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Generalized net model of the work of the car's electronic systems

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Abstract: The present paper describes the process work of the car's electronic systems. For the purpose we use Generalized Nets. The model represents few different electronic systems in car.
Keywords: Generalized nets, car's electronic systems, Modelling.

Introduction

Anti-Blocker System is a safety system on motor vehicles which prevents the wheels from locking while braking. A non-locking braking system allows the driver to maintain steering control under heavy braking, by preventing a skid, and allowing the wheel to continue to forward roll and create lateral control, as directed by driver steering inputs. Disadvantages of the system include increased braking distances under some limited circumstances (ice, snow, gravel, "soft" surfaces), and the creation of a "false sense of security" among drivers who do not understand the operation, and limitations of ABS.

A typical ABS is composed of a central electronic control unit (ECU), four wheel speed sensors (one for each wheel), and two or more hydraulic valves within the vehicle brake circuit. The ECU constantly monitors the rotational speed of each wheel. When it senses that any number of wheels are rotating considerably slower than the others (a condition that is likely to bring it to lock - see note below), it actuates the valves to decrease the pressure on the specific braking circuit for the individual wheel, effectively reducing the braking force on that wheel. The wheel(s) then turn faster; when they turn too fast, the force is reapplied. This process is repeated continuously, and this causes the characteristic pulsing feel through the brake pedal. A typical anti-lock system can apply and release braking pressure up to 20 times a second.

The ECU needs to determine when some of the wheels turn considerably slower than any of the others because when the car is turning the two wheels towards the center of the curve inherently move slightly slower than the other two – which is the reason why a differential is used in virtually all commercial cars.

One step beyond ABS is modern Electronic Stability Control (ESC or ESP) systems. Here, two more additional sensors are added to help the system work: these are a steering wheel angle sensor, and a gyroscopic sensor. The theory of operation is simple: when the gyroscopic sensor detects that the direction taken by the car doesn't coincide with what the steering wheel sensor reports, the ESC software will break the necessary individual wheel(s) (up to three with the most sophisticated systems), so that the vehicle goes the way the driver intends. The steering wheel sensor also helps in the operation of Cornering Brake Control (CBC), since this will tell the ABS that wheels on the inside of the curve should brake more than wheels on the outside, and by how much.

The ABS equipment may also be used to implement traction control system (TCS, ASR) on acceleration of the vehicle. If, when accelerating, the tire loses traction, the ABS controller can detect the situation and take suitable action so that traction is regained.

On high-traction surfaces such as bitumen, or concrete, many (though not all) ABS-equipped cars are able to attain braking distances better (i.e. shorter) than those that would be easily possible without the benefit of ABS. Even an alert, skilled driver without ABS would find it difficult, even through the use of techniques like threshold braking, to match or improve on the performance of a typical driver with an ABS-equipped vehicle, in real world conditions. ABS reduces chances of crashing, and/or the severity of impact. The recommended technique for non-expert drivers in an ABS-equipped car, in a typical full-braking emergency, is to press the brake pedal as firmly as possible and, where appropriate, to steer around obstructions. In such situations, ABS will significantly reduce the chances of a skid and subsequent loss of control.

In gravel, sand and deep snow, ABS tends to increase braking distances. On these surfaces, locked wheels dig in and stop the vehicle more quickly. ABS prevents this from occurring. Some ABS calibrations reduce this problem by slowing the cycling time, thus letting the wheels repeatedly briefly lock and unlock. The primary benefit of ABS on such surfaces is to increase the ability of the driver to maintain control of the car rather than go into a skid — though loss of control remains more likely on soft surfaces like gravel or slippery surfaces like snow or ice. On a very slippery surface such as sheet ice or gravel, it is possible to lock multiple wheels at once, and this can defeat ABS (which relies on comparing all four wheels and detecting individual wheels skidding). Availability of ABS relieves most drivers from learning threshold braking.

When activated, some earlier ABS systems caused the brake pedal to pulse noticeably. As most drivers rarely or never brake hard enough to cause brake lock-up, and a significant number rarely bother to read the car's manual, this may not be discovered until an emergency. When drivers do encounter an emergency that causes them to brake hard, and thus encounter this pulsing for the first time, many are believed to reduce pedal pressure, and thus lengthen braking distances, contributing to a higher level of accidents than the superior emergency stopping capabilities of ABS would otherwise promise. Some manufacturers have therefore implemented a brake assist system that determines that the driver is attempting a "panic stop" and the system automatically increases braking force where not enough pressure is applied. Nevertheless, ABS significantly improves safety and control for drivers in most on-road situations.

