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Applicant: Robert R. Tucci

Application Title: Method for Performing Classical Bayesian Net Calculations Using a Quantum Computer

Art Unit: 2124

Mailed: Dec. 19, 2005

AMENDMENT A

Commissioner For Patents

Mail Stop Amendments(non-fee)

P.O. Box 1450

Washington, D.C., 22313-1450

Sir:

This is a Preliminary Amendment (i.e., before the first office action) to my Patent Application. Kindly amend my application as follows.

SPECIFICATION:

1. On page 2, line 3 counting from the bottom, replace "A quantum computer follows" with "A quantum computer can follow"

2. On page 4, line 4, replace "with complex numbers called probability amplitudes or just amplitudes as entries" with "with complex numbers, called probability amplitudes or just amplitudes, as entries"

3. On page 6, line 5, replace "accomplishing this is" with "accomplishing this task is".

4. On page 7, line 2 from the bottom, replace "with complex numbers called probability amplitudes or just amplitudes as entries" with "with complex numbers, called probability amplitudes or just amplitudes, as entries"

5. On page 24, line 5 (counting from top, not counting equation lines), replace "Also, the angle between e_1 and Ψ is $\theta/2$" with "Call $\theta/2$ the angle between e_1 and Ψ"

CLAIMS:

Please cancel all the claims of record (1 to 28) and replace them with the following 28 new claims:

29. (NEW) A method of operating a classical computer to calculate a q-net data-set based on a c-net data-set, with the purpose of inducing a quantum computer to calculate a desired probability by operating said quantum computer in accordance with said q-net data-set, said method comprising the steps of:

storing said c-net data-set in said classical computer, wherein said c-net data-set comprises:

(a) c-graph information comprising a c-node label for each c-node of a plurality of N c-nodes, and also comprising a plurality of directed c-lines, wherein a directed c-line comprises an ordered pair of said c-node labels, wherein one member of the label pair labels the source c-node and the other member labels the destination c-node of the directed c-line,

(b) c-state information comprising, for each $j \in \{1, 2, \cdots N\}$, a finite set S_j containing labels for the states that the j'th c-node $\hat{x}_j$ may assume, and

(c) c-probability information comprising, for each $j \in \{1, 2, \cdots N\}$, a representation of a non-negative real number $P_j[x_j | x_{k_1}, x_{k_2}, \cdots, x_{k_{|\Gamma_j|}}]$ for each vector $(x_j, (x.)_{\Gamma_j}) = (x_j, x_{k_1}, x_{k_2}, \cdots, x_{k_{|\Gamma_j|}})$ such that $x_j \in S_j$, $x_{k_1} \in S_{k_1}$, $x_{k_2} \in S_{k_2}$, $\cdots$, and $x_{k_{|\Gamma_j|}} \in S_{k_{|\Gamma_j|}}$, wherein $(\hat{x}_{k_1}, \hat{x}_{k_2}, \cdots, \hat{x}_{k_{|\Gamma_j|}})$ are the $|\Gamma_j|$ c-nodes connected to $\hat{x}_j$ by directed c-lines entering $\hat{x}_j$, wherein $|\Gamma_j| \geq 0$,

composing said q-net data-set using said classical computer and said c-net data-set, wherein said q-net data-set comprises:

(a′) q-graph information comprising a q-node label for each q-node of a plurality of N' q-nodes, and also comprising a plurality of directed q-lines, wherein a directed q-line comprises an ordered pair of said q-node labels, wherein one member of the label pair labels the source q-node and the other member labels the destination q-node of the directed q-line,

(b′) q-state information comprising, for each $j \in \{1, 2, \cdots N'\}$, a finite set S'_j containing labels for the states that the j'th q-node $\hat{y}_j$ may assume, and

(c′) q-amplitude information comprising, for each $j \in \{1, 2, \cdots N'\}$, a representation of a complex number $A_j[y_j | y_{k_1}, y_{k_2}, \cdots, y_{k_{|\Gamma'_j|}}]$ for each vector $(y_j, (y.)_{\Gamma'_j}) = (y_j, y_{k_1}, y_{k_2}, \cdots, y_{k_{|\Gamma'_j|}})$ such that $y_j \in S'_j$, $y_{k_1} \in S'_{k_1}$, $y_{k_2} \in S'_{k_2}$, $\cdots$, and $y_{k_{|\Gamma'_j|}} \in S'_{k_{|\Gamma'_j|}}$, wherein $(\hat{y}_{k_1}, \hat{y}_{k_2}, \cdots, \hat{y}_{k_{|\Gamma'_j|}})$ are the $|\Gamma'_j|$ nodes connected to $\hat{y}_j$ by directed lines entering $\hat{y}_j$, wherein $|\Gamma'_j| \geq 0$,

