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

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- **Basic Model of Timeseries Classification**
- One Class Timeseries Classifier
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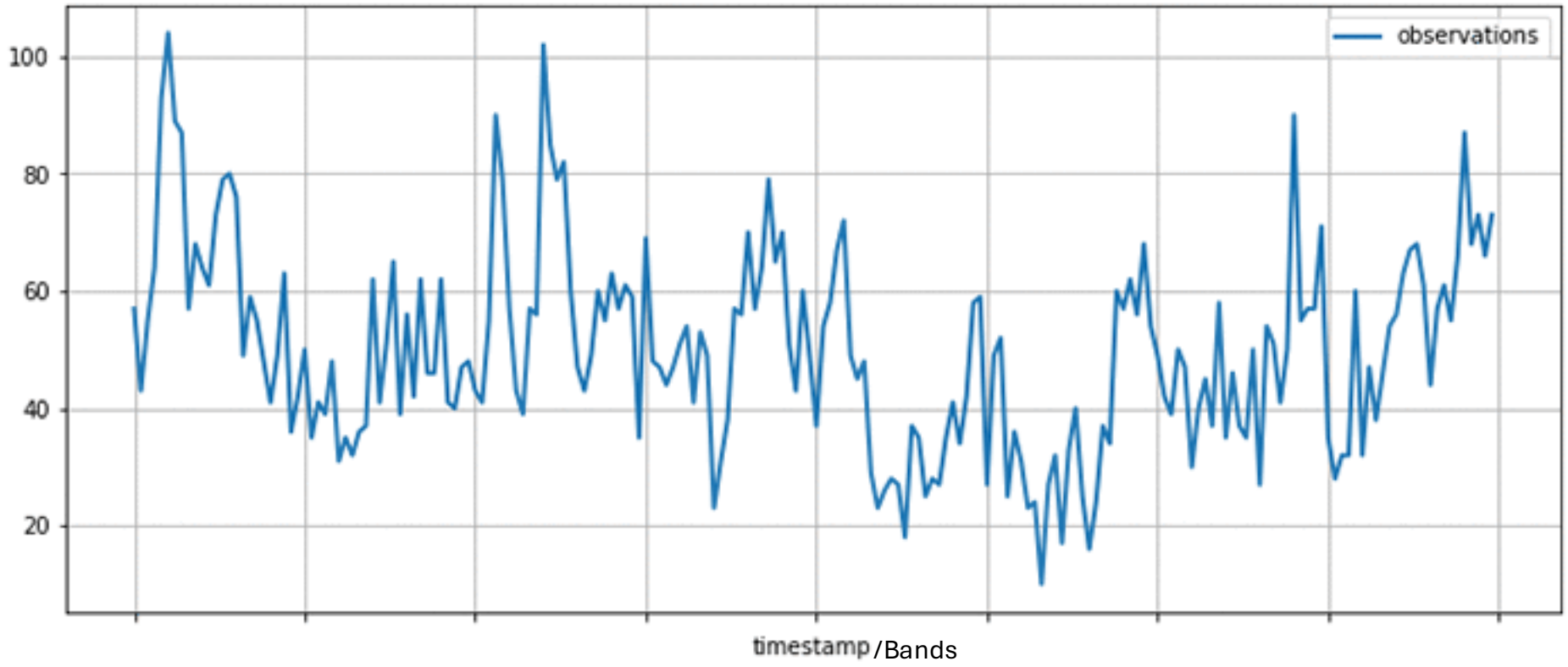
Timeseries

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



Time series classification

class label

Band Values

Mineral

100, 98, 99, 97, ...

Gold

80, 88, 78, 76, ...

Petroleum

98, 99, 90, 98, ...

Guess condition

?

Gold/Petroleum

Generalization of Time Series Classification

Gold

Petroleum

100,98,99,97

98,99,97,100

100,99,99,100

98,98,98,98

82,88,80,80

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

Petroleum

100,98,99,97

98,99,97,100

100,99,99,100

98,98,98,98

82,88,80,80

11.6

12.2

13.6

11.4

24

Find the nearest training instance

80,88,78,76

78,72,79,70

70,79,89,82

70,72,77,78

28

40.6

35.3

42.7

Training instances

98, 99, 90, 98, …

Guess condition

?

