PNEUMONIA DETECTION USING NON-LINEAR SVM

SUPERVISED CLASSIFICATION OF X-RAY CHEST IMAGES

01 SUPPORT VECTOR MACHINE

Linear and nonlinear

02 DATASET

X ray chest images

03 DATA PROCESSING

Image resize
Image Enhacement
Image Denoising

04 PERFORMANCE MEASURES

Accuracy - Precision
Recall -F1- Score

01 SUPPORT VECTOR MACHINE

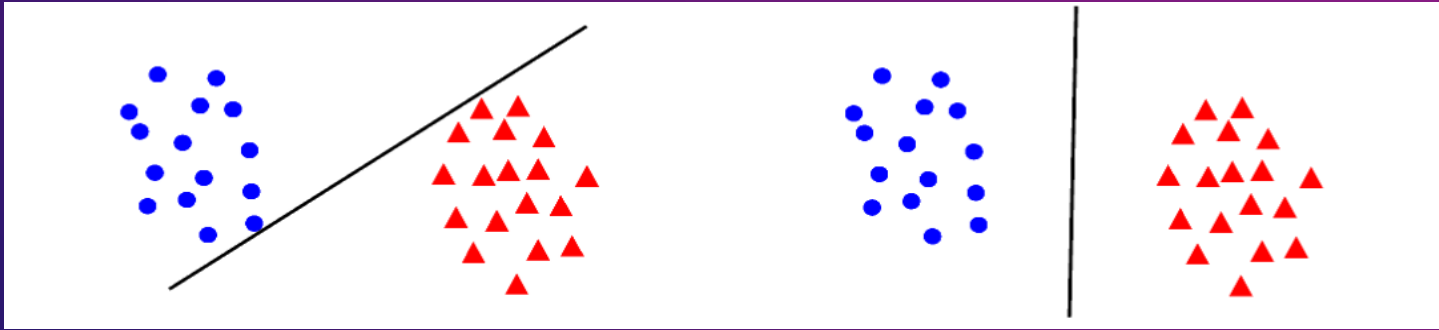
Linear and nonlinear

SVM

Let's assume that A and B are linearly separable sets, meaning there exists a hyperplane H = { x ∈ R^n : w^T x + b = 0 } such that

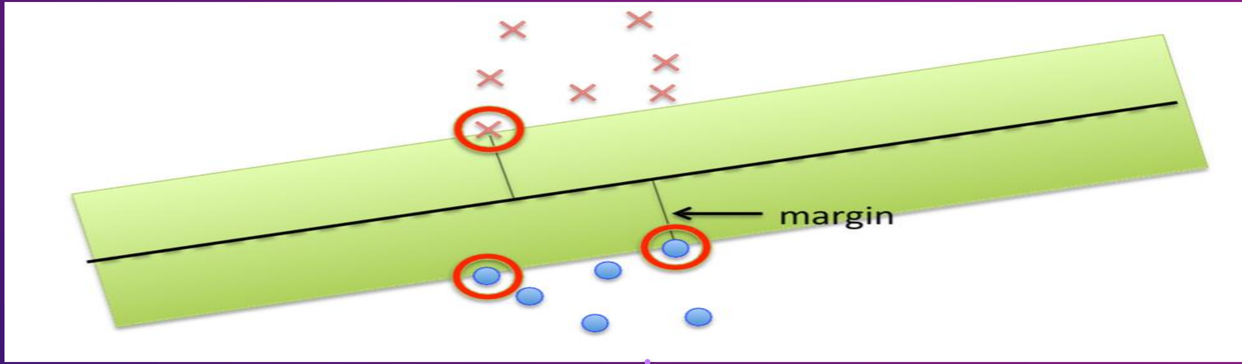
$$\begin{cases} w^T x + b > 0. & y_i = +1 \\ w^T x + b < 0. & y_i = -1 \end{cases} \longrightarrow y_i(w^T x + b) > 0$$

The separating hyperplane is not unique.



SVM GOAL

Find the separating hyperplane that maximizes the distance between the closest training set and the separating hyperplane.

