

CLAIMS

What is claimed is:

1. A computer-implemented method, comprising:
 - determining a plurality of system indicators to be monitored in a computing system, wherein a first system indicator of the plurality of system indicators is correlated with one or more second system indicators of the plurality of system indicators;
 - obtaining training data based on historical data of the plurality of system indicators;
 - training a long short-term memory (LSTM) model using the training data as a trained LSTM model;
 - simultaneously monitoring the plurality of system indicators in the computing system based on the trained LSTM model, wherein simultaneously monitoring the plurality of system indicators in the computing system based on the trained LSTM model comprises:
 - obtaining real-time data of the plurality of system indicators;
 - obtaining historical data of the plurality of system indicators within a previous time period;
 - inputting the historical data of the plurality of system indicators within the previous time period into the trained LSTM model;
 - obtaining predicted data of the plurality of system indicators from the trained LSTM model based on the inputting of the historical data of the plurality of system indicators within the previous time period; and
 - comparing the real-time data of the plurality of system indicators with the predicted data of the plurality of system indicators; and
 - raising an alarm in response to detecting one or more co-movement anomalies between the first system indicator and the one or more second system indicators, wherein a co-movement anomaly is detected when an anomaly has occurred in one of the one or more second system indicators and has not occurred in the first system indicator.
2. The computer-implemented method of claim 1, wherein obtaining training data based on historical data of the plurality of system indicators comprises:
 - determining a historical time period; and
 - for each particular system indicator of the plurality of system indicators:
 - collecting historical data of the particular system indicator within the historical time period; and

arranging, in a chronological order, the historical data of the particular system indicator within the historical time period.

3. The computer-implemented method of claim 2, wherein the historical time period includes n predetermined time intervals, the plurality of system indicators include a first system indicator x and a second system indicator y , and the method further comprises:

for each particular predetermined time interval in the historical time period, constructing $\begin{bmatrix} x_{i-t} & \dots & x_{i-1}x_i \\ y_{i-t} & \dots & y_{i-1}y_i \end{bmatrix}$, a matrix i , wherein i is the particular predetermined time interval in the historical time period, t is a data cycle, x_i is historical data of the first system indicator x at the particular predetermined time interval i , and y_i is historical data of the second system indicator y at the particular predetermined time interval i ; and

constructing the training data using the n constructed matrices.

4. The computer-implemented method of claim 3, wherein training the LSTM model using the training data comprises input of the matrix i into the LSTM model with $\begin{bmatrix} x_i \\ y_i \end{bmatrix}$ input as a label dataset and $\begin{bmatrix} x_{i-t} & \dots & x_{i-1} \\ y_{i-t} & \dots & y_{i-1} \end{bmatrix}$ input as a feature dataset.

5. The computer-implemented method of claim 1, wherein comparing the real-time data of the plurality of system indicators with the predicted data of the plurality of system indicators comprises:

for each particular system indicator of the plurality of system indicators, calculating an absolute value of a difference between the real-time data of the particular system indicator and the predicted data of the particular system indicator;

summing up the calculated absolute values for the plurality of system indicators; and

determining an anomaly if the summed absolute values exceeds a predetermined threshold.

6. The computer-implemented method of claim 1, further comprising:

determining that one or more system indicators are to be added to or removed from the plurality of system indicators;

obtaining updated training data based on historical data of the updated plurality of system indicators; and

retraining the LSTM model using the updated training data.

7. A non-transitory, computer-readable medium storing one or more instructions executable by a computer system to perform operations comprising:

- determining a plurality of system indicators to be monitored in a computing system, wherein a first system indicator of the plurality of system indicators is correlated with one or more second system indicators of the plurality of system indicators;

- obtaining training data based on historical data of the plurality of system indicators;

- training a long short-term memory (LSTM) model using the training data as a trained LSTM model;

- simultaneously monitoring the plurality of system indicators in the computing system based on the trained LSTM model, wherein simultaneously monitoring the plurality of system indicators in the computing system based on the trained LSTM model comprises:

 - obtaining real-time data of the plurality of system indicators;

 - obtaining historical data of the plurality of system indicators within a previous time period;

 - inputting the historical data of the plurality of system indicators within the previous time period into the trained LSTM model;

 - obtaining predicted data of the plurality of system indicators from the trained LSTM model based on the inputting of the historical data of the plurality of system indicators within the previous time period; and

 - comparing the real-time data of the plurality of system indicators with the predicted data of the plurality of system indicators; and

 - raising an alarm in response to detecting one or more co-movement anomalies between the first system indicator and the one or more second system indicators, wherein a co-movement anomaly is detected when an anomaly has occurred in one of the one or more second system indicators and has not occurred in the first system indicator.

