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THE RELATIONS BETWEEN URBAN PARKS AND PERSONAL WELL-BEING IN BRISBANE, SOUTH-EAST QUEENSLAND, AUSTRALIA

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ABSTRACT

The positive impacts of urban parks on human health have been analysed in many studies, but nearly none of them provide a suitable method to explain quantitatively the satisfaction and dissatisfaction of park uses on personal health. Bayesian Belief Network (BBN) was employed to examine individually well-being spirit in relation to the changes of quality of parks and the joyfulness on access to parks. This study aims to find answers for questions 'why and where are people happy or unhappy with their health in connections to urban parks?' The data for Brisbane area were extracted from the quality of life survey in South-East Queensland, Australia. 70% data was used for learning model parameters; the rest was for model testing. The generated model had 73.17% accuracy, and it was imported to ArcGIS for constructing probabilistic maps. Due to the high density of sample points, Inverse Distance Weighted (IDW) interpolation was chosen to illustrate the probable happiness and unhappiness on personal health. The result shows that quality of urban parks controlled strongly the fulfilment of personal health. Local governors can successfully enrich the quality of urban lives by improving the quality of parks in some specific regions.

Keywords: urban parks, bayesian belief network, probabilistic map, quality of parks, personal health.

ABSTRAK

Dampak positif dari keberadaan taman kota terhadap kesehatan manusia telah dianalisis dalam banyak studi, namun hampir tidak ada satupun yang memberikan metode yang sesuai untuk menjelaskan secara kuantitatif tingkat kepuasan dan ketidakpuasan penggunaan taman kota terhadap kesehatan pribadi. Bayesian Belief Network (BBN) digunakan untuk menilai kesehatan jiwa secara individual dalam kaitannya dengan perubahan kualitas taman dan kesenangan untuk mengakses taman. Studi ini bertujuan untuk mendapatkan jawaban 'mengapa dan dimana orang bahagia atau tidak bahagia dengan kesehatannya dalam kaitannya dengan keberadaan taman kota?' Data yang digunakan untuk daerah Brisbane diekstrak dari survey kualitas hidup di South-East Queensland, Australia. 70% dari data

digunakan untuk mempelajari parameter model; sedangkan sisanya untuk test model. Model yang dibangun memiliki akurasi 73,17%, dan diimport ke ArcGIS untuk menyusun peta probabilitas. Dikarenakan kerapatan titik sampel sangat tinggi, maka digunakan interpolasi Inverse Distance Weighted (IDW) untuk mengilustrasikan probabilitas dari tingkat kebahagiaan dan ketidakbahagiaan kaitannya dengan kesehatan pribadi. Hasil studi menunjukkan bahwa kualitas dari taman kota sangat menentukan terpenuhinya kesehatan pribadi. Pemerintah lokal dapat berhasil meningkatkan kualitas kehidupan kota dengan meningkatkan kualitas taman kota di wilayah tertentu.

Kata kunci: taman kota bayesian belief network, peta probabilitas, kualitas taman, kesehatan pribadi

INTRODUCTION

Accessing parks is the only way for people to contact with nature in urban areas. This might promotes healing and provides psychological and spiritual benefits to personal health. Several studies have proved that parks are good places for people to escape from crowded city and fulfil positive feelings about their lives [*Rossman* and *Ulehla*, 1977; *Bishop et al.* 2001; *Chiesura*, 2004]. The open spaces of parks are possibly forming many hubs for transporting fresh air around the urban; bring up natural flora and fauna. Obviously, parks have a crucial role in controlling thermal effects in built-up areas due to its natural characteristics such as shade, moisture, and evaporation [*Givoni*, 1991; *Spronken-Smith* and *Oke*, 1998]. Therefore, hot temperature in summer, cold winds in winter, noise and air pollution might be no longer the problems for near residential areas. In fact, many small parks spread over the built-up area could improve the overall urban climate [*Givoni*, 1991]. The total area of parks, nonetheless, does not indicate strong environmental meaning to the well-being of neighbourhood [*Burgess et al.* 1988].

The positive influences of urban parks on personal health were clearly proved in many researches such as in *Maller et al*. [2002], *Jackson* [2003], Maas *et al*. (2006), *Nielsen* and *Hansen* [2007], *Bell et al.* [2008], and *Grahn* and *Stigsdotter* [2010]. Most of them focus on qualitative analyses or do not provide any method to describe park-health relationships on a map. The purpose of this paper is to evaluate and illustrate the connections between urban parks and personal health.

