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RESEARCH ARTICLE

Integrated human-machine-environment system model of proportional stop lamps in braking situations

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Abstract

This paper introduces a new system model for braking situations. Its name is integrated human-machine-environment system model. This system model is used to model braking simulations. It shows the differences between the effect of standard brake lamps and proportional brake lamps or displays. This model is applicable for on board simulation and it is usable in transportation and traffic psychology.

Keywords

Integrated · system · model · vehicular · braking · deceleration · human · technical · environment · proportional

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1 Introduction

Driving is a fairly complicated and complex process, because it has got many fields and these fields belong to different sciences. These are cognitive science, mechanical science, transportation science and system science. All of these sciences try to produce a model for simulation of driving, but only a rather few of them succeed to do so.

Mathematical models are very useful applications to analyse tasks of driving, while the system models are the best to predict the driving activity.

The most widespread model for introducing the driving procedure is the general human-vehicle-road system model. There is a general block-diagram to show parts of the system.

Driving is a negative feedback system, in which the driver gets a signal about the spatial position of the vehicle, and compares this signal with the target signal. Then the difference determines the human response. The most important elements are human parameters, machine parameters and environmental parameters. This model expresses the total driving process from human to road.

Although this model is fairly useful, its usage has many limits. For example this model does not take signals into account which influence drivers. It does not care about requisite behaviours of drivers. Finally this model does not work with non-linear, adaptive and altering conditions.

2 Integrated human-machine-environment system model for braking situations

The integrated human-machine-environment system model is a fairly simple, but compound unit. It has many elements, parameters and disturbance variables. It contains three subsystems: the human subsystem, the technical subsystem and the environmental subsystem.

The human subsystem consists of two parts. One of them includes human sensors, the other one includes human manual actuators and human cognitive processors.

The technical subsystem contains vehicular actuators, parameters and latent environmental parameters.

