

Original Articles

An accelerated-time simulation of baggage traffic in an airport terminal

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Abstract

This paper introduces the new ATISBAT model for generating accelerated-time simulations of baggage handling in an airport terminal. The philosophy of this model combines ideas from cellular automaton and neural network theories. The basics of this model was presented at ACA'2012 (in the Nonstandard Applications of Computer Algebra Session).

The algorithms involved in the ATISBAT model have been implemented using a Computer Algebra System since some symbolic computations are needed. On the other hand, a JAVA application that shows the simulation graphically has also been developed.

One of the most important characteristics of ATISBAT is its flexibility in two different ways. It allows for the simulation of a wide variety of baggage handling systems. It also allows users to choose from among a great list of random distributions (or even create an “ad hoc” one) to simulate the behavior of the random events within the system.

The accelerated-time simulations obtained with ATISBAT, can be used both as an aid during the terminal's design process (in order to optimize the baggage handling network's topology) and also to analyze the impact of any possible proposed changes in an already built baggage handling system.

The graphic interface developed produces important visual information about the simulation. This approach is very useful, since the effects of making any change to the system can be immediately visualized.

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1. Introduction

The handling of baggage is one of the most important activities in an airport. A good airport baggage handling system is crucial for both passengers and employees. A bad design may lead to undesirably long queues or even a collapse of the system.

The cost of a baggage control system is quite high. Therefore, it would be very important to test it in advance, using computer simulations, to determine the most appropriate system for an airport.

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In this paper, we describe the ATISBAT (Accelerated Time Simulation of Baggage in an Airport Terminal) model in order to simulate the traffic of baggage in an airport. Other works which deal with accelerated-time simulation can be found in [2,8,14].

One of the most important characteristics of ATISBAT is its flexibility. ATISBAT is flexible both in a physical and a theoretical sense. In the physical sense, our model can simulate a great variety of baggage handling systems, not only for an specific airport but for many airports and different conditions. For example, the number of check-in desks, the number of output rings, the capacity of the warehouse, the number of safety levels and the length of the belts are all configurable in ATISBAT. In the theoretical sense, ATISBAT allows to choose among different standard random distributions for controlling how baggages access the system. Furthermore, the user can define an “ad hoc” random distribution for this matter. On the other hand, ATISBAT also allows one to choose among different standard random distributions or an “ad hoc” one, for controlling different characteristics of random phenomena occurring in the system. Some examples of these events are: accessing the warehouse, entering into a safety level zone, getting stuck on the conveyor belt or loosing an identification label.

ATISBAT combines ideas from cellular automaton methods and neural networks. In one hand, cells (pieces of the belt) have two possible states (empty or occupied) and the movement within the system is generated using cellular automaton theory. On the other hand, each occupied cell (suitcase) stores special characteristics in its state vector as in neural networks theory. The content of the state vector also affects the movement. That is, at any step, each cell changes its state depending on both the neighbor cells states and the individual values of the vector associated to the item in the cell (if occupied).

The idea of combining cellular automata methods and neural network theories to produce accelerated-time simulations has been previously explored by the authors in [2,10].

The first well known cellular automaton was Conway’s Game of Life [7]. This cellular automaton can be characterized as a simulation of the behavior of a community of cells. In each step of this simulation, cells die either because of overcrowding (more than three live neighbors) or because of under-population (fewer than two live neighbors). When a dead cell has exactly three live neighbors, a new live cell appears (reproduction). Otherwise, cells remain within their same state. These few rules produce movements in the system and simulate some kind of life.

Other cellular automata related to the simulation of movement are: Rule 184 [15], the Nagel-Schreckenberg model [12] and the Knospe-Santen-Schadschneider-Schreckenberg model [9].

ATISBAT has been implemented in two interconnected parts. The first, the multi-platform language JAVA, is used to develop the graphical user interface (GUI) for the system. The second uses a Computer Algebra System (CAS), specifically Maxima to deal with all mathematical computations within ATISBAT. The CAS is needed since some processes require symbolic computations.

This idea of developing a GUI for a CAS application, was also used in [2,3,11].

The basic aspects of ATISBAT model were introduced in the *Non-Standard Applications of Computer Algebra* Session of ACA 2012 Conference, held in Sofia.

In Sections 2 and 3, the physical aspects and mathematical model of ATISBAT, respectively, are described. Section 4 is devoted to the implementation of the ATISBAT model. Some results are shown in Section 5. Finally, the conclusions and future work are discussed in Section 6.

2. The physical level of ATISBAT

The physical level of ATISBAT is a flexible model that allows for the simulation of many baggage handling systems found in different airports. The general scheme and initial data have been obtained from the baggage handling system of the Málaga airport.

ATISBAT models the process followed by pieces of luggage from the check-in desks to the aircraft. The process from the arriving aircraft to the baggage claim is not considered since in most cases, this is an simple process which consists of carrying the pieces of luggage from the holds of the aircraft directly to the baggage claim area.

The physical level of ATISBAT model consist of several parts:

- The main baggage handling belt. It is made up of many individual conveyor belts forming the central ring (main ring) of the physical model.

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