, road marking detection/recognition. Speed breaker (called sometimes Speed Humps or Speed Ramps) relates to road signs or obstacles that encourage drivers not to exceed the speed limit [21]. The research utilized an Optical Character Recognition (OCR) algorithm to distinguish traffic signs such as a "STOP" sign. For best detection of lines, "Hough" transform was adopted, which acts as a pre-processing phase to make decisions about when the proposed technique should go on OCR, or to optimize speed breaker. The research considered the extracted Local Binary Pattern (LBP) as a feature employed to train the Support Vector Machine (SVM) classifier to optimize speed breaker recognition. The research claims that experimental results show 79% for recognizing "STOP" signs, while reaching up to 100% of "speed breaker recognitions". The suggested system worked perfectly for the roads that employed proper signage, regardless of their dimensions.

[22] Suggested an algorithm that provides perfect text extraction from digital images for the purpose of translation. The research utilized OCR as tool to recognize the characters from images via a Prewitt operator. Different filters were used to remove noise from images to help optimize the speed and quality of character recognition. The research results showed 100% accuracy in five scenarios out of 9. While less precise in other cases, they were still very close to the previous results.
[23] Implemented Maximally Stable Extremal Regions (MSER) algorithm built in Matlab 2016b. The researchers also used open OCR training in the same Matlab version to increase the comparison rate. The majority of the work was done utilizing manual segmentation of the image to split and isolate numbers from other features before feeding them into the OCR function. The research mentioned that the suggested algorithm gained a 93.17% recognition ratio when implemented on data set containing 169 images; each image has seven segment numerals.

Regarding the preprocessing phase, many studies were carried out to remove the noise from captured still images. As the images have been acquired directly in this research, a noise reducing Charge Coupled Device is generated [24]. The research compares three types of filters (Linear, median, and adaptive filter). It concludes that the median filter is better for real time image acquisition regarding the lowest sensitivity to edge detection (outliers), which is similar to the purpose of the current research. This result has encouraged researchers to adopt the median filter as their noise removal filter.

In order to isolate and extract the relevant image part that contains the numbers, the current research began to segment the initial image into two parts utilizing the idea of the Grab Cut [25].

3. RESEARCH METHODOLOGY

To achieve the goal of this research, a set of meter images is essential, required to test the suggested approach. Deep searches have been done to find any dataset of approved manual energy meters, but none have been found related to the present study case. The alternative was to build a dataset based on 2 types of manual meters with different imaging situations. For this data set, all images were taken with no flash on, to exclude the noise from reflections on the meter screen. Also, the camera was used only in daylight, to get enough light without using the flash. A set of 65 images were collected where the meter shows different readings, containing all possible numbers (0-9).
The below steps briefly describe the suggested approach to creating the dataset:
1- Clear all the obstacles on the meter screen, such as dust or any other pieces of dirt.
2- Fix the distance and position of the camera to face the manual meter’s screen. This step will help find the best posture (gaining suitable zoom) that contains the numbers in the image.
3- Take a picture of the screen of the meter without using the flash. The flash would produce reflections on the meter screen, which are considered as extra noise needing to be removed.

To isolate and extract the relevant image part that contains the numbers, the current research began to segment the initial image into two parts, the first part is the red color box, which is utilized to determine the size and coordinates for each box that contains any single number, Figure 2 below illustrates the sequence of processing the input image to extract the digital numbers:

The algorithm:

