Prediction Method of Public Participation in Decision-making Based on Bayes Theorem

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Abstract. Public participation is an activity that citizens participate in the decision-making without government and experts. It could create better informed and more creative decision-making. However, it is difficult to invite all stakeholders to participate in the urban design and planning project. So most of projects could just receive a few decisions from the public. This article would introduce a model based on Bayes theorem. This algorithm model can predict the possibility of other stakeholders' decision-making on a proposal based on the feedback results of a small part of the surveyed participants and big data analysis. This article mainly studies how the algorithm model can be displayed in the actual project through a case of local residents' decision-making and prediction of the building height of the planned area in a planning project.

Key words: Public participation, Decision-making prediction, Bayes theorem

1. Introduction
Public participation is a manifestation of a country's democracy [1]. There are many reasons to organize public participation in the decision-making project. First of all, public participation could create more innovative decisions. Different participants’ ideas could open new ways for decision-making. Secondly, public participation could increase the acceptance of public for the decision-making. Because it fully consults the public before making decisions [2]. Thirdly, public participation could increase the openness and integration of government. It could make government policies and decisions more open and transparent [3,4]. Overall, public participation could increase the democracy and wisdom of government decisions.
However, it is not easy for government or urban planners to organize all stakeholders to participate in the decision-making. For example, a community renovation project needs to renovate the public space and infrastructures in this community. There are almost 2000 people in this community, include aging people, young adults and children. They are all stakeholders of this project but it is difficult and impossible to organize 2000 people to participate in every stage of decision-making in this project. So this literature would describe a method to help government and urban planners to predict other stakeholders’ decision-making intentions based on Bayes theorem.

2. Related work of Bayes theorem on public participation promotion
The project helps Danish people participate in the supervision and prediction of the water quality of Havelse Water Plant by building a Bayesian network. Bayesian network (Bn) is a decision support system, which is based on probability theory [5–8]. Bayes network is used as a tool for water resources management and forecasting simulation in this case. The main source of the Danish people’s domestic...
water is groundwater. The Havel Water Plant is a large underground water plant in Denmark, with a catchment area covering an area of approximately 26 square kilometers. After local people investigate, most of the water pollution is mainly from pesticides. The goal of the project is to help local residents participate in the control of groundwater quality through the Bayesian network, so that the groundwater is free of pesticides [8].

According to figure 1, the project uses 7 steps to build the Bayes network. First of all, the project defines the project background and boundary. The project defines the indicators by defining physical and socio-economic boundaries, areas of interest, alternative actions, etc. Secondly, the project has identified influencing factors, actions to be taken and related indicators. The project also formulated some indicators of public concern, such as groundwater quality. Thirdly, the project identifies important variables and analyzes their possible impact on the results. Fourthly, the project collects various data and conducts data analysis. Fifthly, the project collects and analyzes the suggestions of stakeholders. Sixth, the project establishes a conditional probability table by analyzing and calculating the collected data and determined variables. At the same time, review the list of stakeholders. At last, the project collects feedback from stakeholders on the final results and draws conclusions based on the Bayesian network [8].

So this project builds a Bayesian network and collects and calculates relevant data and public suggestions. In this way, the conditional probability of various events is predicted, so that the public can directly participate in the management and monitoring of water quality. It can be seen that Bayes' law can predict the probability of related events through the control of event variables and data analysis.

3. Methodology
This project would introduce a prediction model that could predict the probability of the public decision-making. The core algorithms of this model is Bayes Theorem. The Bayes' Theorem is a simple mathematical formula, which is mainly for calculating conditional probabilities [9]. It plays an importation role in probabilistic machine learning. According to formula 1, it is the formula of Bayes Theorem. ‘P(H)’ is the prior probability. It represents the probability data from sample. P(H|D) is the probability of posterior. It represents probability data from other people in the groups of sample. ‘P(D|H)’ is likelihood. It represents The probability of the event occurring. ‘P(D)’ is the evidence.

\[
P(H|D) = \frac{P(D|H)P(H)}{P(D)}
\]

Formula 1 is the formula of Bayes Theorem (Adapted from [10]).

According to figure 2, this system could calculate the probability of all people’s choice for some specific urban renovation project based on limited example investigation. At first, system would collect the data for one sample. In this sample, it includes all kinds of stakeholders of the project but the number of examples is limited. After that the system would calculate the prior probability based on big data analysis. And then it would calculate the likelihood based on the sample investigation and get the probability trend at last.
According to formula 2 and figure 3, for the floor height willingness survey, the system collects the stakeholders’ data about the desire for community building height renovation, from an example’s groups, include young people, children and aging people at first. The number of examples is ‘N’. This system
collect data mainly from online and offline questionnaire investigation. These questionnaires just have limited choices, like high-rise and mid-rise buildings. There are ‘n’ residents choosing high-rise building. After that, the system would make a big data analysis for floor choice of residents in this city to analyses the probability (p) of community residents choosing high-rise buildings. And then the system would calculate the likelihood based on the outcomes of the sample investigation based on the second formula. At last, the system would calculate the trend of other community residents choosing high-rise buildings based on the third formula below and provide the results to the urban designers. Overall, this system increases the efficiency of public data investigation and collection in the process of public participation.

01.Algorithm formula 02.Likelihood Calculation 03.Numerical Integration

\[
    P(p|n,N) = \frac{P(n|p,N)P(p)}{P(n|N)} = \frac{N!}{n!(N-n)!} p^n(1-p)^{N-n}
\]

Formula 2 is the formula of algorithms in system (Adapted from [10]).

4. Conclusion

In summary, this prediction model could help government or urban planners to predict the probability of all stakeholders’ decision-making in a limited investigation group. However, it also needs more specific study on the screening of survey groups and determination of the number of groups in specific project. In addition, over time, people’s choices may also change. How to predict people’s dynamic needs through algorithms still needs further exploration. Therefore, the application of predictive models still needs to consider many complex factors.

In the future, the predict method based on Bayes theorem is a useful tool to help people to save time for investigation. It would be widely used in different fields. It needs people to explore more methods to apply it and increase the accuracy of probability prediction.

5. References

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