



Sliding CUSUM and its Solutions to Anomaly Detection problems in the field of

Digital Currency

Dang Thanh Lam - 20194442
Nguyen Vu Thien Trang - 20194459
Nguyen Van Thanh Tung - 20190090

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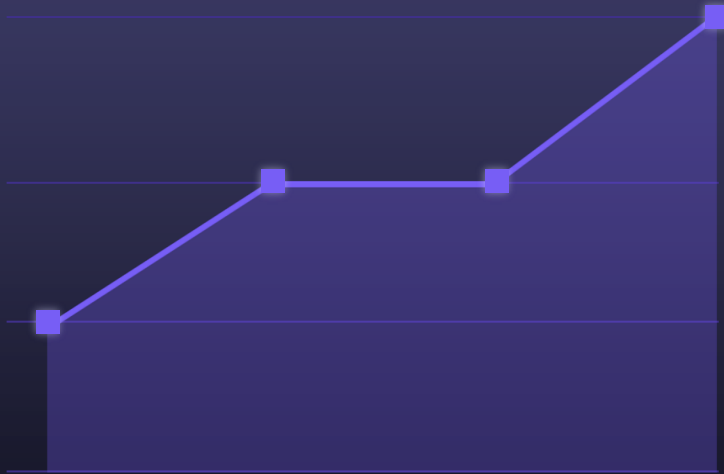
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Problem Statement



Concept Drift

The phenomenon where statistical properties of the target variable change overtime in unforeseen ways.

→ Predictions become less accurate as time passes



Sliding CUSUM

Basis Knowledge | Sliding Window



Sliding Window

Split an unbounded stream of data (events) into finite sets. Observes the most recent data points measurements and moves by a fixed step size along the time axis as new ones arrive.

Basis Knowledge | CUSUM

One-sided CUmulative SUM

μ	The expected mean
σ	The expected standard deviation
k	The size of the shift to be detected
H	The control limit

$$S_0 = 0$$

$$S_{n+1} = \max(0, S_n + X_n - \mu - k)$$

$$\text{for } n = 1, 2, \dots, N$$

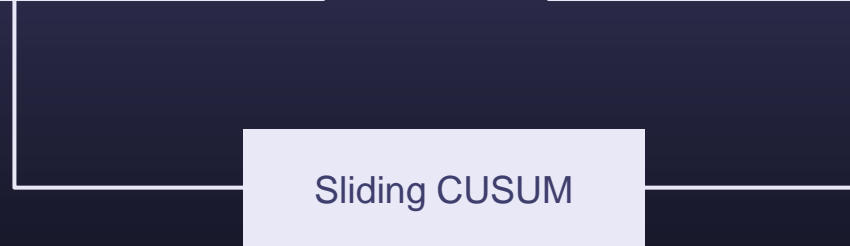
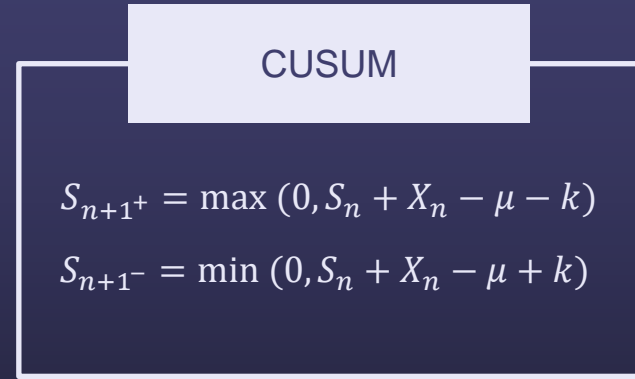
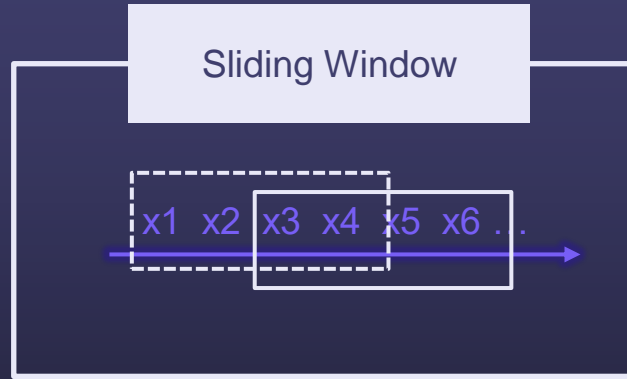
Basis Knowledge | CUSUM

