ADAPTIVE SIMULATION-BASED CONCEPT FOR CONSTRUCTION LOGISTICS

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I. INTRODUCTION

Practical application of simulation modelling requires exact models. This means that model parameters should have exactly realistic values. As the modelled system is changing over time, the model should follow it as well. Adaptive simulation methods build up advanced modelling tools for this problem. In adaptive models (similar as the DDDAS, see [1]), properties are subject to continuous adaptation. Necessary information comes directly from the modelled system. The model is adapted using this information in defined time interval. In this paper basic principles and operations of an adaptive material flow simulator are presented. The elaborated methods is a part of our research project (KTIAAIK-12-1-2013-0009) financed by the National Development Agency of Hungary, total financial support is HUF 419 904 851) which aims to improve logistics processes in the building industry.

Figure 1. Positioning of the development areas in the areas of production and logistics using the “Gartner Hype Cycle” [2]
II. LATEST TRENDS IN ADAPTIVE SIMULATIONS

The Gartner Hype Cycle [2] includes the stages of public attention that goes through a new technology when it was introduced. The phase "technology trigger" characterizes an event that attracts the interest of the professional public in coming. With the phase "peak of inflated expectations" enthusiastic expectations for technological development are created. The "trough of disillusionment" highlights the fact that the expectations associated with the development, cannot be satisfied. Publications on this phase are rare. In the "path of illumination" (slope of enlightenment) realistic estimates lead to a new understanding of the developments. The last phase of the Gartner Hype Cycle "plateau of productivity" is achieved when the benefits of development are widely accepted. The technology developed in this phase in the second or third generation. Adaptive simulations are closest to the category in Fig. 2 called „Automatic model generation“. As seen there have already much research in this area, however next a period of disillusionment is expected. Therefore actually research in this area should much concentrate on practical applications, in order to prove usability.

Figure 2. Framework for adaptive real-time tracking and simulation [2]

Lingguang Song and Neil N. Eldin in their paper [2] presents an adaptive real-time tracking and simulation algorithm for heavy construction operations of heavy construction operations. In this method construction data are continuously recorded by the means of different sensors. The framework presented in Figure 2, enables continuous adaption of the simulation by generation of the necessary empirical distribution functions. This implies that the simulation model itself has a special construction which enables adaptive features.

Above paper belongs to the parametric adaption of simulation models. Our previous research has also been addressed this problem. In an earlier publication [3] an
adaptive simulation technique was presented for modeling material flow systems. This paper describes a simulation model with internal parameters based on neural networks. Neural networks can be used for adaptive simulation. Gregor in his paper [4] describes applicability of neural networks for metamodels. We should however point out that neural networks are not an exclusive solution for the problem. In our current approach we will use an empirical distribution type solution, like in [2].

III. ADAPTIVE SIMULATION-BASED CONCEPT FOR CONSTRUCTION LOGISTICS

Current results belong to a comprehensive research in construction logistics. During this a demonstrational system’s concept is worked out (see Fig. 3). The system’s
main objective is to be able to analyse on it, how an advanced, simulation-based process control system operates. The system is composed of following main modules:

“Simulation” module, which is the core element of the system. It can operate in three modes: “Data collection” (acquires and processes data from the physical system), “Prediction” (classical simulation task, the model gives forecast for the future from the current state), “Visualization” (it is same as emulation functionality of simulations, where physical and simulated processes run parallel). The “Simulation” module exchanges information with the modelled system. Human interactions into the system are carried out using the “Task editor”. The functionality is further supported by external “Decision support support” for e.g. selection of the best task-matching machines.

“Interface” module, which operates as a connecting element between the physical, modelled system and the model.

“Physical, modelled system” which consist of several components. This is therefore a group of elements. There are first of all data collection devices among them (see Fig. 3.), which serve for not only for the sake of modelling, but used in the logistics processes as well. These are “Data collector Omron FH1050” which is a camera system for gathering data upon visual identification. “CK3 hand terminal” is a special data collection device, which uses Barcode and RFID information from the logistics objects. There are two physically implemented machines in the system as well. The “Machine” is a real earthwork machine (bagger), equipped with the necessary sensors and communication devices, to obtain tasks and send confirmations. Transportation device inside der “construction site” is modelled using an AGV. It is able to acquire and transfer position information, and obtain goal positions. Transport machines that move outside of the construction site is virtual.

The demonstrated example will focus on the AGV and its simulation model. It travels in a single loop with 6 stations. The machine stops at the stations if loading and unloading of unit loads is necessary. The AGV is able to record position information (position code and time stamp) and sends it via the interface to the list of transactions into the database. This is the information source for the simulation.

IV. INTRODUCTION OF THE IMPLEMENTATION OF THE SIMULATION ENVIRONMENT

Current implemented version of the simulation has two operational modes. In “Data collection” mode the simulation continuously observes the process via circular reading of the list of transactions. If the model finds appropriate data in the transactions it actualizes the simulation using this one. Calculation of the upgraded data is simple. Assuming that we already have collected “N” time data for the actual found relation (e.g.: form Stock 2 to Stock 3), the new travel time between these nodes can be calculated using the equation of the weighted average:
The model has been implemented using Simul8 logistic simulation software. In this model there is a virtual Work Item which is rotated between two simulation elements, triggering periodically the code section for acquiring new data. The code searches for event combinations in the collected data which corresponds to travel options along the path by the AGV. These data is transferred into a Simul8 table in a direct usable form for Simul8.

Later acquire of additional data, such as handling time will be implemented as well. This enables continuous adaption of the model to the actual system.

The simulation model has further two operational modes (see Fig. 4). Visualization operates as comes from its name an online representation of the system state. For the AGV it means that using the information from transaction, the model signals if the AGV reached the positions. Travel between the nodes is upon collected data, so here a small modelling inaccuracy is experienced.

In operational mode “Prediction”, the model can forecast future state of the model. Here not only the collected data can be used, what-if scenarios can also be tried out. This is useful if the planners would like to try out for example effect of a faster AGV or other transport device.

![Figure 4. A Operational modes’ selection in the simulation environment](image)

The simulation modes can be changed at each start of the model by giving an appropriate number in the pop-up window (see Fig. 4.).
V. SUMMARY

This paper presented an adaptive simulation related method, rather than detailed analysis. The results are however practical as the system has been tested in live conditions using real hardware and it proved it’s functionality and effectiveness. Main advantage of this system that it builds up a solid foundation for creating and connecting more adaptive modules.

REFERENCES


