



User Manual of IoTDB-Quality

Author: Data Quality Group

Institute: School of Software, Tsinghua University

Date: August 23, 2021

Contents

1	Get Started	1
1.1	Introduction	1
1.2	Comparison	1
1.3	Q&A	2
2	Data Profiling	3
2.1	Distinct	3
2.2	Histogram	4
2.3	Integral	5
2.4	Mad	7
2.5	Median	9
2.6	MinMax	10
2.7	Mode	12
2.8	MovingAverage	13
2.9	PACF	15
2.10	Percentile	16
2.11	Period	18
2.12	QLB	19
2.13	Resample	20
2.14	Sample	23
2.15	Segment	24
2.16	Skew	26
2.17	Spline	27
2.18	Spread	32
2.19	Stddev	33
2.20	TimeWeightedAvg	34
2.21	ZScore	35
3	Data Quality	38
3.1	Completeness	38
3.2	Consistency	40
3.3	Timeliness	43
3.4	Validity	45

4	Data Repairing	48
4.1	ValueFill	48
4.2	TimestampRepair	50
4.3	ValueRepair	52
5	Data Matching	55
5.1	Cov	55
5.2	CrossCorrelation	56
5.3	DTW(TODO)	57
5.4	PatternSymmetric	57
5.5	Pearson	59
5.6	SelfCorrelation	60
5.7	SeriesAlign(TODO)	61
5.8	SeriesSimilarity(TODO)	61
5.9	ValueAlign(TODO)	61
6	Anomaly Detection	62
6.1	ADWIN	62
6.2	IQR	63
6.3	KSigma	65
6.4	LOF	66
6.5	Range	69
6.6	TwoSidedFilter	70
7	Frequency Domain	73
7.1	Conv	73
7.2	Deconv	74
7.3	FFT	75
7.4	HighPass	77
7.5	LowPass	79
8	Series Discovery	81
8.1	ConsecutiveSequences	81
8.2	ConsecutiveWindows	82
9	Complex Event Processing	85
9.1	AND(TODO)	85
9.2	EventMatching(TODO)	85
9.3	EventNameRepair(TODO)	85
9.4	EventTag(TODO)	85

9.5 EventTimeRepair(TODO) 85

9.6 MissingEventRecovery(TODO) 85

9.7 SEQ(TODO) 85

Chapter 1 Get Started

1.1 Introduction

1.1.1 What is IoTDB-Quality

Apache IoTDB (Internet of Things Database) is a data management system for time series data, which can provide users specific services, such as, data collection, storage and analysis.

For applications based on time series data, data quality is vital. **IoTDB-Quality** is IoTDB User Defined Functions (UDF) about data quality, including data profiling, data quality evaluation and data repairing. It effectively meets the demand for data quality in the industrial field.

1.1.2 Quick Start

1. Download the JAR with all dependencies and the script of registering UDF.
2. Copy the JAR package to `ext\udf` under the directory of IoTDB system.
3. Run `sbin\start-server.bat` (for Windows) or `sbin\start-server.sh` (for Linux or MacOS) to start IoTDB server.
4. Copy the script to the directory of IoTDB system and run it to register UDF.

1.1.3 Contact

- Email: iotdb-quality@protonmail.com

1.2 Comparison

1.2.1 InfluxDB v2.0

InfluxDB is a popular time series database. InfluxQL is its query language, some of whose universal functions are related to data profiling. The comparison is shown below. *Native* means this function has been the native function of IoTDB and *Built-in UDF* means this function has been the built-in UDF of IoTDB.

Data profiling functions of IoTDB-Quality	Univeral functions from InfluxQL
<i>Native</i>	COUNT()
Distinct	DISTINCT()
Integral	INTEGRAL()
<i>Native</i>	MEAN()
Median	MEDIAN()
Mode	MODE()
Spread	SPREAD()
Stddev	STDDEV()
<i>Native</i>	SUM()
<i>Built-in UDF</i>	BOTTOM()
<i>Native</i>	FIRST()
<i>Native</i>	LAST()
<i>Native</i>	MAX()
<i>Native</i>	MIN()
Percentile	PERCENTILE()
Sample	SAMPLE()
<i>Built-in UDF</i>	TOP()
Histogram	HISTOGRAM()
Mad	
Skew	SKEW()
TimeWeightedAVG	TIMEWEIGHTEDAVG()
SelfCorrelation	
CrossCorrelation	

Kapacitor offers UDF to realize user-defined anomaly detection. Python scripts can be applied to Kapacitor, and no native function for anomaly detection is offered in **InfluxDB**.

1.3 Q&A

1.3.1 Is the name of UDF case sensitive

The name of UDF is not case sensitive. Users can choose uppercase, lowercase or mixed case according to their own habits.

Chapter 2 Data Profiling

2.1 Distinct

2.1.1 Usage

This function returns all unique values in time series.

Name: DISTINCT

Input Series: Only support a single input series. The type is arbitrary.

Output Series: Output a single series. The type is the same as the input.

Note:

- The timestamp of the output series is meaningless. The output order is arbitrary.
- Missing points and null points in the input series will be ignored, but `NaN` will not.

2.1.2 Examples

Input series:

```
+-----+-----+
|               Time|root.test.d2.s2|
+-----+-----+
|2020-01-01T08:00:00.001+08:00|      Hello|
|2020-01-01T08:00:00.002+08:00|      hello|
|2020-01-01T08:00:00.003+08:00|      Hello|
|2020-01-01T08:00:00.004+08:00|      World|
|2020-01-01T08:00:00.005+08:00|      World|
+-----+-----+
```

SQL for query:

```
select distinct(s2) from root.test.d2
```

Output series:

```
+-----+-----+
|               Time|distinct(root.test.d2.s2)|
+-----+-----+
|1970-01-01T08:00:00.001+08:00|      Hello|
|1970-01-01T08:00:00.002+08:00|      hello|
|1970-01-01T08:00:00.003+08:00|      World|
+-----+-----+
```

2.2 Histogram

2.2.1 Usage

This function is used to calculate the distribution histogram of a single column of numerical data.

Name: HISTOGRAM

Input Series: Only supports a single input sequence, the type is INT32 / INT64 / FLOAT / DOUBLE

Parameters:

- **start** : The lower limit of the requested data range, the default value is -Double.MAX_VALUE.
- **end** : The upper limit of the requested data range, the default value is Double.MAX_VALUE, and the value of start must be less than or equal to end.
- **count** : The number of buckets of the histogram, the default value is 1. It must be a positive integer.

Output Series: The value of the bucket of the histogram, where the lower bound represented by the i -th bucket (index starts from 1) is $start + (i - 1) \cdot \frac{end - start}{count}$ and the upper bound is $start + i \cdot \frac{end - start}{count}$.

Note:

- If the value is lower than **start**, it will be put into the 1st bucket. If the value is larger than **end**, it will be put into the last bucket.
- Missing points, null points and **NaN** in the input series will be ignored.

2.2.2 Examples

Input series:

Time root.test.d1.s1	
[2020-01-01T00:00:00.000+08:00]	1.0
[2020-01-01T00:00:01.000+08:00]	2.0
[2020-01-01T00:00:02.000+08:00]	3.0
[2020-01-01T00:00:03.000+08:00]	4.0
[2020-01-01T00:00:04.000+08:00]	5.0
[2020-01-01T00:00:05.000+08:00]	6.0
[2020-01-01T00:00:06.000+08:00]	7.0
[2020-01-01T00:00:07.000+08:00]	8.0
[2020-01-01T00:00:08.000+08:00]	9.0
[2020-01-01T00:00:09.000+08:00]	10.0
[2020-01-01T00:00:10.000+08:00]	11.0
[2020-01-01T00:00:11.000+08:00]	12.0
[2020-01-01T00:00:12.000+08:00]	13.0

2020-01-01T00:00:13.000+08:00	14.0
2020-01-01T00:00:14.000+08:00	15.0
2020-01-01T00:00:15.000+08:00	16.0
2020-01-01T00:00:16.000+08:00	17.0
2020-01-01T00:00:17.000+08:00	18.0
2020-01-01T00:00:18.000+08:00	19.0
2020-01-01T00:00:19.000+08:00	20.0
+-----+-----+	

SQL for query:

```
select histogram(s1, "start"="1", "end"="20", "count"="10") from root.test.d1
```

Output series:

Time histogram(root.test.d1.s1, "start"="1", "end"="20", "count"="10")	
+-----+-----+	
1970-01-01T08:00:00.000+08:00	2
1970-01-01T08:00:00.001+08:00	2
1970-01-01T08:00:00.002+08:00	2
1970-01-01T08:00:00.003+08:00	2
1970-01-01T08:00:00.004+08:00	2
1970-01-01T08:00:00.005+08:00	2
1970-01-01T08:00:00.006+08:00	2
1970-01-01T08:00:00.007+08:00	2
1970-01-01T08:00:00.008+08:00	2
1970-01-01T08:00:00.009+08:00	2
+-----+-----+	

2.2.2.1 examples on zeppelin

link: <<http://101.6.15.213:18181/#/notebook/2GC1HE97R>>

2.3 Integral

2.3.1 Usage

This function is used to calculate the integration of time series, which equals to the area under the curve with time as X-axis and values as Y-axis.

Name: INTEGRAL

Input Series: Only support a single input numeric series. The type is INT32 / INT64 / FLOAT / DOUBLE.

Parameters:

- **unit**: The unit of time used when computing the integral.

The value should be chosen from "1S", "1s", "1m", "1H", "1d"(case-sensitive), and each represents taking one millisecond / second / minute / hour / day as 1.0 while calculating the area and integral.

Output Series: Output a single series. The type is DOUBLE. There is only one data point in the series, whose timestamp is 0 and value is the integration.

Note:

- The integral value equals to the sum of the areas of right-angled trapezoids consisting of each two adjacent points and the time-axis.

Choosing different `unit` implies different scaling of time axis, thus making it apparent to convert the value among those results with constant coefficient.

- `NaN` values in the input series will be ignored. The curve or trapezoids will skip these points and use the next valid point.

2.3.2 Examples

2.3.2.1 Default Parameters

With default parameters, this function will take one second as 1.0.

Input series:

Time root.test.d1.s1	
[2020-01-01T00:00:01.000+08:00]	1
[2020-01-01T00:00:02.000+08:00]	2
[2020-01-01T00:00:03.000+08:00]	5
[2020-01-01T00:00:04.000+08:00]	6
[2020-01-01T00:00:05.000+08:00]	7
[2020-01-01T00:00:08.000+08:00]	8
[2020-01-01T00:00:09.000+08:00]	NaN
[2020-01-01T00:00:10.000+08:00]	10

SQL for query:

```
select integral(s1) from root.test.d1 where time <= 2020-01-01 00:00:10
```

Output series:

Time integral(root.test.d1.s1)	
[1970-01-01T08:00:00.000+08:00]	57.5

Calculation expression:

$$\frac{1}{2}[(1+2) \times 1 + (2+5) \times 1 + (5+6) \times 1 + (6+7) \times 1 + (7+8) \times 3 + (8+10) \times 2] = 57.5$$

2.3.2.2 Specific time unit

With time unit specified as "1m", this function will take one minute as 1.0.

Input series is the same as above, the SQL for query is shown below:

```
select integral(s1, "unit"="1m") from root.test.d1 where time <= 2020-01-01 00:00:10
```

Output series:

Time	integral(root.test.d1.s1)
[1970-01-01T08:00:00.000+08:00]	0.958

Calculation expression:

$$\frac{1}{2 \times 60}[(1+2) \times 1 + (2+5) \times 1 + (5+6) \times 1 + (6+7) \times 1 + (7+8) \times 3 + (8+10) \times 2] = 0.958$$

2.4 Mad

2.4.1 Usage

The function is used to compute the exact or approximate median absolute deviation (MAD) of a numeric time series. MAD is the median of the deviation of each element from the elements' median.

Take a dataset $\{1, 3, 3, 5, 5, 6, 7, 8, 9\}$ as an instance. Its median is 5 and the deviation of each element from the median is $\{0, 0, 1, 2, 2, 2, 3, 4, 4\}$, whose median is 2. Therefore, the MAD of the original dataset is 2.

Name: MAD

Input Series: Only support a single input series. The data type is INT32 / INT64 / FLOAT / DOUBLE.

Parameter:

- error**: The relative error of the approximate MAD. It should be within $[0,1)$ and the default value is 0. Taking **error**=0.01 as an instance, suppose the exact MAD is a and the approximate MAD is b , we have $0.99a \leq b \leq 1.01a$. With **error**=0, the output is the exact MAD.

Output Series: Output a single series. The type is DOUBLE. There is only one data point in the series, whose timestamp is 0 and value is the MAD.

Note: Missing points, null points and NaN in the input series will be ignored.

2.4.2 Examples

2.4.2.1 Exact Query

With the default `error` (`error=0`), the function queries the exact MAD.

Input series:

Time	root.test.s0
[2021-03-17T10:32:17.054+08:00]	0.5319929
[2021-03-17T10:32:18.054+08:00]	0.9304316
[2021-03-17T10:32:19.054+08:00]	-1.4800133
[2021-03-17T10:32:20.054+08:00]	0.6114087
[2021-03-17T10:32:21.054+08:00]	2.5163336
[2021-03-17T10:32:22.054+08:00]	-1.0845392
[2021-03-17T10:32:23.054+08:00]	1.0562582
[2021-03-17T10:32:24.054+08:00]	1.3867859
[2021-03-17T10:32:25.054+08:00]	-0.45429882
[2021-03-17T10:32:26.054+08:00]	1.0353678
[2021-03-17T10:32:27.054+08:00]	0.7307929
[2021-03-17T10:32:28.054+08:00]	2.3167255
[2021-03-17T10:32:29.054+08:00]	2.342443
[2021-03-17T10:32:30.054+08:00]	1.5809103
[2021-03-17T10:32:31.054+08:00]	1.4829416
[2021-03-17T10:32:32.054+08:00]	1.5800357
[2021-03-17T10:32:33.054+08:00]	0.7124368
[2021-03-17T10:32:34.054+08:00]	-0.78597564
[2021-03-17T10:32:35.054+08:00]	1.2058644
[2021-03-17T10:32:36.054+08:00]	1.4215064
[2021-03-17T10:32:37.054+08:00]	1.2808295
[2021-03-17T10:32:38.054+08:00]	-0.6173715
[2021-03-17T10:32:39.054+08:00]	0.06644377
[2021-03-17T10:32:40.054+08:00]	2.349338
[2021-03-17T10:32:41.054+08:00]	1.7335888
[2021-03-17T10:32:42.054+08:00]	1.5872132
.....	
Total line number = 10000	

SQL for query:

```
select mad(s0) from root.test
```

Output series:

Time	mad(root.test.s0)
------	-------------------

Time	mad(root.test.s0, "error"="0.01")
[1970-01-01T08:00:00.000+08:00]	0.6806197166442871

2.4.2.2 Approximate Query

By setting `error` within (0,1), the function queries the approximate MAD.

SQL for query:

```
select mad(s0, "error"="0.01") from root.test
```

Output series:

Time	mad(root.test.s0, "error"="0.01")
[1970-01-01T08:00:00.000+08:00]	0.6806616245859518

2.5 Median

2.5.1 Usage

The function is used to compute the exact or approximate median of a numeric time series.

Name: MEDIAN

Input Series: Only support a single input series. The data type is INT32 / INT64 / FLOAT / DOUBLE.

Parameter:

- error**: The rank error of the approximate median. It should be within [0,1) and the default value is 0. For instance, a median with `error`=0.01 is the value of the element with rank percentage 0.49~0.51. With `error`=0, the output is the exact median.

Output Series: Output a single series. The type is DOUBLE. There is only one data point in the series, whose timestamp is 0 and value is the median.

2.5.2 Examples

Input series:

Time	root.test.s0
[2021-03-17T10:32:17.054+08:00]	0.5319929
[2021-03-17T10:32:18.054+08:00]	0.9304316
[2021-03-17T10:32:19.054+08:00]	-1.4800133

```
[2021-03-17T10:32:20.054+08:00] 0.6114087|
[2021-03-17T10:32:21.054+08:00] 2.5163336|
[2021-03-17T10:32:22.054+08:00] -1.0845392|
[2021-03-17T10:32:23.054+08:00] 1.0562582|
[2021-03-17T10:32:24.054+08:00] 1.3867859|
[2021-03-17T10:32:25.054+08:00] -0.45429882|
[2021-03-17T10:32:26.054+08:00] 1.0353678|
[2021-03-17T10:32:27.054+08:00] 0.7307929|
[2021-03-17T10:32:28.054+08:00] 2.3167255|
[2021-03-17T10:32:29.054+08:00] 2.342443|
[2021-03-17T10:32:30.054+08:00] 1.5809103|
[2021-03-17T10:32:31.054+08:00] 1.4829416|
[2021-03-17T10:32:32.054+08:00] 1.5800357|
[2021-03-17T10:32:33.054+08:00] 0.7124368|
[2021-03-17T10:32:34.054+08:00] -0.78597564|
[2021-03-17T10:32:35.054+08:00] 1.2058644|
[2021-03-17T10:32:36.054+08:00] 1.4215064|
[2021-03-17T10:32:37.054+08:00] 1.2808295|
[2021-03-17T10:32:38.054+08:00] -0.6173715|
[2021-03-17T10:32:39.054+08:00] 0.06644377|
[2021-03-17T10:32:40.054+08:00] 2.349338|
[2021-03-17T10:32:41.054+08:00] 1.7335888|
[2021-03-17T10:32:42.054+08:00] 1.5872132|
.....
Total line number = 10000
```

SQL for query:

```
select median(s0, "error"="0.01") from root.test
```

Output series:

```
+-----+-----+
|                Time|median(root.test.s0, "error"="0.01")|
+-----+-----+
[1970-01-01T08:00:00.000+08:00]                1.021884560585022|
+-----+-----+
```

2.6 MinMax

2.6.1 Usage

This function is used to standardize the input series with min-max. Minimum value is transformed to 0; maximum value is transformed to 1.

Name: MINMAX

Input Series: Only support a single input series. The type is INT32 / INT64 / FLOAT / DOUBLE.

- **method** : When set to "batch", anomaly test is conducted after importing all data points; when set to "stream", it is required to provide minimum and maximum values. The default method is "batch".
- **min** : The maximum value when method is set to "stream".
- **max** : The minimum value when method is set to "stream".

Output Series: Output a single series. The type is DOUBLE.

