

Claims:

1. A method, comprising:
 - receiving, from a first monitoring device attached to a subject, physiological data of sympathetic nervous system activity in the subject and activity data of the subject;
 - receiving, from a computing device, a plurality of indications associated with a plurality of agitation episodes of the subject;
 - analyzing, using at least one machine learning model, the physiological data, the activity data, and the plurality of indications to determine a probability of an occurrence of an agitation episode of the subject; and
 - sending a signal to a second monitoring device to notify the second monitoring device of the probability of the occurrence of the agitation episode of the subject such that treatment can be provided to the subject to decrease sympathetic nervous system activity in the subject.
2. The method of claim 1, wherein:
 - the activity data includes at least one of audio data or motion data; and
 - the motion data includes at least one of acceleration, rotation, steps, distance, or calories of the subject.
3. The method of claim 1, wherein:
 - the plurality of indications associated with the plurality of agitation episodes includes at least one of an identification of an agitation episode from the plurality of agitation episodes, a severity level of an agitation episode from the plurality of agitation episodes, or an agitation type of an agitation episode from the plurality of agitation episodes.
4. The method of claim 1, wherein:
 - the analyzing includes analyzing, using the at least one machine learning model, the physiological data, the activity data, and the plurality of indications to detect agitation states of the subject for a pre-defined time interval.
5. The method of claim 1, wherein:
 - the analyzing includes analyzing, using at least one of a probability density model or a conditional probability model, the physiological data, the activity data, and the plurality of indications to determine a probability of a change of an agitation severity of the subject.

6. The method of claim 1, wherein:

the analyzing includes analyzing, using the at least one machine learning model, the physiological data, the activity data, and the plurality of indications to detect agitation states of the subject for a sequence of consecutive time intervals; and

the analyzing includes analyzing, using the agitation states of the subject and at least one of conditional random fields or a Markov chain model, to determine the probability of the occurrence of the agitation episode of the subject.

7. The method of claim 1, wherein:

the at least one machine learning model includes at least one of a linear regression, logistic regression, a decision tree, a random forest, a neural network, a deep neural network, or a gradient boosting model.

8. The method of claim 1, further comprising:

training, prior to analyzing using the at least one machine learning model, the at least one machine learning model based on (1) training physiological data of sympathetic nervous system activity associated with a plurality of subjects, (2) training activity data associated with the plurality of subjects, and (3) a plurality of training indications associated with the plurality of subjects, the at least one machine learning model including a plurality of physiological and activity parameters as input, each physiological and activity parameter from the plurality of physiological and activity parameters associated with a weight from a plurality of weights of the machine learning model.

9. The method of claim 1, further comprising:

training, prior to analyzing using the at least one machine learning model, the at least one machine learning model based on (1) training physiological data of sympathetic nervous system activity associated with a plurality of subjects, (2) training activity data associated with the plurality of subjects, and (3) a plurality of training indications associated with the plurality of subjects, the at least one machine learning model including a plurality of physiological and activity parameters as input, each physiological and activity parameter from the plurality of physiological and activity parameters associated with a weight from a plurality of weights of the machine learning model; and

determining, based on the at least one machine learning model, a reference pattern of at least one physiological and activity parameter from the plurality of physiological parameters, the analyzing includes determining an anomaly from the reference pattern to determine the probability of the occurrence of the agitation episode of the subject.

10. The method of claim 1, wherein:
the first monitoring device is a wearable device in contact with the subject.
11. The method of claim 1, wherein:
the computing device is a data annotation device operated by a caregiver of the subject.
12. The method of claim 1, wherein:
the second monitoring device is monitored by a caregiver of the subject.
13. The method of claim 1, wherein:
the computing device and the second monitoring device are included in a same computing device.
14. The method of claim 1, wherein:
the treatment includes administering an anti-agitation agent to the subject.
15. The method of claim 1, wherein:
the physiological data of sympathetic nervous system activity are selected from one or more of the following: change in electrodermal activity; heart rate variability; cognitive assessments such as pupil size; secretion of salivary amylase; blood pressure; pulse; respiratory rate; temperature variability or level of oxygen in the blood.
16. An apparatus, comprising:
a memory; and
a processor operatively coupled to the memory, the processor configured to:
receive, from a first monitoring device attached to a subject, physiological data of sympathetic nervous system activity in the subject and activity data of the subject;

receive, from a computing device, a plurality of indications associated with a plurality of agitation episodes of the subject;

analyze, using at least one of a random forest model or a neural network or the like, the physiological data, the activity data, and the plurality of indications to determine a probability of a change of agitation state of the subject; and

send a signal to a second monitoring device to notify the second monitoring device of the probability of the change of agitation state of the subject such that treatment can be provided to the subject to decrease sympathetic nervous system activity in the subject.