Gold/Petroleum

Test instance(s)

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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

Petroleum

28

80,88,78,76

40.6

78,72,79,70

35.3

70,79,89,82

42.7

70,72,77,78

Training instances

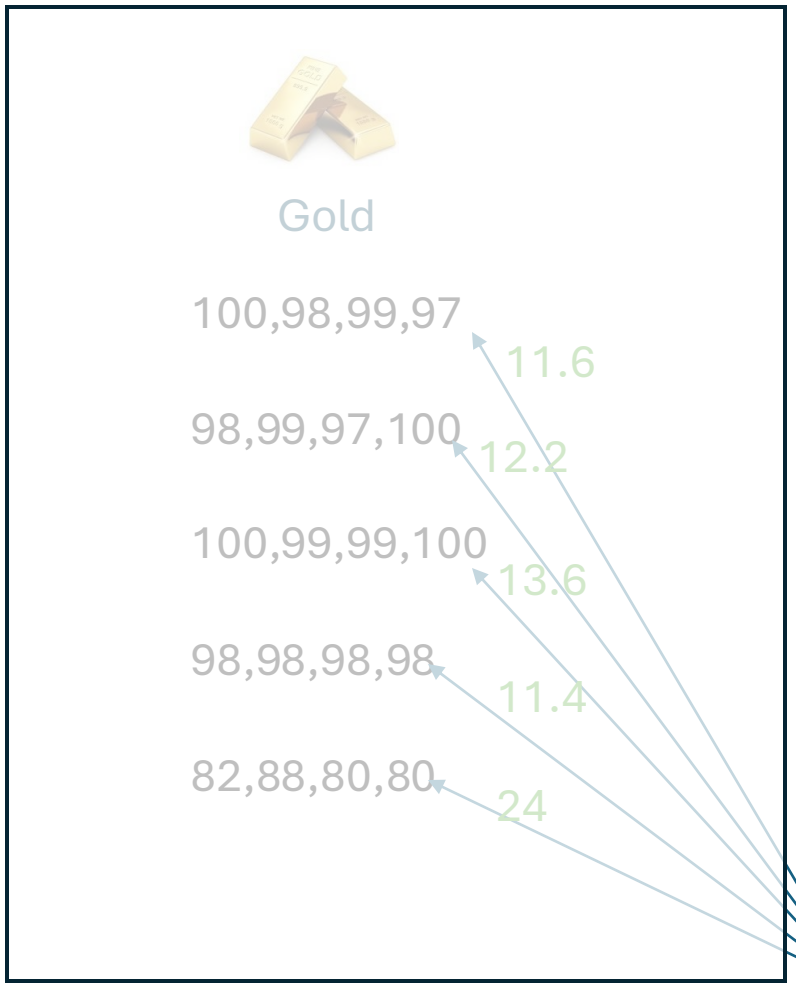
98, 99, 90, 98, ...

Guess condition

?

Test instance(s)

Limitation of Timeseries Classification



Giving data of only one class

Petroleum

Find the nearest training instance

28
80,88,78,76

40.6
78,72,79,70

35.3
70,79,89,82

42.7
70,72,77,78

Training instances

98, 99, 90, 98, ...