2.6.2 Examples

2.6.2.1 Batch computing

Input series:

Time	root.test.s1
[1970-01-01T08:00:00.100+08:00]	0.0
[1970-01-01T08:00:00.200+08:00]	0.0
[1970-01-01T08:00:00.300+08:00]	1.0
[1970-01-01T08:00:00.400+08:00]	-1.0
[1970-01-01T08:00:00.500+08:00]	0.0
[1970-01-01T08:00:00.600+08:00]	0.0
[1970-01-01T08:00:00.700+08:00]	-2.0
[1970-01-01T08:00:00.800+08:00]	2.0
[1970-01-01T08:00:00.900+08:00]	0.0
[1970-01-01T08:00:01.000+08:00]	0.0
[1970-01-01T08:00:01.100+08:00]	1.0
[1970-01-01T08:00:01.200+08:00]	-1.0
[1970-01-01T08:00:01.300+08:00]	-1.0
[1970-01-01T08:00:01.400+08:00]	1.0
[1970-01-01T08:00:01.500+08:00]	0.0
[1970-01-01T08:00:01.600+08:00]	0.0
[1970-01-01T08:00:01.700+08:00]	10.0
[1970-01-01T08:00:01.800+08:00]	2.0
[1970-01-01T08:00:01.900+08:00]	-2.0
[1970-01-01T08:00:02.000+08:00]	0.0

SQL for query:

```
select minmax(s1) from root.test
```

Output series:

Time	minmax(s1)
[1970-01-01T08:00:00.100+08:00]	0.0
[1970-01-01T08:00:00.200+08:00]	0.0
[1970-01-01T08:00:00.300+08:00]	1.0
[1970-01-01T08:00:00.400+08:00]	-1.0
[1970-01-01T08:00:00.500+08:00]	0.0
[1970-01-01T08:00:00.600+08:00]	0.0
[1970-01-01T08:00:00.700+08:00]	-2.0
[1970-01-01T08:00:00.800+08:00]	2.0
[1970-01-01T08:00:00.900+08:00]	0.0
[1970-01-01T08:00:01.000+08:00]	0.0
[1970-01-01T08:00:01.100+08:00]	1.0
[1970-01-01T08:00:01.200+08:00]	-1.0
[1970-01-01T08:00:01.300+08:00]	-1.0
[1970-01-01T08:00:01.400+08:00]	1.0
[1970-01-01T08:00:01.500+08:00]	0.0
[1970-01-01T08:00:01.600+08:00]	0.0
[1970-01-01T08:00:01.700+08:00]	10.0
[1970-01-01T08:00:01.800+08:00]	2.0
[1970-01-01T08:00:01.900+08:00]	-2.0
[1970-01-01T08:00:02.000+08:00]	0.0

Time	minmax(root.test.s1)
1970-01-01T08:00:00.100+08:00	0.16666666666666666
1970-01-01T08:00:00.200+08:00	0.16666666666666666
1970-01-01T08:00:00.300+08:00	0.25
1970-01-01T08:00:00.400+08:00	0.08333333333333333
1970-01-01T08:00:00.500+08:00	0.16666666666666666
1970-01-01T08:00:00.600+08:00	0.16666666666666666
1970-01-01T08:00:00.700+08:00	0.0
1970-01-01T08:00:00.800+08:00	0.3333333333333333
1970-01-01T08:00:00.900+08:00	0.16666666666666666
1970-01-01T08:00:01.000+08:00	0.16666666666666666
1970-01-01T08:00:01.100+08:00	0.25
1970-01-01T08:00:01.200+08:00	0.08333333333333333
1970-01-01T08:00:01.300+08:00	0.08333333333333333
1970-01-01T08:00:01.400+08:00	0.25
1970-01-01T08:00:01.500+08:00	0.16666666666666666
1970-01-01T08:00:01.600+08:00	0.16666666666666666
1970-01-01T08:00:01.700+08:00	1.0
1970-01-01T08:00:01.800+08:00	0.3333333333333333
1970-01-01T08:00:01.900+08:00	0.0
1970-01-01T08:00:02.000+08:00	0.16666666666666666

2.7 Mode

2.7.1 Usage

This function is used to calculate the mode of time series, that is, the value that occurs most frequently.

Name: MODE

Input Series: Only support a single input series. The type is arbitrary.

Output Series: Output a single series. The type is the same as the input. There is only one data point in the series, whose timestamp is 0 and value is the mode.

Note:

- If there are multiple values with the most occurrences, the arbitrary one will be output.
- Missing points and null points in the input series will be ignored, but `NaN` will not.

2.7.2 Examples

Input series:

Time	root.test.d2.s2

1970-01-01T08:00:00.001+08:00	Hello
1970-01-01T08:00:00.002+08:00	hello
1970-01-01T08:00:00.003+08:00	Hello
1970-01-01T08:00:00.004+08:00	World
1970-01-01T08:00:00.005+08:00	World
1970-01-01T08:00:01.600+08:00	World
1970-01-15T09:37:34.451+08:00	Hello
1970-01-15T09:37:34.452+08:00	hello
1970-01-15T09:37:34.453+08:00	Hello
1970-01-15T09:37:34.454+08:00	World
1970-01-15T09:37:34.455+08:00	World

SQL for query:

```
select mode(s2) from root.test.d2
```

Output series:

Time mode(root.test.d2.s2)
1970-01-01T08:00:00.000+08:00 World

2.8 MovingAverage

2.8.1 Usage

This function is used to calculate moving average of input series.

Name: MOVINGAVERAGE

Input Series: Only support a single input series. The type is INT32 / INT64 / FLOAT / DOUBLE.

- **n**: Length of the moving window.

Output Series: Output a single series. The type is DOUBLE.

2.8.2 Examples

2.8.2.1 Batch computing

Input series:

Time root.test.s1
1970-01-01T08:00:00.000+08:00

[1970-01-01T08:00:00.100+08:00]	0.0
[1970-01-01T08:00:00.200+08:00]	0.0
[1970-01-01T08:00:00.300+08:00]	1.0
[1970-01-01T08:00:00.400+08:00]	-1.0
[1970-01-01T08:00:00.500+08:00]	0.0
[1970-01-01T08:00:00.600+08:00]	0.0
[1970-01-01T08:00:00.700+08:00]	-2.0
[1970-01-01T08:00:00.800+08:00]	2.0
[1970-01-01T08:00:00.900+08:00]	0.0
[1970-01-01T08:00:01.000+08:00]	0.0
[1970-01-01T08:00:01.100+08:00]	1.0
[1970-01-01T08:00:01.200+08:00]	-1.0
[1970-01-01T08:00:01.300+08:00]	-1.0
[1970-01-01T08:00:01.400+08:00]	1.0
[1970-01-01T08:00:01.500+08:00]	0.0
[1970-01-01T08:00:01.600+08:00]	0.0
[1970-01-01T08:00:01.700+08:00]	10.0
[1970-01-01T08:00:01.800+08:00]	2.0
[1970-01-01T08:00:01.900+08:00]	-2.0
[1970-01-01T08:00:02.000+08:00]	0.0
+-----+-----+	

SQL for query:

```
select movingaverage(s1, "n"="3") from root.test
```

Output series:

+-----+-----+	
Time	movingaverage(root.test.s1, "n"="3")
+-----+-----+	
[1970-01-01T08:00:00.200+08:00]	0.0
[1970-01-01T08:00:00.300+08:00]	0.3333333333333333
[1970-01-01T08:00:00.400+08:00]	0.0
[1970-01-01T08:00:00.500+08:00]	-0.3333333333333333
[1970-01-01T08:00:00.600+08:00]	0.0
[1970-01-01T08:00:00.700+08:00]	-0.6666666666666666
[1970-01-01T08:00:00.800+08:00]	0.0
[1970-01-01T08:00:00.900+08:00]	0.6666666666666666
[1970-01-01T08:00:01.000+08:00]	0.0
[1970-01-01T08:00:01.100+08:00]	0.3333333333333333
[1970-01-01T08:00:01.200+08:00]	0.0
[1970-01-01T08:00:01.300+08:00]	-0.6666666666666666
[1970-01-01T08:00:01.400+08:00]	0.0
[1970-01-01T08:00:01.500+08:00]	0.3333333333333333
[1970-01-01T08:00:01.600+08:00]	0.0
[1970-01-01T08:00:01.700+08:00]	3.3333333333333335
[1970-01-01T08:00:01.800+08:00]	4.0
[1970-01-01T08:00:01.900+08:00]	0.0

1970-01-01T08:00:02.000+08:00	-0.6666666666666666
+-----+-----+	

2.9 PACF

2.9.1 Usage

This function is used to calculate partial autocorrelation of input series by solving Yule-Walker equation.

Name: PACF

Input Series: Only support a single input series. The type is INT32 / INT64 / FLOAT / DOUBLE.

- **lag** : Maximum lag of pacf to calculate. The default value is $\min(10 \log_{10} n, n - 1)$, where n is the number of data points.

Output Series: Output a single series. The type is DOUBLE.

2.9.2 Examples

2.9.2.1 Assigning maximum lag

Input series:

Time root.test.s1	
+-----+-----+	
2019-12-27T00:00:00.000+08:00	5.0
2019-12-27T00:05:00.000+08:00	5.0
2019-12-27T00:10:00.000+08:00	5.0
2019-12-27T00:15:00.000+08:00	5.0
2019-12-27T00:20:00.000+08:00	6.0
2019-12-27T00:25:00.000+08:00	5.0
2019-12-27T00:30:00.000+08:00	6.0
2019-12-27T00:35:00.000+08:00	6.0
2019-12-27T00:40:00.000+08:00	6.0
2019-12-27T00:45:00.000+08:00	6.0
2019-12-27T00:50:00.000+08:00	6.0
2019-12-27T00:55:00.000+08:00	5.982609
2019-12-27T01:00:00.000+08:00	5.9652176
2019-12-27T01:05:00.000+08:00	5.947826
2019-12-27T01:10:00.000+08:00	5.9304347
2019-12-27T01:15:00.000+08:00	5.9130435
2019-12-27T01:20:00.000+08:00	5.8956523
2019-12-27T01:25:00.000+08:00	5.878261
2019-12-27T01:30:00.000+08:00	5.8608694
2019-12-27T01:35:00.000+08:00	5.843478

.....
Total line number = 18066

SQL for query:

```
select pacf(s1, "lag"="5") from root.test
```

Output series:

Time	pacf(root.test.s1, "lag"="5")
[2019-12-27T00:00:00.000+08:00]	1.0
[2019-12-27T00:05:00.000+08:00]	0.3528915091942786
[2019-12-27T00:10:00.000+08:00]	0.1761346122516304
[2019-12-27T00:15:00.000+08:00]	0.1492391973294682
[2019-12-27T00:20:00.000+08:00]	0.03560059645868398
[2019-12-27T00:25:00.000+08:00]	0.0366222998995286

2.10 Percentile

2.10.1 Usage

The function is used to compute the exact or approximate percentile of a numeric time series. A percentile is value of element in the certain rank of the sorted series.

Name: PERCENTILE

Input Series: Only support a single input series. The data type is INT32 / INT64 / FLOAT / DOUBLE.

Parameter:

- **rank**: The rank percentage of the percentile. It should be (0,1] and the default value is 0.5. For instance, a percentile with **rank**=0.5 is the median.
- **error**: The rank error of the approximate percentile. It should be within [0,1) and the default value is 0. For instance, a 0.5-percentile with **error**=0.01 is the value of the element with rank percentage 0.49~0.51. With **error**=0, the output is the exact percentile.

Output Series: Output a single series. The type is DOUBLE. There is only one data point in the series, whose timestamp is 0 and value is the percentile.

Note: Missing points, null points and NaN in the input series will be ignored.

2.10.2 Examples

Input series:

Time	Value
[2019-12-27T00:00:00.000+08:00]	1.0
[2019-12-27T00:05:00.000+08:00]	0.3528915091942786
[2019-12-27T00:10:00.000+08:00]	0.1761346122516304
[2019-12-27T00:15:00.000+08:00]	0.1492391973294682
[2019-12-27T00:20:00.000+08:00]	0.03560059645868398
[2019-12-27T00:25:00.000+08:00]	0.0366222998995286

Time	root.test.s0
[2021-03-17T10:32:17.054+08:00]	0.5319929
[2021-03-17T10:32:18.054+08:00]	0.9304316
[2021-03-17T10:32:19.054+08:00]	-1.4800133
[2021-03-17T10:32:20.054+08:00]	0.6114087
[2021-03-17T10:32:21.054+08:00]	2.5163336
[2021-03-17T10:32:22.054+08:00]	-1.0845392
[2021-03-17T10:32:23.054+08:00]	1.0562582
[2021-03-17T10:32:24.054+08:00]	1.3867859
[2021-03-17T10:32:25.054+08:00]	-0.45429882
[2021-03-17T10:32:26.054+08:00]	1.0353678
[2021-03-17T10:32:27.054+08:00]	0.7307929
[2021-03-17T10:32:28.054+08:00]	2.3167255
[2021-03-17T10:32:29.054+08:00]	2.342443
[2021-03-17T10:32:30.054+08:00]	1.5809103
[2021-03-17T10:32:31.054+08:00]	1.4829416
[2021-03-17T10:32:32.054+08:00]	1.5800357
[2021-03-17T10:32:33.054+08:00]	0.7124368
[2021-03-17T10:32:34.054+08:00]	-0.78597564
[2021-03-17T10:32:35.054+08:00]	1.2058644
[2021-03-17T10:32:36.054+08:00]	1.4215064
[2021-03-17T10:32:37.054+08:00]	1.2808295
[2021-03-17T10:32:38.054+08:00]	-0.6173715
[2021-03-17T10:32:39.054+08:00]	0.06644377
[2021-03-17T10:32:40.054+08:00]	2.349338
[2021-03-17T10:32:41.054+08:00]	1.7335888
[2021-03-17T10:32:42.054+08:00]	1.5872132
.....	
Total line number = 10000	

SQL for query:

```
select percentile(s0, "rank"="0.2", "error"="0.01") from root.test
```

Output series:

Time	percentile(root.test.s0, "rank"="0.2", "error"="0.01")
[1970-01-01T08:00:00.000+08:00]	0.1801469624042511

2.11 Period

2.11.1 Usage

The function is used to compute the period of a numeric time series.

Name: PERIOD

Input Series: Only support a single input series. The data type is INT32 / INT64 / FLOAT / DOUBLE.

Output Series: Output a single series. The type is INT32. There is only one data point in the series, whose timestamp is 0 and value is the period.

2.11.2 Examples

Input series:

Time	root.test.d3.s1
[1970-01-01T08:00:00.001+08:00]	1.0
[1970-01-01T08:00:00.002+08:00]	2.0
[1970-01-01T08:00:00.003+08:00]	3.0
[1970-01-01T08:00:00.004+08:00]	1.0
[1970-01-01T08:00:00.005+08:00]	2.0
[1970-01-01T08:00:00.006+08:00]	3.0
[1970-01-01T08:00:00.007+08:00]	1.0
[1970-01-01T08:00:00.008+08:00]	2.0
[1970-01-01T08:00:00.009+08:00]	3.0

SQL for query:

```
select period(s1) from root.test.d3
```

Output series:

Time	period(root.test.d3.s1)
[1970-01-01T08:00:00.000+08:00]	3

2.11.2.1 examples on zeppelin

link: <<http://101.6.15.213:18181/#/notebook/2GEJBUSZ9>>

2.12 QLB

2.12.1 Usage

This function is used to calculate Ljung-Box statistics Q_{LB} for time series, and convert it to p value.

Name: QLB

Input Series: Only support a single input series. The type is INT32 / INT64 / FLOAT / DOUBLE.

Parameters:

shift: max lag to calculate. Legal input shall be integer from 1 to n-2, where n is the sample number. Default value is n-2.

Output Series: Output a single series. The type is DOUBLE. The output series is p value, and timestamp means lag.

Note: If you want to calculate Ljung-Box statistics Q_{LB} instead of p value, you may use AutoCorrelation function.

2.12.2 Examples

2.12.2.1 Using Default Parameter

Input series:

Time	root.test.d1.s1
[1970-01-01T00:00:00.100+08:00]	1.22
[1970-01-01T00:00:00.200+08:00]	-2.78
[1970-01-01T00:00:00.300+08:00]	1.53
[1970-01-01T00:00:00.400+08:00]	0.70
[1970-01-01T00:00:00.500+08:00]	0.75
[1970-01-01T00:00:00.600+08:00]	-0.72
[1970-01-01T00:00:00.700+08:00]	-0.22
[1970-01-01T00:00:00.800+08:00]	0.28
[1970-01-01T00:00:00.900+08:00]	0.57
[1970-01-01T00:00:01.000+08:00]	-0.22
[1970-01-01T00:00:01.100+08:00]	-0.72
[1970-01-01T00:00:01.200+08:00]	1.34
[1970-01-01T00:00:01.300+08:00]	-0.25
[1970-01-01T00:00:01.400+08:00]	0.17
[1970-01-01T00:00:01.500+08:00]	2.51
[1970-01-01T00:00:01.600+08:00]	1.42
[1970-01-01T00:00:01.700+08:00]	-1.34
[1970-01-01T00:00:01.800+08:00]	-0.01
[1970-01-01T00:00:01.900+08:00]	-0.49

```
|1970-01-01T00:00:02.000+08:00|      1.63|
+-----+-----+
```

SQL for query:

```
select QLB(s1) from root.test.d1
```

Output series:

```
+-----+-----+
|              Time|QLB(root.test.d1.s1)|
+-----+-----+
|1970-01-01T00:00:00.001+08:00| 0.2168702295315677|
|1970-01-01T00:00:00.002+08:00| 0.3068948509261751|
|1970-01-01T00:00:00.003+08:00| 0.4217859150918444|
|1970-01-01T00:00:00.004+08:00| 0.5114539874276656|
|1970-01-01T00:00:00.005+08:00| 0.6560619525616759|
|1970-01-01T00:00:00.006+08:00| 0.7722398654053280|
|1970-01-01T00:00:00.007+08:00| 0.8532491661465290|
|1970-01-01T00:00:00.008+08:00| 0.9028575017542528|
|1970-01-01T00:00:00.009+08:00| 0.9434989988192729|
|1970-01-01T00:00:00.010+08:00| 0.8950280161464689|
|1970-01-01T00:00:00.011+08:00| 0.7701048398839656|
|1970-01-01T00:00:00.012+08:00| 0.7845536060001281|
|1970-01-01T00:00:00.013+08:00| 0.5943030981705825|
|1970-01-01T00:00:00.014+08:00| 0.4618413512531093|
|1970-01-01T00:00:00.015+08:00| 0.2645948244673964|
|1970-01-01T00:00:00.016+08:00| 0.3167530476666645|
|1970-01-01T00:00:00.017+08:00| 0.2330010780351453|
|1970-01-01T00:00:00.018+08:00| 0.0666611237622325|
+-----+-----+
```

2.13 Resample

2.13.1 Usage

This function is used to resample the input series according to a given frequency, including up-sampling and down-sampling. Currently, the supported up-sampling methods are NaN (filling with NaN), FFill (filling with previous value), BFill (filling with next value) and Linear (filling with linear interpolation). Down-sampling relies on group aggregation, which supports Max, Min, First, Last, Mean and Median.

