Computer vision and digit recognition on dials applied to ionizing radiation. A state of the art

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Abstract. Specificity is an essential feature of a computer vision system, as the older detectors of ionizing radiation do not have a communication interface that allows automated reading of the measurement, it is necessary to develop techniques for digit recognition in these detectors. Twenty-nine scientific publications were found and of these, six were selected as relevant to the topic. The results suggest the need to create a database with images of displays used in ionizing radiation, which will aim to develop a technique for optical character recognition specific to the automation of calibration processes.

Keywords: computer vision, calibration 4.0, ionizing radiation, digital transformation, and metrology 4.0.

1. Introduction

Automating the calibration processes in laboratories, in addition to accelerating them, appears to prevent the reliability of the process from being compromised if the human factor involved in the dynamics makes mistakes that can be caused by fatigue or inherent subjectivity. Automated systems seek to provide precision and accuracy in the processes to which they are applied [1].

Specificity is an essential characteristic of an effective computer vision system, and, for metrological processes to guarantee the reliability and quality of their measurements, it is of paramount importance that data acquisition is carried out accurately.

Older ionizing radiation meters do not have a communication interface between them and the computer, but when considering robustness, stability, and the high cost of replacing them with modern detectors with an intelligent system, many users choose to keep them in use. Thus, with the aim of making the calibration of these detectors adequate to the reality of Metrology 4.0 in a laboratory

environment, it is necessary to develop computer vision techniques focused on the recognition of digits on dials applied to ionizing radiation [2].

2. Materials and Methods

To map this state of the party, online searches were carried out in the databases of the International Atomic Energy Agency (IAEA), Scientific Electronic Library Online (SciELO) and Google Academic with the keywords defined in the inclusion criteria in the April period to June of the year 2022.

2.1. Inclusion criteria

Articles and dissertations published between 2015 and 2023, written in Portuguese and English and containing the keywords:

"Computer vision" and "optical character recognition" and "ionizing radiation";

"Computer vision" and "optical character recognition" and "digits";

"Optical character recognition" and "digits".

2.2. Exclusion criteria

By consensus of at least two authors, documents that met the inclusion criteria were excluded after a critical analysis of the title and abstract because they were not related to the themes of computer vision and optical character recognition. Works that could not be read in full or were the product of course completion work were also excluded.

3. Results and Discussion

A total of fifty-one scientific publications were found, and six of them, after applying the exclusion criteria, were relevant to the theme for the development of this state of the art and are summarized in Table 1.

Table 1: Articles selected for review.

Year	Heading	Main ideas and contributions
2021	A fully AI-based system to automate water meter data collection in Morocco country [3]	Development of a consumption monitoring system, detection of water leaks, visualization of water consumption and geographic map to reduce cost and time.

2020	Implementation of a mobile application (App) for reading water and energy meters based on computer vision [4]	Process automation for meters with analog or digital display using a convolutional neural network with cloud storage.
2020	Deployment framework for the Internet of water meters using computer vision on ARM platform [5]	Automation of the process of meters with analog display using computer vision and machine learning with the possibility of remote supervision.
2016	Digit recognition in images of natural gas consumption meters using computer vision techniques [6]	Recognition of digits in meters, from images acquired under real operating conditions.
2015	Automatic Electricity Meter Reading Based on Image Processing [7]	Automating digital meter reading via cell phone camera using Android Studio software.
2015	Android Based Meter Reading Using OCR [8]	Reduction of time in the process of reading meters and their identifier for generating energy bills by automating the process using optical character recognition techniques.

Source: Research data

Computer vision systems are the main actors when it comes to the development of an interface for the meter and the computer, and the automation of the process of reading analogue and/or digital meters without this interface has made great use of this technology. The works selected above develop and describe various approaches to this automation process for various meters, applied in different areas and with different display formats.

In Morocco, [3] using the MR-AMR database, which has 140,000 images of digits ranging from medium to full state for analogue dials, obtained a reliability of 98.70% in the meter digit recognition system. With the use of this solution, it was possible to reduce water consumption due to the possibility of detecting leaks and geographic mapping made possible with the implementation of the system.

Alvares et. al in [4] and [5] automates meter reading processes. In [5] using a sample formed by a set of 5,000 images of analogue displays for monitoring the consumption of water meters and making

it available for online supervision. In this work Alvares et. al trained three apprenticeships and made a study regarding the image acquisition environment in relation to lighting and reflections on the displays, variables that are quite influential in the measurement processes within laboratories. In [4], a more recent work covering digital displays, a mobile application was developed, Android and iOS, for reading displays of water, gas and energy meters, allowing that, in addition to service providers, the final consumer knows their consumption levels and promote the efficient and sustainable use of water distribution. In this method Alvares et al. the percentage of accuracy based on optical character recognition was based on two methods. With Tesseract, an average accuracy of 85.76% was obtained in a total of 34,463 images detected in the three types of detectors used, and with the CNN method, an average of 97.34% accuracy for 39,115 detected images.

Gonçalves in [6] searched in 903 images captured in situations that were closer to the real environment of use of the gas meters used, to locate the digits. The proposed method using the ELM classifier achieved a hit rate of about 95% in the group of digits presented to it, also presenting the lowest computational cost.

For Elferei et al. [7] a system is tested on analog electricity meters with images obtained from main cell phone cameras in free environment. Of the 21 acquired display images, an accuracy rate of 90.47% was obtained for the recognition of existing digits. These digits were used to develop machine learning and thus obtaining new and more promising results of about 96.49% of digit recognition. With the use of OpenCV and Android Studio libraries, [5] managed post pre-processing, digit segmentation, scanning and recognition to obtain a dial reading accuracy rate of 85.71% in a restricted database.

In 2015, [8] proposes an application that reduces the efforts of energy distribution companies in the process of reading their meters. Unlike the other works presented, [8] sought to determine from mapping the distribution of read meters.

4. Conclusion

The results showed that no publications were found that discuss computer vision techniques developed to meet the reading needs of digital displays of equipment used for metrological processes in ionizing radiation applications.

Alvares et al. [4] showed that with the construction of an application for use on mobile devices, it is possible to read digital displays of light, water and/or gas meters. For future work, the technique

developed by Alvares could be adjusted for specific applications in the calibration process of ionizing radiation detectors.

The analysis of the evaluated literature suggests the need to create a database of images of ionizing radiation detector displays to develop machine learning and develop a computer vision system specialized in the automation of these processes from the reading of these equipment that do not have a communication interface.

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