

Novel Parallel One Class Fuzzy Timeseries Classifier

by

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Outline

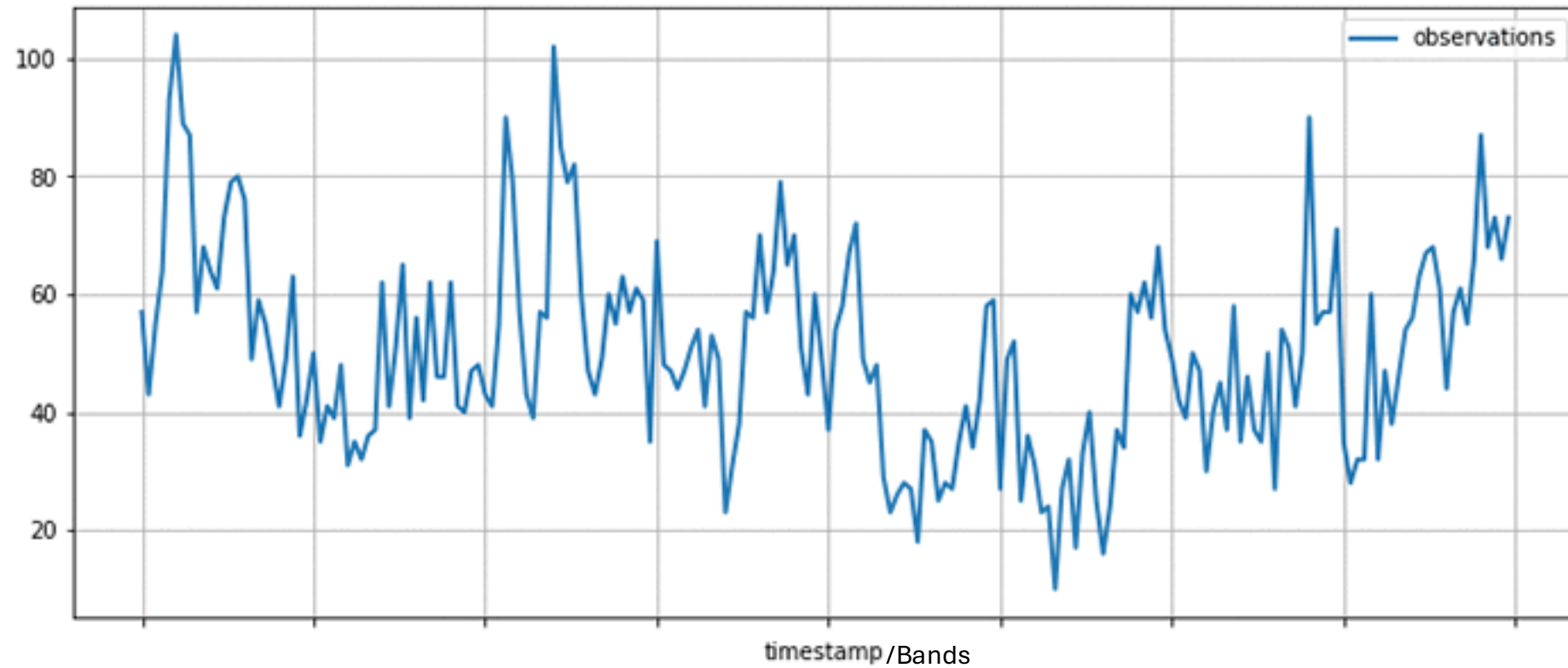
- Basic Model of Timeseries Classification
- One Class Timeseries Classifier
- QGIS plugin
- Experimental Results

Outline

- **Basic Model of Timeseries Classification**
- One Class Timeseries Classifier
- QGIS plugin
- Experimental Results

Timeseries

- A sequence of values ordered by time (or bands)



Time series classification

Band Values

100, 98, 99, 97, ...

class label
↓
Mineral



Gold

80, 88, 78, 76, ...



Petroleum

98, 99, 90, 98, ...

Guess
condition
→

?

Gold/Petroleum

Generalization of Time Series Classification



Gold

100,98,99,97

98,99,97,100

100,99,99,100

98,98,98,98

82,88,80,80



Petroleum

80,88,78,76

78,72,79,70

70,79,89,82

70,72,77,78

Training instances

98, 99, 90, 98, ...