By employing *BBN* in Netica and *ArcGIS* 9.3, this research provides quantitative analyses and explanations on how park usage and its quality affect on personal health feelings. *BBN* theory uses causal relationships and probabilities to solve the problem, for instance, once knowing the appearing probability of a certain event, analysts can obtain quickly the occurring probabilities of other events in the model [*Walker et al.* 2005]. As *BBN* works based on probability, it can deal with the uncertainty in collecting, analysing data especially when data are random and non-normal distribution [*Cain*, 2001]. Another benefit of the belief network is that it can explain the results. The regression method can produce predicted values but cannot explain the changes in the model because it does not concern the causal relationships among the variables.

Study area and data collection

Brisbane, South-East Queensland, centred at 27°28' south and 153°02' east, is the third largest city in Australia (Figure 1). Brisbane is famous for its variety of theme parks and gardens that are providing a huge range of recreation activities for inhabitants and visitors such as picnics, fun walks or sports.

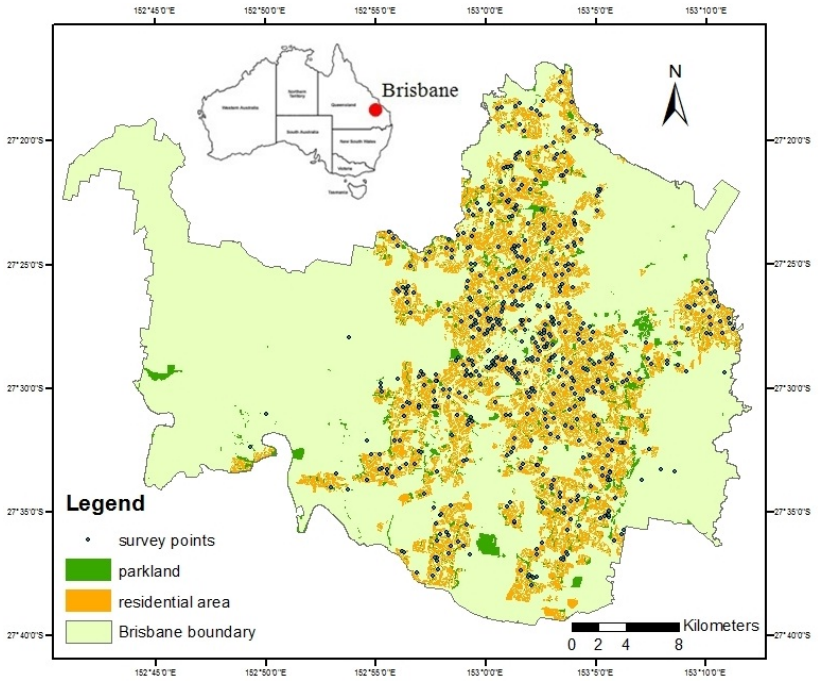

Figure 1. The study area, Brisbane, South-East Queensland, Australia

Five hundred and forty five sample points in Brisbane urban areas (Figure 1) were extracted from the survey about quality of life (*QOL*) in South-East Queensland in 2003. This survey provided a various range of living issues in *SEQ*. Residents aged 18 years and over were interviewed and recorded using Computer Assisted Telephoning Interviewing (*CATI*). Each respondent's street address was matched with geometric location using MapInfo Professional *GIS* and the MapInfo StreetPro database.

This database was divided into a training dataset (70%) for learning model parameters, and a testing dataset (30%) for calculating model accuracy. Three variables for the study on the relations between urban parks and individual health were selected and re-organized as bellow:

1. *Quality of park*: based on a question 'Please rate the quality of local parks in your neighborhood or nearby area', and answered on a five-point scale where 1 = 'not good at all', 2 = 'not very good', 3 = 'neither good nor bad', 4 = 'fairly good', 5 = 'very good'. This scale was reclassified to a three-point scale where 1 = 'not good', 2 = 'neither good nor bad' and 3 = 'very good'. This is because the meanings of some terms such as 'not good at all' and 'not very good' are similar. Additionally, numbers of responses in the five-point scale were too sparse and missing data was significant which might restrict learning model parameters using Expectation-Maximization (*EM*) algorithm [*Geng*, 2000].
2. *Access to park*: was the answer on a five-point scale and reclassified to a three-point scale where 1 = 'dissatisfied', 2 = 'neutral', 3 = 'satisfied' to the question 'How satisfied are you with your access to the parks?'
3. *Your health*: based on a question 'How satisfied are you with your health?' and answered on a

reclassified three-point scale where 1 = 'dissatisfied', 2 = 'neutral' and 3 = 'satisfied'