So the third subsystem, the environmental subsystem is a part

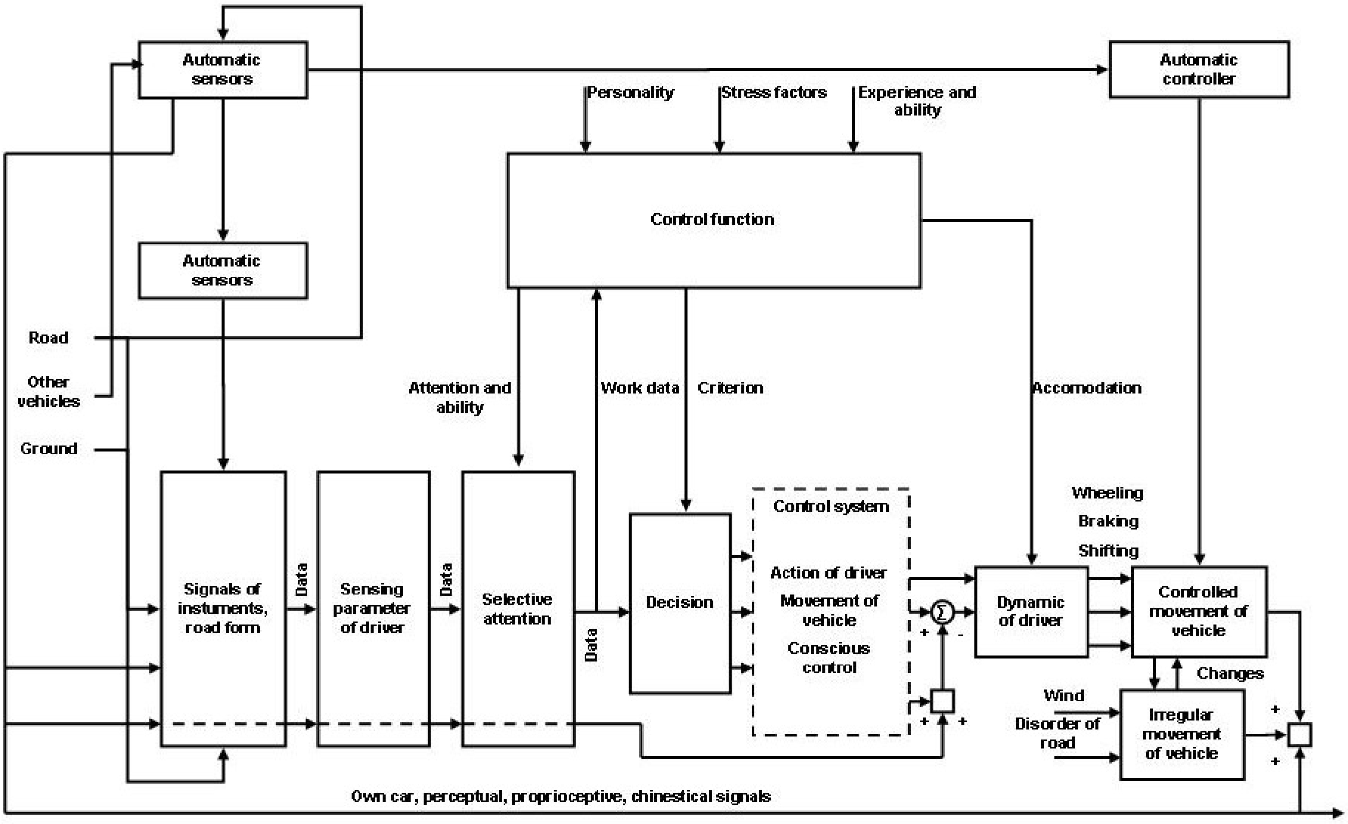

Fig. 1. General human-vehicle-road system model

of the technical subsystem because these are not separated.

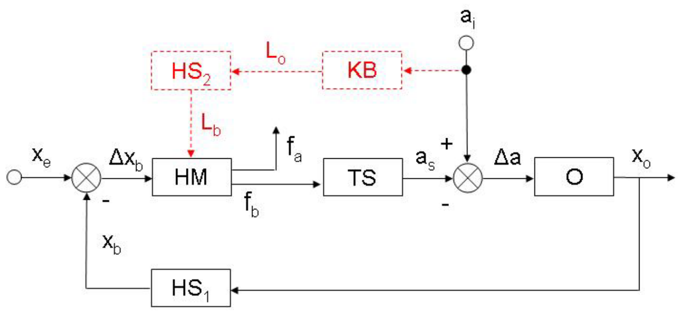

Fig. 2. Integrated human-machine-environment system model

The input variable of the system model is the deceleration of the front car. A differential element transforms this deceleration signal to objective picture size. This picture size is visible by the back driver. This size is the reference input element of this system model.

The output variable is the controlled variable. This is the objective picture size after controlling.

There is a big difference between standard stop lamps and proportional stop lamps. Proportional stop lamps indicate intensity of braking, while standard stop lamps indicate just the fact of braking.

This difference manifests in the system model. The model has got a complementary part. This part shows the difference between standard stop lamps and proportional stop lamps. This part gives the technical subsystem more direct input than the standard one. The difference between the two types of control signal is that the standard one collects data from the standard human sensors, from the human distance rating, while the proportional one collects data from a faster human processing subsystem, from the human width rating.

3 System identification of the model

The integrated human-machine-environmental system model has got ten main elements. These are the following: differential element as reference input element, comparing element or error detector, human cognitive and manual processing element as compensator or control task, technical subsystem such as actuators, comparing element, optical processing or optical converter as converter of the controlled signal and human sensor as transmitter. In addition there is a further part of this system model.

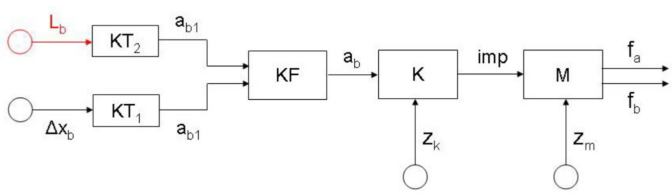

Fig. 3. Human processing

This is a proportional subsystem. It has got three elements: proportional converter to convert the reference signal, further human sensor as transmitter and human cognitive and manual processing as compensator or control task. The differential element converts the deceleration of the front car to an objective picture