Name: RESAMPLE

Input Series: Only support a single input series. The type is INT32 / INT64 / FLOAT / DOUBLE.

Parameters:

- **every** : The frequency of resampling, which is a positive number with an unit. The unit is 'ms' for millisecond, 's' for second, 'm' for minute, 'h' for hour and 'd' for day. This parameter cannot be lacked.
- **interp** : The interpolation method of up-sampling, which is 'NaN', 'FFill', 'BFill' or 'Linear'. By default, NaN is used.
- **aggr** : The aggregation method of down-sampling, which is 'Max', 'Min', 'First', 'Last', 'Mean' or 'Median'. By default, Mean is used.
- **start** : The start time (inclusive) of resampling with the format 'yyyy-MM-dd HH:mm:ss'. By default, it is the timestamp of the first valid data point.
- **end** : The end time (exclusive) of resampling with the format 'yyyy-MM-dd HH:mm:ss'. By default, it is the timestamp of the last valid data point.

Output Series: Output a single series. The type is DOUBLE. It is strictly equispaced with the frequency **every**.

Note: NaN in the input series will be ignored.

2.13.2 Examples

2.13.2.1 Up-sampling

When the frequency of resampling is higher than the original frequency, up-sampling starts.

Input series:

Time root.test.d1.s1	
[2021-03-06T16:00:00.000+08:00]	3.09
[2021-03-06T16:15:00.000+08:00]	3.53
[2021-03-06T16:30:00.000+08:00]	3.5
[2021-03-06T16:45:00.000+08:00]	3.51
[2021-03-06T17:00:00.000+08:00]	3.41

SQL for query:

```
select resample(s1, 'every'='5m', 'interp'='linear') from root.test.d1
```

Output series:

Time resample(root.test.d1.s1, "every"="5m", "interp"="linear")	
[2021-03-06T16:00:00.000+08:00]	3.0899999141693115
[2021-03-06T16:05:00.000+08:00]	3.2366665999094644
[2021-03-06T16:10:00.000+08:00]	3.3833332856496177
[2021-03-06T16:15:00.000+08:00]	3.5299999713897705
[2021-03-06T16:20:00.000+08:00]	3.5199999809265137

[2021-03-06T16:25:00.000+08:00]	3.509999990463257
[2021-03-06T16:30:00.000+08:00]	3.5
[2021-03-06T16:35:00.000+08:00]	3.503333330154419
[2021-03-06T16:40:00.000+08:00]	3.506666660308838
[2021-03-06T16:45:00.000+08:00]	3.509999990463257
[2021-03-06T16:50:00.000+08:00]	3.4766666889190674
[2021-03-06T16:55:00.000+08:00]	3.443333387374878
[2021-03-06T17:00:00.000+08:00]	3.4100000858306885

2.13.2.2 Down-sampling

When the frequency of resampling is lower than the original frequency, down-sampling starts.

Input series is the same as above, the SQL for query is shown below:

```
select resample(s1, 'every'='30m', 'aggr'='first') from root.test.d1
```

Output series:

Time	resample(root.test.d1.s1, "every"="30m", "aggr"="first")
[2021-03-06T16:00:00.000+08:00]	3.0899999141693115
[2021-03-06T16:30:00.000+08:00]	3.5
[2021-03-06T17:00:00.000+08:00]	3.4100000858306885

2.13.2.3 Specify the time period

The time period of resampling can be specified with `start` and `end`. The period outside the actual time range will be interpolated.

Input series is the same as above, the SQL for query is shown below:

```
select resample(s1, 'every'='30m', 'start'='2021-03-06 15:00:00') from root.test.d1
```

Output series:

Time	resample(root.test.d1.s1, "every"="30m", "start"="2021-03-06 15:00:00")
[2021-03-06T15:00:00.000+08:00]	NaN
[2021-03-06T15:30:00.000+08:00]	NaN
[2021-03-06T16:00:00.000+08:00]	3.309999942779541
[2021-03-06T16:30:00.000+08:00]	3.5049999952316284
[2021-03-06T17:00:00.000+08:00]	3.4100000858306885

2.14 Sample

2.14.1 Usage

This function is used to sample the input series, that is, select a specified number of data points from the input series and output them. Currently, two sampling methods are supported: **Reservoir sampling** randomly selects data points. All of the points have the same probability of being sampled. **Isometric sampling** selects data points at equal index intervals.

Name: SAMPLE

Input Series: Only support a single input series. The type is arbitrary.

Parameters:

- **method** : The method of sampling, which is 'reservoir' or 'isometric'. By default, reservoir sampling is used.
- **k** : The number of sampling, which is a positive integer. By default, it's 1.

Output Series: Output a single series. The type is the same as the input. The length of the output series is **k**. Each data point in the output series comes from the input series.

Note: If **k** is greater than the length of input series, all data points in the input series will be output.

2.14.2 Examples

2.14.2.1 Reservoir Sampling

When **method** is 'reservoir' or the default, reservoir sampling is used. Due to the randomness of this method, the output series shown below is only a possible result.

Input series:

	Time root.test.d1.s1
[2020-01-01T00:00:01.000+08:00]	1.0
[2020-01-01T00:00:02.000+08:00]	2.0
[2020-01-01T00:00:03.000+08:00]	3.0
[2020-01-01T00:00:04.000+08:00]	4.0
[2020-01-01T00:00:05.000+08:00]	5.0
[2020-01-01T00:00:06.000+08:00]	6.0
[2020-01-01T00:00:07.000+08:00]	7.0
[2020-01-01T00:00:08.000+08:00]	8.0
[2020-01-01T00:00:09.000+08:00]	9.0
[2020-01-01T00:00:10.000+08:00]	10.0

SQL for query:

```
select sample(s1, 'method'='reservoir', 'k'='5') from root.test.d1
```

Output series:

Time	sample(root.test.d1.s1, "method"="reservoir", "k"="5")
[2020-01-01T00:00:02.000+08:00]	2.0
[2020-01-01T00:00:03.000+08:00]	3.0
[2020-01-01T00:00:05.000+08:00]	5.0
[2020-01-01T00:00:08.000+08:00]	8.0
[2020-01-01T00:00:10.000+08:00]	10.0

2.14.2.2 Isometric Sampling

When `method` is 'isometric', isometric sampling is used.

Input series is the same as above, the SQL for query is shown below:

```
select sample(s1, 'method'='isometric', 'k'='5') from root.test.d1
```

Output series:

Time	sample(root.test.d1.s1, "method"="isometric", "k"="5")
[2020-01-01T00:00:01.000+08:00]	1.0
[2020-01-01T00:00:03.000+08:00]	3.0
[2020-01-01T00:00:05.000+08:00]	5.0
[2020-01-01T00:00:07.000+08:00]	7.0
[2020-01-01T00:00:09.000+08:00]	9.0

2.15 Segment

2.15.1 Usage

This function is used to segment a time series into subsequences according to linear trend, and returns linear fitted values of first values in each subsequence or every data point.

Name: SEGMENT

Input Series: Only support a single input series. The type is INT32 / INT64 / FLOAT / DOUBLE.

Parameters:

- output** : "all" to output all fitted points; "first" to output first fitted points in each subsequence.

- **error**: error allowed at linear regression. It is defined as mean absolute error of a subsequence.

Output Series: Output a single series. The type is DOUBLE.

Note: This function treat input series as equal-interval sampled. All data are loaded, so downsample input series first if there are too many data points.

2.15.2 Examples

Input series:

Time	root.test.s1
[1970-01-01T08:00:00.000+08:00]	5.0
[1970-01-01T08:00:00.100+08:00]	0.0
[1970-01-01T08:00:00.200+08:00]	1.0
[1970-01-01T08:00:00.300+08:00]	2.0
[1970-01-01T08:00:00.400+08:00]	3.0
[1970-01-01T08:00:00.500+08:00]	4.0
[1970-01-01T08:00:00.600+08:00]	5.0
[1970-01-01T08:00:00.700+08:00]	6.0
[1970-01-01T08:00:00.800+08:00]	7.0
[1970-01-01T08:00:00.900+08:00]	8.0
[1970-01-01T08:00:01.000+08:00]	9.0
[1970-01-01T08:00:01.100+08:00]	9.1
[1970-01-01T08:00:01.200+08:00]	9.2
[1970-01-01T08:00:01.300+08:00]	9.3
[1970-01-01T08:00:01.400+08:00]	9.4
[1970-01-01T08:00:01.500+08:00]	9.5
[1970-01-01T08:00:01.600+08:00]	9.6
[1970-01-01T08:00:01.700+08:00]	9.7
[1970-01-01T08:00:01.800+08:00]	9.8
[1970-01-01T08:00:01.900+08:00]	9.9
[1970-01-01T08:00:02.000+08:00]	10.0
[1970-01-01T08:00:02.100+08:00]	8.0
[1970-01-01T08:00:02.200+08:00]	6.0
[1970-01-01T08:00:02.300+08:00]	4.0
[1970-01-01T08:00:02.400+08:00]	2.0
[1970-01-01T08:00:02.500+08:00]	0.0
[1970-01-01T08:00:02.600+08:00]	-2.0
[1970-01-01T08:00:02.700+08:00]	-4.0
[1970-01-01T08:00:02.800+08:00]	-6.0
[1970-01-01T08:00:02.900+08:00]	-8.0
[1970-01-01T08:00:03.000+08:00]	-10.0
[1970-01-01T08:00:03.100+08:00]	10.0
[1970-01-01T08:00:03.200+08:00]	10.0
[1970-01-01T08:00:03.300+08:00]	10.0

1970-01-01T08:00:03.400+08:00	10.0
1970-01-01T08:00:03.500+08:00	10.0
1970-01-01T08:00:03.600+08:00	10.0
1970-01-01T08:00:03.700+08:00	10.0
1970-01-01T08:00:03.800+08:00	10.0
1970-01-01T08:00:03.900+08:00	10.0

SQL for query:

```
select segment(s1, "error"="0.1") from root.test
```

Output series:

Time segment(root.test.s1, "error"="0.1")
1970-01-01T08:00:00.000+08:00 5.0
1970-01-01T08:00:00.200+08:00 1.0
1970-01-01T08:00:01.000+08:00 9.0
1970-01-01T08:00:02.000+08:00 10.0
1970-01-01T08:00:03.000+08:00 -10.0
1970-01-01T08:00:03.200+08:00 10.0

2.16 Skew

2.16.1 Usage

This function is used to calculate the population skewness.

Name: SKEW

Input Series: Only support a single input series. The type is INT32 / INT64 / FLOAT / DOUBLE.

Output Series: Output a single series. The type is DOUBLE. There is only one data point in the series, whose timestamp is 0 and value is the population skewness.

Note: Missing points, null points and NaN in the input series will be ignored.

2.16.2 Examples

Input series:

Time root.test.d1.s1
2020-01-01T00:00:00.000+08:00 1.0
2020-01-01T00:00:01.000+08:00 2.0

2020-01-01T00:00:02.000+08:00	3.0
2020-01-01T00:00:03.000+08:00	4.0
2020-01-01T00:00:04.000+08:00	5.0
2020-01-01T00:00:05.000+08:00	6.0
2020-01-01T00:00:06.000+08:00	7.0
2020-01-01T00:00:07.000+08:00	8.0
2020-01-01T00:00:08.000+08:00	9.0
2020-01-01T00:00:09.000+08:00	10.0
2020-01-01T00:00:10.000+08:00	10.0
2020-01-01T00:00:11.000+08:00	10.0
2020-01-01T00:00:12.000+08:00	10.0
2020-01-01T00:00:13.000+08:00	10.0
2020-01-01T00:00:14.000+08:00	10.0
2020-01-01T00:00:15.000+08:00	10.0
2020-01-01T00:00:16.000+08:00	10.0
2020-01-01T00:00:17.000+08:00	10.0
2020-01-01T00:00:18.000+08:00	10.0
2020-01-01T00:00:19.000+08:00	10.0
+-----+-----+	

SQL for query:

```
select skew(s1) from root.test.d1
```

Output series:

+-----+-----+	
Time	skew(root.test.d1.s1)
+-----+-----+	
1970-01-01T08:00:00.000+08:00	-0.9998427402292644
+-----+-----+	

2.17 Spline

2.17.1 Usage

This function is used to calculate cubic spline interpolation of input series.

Name: SPLINE

Input Series: Only support a single input series. The type is INT32 / INT64 / FLOAT / DOUBLE.

- **points** : Number of resampling points.

Output Series: Output a single series. The type is DOUBLE.

Note: Output series retains the first and last timestamps of input series. Interpolation points are selected at equal intervals. The function tries to calculate only when there are no less than 4 points in input series.

2.17.2 Examples

2.17.2.1 Assigning number of interpolation points

Input series:

Time root.test.s1	
[1970-01-01T08:00:00.000+08:00]	0.0
[1970-01-01T08:00:00.300+08:00]	1.2
[1970-01-01T08:00:00.500+08:00]	1.7
[1970-01-01T08:00:00.700+08:00]	2.0
[1970-01-01T08:00:00.900+08:00]	2.1
[1970-01-01T08:00:01.100+08:00]	2.0
[1970-01-01T08:00:01.200+08:00]	1.8
[1970-01-01T08:00:01.300+08:00]	1.2
[1970-01-01T08:00:01.400+08:00]	1.0
[1970-01-01T08:00:01.500+08:00]	1.6

SQL for query:

```
select spline(s1, "points"="151") from root.test
```

Output series:

Time spline(root.test.s1, "points"="151")	
[1970-01-01T08:00:00.000+08:00]	0.0
[1970-01-01T08:00:00.010+08:00]	0.04870000251134237
[1970-01-01T08:00:00.020+08:00]	0.09680000495910646
[1970-01-01T08:00:00.030+08:00]	0.14430000734329226
[1970-01-01T08:00:00.040+08:00]	0.19120000966389972
[1970-01-01T08:00:00.050+08:00]	0.23750001192092896
[1970-01-01T08:00:00.060+08:00]	0.2832000141143799
[1970-01-01T08:00:00.070+08:00]	0.32830001624425253
[1970-01-01T08:00:00.080+08:00]	0.3728000183105469
[1970-01-01T08:00:00.090+08:00]	0.416700020313263
[1970-01-01T08:00:00.100+08:00]	0.4600000222524008
[1970-01-01T08:00:00.110+08:00]	0.5027000241279602
[1970-01-01T08:00:00.120+08:00]	0.5448000259399414
[1970-01-01T08:00:00.130+08:00]	0.5863000276883443
[1970-01-01T08:00:00.140+08:00]	0.627200029373169
[1970-01-01T08:00:00.150+08:00]	0.6675000309944153
[1970-01-01T08:00:00.160+08:00]	0.7072000325520833
[1970-01-01T08:00:00.170+08:00]	0.7463000340461731
[1970-01-01T08:00:00.180+08:00]	0.7848000354766846

1970-01-01T08:00:00.190+08:00	0.8227000368436178
1970-01-01T08:00:00.200+08:00	0.8600000381469728
1970-01-01T08:00:00.210+08:00	0.8967000393867494
1970-01-01T08:00:00.220+08:00	0.9328000405629477
1970-01-01T08:00:00.230+08:00	0.9683000416755676
1970-01-01T08:00:00.240+08:00	1.0032000427246095
1970-01-01T08:00:00.250+08:00	1.037500043710073
1970-01-01T08:00:00.260+08:00	1.071200044631958
1970-01-01T08:00:00.270+08:00	1.1043000454902647
1970-01-01T08:00:00.280+08:00	1.1368000462849934
1970-01-01T08:00:00.290+08:00	1.1687000470161437
1970-01-01T08:00:00.300+08:00	1.2000000476837158
1970-01-01T08:00:00.310+08:00	1.2307000483103594
1970-01-01T08:00:00.320+08:00	1.2608000489139557
1970-01-01T08:00:00.330+08:00	1.2903000494873524
1970-01-01T08:00:00.340+08:00	1.3192000500233967
1970-01-01T08:00:00.350+08:00	1.3475000505149364
1970-01-01T08:00:00.360+08:00	1.3752000509548186
1970-01-01T08:00:00.370+08:00	1.402300051335891
1970-01-01T08:00:00.380+08:00	1.4288000516510009
1970-01-01T08:00:00.390+08:00	1.4547000518929958
1970-01-01T08:00:00.400+08:00	1.480000052054723
1970-01-01T08:00:00.410+08:00	1.5047000521290301
1970-01-01T08:00:00.420+08:00	1.5288000521087646
1970-01-01T08:00:00.430+08:00	1.5523000519867738
1970-01-01T08:00:00.440+08:00	1.575200051755905
1970-01-01T08:00:00.450+08:00	1.597500051409006
1970-01-01T08:00:00.460+08:00	1.619200050938924
1970-01-01T08:00:00.470+08:00	1.6403000503385066
1970-01-01T08:00:00.480+08:00	1.660800049600601
1970-01-01T08:00:00.490+08:00	1.680700048718055
1970-01-01T08:00:00.500+08:00	1.7000000476837158
1970-01-01T08:00:00.510+08:00	1.7188475466453037
1970-01-01T08:00:00.520+08:00	1.7373800457262996
1970-01-01T08:00:00.530+08:00	1.7555825448831923
1970-01-01T08:00:00.540+08:00	1.7734400440724702
1970-01-01T08:00:00.550+08:00	1.790937543250622
1970-01-01T08:00:00.560+08:00	1.8080600423741364
1970-01-01T08:00:00.570+08:00	1.8247925413995016
1970-01-01T08:00:00.580+08:00	1.8411200402832066
1970-01-01T08:00:00.590+08:00	1.8570275389817397
1970-01-01T08:00:00.600+08:00	1.8725000374515897
1970-01-01T08:00:00.610+08:00	1.8875225356492449
1970-01-01T08:00:00.620+08:00	1.902080033531194
1970-01-01T08:00:00.630+08:00	1.9161575310539258
1970-01-01T08:00:00.640+08:00	1.9297400281739288
1970-01-01T08:00:00.650+08:00	1.9428125248476913

