AIM-CU

Version 1.0.0

Table of Contents

Contents:

AIM-CU documentation

A CUSUM-based tool for AI Monitoring

AIM-CU is a statistical tool for AI monitoring using cumulative sum (AIM-CU). AIM-CU computes:

- The parameter choices for change-point detection based on an acceptable false alarm rate
- Detection delay estimates for a given displacement of the performance metric from the target for those parameter choices.

Code execution

Clone AIM-CU repository.

```
git clone https://github.com/DIDSR/AIM-CU.git
```

Run the following commands to install required dependencies (Python = 3.10 is used).

```
apt-get -y install python3
apt-get -y install pip
cd AIM-CU
pip install -r requirements.txt
```

Run AIM-CU.

```
python3 app.py
```

Open the URL http://0.0.0.0:7860 that is running the AIM-CU locally.

Demo

AIM-CU can also be run through the demo available at https://huggingface.co/spaces/didsr/AIM-CU . If Space is paused, click on Restart button.

Methods

A two-sided CUSUM control chart computes the cumulative differences or deviations of individual observations from the target mean (or in-control mean, μ_{in}). The positive and negative cumulative sums are calculated:

$$\begin{split}\\ S_{hi}(d) = max(0, S_{hi}(d-1) + x_d - \hat{\mu}_{in} - K) \\ S_{lo}(d) = max(0, S_{lo}(d-1) - x_d + \hat{\mu}_{in} - K)\end{split}$$

where *d* denotes a unit of time, x_d is the value of quantity being monitored at time d , $\hat{\mu}_{in}$ is the in-control mean of x_d , and K is a “reference value” related to the magnitude of change that one is interested in detecting. S_{hi} and S_{lo} are the cumulative sum of positive and negative changes. To detect a change in the observed values from the in-control mean, the CUSUM scheme accumulates deviations that are K units away from the in-control mean. Let σ_{in} denote the in-control standard deviation of x_d .

Performance Assessment for CUSUM

Let *d=0,...n-1* indicate the days (or time), where *n* is the total length of time during which the AI model performance is monitored. We assume that the AI model performance is in-control between days 0 and d_s , $d_s<d_{n-1}$, and a change in performance occurs on day d_s such that $x_{0...d_{s-1}}$ and $x_{d_{s}...d_{n-1}}$ are AI performance measure values for the pre-change and the post-change periods respectively.

In this setting, three different cases are of interest:

- Change-point is detected at $d_d : d_d \ge d_s$ with a detection delay $d_d - d_s$.
- Change-point is detected at $d_d : d_d < d_s$. This is called a false alarm (type-I error).
- Change-point is not detected. This is a missed detection (type-II error).

Mean time between false alarms (MTBFA)

\[\label{MTBFA_estimate} \widehat{MTBFA} = \frac{\sum_{j=1} ^{N} z_j}{\sum_{j=1} ^{N} d_j}\] where \(N\) is the number of independent experiments, \(d_j\) is a binary value for each experiment indicating whether or not a change was detected in the pre-change regime, \(d_j \in \{0,1\}\) and \(z_j = min(d_d(j), d_s)\) .

Average Detection Delay (ADD)

\[\label{ADD_estimate} \widehat{ADD} = \frac{\sum_{j=1} ^{N} z_j- d_s}{\sum_{j=1} ^{N} c_j}\] where \(c_j\) is a binary value for each experiment indicating whether or not a change was detected in the post change regime, \(c_j \in \{0,1\}\) and \(z_j = min(d_d(j), n)\) .

CUSUM

Cumulative Sum (CUSUM)

@author: smriti.prathapan

class package.cusum. CUSUM

CUSUM class and its functionalities.

change_detection (*pre_change_days : int* , *normalized_ref_value : float = 0.5* , *normalized_threshold : float = 4*) → None

Detects a change in the process.

Parameters :

- **pre_change_days** (*int*) – Number of days for in-control phase.
- **normalized_ref_value** (*float* , *optional*) – Normalized reference value for detecting a unit standard deviation change in mean of the process. Defaults to 0.5.
- **normalized_threshold** (*float* , *optional*) – Normalized threshold. Defaults to 4.

compute_cusum (*x : list [float]* , *mu_0 : float* , *k : float*) → tuple [list [float] , list [float] , list [float]]

Compute CUSUM for the observations in x

Parameters :

- x (*list [float]*) – Performance metric to be monitored
- mu_0 (*float*) – In-control mean of the observations/ performance metric
- k (*float*) – Reference value related to the magnitude of change that one is interested in detecting

Returns :

Positive cumulative sum, negative cumulative sum, and CUSUM

Return type :

tuple[list[float], list[float], list[float]]

initialize ( ) → None

Initialize with the configuration file.

plot_cusum_plotly ( ) → Figure

Plot CUSUM value using Plotly

Returns :

CUSUM plot using Plotly graph object.

