following discussion. In the case that an observation of a certain latent state is a polynomial curve, it is necessary to correctly select an order of the curve, such as a first-order curve (straight line), a second-order curve, and a third-order curve. In the above methods, it is necessary to calculate an information amount criterion with respect to all model candidates, such as the case including three latent state numbers, two straight lines, and two second-order curves and the case including five latent state numbers, three third-order curves, and two fourth-order curves. Assuming that the latent state number is 10 and the maximum order of the curve is 10, there are hundreds of thousands of model candidates. Assuming that the latent state number is 20 and the maximum order of the curve is 20, there are tens of billions of model candidates. The number of model candidates increases exponentially with increasing complexity of the model to be searched. Accordingly, it is virtually difficult to perform the calculation by the methods disclosed in NPTL 2 and NPTL 3.

[0013]

The technology disclosed in NPTL 4 cannot be applied to the latent variable model having the sequential dependence because the independence is required between the latent variables. In the technology disclosed in NPTL 4, because the sequential dependence between the latent variables is not considered, the variational distribution of the latent variable is calculated as an equation (15) of NPTL 4. However, the equation is not suitable in the case that the sequential dependence exists between the latent variables, and there is no guarantee that the proper model is obtained. Additionally, unfortunately a transition probability between the latent variables cannot be calculated.

[0014]

Therefore, ~~an object~~ embodiments of the invention ~~is~~ seek to implement the model selection at high speed even if the number of model

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.

Solution to Problem

[0015]

~~A~~ According to a first aspect of the present invention, there is provided a latent variable model estimation apparatus ~~according to the present invention includes~~ comprising: a variational probability calculating unit that 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; 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 probability by the variational probability calculating unit, converges.

[0016]

~~Further,~~ According to a second aspect of the present invention, there is provided a latent variable model estimation method ~~according to the present invention includes~~ 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.

[0017]

~~Furthermore,~~ According to a third aspect of the present invention, there is provided a latent variable model estimation program ~~according to the present invention~~ 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.

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 processing unit 104;

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