THE METHODS

BBN structure

Literature review is a valuable source providing necessary variables for the Bayesian network. In this study, access to urban parks and quality of parks are possible factors controlling the individual health feeling (Figure 2). Satisfying with the access to local parks is an indicator of the regular park use. It is likely important for children to burn off their energies in the parks rather than spend their time in front of television. Taking physical risks and building childhood memories are crucial parts for the growing up of children [*Cornell et al.* 2001]. Further, living close to local parks can limit dangerous traffic and provide more chances for children to play in near neighbourhood without surveillance [*Thorén*, 2000]. Distance from parks to residential areas might restrict the satisfaction on using parks. 50% residents will not use local parks if they are placed more than 10 minutes away from home [*Thorén*, 2000]. If locations of parks are closer to home, especially low-income people will be happy to augment the use of park [*Scott and Munson*, 1994]. Age and gender differences were ignored because they involve insignificantly to the uses of parks [*Scott and Munson*, 1994].

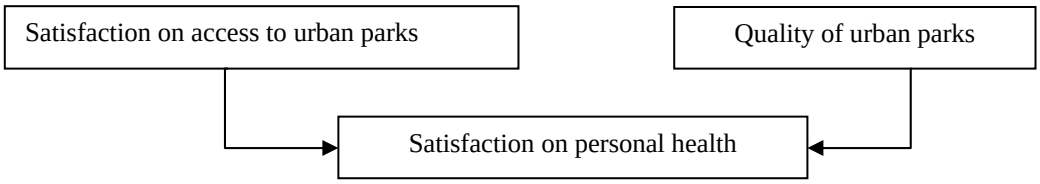

Figure 2. The conceptually cause-effect model examining the satisfaction on personal health

Quality of park is another aspect that may yield the satisfactions on urban park use. If the desires of how green spaces might increase residents' health are incompatible with people socio-cultural backgrounds, they may frustratingly access the local parks or stop using them [E*ng and Niininen*, 2005]. Like an outdoor room within a neighborhood, park may provide more chances for communication and release the racial bias among strangers. Nevertheless, socially heterogeneous characteristics of population in cities might generate more conflicts in the use of park facilities. Explaining this could deal with a complex system of indicators, but *Givoni* [1991] believed that quality of urban parks is probable the cause of that social intension. The actual design of parks might be impractical for analysing the quality of park because the perceptions about the quality of park such as aesthetic are often motivated by the variations of personal backgrounds [*Burgess et al.* 1988].

BBN parameters

Netica used *EM* algorithm to learn model parameters. Practically, data collected for the scientific research randomly miss some values. Some statistical methods such as pair-wise or data deletion were supposed to be the solutions for missing data problem but they may produce some biased assumptions [*Nelwamondo et al.* 2007]. *EM* algorithm, however, is more compatible for handling missing values and learning parameters of a belief network. Parameters are predicted from initial values of incomplete data, then missing data is updated and parameters are re-estimated, processing alternately until the convergence [*McLachlan* and *Krishnan*, 1997]. If the amounts of missing data are significant, EM is impractical because the results might not have much

difference with regular learning and take longer time to calculate [*Geng*, 2000; *Celeux et al.* 2001].

Model accuracy

'Testing case' function in Netica was employed to compare the difference in predicting the probabilities of each state between original model and testing dataset [*Marcot et al.* 2001]. The basic idea of this function is to run confusion matrix previously applied in remote sensing to evaluate the accuracy of image classification with its reference data [*Congalton*, 1991]. For the accuracy assessment of a Bayesian network, producer's accuracy, user's accuracy and overall accuracy will be calculated [*Smith et al.* 2007]. Producer's accuracy (Eq.1) is a measure of the probability of a variable's values being correctly classified; user's accuracy (Eq.2) is a measure of the probability that values of the variable in training case matches those in testing case. Overall accuracy (Eq.3) is computed by dividing the total correct values by the total number of variable's values in the confusion matrix [*Foody*, 2002].