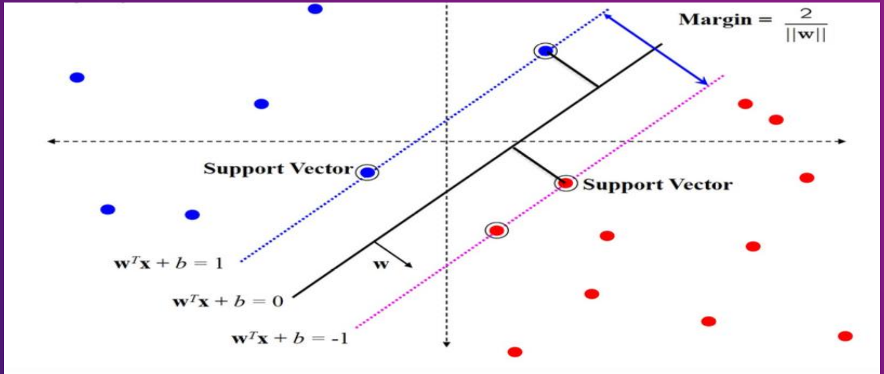


The distance from the closest training point is called the margin.

The circled points are called support vectors.

GEOMETRIC MARGIN

We define the optimal hyperplane (or maximum margin hyperplane) as:
(w∗, b∗) = argmax ρ(w, b)

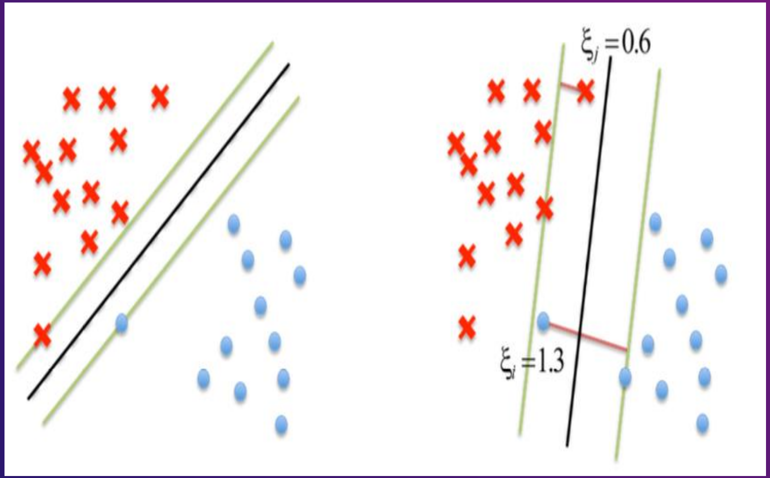


The geometric margin between the two classes is $\frac{2}{\|w\|}$

The larger the margin (separation), the higher the expected generalization

NON LINEARLY SEPARABLE SETS

Linear separability is generally too strong an assumption. However, the concept of an optimal separating hyperplane still makes sense, based on slack variables to handle outliers.



The ξi (Slack Variables) account for the non-separability of the data.
$\xi_i = 0 \Rightarrow x_i$ correctly classified (outside the margin)
$\xi_i \in (0, 1) \Rightarrow x_i$ correctly classified (but within the margin)
$\xi_i > 1 \Rightarrow x_i$ misclassified (on the wrong side of the separating hyperplane))

C-SVM

Maximization of the (Soft) Margin and Minimization of the Number of Misclassified Samples

$$\min \frac{1}{2} \parallel w \parallel_2^2 + c \sum_{i=1}^{n} \xi_i$$

$$\text{s.t. } y_i(w^T x + b) \geq 1 - \xi_i$$

$$\xi_i \geq 0$$

Where C > 0

The regularization parameter C takes into account the penalty for misclassified data.

Larger C⇒ Fewer exceptions (smaller margin, potential overfitting).

Smaller C⇒ more eccezioni exceptions (larger margin, potential underfitting).