wherein if, for some number λ independent of $(x.)$,

$$P(x.) = \lambda \prod_{j=1}^{N} P_j[x_j | (x.)_{\Gamma_j}],$$

and for some number λ' independent of $(y.)$,

$$A(y.) = \lambda' \prod_{j=1}^{N'} A_j[y_j | (y.)_{\Gamma'_j}],$$

and L is the set of all j such that $\hat{y}_j$ is a leaf node of said q-net data-set, and $not(L) = \{1, 2, \ldots N'\} - L$, and

$$A_L[(y.)_L] = \sum_{(y.)_{not(L)}} A(y.),$$

then, for most or all $(x.) \in S_1 \times S_2 \times \ldots S_N$, said $P(x.)$ can be calculated from the numbers in the set

$$\{|A_L[(y.)_L]|^2 : \text{ for all possible values of } (y.)_L\}.$$

30. (NEW) The method of claim 29, wherein said classical computer has a display screen, comprising the additional step of:

    displaying on said display screen a diagram of said c-graph information.

31. (NEW) The method of claim 29, comprising the additional step of:

    calculating using said classical computer and said q-net data set, a q-evolution data-set that specifies a unitary matrix U_{net} and an initial state vector Ψ_0, wherein the evolution from said initial state vector Ψ_0 to the final state vector $\Psi = U_{net}\Psi_0$ describes the situation captured by said q-net data-set.

32. (NEW) The method of claim 31, comprising the additional step of:

    calculating using said classical computer, a sequence of operations, wherein said sequence of operations and said U_{net} both would, if applied to an array of qubits, produce equivalent transformations of the array.

33. (NEW) The method of claim 32, wherein said sequence of operations comprises a sequence of elementary operations on qubits.

34. (NEW) The method of claim 31, comprising the additional steps of:

    calculating using said classical computer, a microscope data-set that specifies a unitary matrix T, wherein if $\Psi = U_{net}\Psi_0$, and $\Psi' = T\Psi$, then a few components of Ψ' have much larger magnitudes than all other components of Ψ'.

35. (NEW) The method of claim 34, comprising the additional step of:

    calculating using said classical computer, a sequence of operations, wherein said sequence of operations and said T both would, if applied to an array of qubits, produce equivalent transformations of the array.

36. (NEW) The method of claim 35, wherein said sequence of operations comprises a sequence of elementary operations on qubits.

37. (NEW) The method of claim 32, also utilizing a quantum computer, comprising the additional step of:

manipulating said quantum computer largely according to said sequence of operations.

38. (NEW) A method of operating a classical computer to calculate a q-net data-set based on a c-net data-set, with the purpose of inducing a quantum computer to calculate a desired probability by operating said quantum computer in accordance with said q-net data-set, said method comprising the steps of:

storing said c-net data-set in said classical computer, wherein said c-net data-set comprises:

(a) c-graph information comprising a c-node label for each c-node of a plurality of N c-nodes, and for each c-node $\hat{x}_j$ where $j \in \{1, 2, \cdots, N\}$, an ordered set $(\hat{x}.)_{\Gamma_j}$ of c-nodes wherein $\Gamma_j \subset \{1, 2, \cdots, N\} - \{j\}$ and $|\Gamma_j| \geq 0$,

(b) c-state information comprising, for each $j \in \{1, 2, \cdots N\}$, a finite set S_j containing labels for the states that the j'th c-node $\hat{x}_j$ may assume, and

(c) c-probability information comprising, for each $j \in \{1, 2, \cdots N\}$, a representation of a non-negative real number $P_j[x_j|(x.)_{\Gamma_j}]$ for each vector $(x_j, (x.)_{\Gamma_j}) = (x_j, x_{k_1}, x_{k_2}, \cdots, x_{k_{|\Gamma_j|}})$ such that $x_j \in S_j$, $x_{k_1} \in S_{k_1}$, $x_{k_2} \in S_{k_2}$, $\cdots$, and $x_{k_{|\Gamma_j|}} \in S_{k_{|\Gamma_j|}}$,

composing said q-net data-set using said classical computer and said c-net data-set, wherein said q-net data-set comprises:

(a′) q-graph information comprising a q-node label for each q-node of a plurality of N' q-nodes, and for each q-node $\hat{y}_j$ where $j \in \{1, 2, \cdots, N'\}$, an ordered set $(\hat{y}.)_{\Gamma'_j}$ of q-nodes wherein $\Gamma'_j \subset \{1, 2, \cdots, N'\} - \{j\}$ and $|\Gamma'_j| \geq 0$,

