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USING THE FACTOR GRAPH TO EVALUATE THE QUALITY OF OUTPUT DATA FOR SHIFT-DAILY LOADING PLANNING

N.M. ARIPOV

Tashkent State Transport University

SH.SH. KAMALETDINOV

Tashkent State Transport University

I.O. ABDUMALIKOV

Tashkent State Transport University

Abstract: Assessing the quality of automated systems is a very difficult task. This article uses a factor graph and a message passing algorithm to evaluate the quality of the output of the automated local work management system (ALWMS). The proposed evaluation method makes it possible to take into account the impact of each element of the system on the output data.

Keywords: data quality, factor graph, message transmission algorithm, automated local work management system.

Introduction. The existing technology for planning shift-daily loading planning is based on manual data collection and processing. It is proposed to automate loading planning processes in order to improve the quality of operational transportation management. To do this, use external primary data sources. The following systems will be used as master data sources:

1. Automated system of operational transportation management (ASOTM).
2. Automatic rolling stock and container monitoring system (ARSCMS).
3. Single-window system of “Uzbekistan Temir Yollari” JSC (E-nakl).

The automated local work ,anagement system (ALWMS) will process input data according to a given algorithm [1-2]. The results of the system are characterized as the basis for making managerial decisions. Dispatching personnel will make decisions based on the readings of this system.

The quality ofoperational transportation management depends on the correct decisions made. The main factor influencing the correctness of decisions is the quality of data on the state of the managed area. ALWMS makes it possible to obtain information about loading resources and ready-made solutions for loading planning.

The quality of output data is the main criterion for information and analytical systems. In this paper, we will consider a method for evaluating the quality of ALWMS data. The factor graph will be used as the main mathematical tool.

Methods. A factor graph is a bipartite graph of factors and variables[3-4]. We will use an undirected quotient graph fig.1.

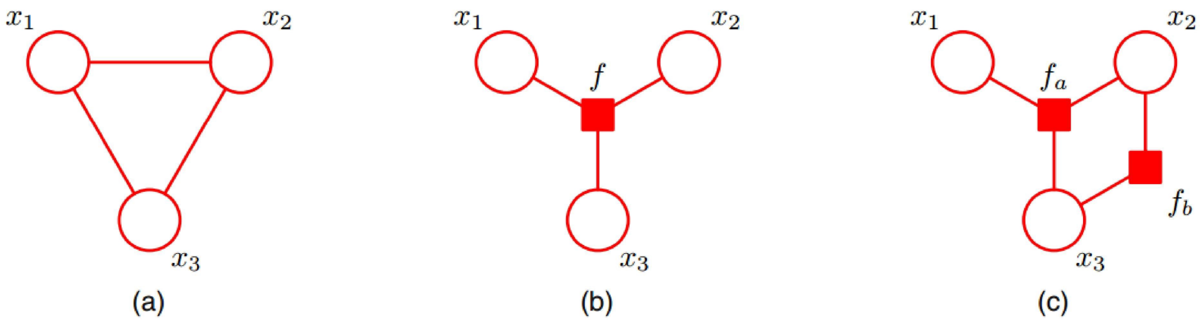

Figure 1. (a) An undirected graph with a single clique potential $\psi(x_1, x_2, x_3)$. (b)

A factor graph with factor$f(x_1, x_2, x_3)$= $\psi(x_1, x_2, x_3)$ representing the same distribution as the undirected graph. (c) A different factorgraph representing the same distribution, whose factors satisfy $f_a(x_1, x_2, x_3) f_b$ (x_1, x_2)= $\psi(x_1, x_2, x_3)$. [7]

We write down the joint distribution over a set of variables as a product of factors.

$$p(x) = \frac{1}{Z} \prod_s f_s(x_s) \tag{1}$$

where, x_{xs} is a subset of variables.
$\frac{1}{Z}$ is the normalizing multiple.
The Z normalizer is:

$$Z = \sum_x \prod_s f_s(x_s) \tag{2}$$

Let's build a factor graph of shift-daily loading planning fig. 2.

