Decision-making system for road-recovery applying deep Q-network

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(1) Introduction: Western Japan was hit by heavy rain from June 28 to July 8, 2018. Record-breaking rain caused approximately 600 road sections to be closed in Hiroshima and Okayama Prefectures. Government has been doing recovery activity pursuant to their recovery plan to make damaged citizens' life return to their original condition as soon as possible. However, it was a week after the disaster that began to restore the roads closely related to their life. The reason is because current procedures in immediate response phase are characterize by a variety of deficiencies especially estimation of people's movement (Alexander, 2015). Recently, it is possible to figure out human mobility using mobile phone GPS and call detail records (CDR) data. In this analysis, we proposed optimal decision-making considered people movement patterns.

(2) Method: There has never been a generalized optimal solution to recovery-work. Because every disaster situation is different according to disaster type, hazard degree, cultural and geographical of the region. Deep Q-Network is one of out-policy algorithm, that is, Q-learning finds a policy that is optimal in the sense that it maximizes the expected value of the total reward over successive steps under a specific circumstance. So, we selected this method to figure out a series of optimal action selection for setting a priority of road-recovery work.

(3) System Architecture: We utilized GPS data to estimate human mobility. In this paper, Origin-Destination (OD) pair is a representative of mobility, and travel time of each Origin-Destination pair was used to represent human mobility numerically. Primary goal in our model is to return ODs' delayed time caused by damaged road to their original travel time as soon as possible, and output is a sequence of optimal action at each time step to achieve their target.

(4) Dataset:

- 「Mobile phone GPS data in Hiroshima and Okayama Prefectures (From June, 2018 to July, 2018)」
- 「Digital Road Map Database」 Japan Digital Road Map Association
- 「Statistics Map of Japan」 Statistics Bureau in Japan

(5) Result: In this analysis, the number of agents is 189, and the total number of Origin-Destination pairs is 2,790. We figured out that agent takes 22 steps to get restoration rate more than 0.93 on average. Figure 1 illustrated required steps of all ODs' shortest route until achieving restoration rate more than 0.93. As Figure 2 shown, agents in Okayama Prefecture take shorter steps to meet their goal than agents in Hiroshima Prefecture. The majority of road section in Okayama Prefecture have high damaged level compared with the case of Hiroshima Prefecture. Therefore, damaged nodes in Okayama Prefecture might tend to selection action with high growth rate of recovery work progress.

(6) Reference:

D. Alexander. (2015) "Disaster and emergency planning for preparedness, response, and recovery".

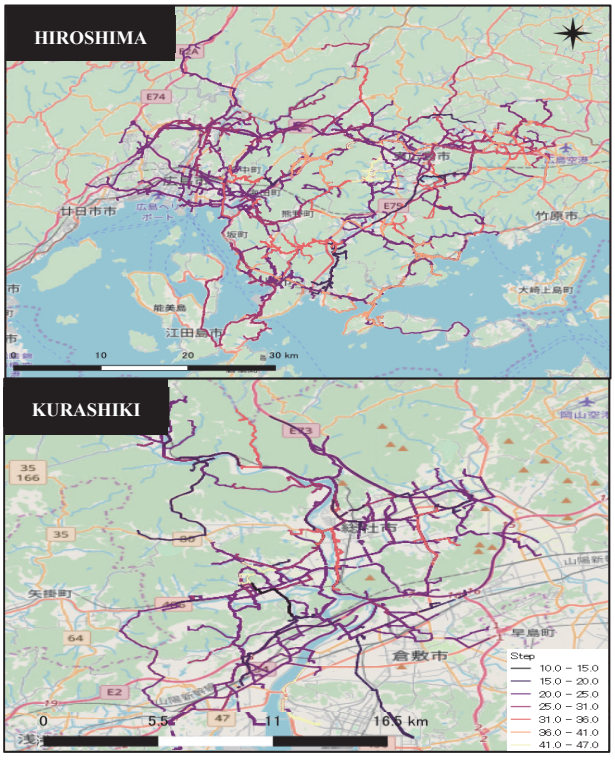

Figure 1: Required steps until achieving target in Hiroshima Prefecture and Kurashiki city in Okayama