(b′) q-state information comprising, for each $j \in \{1, 2, \cdots N'\}$, a finite set S'_j containing labels for the states that the j'th q-node $\hat{y}_j$ may assume, and

(c′) q-amplitude information comprising, for each $j \in \{1, 2, \cdots N'\}$, a representation of a complex number $A_j[y_j|(y.)_{\Gamma'_j}]$for each vector $(y_j, (y.)_{\Gamma'_j}) = (y_j, y_{k_1}, y_{k_2}, \cdots, y_{k_{|\Gamma'_j|}})$ such that $y_j \in S'_j$, $y_{k_1} \in S'_{k_1}$, $y_{k_2} \in S'_{k_2}$, $\cdots$, and $y_{k_{|\Gamma'_j|}} \in S'_{k_{|\Gamma'_j|}}$,

wherein if, for some number λ independent of $(x.)$,

$$P(x.) = \lambda \prod_{j=1}^{N} P_j[x_j|(x.)_{\Gamma_j}],$$

and for some number λ' independent of $(y.)$,

$$A(y.) = \lambda' \prod_{j=1}^{N'} A_j[y_j|(y.)_{\Gamma'_j}],$$

and $not(L) = \cup_{j=1}^{N'} \Gamma'_j$, and $L = \{1, 2, \ldots N'\} - not(L)$, and

$$A_L[(y.)_L] = \sum_{(y.)_{not(L)}} A(y.),$$

then, for most or all $(x.) \in S_1 \times S_2 \times \ldots S_N$, said $P(x.)$ can be calculated from the numbers in the set

$$\{|A_L[(y.)_L]|^2 : \text{ for all possible values of } (y.)_L\}.$$

39. (NEW) The method of claim 38, wherein said classical computer has a display screen, comprising the additional step of:

displaying on said display screen a diagram of said c-graph information.

40. (NEW) The method of claim 38, comprising the additional step of:

calculating using said classical computer and said q-net data set, a q-evolution data-set that specifies a unitary matrix U_{net} and an initial state vector Ψ_0, wherein the evolution from said initial state vector Ψ_0 to the final state vector $\Psi = U_{net}\Psi_0$ describes the situation captured by said q-net data-set.

41. (NEW) The method of claim 40, comprising the additional step of:

calculating using said classical computer, a sequence of operations, wherein said sequence of operations and said U_{net} both would, if applied to an array of qubits, produce equivalent transformations of the array.

42. (NEW) The method of claim 41, wherein said sequence of operations comprises a sequence of elementary operations on qubits.

43. (NEW) The method of claim 40, comprising the additional steps of:

calculating using said classical computer, a microscope data-set that specifies a unitary matrix T, wherein if $\Psi = U_{net}\Psi_0$, and $\Psi' = T\Psi$, then a few components of Ψ' have much larger magnitudes than all other components of Ψ'.

44. (NEW) The method of claim 43, comprising the additional step of:

calculating using said classical computer, a sequence of operations, wherein said sequence of operations and said T both would, if applied to an array of qubits, produce equivalent transformations of the array.

45. (NEW) The method of claim 44, wherein said sequence of operations comprises a sequence of elementary operations on qubits.

46. (NEW) The method of claim 41, also utilizing a quantum computer, comprising the additional step of:

manipulating said quantum computer largely according to said sequence of operations.

47. (NEW) A method of operating a classical computer to calculate a q-evolution data-set based on a c-net data-set, with the purpose of inducing a quantum computer to calculate a desired probability by operating said quantum computer in accordance with said q-evolution data-set, said method comprising the steps of:

storing said c-net data-set in said classical computer, wherein said c-net data-set comprises:

(a) c-graph information comprising a c-node label for each c-node of a plurality of N c-nodes, and for each c-node $\hat{x}_j$ where $j \in \{1, 2, \cdots, N\}$, an ordered set $(\hat{x}.)_{\Gamma_j}$ of c-nodes wherein $\Gamma_j \subset \{1, 2, \cdots, N\} - \{j\}$ and $|\Gamma_j| \geq 0$,

(b) c-state information comprising, for each $j \in \{1, 2, \cdots N\}$, a finite set S_j containing labels for the states that the j'th c-node $\hat{x}_j$ may assume, and

