DISCOVERY OF LAW EQUATIONS GOVERNING HUMAN AFFINITY UNDER TRADE-OFF BETWEEN COST AND RISK

T. Washio and H. Motoda

institute for scientific and industrial research, osaka university, japan
washio@sanken.osaka-u.ac.jp, motoda@sanken.osaka-u.ac.jp

Y. Niwa

institute of nuclear safety system inc., japan
niwa@inss.co.jp

The empirical modeling techniques such as linear system identification and neural network modeling limit the model equation formulae within some preconceived classes. A novel method to discover an admissible model equation reflecting the laws governing the data without the preconceptions is applied to the modeling of human affinity under the trade-off between cost and risk.

The method uses *scale-types* and *quasi-bi-variate fitting*. Stevens (1946) claimed that the most of the observed quantities are categorized into interval scale (e.g., Celsius temperature), ratio scale (e.g., physical mass) and absolute scale (a dimensionless quantity). The interval scale quantity has an arbitrary origin of its value and its admissible unit conversion $x' = kx + c$ where x and x' are the quantities, k and c constants. The ratio scale quantity has an absolute origin and its admissible unit conversion $x' = kx$. The absolute scale quantity does not have any unit. Luce (1959) claimed that a formula to relate two quantities having scale-types is highly limited. Suppose that x and y are ratio scale, and have the relation $y = \log x$. The unit conversion on x changes the relation to $y' = \log x' = \log x + \log k = y + \log k$ which contradicts with the unit conversion on y, i.e., $y' = Ky$ where K is constant. Further discussion deduces $y = \alpha x^{\beta}$ where x and y are ratio scale, $y = \alpha \log x + \beta$ or $y = \alpha x^{\beta} + \delta$ where x is ratio scale and y interval scale, and $y = \alpha x + \beta$ where x and y are interval scale. We proposed the technique of quasi-bi-variate fitting to estimate the coefficient values of these bi-variate relations (1999). A bi-variate relation between x and y is selected based on their scale-types, and the least square error fitting of the relation is applied within the data having similar values for each of the quantity except x and y. This process can extract the bi-variate relation while reducing the influences from the other quantities. The combination of all bi-variate relations into a complete equation derives the admissible model.

This method is applied to the discovery of socio-psychological law equations. The objective data were acquired through the questionnaire investigation on 400 ordinary householders. The questionnaire asks their affinity of house selections for buying under the trade-off between cost x_1(yen) and earth quake risk x_2(number/year). The degree of affinity in acquired data was categorical and transformed to a quantitative interval scale-type quantity y through the method of successive categories. The application of the aforementioned approach derived an admissible model $y = c_1 \log x_1 + c_2 \log x_2 - 2.9$, $c_1 = 0.63$ and $c_2 = 0.34$. Furthermore, we segmented the 400 data into four groups based on the annual family income of the householders, and retried the modeling for each group. Table 1 shows the relation between the income level and the ratio c_1/c_2. The householders having higher income indicates a tendency to pay more cost for the risk. In summary, a highly plausible model in terms of the generic laws underlying the socio-psychological system has been obtained. The consequence indicated by the model is reasonable. More extensive examinations of the model are needed to confirm its further generality.

Table 1: Relation between income level and ratio c_1/c_2

income level(million yen)	0-6	6-9	9-12	12-
ratio	1.49	1.81	1.84	1.94

Key words: law equation, scale-type, quasi-bi-variate fitting, socio-psychological model.

References

Stevens, S.S. (1946). On the Theory of Scales of Measurement. *Science, 103*(2684), 677–680.

Luce, R.D. (1959). On the Possible Psychological Laws. *The Psychological Review, 66*(2), 81–95.

Washio, T., & Motoda, H. (1999). Discovering Admissible Model Equations from Observed Data Based on Scale-Types and Identity Constraints. *Proc. of IJCAI99*(2), 772–779.