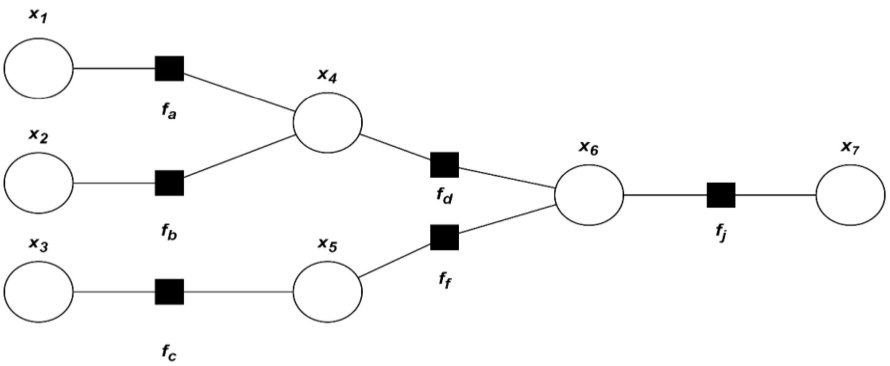

Figure 2. Factor graph of shift-daily loading planning

The joint probability of events will look like this:

$$p(x_1, \ldots, x_7) = \frac{1}{Z} f_a(x_1, x_4) f_b(x_2, x_4) f_d(x_4, x_6) f_c(x_3, x_5) f_j(x_6, x_7) \tag{3}$$

where, x_1 –data about the sending model of ASOTM.
x_2 – data on the wagon model of ARSCMS.
x_3 – data on shippers requests E-nakl.
x_4 – data on loading resources.
x_5 – data on requests from the node's shippers.

x_6 – options for attaching cars to applications.

x_7 –daily shift loading plan.

In order to evaluate the quality of the output data of planning processes, it is necessary to implement the marginalization of the variable x_7.We will use the sum-product algorithm [4-7] to solve this problem. There is an algorithm for exact inference on directed graphs without loops known asbelief propagation, and is equivalent to a special case of the sum-product algorithm. Here we shall consider only the sum-product algorithm because it is simpler to derive and to apply, as well as being more general.

We shall assume that the original graph is an undirected tree or a directed tree or polytree, so that the corresponding factor graph has a tree structure. We first convert the original graph into a factor graph so that we can deal with both directed and undirected models using the same framework. Our goal is to exploit the structure of the graph to achieve two things: (i) to obtain an efficient, exact inference algorithm for finding marginals; (ii) in situations where several marginals are required to allow computations to be shared efficiently[7].

We begin by considering the problem of finding the marginalp(x)for particular variable nodex. For the moment, we shall suppose that all of the variables are hidden. Later we shall see how to modify the algorithm to incorporate evidence corresponding to observed variables. By definition, the marginal is obtained by summing the joint distribution over all variables exceptxso that

$$p(x) = \frac{1}{Z}\sum\nolimits_{\mathrm{x}\setminus x} p\,(\mathrm{x}) \qquad (4)$$

Where $\mathrm{x}\setminus x$ denotes the set of variables in x with variable x omitted. The idea is to substitute for *p*(x)using the factor graph expression (1) and then interchange summations and products in order to obtain an efficient algorithm. Consider the fragment of graph shown in fig. 3 in which we see that the tree structure of the graph allows us to partition the factors in the joint distribution into groups, with one group associated with each of the factor nodes that is a neighbour of the variable node *x.*

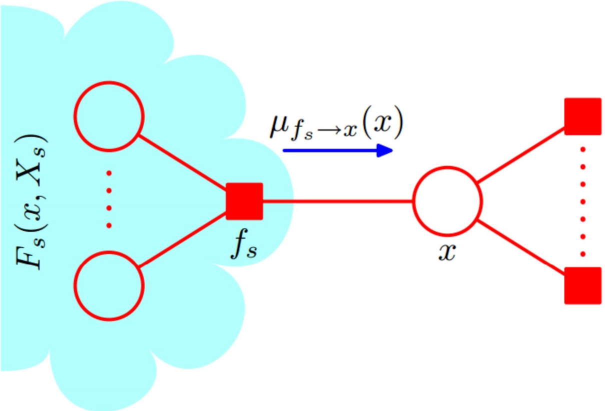

Figure 3. A fragment of a factor graph illustrating the evaluation of the marginal p(*x*)[7]

The message sum-product has the following order:

- as soon as a graph vertex (variable or factor) has receiveda messages from all but one of its neighbors, it starts transmitting a message to this neighbor.

