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The expression of active structural network in intellectual environment design

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Abstract

This essay proposes a combination of commonsense knowledge and the spreading activation theory to strengthen the breadth of spreading activation of user's behavioral information in the field of intelligent environment design. The ontology cited in traditional artificial intelligence is roughly used to express and share knowledge. It is described with concepts, the properties of concepts, and the relationships among concepts, and is mostly presented with the tree-structured classification. However, there are often only vertical subordinate relationships between concepts with no horizontal and cross-layer interactions. Hence, we employ the constrained spreading activation model to perform a series of algorithms, further constructing the knowledge rules which can be commonly utilized to reinforce the breadth of activation process of user's behavioral information in an intelligent environment. These rules can provide a reference to the network service of digitalized cities in the future, and can also support the simulation assessment of applicability of intelligent environment design by employing embedded interactive technology.

Keywords: Behavior, intellectual environment, constrained spreading activation, commonsense knowledge;

1. Introduction

Computing equipment of portable devices allows more diversified and complex spatial situation for urban activities. People can freely move and carry information in any locations in urban environments without space shift. When technology starts blending into physical environments, as well as sensing devices and radio-frequency identification device (RFID) are implanted into daily necessities, these chips can receive, store and pass information to let people use technology naturally and to change the patterns of people's social life and communication gradually. Hence, the current challenges are to create a living environment where technology and humanity co-exist, and further to integrate digital interaction interface, sensing chips, and mobile digital city environment which is sustainable [1][2]. In other words, the

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intelligent environment is to acquire environment-related knowledge, and to apply it to the environment in order to improve users' experiences in the current environment. It is meant for acquiring environment-related knowledge and then applying it in the environment in order to improve user experience in the existing environment. An intelligent environment can constantly track and sense people as well as objects in the real space, give feedback and assistance, and continuously allow users to live more comfortably. Consequently, the future mobile digital city environment can smartly sense users' activities and actively respond to users' needs.

Based on the above research background, the commonsense knowledge model and the reasoning mechanism proposed by the research team led by Marvin Minsky[3], a computer scientist in MIT, are adopted as a conceptual basis in this study. What is different is that, in this study, the theme is the plaza of urban commercial activities. The activity sequence information in more active areas is observed and recorded, with its relevance further analyzed. Moreover, the spreading activation model is cited to constitute the theoretical basis of the knowledge structure, and to convert such sequence information into the commonsense knowledge of the nodes in the semantic network to further infer next behavioral node in which users are interested. By means of capturing people's experiences, a set of rules is researched and developed to regularly record events and construct the knowledge rules which can be commonly utilized and which will be applied to ambient intelligence in smart urban space. The nodes of semantic network are the inputs in the surrounding of an intelligent environment as well as the set points of sensors in the future.

2. Relevant theories

The main operating method of spreading activation network is movement of spreading which is the movement of associating a node with another one. The following is the analysis based on the spreading activation theory defined in this essay:

2.1. Teachable language comprehender

Collins and Quillian[4] utilize the memory organization of computer programs to simulate the understanding of human languages and propose a model called Teachable Language Comprehender (TLC). The TLC model assumes that every node has two kinds of linkage[5]. First of all, between each node and certain nodes are high-level links which can determine the subordinate relationships of categories. This link shows the relationship of "is"; for instance, an eagle "is" a kind of animal. Second, in addition to the link showing subordinate relationships in each node, there are also other links showing the characteristics of the node. Such a link shows the relationship of "has"; for instance, an eagle "has" wings.

In the TLC model, semantic knowledge is claimed to be characterized with the hierarchical network structure, and to follow cognitive economy; that is, the common characteristics which belong to most concepts only exist in the nodes of the highest level. Although the TLC model can illustrate how message is extracted and present that knowledge has considerably structured characteristics, its knowledge structure is a single-level network and may have a flaw of over-simplification.

2.2. Spreading activation model

Collins and Loftus[6] have made some corrections to the flaw of over-simplification of TLC, and proposed the spreading activation model which expresses the relationships between concepts with the non-hierarchical semantic distance of network instead. There are two assumptions in the spreading activation model[5]. First, the degree of relevance between two concepts depends on the length of the linked segment. The shorter the linked segment is, the closer the linkage relationship between two concepts is. Second, not every linkage between concepts has a subordinate relationship; some linkages are of the same level.

