CLAIMS

1. A method for identifying a fault of at least one mechanical machine, comprising:

causing a first plurality of sensors coupled to a corresponding first plurality of mechanical machines to acquire a first plurality of sets of signals emanating from said first plurality of mechanical machines, said first plurality of mechanical machines sharing at least one characteristic;

supplying at least said first plurality of sets of signals of said first plurality of mechanical machines to a pre-existing fault classifier comprising a neural network including a data layer and an input layer for receiving data from said data layer, said neural network being previously trained to automatically identify faults of a second plurality of mechanical machines based on signals emanating therefrom and previously acquired by a second plurality of sensors, said second plurality of sensors being of a different type than said first plurality of sensors, said second plurality of mechanical machines sharing said at least one characteristic;

modifying said pre-existing fault classifier by employing transfer learning, based at least on said first plurality of sets of signals of said first plurality of mechanical machines, thereby providing a modified fault classifier, said modifying comprising adding at least one mapping layer to said neural network between said data layer and said input layer and retraining the modified fault classifier, including said mapping layer, with said first plurality of sets of signals acquired by said first plurality of sensors;

applying said modified fault classifier to at least one additional set of signals acquired by at least one sensor of said first plurality of sensors and emanating from at least one given mechanical machine sharing said at least one characteristic, said modified fault classifier being configured to automatically identify at least one fault of said at least one given mechanical machine based on said at least one additional set of signals; and

providing a human sensible output, by an output device, including at least identification of said fault of said at least one given mechanical machine, at least one of a repair or maintenance operation being performed based on said human sensible output.

2. The method according to claim 1 and also comprising, following said causing said first plurality of sensors to acquire said first plurality of sets of signals and prior to said supplying said first plurality of sets of signals to said pre-existing fault classifier:

obtaining a first plurality of sets of operational condition data for mechanical machines of said first plurality of mechanical machines, each set of operational condition data indicating a state of operation of a mechanical machine of said first plurality of mechanical machines, each state of operation being associated with a least one of said sets of signals;

said supplying at least said first plurality of sets of signals to said pre-existing fault classifier also comprising supplying said operational condition data of said first plurality of mechanical machines to said pre-existing fault classifier;

said modifying said pre-existing fault classifier by employing transfer learning, based at least on said first plurality of sets of signals also comprising modifying said pre-existing fault classifier by employing transfer learning, additionally based on said first plurality of sets of operational condition data of said first plurality of mechanical machines.

3. The method according to claim 1 or claim 2, wherein said identification of said fault comprises identification of a specific fault of said at least one given mechanical machine and a prediction of failure of said at least one given mechanical machine due to said specific fault in the absence of performance of a recommended maintenance operation thereupon, wherein said at least one given mechanical machine would indeed fail in the absence of performance of said recommended maintenance operation.

4. The method according to claim 2 or claim 3, wherein said neural network is otherwise unmodified by said modifying, besides the addition of said at least one mapping layer.

5. The method according to claim 4, wherein said at least one mapping layer is configured to receive said data from said data layer in said modified fault classifier.

6. The method according to claim 4 or claim 5, wherein said first plurality of sensors has a first frequency response distribution and said second plurality of sensors has a second frequency response distribution, said mapping layer being configured to map between said first and second frequency response distributions.

7. The method according to any one of the preceding claims, wherein said first plurality of sensors is operative to sense a same type of signal as sensed by said second plurality of sensors.

8. The method according to claim 7, wherein said same type of signal comprises one of a vibration signal, a magnetic flux signal, a current, a temperature and an internal machine pressure signal.

9. The method according to any one of claims 1 – 6, wherein said first plurality of sensors and said second plurality of sensors are operative to sense mutually different types of signals.

10. The method according to claim 9, wherein said mutually different types of signals comprise at least one of:

vibration and magnetic flux signals;
vibration and electric current signals;
vibration and temperature signals;
electric current and magnetic flux signals; and
vibration and internal machine pressure signals.

11. The method according to any one of claims 2 - 10, wherein at least some of said states of operation of a mechanical machine of said first plurality of mechanical machines, as indicated by said first plurality of sets of operational condition data, are states of faulty operation.