- the edge message between a factor and a variable is a factor from that variable.
- the variable x sends a message to the factor:

$$\mu_{x\to f}(x) = \prod_{g\in\neq(\mathrm{x})f} \mu_{x\to f}(x) \tag{5}$$

- the factor $f(x, Y)$ passes the message to the variable:

$$\mu_{f\to x}(x) = \sum_{y\in Y} f(x, Y) \prod_{y\in Y} \mu_{y\to f}(y); \tag{6}$$

- initial messages in leaves:

$$\mu_{x\to f}(x) = 1,\ \mu_{f\to x}(x) = f(x) \tag{7}$$

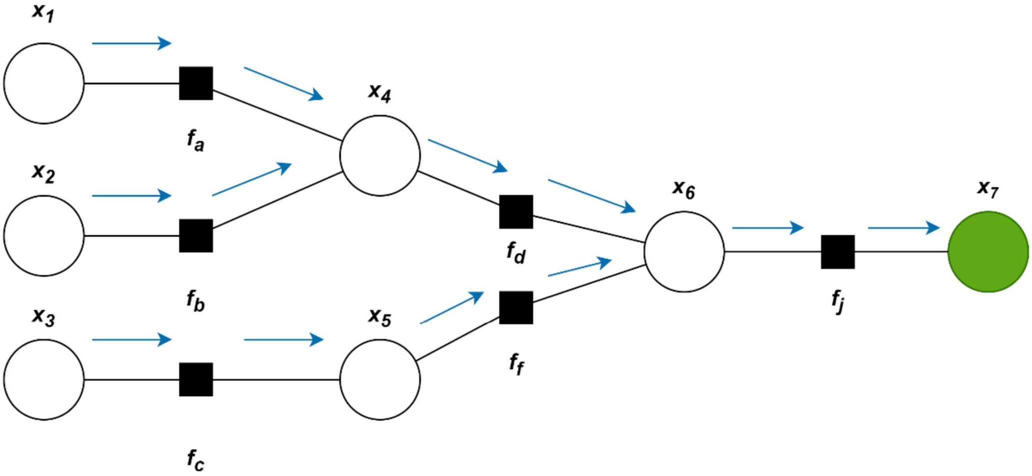

Figure 4. Sending messages to Node x_7

Results. An illustration of the movement of messages is shown in Fig.4. The decision to marginalize a variable is made in the following order:

$$\mu_{x_1\to f_a}(x_1) = 1 \tag{8}$$
$$\mu_{f_a\to x_4}(x_4) = \sum_{x_1} f_a(x_1, x_4) \tag{9}$$
$$\mu_{x_2\to f_b}(x_2) = 1 \tag{10}$$
$$\mu_{f_b\to x_4}(x_4) = \sum_{x_2} f_b(x_2, x_4) \tag{11}$$
$$\mu_{x_4\to f_d}(x_4) = \mu_{f_a\to x_4}(x_4)\mu_{f_b\to x_4}(x_4) \tag{12}$$
$$\mu_{f_d\to x_6}(x_6) = \sum_{x_4} f_b(x_4, x_6)\, \mu_{x_4\to f_d}(x_4) \tag{13}$$
$$\mu_{x_3\to f_c}(x_3) = 1 \tag{14}$$
$$\mu_{f_c\to x_5}(x_5) = \sum_{x_3} f_c(x_3, x_5) \tag{15}$$
$$\mu_{x_5\to f_f}(x_5) = \mu_{f_c\to x_5}(x_5) \tag{16}$$
$$\mu_{f_f\to x_6}(x_6) = \sum_{x_5} f_c(x_5, x_6)\, \mu_{x_5\to f_f}(x_5) \tag{17}$$
$$\mu_{x_6\to f_j}(x_6) = \mu_{f_d\to x_6}(x_6)\mu_{f_f\to x_6}(x_6) \tag{18}$$
$$\mu_{f_j\to x_7}(x_7) = \sum_{x_6} f_j(x_6, x_7)\, \mu_{x_6\to f_j}(x_6) \tag{19}$$

Since the quotient is a graph of undirected type, $the\ marginalization_{x7}$ has the following form:

$$p(x_7) = \frac{1}{Z}\mu_{f_j\to x_7}(x_7) \tag{20}$$

Discussion. Using the easy sum-product algorithm, you can calculate the marginalization of each node. Messages are sent from each node and sent along the specified route, namely in the direction of the desired node x_7. Each factor will indicate the data quality of the transmitted message. The data quality will change with each hop through the node.

In our cases, ASUMR will accept information about each individual system. It will process this data, giving a new level of output quality.

Using the message transfer algorithm will make it possible to evaluate the quality of ASUMR output data. You can compare alternative loading planning options depending on the sources of primary information.

References

1. Aripov, N. M., Kamaletdinov, Sh. Sh. Modeling of shift-daily planning of unloading and loading of wagons. Academic Research in Educational Sciences, 3(9), 2022 – 34–43.

2. Kamaletdinov, Sh. Sh., Aripov, N. M. (2022). Functional modeling of current local work planning. Academic Research in Educational Sciences, 3(9), 2022 – 119–124.

3. Frey, B. J. Graphical Models for Machine Learning and Digital Communication MIT Press (1998).

4. Kschischnang, F. R., B. J. Frey, and H. A. Loeliger Factor graphs and the sum-product algorithm. IEEE Transactions on Information Theory47(2), 498–519 (2001).