Two-sided CUmulative SUM

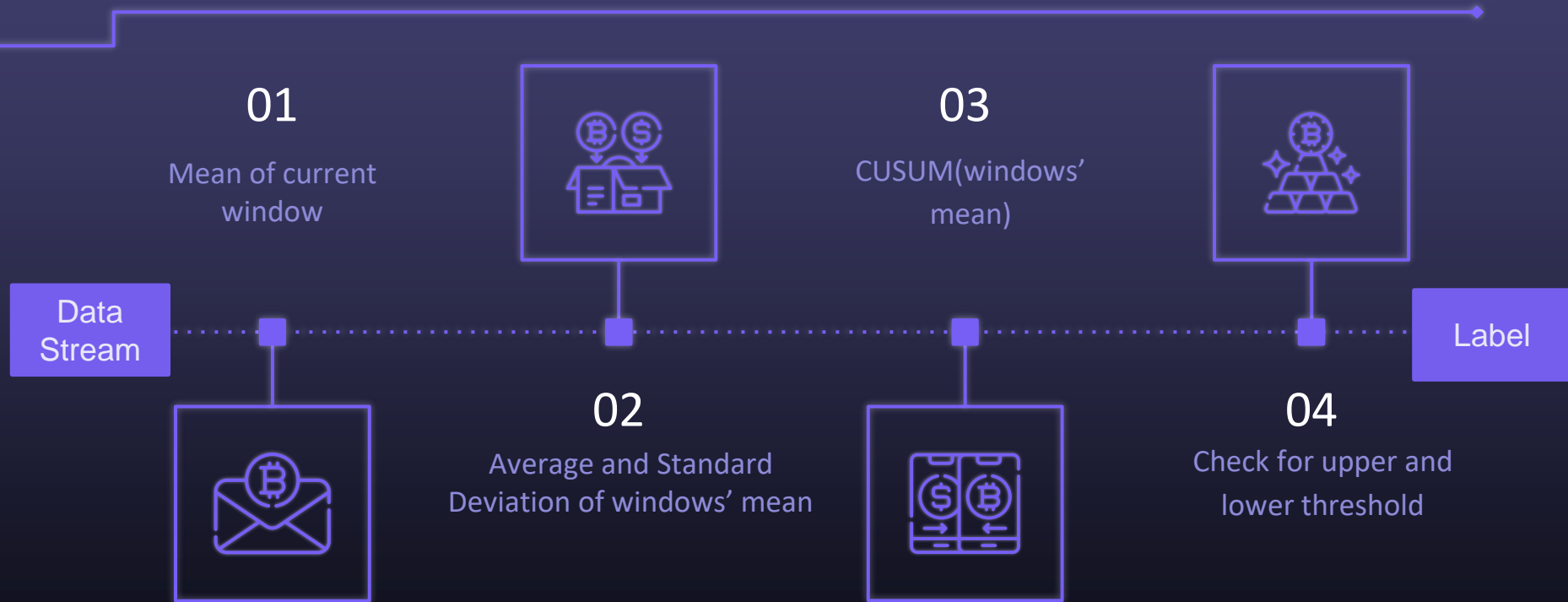
μ	The expected mean
σ	The expected standard deviation
k	The size of the shift to be detected
H	The control limit