12. The method according to claim 11, wherein said first plurality of sets of signals and said first plurality of sets of operational condition data of said first plurality of mechanical machines include less than 30 of said states of faulty operation.

13. A system for identifying a fault of at least one mechanical machine, comprising:

a first plurality of sensors coupled to a corresponding first plurality of mechanical machines and operative to acquire a first plurality of sets of signals emanating from said first plurality of mechanical machines, said first plurality of mechanical machines sharing at least one characteristic;

a data processing unit operative to:

receive said first plurality of sets of signals of said first plurality of mechanical machines, said data processing unit comprising a pre-existing fault classifier comprising a neural network including a data layer and an input layer for

receiving data from said data layer, said neural network being previously trained to automatically classify states of operation of a second plurality of mechanical machines based on signals emanating therefrom and previously acquired by a second plurality of sensors, said second plurality of sensors being of a different type than said first plurality of sensors, said second plurality of mechanical machines sharing said at least one characteristic;

modify said pre-existing fault classifier by employing transfer learning, based at least on said first plurality of sets of signals of said first plurality of mechanical machines, thereby providing a modified fault classifier, said data processing unit being operative to modify said pre-existing fault classifier comprising said data processing unit being operative to add at least one mapping layer to said neural network between said data layer and said input layer and to retrain the modified fault classifier, including said mapping layer, with said first plurality of sets of signals acquired by said first plurality of sensors; and

apply said modified fault classifier to at least one additional set of signals acquired by at least one sensor of said first plurality of sensors and emanating from at least one given mechanical machine sharing said at least one characteristic, said modified fault classifier being configured to automatically identify at least one fault of said at least one given mechanical machine based on said at least one additional set of signals, and

an output device in communication with said data processing unit and operative to provide a human sensible output including at least identification of said fault of said at least one given mechanical machine, at least one of a repair or maintenance operation being performed based on said human sensible output.

14. The system according to claim 13 and also comprising a data collection unit operative to obtain a first plurality of sets of operational condition data for mechanical machines of said first plurality of mechanical machines, each set of operational condition data indicating a state of operation of a mechanical machine of said first plurality of mechanical machines, each state of operation being associated with a least one of said sets of signals;

said data processing unit being operative to receive said operational condition data of said first plurality of mechanical machines and to modify said pre-existing fault classifier additionally based on said first plurality of sets of operational condition data of said first plurality of mechanical machines.

15. The system according to claim 13 or claim 14, wherein said identification of said fault comprises identification of a specific fault of said at least one given mechanical machine and a prediction of failure of said at least one given mechanical machine due to said specific fault in the absence of performance of a recommended maintenance operation thereupon, wherein said at least one given mechanical machine would indeed fail in the absence of performance of said recommended maintenance operation.

16. The system according to claim 14 or claim 15, wherein said neural network is otherwise unmodified by said modification, besides the addition of said at least one mapping layer.

17. The system according to claim 16, wherein said at least one mapping layer is configured to receive said data from said data layer in said modified fault classifier.

18. The system according to claim 16 or claim 17, wherein said first plurality of sensors has a first frequency response distribution and said second plurality of sensors has a second frequency response distribution, said mapping layer being configured to map between said first and second frequency response distributions.

19. The system according to any one of claims 13 - 18, wherein said first plurality of sensors is operative to sense a same type of signal as sensed by said second plurality of sensors.

20. The system according to claim 19, wherein said same type of signal comprises one of a vibration signal, a magnetic flux signal, a current, a temperature and an internal machine pressure signal.

21. The system according to any one of claims 13 – 18, wherein said first plurality of sensors and said second plurality of sensors are operative to sense mutually different types of signals.

22. The system according to claim 21, wherein said mutually different types of signals comprise at least one of:

vibration and magnetic flux signals;
vibration and electric current signals;
vibration and temperature signals;

electric current and magnetic flux signals; and

vibration and internal machine pressure signals.

23. The system according to any one of claims 14 - 22, wherein at least some of said states of operation of a mechanical machine of said first plurality of mechanical machines, as indicated by said first plurality of sets of operational condition data, are states of faulty operation.

24. The system according to claim 23, wherein said first plurality of sets of signals and said first plurality of sets of operational condition data of said first plurality of mechanical machines include less than 30 of said states of faulty operation.