Guess
condition
→

?

Gold/Petroleum

Test
instance(s)

Illustration of 1-NN



Gold

100,98,99,97

11.6

98,99,97,100

12.2

100,99,99,100

13.6

98,98,98,98

11.4

82,88,80,80

24

98, 99, 90, 98, ...

Find the nearest training instance

Guess condition

Gold/Petroleum



Petroleum

80,88,78,76

28

78,72,79,70

40.6

70,79,89,82

35.3

70,72,77,78

42.7

Training instances

Test instance(s)

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- Basic Model of Timeseries Classification
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Limitation of Timeseries Classification



Gold

100,98,99,97

11.6

98,99,97,100

12.2

100,99,99,100

13.6

98,98,98,98

11.4

82,88,80,80

24

Giving data of only one class

98, 99, 90, 98, ...

Guess
condition

?



Petroleum

80,88,78,76

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42.7

Training
instances

Test
instance(s)

Limitation of Timeseries Classification



Gold

100,98,99,97
98,99,97,100
100,99,99,100
98,98,98,98
82,88,80,80

11.6
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24



Petroleum

80,88,78,76
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40.6
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Giving data of only one class

Find the nearest training instance

Guess condition

?

98, 99, 90, 98, ...

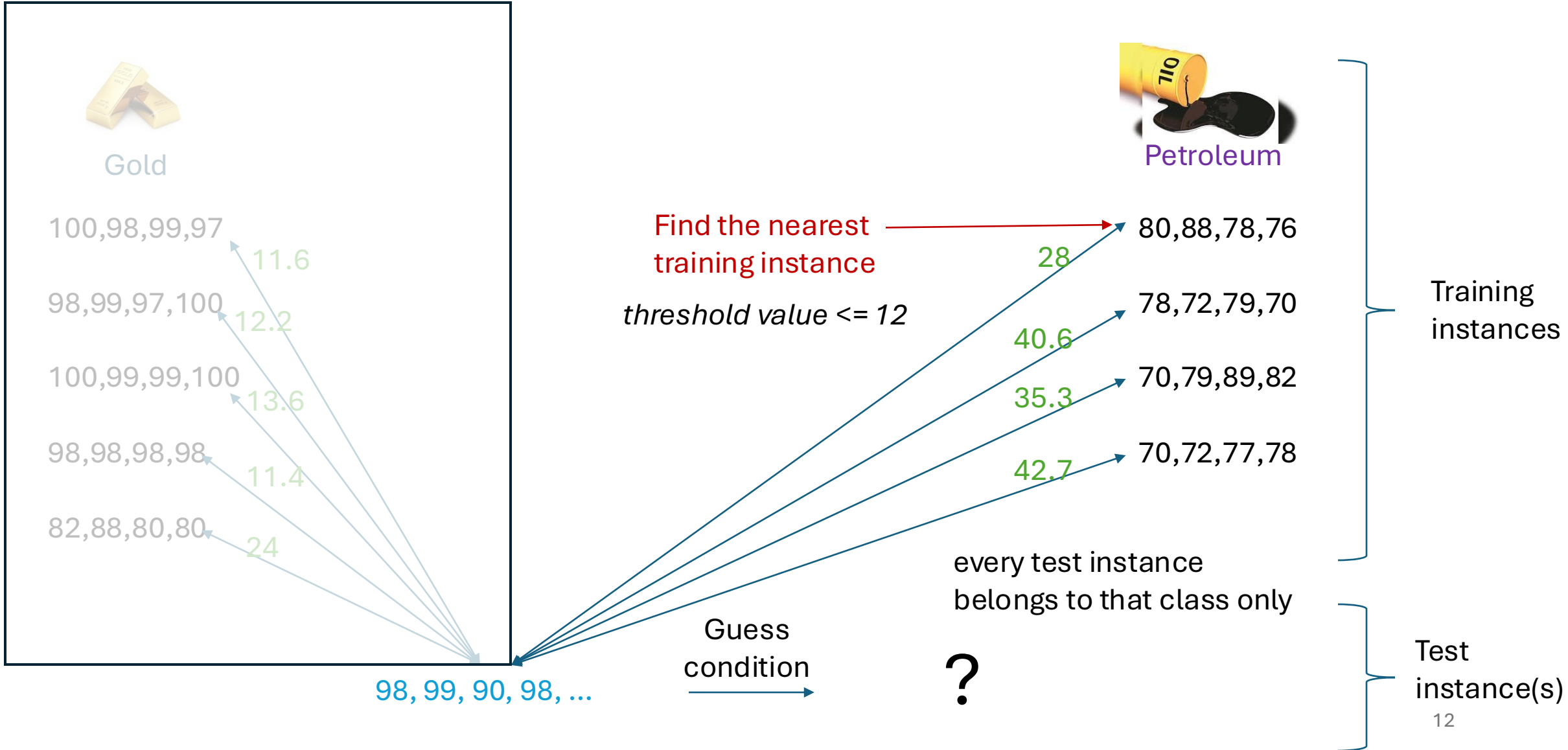
Training instances

Test instance(s)

Solutions: One Class Classifier

- Usage of threshold value
 - if a test series threshold value is more than the threshold value it will not belong to any class.

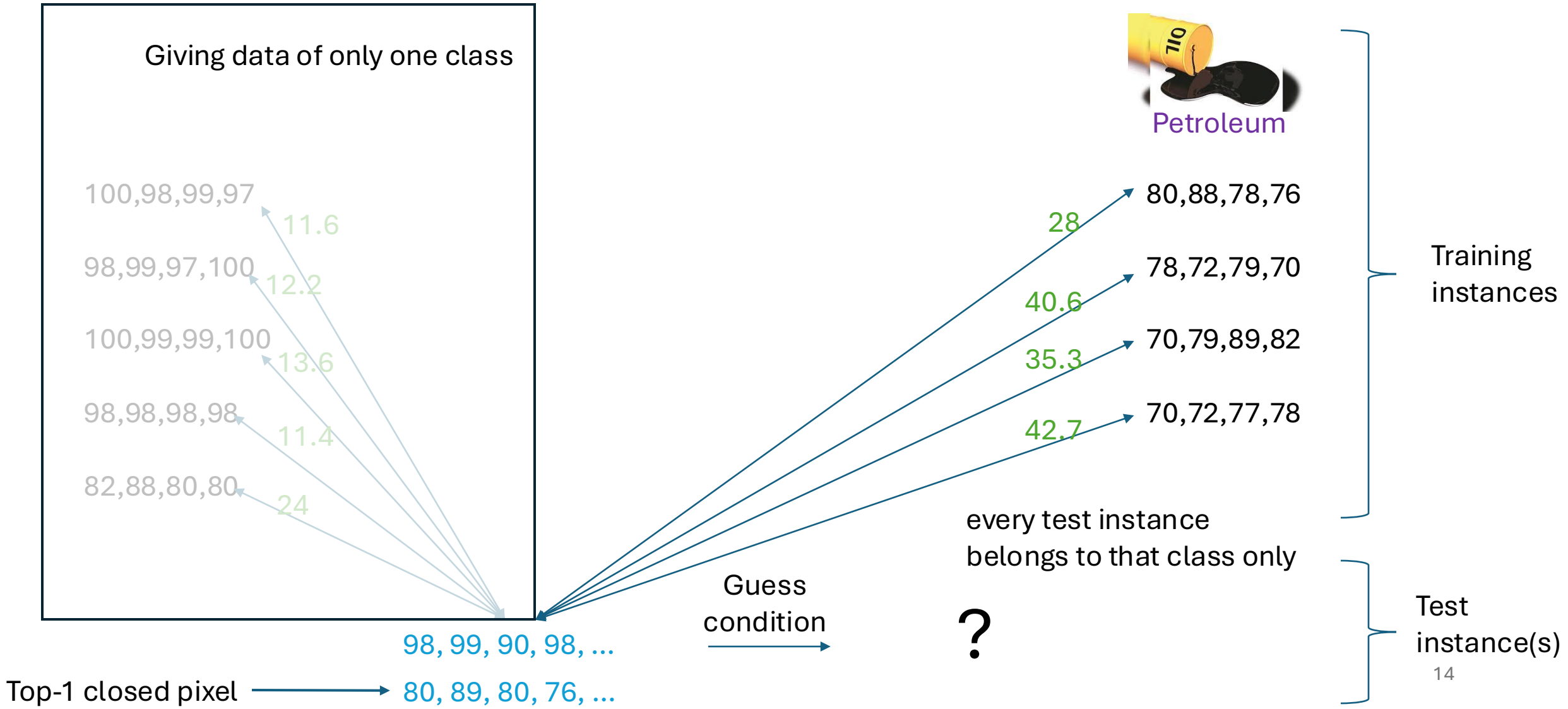
Giving data of only one class



Solutions: One Class Classifier

- Usage of threshold value
 - if a test series threshold value is more than the threshold value it will not belong to any class.
- Finding Top-k similar test instances

