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Demo Paper: A Tool for Analyzing COVID-19-related Measurements Using Agent-based Support Simulator for Airport Terminal Operations

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Abstract. This paper presents a demonstration of our PAAMS 2021 paper using data-driven analysis of airport terminal operations and An Agent-based Airport Terminal Operations Model Simulator (AATOM). The goal of this paper is to demonstrate and analyze the impact of the current COVID-19 and future pandemic-related measures on airport terminal operations and to identify plans that airport management agents can take into account to control the flow of passengers in a safe, efficient, secure and resilient way. To analyze the impact of the identified COVID-19 measures on the airport operations, the existing agent-based AATOM model was need to be modified in order to implement these measures. In this paper, we illustrate a demo of a developed simulator tool by investigating the effects of different degrees of physical distancing rules among agents on the performances of the airport. In the demo session the attendees will have the possibility to (i) work with the simulator tool on different relevant parameters regarding different sections and agents in the airport; (ii) view and analyze different performance indicator analyzers of the simulator.

Keywords: Airport operations, Physical distancing, Analyzer, AATOM.

1 Introduction

Due to the COVID-19, many countries closed their borders to mitigate the spread of the virus and to reduce COVID-19 deaths. As a result, global passenger demand of April 2020 (in revenue passenger kilometer or RPK) plunged with 94.3 percent compared to last year [5]. A vaccine is considered as the only solution to completely eradicate the spread of COVID-19. Moreover, the COVID-19 situation is dynamic as restrictions are modified regularly, to study these restrictions we need a model that is able to capture this highly complex system and is able to adapt to varying conditions. Agent-based modelling is a suitable paradigm to model and study complex socio-economic systems, such as airport operations [2]. Agent based models are also very suited to study the resilience of the system [2], for example what is the effect of a sudden disruption in the flight schedule on the airport operations.

To address this problem agent-based modelling and simulation is used. In agent-based modelling, humans can be modelled as intelligent entities, called agents. These agents can be given certain traits and behavior that organize their interaction with the environment. This bottom-up approach allows for modelling complex sociotechnical systems, such as an airport terminal. It also allows for simulating local interactions in the system, for instance, physical distancing between passengers and analyzing the emergent properties of the global system. These emergent properties can be translated into system-wide key performance indicators.

The airport is a highly complex socio-technical system that consists of many different processes that are linked with each other. The passenger flow can be generally split up in departing passengers, arriving passengers and connecting passengers. An airport terminal generally consists out of three areas: the transit hall, the departure hall and the arrival hall. The transit hall is the area where departing passengers enter the airport and arrived passengers leave the airport. In this area the departing passengers can check in at the check-in desks or make use of other facilities such as shopping or restaurants. The transit hall and the departure hall are connected by the security check area. In the departure hall the gates are located where the departing passengers can wait for their flight. The arrival hall is solely used by the arriving passengers and connecting passengers. Based on the work of Schultz et al [4] it was found that the passenger characteristics have an impact on their walking speed. It was concluded that passenger speed is significantly influenced by age, gender, group size and travel purpose such as business or leisure.

This paper presents a demonstration of our PAAMS 2021 paper [7] on modeling the effects of COVID-19 measures in airports terminal using an agent-based airport terminal operations simulator (AATOM) [1]. Figure 1 shows the environment of this simulator. It consists of different sections such as check-in, security check point and gates. In this demo paper we propose a model that can be used to asses airport’s efficiency and passenger safety.

2 Main Purpose

The passengers and airport staff are modelled as autonomous intelligent entities, called agents. These agents can be modelled with a particular behavior approximating passengers/staff and located in an environment, in our case the airport. The behaviors and interactions of the agents may be formalized by equations, but also more generally by decision rules such as if-then kind of rules. Global system-wide emergent properties can be generated and studies without having to make assumptions in advance regarding the system as a whole. The simulation fills the gap between the individual behavior of the passengers and the collective effects on the airport operations performance. Furthermore, the behavioral rules of agents can be varied (heterogeneity) or random influences can be incorporated (stochasticity). Agents characteristics can also be varied. For passenger one can define: gender, age, business vs leisure and the walking speed. Furthermore, agent-based simulation can be well used interdependencies between agent types and emergent properties in the model [2], for instance which passenger type has a higher risk of COVID-19 infection. It can be considered as a sort of magnifying glass to understand the reality better. The results of the interdependencies between passenger speed and passenger characteristics were given by Schultz et al [4] in the form of statistical distributions. These distributions are implemented in AATOM such that different passenger types are created. Then also a risk-analysis will be done in the model output analysis to observe for different types of passengers.