Guess condition

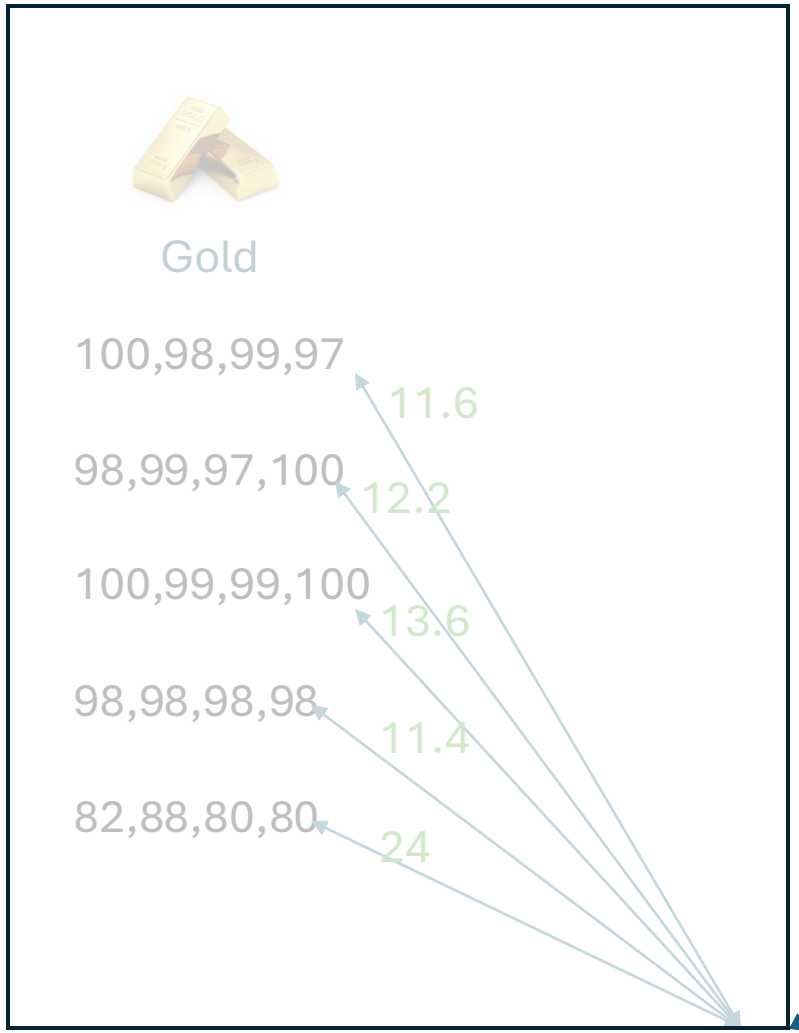
?

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



Petroleum

Find the nearest training instance

threshold value <= 12

28 → 80,88,78,76

40.6 → 78,72,79,70

35.3 → 70,79,89,82

42.7 → 70,72,77,78

Training instances

every test instance belongs to that class only

98, 99, 90, 98, …

Guess condition →

?

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.

- Finding Top-k similar test instances

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

Giving data of only one class

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

Petroleum

28 → 80,88,78,76
40.6 → 78,72,79,70
35.3 → 70,79,89,82
42.7 → 70,72,77,78

Training instances

every test instance belongs to that class only

?

Test instance(s)

Guess condition

98, 99, 90, 98, ...

Top-1 closed pixel → 80, 89, 80, 76, ...

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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