17. The apparatus of claim 16, wherein:
the activity data includes at least one of audio data or motion data; and
the motion data includes at least one of acceleration, rotation, steps, distance, or calories of the subject.
18. The apparatus of claim 16, wherein:
the plurality of indications associated with the plurality of agitation episodes includes at least one of an identification of an agitation episode from the plurality of agitation episodes, a severity level of an agitation episode from the plurality of agitation episodes, or an agitation type of an agitation episode from the plurality of agitation episodes.
19. The apparatus of claim 16, wherein:
the analyzing includes analyzing, using the at least one machine learning model, the physiological data, the activity data, and the plurality of indications to detect agitation states of the subject for a pre-defined time interval.
20. The apparatus of claim 16, wherein:
the analyzing includes analyzing, using at least one of a probability density model or a conditional probability model, the physiological data, the activity data, and the plurality of indications to determine a probability of a change of an agitation severity of the subject.
21. The apparatus of claim 16, wherein:

the analyzing includes analyzing, using the at least one machine learning model, the physiological data, the activity data, and the plurality of indications to detect agitation states of the subject for a sequence of consecutive time intervals; and

the analyzing includes analyzing, using the agitation states of the subject and at least one of conditional random fields or a Markov chain model, to determine the probability of the occurrence of the agitation episode of the subject.

22. The apparatus of claim 16, wherein:

the at least one machine learning model includes at least one of a linear regression, logistic regression, a decision tree, a random forest, a neural network, a deep neural network, or a gradient boosting model.

23. The apparatus of claim 16, further comprising:

training, prior to analyzing using the at least one machine learning model, the at least one machine learning model based on (1) training physiological data of sympathetic nervous system activity associated with a plurality of subjects, (2) training activity data associated with the plurality of subjects, and (3) a plurality of training indications associated with the plurality of subjects, the at least one machine learning model including a plurality of physiological and activity parameters as input, each physiological and activity parameter from the plurality of physiological and activity parameters associated with a weight from a plurality of weights of the machine learning model.

24. The apparatus of claim 16, further comprising:

training, prior to analyzing using the at least one machine learning model, the at least one machine learning model based on (1) training physiological data of sympathetic nervous system activity associated with a plurality of subjects, (2) training activity data associated with the plurality of subjects, and (3) a plurality of training indications associated with the plurality of subjects, the at least one machine learning model including a plurality of physiological and activity parameters as input, each physiological and activity parameter from the plurality of physiological and activity parameters associated with a weight from a plurality of weights of the machine learning model; and

determining, based on the at least one machine learning model, a reference pattern of at least one physiological and activity parameter from the plurality of physiological parameters,

the analyzing includes determining an anomaly from the reference pattern to determine the probability of the occurrence of the agitation episode of the subject.

25. The apparatus of claim 16, wherein:

the physiological data of sympathetic nervous system activity are selected from one or more of the following: change in electrodermal activity; heart rate variability; cognitive assessments such as pupil size; secretion of salivary amylase; blood pressure; pulse; respiratory rate; temperature variability or level of oxygen in the blood.

26. A system, comprising:

a first monitoring device attached to a subject;

a computing device in communication with said first monitoring device; and

a second monitoring device communicating with both said first monitoring device and the computing device, wherein said system configured to

receive, from the first monitoring device attached to the subject, physiological data of sympathetic nervous system activity in the subject and activity data of the subject;

receive, from the computing device, a plurality of indications associated with a plurality of agitation episodes of the subject;

analyze, using at least one of a random forest model or a neural network or the like, the physiological data, the activity data, and the plurality of indications to determine a probability of a change of agitation state of the subject; and

send a signal to the second monitoring device to notify the second monitoring device of the probability of the change of agitation state of the subject such that treatment can be provided to the subject to decrease sympathetic nervous system activity in the subject.

27. The system of claim 26, wherein:

the activity data include at least one of audio data or motion data; and

the motion data include at least one of acceleration, rotation, steps, distance, or calories of the subject.

28. The system of claim 26, wherein:

the plurality of indications associated with the plurality of agitation episodes includes at least one of an identification of an agitation episode from the plurality of agitation episodes, a severity level of an agitation episode from the plurality of agitation episodes, or an agitation type of an agitation episode from the plurality of agitation episodes.

29. The system of claim 26, wherein:

the analyzing includes analyzing, using the at least one machine learning model, the physiological data, the activity data, and the plurality of indications to detect agitation states of the subject for a pre-defined time interval.