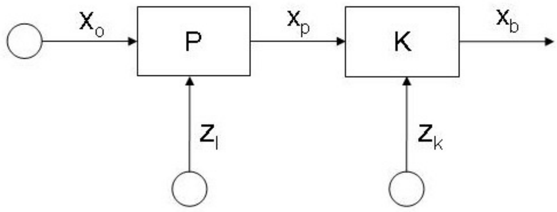

Fig. 4. Human sensor

size. The standard human sensor element transforms the output objective picture size to a rated picture size. The comparing element makes a picture size difference from objective and subjective picture size. This signal is processed by the human cog-

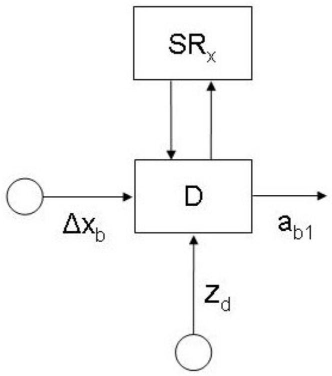

Fig. 5. Cognitive converter

nitive processing element. The human element generates pedal forces to push the gas or the brake. After that the signal goes to the technical subsystem and it transforms it to acceleration or deceleration. Further comparing element makes difference from this deceleration. The deceleration differences between the two cars go through the optical converter which transforms the deceleration difference to output, to objective picture size. If there

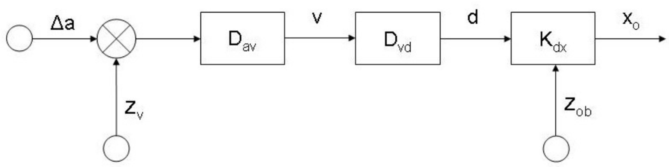

Fig. 6. Optical converter

is a proportional stop lamp in this system, the model works in another way. The system operates with standard human sensor too, but now it gets signal from the other, proportional subsystem. This fact enables that the technical subsystem gets collateral data from the proportional stop lamp. It means the following: Drivers know deceleration intensity of the front car from the first second and it is not necessary to wait for a sensing circle to push brake pedal.

4 Parameters and disturbance variables of the model

The integrated human-machine-environmental system model has got perceptual, cognitive, manual, technical, environmental and object parameters and disturbance variables. There are a lot

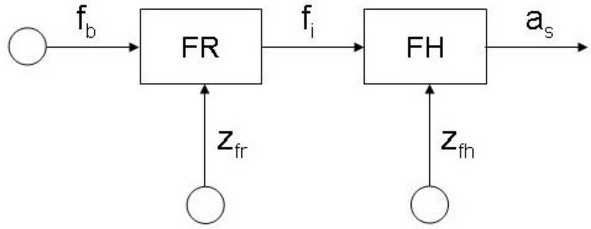

Fig. 7. Technical subsystem

of parameters and disturbance variables so the following are just one part of the whole list.

Perceptual parameters and disturbance variables are the human sight, condition of eyes, hearing, sensory organ container parameters, etc.

Cognitive parameters and disturbance variables are the reactivity, reaction time, attention, processing quality, processing speed, learned parameter, social effect, attitude, style, driving style, further cognitive property, STM, LTM, object, transportation situation, environmental effect, light effect, voice effect, emotional effect, further sensory organs effect, further external effect, etc.

Manual parameters and disturbance variables are the ability of inducement transfer, speed of inducement transfer, movement ability, movement speed, self movement limits, inducement transfer qualifying parameters, etc.

Transfer function of the base system for a_i:

$$-\frac{x_o}{a_i} = \frac{Y_{OPT}}{1 + Y_{loop}} \tag{1}$$

$$Y_{loop} = Y_{HM}(\alpha, \beta, ...) \cdot Y_{HS1}(\gamma, \delta, ...) \cdot Y_{TS} \cdot Y_{OPT} \tag{2}$$

$$-\frac{x_o}{a_i} = \frac{Y_{OPT}}{1 + Y_{HM}(\alpha, \beta, ...) \cdot Y_{HS1}(\gamma, \delta, ...) \cdot Y_{TS} \cdot Y_{OPT}} \tag{3}$$

Technical parameters and disturbance variables are the pedal factors and parameters, brake system force, transfer ability, brake lining, brake dial, stage of wheels, mass of car, gripping force, gripping surface, dynamical effects, etc.

