Seminar
on
Automatic Meter Reading Using Deep Learning

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March 24, 2022

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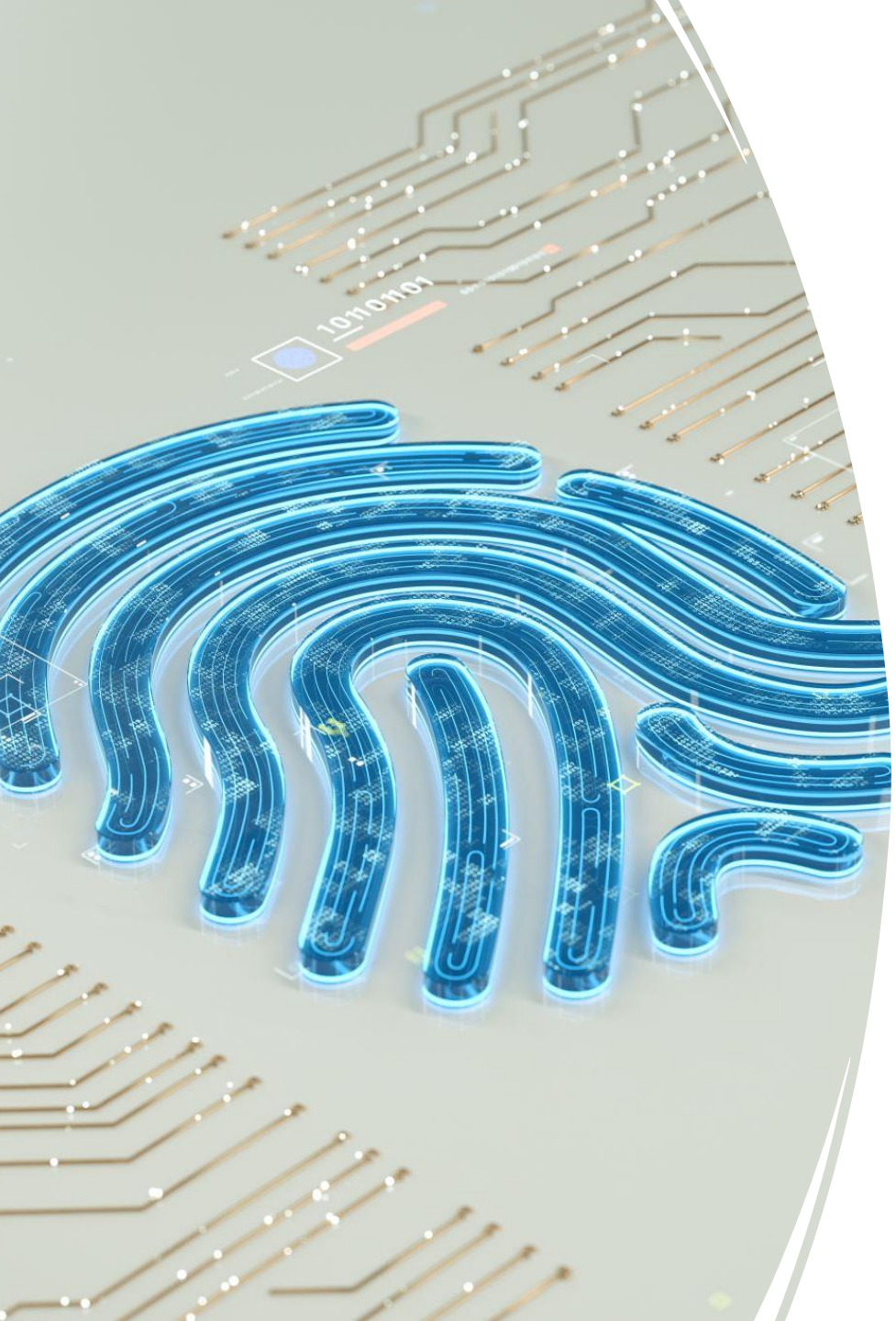


Introduction

Automatic Meter Reading (AMR) refers to the technology whose goal is to automatically record the consumption of electric energy, gas and water for both monitoring and billing. Although smart meters are gradually replacing old meters, in many regions (especially in developing countries) the reading is still done manually in the field, on a monthly basis, by an employee of the service company who takes a picture as reading proof.

