Development of smart traffic evaluation- and influence-modules

based on non-declarative rules of artificial intelligence

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**Abstract**

*The paper delivers a mid-term report about a Hungarian GINOP-project, where the objectives are: development of a new methodology for evaluation and smart influence of traffic based on artificial intelligence. The basic pillars of the project are from KNUTH (1992: Science is what we understand well enough to explain to a computer. Art is everything else we do.), and from BOSTROM (2015: …we should work out a solution to the control problem in advance…). The online engine for artificial intelligence is a product of a Hungarian INNOCSEKK project (2006-2009) – prized two times (2012ITBN, 2014HUNINNO) in frame of its applications. The similarity analysis as such in the background of artificial intelligence is capable to support lateral thinking. Therefore the problems of evaluation and influence of traffic can be handled without classic physics – based on the behaviour patterns of moving objects. Similarities make it possible to derive non-declarative rules like strategical directions for smart influence of traffic constellations. And also similarities ensure an anti-discriminative, multi-layered evaluation in an automated way, where evaluation is the input for control simulations about traffic alternatives. The first results show, that the anti-discriminative evaluation can involve arbitrary components like moving, stopping, accelerating, and/or environmental variables incl. emissions, noises, etc. The aggregated evaluation can be derived for the entire traffic system and/or also for its parts. The smart influence of traffic aiming a better evaluation value in the future involves the time series of the evaluation module and it derives parallel models being able to estimate the next aggregated evaluation value of traffic. The staircase functions of the models make it possible to derive effective and efficient strategies in form of preferred direction of traffic lights. The results can be checked concerning their consistence (logical connections). The next challenges in the project will be the estimation of the consistence of traffic to explore the most instable variables and the development of models being capable of deriving connection (production functions) between variables. The project involves researchers from the disciplines of social sciences in order to add multidisciplinary approach and a high level of socio-economical view to the goals and also to the execution of the project. It is nice to percept their affection on the set of goals, and on the more abstract ideas to be achieved with the mathematical an AI model like competitive advantage, added value or the phenomenon of smart products. It is revelation to be able to observe the way how an R+D project fits to the Industry 4.0 paradigm and the Smart City, Smart Transportation, Smart Metering ideas from a helicopter view. Our paper will reflect on both the mathematical and the socio-economical approach highlighting the result of their symbiosis.*

**Keywords:** behaviour pattern, evaluation, strategy, automation, similarity analysis

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# Introduction

Complex, *multilayered* system (like traffic) can only be influenced in an *efficient* way, if arbitrary parts of the system can be evaluated continuously and *consistent*, where *efficiency* means more and more needed effects per influencing activities. *Multilayered* is a system, if unlimited (measurable) attributes (like speed, acceleration, noise, stops, gas emission, etc. with preferred directions: e.g. the more the more or the more the less) can/should be aggregated in frame of an evaluation, where objects are time and space intervals (like traffic in a given street between 08.00-09.00 a.m.). System evaluation may not have *subjective* parameters (like arbitrary weights, scores set by humans), but an *objective* evaluation should prove, whether each object can be evaluated with the same value (c.f. **principle of enforced sameness**) based a *consistent* and *optimized* scoring system. *Subjective* settings are conscious or unconscious preconceptions. An *objective* evaluation needs algorithms being capable of *optimizing* scores for each attribute level, where *consistency* means that a better performance level can not be scored with a less value than a worse level of performance and attributes can only have scores through their levels in frame of an *optimization*. An *optimization* task can be defined through an objective function, where the principle of the enforced sameness (the **anti-discriminative modeling**) should be ensured as far as possible. The *anti-discriminative modeling* is able to deliver dynamic *norm values* and it is also capable of handling with the ‘*none-of-them*’ option, where the artificial intelligence do not have a valid answer for a given question. In an entire *anti-discriminative* system, each object has just the *norm value* – therefore there is no possibility to evaluate.

The paper will show, how a complex evaluation can be built and how the traffic can be influenced based on similarities, where each evaluation should always have a kind of data visualization effect tool.

