

candidates increases exponentially as the latent state number and the kind of the observation probability increase in a learning problem of the latent variable model having the sequential dependence with respect to the multivariate data.

5 **Solution to Problem**

[0015]

According to a first aspect of the present invention, there is provided a latent variable model estimation apparatus comprising: a variational probability calculating unit that calculates a variational probability
10 by maximizing a reference value, the reference value being defined as a lower bound of an approximation amount in which Laplace approximation of a marginalized log likelihood function is performed with respect to an estimator for a complete variable; a model estimation unit that estimates an optimum latent variable model by estimating a kind and a parameter of
15 an observation probability in each latent state; and a convergence determination unit that determines whether a reference value, which is used to calculate the variational probability by the variational probability calculating unit, converges; and a latent state removing unit that removes the latent state satisfying a predetermined condition
20 according to a calculation result of the variational probability calculating unit in repeating loop processing in which the variational probability calculating unit calculates the variational probability, the model estimation unit estimates the optimum latent variable model, and the convergence determination unit determines whether the
25 reference value converges.

[0016]

According to a second aspect of the present invention, there is provided a latent variable model estimation method comprising: calculating
30 a variational probability by maximizing a reference value, the reference value being defined as a lower bound of an approximation amount in which Laplace approximation of a marginalized log likelihood function is performed with respect to an estimator for a complete variable; estimating an optimum latent variable model by estimating a kind and a parameter of an observation

probability in each latent state; ~~and determining whether a reference value,~~
which is used to calculate the variational probability, converges-; and removing the latent state satisfying a predetermined condition
according to a calculation result of the variational probability
5 in repeating loop processing in which the variational probability
is calculated, the optimum latent variable model is estimated, and
whether the reference value converges is determined.

[0017]

According to a third aspect of the present invention, there
10 is provided a latent variable model estimation program causes a
computer to execute:

a variational probability calculation processing of calculating a variational probability by maximizing a reference value, the reference value being defined as a lower bound of an approximation amount in which Laplace approximation of a marginalized log likelihood function is performed with respect to an estimator for a complete variable; a model estimation processing of estimating an optimum latent variable model by estimating a kind and a parameter of an observation probability in each latent state; and a convergence determination processing of determining whether a reference value, which is used to calculate the variational probability in the variational probability calculation processing, converges, wherein the latent variable model estimation program causes the computer to execute latent state removing processing of removing the latent state satisfying a predetermined condition according to a calculation result of the variational probability calculation processing in repeating loop processing of the variational probability calculation processing, the model estimation processing, and the convergence determination processing.

Advantageous Effect of Invention

[0018]

According to embodiments of the invention, the model can be selected at high speed even if the number of model candidates increases exponentially as the numbers of latent states and kinds of the observation probability increase.

Brief Description of Drawings

[0019]

[FIG. 1] FIG. 1 is a block diagram illustrating a latent variable model estimation apparatus according to a first exemplary embodiment of the invention;

[FIG. 2] FIG. 2 is a block diagram illustrating an example of a latent variable variational probability calculation processing unit 104;

[FIG. 3] FIG. 3 is a flowchart illustrating an example of

a processing procedure of the first exemplary embodiment of the invention;

[FIG. 4] FIG. 4 is a flowchart illustrating an operation of the latent variable variational probability calculation

5 processing unit 104;

[FIG. 5] FIG. 5 is a block diagram illustrating a latent variable model estimation apparatus according to a second

Claims

1. A latent variable model estimation apparatus comprising:
a variational probability calculating unit that
5 calculates a variational probability by maximizing a reference
value, the reference value being defined as a lower bound of
an approximation amount in which Laplace approximation of a
marginalized log likelihood function is performed with respect
to an estimator for a complete variable;

10 a model estimation unit that estimates an optimum latent
variable model by estimating a kind and a parameter of an
observation probability in each latent state;—and

a convergence determination unit that determines whether
a reference value, which is used to calculate the variational
15 probability by the variational probability calculating unit,
converges; and

a latent state removing unit that removes the latent state
satisfying a predetermined condition according to a calculation
result of the variational probability calculating unit in
20 repeating loop processing in which the variational probability
calculating unit calculates the variational probability, the
model estimation unit estimates the optimum latent variable model,
and the convergence determination unit determines whether the
reference value converges.