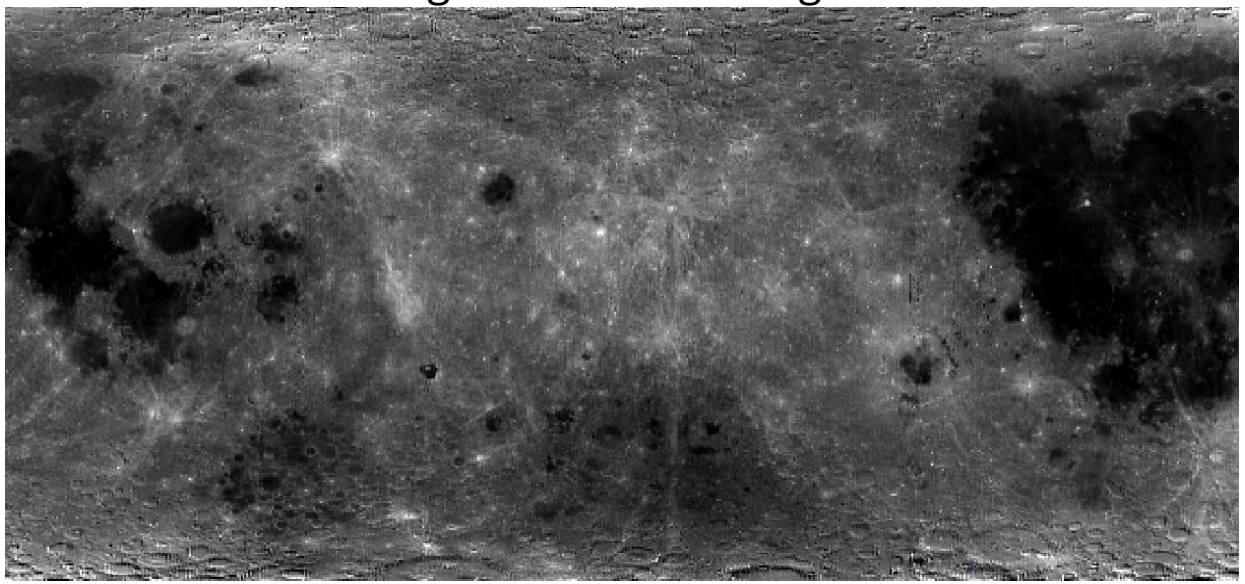


Table 3: Pixels in raster image

#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
…	..

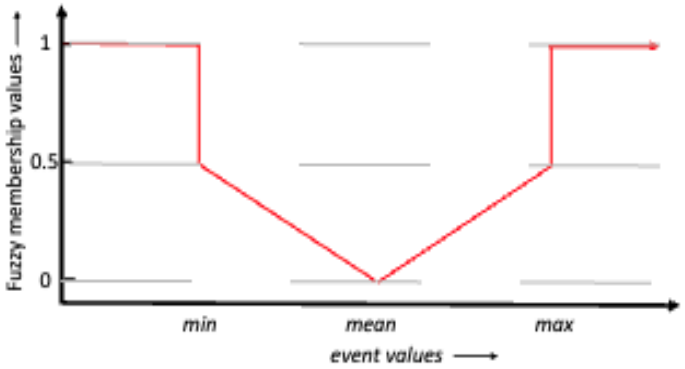


Fig. 2: Fuzzy membership function

fuzzy membership function

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

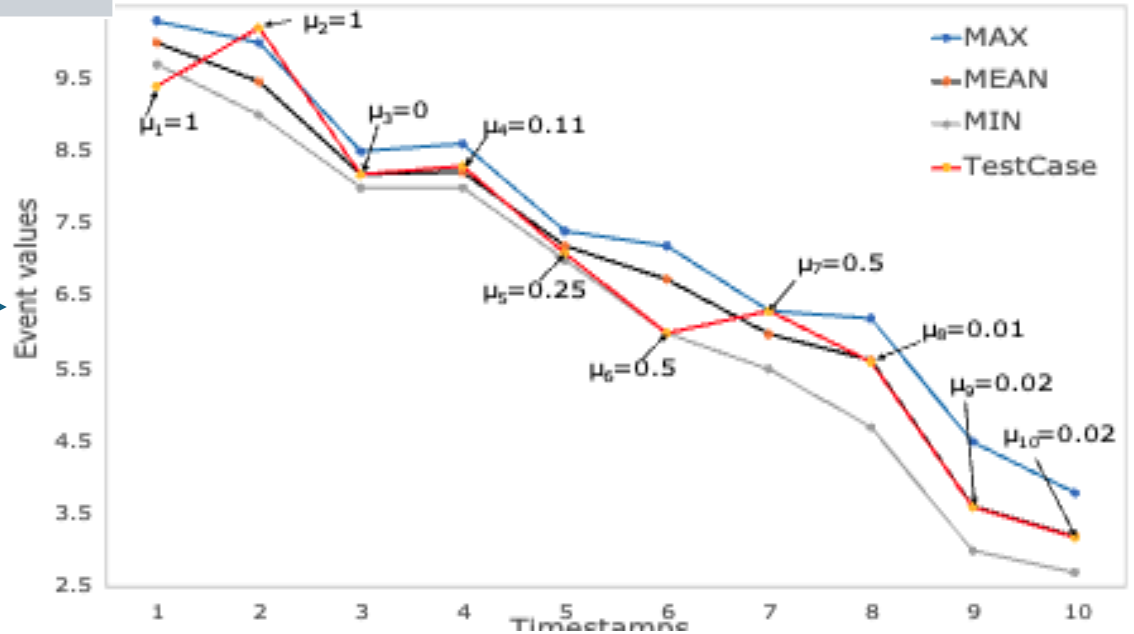
$$Where \quad A = \frac{ts^{mean}_{cl_k}.v_a - tts_{id}.v_a}{ts^{mean}_{cl_k}.v_a - ts^{min}_{cl_k}.v_a} \quad and \quad B = \frac{tts_{id}.v_a - ts^{mean}_{cl_k}.v_a}{ts^{max}_{cl_k}.v_a - ts^{mean}_{cl_k}.v_a}$$