The original idea the traffic influencing based on similarities comes from an R’n’D project named TRAFO (Traffic Optimization System) financed by the EU and the Hungarian government in accordance with the EU tendering processes and the EU cohesion fund policy. (GINOP-2.1.1-15-2016) TRAFO project is truly technology project. (GINOP-2.1.1-15-2016-00912)

This R’n’D project aims to develop a traffic simulator and a proactive traffic management methodology based on mathematical forecast of upcoming traffic events. The central AI based application modules – will be detailed in the next chapters - are the central elements of project. The algorithm is responsible for finding the better cases and rising the goodness index of the complex traffic situation. The mathematical goal is to reach a better status of the traffic than the previous one. The other components and modules of the system are liable for data gathering and data transformation for reasons like evaluation, calibration and for real operation: Each are subordinated by the central AI module.

Through the development of the evaluation and influencing modules for traffic systems, the principles of KNUTH (1992: *Science is what we understand well enough to explain to a computer. Art is everything else we do.*), and BOSTROM (2015: …*we should work out a solution to the control problem in advance*…) will be operationalized based on artificial intelligence methods (like chains of similarity analyses).

# Evaluation module

The following chapters show the data requirements, modeling steps and the data-visualization possibilities. The basic expectation concerning the methodology for evaluation and influencing are the scalability and the generalizability. Scalability means: the evaluation and the influencing logics may not use any parameter of size according to the focused traffic system. Generalizability means: it is also forbidden to use specific parameters of a traffic systems – each involved phenomenon should be valid in every potential system.

## Data requirements

In order to ensure the above mentioned requirements, data for evaluation of an arbitrary traffic system will always be measured without any restriction – merely the phenomena needing descriptive values are pre-defined. Of course, the more standard the measurements are, the more robust will be the results, but the feasibility of the modeling steps remains unlimited. Phenomena being handled are:

* in case of group of moving objects:
  + speeds
  + accelerations
  + stops
  + gas emissions
  + noise emissions
  + …
* in case of the environment:
  + temperatures
  + precipitations
  + winds
  + radiations
  + gas concentrations
  + noise exposures
  + …

The lists above can be unlimited flexible changed. In the modeling, data will be involved in an absolute and/or relative way that means: changes of phenomena will also be calculated. In case of a new variable, these changes are always zero for the past periods. In case of absolute values: the first/last known value is the norm for not available information units. Therefore, the following direction are able to describe an ideal system, where the environmental factors play only a role for relativisms:

* absolute values:
  + average speeds: the more the better
  + standard deviation of speed-data: the less the better
  + average accelerations, emissions/exposures: the less the better
  + standard deviation of acceleration-data: the less the better
  + count of stops and time being stopped: the less the better
  + …
* relative values:
  + differences of speed-data in time series: the less the better
  + differences of acceleration-data in time series: the less the better
  + …

As it can be seen based on the preferred direction: the traffic is ideal, if the moving object can drive rel. fast, rel. uninfluenced by stops and/or accelerations, therefore rel. clean (efficient). Measurements can be made for each moving objects or for an arbitrary part of them. The even given part represents always the entire set. Instead of emission, gas concentrations and/or noise exposures can also be measured in different parts of the space (e.g. distances and/or heights).

## Modeling

Data for modeling will always be structured into OAM (object-attribute-matrix). Objects are time and space units (like a set of crossroads from 08.00 to 09.00 a.m.), where averages and/or standard deviation can be calculated. The amount of objects can be arbitrary high, but the resolution of the object ranking can also be manipulated in a free way – mostly in direction of lower resolution. Attributes are the above listed phenomena. The absolute and/or relative values of the phenomena will be standardized based on ranking, where the pre-defined directions regulate the rankings logic. For the LP-based optimization, the ranked OAMs are the inputs. The calculations deliver staircase-function for each attribute and for each ranking levels – in an optimized way. Always at least two optimizations run parallel, in order to be capable of checking symmetries between the staircase-structures as a minimal action for a consistency-oriented model quality assurance. The estimated evaluation values can be the same in an antidiscriminative model based on similarities, if each object has advantages and disadvantages. If the estimated evaluation values can not be forced to become the same (norm) value, then the system (described through their time-space-objects) has better, worse, norm-like and undefined phases (c.f. Pitlik et al 2018a).

## Data-visualization

Figure 1 shows a static evaluation for a given time interval and for 5\*5 parts of a traffic system, where greenish stands for better evaluations, reddish means worse circumstances, and yellowish is for the norm-like situations. Grayish would be a spot, if the symmetry-check could not deliver valid estimations. The evaluation can be re-calculated every time, if a new object is given. The animation of the static evaluation delivers a movie with some changes of colors for the focused spots.