GN-model

The paper models the process of the work of the car’s electronic systems. For the purpose we use Generalized Nets (GNs) [1, 2].

The generalized nets are introduced by the set of transitions [1, 2]:

$$A = \{Z_1, Z_2, Z_3, Z_4, Z_5, Z_6, Z_7\},$$

where the transitions describe the following processes:

Z_1 - The work of the sensors;
Z_2 - The work of the CPU;
Z_3 - The work of the front left wheel;
Z_4 - The work of the front right wheel;
Z_5 - The work of the back left wheel;
Z_6 - The work of the back right wheel;
Z_7 - The work of the belt.

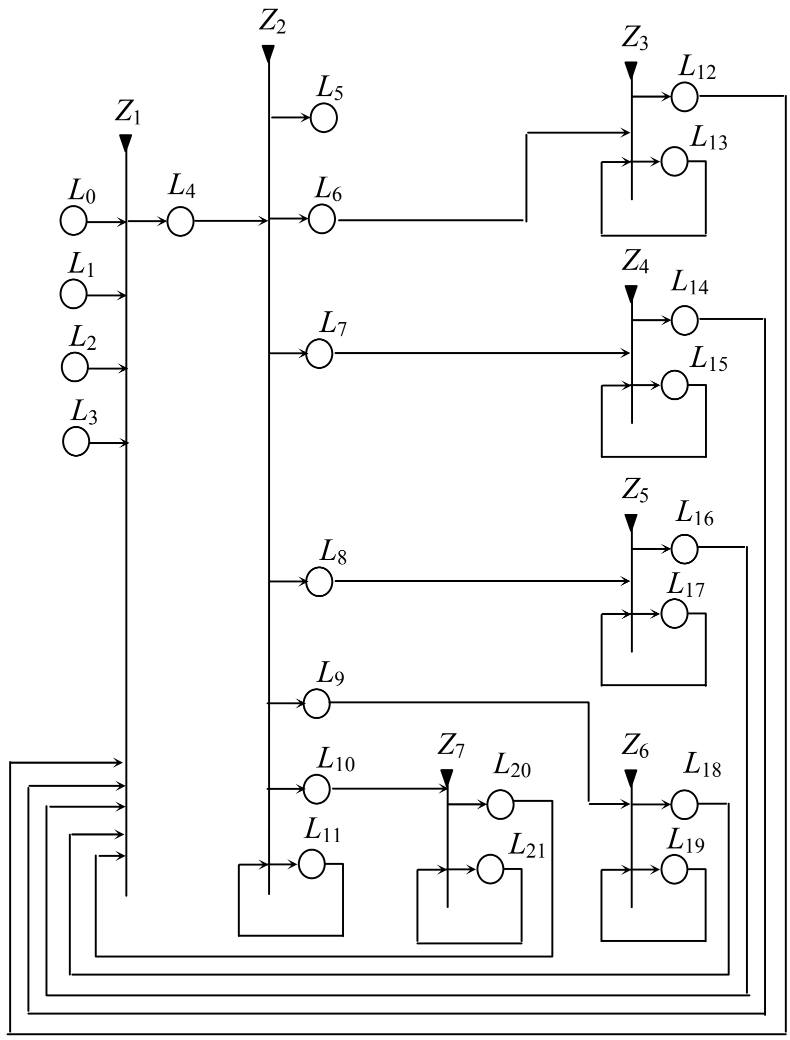

Figure 1. The GN model of the work of the car's electronic systems

Initially in places L_{11}, L_{13}, L_{15}, L_{17}, L_{19} and L_{21} stay the next tokens:

- in place L_{11} – one token with characteristic ”CPU status”;
- in place L_{13} – one token with characteristic “front left wheel status”;
- in place L_{15} – one token with characteristic ” front right wheel status”;
- in place L_{17} – one token with characteristic “back left wheel status”;
- in place L_{19} – one token with characteristic ” back right wheel status”.
- in place L_{21} – one token with characteristic ”belts status”.

These tokens will be in their own places during the whole time during which the GN functions.

The forms of the transitions are the following.

