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Identification of important factors influencing nonlinear counting systems

Key words: Important factors; Nonlinear counting system; Generalized Gaussian process regression; Sensitivity analysis; Steel casting-rolling process

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Motivation

1. Evaluating factors that have an impact on system output is critical for decision-makers to identify critical control points (CCPs). For example, the steel industry is committed to reducing defects in steel products based on the defect analysis critical control point (DACCP) system. One step in the DACCP system is to determine CCPs where defect management efforts can be focused.

2. Identifying factors that exert more influence on system output from data is one of the most challenging tasks in science and engineering.

Main idea

1. Study of important factor identification from observational data is usually based on the supervised learning model.

2. The GGPR model with Poisson likelihood is adopted to describe the nonlinear counting system.

3. The GGPR model inherits the merits of nonparametric kernel learning and Poisson distribution, and can deal with complex nonlinear counting systems.

4. For the GGPR model, the identification of model inputs that have a significant effect on the system output is not easily accessible due to its nonparametric and kernel structure.

Method

1. A novel method called the sensitivity analysis of GGPR (SA-GGPR) model is proposed to identify important factors of the nonlinear counting system.

2. SA-GGPR determines the factors that have a significant effect on the system output in terms of the sensitivity measure.

Major results

1. Test results of our model and related methods in the simulated nonlinear counting system

Table 3 Identification results of important factors by different methods in the numerical example

Method	Accuracy	Recall	Selectivity
PLS-Beta	0.60	0.67	0.50
PLS-VIP	0.20	0.33	0
RF-PI	0.47	0.56	0.34
SA-GPR	0.61	0.67	0.51
SA-GGPR	0.98	0.98	0.97

Major results (Cont'd)

2. Test results of our model and related methods in the casting-rolling process

Table 6 Important factors identified by different methods in the casting-rolling process

Method	Accuracy	Recall	Selectivity
PLS-Beta	0.47	0.37	0.52
PLS-VIP	0.54	0.43	0.61
RF-PI	0.51	0.43	0.55
SA-GPR	0.70	0.69	0.70
SA-GGPR	0.80	0.75	0.84

Conclusions

1. In this research, the SA-GGPR model is proposed to identify important factors of the nonlinear counting system.

2. SA-GGPR implements a quantitative assessment of how different inputs affect the system output based on the sensitivity measure.

3. The application results show that SA-GGPR is feasible and more accurate in identifying important factors of the nonlinear counting system compared with several state-of-the-art methods.

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