A Fuzzy-Based Decision System for Sightseeing Spots Considering Hot Spot Access as a New Parameter

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Abstract. Discovering and recommending points of interest are drawing more attention to meet the increasing demand from personalized tours. In this paper, we propose and evaluate a new fuzzy-based system for decision of sightseeing spots considering different conditions. In our system, we considered four input parameters: Ambient Temperature (AT), Air Quality (AQ), Noise Levle (NL) and Hot Spot Access (HSA) to decide the sightseeing spots Visit or Not Visit (VNV). We evaluate the proposed system by computer simulations. From the simulations results, we conclude that when the AT is normal, the VNN is the best. But when AQ and NL are increased, the VNV is decreased. Considering the effect of HSA parameter, we found that when HSA is increased, the VNV is increased. The simulation results have shown that the proposed system has a good performance and can choose good sightseeing spots.

1 Introduction

Social image hosting websites have recently become very popular. On these sites, users can upload and tag images for sharing their travelling experiences. The geotagged images are widely used in landmark recognitions and trip recommendations. Large amount of information generated from these location-based social services covers not only popular locations but also obscure ones. Since personalized tours are becoming popular, more attention is focusing on obscure sightseeing locations that are less well-known while still worth visiting. In Fig. 1 are show two dimensions of diverse sightseeing resources. The evaluation can be done using the sightseeing quality and popularity [1–5].

In this work, we use Fuzzy Logic (FL) for decision of sightseeing spots. The FL is the logic underlying modes of reasoning which are approximate rather then exact. The importance of FL derives from the fact that most modes of human reasoning and especially common sense reasoning are approximate in nature [6]. FL uses linguistic variables to describe the control parameters. By

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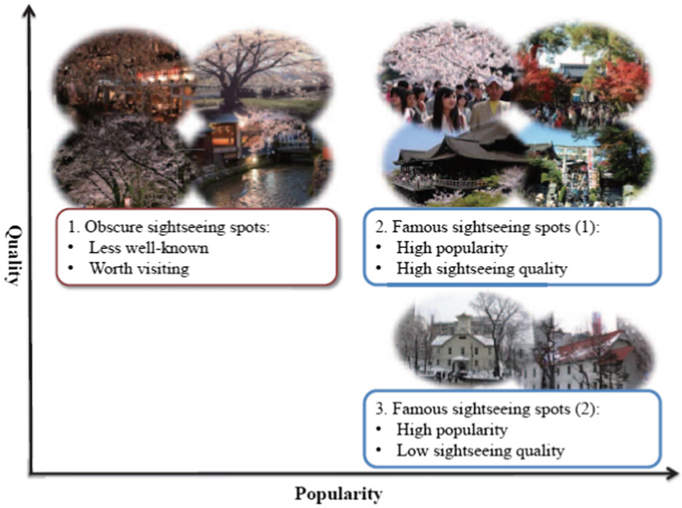


Fig. 1. Two dimensions of diverse sightseeing resources.

using relatively simple linguistic expressions it is possible to describe and grasp very complex problems. A very important property of the linguistic variables is the capability of describing imprecise parameters.

The concept of a fuzzy set deals with the representation of classes whose boundaries are not determined. It uses a characteristic function, taking values usually in the interval [0, 1]. The fuzzy sets are used for representing linguistic labels. This can be viewed as expressing an uncertainty about the clear-cut meaning of the label. But important point is that the valuation set is supposed to be common to the various linguistic labels that are involved in the given problem.

The fuzzy set theory uses the membership function to encode a preference among the possible interpretations of the corresponding label. A fuzzy set can be defined by examplification, ranking elements according to their typicality with respect to the concept underlying the fuzzy set [7].

In this paper, we propose and evaluate a fuzzy-based system for decision of sightseeing spots considering hot spot access as a new parameter. In our system, we considered four input parameters: Ambient Temperature (AT), Air Quality (AQ), Noise Levle (NL) and Hot Spot Access (HSA) to decide the output parameter Visit or Not Visit (VNV).

The structure of this paper is as follows. In Sect. 2, we introduce FL used for control. In Sect. 3, we present the proposed fuzzy-based system. In Sect. 4, we discuss the simulation results. Finally, conclusions and future work are given in Sect. 5.

2 Application of Fuzzy Logic for Control

The ability of fuzzy sets and possibility theory to model gradual properties or soft constraints whose satisfaction is matter of degree, as well as information pervaded with imprecision and uncertainty, makes them useful in a great variety of applications [8–16].

