

## Strictly Mechanical Dials Reading by Pattern Recognition Methods.

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### Abstract

This paper purposes the primary part of a cheap and automatic control, applied to mechanical dials, using a pattern recognition-based machine learning method, designed for reading quantities as flow rate, speed, energy consumption and so on.

A MATLAB<sup>®</sup> algorithm is developed, able to process previously obtained photos in which the dial's handle position is identified and the pointed value is converted from pixels format to a float variable, passing through image processing and matrix algebra that inspires Optical Character Recognition.

*Keywords: Machine Learning, Pattern Recognition, Mechanical Dials.*

### Introduction

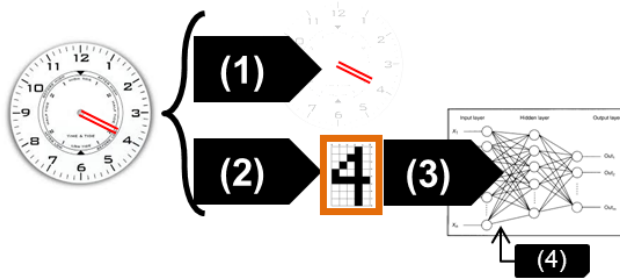
Methodological sequence was similar to stated by Rosin & Adamatzky (2014)<sup>[1]</sup> in their papers on cellular automata and image processing.

To advance progressively on this theme, it was set that recognition process would occur through three study cores of specific literature, as showed by **Image 1**:

**(1) Image Processing:** the dial's handle localization, spotted by Hough Transform, which transfers collinear points from  $x \times y$  space to concurrent curves in the  $\rho \times \theta$  space, with  $\rho = d(\vec{O}, r) = x \cdot \cos(\theta) + y \cdot \sin(\theta)$  and  $r: y = a \cdot x + b$  being the equation of handle's graphic representation;

**(2) Segmentation:** the delimitations of sweeping region,  $8 \times 5$  pixels (40 elements), starting from handle's position, to identify the pointed digit and

**(3) Classification:** the recognition of a single one digit from an Artificial Neural Network (ANN)<sup>[3]</sup>, trained by MNIST database **(4)**, with 40 input elements, 20 and 15 hidden neurons which activate the linear and sigmoid functions and 10 output elements, representing, according to the largest value position, the classification between 0 to 9 digits.



**Image 1.** Overview of the paper, analytically structured.

### Results and Discussion

Adequacy between sweeping window and character region is mathematically expressed by the maximum of convolution product of these surfaces, i.e., their maximum overlapping.

The percentage ANN classification error rate  $\varepsilon$  (%) is expressed by **Chart 1**. Average error was 4.25%.

**Chart 1.** Classification percentage error rate of each digit.

Digit	0	1	2	3	4	5	6	7	8	9
Error(%)	4.5	1.5	5.0	3.5	4.5	5.0	5.0	4.0	4.5	5.0

### Conclusions

Similarly to human vision, the applied pattern recognition process aimed to read, autonomously, the strictly mechanical dials through two principal moments: the first one was directed to restrict the field of vision and, the second one, to visualize what is therein. Clearly, the techniques that make machine vision possible have some theoretical sophistication and algorithm implementation tricks. We highlight that characters classification is probabilistic.

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<sup>[1]</sup>ROSIN, P.; ADAMATZKY, A.; SUN, X. (Eds.) **Cellular Automata in Image Processing and Geometry**. XVI, 304 p., 2014.

<sup>[2]</sup>THEODORIDIS, S.; KOUTROUMBAS, K. **Pattern recognition**. 4. ed. San Diego: Academic Press, c2009. 957 p.

<sup>[3]</sup>HAGAN, M. DEMUTH, H.; BEALE, M. **Neural Network Design**. PWS Publishing Company, Boston, MA, 1996.