The characterization of the spreading activation model is like the distribution of brain neural cells. After a concept is activated, it will move along the linked segment linked with this concept to activate other concepts. The closer the linked segment is, the faster the activation speed is. The factors such as the intensity of activation, the duration of activation time, the distance between concepts, and whether activated concepts are core concepts or not, will all affect whether concepts will be activated or not. For example, the initially activated concept will not spread to other concepts if it is an unfamiliar one. However, if what is activated is a complex network core concept, then many connected concepts will be activated. To summarize above discussions, the spreading activation model is considered a model in which the message, once activated, will spread to all the directions along the linked network. Such message extraction can be faster as well as prevent the flaw of being simplified, which may result from the single-level network.

3. Research methods

To meet the research purpose, the Constrained Spreading Activation proposed by Crestani et al.[7][8] is cited to modify the spreading activation model. The following are illustrations of three algorithm steps, including spreading criteria and constraints, parameter setting, and spreading procedure:

3.1. Spreading criteria and constraints

Constraint condition must be set for the spreading activation model; otherwise, the activation value of the starting point will spread to the whole network. Therefore, the spreading distance must be restricted. The importance of different relevances to spreading varies as well. Hence, for this problem, the criteria and constraints are proposed below in this study.

- The weight of hypernymy must be larger than that of hyponymy because the Child Node definitely contains all the properties of the Parent Node while the Parent Node doesn’t necessarily contain all the properties of the Child Node.
- The activation value must decrease with the increase of the distance. This means the closer the behavioral node is to the starting node, the more easily it will be associated. The farther the behavioral node is, the less easily it will be associated. Therefore, the relevance weight must be smaller than 1. And the activation procedure can be optionally terminated at a specific distance. The distance of termination is generally set to be 2.
- The activation value can be cumulative. The more the preferred activities of surrounding users are, the higher the activation value of the behavioral node is. This means this activity behavior interests users more easily.

3.2. Parameter setting

To employ the algorithm of spreading activation, the message structure and relevance properties of behavioral nodes will be defined in this study. Each behavioral node includes the following five properties: “name of behavior,” “interest value,” “activation value,” “activation index,” and “activation distance.”

- Name of behavior: This property represents the only identified property.

- Interest value: This value is given during preference extraction, representing the degree to which users like this activity.
- Activation value: It is the value activated in the process of spreading activation. The higher this value is, the more it is related with users' preference. The default value is 0.
- Activation index: This is a Boolean variable. Its purpose is to prevent Node B from activating Node A after Node A activates Node B.
- Activation distance: It is the distance from the point where activation starts. The distance traveled for one relevance is 1.

Between nodes there are three kinds of relevance - hypernymy, hyponymy, and correlations. As for the setting of relevance weight, refer to the method with which Paice sets for the relevance weight[9]. In this study, these weights are regarded as system parameters, which can be adjusted, depending on the situation.

- Hypernymy: If Node A is the Parent Node of Node B, the relevance for Node B with Node A is hypernymy. The setting of relevance weight is 0.7.
- Hyponymy: If Node A is the Child Node of Node B, the relevance for Node B with Node A is hyponymy. The setting of relevance weight is 0.4.
- Correlations: If there is a non-subordinate relationship existing between Node A and Node B, Node A is correlated with Node B. The setting of relevance weight is 0.5.

3.3. Spreading procedure

Based on the abovementioned spreading criteria and contraints, the following spreading procedure is designed:

1) Setting of starting nodes: This step is to determine starting nodes; that is, the behavioral nodes preferred by users. Therefore, generally speaking, there are many starting nodes. Each behavioral node is set with the interest value, and then the activation value and the activation index are set to be the default values. Finally, read the weights of hypernymy, hyponymy and correlations of the system.