The most popular area of application is Fuzzy Control (FC), since the appearance, especially in Japan, of industrial applications in domestic appliances, process control, and automotive systems, among many other fields.

In the FC systems, expert knowledge is encoded in the form of fuzzy rules, which describe recommended actions for different classes of situations represented by fuzzy sets.

In fact, any kind of control law can be modeled by the FC methodology, provided that this law is expressible in terms of "if ... then ..." rules, just like in the case of expert systems. However, FL diverges from the standard expert system approach by providing an interpolation mechanism from several rules. In the contents of complex processes, it may turn out to be more practical to get knowledge from an expert operator than to calculate an optimal control, due to modeling costs or because a model is out of reach.

A concept that plays a central role in the application of FL is that of a linguistic variable. The linguistic variables may be viewed as a form of data compression. One linguistic variable may represent many numerical variables. It is suggestive to refer to this form of data compression as granulation.

The same effect can be achieved by conventional quantization, but in the case of quantization, the values are intervals, whereas in the case of granulation the values are overlapping fuzzy sets. The advantages of granulation over quantization are as follows:

- it is more general;
- it mimics the way in which humans interpret linguistic values;
- the transition from one linguistic value to a contiguous linguistic value is gradual rather than abrupt, resulting in continuity and robustness.

FC describes the algorithm for process control as a fuzzy relation between information about the conditions of the process to be controlled, x and y, and the output for the process z. The control algorithm is given in "if ... then ..." expression, such as:

If x is small and y is big, then z is medium;
If x is big and y is medium, then z is big.

These rules are called *FC rules*. The "if" clause of the rules is called the antecedent and the "then" clause is called consequent. In general, variables x and y are called the input and z the output. The "small" and "big" are fuzzy values for x and y, and they are expressed by fuzzy sets.

Fuzzy controllers are constructed of groups of these FC rules, and when an actual input is given, the output is calculated by means of fuzzy inference.

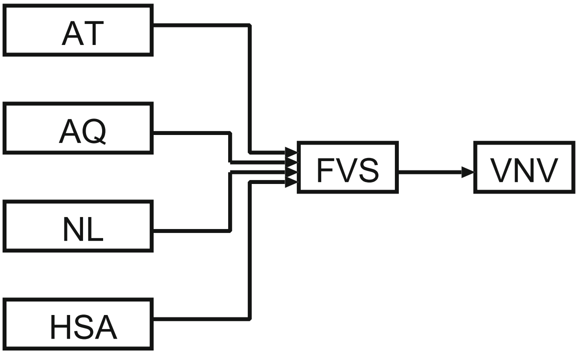


Fig. 2. FVS structure.

3 Proposed Fuzzy-Based System

The proposed system stucture is show in Fig. 2. We call this system: Fuzzy-based Visiting Spots (FVS) system. In this work, we consider four parameters: Ambient Temperature (AT), Air Quality (AQ), Noise Level (NL) and Hot Spot Access (HSA) to decide the sightseeing spots Visit or Not Visit (VNV). The AT is the temperature at the sightseeing spots. We use the air pollution data around sightseeing spots to decide the AQ. The NL is the amplitude level of the noise. For HSA, we consider the access by walk, train, bus, car and airplane. These four parameters are not correlated with each other, for this reason we use fuzzy system. The membership functions for our system are shown in Fig. 3. In Table 1, we show the fuzzy rule base of our proposed system, which consists of 135 rules.

The input parameters for FVS are: AT, AQ, NL and HSA. The output linguistic parameter is VNV. The term sets of *AT*, *AQ*, *NL* and *HSA* are defined respectively as:

$$\begin{aligned} AT &= \{Very\ Cold,\ Cold,\ Normal,\ Hot,\ Very\ Hot\} \\ &= \{VC,\ Co,\ No,\ Ho,\ VH\}; \\ AQ &= \{Good,\ Normal,\ Bad\} \\ &= \{Good,\ Nor,\ Bad\}; \\ NL &= \{Low,\ Middle,\ High\} \\ &= \{Lo,\ Mi,\ Hi\}; \\ HSA &= \{Bad,\ Normal,\ Good\} \\ &= \{Bd,\ N,\ Gd\}. \end{aligned} \tag{1}$$

Table 1. FRB.