Limitation: Too much computational cost.
Time Complexity: $O(n)$



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Fuzzy Timeseries Classifier

Table 1: Manual selection of Pixels

#Pixel	Band Values of the Pixels
1	10, 9, 8, 8, 7, 6.9, 6, 6, 4, 3.8
2	10.3, 9.8, 8.5, 8.6, 7.3, 6.8, 6, 6.2, 4.5, 3.5
3	10, 9.4, 8.2, 8, 7, 6, 5.5, 5, 3.1, 3
4	10, 10, 8, 8.4, 7.4, 6.8, 6.1, 4.7, 3, 2.7
5	9.7, 9.1, 8.2, 8.1, 7.3, 7.2, 6.3, 6.2, 3.5, 3

Table 1: Manual selection of Pixels

#Pixel	Band Values of the Pixels
1	10, 9, 8, 8, 7, 6.9, 6, 6, 4, 3.8
2	10.3, 9.8, 8.5, 8.6, 7.3, 6.8, 6, 6.2, 4.5, 3.5
3	10, 9.4, 8.2, 8, 7, 6, 5.5, 5, 3.1, 3
4	10, 10, 8, 8.4, 7.4, 6.8, 6.1, 4.7, 3, 2.7
5	9.7, 9.1, 8.2, 8.1, 7.3, 7.2, 6.3, 6.2, 3.5, 3

Table 2: Capturing the distribution

	Distributed Band Values
min	9.7,
avg	10,
max	10.3,



Table 1: Manual selection of Pixels

#Pixel	Band Values of the Pixels
1	10, 9, 8, 8, 7, 6.9, 6, 6, 4, 3.8
2	10.3, 9.8, 8.5, 8.6, 7.3, 6.8, 6, 6.2, 4.5, 3.5
3	10, 9.4, 8.2, 8, 7, 6, 5.5, 5, 3.1, 3
4	10, 10, 8, 8.4, 7.4, 6.8, 6.1, 4.7, 3, 2.7
5	9.7, 9.1, 8.2, 8.1, 7.3, 7.2, 6.3, 6.2, 3.5, 3



Table 2: Capturing the distribution

	Distributed Band Values
min	9.7, 9, 8, 8, 7, 6, 5.5, 4.7, 3, 2.7
avg	10, 9.46, 8.18, 8.22, 7.2, 6.74, 5.98, 5.62, 3.62, 3.2
max	10.3, 10, 8.5, 8.6, 7.4, 7.2, 6.3, 6.2, 4.5, 3.8

