

LEVERAGING CAUSAL DISCOVERY METHODS TO ENHANCE PASSENGER EXPERIENCE AT AIRPORT – AN ANALYSIS METHOD FOR AGENT-BASED SIMULATORS

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ABSTRACT

Passenger experience of non-aeronautical activities has become an important concern for designing and managing airports. There has been an increasing interest on developing agent-based simulators to facilitate the design for enhancing passenger experience. Coupled with such simulators, systematic and effective analysis methods which can guide the design based on causal explanations of simulation outputs are critical yet challenging. In this work, we propose such an analysis method leveraging causal discovery technologies and integrate it to an agent-based simulator, which is developed for signage system design by modeling passengers' realistic routing behaviors in a virtual airport terminal. By systematically discovering the causal relations among signage system, airport environment, passengers' characteristics, and their experience under different situations, the proposed analysis method can strengthen the explanation of simulation results and inform indirect control policies leading to positive passenger experience of non-aeronautical activities.

1 INTRODUCTION

Passenger experience of non-aeronautical activities has become an important concern for designing and managing airports, since positive experience may lead to repeat visits of airports and thus increase the airport revenue (Cheng et al. 2014). There has been an increasing body of works on airport terminal design, especially on signage system design, for improving the airport services by deploying bottom-up modelling and simulation approaches. Utsumi et al. (2015) built an agent-based simulation tool to evaluate different design of signage systems in a virtual airport terminal by simulating passengers' walking behaviors and their interactions with the signs and facilities. Based on this simulation, Yamane et al. (2018) proposed a micro-dynamic analysis method to analyze the congestion situation of airport facilities from the perspective of passengers' behavioral characteristics. However, there is still a lack of analysis methods to systematically guide the design based on causal explanations of how the airport environment and resulted passengers' behaviors can lead to positive experience of non-aeronautical activities under different situations. Therefore, this work aims to fill this research gap by proposing a systematic analysis method leveraging causal discovery methods to facilitate the airport design based on a causal explanation of the target phenomenon.

2 METHOD AND APPLICATION

We integrate the proposed method to an agent-based simulator (Utsumi et al. 2015) that models the essential features of signs and passengers' routing behaviors before departure in a virtual airport terminal. The analysis procedures are illustrated in Figure 1. Passengers will plan their route, walk and select facilities to take up services based on their goals and perception of the external environment. The analysis method aims to offer indirect control means to enhance passenger experience by enabling a causal explanation on how passengers' goals, behaviors navigated by the signs, and environmental factors influence the experience.

The method first randomly selects logs from different simulation runs. It then categorizes the simulation outcomes into passenger' goals (restaurant, exchange, etc.), actions (walking time, information searching time, waiting time, etc.), environmental factors (sign distribution, congestion situation, etc.) and target of analysis (to what extent they can complete goals). We adopt two popular causal discovery methods, DirectLiNGAM (Shimitsu et al. 2011) and GFCI (Ogarrio et al. 2014) to discover the causal relations and select those commonly identified by both methods. These two methods pose different assumptions on input datasets, and thus will provide relatively more informative results. Indirect control means to improve the passenger experience will be informed from the causal analysis and evaluated through re-simulation.

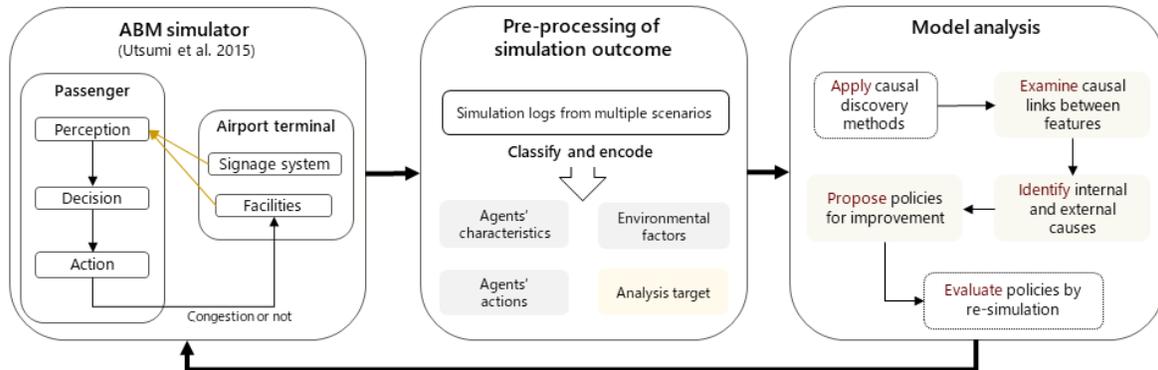


Figure 1: Procedures of the proposed method.

3 RESULTS AND DISCUSSION

The analysis results show that the preferred goal of passengers, and the time spent at waiting at congested facilities and searching information from signs are major causes of whether passengers can complete over half of their goals. It indicates that providing information of the congested facilities as indirect control means may lead to positive passenger experience. Two ways to distribute the congestion information are proposed and evaluated by re-simulation. It shows that they not only relieve the congestion situation, but also reduce the passengers' total waiting time. This impact is further explained and validated by the identified causal path among different distribution methods, the waiting time and the target of analysis.

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