1970-01-01T08:00:00.660+08:00	1.9553600210317021
1970-01-01T08:00:00.670+08:00	1.96736751668245
1970-01-01T08:00:00.680+08:00	1.9788200117564232
1970-01-01T08:00:00.690+08:00	1.9897025062101101
1970-01-01T08:00:00.700+08:00	2.0
1970-01-01T08:00:00.710+08:00	2.0097024933913334
1970-01-01T08:00:00.720+08:00	2.0188199867081615
1970-01-01T08:00:00.730+08:00	2.027367479995188
1970-01-01T08:00:00.740+08:00	2.0353599732971155
1970-01-01T08:00:00.750+08:00	2.0428124666586482
1970-01-01T08:00:00.760+08:00	2.049739960124489
1970-01-01T08:00:00.770+08:00	2.056157453739342
1970-01-01T08:00:00.780+08:00	2.06207994754791
1970-01-01T08:00:00.790+08:00	2.067522441594897
1970-01-01T08:00:00.800+08:00	2.072499935925006
1970-01-01T08:00:00.810+08:00	2.07702743058294
1970-01-01T08:00:00.820+08:00	2.081119925613404
1970-01-01T08:00:00.830+08:00	2.0847924210611
1970-01-01T08:00:00.840+08:00	2.0880599169707317
1970-01-01T08:00:00.850+08:00	2.0909374133870027
1970-01-01T08:00:00.860+08:00	2.0934399103546166
1970-01-01T08:00:00.870+08:00	2.0955824079182768
1970-01-01T08:00:00.880+08:00	2.0973799061226863
1970-01-01T08:00:00.890+08:00	2.098847405012549
1970-01-01T08:00:00.900+08:00	2.0999999046325684
1970-01-01T08:00:00.910+08:00	2.1005574051201332
1970-01-01T08:00:00.920+08:00	2.1002599065303778
1970-01-01T08:00:00.930+08:00	2.0991524087846245
1970-01-01T08:00:00.940+08:00	2.0972799118041947
1970-01-01T08:00:00.950+08:00	2.0946874155104105
1970-01-01T08:00:00.960+08:00	2.0914199198245944
1970-01-01T08:00:00.970+08:00	2.0875224246680673
1970-01-01T08:00:00.980+08:00	2.083039929962151
1970-01-01T08:00:00.990+08:00	2.0780174356281687
1970-01-01T08:00:01.000+08:00	2.0724999415874406
1970-01-01T08:00:01.010+08:00	2.06653244776129
1970-01-01T08:00:01.020+08:00	2.060159954071038
1970-01-01T08:00:01.030+08:00	2.053427460438006
1970-01-01T08:00:01.040+08:00	2.046379966783517
1970-01-01T08:00:01.050+08:00	2.0390624730288924
1970-01-01T08:00:01.060+08:00	2.031519979095454
1970-01-01T08:00:01.070+08:00	2.0237974849045237
1970-01-01T08:00:01.080+08:00	2.015939990377423
1970-01-01T08:00:01.090+08:00	2.0079924954354746
1970-01-01T08:00:01.100+08:00	2.0
1970-01-01T08:00:01.110+08:00	1.9907018211101906
1970-01-01T08:00:01.120+08:00	1.9788509124245144

1970-01-01T08:00:01.130+08:00	1.9645127287932083
1970-01-01T08:00:01.140+08:00	1.9477527250665083
1970-01-01T08:00:01.150+08:00	1.9286363560946513
1970-01-01T08:00:01.160+08:00	1.9072290767278735
1970-01-01T08:00:01.170+08:00	1.8835963418164114
1970-01-01T08:00:01.180+08:00	1.8578036062105014
1970-01-01T08:00:01.190+08:00	1.8299163247603802
1970-01-01T08:00:01.200+08:00	1.7999999523162842
1970-01-01T08:00:01.210+08:00	1.7623635841923329
1970-01-01T08:00:01.220+08:00	1.7129696477516976
1970-01-01T08:00:01.230+08:00	1.6543635959181928
1970-01-01T08:00:01.240+08:00	1.5890908816156328
1970-01-01T08:00:01.250+08:00	1.5196969577678319
1970-01-01T08:00:01.260+08:00	1.4487272772986044
1970-01-01T08:00:01.270+08:00	1.3787272931317647
1970-01-01T08:00:01.280+08:00	1.3122424581911272
1970-01-01T08:00:01.290+08:00	1.251818225400506
1970-01-01T08:00:01.300+08:00	1.2000000476837158
1970-01-01T08:00:01.310+08:00	1.1548000470995912
1970-01-01T08:00:01.320+08:00	1.1130667107899999
1970-01-01T08:00:01.330+08:00	1.0756000393033045
1970-01-01T08:00:01.340+08:00	1.043200033187868
1970-01-01T08:00:01.350+08:00	1.016666692992053
1970-01-01T08:00:01.360+08:00	0.9968000192642223
1970-01-01T08:00:01.370+08:00	0.9844000125527389
1970-01-01T08:00:01.380+08:00	0.9802666734059655
1970-01-01T08:00:01.390+08:00	0.9852000023722649
1970-01-01T08:00:01.400+08:00	1.0
1970-01-01T08:00:01.410+08:00	1.023999999165535
1970-01-01T08:00:01.420+08:00	1.0559999990463256
1970-01-01T08:00:01.430+08:00	1.0959999996423722
1970-01-01T08:00:01.440+08:00	1.1440000009536744
1970-01-01T08:00:01.450+08:00	1.2000000029802322
1970-01-01T08:00:01.460+08:00	1.264000005722046
1970-01-01T08:00:01.470+08:00	1.3360000091791153
1970-01-01T08:00:01.480+08:00	1.4160000133514405
1970-01-01T08:00:01.490+08:00	1.5040000182390214
1970-01-01T08:00:01.500+08:00	1.600000023841858

+

2.18 Spread

2.18.1 Usage

This function is used to calculate the spread of time series, that is, the maximum value minus the minimum value.

Name: SPREAD

Input Series: Only support a single input series. The type is INT32 / INT64 / FLOAT / DOUBLE.

Output Series: Output a single series. The type is the same as the input. There is only one data point in the series, whose timestamp is 0 and value is the spread.

Note: Missing points, null points and NaN in the input series will be ignored.

2.18.2 Examples

Input series:

Time	root.test.d1.s1
[2020-01-01T00:00:02.000+08:00]	100.0
[2020-01-01T00:00:03.000+08:00]	101.0
[2020-01-01T00:00:04.000+08:00]	102.0
[2020-01-01T00:00:06.000+08:00]	104.0
[2020-01-01T00:00:08.000+08:00]	126.0
[2020-01-01T00:00:10.000+08:00]	108.0
[2020-01-01T00:00:14.000+08:00]	112.0
[2020-01-01T00:00:15.000+08:00]	113.0
[2020-01-01T00:00:16.000+08:00]	114.0
[2020-01-01T00:00:18.000+08:00]	116.0
[2020-01-01T00:00:20.000+08:00]	118.0
[2020-01-01T00:00:22.000+08:00]	120.0
[2020-01-01T00:00:26.000+08:00]	124.0
[2020-01-01T00:00:28.000+08:00]	126.0
[2020-01-01T00:00:30.000+08:00]	NaN

SQL for query:

```
select spread(s1) from root.test.d1 where time <= 2020-01-01 00:00:30
```

Output series:

Time	spread(root.test.d1.s1)
[1970-01-01T08:00:00.000+08:00]	26.0

2.19 Stddev

2.19.1 Usage

This function is used to calculate the population standard deviation.

Name: STDDEV

Input Series: Only support a single input series. The type is INT32 / INT64 / FLOAT / DOUBLE.

Output Series: Output a single series. The type is DOUBLE. There is only one data point in the series, whose timestamp is 0 and value is the population standard deviation.

Note: Missing points, null points and NaN in the input series will be ignored.

2.19.2 Examples

Input series:

Time	root.test.d1.s1
[2020-01-01T00:00:00.000+08:00]	1.0
[2020-01-01T00:00:01.000+08:00]	2.0
[2020-01-01T00:00:02.000+08:00]	3.0
[2020-01-01T00:00:03.000+08:00]	4.0
[2020-01-01T00:00:04.000+08:00]	5.0
[2020-01-01T00:00:05.000+08:00]	6.0
[2020-01-01T00:00:06.000+08:00]	7.0
[2020-01-01T00:00:07.000+08:00]	8.0
[2020-01-01T00:00:08.000+08:00]	9.0
[2020-01-01T00:00:09.000+08:00]	10.0
[2020-01-01T00:00:10.000+08:00]	11.0
[2020-01-01T00:00:11.000+08:00]	12.0
[2020-01-01T00:00:12.000+08:00]	13.0
[2020-01-01T00:00:13.000+08:00]	14.0
[2020-01-01T00:00:14.000+08:00]	15.0
[2020-01-01T00:00:15.000+08:00]	16.0
[2020-01-01T00:00:16.000+08:00]	17.0
[2020-01-01T00:00:17.000+08:00]	18.0
[2020-01-01T00:00:18.000+08:00]	19.0
[2020-01-01T00:00:19.000+08:00]	20.0

SQL for query:

```
select stddev(s1) from root.test.d1
```

Output series:

Time	stddev(root.test.d1.s1)
[1970-01-01T08:00:00.000+08:00]	5.7662812973353965

2.20 TimeWeightedAvg

2.20.1 Usage

This function is used to calculate the time-weighted average of time series. Time is weighted using the linearly interpolated integral of values, and the output equals to the area divided by the time interval using the same time **unit**. For more information of the area under the curve, please refer to **Integral** function.

Name: TIMEWEIGHTEDAVG

Input Series: Only support a single input numeric series. The type is INT32 / INT64 / FLOAT / DOUBLE.

Output Series: Output a single series. The type is DOUBLE. There is only one data point in the series, whose timestamp is 0 and value is the time-weighted average.

Note:

- The time-weighted value equals to the integral value with any **unit** divided by the time interval of input series.

The result is irrelevant to the time unit used in integral, and it's consistent with the timestamp precision of IoTDB by default.

- **NaN** values in the input series will be ignored. The curve or trapezoids will skip these points and use the next valid point.
- If the input series is empty, the output value will be 0.0, but if there is only one data point, the value will equal to the input value.

2.20.2 Examples

Input series:

Time	root.test.d1.s1
[2020-01-01T00:00:01.000+08:00]	1
[2020-01-01T00:00:02.000+08:00]	2

2020-01-01T00:00:03.000+08:00	5
2020-01-01T00:00:04.000+08:00	6
2020-01-01T00:00:05.000+08:00	7
2020-01-01T00:00:08.000+08:00	8
2020-01-01T00:00:09.000+08:00	NaN
2020-01-01T00:00:10.000+08:00	10
+-----+-----+	

SQL for query:

```
select timeweightdavg(s1) from root.test.d1 where time <= 2020-01-01 00:00:10
```

Output series:

+-----+-----+	
	Time timeweightdavg(root.test.d1.s1)
+-----+-----+	
1970-01-01T08:00:00.000+08:00	5.75
+-----+-----+	

Calculation expression:

$$\frac{1}{2}[(1+2) \times 1 + (2+5) \times 1 + (5+6) \times 1 + (6+7) \times 1 + (7+8) \times 3 + (8+10) \times 2] / 10 = 5.75$$

2.21 ZScore

2.21.1 Usage

This function is used to standardize the input series with z-score.

Name: ZSCORE

Input Series: Only support a single input series. The type is INT32 / INT64 / FLOAT / DOUBLE.

- **method**: When set to "batch", anomaly test is conducted after importing all data points; when set to "stream", it is required to provide mean and standard deviation. The default method is "batch".
- **avg**: Mean value when method is set to "stream".
- **sd**: Standard deviation when method is set to "stream".

Output Series: Output a single series. The type is DOUBLE.

2.21.2 Examples

2.21.2.1 Batch computing

Input series:

Time root.test.s1	
[1970-01-01T08:00:00.100+08:00]	0.0
[1970-01-01T08:00:00.200+08:00]	0.0
[1970-01-01T08:00:00.300+08:00]	1.0
[1970-01-01T08:00:00.400+08:00]	-1.0
[1970-01-01T08:00:00.500+08:00]	0.0
[1970-01-01T08:00:00.600+08:00]	0.0
[1970-01-01T08:00:00.700+08:00]	-2.0
[1970-01-01T08:00:00.800+08:00]	2.0
[1970-01-01T08:00:00.900+08:00]	0.0
[1970-01-01T08:00:01.000+08:00]	0.0
[1970-01-01T08:00:01.100+08:00]	1.0
[1970-01-01T08:00:01.200+08:00]	-1.0
[1970-01-01T08:00:01.300+08:00]	-1.0
[1970-01-01T08:00:01.400+08:00]	1.0
[1970-01-01T08:00:01.500+08:00]	0.0
[1970-01-01T08:00:01.600+08:00]	0.0
[1970-01-01T08:00:01.700+08:00]	10.0
[1970-01-01T08:00:01.800+08:00]	2.0
[1970-01-01T08:00:01.900+08:00]	-2.0
[1970-01-01T08:00:02.000+08:00]	0.0

SQL for query:

```
select zscore(s1) from root.test
```

Output series:

Time zscore(root.test.s1	
[1970-01-01T08:00:00.100+08:00]	-0.20672455764868078
[1970-01-01T08:00:00.200+08:00]	-0.20672455764868078
[1970-01-01T08:00:00.300+08:00]	0.20672455764868078
[1970-01-01T08:00:00.400+08:00]	-0.6201736729460423
[1970-01-01T08:00:00.500+08:00]	-0.20672455764868078
[1970-01-01T08:00:00.600+08:00]	-0.20672455764868078
[1970-01-01T08:00:00.700+08:00]	-1.033622788243404
[1970-01-01T08:00:00.800+08:00]	0.6201736729460423
[1970-01-01T08:00:00.900+08:00]	-0.20672455764868078
[1970-01-01T08:00:01.000+08:00]	-0.20672455764868078
[1970-01-01T08:00:01.100+08:00]	0.20672455764868078
[1970-01-01T08:00:01.200+08:00]	-0.6201736729460423
[1970-01-01T08:00:01.300+08:00]	-0.6201736729460423
[1970-01-01T08:00:01.400+08:00]	0.20672455764868078


```
|1970-01-01T08:00:01.500+08:00|-0.20672455764868078|  
|1970-01-01T08:00:01.600+08:00|-0.20672455764868078|  
|1970-01-01T08:00:01.700+08:00| 3.9277665953249348|  
|1970-01-01T08:00:01.800+08:00| 0.6201736729460423|  
|1970-01-01T08:00:01.900+08:00| -1.033622788243404|  
|1970-01-01T08:00:02.000+08:00|-0.20672455764868078|
```

+-----+-----+

Chapter 3 Data Quality

3.1 Completeness

3.1.1 Usage

This function is used to calculate the completeness of time series. The input series are divided into several continuous and non overlapping windows. The timestamp of the first data point and the completeness of each window will be output.

Name: COMPLETENESS

Input Series: Only support a single input series. The type is INT32 / INT64 / FLOAT / DOUBLE.

Parameters:

- **window** : The size of each window. It is a positive integer or a positive number with an unit. The former is the number of data points in each window. The number of data points in the last window may be less than it. The latter is the time of the window. The unit is 'ms' for millisecond, 's' for second, 'm' for minute, 'h' for hour and 'd' for day. By default, all input data belongs to the same window.
- **downtime** : Whether the downtime exception is considered in the calculation of completeness. It is 'true' or 'false' (default). When considering the downtime exception, long-term missing data will be considered as downtime exception without any influence on completeness.

Output Series: Output a single series. The type is DOUBLE. The range of each value is [0,1].

Note: Only when the number of data points in the window exceeds 10, the calculation will be performed. Otherwise, the window will be ignored and nothing will be output.

3.1.2 Examples

3.1.2.1 Default Parameters

With default parameters, this function will regard all input data as the same window.

Input series:

Time root.test.d1.s1	
2020-01-01T00:00:02.000+08:00	100.0
2020-01-01T00:00:03.000+08:00	101.0
2020-01-01T00:00:04.000+08:00	102.0
2020-01-01T00:00:06.000+08:00	104.0

2020-01-01T00:00:08.000+08:00	126.0
2020-01-01T00:00:10.000+08:00	108.0
2020-01-01T00:00:14.000+08:00	112.0
2020-01-01T00:00:15.000+08:00	113.0
2020-01-01T00:00:16.000+08:00	114.0
2020-01-01T00:00:18.000+08:00	116.0
2020-01-01T00:00:20.000+08:00	118.0
2020-01-01T00:00:22.000+08:00	120.0
2020-01-01T00:00:26.000+08:00	124.0
2020-01-01T00:00:28.000+08:00	126.0
2020-01-01T00:00:30.000+08:00	NaN
+-----+-----+	

SQL for query:

```
select completeness(s1) from root.test.d1 where time <= 2020-01-01 00:00:30
```

Output series:

+-----+-----+	
	Time completeness(root.test.d1.s1)
+-----+-----+	
2020-01-01T00:00:02.000+08:00	0.875
+-----+-----+	

3.1.2.2 Specific Window Size

When the window size is given, this function will divide the input data as multiple windows.

Input series:

+-----+-----+	
	Time root.test.d1.s1
+-----+-----+	
2020-01-01T00:00:02.000+08:00	100.0
2020-01-01T00:00:03.000+08:00	101.0
2020-01-01T00:00:04.000+08:00	102.0
2020-01-01T00:00:06.000+08:00	104.0
2020-01-01T00:00:08.000+08:00	126.0
2020-01-01T00:00:10.000+08:00	108.0
2020-01-01T00:00:14.000+08:00	112.0
2020-01-01T00:00:15.000+08:00	113.0
2020-01-01T00:00:16.000+08:00	114.0
2020-01-01T00:00:18.000+08:00	116.0
2020-01-01T00:00:20.000+08:00	118.0
2020-01-01T00:00:22.000+08:00	120.0
2020-01-01T00:00:26.000+08:00	124.0
2020-01-01T00:00:28.000+08:00	126.0
2020-01-01T00:00:30.000+08:00	NaN

[2020-01-01T00:00:32.000+08:00]	130.0
[2020-01-01T00:00:34.000+08:00]	132.0
[2020-01-01T00:00:36.000+08:00]	134.0
[2020-01-01T00:00:38.000+08:00]	136.0
[2020-01-01T00:00:40.000+08:00]	138.0
[2020-01-01T00:00:42.000+08:00]	140.0
[2020-01-01T00:00:44.000+08:00]	142.0
[2020-01-01T00:00:46.000+08:00]	144.0
[2020-01-01T00:00:48.000+08:00]	146.0
[2020-01-01T00:00:50.000+08:00]	148.0
[2020-01-01T00:00:52.000+08:00]	150.0
[2020-01-01T00:00:54.000+08:00]	152.0
[2020-01-01T00:00:56.000+08:00]	154.0
[2020-01-01T00:00:58.000+08:00]	156.0
[2020-01-01T00:01:00.000+08:00]	158.0
+-----+-----+	

SQL for query:

```
select completeness(s1, "window"="15") from root.test.d1 where time <= 2020-01-01 00:01:00
```

Output series:

+-----+-----+	
	Time completeness(root.test.d1.s1, "window"="15")
+-----+-----+	
[2020-01-01T00:00:02.000+08:00]	0.875
[2020-01-01T00:00:32.000+08:00]	1.0
+-----+-----+	

3.2 Consistency

3.2.1 Usage

This function is used to calculate the consistency of time series. The input series are divided into several continuous and non overlapping windows. The timestamp of the first data point and the consistency of each window will be output.

Name: CONSISTENCY

Input Series: Only support a single input series. The type is INT32 / INT64 / FLOAT / DOUBLE.