Score Calculation

Table 2: distribution of training data

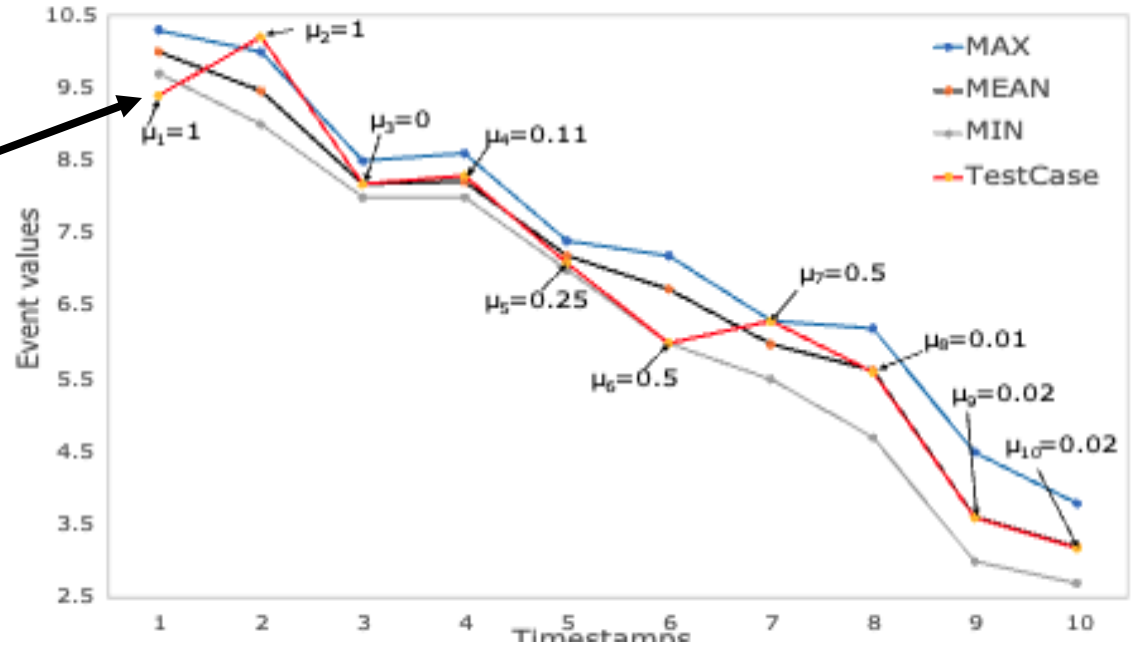
	Distributed Band Values
min	9.7, 9, 8, 8, 7, 6, 5.5, 4.7, 3, 2.7
avg	10, 9.46, 8.18, 8.22, 7.2, 6.74, 5.98, 5.62, 3.62, 3.2
max	10.3, 10, 8.5, 8.6, 7.4, 7.2, 6.3, 6.2, 4.5, 3.8