Problem Statement

What

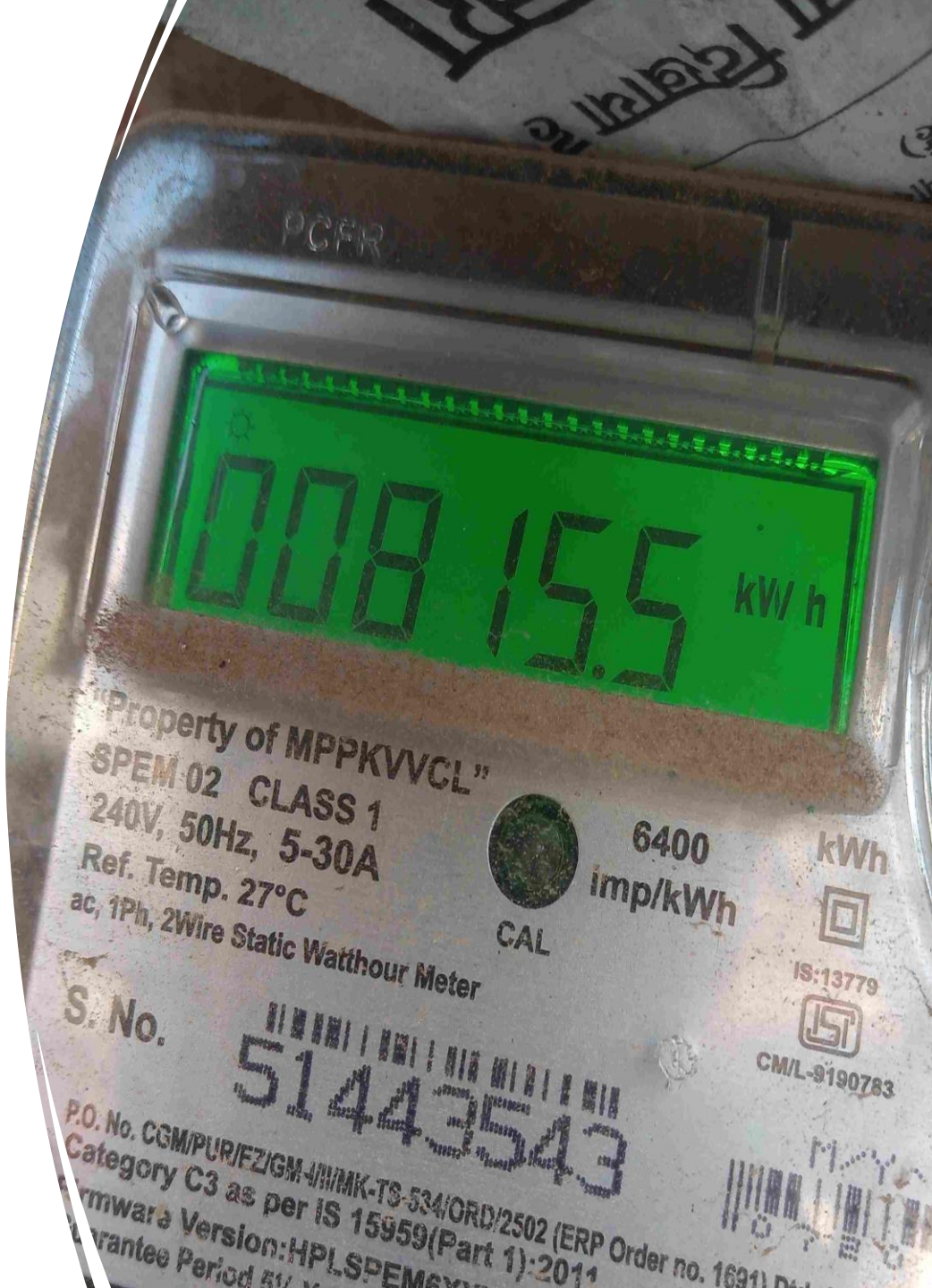
Using Deep Learning Techniques to Identify the Meter Reading from an Image.

Why

Manual meter reading is a time consuming, error prone and hectic procedure.

How

By extending help in automating meter reading hence reducing time, effort and resources used.



