Analyzing passenger train arrival delays with support vector regression

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ABSTRACT

We propose machine learning models that capture the relation between passenger train arrival delays and various characteristics of a railway system. Such models can be used at the tactical level to evaluate effects of various changes in a railway system on train delays. We present the first application of support vector regression in the analysis of train delays and compare its performance with the artificial neural networks which have been commonly used for such problems. Statistical comparison of the two models indicates that the support vector regression outperforms the artificial neural networks. Data for this analysis are collected from Serbian Railways and include expert opinions about the influence of infrastructure along different routes on train arrival delays.

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1. Introduction

Train delays are causing substantial losses to railway operators and passengers. The National Audit Office in United Kingdom reported that there were about 800,000 delays on the British national rail network during 2006–2007. This led to 14 million train-minutes of delays, which cost the passengers about £1 billion in lost time (Burr et al., 2008; Preston et al., 2009). Such numbers provide evidence that reducing train delays in an economically viable way would be highly desirable. An important step in this direction is to establish a functional relation between train delays and various characteristics of a railway system (i.e., infrastructure, timetables and trains). Such a functional relation would allow planners to evaluate how changes in the system would affect delays, and thereby help them determine the changes that would reduce delays in the most economical way.

Let us consider two specific situations in which a functional relation between train delays and characteristics of the railway system would be useful for tactical planning:

- **Investment planning.** Managers are interested in reducing train *arrival* delays at a station by investing in the infrastructure. The investments may include track renewal to increase the speed profile along some routes, building an overpass to avoid train conflicts, or introducing more advanced signaling systems that resolve rights-of-way more efficiently. A functional relation between train delays and characteristics of the infrastructure would enable the planners to evaluate the effects that different infrastructure projects (or their combination) would have on delays. This would assist the management in selecting the most effective investment plan, given the available budget.
Various techniques have been used to analyze train delays at both operational and tactical level. They can be roughly classified into three groups:

- **Analytic models.** Probability distributions of train delays are derived from track occupancy and release records, or other data containing information on train movements. The obtained distributions of the underlying random variables are then used within stochastic queuing models (Huisman et al., 2002; Schwanhäußer, 1974). An analytic stochastic model is used...
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