CLAIMS

1. ~~—~~A method (1200) for hybrid classical-quantum decision maker training, the method comprising:

~~—~~receiving (1202) a training data set (1004);

~~—~~selecting (1204), by a first processor (502), a sampling of objects from the training data set, each object represented by at least one vector, wherein the first processor is a classical processor;

~~—~~preparing a plurality of different quantum feature map circuits corresponding to a plurality of different quantum kernel families, wherein each quantum feature map circuit of the plurality of different quantum feature map circuits has a different respective arrangement of quantum gates;

identifying, from among the prepared plurality of different quantum feature map circuits, a quantum feature map circuit that satisfies a threshold level of accuracy by performing one or more iterations of an optimization algorithm, wherein each iteration comprises:

applying (1208), by a quantum processor (504), a ~~set~~plurality of quantum feature maps to the selected sampling of objects, the ~~set~~plurality of quantum feature maps corresponding to ~~a set~~the plurality of different quantum kernel~~s~~ families;

~~—~~evaluating (1210), by ~~a~~the quantum processor, ~~a set of~~ parameters for ~~a~~quantum logic gates of the plurality of different quantum feature map circuits each corresponding to at least one of the ~~set~~plurality of quantum feature maps;

~~—~~determining (1212), by the first processor, a new set of parameters for the quantum ~~feature map circuit; and~~logic gates of a quantum feature map circuit of the plurality of different quantum feature map circuits;

~~—param~~determi~~z~~ning, by the first processor, whether the quantum feature map circuit with the new set of parameters~~.~~ for the quantum logic gates of the quantum feature map circuit produces a measure of accuracy greater than a predetermined threshold value; and

parameterizing (1214), by the first processor, the quantum logic gates of the quantum feature map circuit with the new set of parameters that satisfy the threshold of accuracy.

2. ~~—~~The method of claim 1, further comprising:

~~—~~varying an amplitude of a microwave pulse of the quantum processor to parameterize the quantum feature map circuit.

3. ~~—~~The method of claim 1, further comprising:

~~—~~varying a phase of a microwave pulse of the quantum processor to parameterize the quantum feature map circuit.

~~4. The method of claim 1, further comprising:~~

~~determining that the new set of parameters produces a measure of accuracy greater than a predetermined threshold value.~~

~~5~~4. ~~The~~ The method of claim 1, further comprising:

~~applying~~ applying the parameterized quantum feature map circuit to the selected sampled objects to compute new output vectors.

~~6.~~ 5. The method of claim 1, wherein the quantum feature map circuit includes a set of single qubit rotation gates.

~~7.~~ 6. The method of claim ~~6~~5, wherein a subset of the set of single qubit rotation gates include a rotation angle.

~~8.~~ 7. The method of claim ~~7~~6, wherein the rotation angle corresponds to the new set of parameters.

~~9. The method of claim 1, wherein the first processor is a classical processor.~~

~~10.~~ 8. The method of claim 1, wherein the set of parameters correspond to a set of weights and a set of biases of a neural network.

~~11~~9. ~~The~~ The method of claim 1, wherein the quantum feature map circuit includes a set of controlled phase gates.

1~~2~~0. ~~The~~ The method of claim ~~11~~9, wherein the set of controlled phase gates include a phase gate angle.

1~~3~~1. ~~The~~ The method of claim ~~12~~10, wherein the phase gate angle corresponds to the set of parameters.

~~14. A computer usable program product comprising one or more computer-readable storage devices, and program instructions stored on at least one of the one or more storage devices, the stored program instructions comprising:~~

~~program instructions to receive a training data set;~~

~~program instructions to select, by a first processor, a sampling of objects from the training set, each object represented by at least one vector;~~

~~program instructions to apply, by a quantum processor, a set of quantum feature maps to the selected objects, the set of quantum maps corresponding to a set of quantum kernels;~~

~~program instructions to evaluate, by a quantum processor, a set of parameters for a quantum feature map circuit corresponding to at least one of the set of quantum feature maps;~~

~~program instructions to determine, by the first processor, a new set of parameters for the quantum feature map circuit; and~~

~~program instructions to parameterize, by the first processor, the quantum feature map circuit with the new set of parameters.~~

~~15. The computer usable program product of claim 14, further comprising:~~

~~program instructions to vary an amplitude of a microwave pulse of the quantum processor to parameterize the quantum feature map circuit.~~

~~16. The computer usable program product of claim 14, further comprising:~~

~~program instructions to vary a phase of a microwave pulse of the quantum processor to parameterize the quantum feature map circuit.~~

