

CLAIMS

1. A method (400) for detecting anomalies in a water distribution system
5 composed of a network of nodes, said method comprising:
- parametrizing (220) a hydraulic model (211) of the water distribution system with a set of values (210) of control variables characterizing the network and its output at the nodes;
 - using sensors on the network to acquire (230) observations of a
10 subset of state variables at first time references;
 - identifying (410) at least one target entity where to change the values of control variables based on at least said observations;
 - changing (250) the set of values of control variables using a stepwise adjustment of the control variables and a break criterion based on
15 residue values of the state variables;
 - performing a classification (270) of at least one entity of the network in a state according to the set of control variables.
2. The method of claim 1, further comprising identifying at least one control
20 variable to change based on at least said observations.
3. The method of one of claims 1 and 2, wherein identifying at least one target entity where to change the values of control variables based on at least said observations comprises:
- 25 - using the hydraulic model to calculate (320) predicted values of a set of state variables characterizing at least a water velocity and pressure at the nodes, said predicted values being associated to second time references;
 - computing (330) residue values of the subset of the state variables as
30 a difference between predicted values and observations at the second time references;

- performing (510) a statistical analysis of residue values at an entity of the network at a selection of the time references;
- classifying (520) the entities of the network based on rules applied to the output of the statistical analysis.

5

4. The method of claim 3, wherein said at least one target entity is identified by being classified in an abnormal state based on the comparison of residue values and a predefined threshold.

10 5. The method of one of claims 1 and 2, wherein identifying at least one target entity where to change the values of control variables based on at least said observations comprises identifying an arc of the network wherein a value of an observation of water speed exceeds a threshold at a target entity.

15 6. The method of one of claims 1 to 5, wherein changing (250) the set of values of control variables is performed for at least one event type, and the control variables to modify are based on said at least one event type.

20 7. The method of claim 6, wherein a plurality of event types is tested, and one instance of changing (250) the set of values of control variables is performed for each event type.

25 8. The method of one of claims 6 and 7, when they depend on claim 3, wherein at least changing the set of values of control variables is performed for said at least one event type chosen using classification (520) of the entities of the network based on rules applied to the output of the statistical analysis.

30 9. The method of one of claims 1 to 8, comprising:
 - detecting (530) an anomaly based on the output of identifying (410) at least one target entity where to change the values of control variables based on at least said observations;

- if no anomaly is detected, enriching a database of normal states of the entities (540);
- if an anomaly is detected:
 - o Changing (250) the set of values of control variables using a stepwise adjustment of the control variables and a break criterion based on residue values of the state variables;
 - o Performing the second classification (270) of at least one entity of the network in a state according to the set of control variables.

10

10. The method of one of claims 1 to 9, wherein changing the set of values of control variables using a stepwise adjustment of the control variables and a break criterion based on residue values of the state variables comprises:

- A) changing the set of values of the control variables (310);
- B) using the hydraulic model to calculate (320) predicted values of a set of state variables characterizing at least water velocity and pressure at the nodes at the time references;
- C) computing residue values (330) of the set of state variables as a difference between predicted values and observations at the time references;
- D) if said differences satisfy a break criterion (340), going to step F);
- E) if not, changing the set of values of the control variables (350) and going back to step B);
- F) if said differences do not satisfy a refinement criterion (360), selecting a subset of the network (370) where to calculate predicted values, going back to step B)

25

11. The method of claim 10, wherein the refinement criterion comprises the calculation of values of one of a least square and a Bayesian objective function, and the selection and modification of control variables is determined by a Levenberg-Marquardt algorithm.

30

12. The method of one of claims 1 to 10, wherein performing a classification of at least one entity of the network in a state according to the set of control variables is performed by a previously trained machine learning algorithm.

5

13. The method of one of claims 1 to 12, wherein the control variables comprise scalar variables characterizing the topology and the topography of the network, and time-based variables characterizing the inputs and outputs of the network having at least one value at each time reference.

10

14. The method of one of claims 1 to 13, wherein state variables further characterize pressure.

15. A system for detecting anomalies in a water distribution system composed of a network of nodes, said system comprising:

15

- sensors of at least water velocity and pressure at a subset of nodes of the network;
- a computing device comprising a processor;
- communication links between sensors and the computing device;
- a storage media;

20

wherein the computing device is configured to:

- Retrieve an initial set of values of control variables characterizing the network and its output at the nodes from the storage media and using it to parametrize a hydraulic model of the water distribution system;
- use communication links between sensors on the network to acquire observations of a subset of the state variables, said observations having time references;
- execute a method according to any one of claims 1 to 14.

25

16. A computer program product, stored on a non-transitory computer-readable medium, for detecting anomalies in a water distribution system

30

composed of a network of nodes, said computer program product comprising code instructions for executing a method according to any one of claims 1 to 14.