There are different agents and interactions possible in AATOM. Firstly, check-in operators are able to interact with the environment, especially the flights. For example, they can update the state of a certain flight when everyone has checked-in [3]. Secondly, operators can interact with each other. For example, operator responsible for X-Ray scanning and the operator responsible for luggage checking can communicate with each other. Thirdly, operators and passenger agents can interact with each other. For instance, a check-in agent can order a passenger to wait for a specific time at the check-in desk. Lastly, an orchestration agent can be implemented overall for coordination of terminal operations, such as optimizing physical distance between agents. To coordinate, the orchestration needs to interact with operators, passengers and the environment [3]. Helbing et al. came up with the social force model for analyzing physical distancing [2]. The social-force model uses psychological forces that drive pedestrians to move towards their goal as well as keep a proper distance from other pedestrians and objects.

3 Demonstration

AATOM contains calibrated templates of basic airport terminal configurations that can be easily adjusted and used for analysis of airport operations [9]. The model simulates the main handling processes for departing passengers in the airport terminal, this includes check-in, security checkpoint and border control. Figure 2 illustrates performance indicators of the airport. That consist of passenger agents in queue, average time in queue, activity distribution, time to gate, number of passenger agents, number of missed flights, and finally average physical distancing. Furthermore, there is a need for additional passenger safety indicators. Since currently the transmission of the respiratory syndrome COVID-19 is not fully understood yet, many experts assume that the spread is found by physical contact, droplets and airborne routes [6]. In the proposed model, the proposed safety indicator is the physical distancing. Therefore, there is a need for a flexible model that does not rely on specific assumptions of the disease and initial condition's such as the amount of infected people enter the terminal [8]. We implemented the proposed model using AATOM simulator. During the demonstration, the simulator for one run will be used. Attendees will be able to see the live run of the simulator with some predefined configuration (and can change) for different sections in the airport such as check-in, security checkpoint, and gates. These configurations are for instance the walking speed, number of lanes at the security checkpoint, number of check-in desks, and passenger arrival distribution.

The outputs of the AATOM model can be investigated in this demonstration. These output indicators are purely performance based, such as: amount of passengers in a queue, average time in a queue, time to gate, average physical distancing and others.

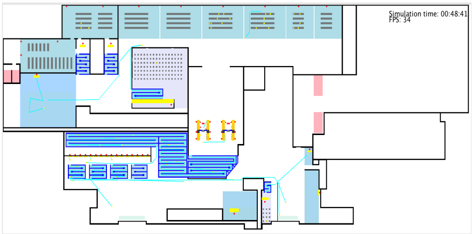

Fig. 1. AATOM environment.

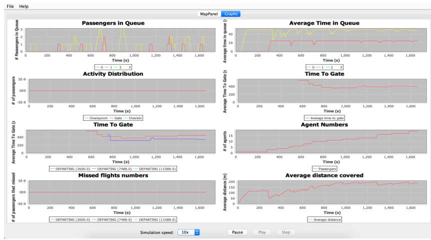

Fig. 2. AATOM analyzers.

4 Conclusion

The purpose of the developed simulator tool was to model and provide a proper understanding of the impact of the COVID-19 measures on airport operations' performance and the associated safety of passengers. The model is an extension of the existing AATOM model and includes a redefined passenger dynamics model based on the social force model of Helbing to simulate physical distancing. The agent-based model also consists of a new model environment (check-in, security and boarding infrastructure) to represent realistically an airport under COVID-19 conditions. The metrics to assess the health safety of the passengers are based on existing studies regarding COVID-19 transmission. Because of the COVID-19 pandemic, passenger safety has become an essential topic on airport operators' agenda. With the possibility of new pandemics arising, this study is not only relevant for today but also for the future. This study can help airport operators in their decision-making and make airports more resilient for future crises.

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