

CLAIMS:

1. A method of monitoring an evolving system, the method including the steps of:

5 obtaining a plurality of sensor data streams relating to outputs from sensors monitoring said system, wherein at least one of said sensors monitors a condition of said system, and wherein at least one of said sensors monitors a causal agent for said condition;

10 iteratively constructing a plurality of functional nests, each functional nest being a functional formed from a combination of selected functionals from a basic set of functionals;

determining an output data stream for each functional nest by inputting said sensor data streams into said functional nests;

15 selecting a functional nest from said plurality of functional nests based on said output data streams; and

using said selected functional nest to monitor said system, **characterized in that** the method further includes the steps of:

obtaining a data stream relating to said condition of said system;

20 selecting as said selected functional nest, a functional nest that has an output data stream that is a best-fit to said condition data stream;
and

constructing said basic set of functionals by dissecting theories relating to the behavior of said system.

25 ~~2. The method of claim 1, including the steps of:~~

~~obtaining a data stream relating to a condition of said system; and~~

~~selecting as said selected functional nest, a functional nest that has an output data stream that is a best fit to said condition data stream.~~

30 ~~32.~~ The method of claim 1 ~~or 2~~, wherein a functional nest is constructed from a combination of selected functionals and a combination of selected sensor data streams.

~~4. The method of any preceding claim, including the step of constructing said basic set of functionals by dissecting theories relating to the behaviour of said system.~~

53. The method of any preceding claim 1 or claim 2, wherein functionals in said basic set have different types of nonlinearity.

64. The method of any preceding claim, wherein functionals of said basic set have no more than one coefficient, if operating on one data stream, and/or wherein functionals of said basic set have no coefficients, if operating on two or more data streams.

75. The method of any preceding claim, including the steps of:
constructing an optimum set of functional nests;
monitoring for new data values for said sensor data streams;
optimizing coefficients of functional nests in said optimum set using said new data values to form optimized functional nests; and
selecting one of said optimized functional nests from said optimum set as said selected functional nest.

~~8. The method of claim 7, including the steps of:
monitoring for an update condition for said optimum set; and
when said update condition occurs, reconstructing said optimum set by searching for optimum combinations of functionals from said set of functionals.~~

96. The method of any preceding claim, including the steps of:
providing a set of functional nests from said set of functionals;
combining functional nests from said set of functional nests with further functionals to provide further functional nests;

forming an updated set of functional nests from said set of functional nests and said further functional nests;

ordering said functional nests in said updated set according to a best-fit condition;

5 reducing said number of functional nests in said updated set to below a maximum number by discarding functional nests that provide worst fits and by retaining functional nests that provide best fits;

repeating said combining, forming, ordering, and reducing steps until a stop condition is reached; and

10 selecting said selected functional nest from said updated set of functional nests.

407. The method of any preceding claim, wherein said functional nests are constructed in accordance with one or more rules, including one or more of:

15 a limitation based on duplications in functional combinations; a limitation based on system behaviour of a nest, e.g. inappropriate system behaviour; a limitation based on numerical behaviour of a nest; a limitation on permutation of functionals rather than combination.

20 418. The method of any preceding claim, wherein functional nests that provide an output data stream that does not conform to an expected characteristic of said monitored system are rejected.

25 429. The method of any preceding claim, including the step of using said selected functional nest to provide diagnostics information regarding said system state.

30 4310. The method of any preceding claim, including the step of using said selected functional nest to provide prognostic information regarding said system state.

14. ~~The method of claim 13, wherein said prognostics information is provided by predicting future sensed data streams, and inputting said predicted data streams into said selected functional nest.~~

15. ~~The method of claim 14, wherein said future sensed data streams are based on prior sensed data streams.~~

1611. The method of any preceding claim, wherein said system is a first system, and wherein functional nest data of said first system is compared to functional nest data of a second system, and wherein, when said functional nest data of said two systems correlate, functional nest data of said second system is used in determining a selected functional nest for said first system.