2) Spreading activation: Each behavior will activate adjacent behavioral nodes, and adjacent nodes will activate their adjacent nodes. Thus, a recursive way is formed and will not stop until the restriction on the spreading distance is exceeded. If the behavioral node is a starting one, the output activation value is:

$$\textit{output activation value} = \textit{interest value} \times \textit{relevance weight}$$

If the behavioral node is the concept to activate the path, the behavioral node will output the input activation value to adjacent nodes in order to activate adjacent nodes. Its output activation value is:

$$\textit{output activation value} = \textit{input activation value} \times \textit{relevance weight}$$

And the activation value of the behavioral node itself will increase because of the output of adjacent nodes. Its value is:

$$\textit{activation value} = \textit{activation value} + \textit{input activation value}$$

Finally, when the recursive spreading activation ends, start the spreading activation from next starting behavioral node until all the starting nodes finish spreading.

3) Confirmation of spreading nodes: When all the spreading activations are completed, the activation value accumulated by each node varies. The higher the activation value is, it means the more the adjacent user preferred activities are. The lower the activation value is, it means the farther the behavioral node is from user preferred behavioral node.

4. Application of cases

Through the observation of the activities, users' various activity paths and event information in the plaza of Kuang San SOGO Department Store in Taichung are recorded as shown in Fig 1. After accumulation for a period of time, some important characteristics of behavior can be induced from the overlapping relationships between different spatial points and users.

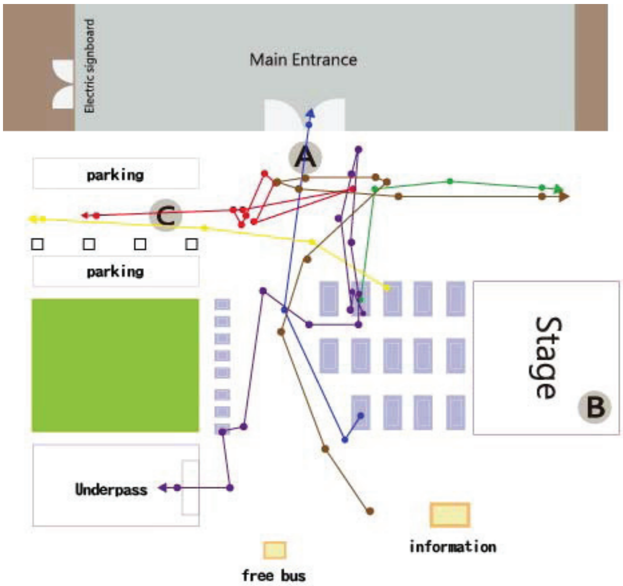

Fig 1. Observation of human behavior sequence in the plaza of Kuang San SOGO department store in Taichung

The spreading procedure in this research method is divided into three procedures - setting of starting nodes, spreading activation, and confirmation of spreading nodes. In the initial stage of setting, starting nodes need to be determined and parameters to be set. In this case, starting nodes are four behavioral nodes including "watching the activities at plazas," "watching TV screen or electronic billboards," "having a conversation," and "waiting for activity held by plazas." And, parameters are set as follows: "activation distance＝l," "activation threshold value＝2.4," "Hypernymy＝0.7," "Hyponymy＝0.4," and "correlations＝0.5."

In the stage of spreading activation, the degree of interest of the starting behavioral node will spread to adjacent nodes. The adjacent nodes of watching the activities at plazas" are "watching the people in the plaza," "watching TV screen or electronic billboards," and "waiting for activity held by plazas." Among them, "watching the people in the plaza" and "watching the activities at plazas" are hyponymy. The activation value is 5*0.4=2; "watching TV screen or electronic billboards," "waiting for activity held by plazas," and "watching the activities at plazas" are correlations. The activation value is 5*0.5=2.5. See Fig. 2 The numerical values within nodes represent the activation values of behavioral nodes.

The last step is to confirm spreading nodes; that is, to choose the behavioral nodes whose values are higher than threshold values and which are not starting points. After completing the previous step, the activation value of each behavioral node must be accumulated, which is the degree of interest of the node. The result is as shown in Table 1. Owing to the fact that the activation threshold value is set to be 2.4, the behavioral nodes of activation are “waiting for movie,” “eating and drinking,” “playing with children,” “waiting for the partners,” and “watching the fountain.”