Figure 1: Raster Image

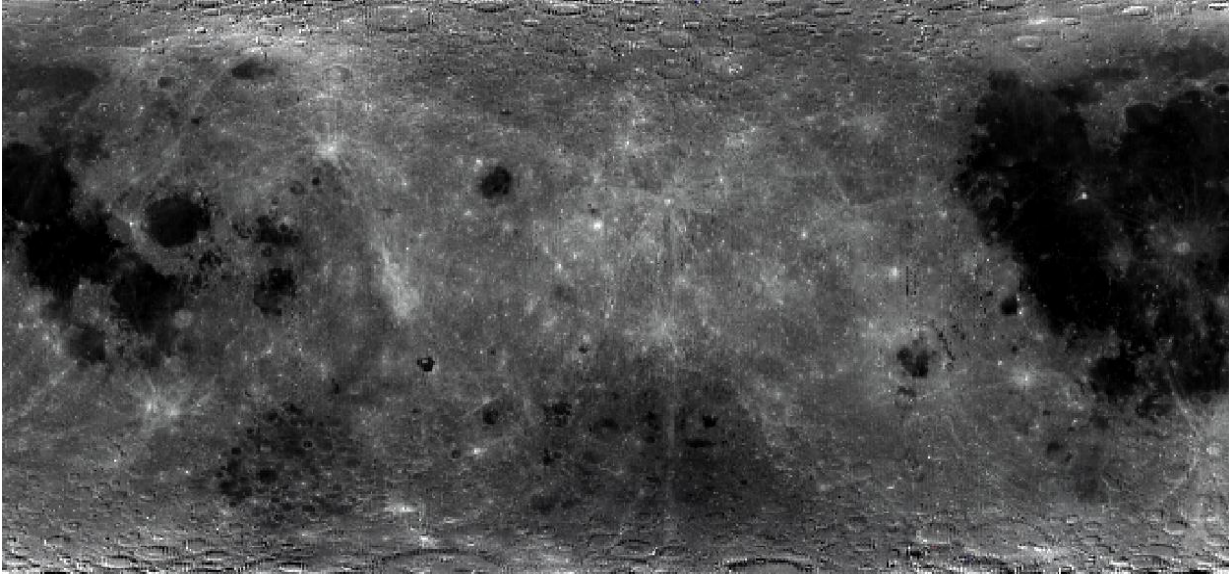
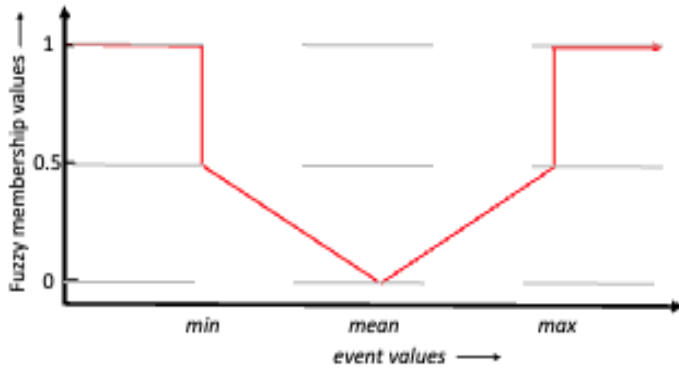


Table 3: Pixels in raster image

#Pixel	Test instances
1	9.4,10.2,8.18,8.3,7.1,6,6.3,5.6,3.6,3.18
2	11,13,16,10,7.1,6,6.3,5.6,3.6,6
3	9.9,10,8.3,8.4,7.1,6,6.3,5.6,3.6,2.8
...	..



fuzzy membership function

$$\mu_a = \begin{cases} 1 & \text{if } tts_{id}.v_a < ts_{cl_k}^{min}.v_a \\ 1 & \text{if } tts_{id}.v_a > ts_{cl_k}^{max}.v_a \\ 0 & \text{if } tts_{id}.v_a = ts_{cl_k}^{mean}.v_a \\ 0.5 \times A & \text{if } ts_{cl_k}^{min}.v_a \leq tts_{id}.v_a < ts_{cl_k}^{mean}.v_a \\ 0.5 \times B & \text{if } ts_{cl_k}^{max}.v_a \geq tts_{id}.v_a > ts_{cl_k}^{mean}.v_a \end{cases}$$

Where $A = \frac{ts_{cl_k}^{mean}.v_a - tts_{id}.v_a}{ts_{cl_k}^{mean}.v_a - ts_{cl_k}^{min}.v_a}$ and $B = \frac{tts_{id}.v_a - ts_{cl_k}^{mean}.v_a}{ts_{cl_k}^{max}.v_a - ts_{cl_k}^{mean}.v_a}$