Parameters:

- **window**: The size of each window. It is a positive integer or a positive number with an unit. The former is the number of data points in each window. The number of data points in the last window may be less than it. The latter is the time of the window. The unit is

'ms' for millisecond, 's' for second, 'm' for minute, 'h' for hour and 'd' for day. By default, all input data belongs to the same window.

Output Series: Output a single series. The type is DOUBLE. The range of each value is [0,1].

Note: Only when the number of data points in the window exceeds 10, the calculation will be performed. Otherwise, the window will be ignored and nothing will be output.

3.2.2 Examples

3.2.2.1 Default Parameters

With default parameters, this function will regard all input data as the same window.

Input series:

Time root.test.d1.s1	
[2020-01-01T00:00:02.000+08:00]	100.0
[2020-01-01T00:00:03.000+08:00]	101.0
[2020-01-01T00:00:04.000+08:00]	102.0
[2020-01-01T00:00:06.000+08:00]	104.0
[2020-01-01T00:00:08.000+08:00]	126.0
[2020-01-01T00:00:10.000+08:00]	108.0
[2020-01-01T00:00:14.000+08:00]	112.0
[2020-01-01T00:00:15.000+08:00]	113.0
[2020-01-01T00:00:16.000+08:00]	114.0
[2020-01-01T00:00:18.000+08:00]	116.0
[2020-01-01T00:00:20.000+08:00]	118.0
[2020-01-01T00:00:22.000+08:00]	120.0
[2020-01-01T00:00:26.000+08:00]	124.0
[2020-01-01T00:00:28.000+08:00]	126.0
[2020-01-01T00:00:30.000+08:00]	NaN

SQL for query:

```
select consistency(s1) from root.test.d1 where time <= 2020-01-01 00:00:30
```

Output series:

Time consistency(root.test.d1.s1)	
[2020-01-01T00:00:02.000+08:00]	0.9333333333333333

3.2.2.2 Specific Window Size

When the window size is given, this function will divide the input data as multiple windows.

Input series:

Time	root.test.d1.s1
[2020-01-01T00:00:02.000+08:00]	100.0
[2020-01-01T00:00:03.000+08:00]	101.0
[2020-01-01T00:00:04.000+08:00]	102.0
[2020-01-01T00:00:06.000+08:00]	104.0
[2020-01-01T00:00:08.000+08:00]	126.0
[2020-01-01T00:00:10.000+08:00]	108.0
[2020-01-01T00:00:14.000+08:00]	112.0
[2020-01-01T00:00:15.000+08:00]	113.0
[2020-01-01T00:00:16.000+08:00]	114.0
[2020-01-01T00:00:18.000+08:00]	116.0
[2020-01-01T00:00:20.000+08:00]	118.0
[2020-01-01T00:00:22.000+08:00]	120.0
[2020-01-01T00:00:26.000+08:00]	124.0
[2020-01-01T00:00:28.000+08:00]	126.0
[2020-01-01T00:00:30.000+08:00]	NaN
[2020-01-01T00:00:32.000+08:00]	130.0
[2020-01-01T00:00:34.000+08:00]	132.0
[2020-01-01T00:00:36.000+08:00]	134.0
[2020-01-01T00:00:38.000+08:00]	136.0
[2020-01-01T00:00:40.000+08:00]	138.0
[2020-01-01T00:00:42.000+08:00]	140.0
[2020-01-01T00:00:44.000+08:00]	142.0
[2020-01-01T00:00:46.000+08:00]	144.0
[2020-01-01T00:00:48.000+08:00]	146.0
[2020-01-01T00:00:50.000+08:00]	148.0
[2020-01-01T00:00:52.000+08:00]	150.0
[2020-01-01T00:00:54.000+08:00]	152.0
[2020-01-01T00:00:56.000+08:00]	154.0
[2020-01-01T00:00:58.000+08:00]	156.0
[2020-01-01T00:01:00.000+08:00]	158.0

SQL for query:

```
select consistency(s1,"window"="15") from root.test.d1 where time <= 2020-01-01 00:01:00
```

Output series:

Time	consistency(root.test.d1.s1, "window"="15")
------	---

[2020-01-01T00:00:02.000+08:00]	0.9333333333333333
[2020-01-01T00:00:32.000+08:00]	1.0

3.3 Timeliness

3.3.1 Usage

This function is used to calculate the timeliness of time series. The input series are divided into several continuous and non overlapping windows. The timestamp of the first data point and the timeliness of each window will be output.

Name: TIMELINESS

Input Series: Only support a single input series. The type is INT32 / INT64 / FLOAT / DOUBLE.

Parameters:

- **window**: The size of each window. It is a positive integer or a positive number with an unit. The former is the number of data points in each window. The number of data points in the last window may be less than it. The latter is the time of the window. The unit is 'ms' for millisecond, 's' for second, 'm' for minute, 'h' for hour and 'd' for day. By default, all input data belongs to the same window.

Output Series: Output a single series. The type is DOUBLE. The range of each value is [0,1].

Note: Only when the number of data points in the window exceeds 10, the calculation will be performed. Otherwise, the window will be ignored and nothing will be output.

3.3.2 Examples

3.3.2.1 Default Parameters

With default parameters, this function will regard all input data as the same window.

Input series:

Time root.test.d1.s1	
[2020-01-01T00:00:02.000+08:00]	100.0
[2020-01-01T00:00:03.000+08:00]	101.0
[2020-01-01T00:00:04.000+08:00]	102.0
[2020-01-01T00:00:06.000+08:00]	104.0
[2020-01-01T00:00:08.000+08:00]	126.0
[2020-01-01T00:00:10.000+08:00]	108.0
[2020-01-01T00:00:14.000+08:00]	112.0
[2020-01-01T00:00:15.000+08:00]	113.0

2020-01-01T00:00:16.000+08:00	114.0
2020-01-01T00:00:18.000+08:00	116.0
2020-01-01T00:00:20.000+08:00	118.0
2020-01-01T00:00:22.000+08:00	120.0
2020-01-01T00:00:26.000+08:00	124.0
2020-01-01T00:00:28.000+08:00	126.0
2020-01-01T00:00:30.000+08:00	NaN
+-----+-----+	

SQL for query:

```
select timeliness(s1) from root.test.d1 where time <= 2020-01-01 00:00:30
```

Output series:

+-----+-----+	
	Time timeliness(root.test.d1.s1)
+-----+-----+	
2020-01-01T00:00:02.000+08:00	0.9333333333333333
+-----+-----+	

3.3.2.2 Specific Window Size

When the window size is given, this function will divide the input data as multiple windows.

Input series:

+-----+-----+	
	Time root.test.d1.s1
+-----+-----+	
2020-01-01T00:00:02.000+08:00	100.0
2020-01-01T00:00:03.000+08:00	101.0
2020-01-01T00:00:04.000+08:00	102.0
2020-01-01T00:00:06.000+08:00	104.0
2020-01-01T00:00:08.000+08:00	126.0
2020-01-01T00:00:10.000+08:00	108.0
2020-01-01T00:00:14.000+08:00	112.0
2020-01-01T00:00:15.000+08:00	113.0
2020-01-01T00:00:16.000+08:00	114.0
2020-01-01T00:00:18.000+08:00	116.0
2020-01-01T00:00:20.000+08:00	118.0
2020-01-01T00:00:22.000+08:00	120.0
2020-01-01T00:00:26.000+08:00	124.0
2020-01-01T00:00:28.000+08:00	126.0
2020-01-01T00:00:30.000+08:00	NaN
2020-01-01T00:00:32.000+08:00	130.0
2020-01-01T00:00:34.000+08:00	132.0
2020-01-01T00:00:36.000+08:00	134.0
2020-01-01T00:00:38.000+08:00	136.0

[2020-01-01T00:00:40.000+08:00]	138.0
[2020-01-01T00:00:42.000+08:00]	140.0
[2020-01-01T00:00:44.000+08:00]	142.0
[2020-01-01T00:00:46.000+08:00]	144.0
[2020-01-01T00:00:48.000+08:00]	146.0
[2020-01-01T00:00:50.000+08:00]	148.0
[2020-01-01T00:00:52.000+08:00]	150.0
[2020-01-01T00:00:54.000+08:00]	152.0
[2020-01-01T00:00:56.000+08:00]	154.0
[2020-01-01T00:00:58.000+08:00]	156.0
[2020-01-01T00:01:00.000+08:00]	158.0
+-----+-----+	

SQL for query:

```
select timeliness(s1,"window"="15") from root.test.d1 where time <= 2020-01-01 00:01:00
```

Output series:

+-----+-----+	
	Time timeliness(root.test.d1.s1, "window"="15")
+-----+-----+	
[2020-01-01T00:00:02.000+08:00]	0.9333333333333333
[2020-01-01T00:00:32.000+08:00]	1.0
+-----+-----+	

3.4 Validity

3.4.1 Usage

This function is used to calculate the Validity of time series. The input series are divided into several continuous and non overlapping windows. The timestamp of the first data point and the Validity of each window will be output.

Name: VALIDITY

Input Series: Only support a single input series. The type is INT32 / INT64 / FLOAT / DOUBLE.

Parameters:

- **window**: The size of each window. It is a positive integer or a positive number with an unit. The former is the number of data points in each window. The number of data points in the last window may be less than it. The latter is the time of the window. The unit is 'ms' for millisecond, 's' for second, 'm' for minute, 'h' for hour and 'd' for day. By default, all input data belongs to the same window.

Output Series: Output a single series. The type is DOUBLE. The range of each value is [0,1].

Note: Only when the number of data points in the window exceeds 10, the calculation will be performed. Otherwise, the window will be ignored and nothing will be output.

3.4.2 Examples

3.4.2.1 Default Parameters

With default parameters, this function will regard all input data as the same window.

Input series:

Time	root.test.d1.s1
[2020-01-01T00:00:02.000+08:00]	100.0]
[2020-01-01T00:00:03.000+08:00]	101.0]
[2020-01-01T00:00:04.000+08:00]	102.0]
[2020-01-01T00:00:06.000+08:00]	104.0]
[2020-01-01T00:00:08.000+08:00]	126.0]
[2020-01-01T00:00:10.000+08:00]	108.0]
[2020-01-01T00:00:14.000+08:00]	112.0]
[2020-01-01T00:00:15.000+08:00]	113.0]
[2020-01-01T00:00:16.000+08:00]	114.0]
[2020-01-01T00:00:18.000+08:00]	116.0]
[2020-01-01T00:00:20.000+08:00]	118.0]
[2020-01-01T00:00:22.000+08:00]	120.0]
[2020-01-01T00:00:26.000+08:00]	124.0]
[2020-01-01T00:00:28.000+08:00]	126.0]
[2020-01-01T00:00:30.000+08:00]	NaN]

SQL for query:

```
select Validity(s1) from root.test.d1 where time <= 2020-01-01 00:00:30
```

Output series:

Time	validity(root.test.d1.s1)
[2020-01-01T00:00:02.000+08:00]	0.8833333333333333]

3.4.2.2 Specific Window Size

When the window size is given, this function will divide the input data as multiple windows.

Input series:

Time	
------	--

Time	root.test.d1.s1
[2020-01-01T00:00:02.000+08:00]	100.0]
[2020-01-01T00:00:03.000+08:00]	101.0]
[2020-01-01T00:00:04.000+08:00]	102.0]
[2020-01-01T00:00:06.000+08:00]	104.0]
[2020-01-01T00:00:08.000+08:00]	126.0]
[2020-01-01T00:00:10.000+08:00]	108.0]
[2020-01-01T00:00:14.000+08:00]	112.0]
[2020-01-01T00:00:15.000+08:00]	113.0]
[2020-01-01T00:00:16.000+08:00]	114.0]
[2020-01-01T00:00:18.000+08:00]	116.0]
[2020-01-01T00:00:20.000+08:00]	118.0]
[2020-01-01T00:00:22.000+08:00]	120.0]
[2020-01-01T00:00:26.000+08:00]	124.0]
[2020-01-01T00:00:28.000+08:00]	126.0]
[2020-01-01T00:00:30.000+08:00]	NaN]
[2020-01-01T00:00:32.000+08:00]	130.0]
[2020-01-01T00:00:34.000+08:00]	132.0]
[2020-01-01T00:00:36.000+08:00]	134.0]
[2020-01-01T00:00:38.000+08:00]	136.0]
[2020-01-01T00:00:40.000+08:00]	138.0]
[2020-01-01T00:00:42.000+08:00]	140.0]
[2020-01-01T00:00:44.000+08:00]	142.0]
[2020-01-01T00:00:46.000+08:00]	144.0]
[2020-01-01T00:00:48.000+08:00]	146.0]
[2020-01-01T00:00:50.000+08:00]	148.0]
[2020-01-01T00:00:52.000+08:00]	150.0]
[2020-01-01T00:00:54.000+08:00]	152.0]
[2020-01-01T00:00:56.000+08:00]	154.0]
[2020-01-01T00:00:58.000+08:00]	156.0]
[2020-01-01T00:01:00.000+08:00]	158.0]

SQL for query:

```
select Validity(s1,"window"="15") from root.test.d1 where time <= 2020-01-01 00:01:00
```

Output series:

Time	validity (root.test.d1.s1, "window"="15")
[2020-01-01T00:00:02.000+08:00]	0.8833333333333333]
[2020-01-01T00:00:32.000+08:00]	1.0]

Chapter 4 Data Repairing

4.1 ValueFill

4.1.1 Usage

This function is used to impute time series. Several methods are supported.

Name: ValueFill **Input Series:** Only support a single input series. The type is INT32 / INT64 / FLOAT / DOUBLE.

Parameters:

- **method**: {"mean", "previous", "linear", "likelihood", "AR", "MA", "SCREEN"}, default "linear".

Method to use for imputation in series. "mean": use global mean value to fill holes; "previous": propagate last valid observation forward to next valid. "linear": simplest interpolation method; "likelihood": Maximum likelihood estimation based on the normal distribution of speed; "AR": auto regression; "MA": moving average; "SCREEN": speed constraint.

Output Series: Output a single series. The type is the same as the input. This series is the input after repairing.

4.1.2 Examples

4.1.2.1 Fill with linear

When **method** is "linear" or the default, Screen method is used to impute.

Input series:

	Time root.test.d2.s1
[2020-01-01T00:00:02.000+08:00]	NaN
[2020-01-01T00:00:03.000+08:00]	101.0
[2020-01-01T00:00:04.000+08:00]	102.0
[2020-01-01T00:00:06.000+08:00]	104.0
[2020-01-01T00:00:08.000+08:00]	126.0
[2020-01-01T00:00:10.000+08:00]	108.0
[2020-01-01T00:00:14.000+08:00]	NaN
[2020-01-01T00:00:15.000+08:00]	113.0
[2020-01-01T00:00:16.000+08:00]	114.0
[2020-01-01T00:00:18.000+08:00]	116.0
[2020-01-01T00:00:20.000+08:00]	NaN
[2020-01-01T00:00:22.000+08:00]	NaN
[2020-01-01T00:00:26.000+08:00]	124.0
[2020-01-01T00:00:28.000+08:00]	126.0

Time	valuefill(root.test.d2)
[2020-01-01T00:00:30.000+08:00]	128.0

SQL for query:

```
select valuefill(s1) from root.test.d2
```

Output series:

Time	valuefill(root.test.d2)
[2020-01-01T00:00:02.000+08:00]	NaN
[2020-01-01T00:00:03.000+08:00]	101.0
[2020-01-01T00:00:04.000+08:00]	102.0
[2020-01-01T00:00:06.000+08:00]	104.0
[2020-01-01T00:00:08.000+08:00]	126.0
[2020-01-01T00:00:10.000+08:00]	108.0
[2020-01-01T00:00:14.000+08:00]	108.0
[2020-01-01T00:00:15.000+08:00]	113.0
[2020-01-01T00:00:16.000+08:00]	114.0
[2020-01-01T00:00:18.000+08:00]	116.0
[2020-01-01T00:00:20.000+08:00]	118.7
[2020-01-01T00:00:22.000+08:00]	121.3
[2020-01-01T00:00:26.000+08:00]	124.0
[2020-01-01T00:00:28.000+08:00]	126.0
[2020-01-01T00:00:30.000+08:00]	128.0

4.1.2.2 Previous Fill

When `method` is "previous", previous method is used.

Input series is the same as above, the SQL for query is shown below

```
select valuefill(s1,"method"="previous") from root.test.d2
```

Output series:

Time	valuefill(root.test.d2,"method"="previous")
[2020-01-01T00:00:02.000+08:00]	NaN
[2020-01-01T00:00:03.000+08:00]	101.0
[2020-01-01T00:00:04.000+08:00]	102.0
[2020-01-01T00:00:06.000+08:00]	104.0
[2020-01-01T00:00:08.000+08:00]	126.0
[2020-01-01T00:00:10.000+08:00]	108.0
[2020-01-01T00:00:14.000+08:00]	110.5
[2020-01-01T00:00:15.000+08:00]	113.0

[2020-01-01T00:00:16.000+08:00]	114.0
[2020-01-01T00:00:18.000+08:00]	116.0
[2020-01-01T00:00:20.000+08:00]	116.0
[2020-01-01T00:00:22.000+08:00]	116.0
[2020-01-01T00:00:26.000+08:00]	124.0
[2020-01-01T00:00:28.000+08:00]	126.0
[2020-01-01T00:00:30.000+08:00]	128.0

4.2 TimestampRepair

This function is used for timestamp repair. According to the given standard time interval, the method of minimizing the repair cost is adopted. By fine-tuning the timestamps, the original data with unstable timestamp interval is repaired to strictly equispaced data. If no standard time interval is given, this function will use the **median**, **mode** or **cluster** of the time interval to estimate the standard time interval.

Name: TIMESTAMPREPAIR

Input Series: Only support a single input series. The data type is INT32 / INT64 / FLOAT / DOUBLE.

Parameters:

- **interval** : The standard time interval whose unit is millisecond. It is a positive integer. By default, it will be estimated according to the given method.
- **method** : The method to estimate the standard time interval, which is 'median', 'mode' or 'cluster'. This parameter is only valid when **interval** is not given. By default, median will be used.

Output Series: Output a single series. The type is the same as the input. This series is the input after repairing.

4.2.1 Examples

4.2.1.1 Manually Specify the Standard Time Interval

When **interval** is given, this function repairs according to the given standard time interval.