8. The non-transitory, computer-readable medium of claim 7, wherein obtaining training data based on historical data of the plurality of system indicators comprises:

- determining a historical time period; and

- for each particular system indicator of the plurality of system indicators:

collecting historical data of the particular system indicator within the historical time period; and

arranging, in a chronological order, the historical data of the particular system indicator within the historical time period.

9. The non-transitory, computer-readable medium of claim 8, wherein the historical time period includes n predetermined time intervals, the plurality of system indicators include a first system indicator x and a second system indicator y , and the operations further comprises:

for each particular predetermined time interval in the historical time period, constructing $\begin{bmatrix} x_{i-t} & \dots & x_{i-1} & x_i \\ y_{i-t} & \dots & y_{i-1} & y_i \end{bmatrix}$, a matrix i , wherein i is the particular predetermined time interval in the historical time period, t is a data cycle, x_i is historical data of the first system indicator x at the particular predetermined time interval i , and y_i is historical data of the second system indicator y at the particular predetermined time interval i ; and

constructing the training data using the n constructed matrices.

10. The non-transitory, computer-readable medium of claim 9, wherein training the LSTM model using the training data comprises input of the matrix i into the LSTM model with $\begin{bmatrix} x_i \\ y_i \end{bmatrix}$ input as a label dataset and $\begin{bmatrix} x_{i-t} & \dots & x_{i-1} \\ y_{i-t} & \dots & y_{i-1} \end{bmatrix}$ input as a feature dataset.

11. The non-transitory, computer-readable medium of claim 7, wherein comparing the real-time data of the plurality of system indicators with the predicted data of the plurality of system indicators comprises:

for each particular system indicator of the plurality of system indicators, calculating an absolute value of a difference between the real-time data of the particular system indicator and the predicted data of the particular system indicator;

summing up the calculated absolute values for the plurality of system indicators; and

determining an anomaly if the summed absolute values exceeds a predetermined threshold.

12. The non-transitory, computer-readable medium of claim 7, the operations further comprising:

determining that one or more system indicators are to be added to or removed from the plurality of system indicators;

obtaining updated training data based on historical data of the updated plurality of system indicators; and

retraining the LSTM model using the updated training data.

13. A computer-implemented system, comprising:

one or more computers; and

one or more computer memory devices interoperably coupled with the one or more computers and having tangible, non-transitory, machine-readable media storing one or more instructions that, when executed by the one or more computers, perform one or more operations comprising:

determining a plurality of system indicators to be monitored in a computing system, wherein a first system indicator of the plurality of system indicators is correlated with one or more second system indicators of the plurality of system indicators;

obtaining training data based on historical data of the plurality of system indicators;

training a long short-term memory (LSTM) model using the training data as a trained LSTM model;

simultaneously monitoring the plurality of system indicators in the computing system based on the trained LSTM model, wherein simultaneously monitoring the plurality of system indicators in the computing system based on the trained LSTM model comprises:

obtaining real-time data of the plurality of system indicators;

obtaining historical data of the plurality of system indicators within a previous time period;

inputting the historical data of the plurality of system indicators within the previous time period into the trained LSTM model;

obtaining predicted data of the plurality of system indicators from the trained LSTM model based on the inputting of the historical data of the plurality of system indicators within the previous time period; and

comparing the real-time data of the plurality of system indicators with the predicted data of the plurality of system indicators; and

raising an alarm in response to detecting one or more co-movement anomalies between the first system indicator and the one or more second system indicators, wherein a co-movement anomaly is detected when an anomaly has occurred in one of the one or more second system indicators and has not occurred in the first system indicator.

14. The computer-implemented system of claim 13, wherein obtaining training data based on historical data of the plurality of system indicators comprises:

determining a historical time period; and

for each particular system indicator of the plurality of system indicators:

collecting historical data of the particular system indicator within the historical time period; and

arranging, in a chronological order, the historical data of the particular system indicator within the historical time period.

15. The computer-implemented system of claim 14, wherein the historical time period includes n predetermined time intervals, the plurality of system indicators include a first system indicator x and a second system indicator y , and the operations further comprises:

for each particular predetermined time interval in the historical time period, constructing $\begin{bmatrix} x_{i-t} & \dots & x_{i-1} & x_i \\ y_{i-t} & \dots & y_{i-1} & y_i \end{bmatrix}$, a matrix i , wherein i is the particular predetermined time interval in the historical time period, t is a data cycle, x_i is historical data of the first system indicator x at the particular predetermined time interval i , and y_i is historical data of the second system indicator y at the particular predetermined time interval i ; and

constructing the training data using the n constructed matrices.