Input: the image (I), and tow thresholds (th1, th2) to convert gray image into binary image, in this study used (th1=0.2, th2=0.7) for all images.
Output: reading the counter part in the input image and converting it to text.
Steps:
i- Reverse the elements in each column in (I), obtain (If) the mirror image for displaying, Figure 3: a, b.
ii- Convert (If) to gray scale intensity image (G), so that easy to extract the red target from, as illustrated in next step.
iii-Extract only the red target of the flipped image (If) in a new output image (Id), by getting the red band (Ir) of (If), then subtracting each element in (Ir) from the corresponding element in (G) and returning the difference in the corresponding element of the output image (Id), (Id = Ir - G), Figure 2: c.
iv-Filter out the noise by using median filter with size window (3×3), where each output pixel contains the median value in the 3-by-3 neighborhood around the corresponding pixel in (Id); (I_filt) is the output image (filtered image).
v- Convert (I_filt) into a binary image (Ib), with the red objects as white, based on threshold (th1), by replacing all pixels in the (I_filt) with luminance greater than (th1) with the value 1 (white) and replacing all other pixels with the value 0 (black), Figure 3: d.
vi-Fill holes (I_fill) in the white object in (Ib), so that extracting it from the whole image becomes easier, Figure 3: e.
vii- Bound the white object with the smallest rectangle containing it, by specifying the size and position of the crop rectangle as the vector of four values, rect= [x, y, w, h], where (x,y) is the upper left corner of the specified rectangle, and w & h are the width and height of the rectangle respectively.
viii- Clip the white part of the image (J1) using the imcrop function, according to vector (rect), but the cropping process is done on the flipped image (If), to get only the red object in the image, Figure 3: f.
ix-Enlarge crop rectangle (rect) to get new crop regian vecter in order to crop the image containing the counterpart, which contains only counter numbers, in the flipped image, as follows: rect_new=[x+w, y, w*5-w, h] .
Example: for rect= [105, 62, 54, 70], so the new regian will be:
rec_new= [159, 62, 216, 70].
x- Clip the counterpart of the image (J2) using the imcrop function, but now according to vector (rect_new). Also, the cropping process is done on the flipped image (If), to get only the counter numbers part of the image, Figure 3: g.
xi-Return the image correctly (Jf), by reversing the elements in each column in (J2), Figure 3: h.
xii- Resize (Jf), and then convert to gray image, and convert to binary image (Jb), based on threshold, th2=0.7, Figure 3: i.
xiii- Recognize text using optical character recognition (OCR).
xiv- Display both images: the input image (I) and the output image (Jb) of the numbers in the counter with text that includes the numbers in the counter as a text, Figure 3: j.
xv- End.