Input series:

Time root.test.d2.s1	
[2021-07-01T12:00:00.000+08:00]	1.0
[2021-07-01T12:00:10.000+08:00]	2.0
[2021-07-01T12:00:19.000+08:00]	3.0
[2021-07-01T12:00:30.000+08:00]	4.0
[2021-07-01T12:00:40.000+08:00]	5.0

[2021-07-01T12:00:50.000+08:00]	6.0
[2021-07-01T12:01:01.000+08:00]	7.0
[2021-07-01T12:01:11.000+08:00]	8.0
[2021-07-01T12:01:21.000+08:00]	9.0
[2021-07-01T12:01:31.000+08:00]	10.0
+-----+-----+	

SQL for query:

```
select timestamprepair(s1, 'interval'='10000') from root.test.d2
```

Output series:

Time timestamprepair(root.test.d2.s1, "interval"="10000")	
+-----+-----+	
[2021-07-01T12:00:00.000+08:00]	1.0
[2021-07-01T12:00:10.000+08:00]	2.0
[2021-07-01T12:00:20.000+08:00]	3.0
[2021-07-01T12:00:30.000+08:00]	4.0
[2021-07-01T12:00:40.000+08:00]	5.0
[2021-07-01T12:00:50.000+08:00]	6.0
[2021-07-01T12:01:00.000+08:00]	7.0
[2021-07-01T12:01:10.000+08:00]	8.0
[2021-07-01T12:01:20.000+08:00]	9.0
[2021-07-01T12:01:30.000+08:00]	10.0
+-----+-----+	

4.2.1.2 Automatically Estimate the Standard Time Interval

When `interval` is default, this function estimates the standard time interval.

Input series is the same as above, the SQL for query is shown below:

```
select timestamprepair(s1) from root.test.d2
```

Output series:

Time timestamprepair(root.test.d2.s1)	
+-----+-----+	
[2021-07-01T12:00:00.000+08:00]	1.0
[2021-07-01T12:00:10.000+08:00]	2.0
[2021-07-01T12:00:20.000+08:00]	3.0
[2021-07-01T12:00:30.000+08:00]	4.0
[2021-07-01T12:00:40.000+08:00]	5.0
[2021-07-01T12:00:50.000+08:00]	6.0
[2021-07-01T12:01:00.000+08:00]	7.0
[2021-07-01T12:01:10.000+08:00]	8.0
[2021-07-01T12:01:20.000+08:00]	9.0

A horizontal timeline with a light blue background. On the left, the text "[2021-07-01T12:01:30.000+08:00]" is displayed. On the right, the text "10.0|" is displayed. A horizontal line with three tick marks spans the width of the box.

4.3 ValueRepair

4.3.1 Usage

This function is used to repair the value of the time series. Currently, two methods are supported: **Screen** is a method based on speed threshold, which makes all speeds meet the threshold requirements under the premise of minimum changes; **LsGreedy** is a method based on speed change likelihood, which models speed changes as Gaussian distribution, and uses a greedy algorithm to maximize the likelihood.

Name: VALUEREPAIR

Input Series: Only support a single input series. The type is INT32 / INT64 / FLOAT / DOUBLE.

Parameters:

- **method** : The method used to repair, which is 'Screen' or 'LsGreedy'. By default, Screen is used.
- **minSpeed** : This parameter is only valid with Screen. It is the speed threshold. Speeds below it will be regarded as outliers. By default, it is the median minus 3 times of median absolute deviation.
- **maxSpeed** : This parameter is only valid with Screen. It is the speed threshold. Speeds above it will be regarded as outliers. By default, it is the median plus 3 times of median absolute deviation.
- **center** : This parameter is only valid with LsGreedy. It is the center of the Gaussian distribution of speed changes. By default, it is 0.
- **sigma** : This parameter is only valid with LsGreedy. It is the standard deviation of the Gaussian distribution of speed changes. By default, it is the median absolute deviation.

Output Series: Output a single series. The type is the same as the input. This series is the input after repairing.

Note: NaN will be filled with linear interpolation before repairing.

4.3.2 Examples

4.3.2.1 Repair with Screen

When **method** is 'Screen' or the default, Screen method is used.

Input series:

A horizontal timeline with a light blue background. On the left, the text "| Time|root.test.d2.s1|" is displayed. A horizontal line with three tick marks spans the width of the box.

[2020-01-01T00:00:02.000+08:00]	100.0]
[2020-01-01T00:00:03.000+08:00]	101.0]
[2020-01-01T00:00:04.000+08:00]	102.0]
[2020-01-01T00:00:06.000+08:00]	104.0]
[2020-01-01T00:00:08.000+08:00]	126.0]
[2020-01-01T00:00:10.000+08:00]	108.0]
[2020-01-01T00:00:14.000+08:00]	112.0]
[2020-01-01T00:00:15.000+08:00]	113.0]
[2020-01-01T00:00:16.000+08:00]	114.0]
[2020-01-01T00:00:18.000+08:00]	116.0]
[2020-01-01T00:00:20.000+08:00]	118.0]
[2020-01-01T00:00:22.000+08:00]	100.0]
[2020-01-01T00:00:26.000+08:00]	124.0]
[2020-01-01T00:00:28.000+08:00]	126.0]
[2020-01-01T00:00:30.000+08:00]	NaN]

SQL for query:

```
select valuerespair(s1) from root.test.d2
```

Output series:

Time	valuerespair(root.test.d2.s1)
[2020-01-01T00:00:02.000+08:00]	100.0]
[2020-01-01T00:00:03.000+08:00]	101.0]
[2020-01-01T00:00:04.000+08:00]	102.0]
[2020-01-01T00:00:06.000+08:00]	104.0]
[2020-01-01T00:00:08.000+08:00]	106.0]
[2020-01-01T00:00:10.000+08:00]	108.0]
[2020-01-01T00:00:14.000+08:00]	112.0]
[2020-01-01T00:00:15.000+08:00]	113.0]
[2020-01-01T00:00:16.000+08:00]	114.0]
[2020-01-01T00:00:18.000+08:00]	116.0]
[2020-01-01T00:00:20.000+08:00]	118.0]
[2020-01-01T00:00:22.000+08:00]	120.0]
[2020-01-01T00:00:26.000+08:00]	124.0]
[2020-01-01T00:00:28.000+08:00]	126.0]
[2020-01-01T00:00:30.000+08:00]	128.0]

4.3.2.2 Repair with LsGreedy

When `method` is 'LsGreedy', LsGreedy method is used.

Input series is the same as above, the SQL for query is shown below:

```
select valuerepair(s1, 'method'='LsGreedy') from root.test.d2
```

Output series:

Time	valuerepair(root.test.d2.s1, "method"="LsGreedy")
[2020-01-01T00:00:02.000+08:00]	100.0
[2020-01-01T00:00:03.000+08:00]	101.0
[2020-01-01T00:00:04.000+08:00]	102.0
[2020-01-01T00:00:06.000+08:00]	104.0
[2020-01-01T00:00:08.000+08:00]	106.0
[2020-01-01T00:00:10.000+08:00]	108.0
[2020-01-01T00:00:14.000+08:00]	112.0
[2020-01-01T00:00:15.000+08:00]	113.0
[2020-01-01T00:00:16.000+08:00]	114.0
[2020-01-01T00:00:18.000+08:00]	116.0
[2020-01-01T00:00:20.000+08:00]	118.0
[2020-01-01T00:00:22.000+08:00]	120.0
[2020-01-01T00:00:26.000+08:00]	124.0
[2020-01-01T00:00:28.000+08:00]	126.0
[2020-01-01T00:00:30.000+08:00]	128.0

Chapter 5 Data Matching

5.1 Cov

5.1.1 Usage

This function is used to calculate the population covariance.

Name: COV

Input Series: Only support two input series. The types are both INT32 / INT64 / FLOAT / DOUBLE.

Output Series: Output a single series. The type is DOUBLE. There is only one data point in the series, whose timestamp is 0 and value is the population covariance.

Note:

- If a row contains missing points, null points or `NaN`, it will be ignored;
- If all rows are ignored, `NaN` will be output.

5.1.2 Examples

Input series:

Time	root.test.d2.s1	root.test.d2.s2
[2020-01-01T00:00:02.000+08:00]	100.0	101.0
[2020-01-01T00:00:03.000+08:00]	101.0	null
[2020-01-01T00:00:04.000+08:00]	102.0	101.0
[2020-01-01T00:00:06.000+08:00]	104.0	102.0
[2020-01-01T00:00:08.000+08:00]	126.0	102.0
[2020-01-01T00:00:10.000+08:00]	108.0	103.0
[2020-01-01T00:00:12.000+08:00]	null	103.0
[2020-01-01T00:00:14.000+08:00]	112.0	104.0
[2020-01-01T00:00:15.000+08:00]	113.0	null
[2020-01-01T00:00:16.000+08:00]	114.0	104.0
[2020-01-01T00:00:18.000+08:00]	116.0	105.0
[2020-01-01T00:00:20.000+08:00]	118.0	105.0
[2020-01-01T00:00:22.000+08:00]	100.0	106.0
[2020-01-01T00:00:26.000+08:00]	124.0	108.0
[2020-01-01T00:00:28.000+08:00]	126.0	108.0
[2020-01-01T00:00:30.000+08:00]	NaN	108.0

SQL for query:

```
select cov(s1,s2) from root.test.d2
```

Output series:

	Time cov(root.test.d2.s1, root.test.d2.s2)
1970-01-01T08:00:00.000+08:00	12.291666666666666

5.2 CrossCorrelation

5.2.1 Usage

This function is used to calculate the cross correlation function of given two time series. For discrete time series, cross correlation is given by

$$CR(n) = \frac{1}{N} \sum_{m=1}^N S_1[m]S_2[m+n]$$

which represent the similarities between two series with different index shifts.

Name: CROSSCORRELATION

Input Series: Only support two input numeric series. The type is INT32 / INT64 / FLOAT / DOUBLE.

Output Series: Output a single series with DOUBLE as datatype. There are $2N - 1$ data points in the series, the center of which represents the cross correlation calculated with pre-aligned series(that is $CR(0)$ in the formula above), and the previous(or post) values represent those with shifting the latter series forward(or backward otherwise) until the two series are no longer overlapped(not included). In short, the values of output series are given by(index starts from 1)

$$OS[i] = CR(-N + i) = \frac{1}{N} \sum_{m=1}^i S_1[m]S_2[N - i + m], \text{ if } i \leq N$$

$$OS[i] = CR(i - N) = \frac{1}{N} \sum_{m=1}^{2N-i} S_1[i - N + m]S_2[m], \text{ if } i > N$$

Note:

- `null` and `NaN` values in the input series will be ignored and treated as 0.

5.2.2 Examples

Input series:

	Time root.test.d1.s1 root.test.d1.s2

2020-01-01T00:00:01.000+08:00	null	6
2020-01-01T00:00:02.000+08:00	2	7
2020-01-01T00:00:03.000+08:00	3	NaN
2020-01-01T00:00:04.000+08:00	4	9
2020-01-01T00:00:05.000+08:00	5	10
+-----+-----+		

SQL for query:

```
select crosscorrelation(s1, s2) from root.test.d1 where time <= 2020-01-01 00:00:05
```

Output series:

Time crosscorrelation(root.test.d1.s1, root.test.d1.s2)	
1970-01-01T08:00:00.001+08:00	0.0
1970-01-01T08:00:00.002+08:00	4.0
1970-01-01T08:00:00.003+08:00	9.6
1970-01-01T08:00:00.004+08:00	13.4
1970-01-01T08:00:00.005+08:00	20.0
1970-01-01T08:00:00.006+08:00	15.6
1970-01-01T08:00:00.007+08:00	9.2
1970-01-01T08:00:00.008+08:00	11.8
1970-01-01T08:00:00.009+08:00	6.0
+-----+-----+	

5.2.2.1 examples on zeppelin

link: <<http://101.6.15.213:18181/#/notebook/2GETVW6AT>>

5.3 DTW(TODO)

5.4 PatternSymmetric

5.4.1 Usage

This function is used to find all symmetric subseries in the input whose degree of symmetry is less than the threshold. The degree of symmetry is calculated by DTW. The smaller the degree, the more symmetrical the series is.

Name: PATTERNSYMMETRIC

Input Series: Only support a single input series. The type is INT32 / INT64 / FLOAT / DOUBLE

Parameter:

- **window** : The length of the symmetric subseries. It's a positive integer and the default value is 10.
- **threshold** : The threshold of the degree of symmetry. It's non-negative. Only the subseries whose degree of symmetry is below it will be output. By default, all subseries will be output.

Output Series: Output a single series. The type is DOUBLE. Each data point in the output series corresponds to a symmetric subseries. The output timestamp is the starting timestamp of the subseries and the output value is the degree of symmetry.

5.4.2 Example

Input series:

Time root.test.d1.s4	
[2021-01-01T12:00:00.000+08:00]	1.0
[2021-01-01T12:00:01.000+08:00]	2.0
[2021-01-01T12:00:02.000+08:00]	3.0
[2021-01-01T12:00:03.000+08:00]	2.0
[2021-01-01T12:00:04.000+08:00]	1.0
[2021-01-01T12:00:05.000+08:00]	1.0
[2021-01-01T12:00:06.000+08:00]	1.0
[2021-01-01T12:00:07.000+08:00]	1.0
[2021-01-01T12:00:08.000+08:00]	2.0
[2021-01-01T12:00:09.000+08:00]	3.0
[2021-01-01T12:00:10.000+08:00]	2.0
[2021-01-01T12:00:11.000+08:00]	1.0

SQL for query:

```
select patternsymmetric(s4, 'window'='5', 'threshold'='0') from root.test.d1
```

Output series:

Time patternsymmetric(root.test.d1.s4, "window"="5", "threshold"="0")	
[2021-01-01T12:00:00.000+08:00]	0.0
[2021-01-01T12:00:07.000+08:00]	0.0

5.5 Pearson

5.5.1 Usage

This function is used to calculate the Pearson Correlation Coefficient.

Name: PEARSON

Input Series: Only support two input series. The types are both INT32 / INT64 / FLOAT / DOUBLE.

Output Series: Output a single series. The type is DOUBLE. There is only one data point in the series, whose timestamp is 0 and value is the Pearson Correlation Coefficient.

Note:

- If a row contains missing points, null points or `NaN`, it will be ignored;
- If all rows are ignored, `NaN` will be output.

5.5.2 Examples

Input series:

Time	root.test.d2.s1	root.test.d2.s2
[2020-01-01T00:00:02.000+08:00]	100.0	101.0
[2020-01-01T00:00:03.000+08:00]	101.0	null
[2020-01-01T00:00:04.000+08:00]	102.0	101.0
[2020-01-01T00:00:06.000+08:00]	104.0	102.0
[2020-01-01T00:00:08.000+08:00]	126.0	102.0
[2020-01-01T00:00:10.000+08:00]	108.0	103.0
[2020-01-01T00:00:12.000+08:00]	null	103.0
[2020-01-01T00:00:14.000+08:00]	112.0	104.0
[2020-01-01T00:00:15.000+08:00]	113.0	null
[2020-01-01T00:00:16.000+08:00]	114.0	104.0
[2020-01-01T00:00:18.000+08:00]	116.0	105.0
[2020-01-01T00:00:20.000+08:00]	118.0	105.0
[2020-01-01T00:00:22.000+08:00]	100.0	106.0
[2020-01-01T00:00:26.000+08:00]	124.0	108.0
[2020-01-01T00:00:28.000+08:00]	126.0	108.0
[2020-01-01T00:00:30.000+08:00]	NaN	108.0

SQL for query:

```
select pearson(s1,s2) from root.test.d2
```

Output series:

Time	pearson(root.test.d2.s1, root.test.d2.s2)
------	---

1970-01-01T08:00:00.000+08:00	0.5630881927754872
-------------------------------	--------------------

5.6 SelfCorrelation

5.6.1 Usage

This function is used to calculate the self-correlation function of the input time series, which equals to cross correlation between the same series. For more information, please refer to `CrossCorrelation` function.

Name: SELFCORRELATION

Input Series: Only support a single input numeric series. The type is INT32 / INT64 / FLOAT / DOUBLE.

Output Series: Output a single series. The type is DOUBLE. There are $2N - 1$ data points in the series, and the values are interpreted in details in `CrossCorrelation` function.

Note:

- `null` and `NaN` values in the input series will be ignored and treated as 0.

5.6.2 Examples

Input series:

Time root.test.d1.s1	
2020-01-01T00:00:01.000+08:00	1
2020-01-01T00:00:02.000+08:00	null
2020-01-01T00:00:03.000+08:00	3
2020-01-01T00:00:04.000+08:00	NaN
2020-01-01T00:00:05.000+08:00	5

SQL for query:

```
select selfcorrelation(s1) from root.test.d1 where time <= 2020-01-01 00:00:05
```

Output series:

Time selfcorrelation(root.test.d1.s1)	
1970-01-01T08:00:00.001+08:00	1.0
1970-01-01T08:00:00.002+08:00	0.0
1970-01-01T08:00:00.003+08:00	3.6

1970-01-01T08:00:00.004+08:00	0.0
1970-01-01T08:00:00.005+08:00	7.0
1970-01-01T08:00:00.006+08:00	0.0
1970-01-01T08:00:00.007+08:00	3.6
1970-01-01T08:00:00.008+08:00	0.0
1970-01-01T08:00:00.009+08:00	1.0
+-----+-----+	

5.6.2.1 examples on zeppelin

link: <<http://101.6.15.213:18181/#/notebook/2GC91M5DY>>

5.7 SeriesAlign(TODO)

5.8 SeriesSimilarity(TODO)

5.9 ValueAlign(TODO)

Chapter 6 Anomaly Detection

6.1 ADWIN

6.1.1 Usage

This function is used to detect possible concept drift of time series. According to delta parameter, the function judges if concept drift occurs at an input value using ADWIN algorithm, and a new time series of detected concept drifts will be output. For detail, see

Learning from Time-Changing Data with Adaptive Windowing, A Bifet et al., 2005

Name: ADWIN

Input Series: Only support a single input series. The type is INT32 / INT64 / FLOAT / DOUBLE.

- **delta**: a threshold to distinguish concept drifts. See the δ defined in the paper. Default value is 0.01.
- **windowsize**: the size of window to detect. Should be larger than 2

Output Series: Output a single series. The type is INT32. 1 for anomaly, and 0 for others.