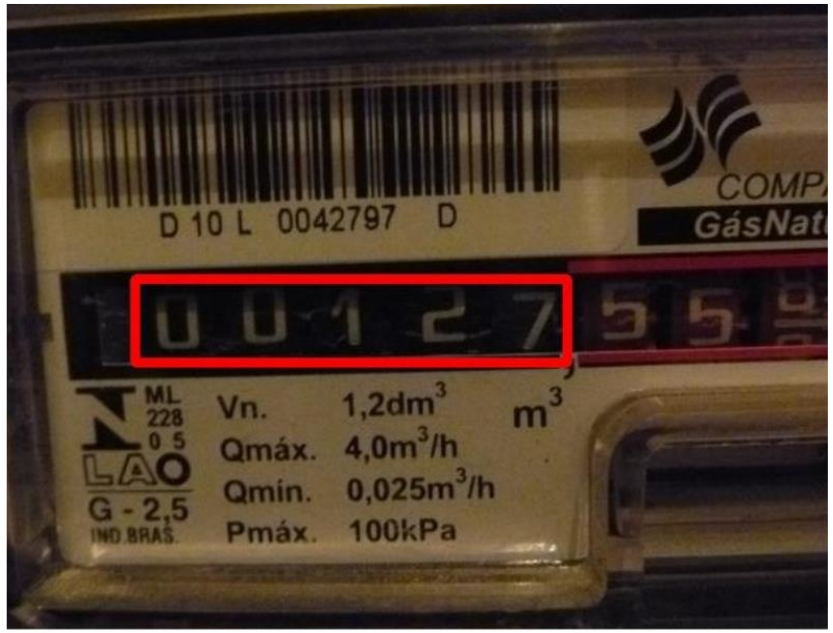
State of the Art

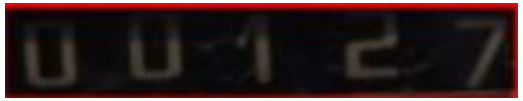
- R. Laroca et al[2] uses two stage approach for AMR and used UFPR-AMR dataset.
  - **Detect the counter region** employs a smaller version of the YOLO object detector, called Fast-YOLO for counter detection
  - **Digit segmentation and recognition** evaluate by three CNN-based approaches
    - **CR-NET**
    - **Multi-Task Learning**
    - **Convolutional Recurrent Neural Network**

Method Used

Table 9 Results obtained in the Meter-Integration subset by previous works and using Fast-YOLO & CR-NET.

Approach	Accuracy (%) Digits	Counters
Gallo et al.[2] (original training set)	–	85.00
Vanetti et al.[5] (original training set)	–	87.00
Fast-YOLO & CR-NET (original training set)	97.94 ± 0.85	94.50 ± 1.72
Fast-YOLO & CR-NET (data augmentation)	$\mathbf{99.56 \pm 0.34}$	$\mathbf{97.30 \pm 1.42}$





[0 0 1 2 7]