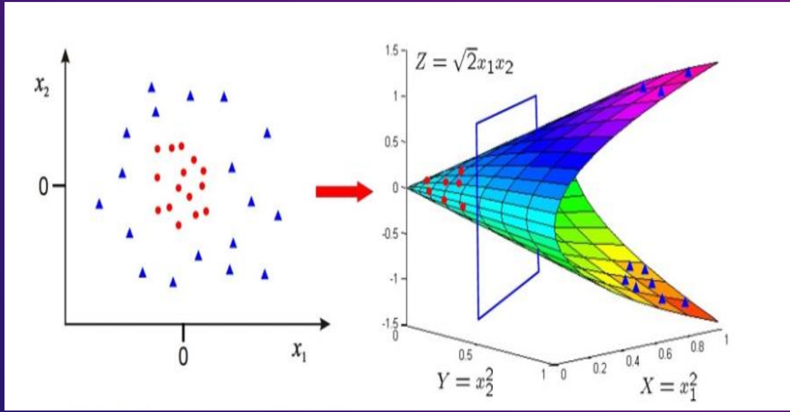
Non linear SVM

A classification problem of complex patterns thrown into a high-dimensional nonlinear space is more likely to be linearly separable than in a low-dimensional space. (Thomas Cover, 1965)
The goal is to project into high-dimensional space and solve with a linear model

Mapping the data (input space) into a feature space of higher dimensions using a non-linear transformation $\Phi(x) \in R^p$ $(p > n)$

KERNEL

Applying SVM to $\Phi(x_i)$ rather than to x_i, such that the formulation of SVM (in the feature space) is expressed only using the inner product $\langle\Phi(x_i), \Phi(x_j)\rangle$. To achieve this, it is sufficient to know how to compute the scalar product $k(x_i, x_j)$ in the feature space.
k is called a kernel, and the same kernel can correspond to different feature maps Φ.



The idea of the kernel function is to perform operations in the input space rather than in the potentially high-dimensional feature space. Therefore, the inner product does not need to be evaluated in the feature space. We want the function to map observations from the input space to the feature space.

02 DATASET

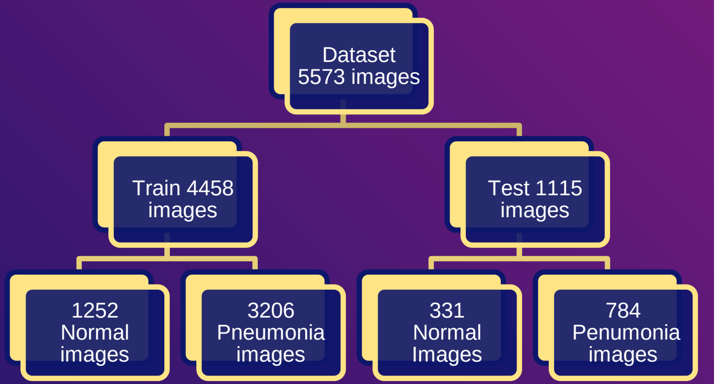
X ray chest images

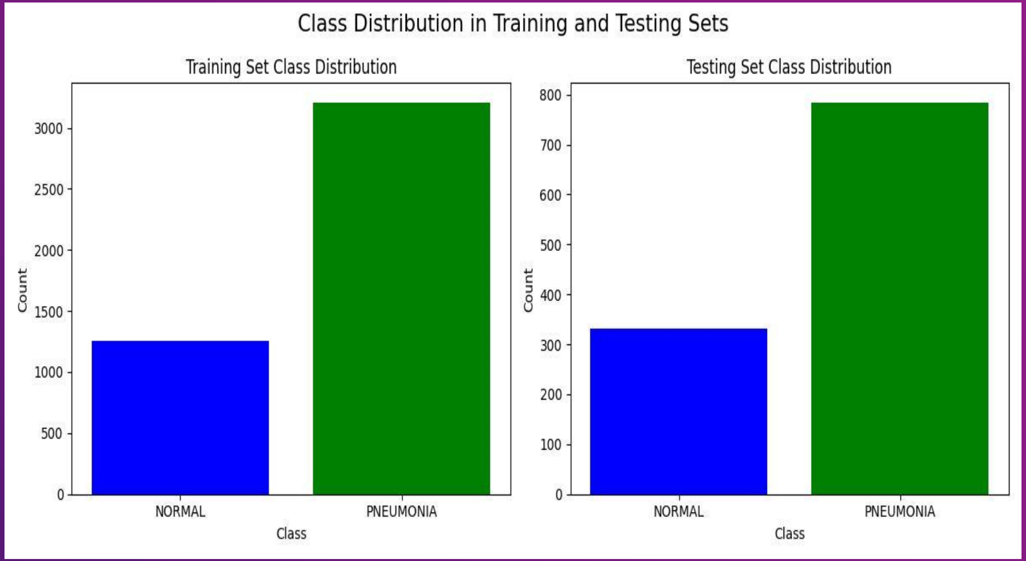
DATASET

The dataset is organized into 2 different types (train and test) and contains various categories of images (Pneumonia/Normal). There are 5,573 chest X-ray images (JPEG) and 2 categories (Pneumonia/Normal).