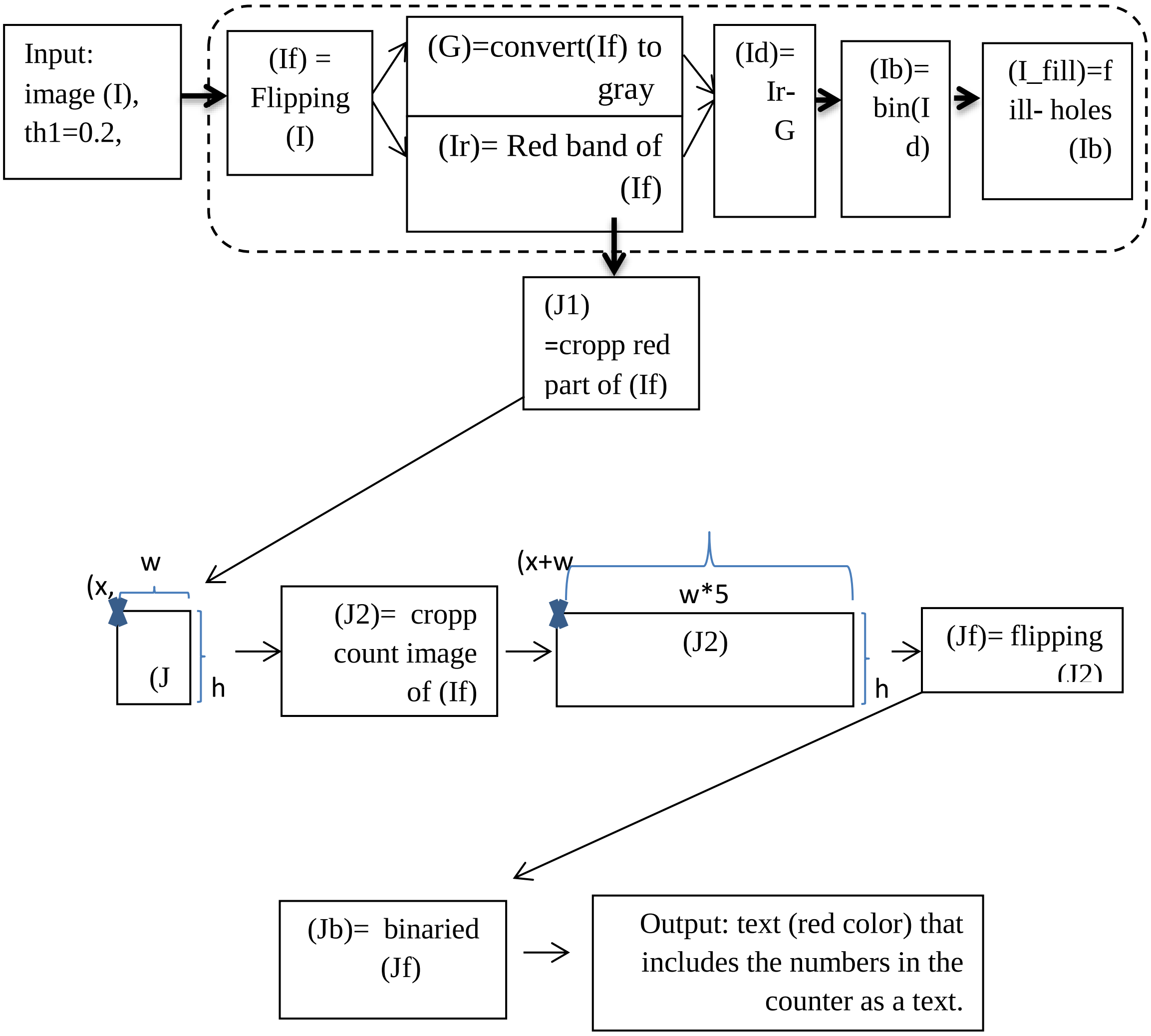
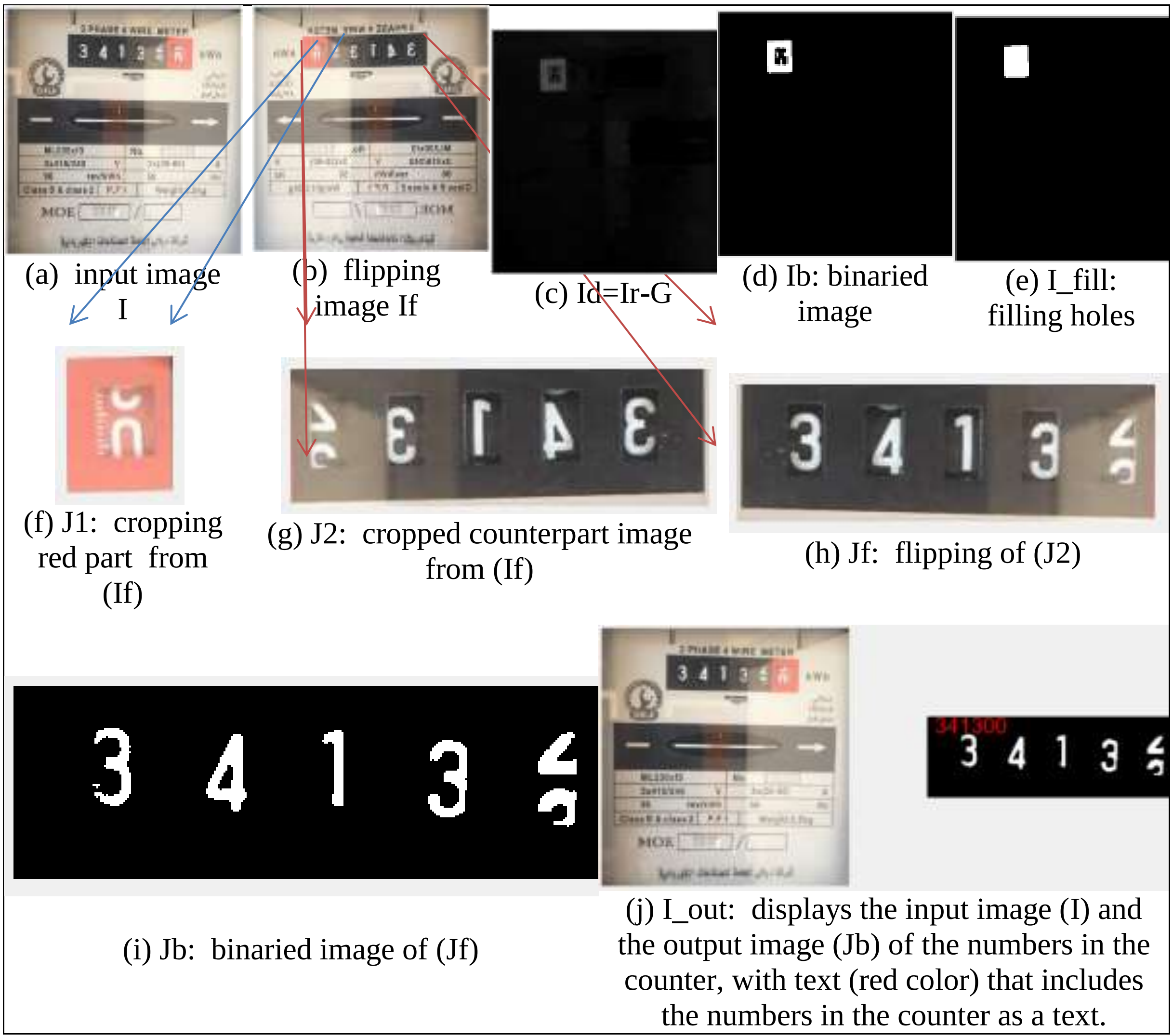