$Z_1 = < \{L_0, L_1, L_2, L_3, L_{20}, L_{18}, L_{16}, L_{14}, L_{12}\}, \{L_4\}, R_1, \vee(L_0, L_1, L_2, L_3, L_{20}, L_{18}, L_{16}, L_{14}, L_{12}) >$

where:

$$R_1 = \begin{array}{c|c} & L_4 \\ \hline L_0 & True \\ L_1 & True \\ L_2 & True \\ L_3 & True \\ L_{20} & True \\ L_{18} & True \\ L_{16} & True \\ L_{14} & True \\ L_{12} & True \end{array},$$

The tokens entering place L_4 obtain characteristics

"Information from sensors".

$$Z_2 = < \{L_4, L_{11}\}, \{ L_5, L_6, L_7, L_8, L_9, L_{10}, L_{11}\}, R_2, \vee(L_4, L_{11}) >$$

where:

$$R_2 = \begin{array}{c|ccccccc} & L_5 & L_6 & L_7 & L_8 & L_9 & L_{10} & L_{11} \\ \hline L_4 & False & False & False & False & False & False & True \\ L_{11} & W_{11,5} & W_{11,6} & W_{11,7} & W_{11,8} & W_{11,9} & W_{11,10} & True \end{array}$$

where:

$W_{11,5}$ = " There is activity for airbags",

$W_{11,6}$ = " There is activity for the front left wheel",

$W_{11,7}$ = " There is activity for the front right wheel",

$W_{11,8}$ = " There is activity for the back left wheel",

$W_{11,9}$ = " There is activity for the back right wheel",

$W_{11,10}$ = " There is activity for the belt".

The tokens entering places L_5, L_6, L_7, L_8, L_9 and L_{10} obtain characteristics respectively:

"Command for the airbags",

"Command for the front left wheel",

" Command for the front right wheel",

" Command for the back left wheel",

" Command for the back right wheel",

" Command for the belt".

$$Z_3 = < \{L_6, L_{13}\}, \{L12, L_{13}\}, R_3, \vee(L_6, L_{13}) >$$

where:

$$R_3 = \begin{array}{c|cc} & L_{12} & L_{13} \\ \hline L_6 & False & True \\ L_{13} & W_{13,12} & True \end{array}$$

where:
$W_{13,12}$ = " There is activity in the front left wheel".

The token entering place L_{12} obtain characteristic:
" Information from the front left wheel".

$$Z_4 = < \{L_7, L_{15}\}, \{L_{14}, L_{15}\}, R_4, \vee(L_7, L_{15}) >$$

where:

$$R_4 = \begin{array}{c|cc} & L_{14} & L_{15} \\ \hline L_7 & False & True \\ L_{15} & W_{15,14} & True \end{array}$$

where:
$W_{15,14}$ = " There is activity in the front right wheel".

The token entering place L_{14} obtain characteristic:
" Information from the front right wheel".

$$Z_5 = < \{L_8, L_{17}\}, \{L_{16}, L_{17}\}, R_5, \vee(L_8, L_{17}) >$$

where:

$$R_5 = \begin{array}{c|cc} & L_{16} & L_{17} \\ \hline L_8 & False & True \\ L_{17} & W_{17,16} & True \end{array}$$

where:
$W_{17,16}$ = " There is activity in the back left wheel".

The token entering place L_{16} obtain characteristic:
" Information from the back left wheel".

$$Z_6 = < \{L_9, L_{19}\}, \{L_{18}, L_{19}\}, R_6, \vee(L_9, L_{19}) >$$

where:

$$R_6 = \begin{array}{c|cc} & L_{18} & L_{19} \\ \hline L_9 & False & True \\ L_{19} & W_{19,18} & True \end{array}$$

where:
$W_{19,18}$ = " There is activity in the back right wheel".

The token entering place L_{18} obtain characteristic:
" Information from the back right wheel".

$$Z_7 = < \{L_{10}, L_{20}\}, \{L_{20}, L_{21}\}, R_7, \vee(L_{10}, L_{20}) >$$

where:

$$R_7 = \begin{array}{c|cc} & L_{20} & L_{21} \\ \hline L_{10} & False & True \\ L_{21} & W_{21,20} & True \end{array}$$

where:
$W_{21,20}$ = " There is activity in the belt".

The token entering place L_{20} obtain characteristic:
" Information from the belt".

Conclusion

The Generalized Net model described here is a possible model for the process of work of the car's electronic systems.

Most of the model parameters can also be regarded as characteristics of tokens from an additional contour, thus achieving optimization with respect to our given aim. Statistical information would need to be collected in order to monitor the development of the process.

REFERENCES

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