(c) c-probability information comprising, for each $j \in \{1, 2, \cdots N\}$, a representation of a non-negative real number $P_j[x_j|(x.)_{\Gamma_j}]$ for each vector $(x_j, (x.)_{\Gamma_j}) = (x_j, x_{k_1}, x_{k_2}, \cdots, x_{k_{|\Gamma_j|}})$ such that $x_j \in S_j$, $x_{k_1} \in S_{k_1}$, $x_{k_2} \in S_{k_2}$, $\cdots$, and $x_{k_{|\Gamma_j|}} \in S_{k_{|\Gamma_j|}}$, wherein, for each $j \in \{1, 2, \cdots N\}$, $\sum_{x_j \in S_j} P_j[x_j|(x.)_{\Gamma_j}]$ is independent of $(x.)_{\Gamma_j}$,

composing said q-evolution data-set using said classical computer and said c-net data-set, wherein said q-evolution data-set specifies a unitary matrix U_{net} and an initial state vector Ψ_0,

wherein if

$$P(x.) = \prod_{j=1}^{N} P_j[x_j|(x.)_{\Gamma_j}],$$

then, for most or all $(x.) \in S_1 \times S_2 \times \ldots S_N$, said $P(x_.)$ can be calculated from the components of the final state vector $\Psi = U_{net}\Psi_0$.

48. (NEW) The method of claim 47, wherein the c-node connections implied by said c-graph information describe a directed acyclic graph.

49. (NEW) The method of claim 47, wherein said classical computer has a display screen, comprising the additional step of:

    displaying on said display screen a diagram of said c-graph information.

50. (NEW) The method of claim 47, comprising the additional step of:

    calculating using said classical computer, a sequence of operations, wherein said sequence of operations and said U_{net} both would, if applied to an array of qubits, produce equivalent transformations of the array.

51. (NEW) The method of claim 50, wherein said sequence of operations comprises a sequence of elementary operations on qubits.

52. (NEW) The method of claim 47, comprising the additional steps of:

    calculating using said classical computer, a microscope data-set that specifies a unitary matrix T, wherein if $\Psi = U_{net}\Psi_0$, and $\Psi' = T\Psi$, then a few components of Ψ' have much larger magnitudes than all other components of Ψ'.

53. (NEW) The method of claim 52, comprising the additional step of:

    calculating using said classical computer, a sequence of operations, wherein said sequence of operations and said T both would, if applied to an array of qubits, produce equivalent transformations of the array.

54. (NEW) The method of claim 53, wherein said sequence of operations comprises a sequence of elementary operations on qubits.

55. (NEW) The method of claim 50, also utilizing a quantum computer, comprising the additional step of:

manipulating said quantum computer largely according to said sequence of operations.

56. (NEW) The method of claim 47, also utilizing a quantum computer with an array of qubits, comprising the additional steps of:

placing, one or more times, said array of qubits in a state described by said final state vector Ψ,

performing measurements on said array of qubits when its state is described by said final state vector Ψ,

estimating the value of $P(x_.)$ for some $(x.) \in S_1 \times S_2 \times \ldots S_N$, from the outcome of said measurements.

Remarks:

Below are explanations for each of the specification changes that I am requesting:

1. **Change:** On page 2, line 3 counting from the bottom, replace "A quantum computer follows" with "A quantum computer can follow"

   Explanation: I didn't mean to imply that elementary operations are the only thing that a quantum computer can follow. It's very clear from the general literature on quantum computers that a quantum computer can follow more general operations than elementary operations. By adding the word "can", I make my original meaning more explicit.

2. **Change:** On page 4, line 4, replace "with complex numbers called probability amplitudes or just amplitudes as entries" with "with complex numbers, called probability amplitudes or just amplitudes, as entries"

   Explanation: Adding these two commas makes it easier to read the sentence and understand what I am saying.

3. **Change:** On page 6, line 5, replace "accomplishing this is" with "accomplishing this task is".

   Explanation: This change increases the clarity of the specification without introducing new matter into it.

4. **Change:** On page 7, line 2 from the bottom, replace "with complex numbers called probability amplitudes or just amplitudes as entries" with "with complex numbers, called probability amplitudes or just amplitudes, as entries"

   Explanation: This change increases the clarity of the specification without introducing new matter into it.

5. **Change:** On page 24, line 5 (counting from top, not counting equation lines), replace "Also, the angle between e_1 and Ψ is $\theta/2$" with "Call $\theta/2$ the angle between e_1 and Ψ"

Explanation: This change increases the clarity of the specification without introducing new matter into it.

Final Comments:

If the examiner deems that the amended claims are not allowable, the applicant respectfully requests the assistance of the examiner, pursuant MPEP 707.07(j) and MPEP 706.03(d).

Respectfully,

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