25 2. ~~The latent variable model estimation apparatus according
to claim 1, further comprising an optimum model selection unit
that selects a latent variable model as the optimum latent-
variable model, the latent variable model corresponding to the
30 larger reference value when the reference value converges in
repeating loop processing in which the variational probability
calculating unit calculates the variational probability, the
model estimation unit estimates the optimum latent variable model,
and the convergence determination unit determines whether the~~

~~reference value converges, and when the reference value in the current loop processing is compared to the reference value in the preceding loop processing.~~

- 5 3. ~~— The latent variable model estimation apparatus according to claim 1, further comprising a latent state removing unit that removes the latent state satisfying a predetermined condition according to a calculation result of the variational probability~~

~~calculating unit in repeating loop processing in which the
variational probability calculating unit calculates the
variational probability, the model estimation unit estimates
the optimum latent variable model, and the convergence-
determination unit determines whether the reference value
converges.~~

~~4. 2. The latent variable model estimation apparatus according
to any one of claims 1 to 3 claim 1, wherein the model estimation
unit estimates a hidden Markov model as a latent variable model.~~

~~5. 3. A latent variable model estimation method comprising:
calculating a variational probability by maximizing a
reference value, the reference value being defined as a lower
bound of an approximation amount in which Laplace approximation
of a marginalized log likelihood function is performed with
respect to an estimator for a complete variable;~~

~~estimating an optimum latent variable model by estimating
a kind and a parameter of an observation probability in each
latent state; and~~

~~determining whether a reference value, which is used to
calculate the variational probability, converges; and~~

~~removing the latent state satisfying a predetermined
condition according to a calculation result of the variational
probability in repeating loop processing in which the variational
probability is calculated, the optimum latent variable model
is estimated, and whether the reference value converges is
determined.~~

~~6. The latent variable model estimation method according to
claim 5, further comprising selecting a latent variable model
as the optimum latent variable model, the latent variable model
corresponding to the larger reference value when the reference
value converges in repeating loop processing in which the~~

~~variational probability is calculated, the optimum latent
variable model is estimated, and whether the reference value
converges is determined, and when the reference value in the
current loop processing is compared to the reference value in
5 the preceding loop processing.~~

7. ~~The latent variable model estimation method according to claim 5, further comprising removing the latent state satisfying a predetermined condition according to a calculation result of the variational probability in repeating loop processing in which the variational probability is calculated, the optimum latent variable model is estimated, and whether the reference value converges is determined.~~

8. ~~4.~~ The latent variable model estimation method according to ~~any one of claims 5 to 7~~ claim 3, wherein a hidden Markov model is estimated as a latent variable model.

9. ~~5.~~ A latent variable model estimation program causing a computer to execute:

a variational probability calculation processing of calculating a variational probability by maximizing a reference value, the reference value being defined as a lower bound of an approximation amount in which Laplace approximation of a marginalized log likelihood function is performed with respect to an estimator for a complete variable;

a model estimation processing of estimating an optimum latent variable model by estimating a kind and a parameter of an observation probability in each latent state; and

a convergence determination processing of determining whether a reference value, which is used to calculate the variational probability in the variational probability calculation processing, converges,

wherein the latent variable model estimation program causes the computer to execute latent state removing processing of removing the latent states satisfying a predetermined condition according to a calculation result of the variational probability calculation processing in repeating loop processing of the variational probability calculation processing, the model

estimation processing, and the convergence determination processing.

10. ~~The latent variable model estimation program according~~
5 ~~to claim 9, wherein the latent variable model estimation program~~
~~causes the computer to execute optimum model selection processing~~
~~of selecting a latent variable model as the optimum latent~~
~~variable model, the latent variable model corresponding to the~~
~~larger reference value when the reference value converges in~~

~~repeating loop processing of the variational probability calculation processing, the model estimation processing, and the convergence determination processing, and when the reference value in the current loop processing is compared to the reference value in the preceding loop processing.~~

~~11. The latent variable model estimation program according to claim 9, wherein the latent variable model estimation program causes the computer to execute latent state removing processing of removing the latent states satisfying a predetermined condition according to a calculation result of the variational probability calculation processing in repeating loop processing of the variational probability calculation processing, the model estimation processing, and the convergence determination processing.~~

~~12.~~ 6. The latent variable model estimation program according to ~~any one of claims 9 to 11~~ claim 5, wherein the latent variable model estimation program causes the computer to estimate a hidden Markov model as the latent variable model in the model estimation processing.