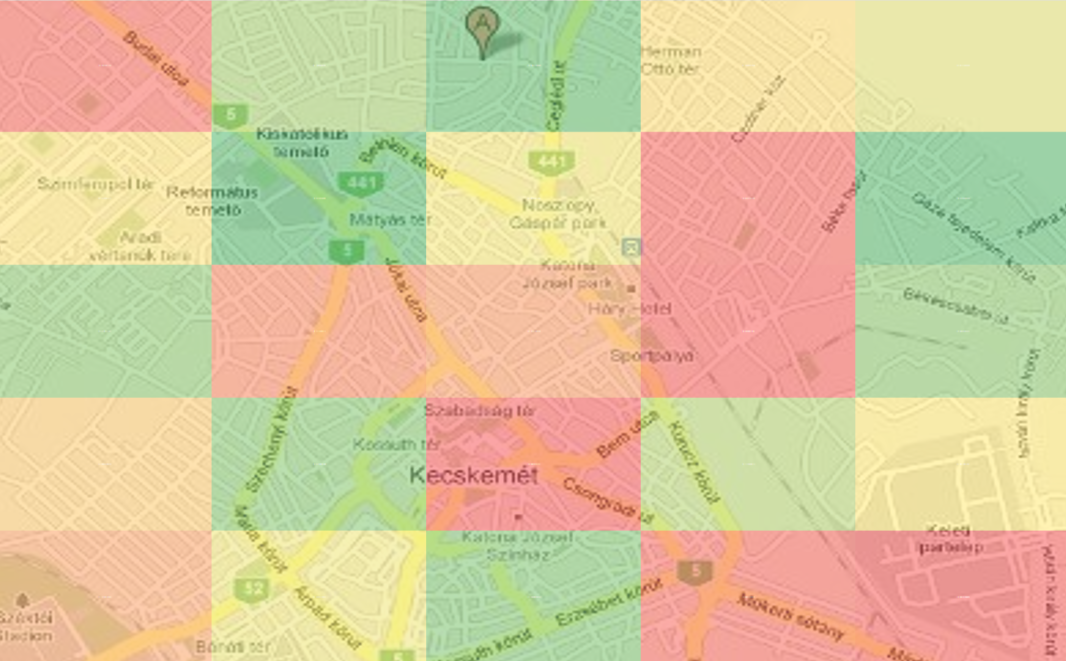
 

Figure 1 Demo map without and with evaluation layer

Source: <http://www.bestinfo.hu/terkep.jpg>, 2018, and own presentation

# Influence module

The AI-based influencing effects are decentralized in a lot of specific functions (like supporting highlighted objects: e.g. vehicles of fire-fighters) collaborating with a common big-data-sea in the background. Influencing effects can be achieved in two different ways: detecting problems and reacting and/or forecasting problems and preventing.

The reaction-based strategy (like specific solution of chartists) needs facts and mostly declarative rules (e.g. AAA - autonomous adaptive agents), where adaptation means interpretation of facts through relative simple rules.

The prevention-based strategy needs forecasts e.g. about the goodness of traffic in the next time-intervals. Models being capable of description of traffic changes in the future can also deliver functions between raw measurements and aggregated goodness values. The raw measurements (like average speed of moving objects) can be influenced in order to avoid/minimize the forecasted problems.

The next two chapters show examples for the prevention-based modelling:

## Derivation of strategies

An arbitrary traffic system can be described through e.g. the streams (amount of vehicles / time-interval) on different spots (c.f. Pitlik et al 2018b). These raw variables will always be involved into the modelling of goodness. The goodness values of the previous time-intervals can have a trend. If this trend shows a kind of increasing (it means: the traffic will even be better without any influencing), then the influencing module do not send any commands to the influencing motoric. If the trend is negative concerning the goodness values, then it is necessary to search for preventing actions. Traffic can only be influenced in a rational way, if the logic of changes can be modelled. With other words: If the changes in the future can be forecasted. The simplest forecasting structure is, where the raw data for anti-discriminative evaluation have to forecast the evaluation value for the next time-interval. It is also possible to work in a parallel way, where forecasts can also be generated for further time-intervals in the future and these forecasts can increase or decrease the intensity of preventions (e.g. forecasts about more and more consolidated future make possible to decrease the intensity of interventions and vice versa). If a robust forecasting model is given, then the needed simulation tool is also given in case of staircase functions of the similarity analyses. The explored stairs show, whether each raw variable has influencing potential at all or what kind of stairs of a given raw variable have relevant influencing potential. The simulation system has only one challenge to manage: the next time-interval based on the last facts from the big-data-sea. A traffic system can be influenced in several ways at first based on one raw variable needing changes. For each alternative, a lot of descriptive statistics can be calculated (like risk, inertia, etc.). The best solution can be derived based on the (already known) antidiscriminative modelling approach –involved into the evaluation module. It is also possible to influence more than one raw variable. The hybrid solutions can also be evaluated through the simulation model. The above outlined logic determine a kind of preferable direction for the next time-interval, where the expected exposure of the entire system can be regulated with the highest impact. The highlighted direction in the traffic system will only be preferred in the reality, if real needs can be detected. Therefore a probably useless estimation for the preferable direction has no negative impact for the system. If the raw variables describe not only outward directions but inward directions too (or in an inverse model exclusively), then the influencing mechanisms can work for a kind of parallel braking effect, where the given system has less and less exposure.

## Exploration of genetic potentials

Genetic potential means (cf. Pitlik et al 2018c) what is the highest raw value in a traffic system being realistic based on the proportionalities in the known system? The derivation of the genetic potential for each raw variable support the risk management for the entire traffic system, because an expected value near to the genetic potential can be realized with less probability, then in the middle of the realistic interval.

Genetic potential is a specific system property: it is an estimation calculating from staircase functions, where the highest value for each raw variable is symbolized through a rank value (=1.). For derivation of a genetic potential value, it is necessary to create production functions between n-1 raw variable and the preferred one, where n is the amount of all the raw variables in the system.

Complex systems like traffic can have complex connections between the raw variables, where the classic directions can not always be pre-defined in an easy way. The best production function can be explored based on the principle of the Occam’s razor, where randomized and/or (stepwise) rational derived set of production functions can also be evaluated based on the anti-discriminative model techniques (like before e.g. in case of the evaluation module). It is possible to have more than one quasi ideal production functions. In this case, the alternative estimations about the genetic potential can be interpreted in the simplest ways: the minimum of the alternatives has the less risk.

Here and now, the term of non-knowledge should be introduced in order to show: artificial intelligence solutions should not always have an answer to the question. Therefore the non-knowledge is also a kind of information, where the big-data-sea produce just foggy estimations. But fogs are dynamic phenomena – so, one of the next time-intervals can support the decision making processes again...

## Bottom-up approach without intertextualities

Analyzing the tender documentation, it is clear that the idea owners have a bottom-up approach. The main idea is clearly articulated as a technology- and algorithm-based solution, detailed before. The high-level design lists the items, the sources, the technologies, the most important list of features. And you can find not a hint on wider context. From the social science and economic point of view it is not wired to any general paradigm. Having the chance to participate in the project, the reason seems to be simple. The idea owners were not aware of the fact they are making something that relates to a wider perspective or it was not important to make the missing links for any reasons.

Summarizing the objectives, the TRAFO R’n’D tender documentation shows that the planned system is divided to multiple autonomous elements with delegated decision making and information generating duties. The communication is based on the cloud solutions. The sensors generate the relevant data. Big data and AI software modules generate the information for the simulation and the modelling. The autonomous modelling makes decisions that could be executed by an outsource traffic management system.

The settings above conclude the Industry 4.0 (I40) technology keywords (Lu, 2017) (Bloem, van Doorn, Duivestein, Excoffier, Maas, van Ommeren, 2014) without making the inevitable mental step, putting the idea into the I40 perspective.

To support this statement, we made a semantic research on the content of the tender documentation. There is no reference to the following terms in it: Industry 4.0, smart traffic, IOT. It means that the project scope was absolutely out of context. On the other hand, several relevant technology related expressions can be found in the tender documentation at the same time: sensor 36 times, parameters 23 times, mobile app 10 times, software 12 times, autonomy 3 times, big data 2 times, M2M 2 times. The reference to these expressions did not have a detailed exposition, specification or specific technology choice. They are more like guidelines or keywords than technology decisions.

According to our previous studies we attempt to analyze the intertextualities and define the missing links to I40 paradigm.