6.1.2 Examples

6.1.2.1 Assigning parameters

Input series:

Time root.test.s1	
[1970-01-01T08:00:00.000+08:00]	5.0
[1970-01-01T08:00:00.100+08:00]	5.0
[1970-01-01T08:00:00.200+08:00]	5.0
[1970-01-01T08:00:00.300+08:00]	5.0
[1970-01-01T08:00:00.400+08:00]	5.0
[1970-01-01T08:00:00.500+08:00]	5.0
[1970-01-01T08:00:00.600+08:00]	5.0
[1970-01-01T08:00:00.700+08:00]	5.0
[1970-01-01T08:00:00.800+08:00]	5.0
[1970-01-01T08:00:00.900+08:00]	5.0
[1970-01-01T08:00:01.000+08:00]	5.0
[1970-01-01T08:00:01.100+08:00]	5.0
[1970-01-01T08:00:01.200+08:00]	5.0
[1970-01-01T08:00:01.300+08:00]	5.0
[1970-01-01T08:00:01.400+08:00]	5.0
[1970-01-01T08:00:01.500+08:00]	5.0

[1970-01-01T08:00:01.600+08:00]	5.0
[1970-01-01T08:00:01.700+08:00]	5.0
[1970-01-01T08:00:01.800+08:00]	5.0
[1970-01-01T08:00:01.900+08:00]	5.0
[1970-01-01T08:00:02.000+08:00]	10.0
[1970-01-01T08:00:02.100+08:00]	10.0
[1970-01-01T08:00:02.200+08:00]	10.0
[1970-01-01T08:00:02.300+08:00]	10.0
[1970-01-01T08:00:02.400+08:00]	10.0
[1970-01-01T08:00:02.500+08:00]	10.0
[1970-01-01T08:00:02.600+08:00]	10.0
[1970-01-01T08:00:02.700+08:00]	10.0
[1970-01-01T08:00:02.800+08:00]	10.0
[1970-01-01T08:00:02.900+08:00]	10.0
[1970-01-01T08:00:03.000+08:00]	10.0
[1970-01-01T08:00:03.100+08:00]	10.0
[1970-01-01T08:00:03.200+08:00]	10.0
[1970-01-01T08:00:03.300+08:00]	10.0
[1970-01-01T08:00:03.400+08:00]	10.0
[1970-01-01T08:00:03.500+08:00]	10.0
[1970-01-01T08:00:03.600+08:00]	10.0
[1970-01-01T08:00:03.700+08:00]	10.0
[1970-01-01T08:00:03.800+08:00]	10.0
[1970-01-01T08:00:03.900+08:00]	10.0
+-----+-----+	

SQL for query:

```
select adwin(s1,"windowsize"="30","delta"="0.01") from root.test
```

Output series:

+-----+-----+	
	Time adwin(root.test.s1, "windowsize"="30", "delta"="0.01")
+-----+-----+	
[1970-01-01T08:00:02.100+08:00]	1
+-----+-----+	

6.2 IQR

6.2.1 Usage

This function is used to detect anomalies based on IQR. Points distributing beyond 1.5 times IQR are selected.

Name: IQR

Input Series: Only support a single input series. The type is INT32 / INT64 / FLOAT / DOUBLE.

- **method** : When set to "batch", anomaly test is conducted after importing all data points; when set to "stream", it is required to provide upper and lower quantiles. The default method is "batch".
- **q1** : The lower quantile when method is set to "stream".
- **q3** : The upper quantile when method is set to "stream".

Output Series: Output a single series. The type is DOUBLE.

Note: $IQR = Q_3 - Q_1$

6.2.2 Examples

6.2.2.1 Batch computing

Input series:

Time	root.test.s1
[1970-01-01T08:00:00.100+08:00]	0.0
[1970-01-01T08:00:00.200+08:00]	0.0
[1970-01-01T08:00:00.300+08:00]	1.0
[1970-01-01T08:00:00.400+08:00]	-1.0
[1970-01-01T08:00:00.500+08:00]	0.0
[1970-01-01T08:00:00.600+08:00]	0.0
[1970-01-01T08:00:00.700+08:00]	-2.0
[1970-01-01T08:00:00.800+08:00]	2.0
[1970-01-01T08:00:00.900+08:00]	0.0
[1970-01-01T08:00:01.000+08:00]	0.0
[1970-01-01T08:00:01.100+08:00]	1.0
[1970-01-01T08:00:01.200+08:00]	-1.0
[1970-01-01T08:00:01.300+08:00]	-1.0
[1970-01-01T08:00:01.400+08:00]	1.0
[1970-01-01T08:00:01.500+08:00]	0.0
[1970-01-01T08:00:01.600+08:00]	0.0
[1970-01-01T08:00:01.700+08:00]	10.0
[1970-01-01T08:00:01.800+08:00]	2.0
[1970-01-01T08:00:01.900+08:00]	-2.0
[1970-01-01T08:00:02.000+08:00]	0.0

SQL for query:

```
select iqr(s1) from root.test
```

Output series:

Time	iqr(root.test.s1)
[1970-01-01T08:00:01.700+08:00]	10.0]

6.3 KSigma

6.3.1 Usage

This function is used to detect anomalies based on the Dynamic K-Sigma Algorithm. Within a sliding window, the input value with a deviation of more than k times the standard deviation from the average will be output as anomaly.

Name: KSIGMA

Input Series: Only support a single input series. The type is INT32 / INT64 / FLOAT / DOUBLE.

- **k** : How many times to multiply on standard deviation to define anomaly, the default value is 3.
- **window** : The window size of Dynamic K-Sigma Algorithm, the default value is 10000.

Output Series: Output a single series. The type is same as input series.

Note: Only when is larger than 0, the anomaly detection will be performed. Otherwise, nothing will be output.

6.3.2 Examples

6.3.2.1 Assigning k

Input series:

Time	root.test.d1.s1]
[2020-01-01T00:00:02.000+08:00]	0.0]
[2020-01-01T00:00:03.000+08:00]	50.0]
[2020-01-01T00:00:04.000+08:00]	100.0]
[2020-01-01T00:00:06.000+08:00]	150.0]
[2020-01-01T00:00:08.000+08:00]	200.0]
[2020-01-01T00:00:10.000+08:00]	200.0]
[2020-01-01T00:00:14.000+08:00]	200.0]
[2020-01-01T00:00:15.000+08:00]	200.0]
[2020-01-01T00:00:16.000+08:00]	200.0]
[2020-01-01T00:00:18.000+08:00]	200.0]
[2020-01-01T00:00:20.000+08:00]	150.0]

[2020-01-01T00:00:22.000+08:00]	100.0
[2020-01-01T00:00:26.000+08:00]	50.0
[2020-01-01T00:00:28.000+08:00]	0.0
[2020-01-01T00:00:30.000+08:00]	NaN

SQL for query:

```
select ksigma(s1,"k"="1.0") from root.test.d1 where time <= 2020-01-01 00:00:30
```

Output series:

Time	ksigma(root.test.d1.s1,"k"="3.0")
[2020-01-01T00:00:02.000+08:00]	0.0
[2020-01-01T00:00:03.000+08:00]	50.0
[2020-01-01T00:00:26.000+08:00]	50.0
[2020-01-01T00:00:28.000+08:00]	0.0

6.4 LOF

6.4.1 Usage

This function is used to detect density anomaly of time series. According to k-th distance calculation parameter and local outlier factor (lof) threshold, the function judges if a set of input values is an density anomaly, and a bool mark of anomaly values will be output.

Name: LOF

Input Series: Multiple input series. The type is INT32 / INT64 / FLOAT / DOUBLE.

- **method**: assign a detection method. The default value is "default", when input data has multiple dimensions. The alternative is "series", when a input series will be transformed to high dimension.
- **k**: use the k-th distance to calculate lof. Default value is 3.
- **window**: size of window to split origin data points. Default value is 10000.
- **windowsize**: dimension that will be transformed into when method is "series". The default value is 5.

Output Series: Output a single series. The type is DOUBLE.

Note: Incomplete rows will be ignored. They are neither calculated nor marked as anomaly.

6.4.2 Examples

6.4.2.1 Using default parameters

Input series:

Time	root.test.d1.s1	root.test.d1.s2
[1970-01-01T08:00:00.100+08:00]	0.0	0.0
[1970-01-01T08:00:00.200+08:00]	0.0	1.0
[1970-01-01T08:00:00.300+08:00]	1.0	1.0
[1970-01-01T08:00:00.400+08:00]	1.0	0.0
[1970-01-01T08:00:00.500+08:00]	0.0	-1.0
[1970-01-01T08:00:00.600+08:00]	-1.0	-1.0
[1970-01-01T08:00:00.700+08:00]	-1.0	0.0
[1970-01-01T08:00:00.800+08:00]	2.0	2.0
[1970-01-01T08:00:00.900+08:00]	0.0	null

SQL for query:

```
select lof(s1,s2) from root.test.d1 where time<1000
```

Output series:

Time	lof(root.test.d1.s1, root.test.d1.s2)
[1970-01-01T08:00:00.100+08:00]	3.8274824267668244
[1970-01-01T08:00:00.200+08:00]	3.0117631741126156
[1970-01-01T08:00:00.300+08:00]	2.838155437762879
[1970-01-01T08:00:00.400+08:00]	3.0117631741126156
[1970-01-01T08:00:00.500+08:00]	2.73518261244453
[1970-01-01T08:00:00.600+08:00]	2.371440975708148
[1970-01-01T08:00:00.700+08:00]	2.73518261244453
[1970-01-01T08:00:00.800+08:00]	1.7561416374270742

6.4.2.2 Diagnosing 1d timeseries

Input series:

Time	root.test.d1.s1
[1970-01-01T08:00:00.100+08:00]	1.0
[1970-01-01T08:00:00.200+08:00]	2.0
[1970-01-01T08:00:00.300+08:00]	3.0
[1970-01-01T08:00:00.400+08:00]	4.0
[1970-01-01T08:00:00.500+08:00]	5.0
[1970-01-01T08:00:00.600+08:00]	6.0
[1970-01-01T08:00:00.700+08:00]	7.0
[1970-01-01T08:00:00.800+08:00]	8.0

1970-01-01T08:00:00.900+08:00	9.0
1970-01-01T08:00:01.000+08:00	10.0
1970-01-01T08:00:01.100+08:00	11.0
1970-01-01T08:00:01.200+08:00	12.0
1970-01-01T08:00:01.300+08:00	13.0
1970-01-01T08:00:01.400+08:00	14.0
1970-01-01T08:00:01.500+08:00	15.0
1970-01-01T08:00:01.600+08:00	16.0
1970-01-01T08:00:01.700+08:00	17.0
1970-01-01T08:00:01.800+08:00	18.0
1970-01-01T08:00:01.900+08:00	19.0
1970-01-01T08:00:02.000+08:00	20.0
+-----+	

SQL for query:

```
select lof(s1, "method"="series") from root.test.d1 where time<1000
```

Output series:

+-----+	
	Time lof(root.test.d1.s1)
+-----+	
1970-01-01T08:00:00.100+08:00	3.77777777777778
1970-01-01T08:00:00.200+08:00	4.32727272727273
1970-01-01T08:00:00.300+08:00	4.85714285714286
1970-01-01T08:00:00.400+08:00	5.40909090909091
1970-01-01T08:00:00.500+08:00	5.94999999999999
1970-01-01T08:00:00.600+08:00	6.43243243243243
1970-01-01T08:00:00.700+08:00	6.79999999999999
1970-01-01T08:00:00.800+08:00	7.0
1970-01-01T08:00:00.900+08:00	7.0
1970-01-01T08:00:01.000+08:00	6.79999999999999
1970-01-01T08:00:01.100+08:00	6.43243243243243
1970-01-01T08:00:01.200+08:00	5.94999999999999
1970-01-01T08:00:01.300+08:00	5.40909090909091
1970-01-01T08:00:01.400+08:00	4.85714285714286
1970-01-01T08:00:01.500+08:00	4.32727272727273
1970-01-01T08:00:01.600+08:00	3.77777777777778
+-----+	

6.4.2.3

6.5 Range

6.5.1 Usage

This function is used to detect range anomaly of time series. According to upper bound and lower bound parameters, the function judges if a input value is beyond range, aka range anomaly, and a new time series of anomaly will be output.

Name: RANGE

Input Series: Only support a single input series. The type is INT32 / INT64 / FLOAT / DOUBLE.

- **lower_bound**: lower bound of range anomaly detection.
- **upper_bound**: upper bound of range anomaly detection.

Output Series: Output a single series. The type is the same as the input.

Note: Only when **upper_bound** is larger than **lower_bound**, the anomaly detection will be performed. Otherwise, nothing will be output.

6.5.2 Examples

6.5.2.1 Assigning Lower and Upper Bound

Input series:

Time root.test.d1.s1	
[2020-01-01T00:00:02.000+08:00]	100.0
[2020-01-01T00:00:03.000+08:00]	101.0
[2020-01-01T00:00:04.000+08:00]	102.0
[2020-01-01T00:00:06.000+08:00]	104.0
[2020-01-01T00:00:08.000+08:00]	126.0
[2020-01-01T00:00:10.000+08:00]	108.0
[2020-01-01T00:00:14.000+08:00]	112.0
[2020-01-01T00:00:15.000+08:00]	113.0
[2020-01-01T00:00:16.000+08:00]	114.0
[2020-01-01T00:00:18.000+08:00]	116.0
[2020-01-01T00:00:20.000+08:00]	118.0
[2020-01-01T00:00:22.000+08:00]	120.0
[2020-01-01T00:00:26.000+08:00]	124.0
[2020-01-01T00:00:28.000+08:00]	126.0
[2020-01-01T00:00:30.000+08:00]	NaN

SQL for query:

```
select range(s1,"lower_bound"="101.0","upper_bound"="125.0") from root.test.d1 where time <= 2020-01-01 00:00:30
```

Output series:

Time	range(root.test.d1.s1,"lower_bound"="101.0","upper_bound"="125.0")
[2020-01-01T00:00:02.000+08:00]	100.0
[2020-01-01T00:00:28.000+08:00]	126.0

6.6 TwoSidedFilter

6.6.1 Usage

The function is used to filter anomalies of a numeric time series based on two-sided window detection.

Name: TWOSIDEDFILTER

Input Series: Only support a single input series. The data type is INT32 / INT64 / FLOAT / DOUBLE

Output Series: Output a single series. The type is the same as the input. It is the input without anomalies.

Parameter:

- **len**: The size of the window which is a positive integer. By default, it's 5. When **len**=3, the algorithm detects forward window and backward window with length 3 and calculates the outlieriness of the current point.
- **threshold**: The threshold of outlieriness, which is a floating number in (0,1). By default, it's 0.3. The strict standard of detecting anomalies is in proportion to the threshold.

6.6.2 Examples

Input series:

Time	root.test.s0
[1970-01-01T08:00:00.000+08:00]	2002.0
[1970-01-01T08:00:01.000+08:00]	1946.0
[1970-01-01T08:00:02.000+08:00]	1958.0
[1970-01-01T08:00:03.000+08:00]	2012.0
[1970-01-01T08:00:04.000+08:00]	2051.0
[1970-01-01T08:00:05.000+08:00]	1898.0

[1970-01-01T08:00:06.000+08:00]	2014.0]
[1970-01-01T08:00:07.000+08:00]	2052.0]
[1970-01-01T08:00:08.000+08:00]	1935.0]
[1970-01-01T08:00:09.000+08:00]	1901.0]
[1970-01-01T08:00:10.000+08:00]	1972.0]
[1970-01-01T08:00:11.000+08:00]	1969.0]
[1970-01-01T08:00:12.000+08:00]	1984.0]
[1970-01-01T08:00:13.000+08:00]	2018.0]
[1970-01-01T08:00:37.000+08:00]	1484.0]
[1970-01-01T08:00:38.000+08:00]	1055.0]
[1970-01-01T08:00:39.000+08:00]	1050.0]
[1970-01-01T08:01:05.000+08:00]	1023.0]
[1970-01-01T08:01:06.000+08:00]	1056.0]
[1970-01-01T08:01:07.000+08:00]	978.0]
[1970-01-01T08:01:08.000+08:00]	1050.0]
[1970-01-01T08:01:09.000+08:00]	1123.0]
[1970-01-01T08:01:10.000+08:00]	1150.0]
[1970-01-01T08:01:11.000+08:00]	1034.0]
[1970-01-01T08:01:12.000+08:00]	950.0]
[1970-01-01T08:01:13.000+08:00]	1059.0]
+-----+-----+	

SQL for query:

```
select TwoSidedFilter(s0, 'len'='5', 'threshold'='0.3') from root.test
```

Output series:

Time root.test.s0	
+-----+-----+	
[1970-01-01T08:00:00.000+08:00]	2002.0]
[1970-01-01T08:00:01.000+08:00]	1946.0]
[1970-01-01T08:00:02.000+08:00]	1958.0]
[1970-01-01T08:00:03.000+08:00]	2012.0]
[1970-01-01T08:00:04.000+08:00]	2051.0]
[1970-01-01T08:00:05.000+08:00]	1898.0]
[1970-01-01T08:00:06.000+08:00]	2014.0]
[1970-01-01T08:00:07.000+08:00]	2052.0]
[1970-01-01T08:00:08.000+08:00]	1935.0]
[1970-01-01T08:00:09.000+08:00]	1901.0]
[1970-01-01T08:00:10.000+08:00]	1972.0]
[1970-01-01T08:00:11.000+08:00]	1969.0]
[1970-01-01T08:00:12.000+08:00]	1984.0]
[1970-01-01T08:00:13.000+08:00]	2018.0]
[1970-01-01T08:01:05.000+08:00]	1023.0]
[1970-01-01T08:01:06.000+08:00]	1056.0]
[1970-01-01T08:01:07.000+08:00]	978.0]
[1970-01-01T08:01:08.000+08:00]	1050.0]

1970-01-01T08:01:09.000+08:00	1123.0
1970-01-01T08:01:10.000+08:00	1150.0
1970-01-01T08:01:11.000+08:00	1034.0
1970-01-01T08:01:12.000+08:00	950.0
1970-01-01T08:01:13.000+08:00	1059.0

+

Chapter 7 Frequency Domain

7.1 Conv

7.1.1 Usage

This function is used to calculate the convolution, i.e. polynomial multiplication.

Name: CONV

Input: Only support two input series. The types are both INT32 / INT64 / FLOAT / DOUBLE.

Output: Output a single series. The type is DOUBLE. It is the result of convolution whose timestamps starting from 0 only indicate the order.

Note: NaN in the input series will be ignored.

7.1.2 Examples

Input series:

Time	root.test.d2.s1	root.test.d2.s2
[1970-01-01T08:00:00.000+08:00]	1.0	7.0
[1970-01-01T08:00:00.001+08:00]	0.0	2.0
[1970-01-01T08:00:00.002+08:00]	1.0	null

SQL for query:

```
select conv(s1,s2) from root.test.d2
```

Output series:

Time	conv(root.test.d2.s1, root.test.d2.s2)
[1970-01-01T08:00:00.000+08:00]	7.0
[1970-01-01T08:00:00.001+08:00]	2.0
[1970-01-01T08:00:00.002+08:00]	7.0
[1970-01-01T08:00:00.003+08:00]	2.0

7.2 Deconv

7.2.1 Usage

This function is used to calculate the deconvolution, i.e. polynomial division.

Name: DECONV

Input: Only support two input series. The types are both INT32 / INT64 / FLOAT / DOUBLE.

Parameters:

- **result** The result of deconvolution, which is 'quotient' or 'remainder'. By default, the quotient will be output.

Output: Output a single series. The type is DOUBLE. It is the result of deconvolving the second series from the first series (dividing the first series by the second series) whose timestamps starting from 0 only indicate the order.