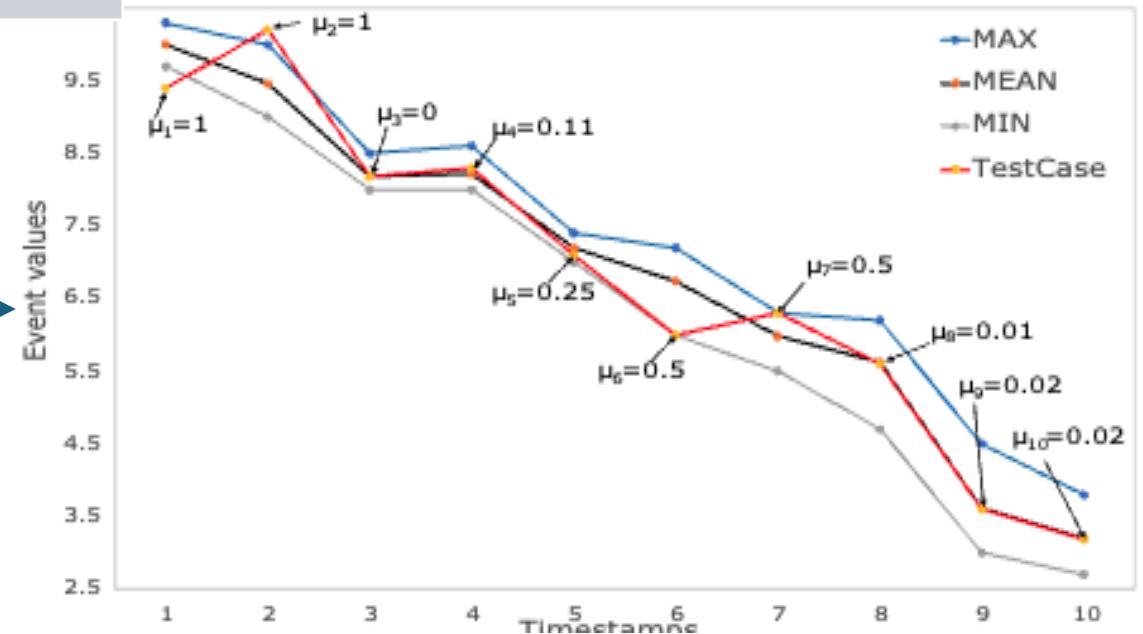
Fig. 2: Fuzzy membership function

Score Calculation

Table 2: distribution of training data

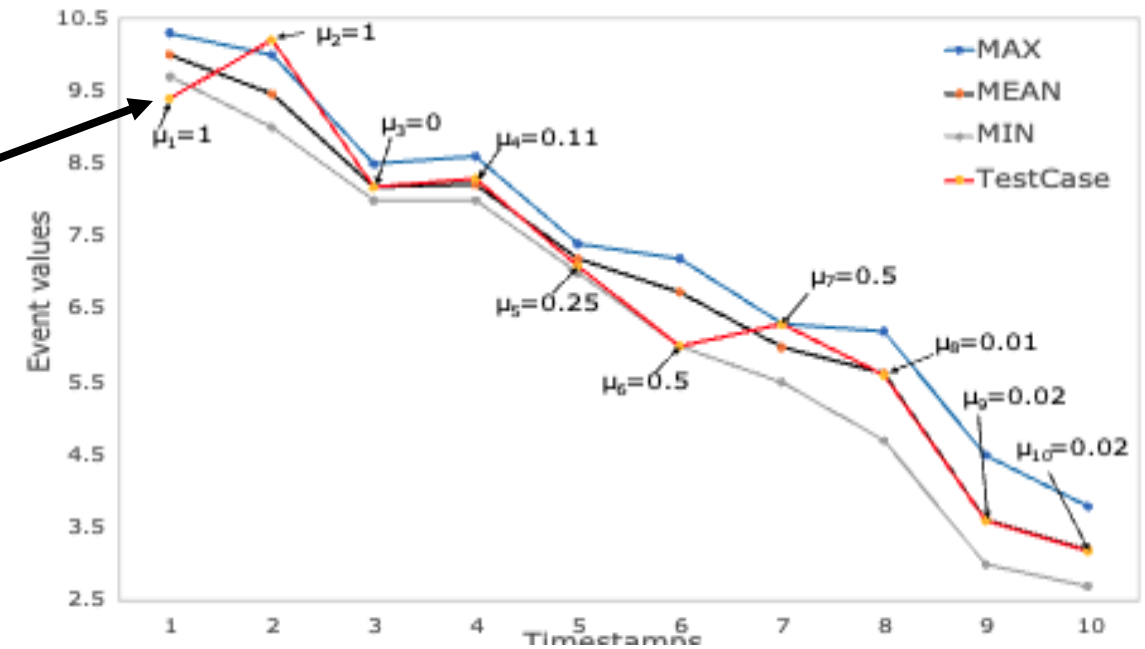
	Distributed Band Values
min	9.7, 9, 8, 8, 7, 6, 5.5, 4.7, 3, 2.7
avg	10, 9.46, 8.18, 8.22, 7.2, 6.74, 5.98, 5.62, 3.62, 3.2
max	10.3, 10, 8.5, 8.6, 7.4, 7.2, 6.3, 6.2, 4.5, 3.8

#Pixel	Test instances
1	9.4,10.2,8.18,8.3,7.1,6,6.3,5.6,3.6,3.18
2	11,13,16,10,7.1,6,6.3,5.6,3.6,6
3	9.9,10,8.3,8.4,7.1,6,6.3,5.6,3.6,2.8
...	..