Our founding about the core function of I40 can be defined as the following regarding value proposition (Gyimesi, 2018):

I40 project value proposition= utilizing the new technologies + generating information + using autonomous decision making procedures + policies for reaching a defined business or operational goal + deficit management + applied I40 framework

By design there are decision levels to be built one-on-one we put to a simple layer model (Gyimesi, 2018):

|  |  |  |  |
| --- | --- | --- | --- |
| Business Goal Layer | Features, key words | Add value | Goals reachable |
| 1. Business-Sales Layer | New products, Smart products, Online connection with the product, Networking, Product-services-information based business, Platforms | Business innovation from Information | New Business, New Revenue |
| 1. Internal Processes – Cost Effectiveness Layer | Efficiency, Cost reduction, Monitoring – controlling, Decentralization, Smart x, Automation, Robotization | Effectiveness from Information | Effectiveness, Competitiveness, Cost Reduction |
| 1. Technology Layer | IoT, Sensors, AI, Mobile, Edge computing, Collaboration, Applications, Autonomy systems, Big-Data, CPS | Information from Data | Information |

The study shows that technology itself does not generate I40 initiative. Clear strategic business goals (Business layer), effective deficit management and risk mitigation, and I40 framework management is needed. (von Leipzig, Gamp, Manz, Schöttle, Ohlhausen, Oosthuizen, Palm, von Leipzig, 2016)

Strategically thinking the decisions about the aimed Business Goal Layer is a must. In the TRAFO case none of the decisions were made by the project owners consciously. Nevertheless, the characteristics have been discussed later on the think-tank meetings.

* Detailed goals of the project
* Comparison to the existing solutions
* Probabilities of installation to the existing traffic management systems
* Add values
* Advantages (articulatable) to other smart city solutions
* Integration issues, links to external systems
* Exclusivity, inclusivity – possibilities of interfacing
* Set of functions – wider the better, useable is the better
* Set of direct impacts on the traffic
* Set of indirect impacts on the surroundings
* The possible ways of usage – local, general, extendable
* Meaning of the term: general solution
* The measurement of the validity of the general solution
* The idea and the meaning of goodness index
* Possibilities of income models
* Value of the data and information generated
* Ways of further development
* Visions of the future traffic and traffic management
* Possibilities of penetrating a social network based traffic management system
* Project deficits
* Lack of element
* Deficits for execution
* Main decisions regarding the project
* Detailed technology decisions and interfacing

The answers to the listed topics draft a complex I40 management framework including strategic and action planning level as well as making core decisions.

TRAFO retroactively became an I40 project. We have to emphasize that there was not a word about that in the tendering documentation. It was not a will. It happened by accident.

The recent understanding is converse. The project itself identified the I40 key characteristics of the TRAFO retrospectively along with the project meetings.

The core I40 related decisions has been finally set and can be seen below:

* I40 Business Goal Layer: Business-Sales layer - New business by I40
* I40 Technologies: Android, MongoDB, Cloud-based AI-server with API
* I40 Deficit management and risk management within the project management along with the TRAFO I40 management framework

We can also show the TRAFO I40 value proposition applying the theoretic function.

TRAFO I40 value proposition = I40 technologies + traffic related data defined controller information + AI decisions for better traffic statuses + new I40 related business opportunities by the project + risk minimization as deficit management within the project management + core decisions by the I40 framework

With these findings the project has been given the missing economic frame extended additional methodical and decision making elements and also new energies.

# Conclusion

Similarity analyses are capable of aggregation multilayered inputs for evaluation of complex systems like traffic. The similarity-based evaluation do not need any subjective numeric value like weights and/or scores. Idealized directions for the involved variable should be pre-defined by human. The evaluation can always be executed in an optimized way. The evaluation process has parallel models for ensuring consistency or leading to exclusion of objects from the evaluation itself. Estimated evaluation values can be visualized in a GIS-like frame layer by layer and in aggregated levels. Influencing of traffic can also be achieved in a similarity-oriented way. In the future, the potential influencing strategies will be evaluated based on the logic of Occam’s razor as the central thought of TRAFO.

The project is – at last - managed by an applicable I40 decision making and management framework. After making the basic evaluations and decisions the focus points can be kept steady. The resources and the priorities are set also. The bottom-up approach attitude of the mathematicians and the top-down value-oriented view of the economists jointly ensure the progress and the quality of the project belonging the I40 paradigm.

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