Automated Reading of High Volume Water Meters

Jessica Ulyate and Riaan Wolhuter
Department of Electronic Engineering
University of Stellenbosch
7600 Stellenbosch, South Africa
Email: 14523590@sun.ac.za, wolhuter@sun.ac.za

***Abstract*—This paper discusses the design and implementation of a system enabling the automatic reading of dials on high volume water meters. The current system of sending out a person to read every individual meter is time and labour intensive and also prone to error. A motivation for the design is given and techniques to realise the concept are discussed. The paper then discusses future work that will be done on the project.**

I. Introduction

In South Africa the municipal water supply infrastructure consists mainly of mechanical dial water meters to monitor water usage. To ensure accurate billing for high volume users, a meter reading has to be performed every month. The current system employed by municipalitites involves sending a person to the meter and manually reading the values of the dials. This process is both time and labour intensive and error prone. In the interest of cutting down costs and making the process more effective, it was proposed to develop a device that can be permanently affixed to a meter that automatically reads the water usage and then sends the information to a central server. This paper proposes a device with a fixed camera and GSM module that transmits data via the GSM network to a central server, where the image can be processed, the data extracted with image recognition and the readings aggregated.

II. Communications Module

The meter reading recording interface consists os a communications module and camera. The unit as developed consists of the Sierra-Wireless Q2686 GSM modem [1] with an attached COMedia C328 UART camera [2]. The camera support image resolutions up to 640 x 480 pixels with JPEG compression. With the Q2686 the images are uploaded to an FTP server via a GPRS connection.

III. Data Processing

Data processing of the transmitted image will take place on a server rather than the device itself. Logistically this makes more sense as a computer is much more versatile than an embedded module with regard to processing power and available memory. By transferring data processing to a server, it also lowers the device's power requirements. Data processing consists of three parts; improving number contrast and cleaning the image, isolating and cropping numbers and performing Optical Character Recognition (OCR) on the result.

A. Isolate Number Window

The dials indicating water consumption are all visible in a rectangular window on the meter. To isolate the rectangle, a high contrast border is placed on the meter around the numbers. OpenCV was used to implement a rectangle detection algorithm. Once the rectangle has been isolated, the imaged is cropped until only the numbers are visible in the new image.

B. Thresholding

Thresholding is the process of creating a black and white image from a greyscale image. A threshold value is chosen and all pixels above the value are set to white while all pixels below the value are set to black. In thresholding it is important to find the ideal threshold value as it can vary according to image quality and lighting conditions. To determine an ideal value, a histogram of the image is inspected. Histograms of images of the dials show two prominent peaks; one for darker pixels and one for lighter pixels. The numbers on the dials are all black, thus to increase their visibility, the darker pixels should be retained and the lighter pixels discarded. To implement this, the maximum histogram value is found. The previous graph values are then inspected until a local minimum is found. All pixels above this value are discarded. This is implemented with the OpenCV library.

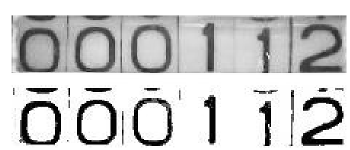

Fig. 1. Meter dials before and after thresholding

C. Isolating Numbers

To find the coordinates of the individual numbers on the dial, the Radon transform is utilized. The Radon transform works by summing all vertical pixel values for every horizontal pixel position [3] [4]. In a full transform, the image is rotated through 180 degrees in 1 degree increments and a summation is performed for every rotated position. The transform is useful for finding straight lines in an image. For isolating numbers the transform is only applied once with no rotation. The Radon transform outputs a one dimensional array equal to the width of the input image. The position of the numbers can be obtained by inspecting the output array values; the numbers are coincide with large continuous blocks with a high count. The coordinates of these continuous blocks can then be used to crop individual numbers from the threshold image.

D. Character Recognition

Tesseract was initially a proprietary OCR program developed by Hewlett-Packard between 1985 and 1995. In 2005 it was released as open source software. It is one of the most accurate free OCR programs available today.[5] Tesseract works well on images that do not contain noise or artefacts. Unfortunately, the spaces between dials on the meter result in artefacts after image thresholding. Much better results are achieved if the individual numbers are cropped out of the image and passed to Tesseract separately, as almost all artefacts are removed by the cropping process.

IV. PROBLEMS

The meter dials are advanced by a series of rotating gears. This means that changeovers between numbers are not discrete, but continuous. At any stage there can be more that one number, or part thereof, visible on the dial. This poses no problems to a human who can interpret what is happening. However, Tesseract was built to recognize linear lines of text and not the rolling numbers of a dial. When confronted with parts of other numbers within an image, Tesseract starts to fail rapidly with regard to accuracy.

V. FUTURE WORK

Tesseract is capable of being trained for a custom character set. Thus it should be possible to train Tesseract with images of partial numbers to improve recognition accuracy. To further ensure accurate readings other possibilities are being investigated, such as processes based on Hidden Markov Models. The camera and communication module has to be mounted permanently on a meter. The casing has to be designed and equipped with an adequate light source, as the meters are usually situated in covered manholes.

VI. CONCLUSION

Techniques were discussed on how to extract numbers from a photo of a water meter and methods of improving image quality. Methods were also discussed on how to manipulate the image to improve the success rate of the character recognition program Tesseract. Future work will involve methods to increase character recognition accuracy as well as designing an appropriate casing for the device.

REFERENCES

[1] Sierra-Wireless, "Sierra Wireless Airprime Product Information[Online]," Available at: http://www.sierrawireless.com/, [2010, June], 2010.

[2] COMedia, "COMedia C328 UART Camera Module[Online]," Available at: http://www.seeedstudio.com/depot/uart-camera-module-with-jpeg-compression-c328-p-209.html, [2010, June], 2010.

[3] B. Anguelov, "Radon Transform[Online]," Available at: http://takinginitiative.wordpress.com/2007/11/07/radon-transform/, [2010, June], 2007.

[4] E. W. Weisstein, "Radon Transform[Online]," From MathWorld, A Wolfram Web Resource. http://mathworld.wolfram.com/RadonTransform.html, [2010, June].

[5] R. Smith, "An Overview of the Tesseract OCR Engine," in *Proc 9th Int. Conf. on Document Analysis and Recognition*, 2007, pp. 629–633.

Jessica Ulyate received her B.Eng. at the University of Stellenbosch in Electronic Engineering with Computer Science. She is currently busy with her M.Sc.Eng in Electronic Engineering, at Stellenbosch University in South Africa.

Riaan Wolhuter has a B.Sc.B.Eng., M.Eng. and a Ph.D. from Stellenbosch University, and a B.Sc(Eng)(Hons) from the University of Pretoria, all in Electronic Engineering.

He is a senior researcher at the Dept of Electrical and Electronic Engineering at Stellenbosch University, South Africa.