#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
…	..	…

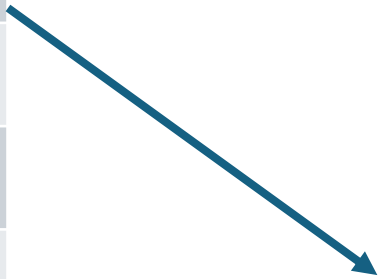


$$\frac{1+1+0+0.11+0.25+0.5+0.5+0.01+0.02+0.02}{10}$$

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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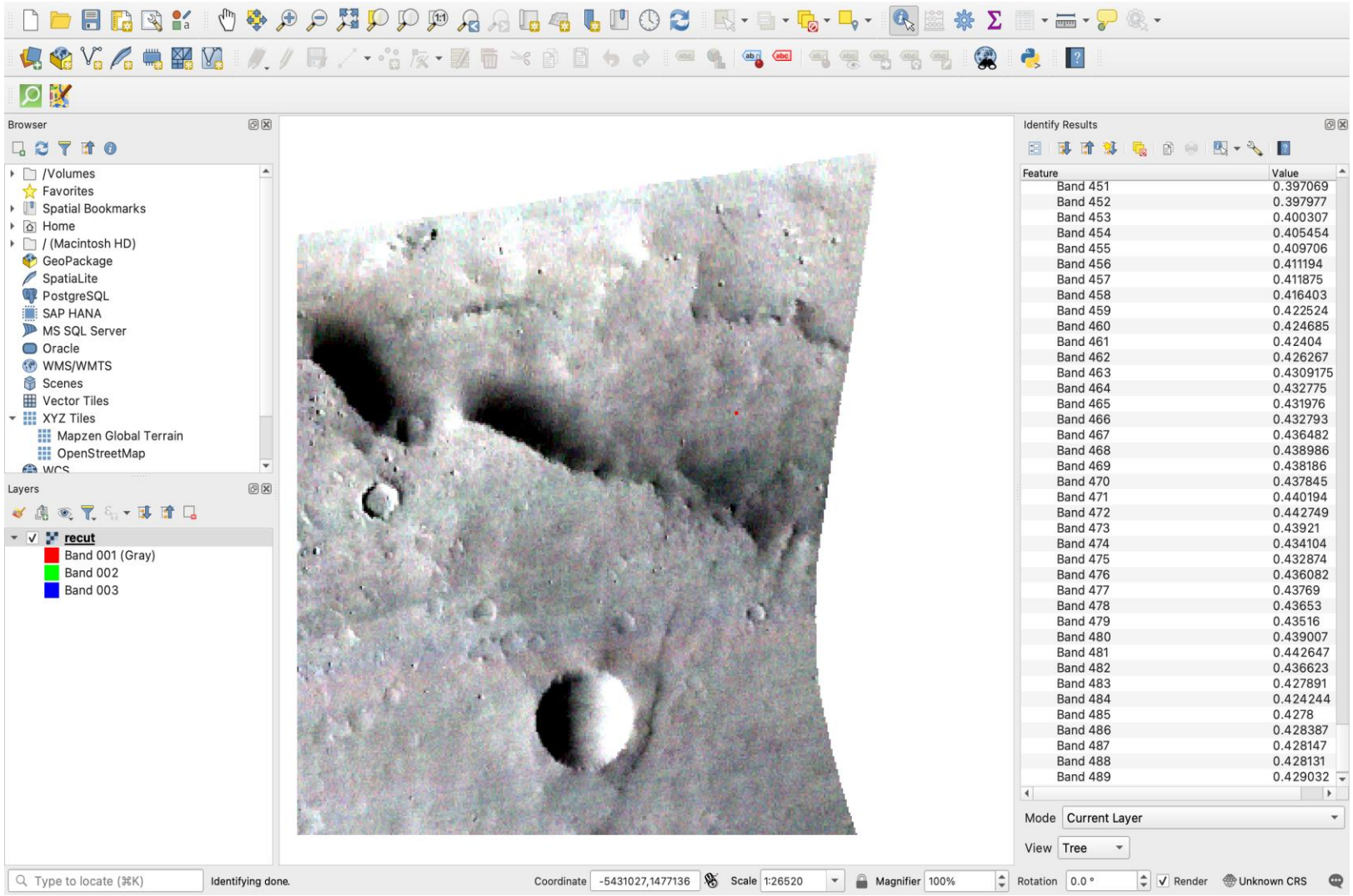
Dataset