Similarity Score Calculation

#Pixel	Test instances	fuzzy similarity Score
1	9.4,10.2,8.18,8.3,7.1,6,6.3,5.6,3.6,3.18	0.341
2	11,13,16,10,7.1,6,6.3,5.6,3.6,6	2
3	9.9,10,8.3,8.4,7.1,6,6.3,5.6,3.6,2.8	0.2
...

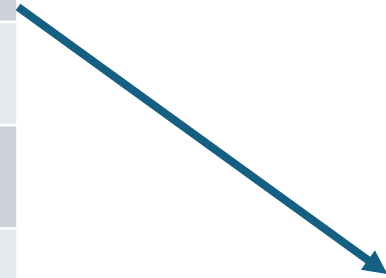


$$\frac{1 + 1 + 0 + 0.11 + 0.25 + 0.5 + 0.5 + 0.01 + 0.02 + 0.02}{10}$$

Ranking

Ranking based on scores

#Pixel	Test instances	Score	Rank
1	9.4,10.2,8.18,8.3,7.1,6,6.3,5.6,3.6,3.18	0.341	2
2	11,13,16,10,7.1,6,6.3,5.6,3.6,6	2	3
3	9.9,10,8.3,8.4,7.1,6,6.3,5.6,3.6,2.8	0.2	1
...	



#Pixel	Test instances	Score	Rank
1	9.4,10.2,8.18,8.3,7.1,6,6.3,5.6,3.6,3.18	0.341	2
3	9.9,10,8.3,8.4,7.1,6,6.3,5.6,3.6,2.8	0.2	1
...	

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Dataset

Browser

- /Volumes
- Favorites
- Spatial Bookmarks
- Home
- / (Macintosh HD)
- GeoPackage
- SpatialLite
- PostgreSQL
- SAP HANA
- MS SQL Server
- Oracle
- WMS/WMTS
- Scenes
- Vector Tiles
- XYZ Tiles
- Mapzen Global Terrain
- OpenStreetMap
- WCS

Layers

- recut
 - Band 001 (Gray)
 - Band 002
 - Band 003

Identify Results

Feature	Value
Band 451	0.397069
Band 452	0.397977
Band 453	0.400307
Band 454	0.405454
Band 455	0.409706
Band 456	0.411194
Band 457	0.411875
Band 458	0.416403
Band 459	0.422524
Band 460	0.424685
Band 461	0.42404
Band 462	0.426267
Band 463	0.4309175
Band 464	0.432775
Band 465	0.431976
Band 466	0.432793
Band 467	0.436482
Band 468	0.438986
Band 469	0.438186
Band 470	0.437845
Band 471	0.440194
Band 472	0.442749
Band 473	0.43921
Band 474	0.434104
Band 475	0.432874
Band 476	0.436082
Band 477	0.43769
Band 478	0.43653
Band 479	0.43516
Band 480	0.439007
Band 481	0.442647
Band 482	0.436623
Band 483	0.427891
Band 484	0.424244
Band 485	0.4278
Band 486	0.428387
Band 487	0.428147
Band 488	0.428131
Band 489	0.429032

Type to locate (%K) Identifying done. Coordinate: -5431027,1477136 Scale: 1:26520 Magnifier: 100% Rotation: 0.0° Render Unknown CRS

Pixels: 146,096

Bands: 490

Mars dataset

Evaluation Results of Basic Algorithm

```
_,topDF = rasterFuzzyTSC(training,testing,10)
```

```
100%|██████████| 146096/146096 [1:20:06<00:00, 30.39it/s]
```

```
/tmp/ipykernel_11629/2886663301.py:42: SettingWithCopyWarning:  
A value is trying to be set on a copy of a slice from a DataFrame.  
Try using .loc[row_indexer,col_indexer] = value instead
```

```
See the caveats in the documentation: https://pandas.pydata.org/pandas  
testing['RD'] = newColumn
```