Return type :

go.Figure

plot_histogram_plotly (*data* , *xlabel* , *title = ''*) → Figure

Plot the histogram of the observations/performance metric being monitored using plotly

Parameters :

- **data** (*_type_*) – Data values to show in histogram.
- **xlabel** (*_type_*) – Title of the label for X-axis.
- **title** (*str , optional*) – Title of the plot. Defaults to “”.

Returns :

Histogram as Plotly graph object.

Return type :

go.Figure

plot_input_metric_plotly ( ) → Figure

Plot the input metric using Plotly.

Returns :

Scatter plot as Plotly graph object.

Return type :

go.Figure

set_df_metric_csv (*data_csv : DataFrame*) → None

Assign the performance metric data to be used for CUSUM.

Parameters :

data_csv (*DataFrame or TextFileReader*) – A comma-separated values (csv) file is returned as two-dimensional data structure with labeled axes.

set_df_metric_default ( ) → None

Read the provided performance metric data to be used for CUSUM for an example.

set_timeline (*data : ndarray*) → None

Set the timeline of observations.

Parameters :

data (*np.ndarray*) – Data of the metric values across the observations.

ARLTheoretical

ARLTheoretical

@author: smriti.prathapan

package.ARLTheoretical. **get_ARL_1** (*h : float* , *shift_in_mean : list [float]* , *dict_ARL0_k : OrderedDict*) → DataFrame

Get the ARL1 along with k values.

Parameters :

- **h** (*float*) – Normalized threshold.
- **shift_in_mean** (*list [float]*) – List of the values of shift in mean.
- **dict_ARL0_k** (*OrderedDict*) – Data dictionary of ARL0 and k

Returns :

Table for ARL1 and k values.

Return type :

pd.DataFrame

package.ARLTheoretical. **get_ARL_1_h_mu1_k** (*h : float* , *k : float* , *mu1 : float*) → float

Calculate ARL_1 with given Shift in Mean (mu1) and k.

Parameters :

- **h** (*float*) – Normalized threshold.
- **k** (*float*) – Normalized reference value.
- **mu1** (*float*) – Intended shift in mean.

Returns :

Detection delay (ARL1).

Return type :

float

package.ARLTheoretical. get_ref_value (*h : float* , *list_ARL_0 : list [float]*) → tuple [DataFrame , OrderedDict]

provides normalized reference values k for provided list of ARL0, given the value of normalized threshold h.

Parameters :

- h (*float*) – Normalized threshold.
- list_ARL_0 (*list*) – List of ARL0 values.

Returns :

Dataframe of ARL0 and k, Data dictionary of ARL0 and k;
where k is normalized reference value.

Return type :

tuple[pd.Dataframe, OrderedDict]

package.ARLTheoretical. get_ref_value_k (*h : float* , *ARL_0 : float*) → float

Calculation for the reference value for given h and ARL_0.

Parameters :

- h (*float*) – Normalized threshold.
- ARL_0 (*float*) – ARL0 value.

Returns :

Normalized reference value k.

Return type :

float

Utils

Utilities to handle different operations

package.utils. get_greattable_as_html (*df : DataFrame*) → GT

Get the great_table as HTML from Pandas dataframe.

Parameters :

df (*pd.DataFrame*) – Dataframe to rendera as a table.

Returns :

Table in HTML format.

Return type :

gt.GT

package.utils. populate_summary_table_ARL0_k (*summary_table_df_ARL0_k : DataFrame* , *h*) → GT

Populate ARLTheoretical.summary_table_df_ARL0_k.

Parameters :

- **summary_table_df_ARL0_k** (*pd.DataFrame*) – Dataframe of ARL0 and its respective values of k.
- **h** (*float*) – Normalized threshold.

Returns :

Table of ARL0 and k in HTML format.

Return type :

gt.GT

package.utils. populate_summary_table_ARL1_k (*summary_table_df_ARL1_k : DataFrame* , *dict_ARL0_k : OrderedDict* , *h*) → GT

Populate Multiindex table specific for ARLTheoretical.summary_table_df_ARL1_k

Parameters :

- **summary_table_df_ARL1_k** (*pd.DataFrame*) – Dataframe with ARL1 and k values.
- **dict_ARL0_k** (*OrderedDict*) – Data Dictionary with the mapping between ARL0 and k.
- **h** (*float*) – Normalized threshold.

Returns :

Table for ARL1 and k in HTML format.

Return type :

gt.GT

Created using Sphinx 8.1.3.