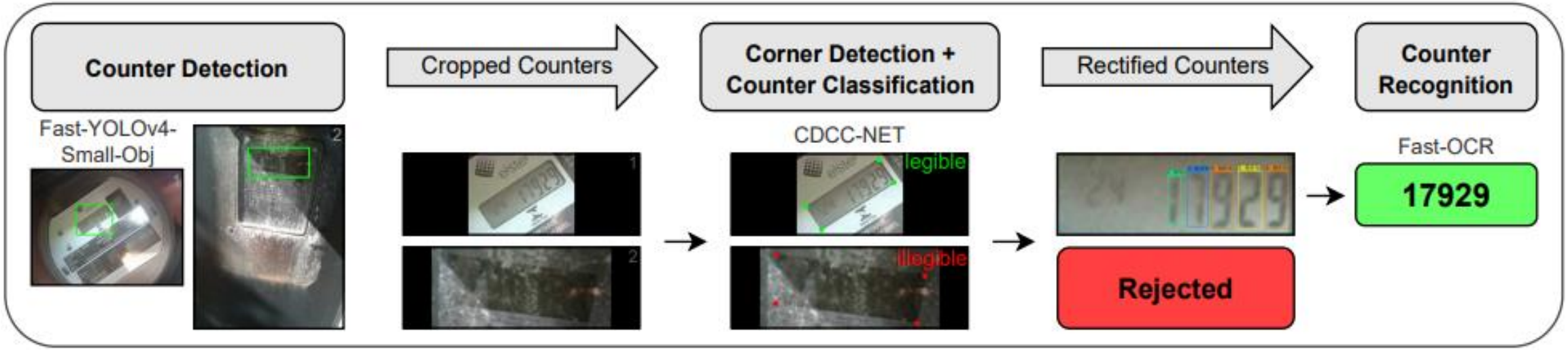
Results obtained by the CR-NET

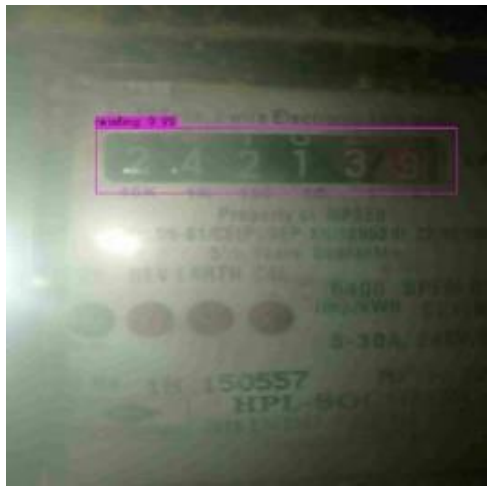
counter detection obtained with the Fast-YOLO model.

State of the Art

- R. Laroca et al. [1] approach consist of three main stages
  - **First stage:** Counter Detection
  - **Second stage:** Corner detection and counter classification
  - **Third stage**: Counter Recognition

Method used


Counter Detection
Fast-YOLOv4-Small-Obj
Cropped Counters
Corner Detection + Counter Classification
CDCC-NET
legible
illegible
Rectified Counters
Rejected
Counter Recognition
Fast-OCR
17929

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About Dataset

- The AMR dataset(private) contains more than 10,000 images of meter readings.
- The AMR dataset composed of images captured in unconstraint environment including blur (due to camera in motion), scale variation, reflections, shadows, occlusions etc.
- The images have resolution of 3072 x 4096 or 2992 x 4000.
- Initially, I have manually labelled 94 meter readings for training and testing.

Preparing labelled dataset.

- YOLO Darknet TXT Annotation Format:

  [object_id, x_center, y_center, width, height]

  where:

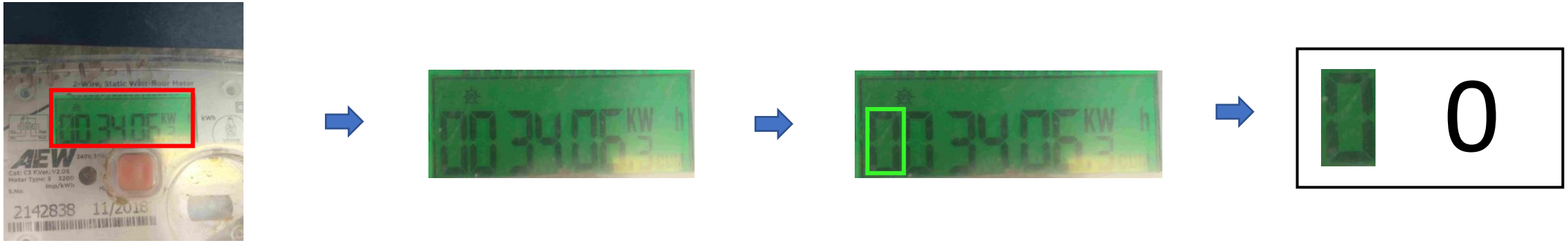
  (<x_center> , <y_center>) : Coordinates of the center.
  <width> : Normalized width.
  <height> : Normalized height.

- Image Labelling tools are:
  - MakeSense.ai
  - labelimg
  - Labelme
  - Roboflow

[0 0.562942 0.535336 0.388251 0.226148]

Implementation

- YOLOv4 detects number area within an image.
- Crop the bounded area.
- Segmentation.
- Digit Recognition.
- Append them together.
- We get the number.



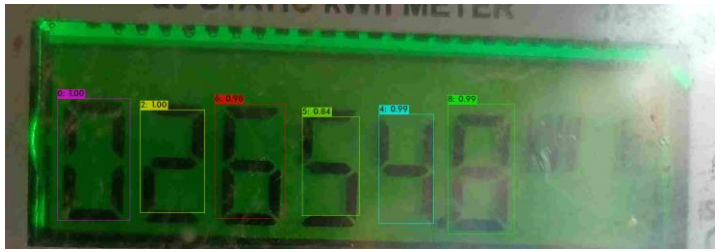
YOLOv4

Counter Detection

Cropping detected region

Cropped Counter

Custom OCR



Digit Recognition

Setup

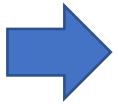
First Phase:

Counter Detection

- Used 70 image for training and 24 images for testing.
- Training took approx. 5 hour to train and saves the best weights file accordingly.
- For cropping purpose, We have used custom function by first converting into TensorFlow weight file and then adding custom function