Mars dataset

Pixels: 146,096

Bands: 490

Evaluation Results of Basic Algorithm

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

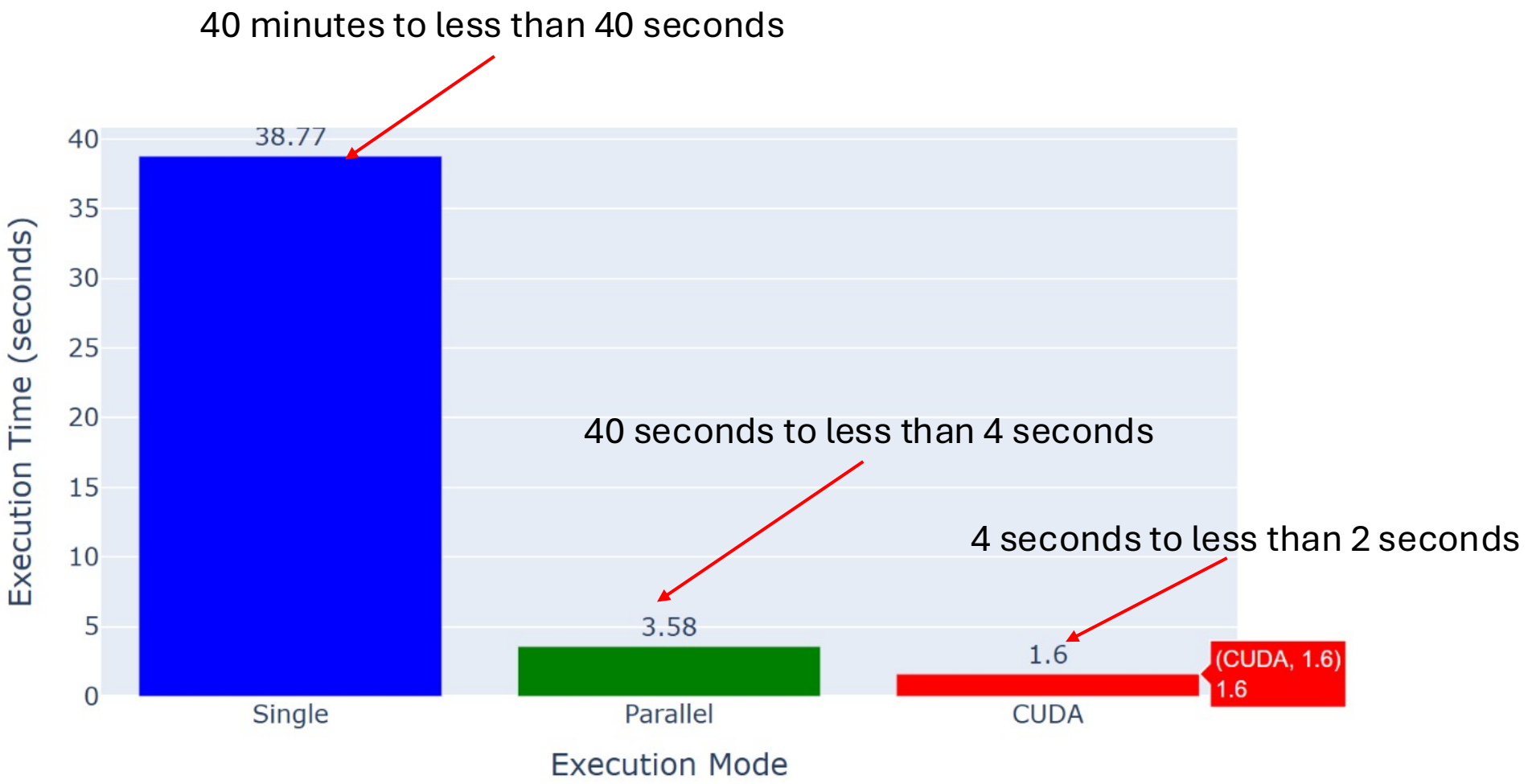
```
100%|██████████| 146096/146096 [1:20:06<00:00, 30.39it/s]
/tmp/ipykernel_11629/2886663301.py:42: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas
  testing['RD'] = newColumn
Total Execution time of proposedAlgo 4807.79144358634 95
Memory of proposedAlgo in KB: 1767864.0
```

number of pixels

runtime in seconds
(40 min approximately)

Results after Optimization



Thank you

Question and Answers