

Claims:

1. A computer-implemented method (100) for training a prediction model (1) for predicting the likelihood that at least one predetermined undesired event will occur during execution of a process (2) using training samples (3), wherein each training sample (3) comprises data that characterizes a state of the process (2), and the method (100) comprises the steps of:
 - obtaining (110) training samples (3) representing states of the process (2) that do not cause the undesired event, and labelling these training samples with a pre-set low likelihood of the undesired event occurring;
 - obtaining (120), based at least in part on a process model (2a) and a set of predetermined rules (2b) that stipulate in which states of the process (2) there is an increased likelihood of the undesired event occurring, further augmented training samples (4) representing states of the process (2) with an increased likelihood to cause the undesired event, and labelling these training samples (4) with said increased likelihood;
 - providing (130) the obtained training samples (3, 4) to the to-be-trained prediction model (1), so as to obtain, from the prediction model (1), a prediction (5) of the likelihood for occurrence of the undesired event in a state of the process (2) represented by the respective sample (3, 4);
 - rating (140) a difference between the prediction (5) and the label of the respective sample (3, 4) by means of a predetermined loss function (6); and
 - optimizing (150) parameters (1a) that characterize the behavior of the prediction model (1), such that, when predictions (5) on further samples (3, 4) are made, the rating (6a) by the loss function (6) is likely to improve.
2. The method (100) of claim 1, wherein the undesired event comprises a safety interlock event that forces an at least partial stop and/or shutdown of the process (2), and/or of the industrial plant or electric network that is executing the process (2).
3. The method (100) of any one of claims 1 to 2, wherein the likelihood of the undesired event occurring is measured
 - on a scale of a probability that the undesired event occurs; and/or
 - on a scale of closeness of the state of the process (2) to a state that causes the undesired event to occur.

4. The method (100) of any one of claims 1 to 3, wherein the process model (2a) is specifically configured (121) to predict a future evolution of the state of the process (2) based on at least one current and/or past state of the process (2).
5. The method (100) of any one of claims 1 to 4, wherein the process model (2a) comprises (122):
 - a machine learning model; and/or
 - a simulation model; and/or
 - a surrogate approximation of this simulation model.
6. The method (100) of any one of claims 1 to 5, further comprising:
 - determining (111), based at least in part on the predetermined rules (2b), which of the variables that characterize the state of the process (2) have an impact on the likelihood of the undesired event occurring; and
 - including (112, 123) these variables, and/or processing results obtained from these variables, in the training samples (3, 4).
7. The method (100) of any one of claims 1 to 6, further comprising: including (113, 124), in the training samples (3, 4), at least one statistical moment, and/or a time series, of at least one state variable of the process (2).
8. The method (100) of any one of claims 1 to 7, further comprising: obtaining (131), by the prediction model (1), a prediction (5) of the likelihood for occurrence of the undesired event at the end of a predetermined time window based on samples (3, 4) within this time window.
9. The method (100) of any one of claims 1 to 8, further comprising: approximating (160) the behavior of the trained prediction model (1*) by means of a surrogate model (1**) that is computationally cheaper to evaluate than the trained prediction model (1*).
10. A method (200) for executing a process (2) on at least one industrial plant or in at least one electric network, comprising the steps of:
 - providing (210) one or more samples (7) representing a state of the process (2) to a prediction model (1*) that has been trained according to the method of any one of claims 1 to 9, and/or to a surrogate approximation (1**) thereof, so as to obtain a prediction (5) of the likelihood for occurrence of

the undesired event in a state of the process (2) represented by the one or more samples;

- testing (220) the prediction (5) against at least one predetermined criterion (8); and
- in response to the criterion (8) being met, outputting (230) an alarm to an operator (16) of the process (2), and/or modifying (240) the execution of the process (2) with the goal of reducing the likelihood for occurrence of the undesired event.

11. The method (100) of claim 10, wherein the modifying (240) the execution of the process comprises:

- providing (241) samples (7) representing multiple candidate states of the process (2) that are different from the current state of the process (2) to the prediction model (1), thereby obtaining likelihoods for occurrence of the undesired event for the candidate states; and
- steering (242) execution of the process (2) towards a candidate state with the least likelihood for occurrence of the undesired event as a target state.

12. The method (100) of claim 11, further comprising:

- collecting (211), by an edge system (10) of an industrial plant or other site that participates in executing the process (2), samples (7) representing states of the process (2);
- providing (250), by the edge system (10), the samples (7) to a cloud platform (11);
- training, and/or updating (260), on the cloud platform (11), based on the samples (7) obtained from the edge system (10), the prediction model (1);
- creating (270), by the cloud platform (11), a surrogate approximation (1**) for the trained and/or updated prediction model (1*), and/or an update to such an approximation (1**);
- providing (280), by the cloud platform (11), the surrogate approximation (1**), and/or the update thereto, to the edge system (10); and
- evaluating (212), on the edge system (10), the surrogate approximation (1**), so as to obtain the prediction (5) of the likelihood for occurrence of the undesired event.

13. A computer program, comprising machine-readable instructions that, when executed by one or more computers, cause the one or more computers to perform a method (100, 200) of any one of claims 1 to 12.

14. A non-transitory machine-readable storage medium,
and/or a download product, with the computer program of claim 13.
15. One or more computers with the computer program
of claim 13, and/or with the non-transitory machine-readable storage medium
and/or download product of claim 14.