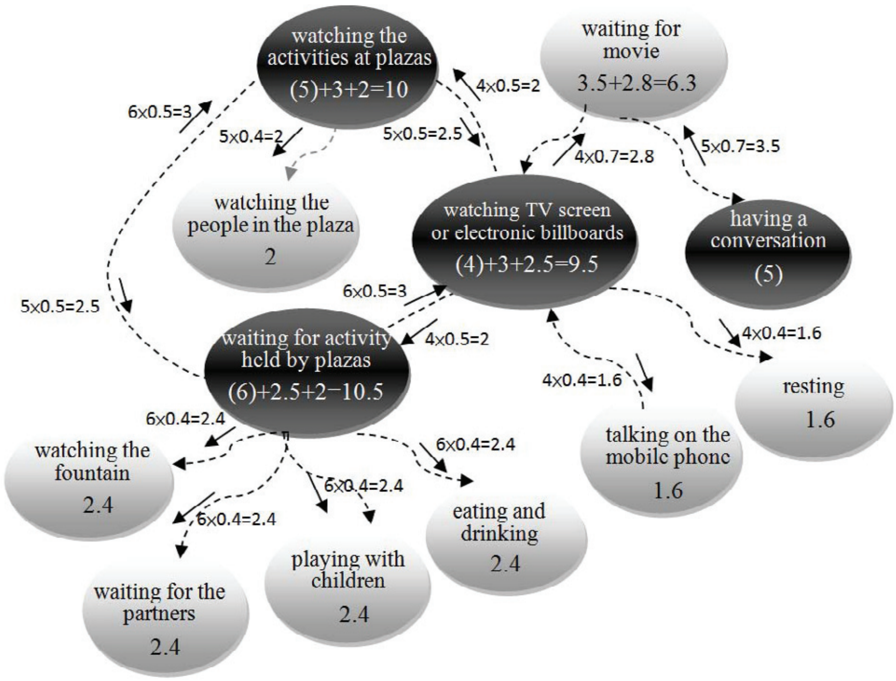

Fig 2. The method of expressing the spreading activation model of behavioral nodes

Table 1. Cumulative results of activation values of behavioral nodes

behavioral nodes	**activation values**	**behavioral nodes**	**activation values**
watching the activities at plazas *	10	having a conversation *	5
watching the fountain	2.4	waiting for movie	6.3
playing with children	2.4	waiting for the partners	2.4
watching the people in the plaza	2	resting	1.6
eating and drinking	2.4	watching TV screen or electronic billboards *	9.5
waiting for activity held by plazas *	10.5	talking on the mobile phone	1.6

Remark: * represents starting nodes

5. Conclusion

Applying the spreading activation model to the spreading activation of users’ behavioral nodes in an intelligent environment design will generate two important issues. First, input values and output values must be adjusted; otherwise, the spreading activation between nodes may continue, making all the nodes in the network activated. In other words, meaningless nodes might be included, causing a problem that the spreading range is too wide. Second, the connection between nodes is only to express the degree of relationship (weight) between nodes, not to involve the semantic meaning of user behavior in an intelligent environment design. Therefore, if the spreading activation model is applied to the field of an intelligent environmental design, the activation distance of nodes, the spreading range, and the spreading critical value must be restricted. Relevant conclusions and suggestions are proposed below based on the research results.

1) Distance constraint: To prevent the spreading range from being too wide, the distance with which starting nodes start must be controlled. The distance between two nodes can be regarded as the length of segment between two connected nodes. The longer the segment between two connected nodes is, it means the lower the relevance degree between two nodes and the semantic correlation that exists between the two are. When the relevance degree is lowered to a certain constraint value, spreading should be stopped. Usually, spreading for two or three times is most commonly seen.

2) Fan-shaped spreading restriction: The range of spreading activation is also related with the degree to which a node is externally connected. In other words, the more external connections a node has, the larger the range of spreading is. Hence, to avoid such a situation, the spreading range of this node must be restricted.

3) Restriction on activation critical values: In the spreading network, a function of critical value is often adopted to control the proceeding of spreading activation. To prevent certain nodes from being activated too many times and generating too wide spreading range, the critical value can be modified to restrict the times of activation.

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