For the analysis of chest X-ray images, all chest X-rays initially underwent a quality check, eliminating all low-quality or unreadable scans. The diagnoses of the images were then classified by two expert physicians before being authorized for model training.

DATASET SPLITTING





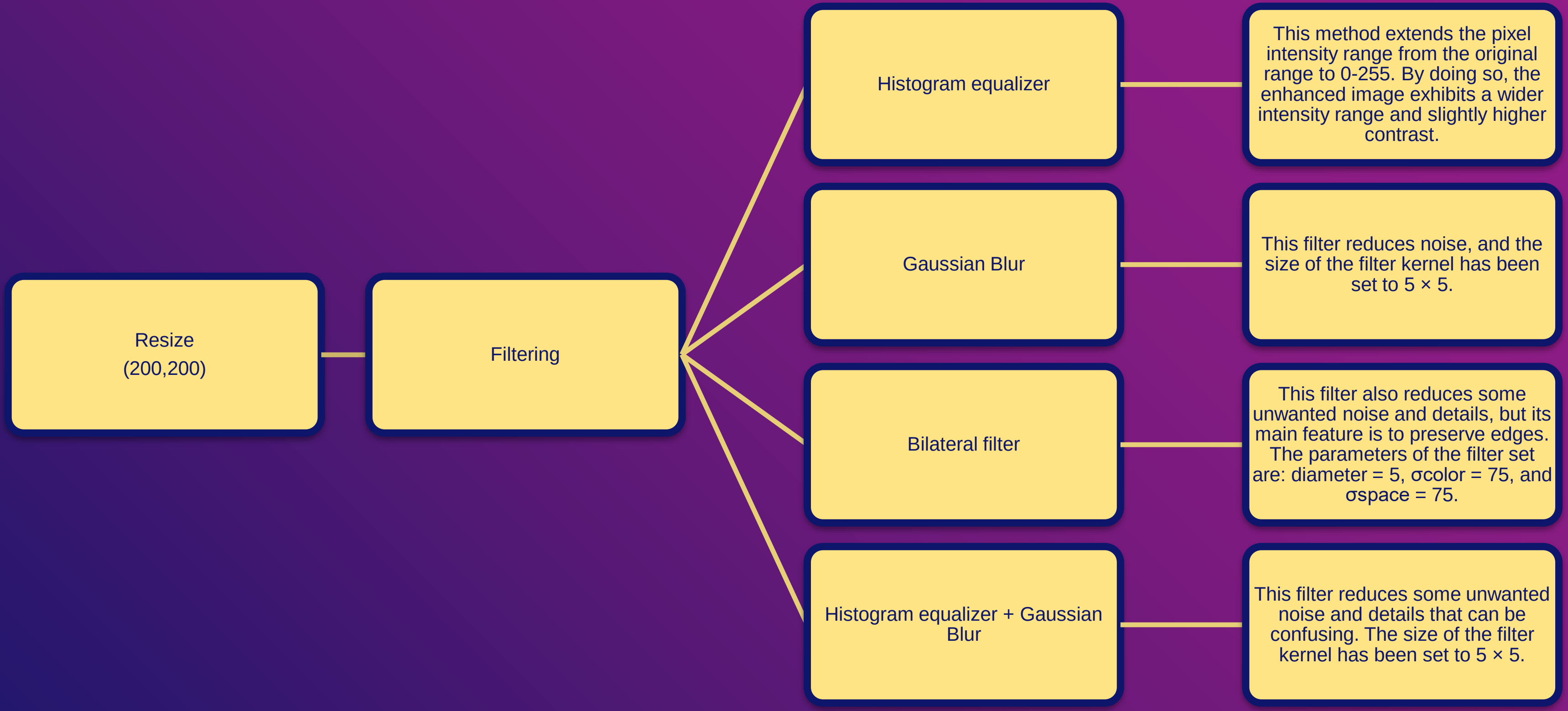
03

DATA PROCESSING

Image resize
Image Enhacement
Image Denoising

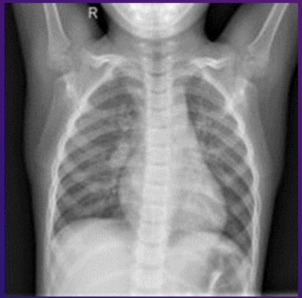
PREPROCESSING DATASET

DATA SCIENCE



RESIZING AND FILTERING

Immagine Resized



Histogram equalizer

Gaussian Blur

Bilateral Filter

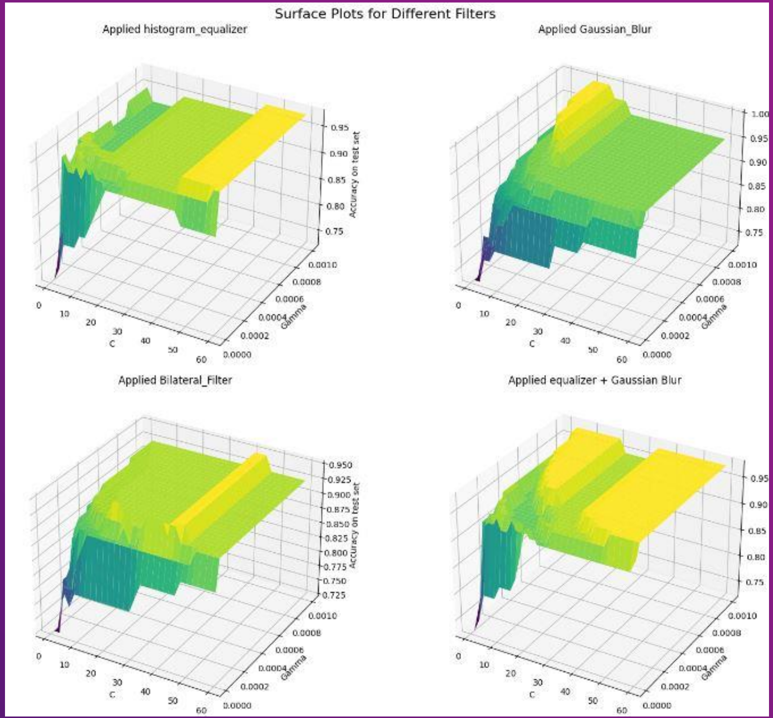
Histogram equalizer + Gaussian Blur

ESTIMATION OF PARAMETERS C AND GAMMA

C beetween 1 and 60

Gamma beetween 1e-05 e 0.01