Producer's accuracy = $\frac{X_{ii}}{X_{+i}}$ (1)#

User's accuracy = $\frac{X_{ii}}{X_{i+}}$ (2)#

Overall accuracy = $\frac{\sum_{i=a}^{r} x_{ii}}{n} * 100$ (3)

Probabilistic map

After having model parameters, 'process case' function in Netica and *IDW* in ArcGIS 9.3 were used to generate probabilistic map of personal satisfaction on health. First, 'process case' function will give back the states' probability in the node *Your health* to each sample point in the study area [*Smith et al.* 2007]. Second, *IDW* will interpolate probabilities of 'satisfied' and 'dissatisfied' states in node *Your health* to generate probabilistic surfaces of satisfaction and dissatisfaction on individual health. *IDW* was a choice because data distribution is quite high density (Figure 2) [*Childs*, 2004]. Regression model such as Geographically Weighted Regression (*GWR*) was not suitable in this case because it provides local predictions that are different to global estimations of *BBN*. Further, *GWR* function in ArcGIS 9.3 cannot create predicted surfaces from point data [*Brunsdon et al.* 2002]

RESULTS AND DISCUSSIONS

The causal relations between parks and personal health

The probability influences of urban parks to personal health were populated in Netica using *EM* algorithm (Figure 3). Generally, people living in Brisbane are quite happy with their health. They believe, with 71% confidence, that if the quality of local parks is very good and they are satisfied with access to local parks, they will feel satisfied with their health and vice versa. One benefit of using causal graph in *BBN* is that it allows clearly illustrating the problems of the study. *BBN* also accepts the contributions of expert knowledge in building the belief network because survey data sometimes cannot be collected adequately [Smith *et al.* 2007].

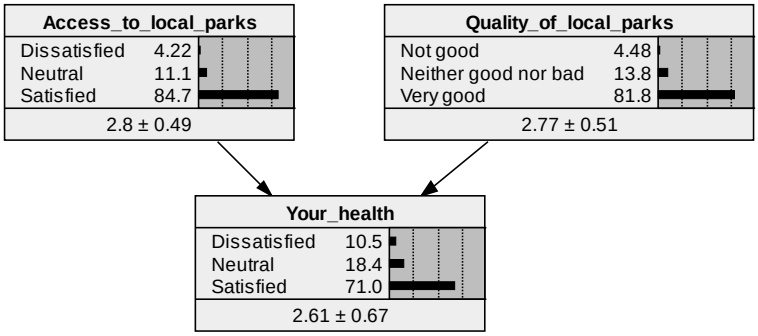

Figure 3. The belief percents of states in each variable after learning parameters.

As node 'Your_health' will be used for building probabilistic maps in *ArcGIS*, each state of that node was assessed by comparing the probability of appearances of each state in the model with those in testing data. The result of this, confusion matrix, clearly indicated that the overall, user and producer's accuracy of network were 73.17%, 99.17% and 73.62% respectively (Table 1). This model, therefore, was good enough for explaining the relations between urban parks and individual health.

Table 1. Confusion matrix of node 'Your_health'

Predicted			Actual
Dissatisfied	Neutral	Satisfied	
0	0	17	Dissatisfied
0	0	25	Neutral
1	0	120	Satisfied
		User accuracy	99.17%
		Producer's accuracy	73.62%
		Overall accuracy	73.17%

Possible places of satisfaction/-dissatisfaction on health

The probabilistic maps were generated by interpolating the appearance probabilities of 'dissatisfied' and 'satisfied' states acquainted from the results of running 'process case' in Netica. The predicted maps have to cover residential area to explain inhabitant feelings. By assuming people in the survey were totally satisfied with their health, there was 84.6% sure that the quality of parks in Brisbane have to be very good, and 86.7% confidence that inhabitants were satisfied with their access to local parks (Figure 4). In Figure 4, dark blue areas illustrate the strongest beliefs of around 79% that Brisbane residents felt happy with the influences of local parks on their health . Red spots, on the other hand, represent a weak belief in those effects. This means local governors have to improve the quality of surrounding parks and/or make inhabitants in those red areas happy about their access to local parks, for example reforming local traffic.