~~17. The computer usable program product of claim 14, further comprising:~~

~~program instructions to determine that the new set of parameters produces a measure of accuracy greater than a predetermined threshold value.~~

~~18. The computer usable program product of claim 14, wherein the computer usable code is stored in a computer readable storage device in a data processing system, and wherein the program instructions are transferred over a network from a remote data processing system.~~

~~19. The computer usable program product of claim 14, wherein the program instructions are stored in a computer readable storage device in a server data processing system, and wherein the program instructions are downloaded over a network to a remote data processing system for use in a computer readable storage device associated with the remote data processing system.~~

~~20.~~ 12. A computer system comprising one or more processors, one or more computer-readable memories, and one or more computer-readable storage devices, and program instructions stored on at least one of the one or more storage devices for execution by at least one of the one or more processors via at least one of the one or more memories, the stored program instructions comprising:

~~—~~program instructions ~~to receive~~for receiving a training data set;

~~—~~program instructions ~~to select~~for selecting, by a first processor, a sampling of objects from the training data set, each object represented by at least one vector, wherein the first processor is a classical processor;

~~—~~program instructions ~~to apply, by a quantum processor,~~for preparing a ~~set~~plurality of different quantum feature map circuits corresponding to a plurality of different quantum kernel families, wherein each quantum feature map circuit of the plurality of different quantum feature map circuits has a different respective arrangement of quantum gates;

program instructions for identifying, from among the prepared plurality of different quantum feature map circuits, a quantum feature map circuit that satisfies a threshold level of accuracy by performing one or more iterations of an optimization algorithm, wherein each iteration comprises:

program instructions for applying, by a quantum processor (504), a plurality of quantum feature maps to the selected sampling of objects, the ~~set~~plurality of quantum feature maps corresponding to a ~~set~~plurality of quantum kernel~~s~~ families;

~~—~~program instructions ~~to evaluate,~~for evaluating (1210), by ~~a~~the quantum processor, ~~a set of~~ parameters for ~~a~~quantum logic gates of the plurality of different quantum feature map circuit~~s~~ each corresponding to at least one of the ~~set~~plurality of quantum feature maps;

~~—~~program instructions ~~to~~for determin~~e~~ing~~e~~, by the first processor, a new set of parameters for the quantum ~~feature map circuit; and~~logic gates of a quantum feature map circuit of the plurality of different quantum feature map circuits;

~~—~~program instructions ~~to parameterize~~for determining, by the first processor, whether the quantum feature map circuit with the new set of parameters for the quantum logic gates of the quantum feature map circuit produces a measure of accuracy greater than a predetermined threshold value; and

program instructions for parameterizing (1214), by the first processor, the quantum logic gates of the quantum feature map circuit with the new set of parameters that satisfy the threshold of accuracy.

~~21. The system of claim 20, wherein the stored program instructions comprise:~~

~~program instructions to vary an amplitude of a microwave pulse of the quantum processor to parameterize the quantum feature map circuit.~~

~~22. The system of claim 20, wherein the stored program instructions comprise:~~

~~program instructions to vary a phase of a microwave pulse of the quantum processor to parameterize the quantum feature map circuit.~~

~~23. The system of claim 20, wherein the stored program instructions comprise:~~

~~program instructions to determine that the new set of parameters produces a measure of accuracy greater than a predetermined threshold value.~~

~~24. The system of claim 20, wherein the stored program instructions comprise:~~

~~program instructions to apply the parameterized quantum feature map circuit to the selected sampled objects to compute new output vectors.~~

~~25. The system of claim 20, wherein the quantum feature map circuit includes a set of single qubit rotation gates.~~

~~26. The system of claim 25, wherein a subset of the set of single qubit rotation gates include a rotation angle.~~

~~27. The system of claim 26, wherein the rotation angle corresponds to the new set of parameters.~~

~~28. The system of claim 20, wherein the first processor is a classical processor.~~

~~29. The system of claim 20, wherein the set of parameters correspond to a set of weights and a set of biases of a neural network.~~

~~30. The system of claim 20, wherein the quantum feature map circuit includes a set of controlled phase gates.~~

~~31. The system of claim 30, wherein the set of controlled phase gates include a phase gate angle.~~

~~32. The method of claim 31, wherein the phase gate angle corresponds to the set of parameters.~~

~~33.~~13. A computer program stored on a computer readable medium and loadable into the internal memory of a digital computer, comprising ~~program~~software code ~~means adapted to perform the method of any of claims 1 to 13~~portions, when said program is run on a computer, for performing the method of any of claims 1 to 11.