Rule	AQ	AT	NL	HSA	VHV	Rule	AQ	AT	NL	HSA	VHV	Rule	AQ	AT	NL	HSA	VHV
1	Good	VC	Lo	Bd	VL2	46	Nor	VC	Lo	Bd	VL1	91	Bad	VC	Lo	Bd	VL1
2	Good	VC	Lo	N	VL3	47	Nor	VC	Lo	N	VL2	92	Bad	VC	Lo	N	VL1
3	Good	VC	Lo	Gd	VL5	48	Nor	VC	Lo	Gd	VL4	93	Bad	VC	Lo	Gd	VL3
4	Good	VC	Mi	Bd	VL1	49	Nor	VC	Mi	Bd	VL1	94	Bad	VC	Mi	Bd	VL1
5	Good	VC	Mi	N	VL2	50	Nor	VC	Mi	N	VL1	95	Bad	VC	Mi	N	VL1
6	Good	VC	Mi	Gd	VL3	51	Nor	VC	Mi	Gd	VL2	96	Bad	VC	Mi	Gd	VL1
7	Good	VC	Hi	Bd	VL1	52	Nor	VC	Hi	Bd	VL1	97	Bad	VC	Hi	Bd	VL1
8	Good	VC	Hi	N	VL1	53	Nor	VC	Hi	N	VL1	98	Bad	VC	Hi	N	VL1
9	Good	VC	Hi	Gd	VL2	54	Nor	VC	Hi	Gd	VL1	99	Bad	VC	Hi	Gd	VL1
10	Good	C	Lo	Bd	VL4	55	Nor	C	Lo	Bd	VL3	100	Bad	C	Lo	Bd	VL2
11	Good	C	Lo	N	VL6	56	Nor	C	Lo	N	VL5	101	Bad	C	Lo	N	VL3
12	Good	C	Lo	Gd	VL7	57	Nor	C	Lo	Gd	VL6	102	Bad	C	Lo	Gd	VL5
13	Good	C	Mi	Bd	VL3	58	Nor	C	Mi	Bd	VL2	103	Bad	C	Mi	Bd	VL1
14	Good	C	Mi	N	VL4	59	Nor	C	Mi	N	VL3	104	Bad	C	Mi	N	VL2
15	Good	C	Mi	Gd	VL6	60	Nor	C	Mi	Gd	VL5	105	Bad	C	Mi	Gd	VL3
16	Good	C	Hi	Bd	VL2	61	Nor	C	Hi	Bd	VL1	106	Bad	C	Hi	Bd	VL1
17	Good	C	Hi	N	VL3	62	Nor	C	Hi	N	VL2	107	Bad	C	Hi	N	VL1
18	Good	C	Hi	Gd	VL4	63	Nor	C	Hi	Gd	VL3	108	Bad	C	Hi	Gd	VL2
19	Good	No	Lo	Bd	VL6	64	Nor	No	Lo	Bd	VL5	109	Bad	No	Lo	Bd	VL3
20	Good	No	Lo	N	VL7	65	Nor	No	Lo	N	VL6	110	Bad	No	Lo	N	VL5
21	Good	No	Lo	Gd	VL7	66	Nor	No	Lo	Gd	VL7	111	Bad	No	Lo	Gd	VL6
22	Good	No	Mi	Bd	VL4	67	Nor	No	Mi	Bd	VL3	112	Bad	No	Mi	Bd	VL2
23	Good	No	Mi	N	VL6	68	Nor	No	Mi	N	VL5	113	Bad	No	Mi	N	VL3
24	Good	No	Mi	Gd	VL7	69	Nor	No	Mi	Gd	VL6	114	Bad	No	Mi	Gd	VL5
25	Good	No	Hi	Bd	VL3	70	Nor	No	Hi	Bd	VL2	115	Bad	No	Hi	Bd	VL1
26	Good	No	Hi	N	VL4	71	Nor	No	Hi	N	VL3	116	Bad	No	Hi	N	VL2
27	Good	No	Hi	Gd	VL6	72	Nor	No	Hi	Gd	VL5	117	Bad	No	Hi	Gd	VL3
28	Good	H	Lo	Bd	VL4	73	Nor	Hi	Lo	Bd	VL3	118	Bad	H	Lo	Bd	VL2
29	Good	H	Lo	N	VL6	74	Nor	H	Lo	N	VL5	119	Bad	H	Lo	N	VL3
30	Good	H	Lo	Gd	VL7	75	Nor	H	Lo	Gd	VL6	120	Bad	H	Lo	Gd	VL5
31	Good	H	Mi	Bd	VL3	76	Nor	H	Mi	Bd	VL2	121	Bad	H	Mi	Bd	VL1
32	Good	H	Mi	N	VL4	77	Nor	H	Mi	N	VL3	122	Bad	H	Mi	N	VL2
33	Good	H	Mi	Gd	VL6	78	Nor	H	Mi	Gd	VL5	123	Bad	H	Mi	Gd	VL3
34	Good	H	Hi	Bd	VL2	79	Nor	H	Hi	Bd	VL1	124	Bad	H	Hi	Bd	VL1
35	Good	H	Hi	N	VL3	80	Nor	H	Hi	N	VL2	125	Bad	H	Hi	N	VL1
36	Good	H	Hi	Gd	VL4	81	Nor	H	Hi	Gd	VL3	126	Bad	H	Hi	Gd	VL2
37	Good	VH	Lo	Bd	VL2	82	Nor	H	Lo	Bd	VL1	127	Bad	VH	Lo	Bd	VL1
38	Good	VH	Lo	N	VL3	83	Nor	VH	Lo	N	VL2	128	Bad	VH	Lo	N	VL1
39	Good	VH	Lo	Gd	VL5	84	Nor	VH	Lo	Gd	VL4	129	Bad	VH	Lo	Gd	VL3
40	Good	VH	Mi	Bd	VL1	85	Nor	VH	Mi	Bd	VL1	130	Bad	VH	Mi	Bd	VL1
41	Good	VH	Mi	N	VL2	86	Nor	VH	Mi	N	VL1	131	Bad	VH	Mi	N	VL1
42	Good	VH	Mi	Gd	VL3	87	Nor	VH	Mi	Gd	VL2	132	Bad	VH	Mi	Gd	VL1
43	Good	VH	Hi	Bd	VL1	88	Nor	VH	Hi	Bd	VL1	133	Bad	VH	Hi	Bd	VL1
44	Good	VH	Hi	N	VL1	89	Nor	VH	Hi	N	VL1	134	Bad	VH	Hi	N	VL1
45	Good	VH	Hi	Gd	VL2	90	Nor	VH	Hi	Gd	VL1	135	Bad	VH	Hi	Gd	VL1