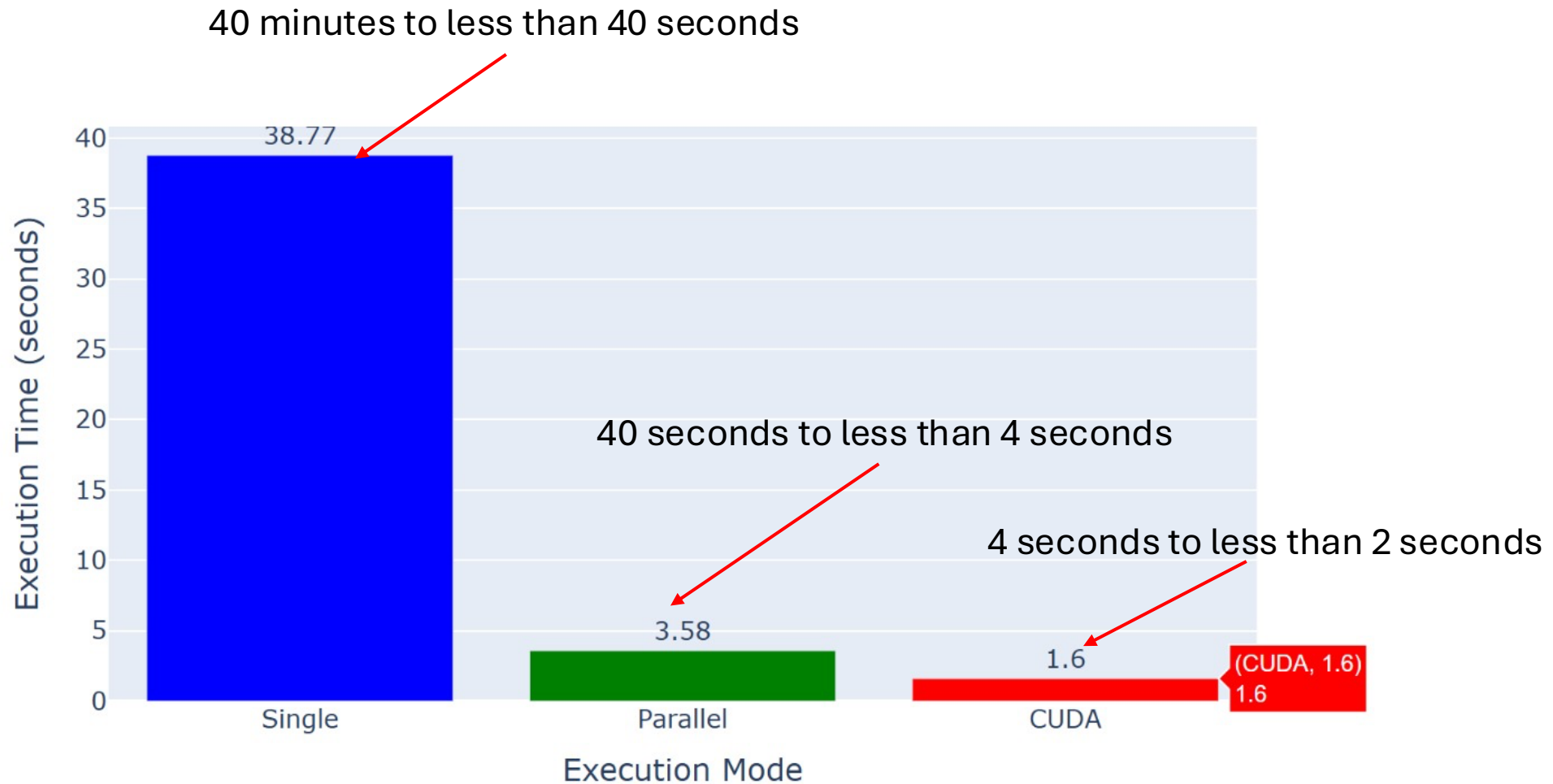
```
Total Execution time of proposedAlgo 4807.7914435863495
```

```
Memory of proposedAlgo in KB: 1767864.0
```

number of pixels

runtime in seconds
(40 min approximately)

Results after Optimization



Thank you

Question and Answers