Solving optimization problems based on System Dynamics models

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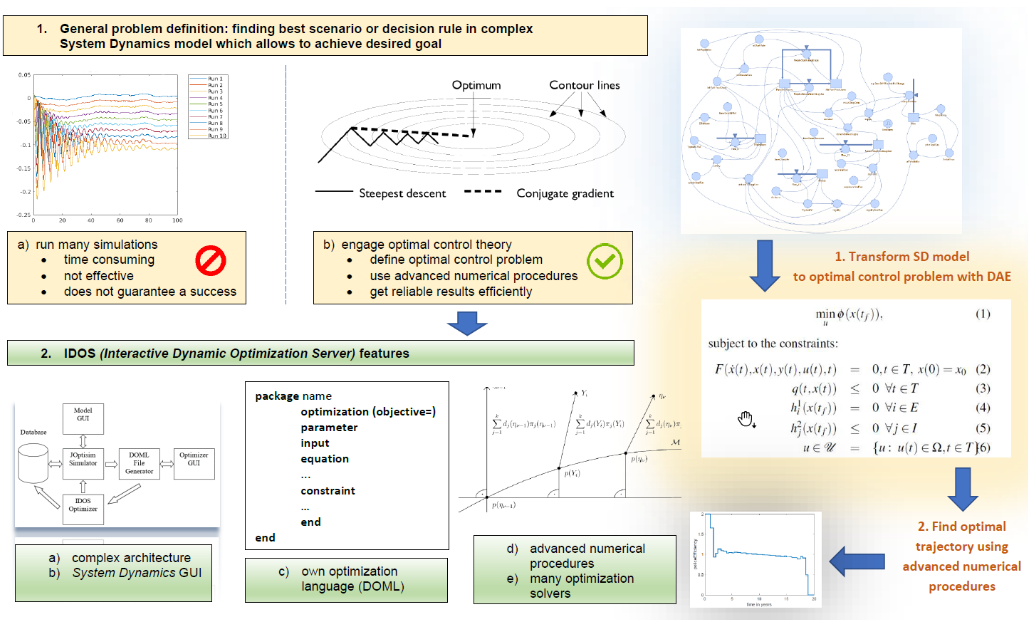
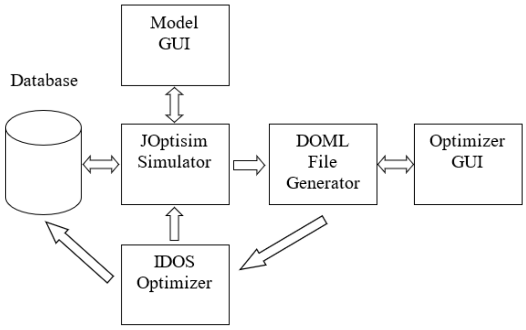
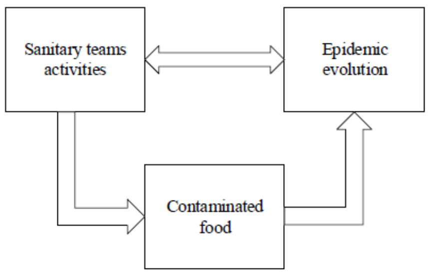
Body of Extended Abstract: The aim of the paper is to show how optimization problems could be defined and solved using advanced tools and techniques together with the System Dynamics methodology. The presented approach is illustrated by three examples related respectively to sanitary teams' efforts to overcome spread of epidemics, general crime development model and drugs prevalence activities. All of them are examples of real world dynamical environments where effectiveness heavily depends on made decisions. One of the widely recognized tool for verification of the decision rules in such environments is a System Dynamics approach which in general is based on differential–algebraic equations (DAE's). Stocks, flows and other variables contained in environment's model can be simply transformed to DAE's form and subsequently computed with the help of advanced numerical procedures. As a result individual gets trajectories of variables which are de facto predictions of the environment behavior. While seeking an optimal decision, researcher needs to change values of particular parameters and compute new trajectories each time after such change. Even if the number of parameters is relatively small finding the optimal solution could be time-consuming task despite using some automation techniques. Other important issue of such approach is that researcher never knows how far is he from the optimal decision rule. Therefore, having a dynamical model described by DAE's, using optimal control theory with particular algorithms implemented in dedicated software we propose to define and solve optimal control problems. Its solution will give optimal trajectories of the variables of interest which could be verified against decision rules previously implemented in the model. Moreover results given by solving optimal control problem can work out new, better decision rules.



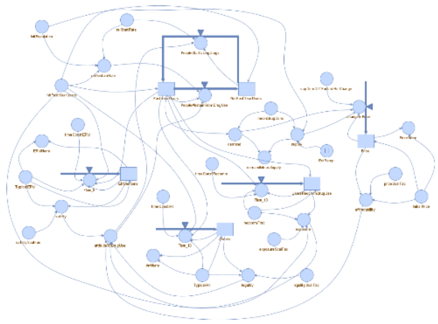
The environment that was built is called **IDOS** (Interactive Dynamic Optimization Server) and it allows to model dynamical systems and solve optimal control problems. One of the main component of IDOS is a graphical modeling one called ”JOptisim” which is presented in Figure 1 and is available at www.optisim.org. The component uses a graphical interface to facilitate building models of complex systems. The simulator can be used to model dynamical processes according to System Dynamics methodology.



Our first approach to optimization of a System Dynamics model that we present in the paper is the example related to a model of an epidemic of a foodborne disease and sanitary teams activities. The model is a modification of the well known SIR model which name follows from the names of the main model variables (Susceptible–Infectious–Recovered). Block model of sanitary teams activities is shown below.



Second problem that we consider using **IDOS** is determination of the optimal time distribution of police forces intended for fighting against drugs. The calculations are based on the drug prevalence model built with the help of System Dynamics methodology. The model is based on the drug prevalence model which in some sense is similar to SIR model and is presented below.



In the paper we described an approach of optimization of complex environments modeled with help of System Dynamics methodology. Basing on above examples it could be concluded that presented in the paper approach togehter with IDOS—the dedicated, advanced computational environment for solving optimal control problems is sutaible for choosing optimal decision rules which are included in System Dynamics models. Because proposed approach does not require running large number of simulations it gives quickly accurate results. Moreover, IDOS environment provides functionality of calibrating System Dynamics models and that gives it substantial advantage over other available System Dynamics tools.