Transfer function of the base system for x_e:

$$\frac{x_o}{x_e} = \frac{Y_{HM}(\alpha, \beta, ...) \cdot Y_{TS}() \cdot Y_{OPT}()}{1 + Y_{loop}} \tag{4}$$

$$Y_{loop} = Y_{HM}(\alpha, \beta, ...) \cdot Y_{HS1}(\gamma, \delta, ...) \cdot Y_{TS} \cdot Y_{OPT} \tag{5}$$

$$\frac{x_o}{x_e} = \frac{Y_{HM}(\alpha, \beta, ...) \cdot Y_{TS}() \cdot Y_{OPT}()}{1 + Y_{HM}(\alpha, \beta, ...) \cdot Y_{HS1}(\gamma, \delta, ...) \cdot Y_{TS} \cdot Y_{OPT}} \tag{6}$$

Environmental parameters and disturbance variables are the road condition, frontal sun light, brilliance, fog, snow, rain, etc.

Object parameters and disturbance variables are the size of front car, colour of front car, etc.

Notations

HM	human actuating (Y_{HM})
TS	technical system (Y_{TS})
O	optical transfer (Y_{OPT})
HS_1	human sensor, perception (Y_{HS1})
x_e	prescribed picture size
Δx_b	rated picture size variation
f_a	pedal force (gas)
f_b	pedal force (brake)
a_s	deceleration of own car
a_i	deceleration of front car
Δa	acceleration different
x_o	objective picture size
x_b	rated picture size
KB	proportional stop lamp
HS_2	human sensor, perception
L_o	objective wide of stop lamp
L_b	subjective wide of stop lamp
KT_1	cognitive transf. of standard s.l
KT_2	cognitive transf. of proportional s.l.
KF	cognitive selecting
K	cognitive processing
M	manual implementation
a_{b1}	rated acceleration of standard s.l.
a_{b2}	rated acceleration of prop. s.l.
a_b	rated acceleration
z_k	cognitive disturbances
z_m	manual disturbances
imp	human information
FR	brake system
FH	effect of braking
z_{fr}	braking disturbances
z_{fh}	interaction disturbances
f_i	pushing force
D_{av}	acceleration – speed difference
D_{vd}	speed – distance difference
K_{dx}	distance – picture size converter
z_v	visual disturbances
v	speed
d	distance
z_{ob}	object disturbances
P	perceptual element
D	differential element
z_l	perceptual disturbances
x_p	perception
SR_x	recollection container
z_d	recollection disturbances

5 Summary

This paper has introduced a new system model for braking situations. Its name is the integrated human-machine-environment system model. This system model is used for braking simulations. It shows the differences between the effect of standard brake lamps and proportional brake lamps or displays. This model is applicable for vehicular simulations and it is usable in transportation and traffic psychology. This system model is not complete yet, but we are stil working on it. These are just the first steps in modelling, so we will have more tasks to come.

References

1 **Réti L**, *Ember – jármű – út.*, Közgazd. és Jogi Kvk., 1977.

2 **Woodworth RS, Schlosberg H**, *Kísérleti pszichológia*, Akadémiai K., 1986.

3 **Czigler I**, *A figyelem pszichológiája*, Akadémiai K., 2005.

4 **Horváth LG**, *Közlekedéspszichológiai ismeretek*, Tankvk., 1975.

5 **Pléh Cs, Kovács Gy, Gulyás B**, *Kognitív idegtudomány*, Osiris, 2003.

6 **Petrik O**, *Rendszertechnika*, Tankvk., 1987.

7 **Bertalan Zs**, *Irányítástechnika*, Műszaki Kvk., 2005.

8 **Keviczky L**, *Szabályozástechnika*, Universitas-Győr Kht., 2006.

9 **Bagdy E, Klein S**, *Alkalmazott pszichológia*, Edge2000, 2006.

10 **Fekete RT, Ábrahám Gy**, *Development of a measurement station and a procedure for measuring differences between standard and proportional stop lamps*, Periodica Polytechnica Transportation Engineering (2008).