Actually, if the percents of state 'very good' in node *quality of local parks* reduce around 20% from 84.6% (Figure 4) to 63.7% (Figure 5), and those of state 'satisfied' in node *access to local parks* also decrease lightly about 7%, there are 100% sure that people will be dissatisfied with their health (Figure 5). The variations in other states of each node were not

concerned due to theirs insignificant changes. Generally, a strong change in the beliefs of quality of parks might affect inversely on inhabitants' feelings about their health. Local governors can employ these probabilistic maps for management purposes. However, they have to concern the accuracy of each map which depends on the errors of Bayesian and *IDW* models. It is confident to use Bayesian model due to its relative high accuracy, but there is some uncertainty in *IDW* model as a cause of sample point density. The interpolation methods not work well with sparse points [*Mitchell*, 2005].

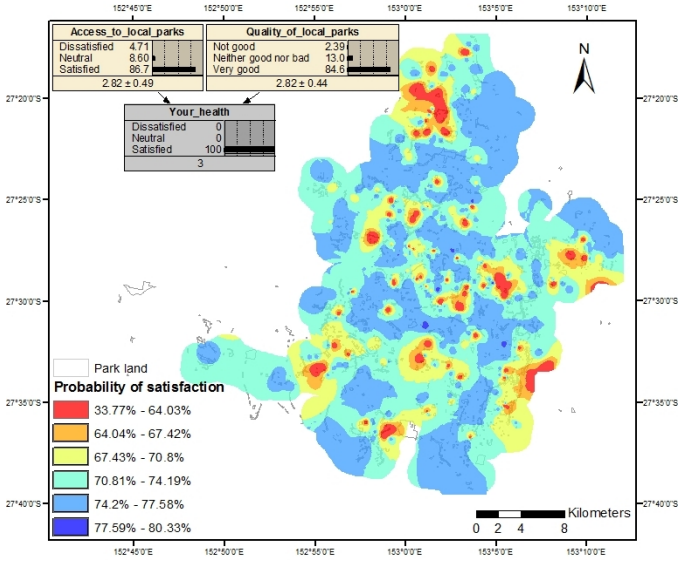

Figure 4. Probabilistic map of satisfaction on health. The Bayesian model provides the explanations for the map. If people are satisfied with their health, they have to be strongly satisfied (86.7% sure) with their access to local parks, and quality of parks has to be very good (84.6% sure). For each location on the map, the higher the percents of satisfaction, the stronger the beliefs in the effects of urban parks on personal health.

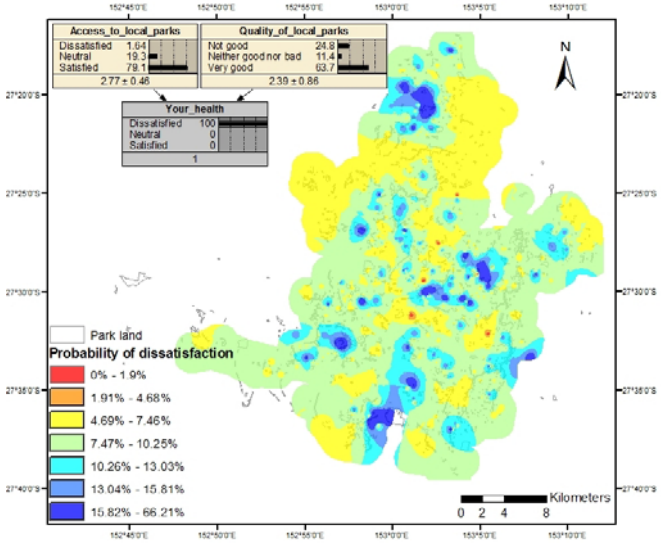

Figure 5. Probabilistic map of dissatisfaction on health. If all people are dissatisfied with their health, they have to be satisfied (79.1% sure) with their access to local parks, and quality of parks has to be very good (but only 63.7% sure). For each location on the map, the higher the percents of dissatisfaction, the weaker the beliefs in the effects of urban parks on personal health.

CONCLUSION

The probabilistic maps, constructed by using *BBN* in Netica and *ArcGIS*, sufficiently elucidated the influences of urban parks on personal health. In comparison to *access to local parks* variable, *quality of local parks* proved its significant effects on the alterations of residents' feelings. Local governors, therefore, can change the quality of particular parks to improve quality of lives of nearby residents. This was an easy explanation because there were only three variables in the study model. Future works have to examine more factors from literature reviews and expert knowledge. Sometimes, data are not adequately collected, so expert contributions are essential for building the belief model. Moreover, as *WinBUGS*, a Bayesian statistical approach, can provide a stable connection between statistical model and *GIS*, it should replace *IDW* to generate probabilistic maps in case of sparse point data.

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