5. Pearl, J. Probabilistic Reasoning in Intelligent Systems. Morgan Kaufmann (1988).

6. Lauritzen, S. L. and D. J. Spiegelhalter Local computations with probabailities on graphical structures and their application to expert systems. Journal of the Royal Statistical Society 50, 157– 224 (1988).

7. Bishop, Christopher M. Pattern Recognition and Machine Learning. New York :Springer, 2006.

8. Clifford (1990), "Markov random fields in statistics", in Grimmett, G.R.; Welsh, D.J.A. (eds.), Disorder in Physical Systems, J.M. Hammersley Festschrift (postscript), Oxford University Press, pp. 19–32, ISBN 9780198532156

9. Frey, Brendan J. (2003), "Extending Factor Graphs so as to Unify Directed and Undirected Graphical Models", in Jain, Nitin (ed.), UAI'03, Proceedings of the 19th Conference in Uncertainty in Artificial Intelligence, Morgan Kaufmann, pp. 257–264, arXiv:1212.2486, ISBN 0127056645

10. Wymeersch, Henk (2007), Iterative Receiver Design, Cambridge University Press, ISBN 978-0-521-87315-4

11. Z. Ghahramani and M. I. Jordan, “Factorial Hidden Markov models.” Neural Information Processing Systems, vol. 8, pp. 472–478, 1995.

12. H.-A. Loeliger, “Some remarks on factor graphs,” Proc. 3rd Int. Symp. on Turbo Codes and Related Topics, Sept. 1–5, 2003, Brest, France, pp. 111–115.

13. Y. Mao and F. R. Kschischang, “On factor graphs and the Fourier transform,” Proc. 2001 IEEE Int. Symp. Inform. Th., Washington, D.C., USA, June 24–29, 2001, p. 224.

14. P. O. Vontobel and H.-A. Loeliger, “On factor graphs and electrical networks,” in Mathematical Systems Theory in Biology, Communication, Computation, and Finance, J. Rosenthal and D. S. Gilliam, eds., IMA Volumes in Math. and Appl., Springer Verlag, pp. 469–492.

15. P. O. Vontobel, Kalman Filters, Factor Graphs, and Electrical Networks. Internal report INT/200202, ISI-ITET, ETH Zurich, April 2002.

16. Balakrishnan, V. K. (1997). Graph Theory (1st ed.). McGraw-Hill. ISBN 978-0-07-005489-9.

17 .Bang-Jensen, J.; Gutin, G. (2000). Digraphs: Theory, Algorithms and Applications. Springer.

18. Bender, Edward A.; Williamson, S. Gill (2010). Lists, Decisions and Graphs. With an Introduction to Probability.

19. Berge, Claude (1958). Théorie des graphes et ses applications (in French). Paris: Dunod.

20. Biggs, Norman (1993). Algebraic Graph Theory (2nd ed.). Cambridge University Press. ISBN 978-0-521-45897-9.

BLOCK DIAGRAM AND MATHEMATICAL MODEL OF AN INVARIANT SYSTEM

KHOLHODJAEV BOKHODIR

Tashkent State Technical University

KURALOV BEKJON

Tashkent State Technical University

DAMINOV KAMOL

Tashkent State Technical University

Abstract. Recently, one of the modern directions of the theory of control, the theory of construction of state monitors of linear and nonlinear dynamic systems has significantly developed [2, 4, 10, 15]. The approach based on the expansion of the system dynamics based on the information of the input and output values due to the construction of a special dynamic system observer whose state converges quickly enough to the initial state of the system over time and the function of the state observer on the output, and the input of the initial system output variables and dynamic feedback can be applied spread out. In this case, the state observer at an arbitrary instant of time is considered as an estimate of the state of the system at a given instant of time [4]. Constructing an observer for a dynamic system is one of the ways to obtain an estimate of the state vector of this dynamic system. Solving such a problem can be of independent value as part of the general problem of dynamic systems control. The article considers the independence of the output value and the error signal from the input actions. In stabilization systems, it is necessary to add independence of the output value from the disturbing influence. The system is invariant with respect to the perturbing influence, if after the completion of the transient process determined by the initial conditions, the system error does not depend on this influence [12-16].

Keywords: automatic control system, invariance, input signal filtering, normalized polynomials, dispersion control, mathematical model, dynamic.

Introduction. Suppose some control object is described in operator form by an equation of the form

$$A(p)y = B_0(p)u + \sum_{k=2}^{\mu} B_k(p) f_k, \qquad p = \frac{d}{dt}, \qquad (1)$$

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