Geometric Modeling of COVID-19 Epidemic Spread

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Abstract

Following the early COVID-19 pandemic in 2020, supermarkets in Europe implemented a policy of limiting the maximum number of people to control the spread of the epidemic. However, this did not prevent the clustering of customers within supermarkets, especially in the shopping area. In order to find ways to reduce the infection rate and risk of exposure to virus, this thesis constructs a supermarket model based on Delay tolerant network and Graph theory to simulate customer mobilities. The Susceptible-Exposed-Infected (SEI) model was also applied to implement the process of virus spread, where susceptible people are considered to be infected after more than 5 minutes of exposure to a virus. It was found that by controlling the purchasing time in shopping area, the infection rate could be reduced from 5.4% to 3%, and by accelerating the checking-out speed, the exposure time in the checking area could be reduced from 52% to 46% of the total exposure time. The experiment showed that the risk of virus transmission could be reduced by controlling the shopping time of customers and increasing the number of checkouts per unit time.
Air circulation is the predominant mode of transmission in enclosed areas, and the Susceptible-Exposed-Infected-Recovered model with indoor airborne transmission was used to study the long-term outbreak development. Experiments have shown that outbreaks last longer when the quanta exchange rate of infected individuals reaches 800 ACH or more because the R0 value exceeds 2.

Keywords: DTN, SEIR, Double Queuing System, Graph Theory, Epidemic Modeling