Note: NaN in the input series will be ignored.

7.2.2 Examples

7.2.2.1 Calculate the quotient

When **result** is 'quotient' or the default, this function calculates the quotient of the deconvolution.

Input series:

Time	root.test.d2.s3	root.test.d2.s2
1970-01-01T08:00:00.000+08:00	8.0	7.0
1970-01-01T08:00:00.001+08:00	2.0	2.0
1970-01-01T08:00:00.002+08:00	7.0	null
1970-01-01T08:00:00.003+08:00	2.0	null

SQL for query:

```
select deconv(s3,s2) from root.test.d2
```

Output series:

Time	deconv(root.test.d2.s3, root.test.d2.s2)
1970-01-01T08:00:00.000+08:00	1.0
1970-01-01T08:00:00.001+08:00	0.0
1970-01-01T08:00:00.002+08:00	1.0

7.2.2.2 Calculate the remainder

When `result` is 'remainder', this function calculates the remainder of the deconvolution.

Input series is the same as above, the SQL for query is shown below:

```
select deconv(s3,s2,'result'='remainder') from root.test.d2
```

Output series:

Time deconv(root.test.d2.s3, root.test.d2.s2, "result"="remainder")
1970-01-01T08:00:00.000+08:00 1.0
1970-01-01T08:00:00.001+08:00 0.0
1970-01-01T08:00:00.002+08:00 0.0
1970-01-01T08:00:00.003+08:00 0.0

7.3 FFT

7.3.1 Usage

This function is used to calculate the fast Fourier transform (FFT) of a numerical series.

Name: FFT

Input: Only support a single input series. The type is INT32 / INT64 / FLOAT / DOUBLE.

Parameters:

- **type**: The type of FFT, which is 'uniform' (by default) or 'nonuniform'. If the value is 'uniform', the timestamps will be ignored and all data points will be regarded as equidistant. Thus, the equidistant fast Fourier transform algorithm will be applied. If the value is 'nonuniform' (TODO), the non-equidistant fast Fourier transform algorithm will be applied based on timestamps.
- **result**: The result of FFT, which is 'real', 'imag', 'abs' or 'angle', corresponding to the real part, imaginary part, magnitude and phase angle. By default, the magnitude will be output.

Output: Output a single series. The type is DOUBLE. The length is the same as the input.

The timestamps starting from 0 only indicate the order.

Note: NaN in the input series will be ignored.

7.3.2 Examples

7.3.2.1 Uniform FFT

With the default `type`, uniform FFT is applied.

Input series:

Time	root.test.d1.s1
[1970-01-01T08:00:00.000+08:00]	2.9021131
[1970-01-01T08:00:01.000+08:00]	1.1755705
[1970-01-01T08:00:02.000+08:00]	-2.1755705
[1970-01-01T08:00:03.000+08:00]	-1.9021131
[1970-01-01T08:00:04.000+08:00]	1.0
[1970-01-01T08:00:05.000+08:00]	1.9021131
[1970-01-01T08:00:06.000+08:00]	0.1755705
[1970-01-01T08:00:07.000+08:00]	-1.1755705
[1970-01-01T08:00:08.000+08:00]	-0.9021131
[1970-01-01T08:00:09.000+08:00]	0.0
[1970-01-01T08:00:10.000+08:00]	0.9021131
[1970-01-01T08:00:11.000+08:00]	1.1755705
[1970-01-01T08:00:12.000+08:00]	-0.1755705
[1970-01-01T08:00:13.000+08:00]	-1.9021131
[1970-01-01T08:00:14.000+08:00]	-1.0
[1970-01-01T08:00:15.000+08:00]	1.9021131
[1970-01-01T08:00:16.000+08:00]	2.1755705
[1970-01-01T08:00:17.000+08:00]	-1.1755705
[1970-01-01T08:00:18.000+08:00]	-2.9021131
[1970-01-01T08:00:19.000+08:00]	0.0

SQL for query:

```
select fft(s1) from root.test.d1
```

Output series:

Time	fft(root.test.d1.s1)
[1970-01-01T08:00:00.000+08:00]	0.0
[1970-01-01T08:00:00.001+08:00]	1.2727111142703152E-8
[1970-01-01T08:00:00.002+08:00]	2.385520799101839E-7
[1970-01-01T08:00:00.003+08:00]	8.723291723972645E-8
[1970-01-01T08:00:00.004+08:00]	19.999999960195904
[1970-01-01T08:00:00.005+08:00]	9.999999850988388
[1970-01-01T08:00:00.006+08:00]	3.2260694930700566E-7
[1970-01-01T08:00:00.007+08:00]	8.723291605373329E-8
[1970-01-01T08:00:00.008+08:00]	1.108657103979944E-7
[1970-01-01T08:00:00.009+08:00]	1.2727110997246171E-8
[1970-01-01T08:00:00.010+08:00]	1.9852334701272664E-23
[1970-01-01T08:00:00.011+08:00]	1.2727111194499847E-8
[1970-01-01T08:00:00.012+08:00]	1.108657103979944E-7
[1970-01-01T08:00:00.013+08:00]	8.723291785769131E-8

1970-01-01T08:00:00.014+08:00	3.226069493070057E-7
1970-01-01T08:00:00.015+08:00	9.999999850988388
1970-01-01T08:00:00.016+08:00	19.99999960195904
1970-01-01T08:00:00.017+08:00	8.723291747109068E-8
1970-01-01T08:00:00.018+08:00	2.3855207991018386E-7
1970-01-01T08:00:00.019+08:00	1.2727112069910878E-8

Note: The input is $y = \sin(2\pi t/4) + 2\sin(2\pi t/5)$ with a length of 20. Thus, there are peaks in $k = 4$ and $k = 5$ of the output.

7.4 HighPass

7.4.1 Usage

This function performs low-pass filtering on the input series and extracts components above the cutoff frequency. The timestamps of input will be ignored and all data points will be regarded as equidistant.

Name: HIGHPASS

Input: Only support a single input series. The type is INT32 / INT64 / FLOAT / DOUBLE.

Parameters:

- **wpass**: The normalized cutoff frequency which values (0,1). This parameter cannot be lacked.

Output: Output a single series. The type is DOUBLE. It is the input after filtering. The length and timestamps of output are the same as the input.

Note: NaN in the input series will be ignored.

7.4.2 Examples

Input series:

Time root.test.d1.s1	
1970-01-01T08:00:00.000+08:00	2.902113
1970-01-01T08:00:01.000+08:00	1.1755705
1970-01-01T08:00:02.000+08:00	-2.1755705
1970-01-01T08:00:03.000+08:00	-1.9021131
1970-01-01T08:00:04.000+08:00	1.0
1970-01-01T08:00:05.000+08:00	1.9021131
1970-01-01T08:00:06.000+08:00	0.1755705
1970-01-01T08:00:07.000+08:00	-1.1755705
1970-01-01T08:00:08.000+08:00	-0.902113
1970-01-01T08:00:09.000+08:00	0.0

1970-01-01T08:00:10.000+08:00	0.902113
1970-01-01T08:00:11.000+08:00	1.1755705
1970-01-01T08:00:12.000+08:00	-0.1755705
1970-01-01T08:00:13.000+08:00	-1.9021131
1970-01-01T08:00:14.000+08:00	-1.0
1970-01-01T08:00:15.000+08:00	1.9021131
1970-01-01T08:00:16.000+08:00	2.1755705
1970-01-01T08:00:17.000+08:00	-1.1755705
1970-01-01T08:00:18.000+08:00	-2.902113
1970-01-01T08:00:19.000+08:00	0.0
+-----+-----+	

SQL for query:

```
select highpass(s1, 'wpass'='0.45') from root.test.d1
```

Output series:

+-----+-----+	
	Time highpass(root.test.d1.s1, "wpass"="0.45")
+-----+-----+	
1970-01-01T08:00:00.000+08:00	0.9999999534830373
1970-01-01T08:00:01.000+08:00	1.7462829277628608E-8
1970-01-01T08:00:02.000+08:00	-0.9999999593178128
1970-01-01T08:00:03.000+08:00	-4.1115269056426626E-8
1970-01-01T08:00:04.000+08:00	0.9999999925494194
1970-01-01T08:00:05.000+08:00	3.328126513330016E-8
1970-01-01T08:00:06.000+08:00	-1.0000000183304454
1970-01-01T08:00:07.000+08:00	6.260191433311374E-10
1970-01-01T08:00:08.000+08:00	1.0000000018134796
1970-01-01T08:00:09.000+08:00	-3.097210911744423E-17
1970-01-01T08:00:10.000+08:00	-1.0000000018134794
1970-01-01T08:00:11.000+08:00	-6.260191627862097E-10
1970-01-01T08:00:12.000+08:00	1.0000000183304454
1970-01-01T08:00:13.000+08:00	-3.328126501424346E-8
1970-01-01T08:00:14.000+08:00	-0.9999999925494196
1970-01-01T08:00:15.000+08:00	4.111526915498874E-8
1970-01-01T08:00:16.000+08:00	0.9999999593178128
1970-01-01T08:00:17.000+08:00	-1.7462829341296528E-8
1970-01-01T08:00:18.000+08:00	-0.9999999534830369
1970-01-01T08:00:19.000+08:00	-1.035237222742873E-16
+-----+-----+	

Note: The input is $y = \sin(2\pi t/4) + 2\sin(2\pi t/5)$ with a length of 20. Thus, the output is $y = \sin(2\pi t/4)$ after high-pass filtering.

7.5 LowPass

7.5.1 Usage

This function performs low-pass filtering on the input series and extracts components below the cutoff frequency. The timestamps of input will be ignored and all data points will be regarded as equidistant.

Name: LOWPASS

Input: Only support a single input series. The type is INT32 / INT64 / FLOAT / DOUBLE.

Parameters:

- **wpass**: The normalized cutoff frequency which values (0,1). This parameter cannot be lacked.

Output: Output a single series. The type is DOUBLE. It is the input after filtering. The length and timestamps of output are the same as the input.

Note: NaN in the input series will be ignored.

7.5.2 Examples

Input series:

Time	root.test.d1.s1
[1970-01-01T08:00:00.000+08:00]	2.902113
[1970-01-01T08:00:01.000+08:00]	1.1755705
[1970-01-01T08:00:02.000+08:00]	-2.1755705
[1970-01-01T08:00:03.000+08:00]	-1.9021131
[1970-01-01T08:00:04.000+08:00]	1.0
[1970-01-01T08:00:05.000+08:00]	1.9021131
[1970-01-01T08:00:06.000+08:00]	0.1755705
[1970-01-01T08:00:07.000+08:00]	-1.1755705
[1970-01-01T08:00:08.000+08:00]	-0.902113
[1970-01-01T08:00:09.000+08:00]	0.0
[1970-01-01T08:00:10.000+08:00]	0.902113
[1970-01-01T08:00:11.000+08:00]	1.1755705
[1970-01-01T08:00:12.000+08:00]	-0.1755705
[1970-01-01T08:00:13.000+08:00]	-1.9021131
[1970-01-01T08:00:14.000+08:00]	-1.0
[1970-01-01T08:00:15.000+08:00]	1.9021131
[1970-01-01T08:00:16.000+08:00]	2.1755705
[1970-01-01T08:00:17.000+08:00]	-1.1755705
[1970-01-01T08:00:18.000+08:00]	-2.902113
[1970-01-01T08:00:19.000+08:00]	0.0

SQL for query:

```
select lowpass(s1, 'wpass'='0.45') from root.test.d1
```

Output series:

Time	lowpass(root.test.d1.s1, "wpass"="0.45")
[1970-01-01T08:00:00.000+08:00]	1.9021130073323922
[1970-01-01T08:00:01.000+08:00]	1.1755704705132448
[1970-01-01T08:00:02.000+08:00]	-1.1755705286582614
[1970-01-01T08:00:03.000+08:00]	-1.9021130389094498
[1970-01-01T08:00:04.000+08:00]	7.450580419288145E-9
[1970-01-01T08:00:05.000+08:00]	1.902113046743454
[1970-01-01T08:00:06.000+08:00]	1.1755705212076808
[1970-01-01T08:00:07.000+08:00]	-1.1755704886020932
[1970-01-01T08:00:08.000+08:00]	-1.9021130222335536
[1970-01-01T08:00:09.000+08:00]	3.552713678800501E-16
[1970-01-01T08:00:10.000+08:00]	1.9021130222335536
[1970-01-01T08:00:11.000+08:00]	1.1755704886020932
[1970-01-01T08:00:12.000+08:00]	-1.1755705212076801
[1970-01-01T08:00:13.000+08:00]	-1.902113046743454
[1970-01-01T08:00:14.000+08:00]	-7.45058112983088E-9
[1970-01-01T08:00:15.000+08:00]	1.9021130389094498
[1970-01-01T08:00:16.000+08:00]	1.1755705286582616
[1970-01-01T08:00:17.000+08:00]	-1.1755704705132448
[1970-01-01T08:00:18.000+08:00]	-1.9021130073323924
[1970-01-01T08:00:19.000+08:00]	-2.664535259100376E-16

Note: The input is $y = \sin(2\pi t/4) + 2\sin(2\pi t/5)$ with a length of 20. Thus, the output is $y = 2\sin(2\pi t/5)$ after low-pass filtering.

Chapter 8 Series Discovery

8.1 ConsecutiveSequences

8.1.1 Usage

This function is used to find locally longest consecutive subsequences in strictly equispaced multidimensional data.

Strictly equispaced data is the data whose time intervals are strictly equal. Missing data, including missing rows and missing values, is allowed in it, while data redundancy and timestamp drift is not allowed.

Consecutive subsequence is the subsequence that is strictly equispaced with the standard time interval without any missing data. If a consecutive subsequence is not a proper subsequence of any consecutive subsequence, it is locally longest.

Name: CONSECUTIVESEQUENCES

Input Series: Support multiple input series. The type is arbitrary but the data is strictly equispaced.

Parameters:

- gap**: The standard time interval which is a positive number with an unit. The unit is 'ms' for millisecond, 's' for second, 'm' for minute, 'h' for hour and 'd' for day. By default, it will be estimated by the mode of time intervals.

Output Series: Output a single series. The type is INT32. Each data point in the output series corresponds to a locally longest consecutive subsequence. The output timestamp is the starting timestamp of the subsequence and the output value is the number of data points in the subsequence.

Note: For input series that is not strictly equispaced, there is no guarantee on the output.

8.1.2 Examples

8.1.2.1 Manually Specify the Standard Time Interval

It's able to manually specify the standard time interval by the parameter `gap`. It's notable that false parameter leads to false output.

Input series:

Time	root.test.d1.s1	root.test.d1.s2
2020-01-01T00:00:00.000+08:00	1.0	1.0
2020-01-01T00:05:00.000+08:00	1.0	1.0
2020-01-01T00:10:00.000+08:00	1.0	1.0

[2020-01-01T00:20:00.000+08:00]	1.0	1.0
[2020-01-01T00:25:00.000+08:00]	1.0	1.0
[2020-01-01T00:30:00.000+08:00]	1.0	1.0
[2020-01-01T00:35:00.000+08:00]	1.0	1.0
[2020-01-01T00:40:00.000+08:00]	1.0	null
[2020-01-01T00:45:00.000+08:00]	1.0	1.0
[2020-01-01T00:50:00.000+08:00]	1.0	1.0

SQL for query:

```
select consecutivesequences(s1,s2,'gap'='5m') from root.test.d1
```

Output series:

Time	consecutive sequences(<code>root.test.d1.s1</code> , <code>root.test.d1.s2</code> , "gap"="5m")
[2020-01-01T00:00:00.000+08:00]	3
[2020-01-01T00:20:00.000+08:00]	4
[2020-01-01T00:45:00.000+08:00]	2

8.1.2.2 Automatically Estimate the Standard Time Interval

When `gap` is default, this function estimates the standard time interval by the mode of time intervals and gets the same results. Therefore, this usage is more recommended.

Input series is the same as above, the SQL for query is shown below:

```
select consecutivesequences(s1,s2) from root.test.d1
```

Output series:

Time consecutivesequences(root.test.d1.s1, root.test.d1.s2)	
2020-01-01T00:00:00.000+08:00	3
2020-01-01T00:20:00.000+08:00	4
2020-01-01T00:45:00.000+08:00	2

8.2 ConsecutiveWindows

8.2.1 Usage

This function is used to find consecutive windows of specified length in strictly equispaced multidimensional data.

Strictly equispaced data is the data whose time intervals are strictly equal. Missing data, including missing rows and missing values, is allowed in it, while data redundancy and timestamp drift is not allowed.

Consecutive window is the subsequence that is strictly equispaced with the standard time interval without any missing data.

Name: CONSECUTIVEWINDOWS

Input Series: Support multiple input series. The type is arbitrary but the data is strictly equispaced.

Parameters:

- **gap**: The standard time interval which is a positive number with an unit. The unit is 'ms' for millisecond, 's' for second, 'm' for minute, 'h' for hour and 'd' for day. By default, it will be estimated by the mode of time intervals.
- **length**: The length of the window which is a positive number with an unit. The unit is 'ms' for millisecond, 's' for second, 'm' for minute, 'h' for hour and 'd' for day. This parameter cannot be lacked.

Output Series: Output a single series. The type is INT32. Each data point in the output series corresponds to a consecutive window. The output timestamp is the starting timestamp of the window and the output value is the number of data points in the window.

Note: For input series that is not strictly equispaced, there is no guarantee on the output.

8.2.2 Examples

Input series:

Time	root.test.d1.s1	root.test.d1.s2
[2020-01-01T00:00:00.000+08:00]	1.0	1.0
[2020-01-01T00:05:00.000+08:00]	1.0	1.0
[2020-01-01T00:10:00.000+08:00]	1.0	1.0
[2020-01-01T00:20:00.000+08:00]	1.0	1.0
[2020-01-01T00:25:00.000+08:00]	1.0	1.0
[2020-01-01T00:30:00.000+08:00]	1.0	1.0
[2020-01-01T00:35:00.000+08:00]	1.0	1.0
[2020-01-01T00:40:00.000+08:00]	1.0	null
[2020-01-01T00:45:00.000+08:00]	1.0	1.0
[2020-01-01T00:50:00.000+08:00]	1.0	1.0

SQL for query:

```
select consecutivewindows(s1,s2,'length'='10m') from root.test.d1
```

Output series:

Time consecutivewindows(root.test.d1.s1, root.test.d1.s2, "length"="10m")	
2020-01-01T00:00:00.000+08:00	3
2020-01-01T00:20:00.000+08:00	3
2020-01-01T00:25:00.000+08:00	3

Chapter 9 Complex Event Processing

9.1 AND(TODO)

9.2 EventMatching(TODO)

9.3 EventNameRepair(TODO)

9.4 EventTag(TODO)

9.5 EventTimeRepair(TODO)

9.6 MissingEventRecovery(TODO)

9.7 SEQ(TODO)