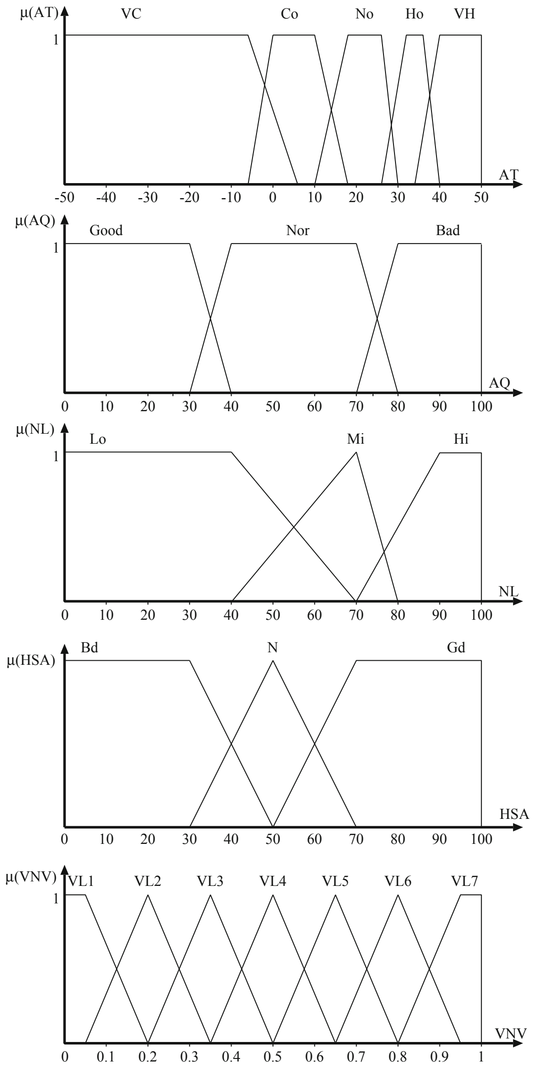


Fig. 3. Membership functions.

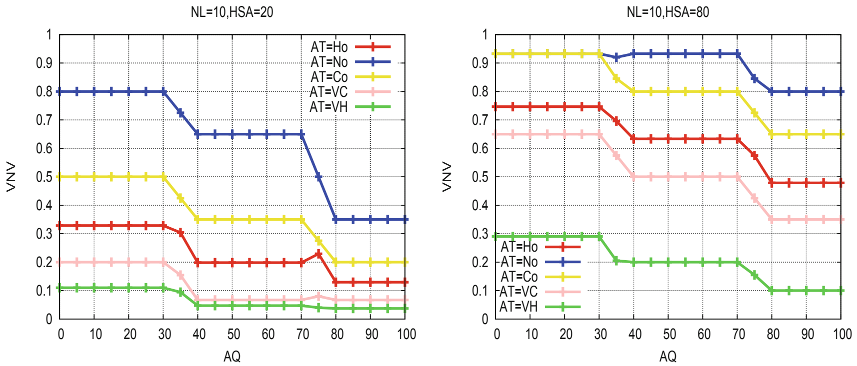
and the term set for the output VNV is defined as:

$$VNV = \begin{pmatrix} VisitLevel1 \\ VisitLevel2 \\ VisitLevel3 \\ VisitLevel4 \\ VisitLevel5 \\ VisitLevel6 \\ VisitLevel7 \end{pmatrix} = \begin{pmatrix} VL1 \\ VL2 \\ VL3 \\ VL4 \\ VL5 \\ VL6 \\ VL7 \end{pmatrix}.$$

4 Simulation Results

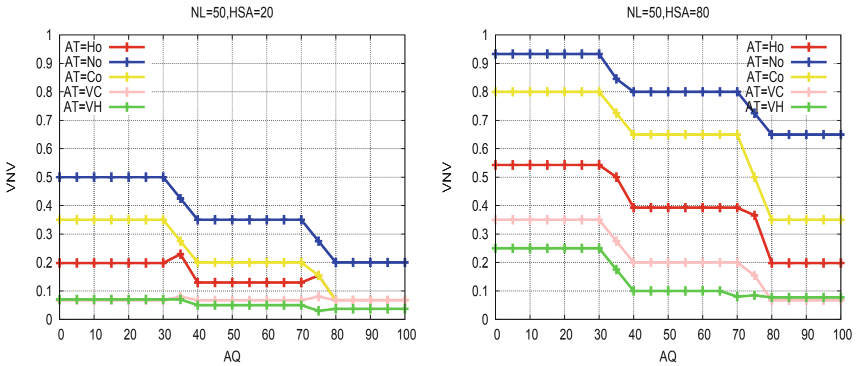
In this section, we present the simulation results for our proposed fuzzy-based system. In our system, we decided the number of term sets by carrying out many simulations.

From Fig. 4, 5 and 6, we show the relation of VNV with AT, AQ, NL and HSA. In these simulations, we consider the NL and HSA as constant parameters. In Fig. 4, we consider NL value 10 units. We change the HSA value from 20 to 80 units. When the HSA increases, the VNV is increased. By increaseing AQ, the VNV is decreased. And when AT is normal, the VNV is the best. In Fig. 5 and Fig. 6, we change NL value to 50 and 90 units, respectively. We see that, when the NL increases, the VNV is decreased.



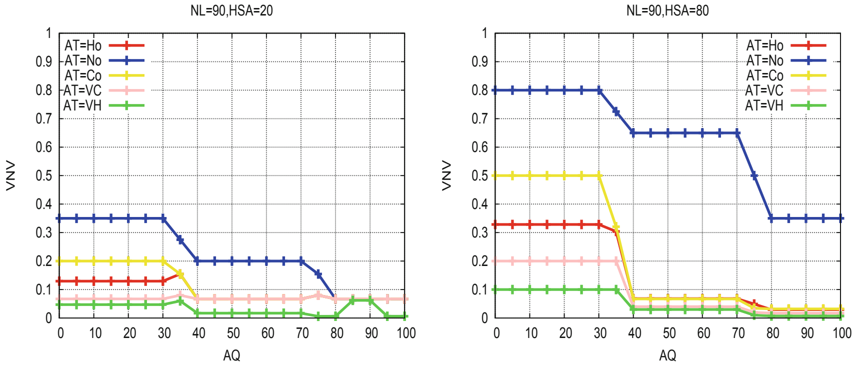
(a) HSA=20 (b) HSA=80

Fig. 4. Relation of VNV with AT and AQ for different HSA when NL = 10.



(a) HSA=20 (b) HSA=80

Fig. 5. Relation of VNV with AT and AQ for different HSA when NL = 50.



(a) HSA=20 (b) HSA=80

Fig. 6. Relation of VNV with AT and AQ for different HSA when NL = 90.

5 Conclusions and Future Work

In this paper, we proposed a fuzzy-based system to decide the sightseeing spots. We took into consideration four parameters: AT, AQ, NL and HSA. We evaluated the performance of proposed system by computer simulations. From the simulations results, we conclude that when AQ and NL are increased, the VNV is decreased. When the AT is normal, the VNV is the best. But by increasing HSA, the VNV is increased.

In the future, we would like to make extensive simulations to evaluate the proposed system and compare the performance of our proposed system with other systems.

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