Figure 2 : the flow chart for the algorithm



(a) input image I

(b) flipping image If

(c) Id=Ir-G

(d) Ib: binaried image

(e) I_fill: filling holes

(f) J1: cropping red part from (If)

(g) J2: cropped counterpart image from (If)

(h) Jf: flipping of (J2)

(i) Jb: binaried image of (Jf)

(j) I_out: displays the input image (I) and the output image (Jb) of the numbers in the counter, with text (red color) that includes the numbers in the counter as a text.

Figure 3: Input and output images steps from the algorithm.

4. RESULTS AND ANALYSIS

Promising results were obtained when the described algorithm was applied to one of the meter types (the one containing a box with red color (referred to as type 1), shown in Figure 3. However, it failed to extract numbers from the second type of meter (the one containing a box with white color (referred as type 2)), shown in Figure 4 and the results in Table 2. . Different meter images belonging to type1 (set of 65 images) were fed into the system and the results produced 100% accuracy. Table1(a&b) clearly shows the meter images and the results for digital numbers that represent the meter reading.

Figure 4 : Manual Meters Type 2.

It is important to mention some challenges that faced this research. The first challenge was the unavailability of a dataset for the specific manual meter images. Although considerable research has been done in this field and datasets are available, these datasets were not identical to the cases studied in this research.

Considerable effort was required to generate the dataset for different readings for each single manual meter: because the research demanding a range of different readings, the photographer was required to wait many days to get fresh images following actual consumed electricity.

The second challenge relates to the case when the number (first order) in the meter was changing but was not yet showing completely, as with image (h) Jf in Figure 2 and image number "7" in Table 1(a). The research suggests substituting the current unclear readings with "0" for two reasons: first, the effect of the number in the first order is comparatively limited. Second, any divergence can be accounted for at the next reading. This challenge potentially provides good material for enhancing the current project in future.

Table 1(a) : Results for type 1 of manual meters.

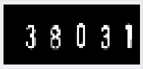
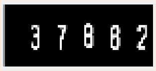
Input image	**Output image**	**The final text**	**Input image**	**Output image**	**The final text**
 1		378220	 2		378680
 3		347100	 4		380310
 5		344240	 6		378820
 7		341300	 8		378400

Table 1(b) : Results for type 1 of manual meters

For the second type of meter, shown in Table 2, the suggested algorithm failed to extract the digit numbers. A special adaptation on the algorithm is needed to improve determining the box that contains the numbers. It is suggested to implement further study on this type of meter in future work

Table 2: Results for second type of meter images

Input image	Output image	The final text	Input image	Output image	The final text
		empty text			empty text

In order to present clear vision of comparison between the results produces by the suggested algorithm in this paper to the closest results published by other research, table 3 summarizes the results for each methods discussed previously alongside the proposed algorithm.

