Paving New Ground: A Markov Chain Model of the Change in Transportation Networks and Land Use (06-0753)

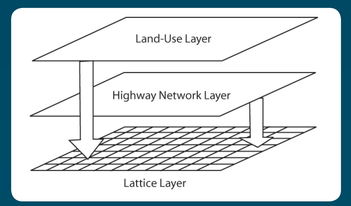
David Levinson, Department of Civil Engineering, University of Minnesota Wei Chen, Lexington Area MPO, LFUCG

Introduction

This paper explores the inter-connectedness of the evolution of transportation networks and land use through the application of a Markov Chain model.

GIS land use and highway network data for the Twin Cities from 1958 to 1990 are merged into a lattice layer (composed of 188*188 m square cells), so that the cells of the lattice layer contain the spatial information of land use and highways.

Figure 1.



Each cell is classified into one of five types of zones: E (Employment Zone), R (Residential Zone), M (Mixed Employment and Residential Zone), A (Agricultural and Recreational Zone), and W (Water Zone). Each cell also has one of the four attributes: U (the cell only contains upper level highways), L (the cell only contains lower level highways), B (the cell contains both upper and lower level highways), and N (the cell does not contain either upper or lower level highways).

Markov Chain

Years 1958, 1968, 1978 and 1990 are the successive states,

S (1958) –> S (1968) –> S (1978) –> S (1990) [02]

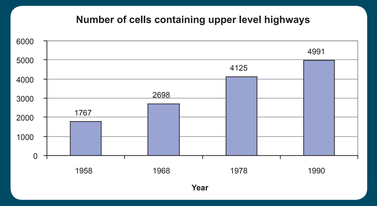
and a transition probability matrix P can be derived from each pair of the successive states.

$$P = \begin{matrix} P_{EU,EU} & P_{EU,MU} & P_{EU,RU} & P_{EU,WU} & P_{EU,AU} & P_{EU,EL} & L & P_{EU,AN} \\ P_{MU,EU} & P_{MU,MU} & P_{MU,RU} & P_{MU,WU} & P_{MU,AU} & P_{MU,EL} & L & P_{MU,AN} \\ P_{RU,EU} & P_{RU,MU} & P_{RU,RU} & P_{RU,WU} & P_{RU,AU} & P_{RU,EL} & L & P_{RU,AN} \\ P_{WU,EU} & P_{WU,MU} & P_{WU,RU} & P_{WU,WU} & P_{WU,AU} & P_{WU,EL} & L & P_{WU,AN} \\ P_{AU,EU} & P_{AU,MU} & P_{AU,RU} & P_{AU,WU} & P_{AU,AU} & P_{AU,EL} & L & P_{AU,AN} \\ P_{EL,EU} & P_{EL,MU} & P_{EL,RU} & P_{EL,WU} & P_{EL,AU} & P_{EL,EL} & L & P_{EL,AN} \\ M & M & M & M & M & M & O & M \\ P_{AN,EU} & P_{AN,MU} & P_{AN,RU} & P_{AN,WU} & P_{AN,AU} & P_{AN,EL} & L & P_{AN,AN} \end{matrix}$$

Analysis

Figure 2. The percentage of land use distribution.

Figure 3. The growth of upper and lower level highways.



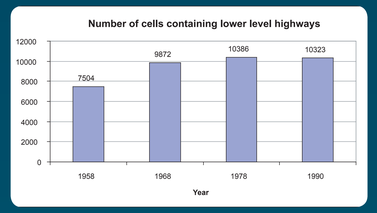
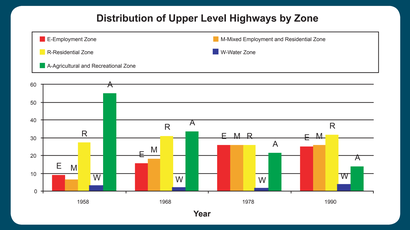


Figure 4. Distribution of upper and lower level highways by zone.



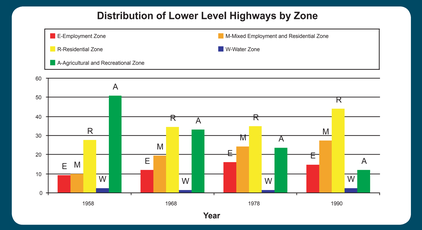
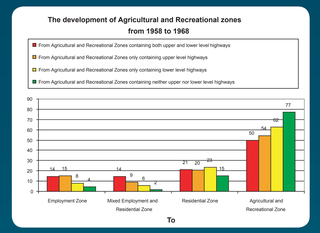
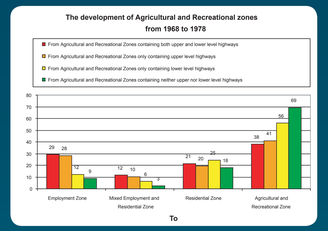
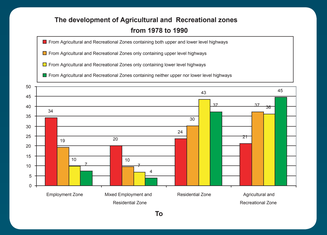


Figure 5. The development of Agricultural and Recreational zones.

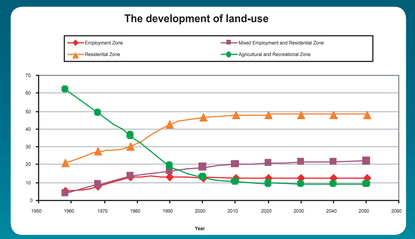






Prediction

Figure 7. The development of land use and highways.



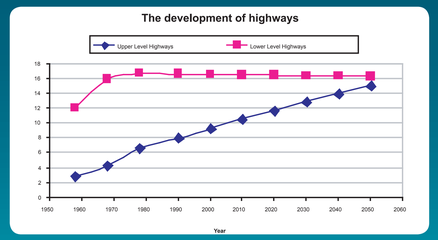
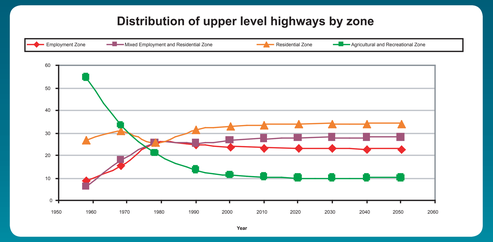
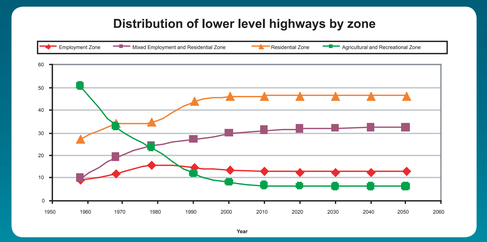



Figure 8. Distribution of upper and lower level highways by zone.