30. The system of claim 26, wherein:

the analyzing includes analyzing, using at least one of a probability density model or a conditional probability model, the physiological data, the activity data, and the plurality of indications to determine a probability of a change of an agitation severity of the subject.

31. The system of claim 26, wherein:

the analyzing includes analyzing, using the at least one machine learning model, the physiological data, the activity data, and the plurality of indications to detect agitation states of the subject for a sequence of consecutive time intervals; and

the analyzing includes analyzing, using the agitation states of the subject and at least one of conditional random fields or a Markov chain model, to determine the probability of the occurrence of the agitation episode of the subject.

32. The system of claim 26, wherein:

the at least one machine learning model includes at least one of a linear regression, logistic regression, a decision tree, a random forest, a neural network, a deep neural network, or a gradient boosting model.

33. The system of claim 26, further comprising:

training, prior to analyzing using the at least one machine learning model, the at least one machine learning model based on (1) training physiological data of sympathetic nervous system activity associated with a plurality of subjects, (2) training activity data associated with the plurality of subjects, and (3) a plurality of training indications associated with the plurality

of subjects, the at least one machine learning model including a plurality of physiological and activity parameters as input, each physiological and activity parameter from the plurality of physiological and activity parameters associated with a weight from a plurality of weights of the machine learning model.

34. The system of claim 26, further comprising:

training, prior to analyzing using the at least one machine learning model, the at least one machine learning model based on (1) training physiological data of sympathetic nervous system activity associated with a plurality of subjects, (2) training activity data associated with the plurality of subjects, and (3) a plurality of training indications associated with the plurality of subjects, the at least one machine learning model including a plurality of physiological and activity parameters as input, each physiological and activity parameter from the plurality of physiological and activity parameters associated with a weight from a plurality of weights of the machine learning model; and

determining, based on the at least one machine learning model, a reference pattern of at least one physiological and activity parameter from the plurality of physiological parameters,

the analyzing includes determining an anomaly from the reference pattern to determine the probability of the occurrence of the agitation episode of the subject.

35. The system of claim 26, wherein:

the first monitoring device is a wearable device in contact with the subject.

36. The system of claim 26, wherein:

the computing device is a data annotation device operated by a caregiver of the subject.

37. The system of claim 26, wherein:

the second monitoring device is monitored by a caregiver of the subject.

38. The system of claim 26, wherein:

the computing device and the second monitoring device are included in a same computing device.

39. The system of claim 26, wherein:

the treatment includes administering an anti-agitation agent to the subject.

40. The system of claim 26, wherein:

the physiological data of sympathetic nervous system activity are selected from one or more of the following: change in electrodermal activity; heart rate variability; cognitive assessments such as pupil size; secretion of salivary amylase; blood pressure; pulse; respiratory rate; temperature variability or level of oxygen in the blood.

41. A processor-readable non-transitory medium storing code representing instructions to be executed by a processor for prediction, estimation and prevention of occurrence of agitation episode in a subject predisposed to agitation, the code comprising code to cause the processor to:

receive, from a first monitoring device attached to a subject, physiological data of sympathetic nervous system activity in the subject and activity data of the subject;

analyze, using at least one machine learning model, the physiological data and the activity data to detect agitation states of the subject for a sequence of consecutive time intervals;

determine, using the at least one machine learning model and based on the agitation states of the subject, a probability of a change of agitation state of the subject; and

send a signal to a second monitoring device to notify the second monitoring device of the probability of the change of agitation state of the subject such that treatment can be provided to the subject to decrease sympathetic nervous system activity in the subject.

42. The processor-readable non-transitory medium of claim 41, wherein the code comprises code to cause the processor to:

receive, from a computing device, a plurality of indications associated with a plurality of agitation episodes of the subject,

the code to cause the processor to analyze includes code to cause the processor to analyze, based on the plurality of indications, to detect the agitation states of the subject.

43. The processor-readable non-transitory medium of claim 41, wherein the code comprises code to cause the processor to:

receive, from a computing device, a plurality of indications associated with a plurality of agitation episodes of the subject; and

analyze, using the at least one machine learning model, (1) the physiological data, (2) the activity data, and (3) the plurality of indications to determine a probability of a change of an agitation severity of the subject.

44. The processor-readable non-transitory medium of claim 41, wherein the code to cause the processor to determine includes code to cause the processor to:

determine, using at least one of a probability density model or a conditional probability model, the probability of the change of agitation state of the subject.

45. A computer program adapted to perform method of claims 1 to 15 for prediction, estimation and prevention of occurrence of agitation episode in a subject predisposed to agitation.

46. A computer program product comprising a processor-readable non-transitory medium of claim 41 being loaded with a computer program adapted to perform method of claims 1 to 15.