Table 3: Results Comparison.

Detection Approach	Accuracy
Suggested method in this research	100%
chain codes	60%-90%
OCR and an integration module	95%
“Hausdorff distance for Meter Reading (HD_MR)”	99.9%
vertical and horizontal scans for a cropped area	85.71%
4 operators including (Object Detection, Noise Removal, Image Segmentation and recognizing the numbers.	79%
(OCR) algorithm and “Hough” transform for line detection	70%-100%
OCR as tool to recognize the characters from images via a Prewitt operator	100% (or less not specified scenario)
MSER algorithm built in MATLAB and manual segmentation	93.17%

5. CONCLUSION

The research concludes that there is a great opportunity to replace the traditional workflow for electricity companies in terms of the way they take meter readings from manual electricity meters, changing it to digital form. The proposed method achieved accuracy reaching 100% when the right imaging conditions are applied, such as appropriate zooming and noise removal from the meter screen before acquiring the digital image, as mentioned previously, the 100% of accuracy only happened when the suggested approach implemented on meters belonging to type1.

Challenges can be considered as potential chances for future work, either to enhance the image acquiring process by lowering the standards of the imaging methodology or adopting image processing techniques for calibrating image zoom and position. On the other hand, the second type of meter images can be considered as a further opportunity to improve the detection process so that it fits the nature of this type of image.

Another line for improving the information system can be to build a mobile application that utilizes the extracted numbers of the meter read and feeds them to the electricity bill counting and issuing, with the chance of involve e-payment for such bills immediately.
The results showed 100% of accuracy when the suggested method implemented on the type 1 of images (the image for meter screen that contain the red box section). Unfortunately, the implemented approach did not achieve any success for type 2 of images (the meter without the red box on the meter screen). This challenge encourages researchers to improve the present technique to be able to solve this issue.

In comparison to related works, the results showed close accuracy results gained for certain approaches, for instance "Preitt operator with OCR" used by [22] and "Hausdorff distance for Meter Reading (HD_MR)" approach adopted by [23], while the lowest accuracy were results when chain code adopted in [12].

6. ACKNOWLEDGEMENTS

This work is supported by Mustansiriyah University, College of Science, Computer Science Department at (https://uomustansiriyah.edu.iq/)

7. REFERENCES

[1] H. H. Mahmoud, "E-Government in Iraq," *Journal of Engineering and Development,* vol. 14, pp. 183-198, 2010.

[2] S. S. Alam, A. A. Khatibi, H. B. Ismail and I. Ahmad, "Perceived Benefits of E-Commerce Adoption in the Electronic Manufacturing Companies in Malaysia," *Journal of Social Sciences,* vol. 1, pp. 88-193, 2005.

[3] A. A. Al-Alawi and J. Kuzic, "Challenges of E-Business in Service Industry," in *Information Technology Interfaces*, July 2008.

[4] M. T. Rashid, "Design and Implementation of Smart Electrical Power Meter System," *Iraq Jornal of Electrical and Electronic Engineering,* vol. 10, pp. 1-14, 2014.

[5] A. Mohan, "Role of e Business- Challenges & Opportunities in an Indian," *International Journal of Advanced Research in Computer Science and Software Engineering,* pp. 471- 475, November 2015.

[6] M. C. Ndinechi, "Digital Metering System: A Better Alternative for Electromechanical Energy Meter in Nigeria," *INTERNATIONAL JOURNAL Of ACADEMIC RESEARCH,* vol. 3, pp. 189-194, 2011.

[7] S. Asht and R. Dass, "Pattern Recognition Techniques: A Review," *International Journal of*

Computer Science and Telecommunications, vol. 3, pp. 25-29, 2012.