$$S_{n+1}^+ = \max(0, S_n + X_n - \mu - k)$$

$$S_{n+1}^- = \min(0, S_n + X_n - \mu + k)$$



Sliding CUSUM | Main Idea



Sliding CUSUM | Notations and Formulas

L_W Length of the windows

β The output rate

M_L The mean of the latest window

D_{mL} The mean of windows' mean values

D_{SL} The mean of the windows' standard deviation

S_{n+1}^+ The upper cumulative sum

S_{n+1}^- The lower cumulative sum

$$S_{n+1}^+ = \max (0, S_n + M_L - D_{mL} - \beta * D_{SL})$$

$$S_{n+1}^- = \min (0, S_n + M_L - D_{mL} + \beta * D_{SL})$$

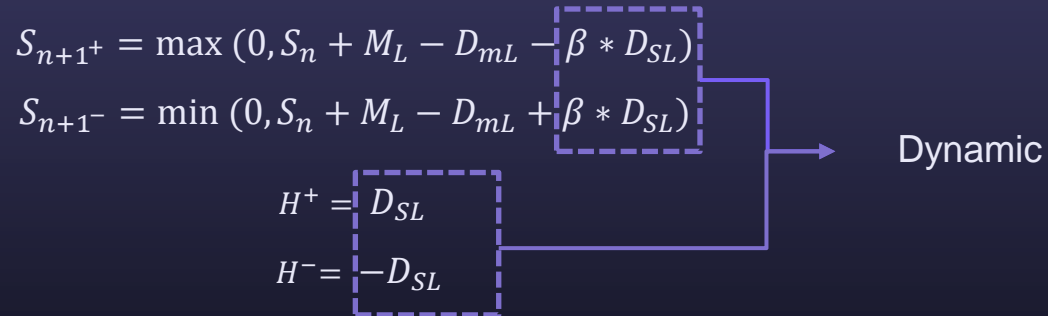
$$H^+ = D_{SL}$$

$$H^- = -D_{SL}$$

Sliding CUSUM | Notations and Formulas

$$\begin{aligned} S_{n+1}^+ &= \max(0, S_n + M_L - D_{mL} - \beta * D_{SL}) \\ S_{n+1}^- &= \min(0, S_n + M_L - D_{mL} + \beta * D_{SL}) \end{aligned}$$
$$\begin{aligned} H^+ &= D_{SL} \\ H^- &= -D_{SL} \end{aligned}$$

Dynamic





Sliding CUSUM

INITIALIZE L_w, β

COMPUTE M_L

UPDATE D_{mL}, D_{SL}

$S_{n+1}^+ = \max(0, S_n + M_L - D_{mL} - \beta * D_{SL})$

$S_{n+1}^- = \min(0, S_n + M_L - D_{mL} + \beta * D_{SL})$

IF $S_{n+1}^+ > D_{SL}$ THEN

$Label \leftarrow Anomaly$

IF $S_{n+1}^- < -D_{SL}$ THEN

$Label \leftarrow Anomaly$

Experiments

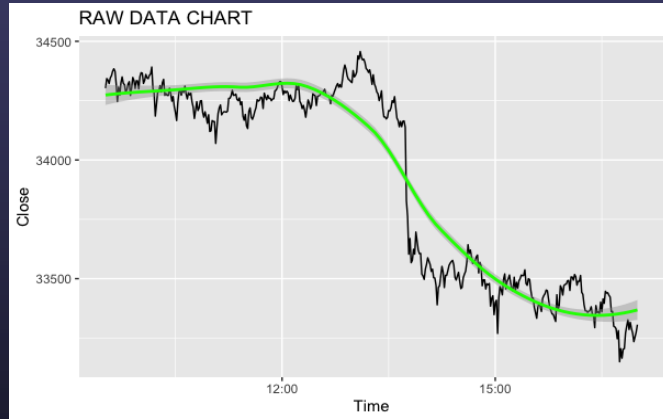


Figure 7. Data analysis diagram

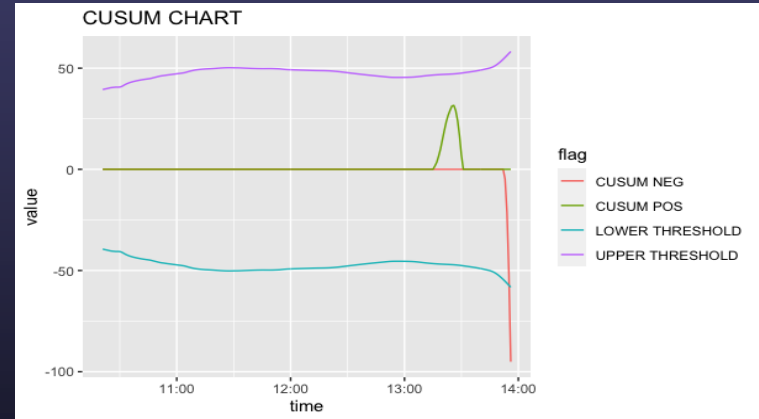


Figure 8. SCUSUM



THANK YOU

Do you have any question?

lam.dt194442@sis.hust.edu.vn
trang.nvt194459@sis.hust.edu.vn
tung.nvt0090@sis.hust.edu.vn