Tenth International Conference on Managing Fatigue: Abstract for Review

A Model for Truck Driver Scheduling with Fatigue Management

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Problem [100 words]

In the United States, approximately 4,000 fatalities due to truck and bus crashes occur each year. Of these, up to 20% are estimated to involve fatigued drivers (National Academies of Sciences, 2016). However, no model currently exists that incorporates a measure of drowsiness or fatigue into the Truck Driver Scheduling Problem (TDSP). We introduce the first fatigue-aware model for determining the optimal schedule for a driver while maintaining an acceptable level of alertness as well as abiding by time windows and hours of service (HOS) regulations.

Method [250 words]

We introduce the Truck Driver Scheduling Problem with Fatigue Monitoring (TDSPFM) which is a mathematical optimization model that supports typical truck driving scheduling constraints (time windows, hours of service regulations) as well as setting a parameter to represent a minimum acceptable alertness level that will be exceeded (while driving) throughout the duration of the route. As with typical TDSPs, we seek to minimize the duration of the route while abiding by the constraints in the model. Essentially, this means we need to choose the optimal locations and durations of rest times.

The alertness level calculations are obtained by way of implementing and incorporating the Three Process Model of Alertness (TPMA) (Åkerstedt, Folkard, & Portin, 2004). The alertness calculations specifically make the TDSPFM a non-linear model and thus a mathematical program (such as an MILP) is impractical. In order to solve the problem, a heuristic was required and we chose to implement a genetic algorithm (GA) solution.

Results [250 words]

We experimented with the TDSPFM model by creating a set of test problems to represent a week's worth of driving. We then solved the TDSPFM with varying levels of the minimum alertness parameter along the TPMA alertness scale. This includes setting the minimum alertness to 0 which essentially allows us to see a mathematical representation of the effect of hours of service constraints on alertness levels.

One of the benefits of incorporating the TPMA into the model is that we had alertness predictions available to us at all stages of the route. This allowed us to use overall minimum alertness and the average alertness along the route (while driving) as key performance indicators along with total duration.

The preliminary results of modifying the minimum alertness threshold are presented in Table 1 below.

Problem (alertness level constraint)	Duration (hours)	Minimum Alertness	Worst Case Minimum Alertness	Average Alertness	Duration % Increase Over Baseline	Minimum Alertness % Increase Over Baseline
Baseline HOS (0)	99.20	7.9	7.0	9.9	-	-
HOS (tired)	99.22	7.9	7.1	9.9	0.02%	0.05%
HOS (semi-tired)	100.37	8.3[a]	8.2	10.0	1.18%	5.13%
HOS (not tired)	104.65[a]	9.3[a]	9.2	10.6[a]	5.49%	17.94%

Table 1: Averaged Results

a: Indicates statistically significant differences from the Baseline HOS (0) at the 0.05 level.

It is somewhat comforting to see that with just the HOS constraints, the average minimum alertness stays above the TPMA sleepiness threshold of 7 (tired), though the worst case scenario was at the 7.0 level. Therefore, it is not surprising to see non-statistically significant increases in either duration or alertness when enforcing an alertness threshold of tired. However, at the semi-tired threshold, we see a 5.13% increase in the minimum alertness score with a mere 1.18% increase in duration. The difference in minimum alertness was statistically significant ($p < 0.0001$) however the increase in duration was not statistically significant at the semi-tired threshold. Finally, when the threshold is set to prevent the driver from getting below the "not tired" stage, we observed statistically significant increases in both duration and minimum alertness ($p < 0.0001$).

Discussion [250 words]

In our view, the TDSPFM is a model that helps to represent and solve a planning problem. As such, we are primarily interested in helping create safer routes that remain cost effective. Aside from the obvious cost reductions, namely avoiding crashes, the TDSPFM can help to reduce risk by lowering the chances of an unexpected fatigue related event.

For instance, real-time fatigue detection technology is fantastic. However, it might also prove expensive depending on the time along the route the event occurs and it will almost certainly lead to unexpected delivery delays. From a scheduling standpoint this type of event represents a risk because they occur at unexpected times and last for an unpredictable amount of time. Reducing the chances that an event like this is necessary would result in reducing the associated risk and ultimately in reducing cost and increasing safety.

Incorporating the TDSPFM into a Fatigue Risk Management System (FRMS) could accomplish the goal of reducing the number of fatigue related events. Additionally, it would allow one to see places along the route where the driver might be close to a pre-defined alertness threshold. As an example: if a driver is predicted to be close the alertness threshold on Thursday afternoon, incentives could be provided for the driver to increase the chances that they get a good night sleep on Wednesday night. This would reduce the chances that their alertness levels dip to a critical level on Thursday afternoon and result in a fatigue event requiring an unexpected stop.

Summary [150 words]

This paper introduces the Truck Driver Scheduling Problem with Fatigue Management (TDSPFM). We present preliminary results that show that it is possible to model HOS constraints and at the same time ensuring that some minimum alertness level is met for the duration of the route. Thus, this work serves as a starting point for developing more cost effective ways to develop safer schedules for commercial truck drivers and safer highways for the traveling public.

References

Åkerstedt, T., Folkard, S., & Portin, C. (2004). Predictions from the Three-Process Model of Alertness. *Aviation, Space, and Environmental Medicine*, *75*(3), A75–A83.

National Academies of Sciences, E. (2016). *Commercial Motor Vehicle Driver Fatigue, Long-Term Health, and Highway Safety: Research Needs*. Retrieved from https://www.nap.edu/catalog/21921/commercial-motor-vehicle-driver-fatigue-long-term-health-and-highway-safety