The model's accuracy was evaluated on the test set for each type of filter *



*Considered a smaller dataset for computational time

DATA SCIENCE

04

PERFORMANCE MEASURES

Accuracy – Precision - Recall - F1- Score

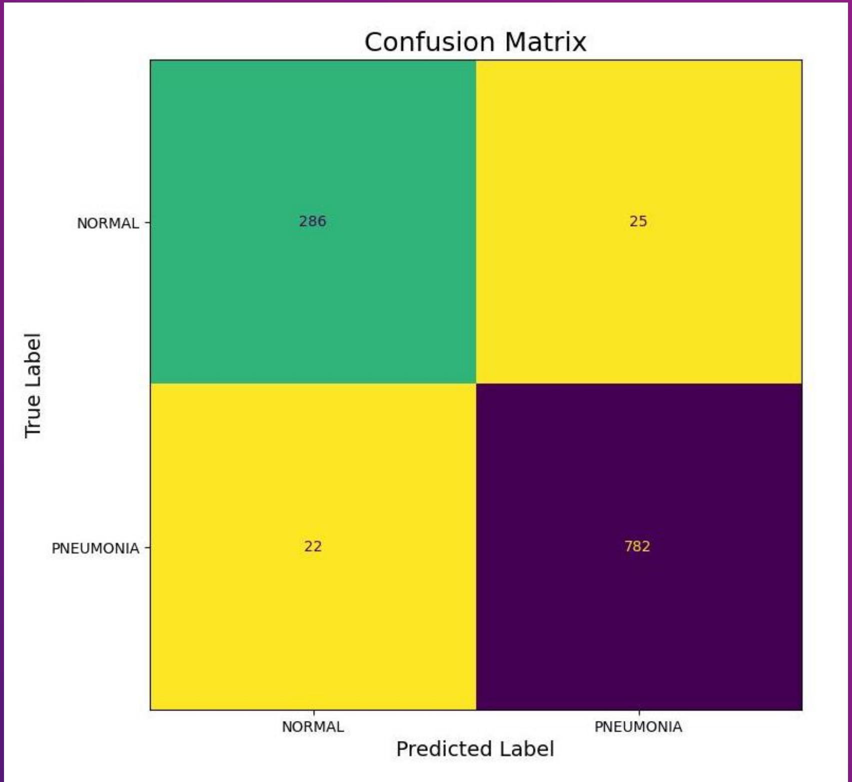
PERFORMANCE MEASURES

Accuracy	• Accuracy represents the percentage of correct predictions compared to the total predictions.
Precision	• Precision indicates the percentage of correct positive class predictions compared to the total positive class predictions.
Recall	• The percentage of correct positive class predictions compared to the total positive cases.
F1-Score	• The harmonic mean of Precision and Recall

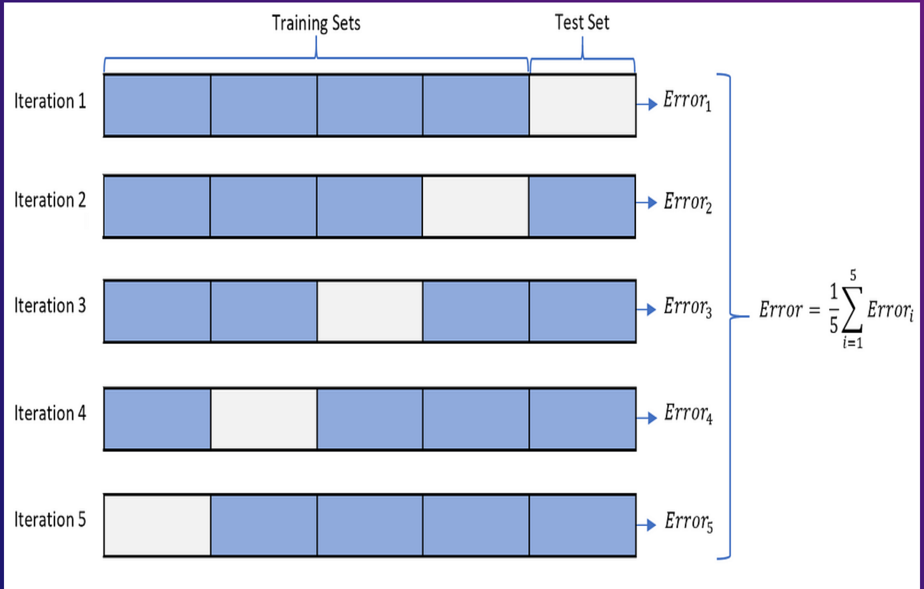
RESULTS

Results of the model with:

- **Histogram Equalizer + Gaussian Blur**
- **C = 47**
- **Gamma = 0.01**
- Accuracy = 0.96
- Precision = 0.97
- Recall = 0.97
- F1 score = 0.97



5 FOLD CROSS VALIDATION RESULTS



	fit_time	score_time	test_accuracy	test_precision	test_recall	test_f1
1 fold	264.046500	146.738816	0.943498	0.977893	0.942356	0.959796
2 fold	219.482963	140.404387	0.963229	0.987130	0.961153	0.973968
3 fold	222.070816	145.075061	0.965919	0.976190	0.976190	0.976190
4 fold	223.573325	147.655448	0.966786	0.984713	0.968672	0.976627
5 fold	168.155565	109.853444	0.858169	0.845572	0.981203	0.908353
Mean results	219.465834	137.945431	0.939520	0.954300	0.965915	0.958987

Thanks for your attention!

OUR TEAM

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