Example:


number: 0.88
12345.6




12345.6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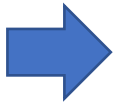


Results

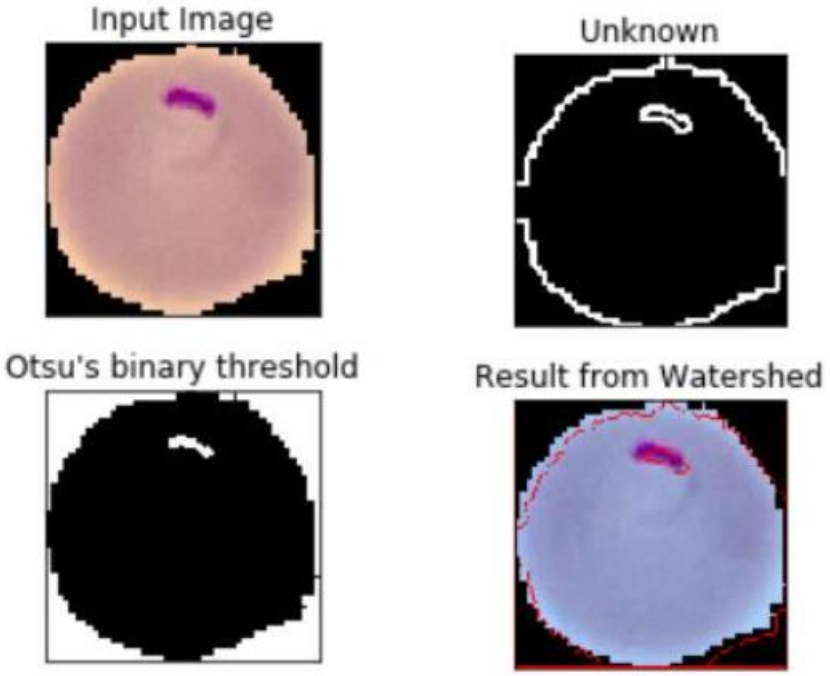
```
 detections_count = 24, unique_truth_count = 18
class_id = 0, name = number, ap = 100.00%        (TP = 18, FP = 0)

 for conf_thresh = 0.25, precision = 1.00, recall = 1.00, F1-score = 1.00
 for conf_thresh = 0.25, TP = 18, FP = 0, FN = 0, average IoU = 78.88 %

 IoU threshold = 50 %, used Area-Under-Curve for each unique Recall
 mean average precision (mAP@0.50) = 1.000000, or 100.00 %
Total Detection Time: 2 Seconds
```

Image Segmentation

The process of splitting images into multiple layers, represented by a smart, pixel-wise mask is known as **Image Segmentation**. It involves merging, blocking, and separating an image from its integration level.



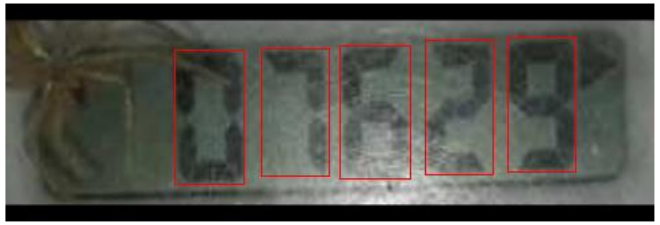
Some Image Segmentation algorithms are-

- Otsu's segmentation
- Edge-based segmentation algorithms
- Region-based segmentation algorithms
- Watershed segmentation algorithms.

Digit Segmentation

Digit Recognition

- The process of identifying the individual digit using the machine learning algorithms is known as Digit Recognition.
- In this the OCR model is trained to predict 10 classes (i.e., 0-9) using the cropped counter patch as well as the class and bounding box of each digit as inputs.



[0 7 6 2 9]

[1 1 1 8]

Further Applications

Reference

- R. Laroca, A. B. Araujo, L. A. Zanlorensi, E. C. De Almeida and D. Menotti, "Towards Image-Based Automatic Meter Reading in Unconstrained Scenarios: A Robust and Efficient Approach," in *IEEE Access*, vol. 9, pp. 67569-67584, 2021, doi: 10.1109/ACCESS.2021.3077415.
- Rayson Laroca, Victor Barroso, Matheus A. Diniz, Gabriel R. Gonçalves, William R. Schwartz, David Menotti, "Convolutional neural networks for automatic meter reading," J. Electron. Imag. 28(1) 013023 (5 February 2019)

Thanks