[8] R. Hussin, M. R. Juhari, N. W. Kang, R. C. Ismail and A. Kamarudin, "Digital Image Processing Techniques for Object Detection From Complex Background Image," *Procedia Engineering,* vol. 41, pp. 340-344, 2012.

[9] Electric Meter , 2021
Available: https://www.dialacompany.com/meter.htm

[10] Md. Rabiul Islam, Chayan Mondal, Md. Kawsar Azam, and Abu Syed Md. Jannatul Islam., "Text Detection and Recognition Using Enhanced MSER Detection and a Novel OCR Technique," *5th International Conference on Informatics, Electronics and Vision (ICIEV),* 2016.

[11] R. P. Ghugardare, S. P. Narote, P. Mukherji and P. M. Kulkarni., "Optical character recognition system for seven segment display images of measuring instruments," in *TENCON 2009 - 2009 IEEE Region 10 Conference*, January 2009.

[12] R. B. Ibrahim, "Number Recognition System Using Chain Code Technique," in *3rd International Conference on Engineering Technology*, December 2011.

[13] R. Huang, S. Oba, S. Palaiahnakote and S. Uchida., "Scene Character Detection and Recognition Based on Multiple Hypotheses Framework," in *21st International Conference on Pattern Recognition (ICPR 2012)*, January 2012.

[14] A. Kumar, P. Ahuja and R. Seth, "Text Extraction and Recognition from an Image Using Image Processing In Matlab," in *Conference on Advances in Communication and Control Systems (CAC2S 2013),* April 2013.

[15] M. Rodriguez, G. Berdugo, D. Jabba, M. Calle and M. Jimeno, "HD MR: a new algorithm for number recognition in electrical meters," *Turkish Journal of Electrical Engineering & Computer Sciences,* vol. 22, pp. 87-96, 2013.

[16] S. Nutanong, E. H. Jacox and H. Samet., "An incremental Hausdorff distance calculation algorithm," in *International Conference on Very Large Data Base*, May 2011.

[17] L. A. Elrefaei, A. Bajaber, S. Natheir, N. AbuSanab and M. Bazi, "Automatic Electricity Meter Reading Based on Image Processing," in *IEEE Jordan Conference on Applied Electrical Engineering and Computing Technologies (AEECT),* Novembe 2015.

[18] P. H. Kulkarni and P. D. Kute, "Optical numeral recognition algorithm for seven segment display," in *Conference on Advances in Signal Processing (CASP)*, June 2016.

[19] B. Barida , I. Chinagolum and M. Shedrack, "An Enhanced Application of Artificial Neural Network Algorithm in Image Segmentation Process," *Journal of Environmental Science, Computer Science and Engineering & Technology,* vol. 8, pp. 28-37, 2019.

[20] M. E. Irhebhude, O. A. Adeyemi and A. Kolawole., "Speed Breakers, Road Marking Detection and Recognition Using Image Processing Techniques," *European Journal of Applied Sciences,* vol. 7, pp. 30-42, 2019.

[21] W.Devapriya, C. K. Babu and T.Srihari, "Advance Driver Assistance System (ADAS) – Speed Bump Detection," in *2015 IEEE International Conference on Computational Intelligence and Computing Research (ICCIC)*, December 2015.

[22] S. A. Kumar, "Texture-based Real-Time Character Extraction and Recognition in Natural Images," *International Journal of Innovative Technology and Exploring Engineering (IJITEE),* pp. 3302-3306, June 2019.

[23] K. Kanagarathinam and K. Sekar , "Text detection and recognition in raw image dataset of seven segment digital energy meter display," *Energy Reports,* vol. 5, pp. 842-852, 2019.

[24] H. H. K. Tin, "Removal of Noise Reduction for Image Processing," in *The 6th Parallel and Soft Computing (PSC 2011)*, December 2011.

[25] D. Khattab, H. M. Ebied, A. S. Hussein and M. F. Tolba, "Color Image Segmentation Based on Different Color Space Models Using Automatic GrabCut," *The Scientific World Journal,* 2014.