17. ~~The method of claim 16, wherein it is determined whether said second system is in a more advanced state than said first system, and, if so, functional nest data of said second system is used in determining a selected functional nest of said first system.~~

18. ~~The method of any preceding claim, wherein said system includes a number of sensed and unsensed sub-systems, and wherein unsensed systems are monitored by using selected functional nests and sensor data streams from sensed sub-systems.~~

19. ~~The method of claim 18, wherein selected functional nests and/or sensor data streams are modified by an extrapolation functional to compensate for differences in sensed and unsensed sub-systems.~~

20. ~~The method of claim 18 or 19, wherein selected functional nests and/or sensor data streams of two or more sensed sub-systems are combined by an interpolation functional to provide a selected functional nest and/or sensor data streams of an unsensed sub-system.~~

21. ~~The method of claim 18, 19 or 20, wherein a selected functional nest of an unsensed sub-system is taken from a first sensed sub-system, and wherein sensor data streams for said unsensed sub-system are taken from a second sensed sub-system.~~

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22. ~~The method of any of claims 18 to 21, including the step of determining sensed sub-systems having functional nest data that correlate with one another, and using said correlated sub-systems to determine similar sub-systems in said system.~~

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23. ~~The method of any preceding claim, wherein said system is a location on a structure undergoing degradation.~~

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24. ~~The method of claim 23, wherein degradation at a location is monitored by sensing degradation at said location and by sensing causal agents of said degradation at said location.~~

25. ~~The method of claim 23 or 24, wherein locations having similar functional nest data are considered to degrade similarly.~~

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26. ~~The method of claim 23, 24 or 25, wherein an unsensed location on said structure is monitored using a selected functional nest derived for a sensed location considered to degrade similarly to said unsensed location.~~

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27. ~~The method of any preceding claim, wherein selection of functional nests is carried out using a discrete optimization algorithm suitable for NP-hard (Nondeterministic Polynomial-time hard), problems.~~

2812. Apparatus for monitoring an evolving system including:

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a set of sensors for monitoring parameters of said system, one of said sensors monitoring a condition of said system, and one of said sensors monitoring a causal agent for said condition; and

processing means for:

receiving data streams from said set of sensors;

interactively constructing a plurality of functional nests, each functional nest being a functional formed from a combination of selected functionals from a basic set of functionals;

applying said functional nests to said data streams to produce an output data stream for each functional nest;

selecting a functional nest based on said output data streams; and monitoring said system using said selected functional nest;

characterized in that the processing means is further configured

to:

obtain a data stream relating to said condition of said system;

select as said selected functional nest, a functional nest that has an output data stream that is a best-fit to said condition data stream; and

construct said basic set of functionals by dissecting theories relating to the behavior of said system.

~~29. The apparatus of claim 28, wherein said sensors are provided together in a sensor cluster at a particular location in said system.~~

~~30. The apparatus of claim 29, wherein a plurality of locations are monitored, each location having a sensor cluster provided thereat.~~

~~31. The apparatus of claim 30, wherein functional nest data of said locations are compared with one another in order to determine whether behaviour of said system at said locations is similar.~~

~~32. The apparatus of claim 29, 30 or 31, wherein locations in said system that are not provided with sensors are monitored by using functional nest data and sensor data streams from sensed locations.~~

3313. ~~Software~~ Computer program product for use with apparatus for monitoring an evolving system, the system including a set of sensors for monitoring parameters of said system, one of said sensors monitoring a condition of said system, and one of said sensors monitoring a causal agent for said condition; and processing means, ~~the software~~ computer program product including ~~a series of instructions for causing the processing means to code~~ which, when executed on a data processing system, causes the following steps to be performed:

~~receive~~ receiving data streams from said set of sensors;
~~interactively contract~~ construct a plurality of functional nests, each functional nest being function formed from a combination of selected functionals from a basic set of functionals.

applying said functional nests to said data streams to produce an output data stream for each functional nest;

selecting a functional nest based upon said output data streams; and monitoring said system using said selected functional nest;

characterized in that the code, when executed on a data processing system, also causes the following further steps to be performed:

obtaining a data stream relating to said condition of said system;
selecting as said selected functional nest, a functional nest that has an output data stream that is a best-fit to said condition data stream;
and

constructing said basic set of functionals by dissecting theories relating to the behavior of said system.