Judge's Commentary: The Ben Fusaro Award for 2014

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Introduction

The Ben Fusaro Award honors the Founding Director of the MCM (who continues to serve as a judge for the contest). First awarded in 2004, it recognizes an entry for an "especially creative approach" to the A Problem in the contest, which generally involves continuous mathematics.

The Fusaro Award for 2014 goes to a team from Tsinghua University, Beijing, China, for their paper titled "Keep Right to Keep 'Right.'" This paper, one of the top group of papers designated as Outstanding, stands out for a remarkably flexible model, combined with exceptional research, detailed analysis, and clear writing.

The Problem

The Keep-Right-Except-To-Pass-Rule Problem asked teams to build and analyze a mathematical model to analyze the performance of this rule in light and in heavy traffic. Is this rule effective in promoting greater throughput? If not, teams were to suggest and analyze alternatives that might promote greater throughput, safety, and/or other factors that they deemed important.

My Comments

I offer my comments on the paper, organized by the categories deemed appropriate for this problem by the judges, who gave the most credit for

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model development, analysis / validation, and conclusions.

Summary

As always, a strong summary is essential. The abstract does a thorough job of describing the breadth of their model and methods. However, such a sophisticated model should include more information about the team's conclusions, besides the one sentence about which lane-changing rules work best. That sentence, their main conclusion, deserves to be featured more prominently in the summary.

Format, Clarity, Writing

These are generally excellent in this entry. This paper is a pleasure to read, and it makes many interesting observations. The numerous charts and tables are informative. The organization is very good, particularly for a paper written over just a few days.

One quibble is that the reader must hunt through the paper to find the conclusions. One wishes there were a section at the end to review the conclusions and bring closure to the whole project. An executive summary would be ideal.

Model Development

Like many of the entries on the Keep Right Problem, this paper adapts the cellular automaton model for traffic flow from the literature, called the Nagel-Schreckenberg Model (or N-S model, for short). While many teams chiefly analyze a 2-lane model, similar to the N-S models in the literature, this paper treats 3- and 4-lane traffic throughout, which is something the judges wanted to see.

Their "basic model" includes buses and trucks, not just cars, which is nice. They do a good job justifying their periodic boundary conditions, which is equivalent to saying their road is treated as a large ring. Their "refined model" incorporates entrance and exit ramps, another important feature only the very best entries treated well.

They introduce 9 different rules for lane-changing, which is an exceptional number, and they successfully compare them by the multiple-criteria-decision-making tool called Fuzzy Synthetic Evaluation (FSE). While FSE is not familiar to most judges, the team gives a reasonable explanation of it.

Models are compared under conditions of both light and heavy traffic, which is very important in the analysis.

Analysis/Validation

The basic model is studied from several perspectives, including average speed, utilization of the different lanes, and driver satisfaction. The imposition of a maximum speed limit is studied, as is a minimum speed limit. An exceptional factor the team considers is signaling behavior.

A sophisticated multiple-criteria evaluation method (FSE) is used to compare 9 different lane-changing rules. This is impressive.

The paper includes sections that discuss left-hand side driving as well as intelligent systems. These are concise, and simulations are run. (Some papers went further with these topics.)

However, the team's analysis is sensible. A strength of the paper is that the team tries to explain the conclusions suggested by their simulations.

Conclusions, Extras

This study involves abundant simulations that appear to address all of the issues raised in the problem, which is extraordinary. It includes many extras, particularly the variety of lane-changing rules. As noted before, there could have been better closure.

Sensitivity Analysis

The paper includes extensive analysis of several parameters in the model, more than almost all other entries did.

Strengths/Weaknesses

The paper concludes with a collection of relevant observations. It is clear that with more time and effort the models could be expanded to encompass many more features.

Research

We mention one more factor that was not a separate category for the judges: Research.

This is another strength of this paper. It references several papers on the N-S model. It lists several Wikipedia articles on traffic, a traffic engineering text, and an engineering article using FSE. The team appears to draw useful information from all of these sources, with numerous literature citations in their text. By comparison, even many of the very good papers in the contest do a less-thorough literature search and / or fail to properly cite the literature when they take ideas from it.

About the Author

Dr. Griggs is Carolina Distinguished Professor of Mathematics at the University of South Carolina, where he has supervised 15 doctoral dissertations as well as several master's and undergraduate theses. He is a Fellow of SIAM (the Society for Industrial and Applied Math), which he has served in various roles, including two terms as Editor-in-Chief of the *SIAM Journal on Discrete Mathematics*. He has judged the MCM since 1988, and he wrote or co-wrote six MCM problems.