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# GUI FORM FOR CAR RETRIEVAL SYSTEMS USING FUZZY THEORY

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Abstract. *This paper develops a practical car search system using fuzzy theory. This system aims at supporting car purchasing for a person which is no good with machines as if they ask casually someone who knows more about cars. Unspecific conditions are expressed by the fuzzy set, and the level matching the conditions are expressed by the grade values. To keep more practical use, a GUI form which only selects some menus is established. In conclusion, it reviews and observes this study, showing its effectiveness, remaining issues, and measures for the issues.*
**Keywords:** Fuzzy theory, Car retrieval system, Purchase support

1. **Introduction.** As car-oriented society has grown these days, the number of cars owned by one household is increasing. It is even no longer one car per household, its one car per person. Car makers provide variety of unique cars suit for individuals. It is fun for people to choose car type, especially for those who has special interest in cars. However, on opposite side, its relatively difficult to choose cars that suit them most. Generally, when people who don't have special interest in cars search for car information over internet and if they don't know or remember appropriate keywords to be input, they may not get satisfaction search results. This study therefore uses fuzzy theory [1-6], which manages daily and sensuous words, aiming at developing a practical car search system (a supportive tool for purchasing cars) and proving their effectiveness. In this system, unspecific words used in daily conversations can be used for searching (Such words are like "relatively large in size", "relatively high power, etc.).

2. **Using Data and Membership Functions.** The car maker used in this system is decided to TOYOTA, which has a largest share in the industry, in order to improve the accuracy of the system. Selectable models are 49 types of current models excluding used ones (excluding the full-size models from the total 52 types (as of January 2008)).

In this paper, fuzzy theory is applied to following items; (1) the car size, (2) the engine displacement, and (3) the power. In general, membership functions are identified subjectively, so we adopt a theory which is based on statistics for the boundary of fuzzy area. We adopt the two standard deviations for the boundaries of fuzzy area, $A$ and $B$ ($A < B$) are

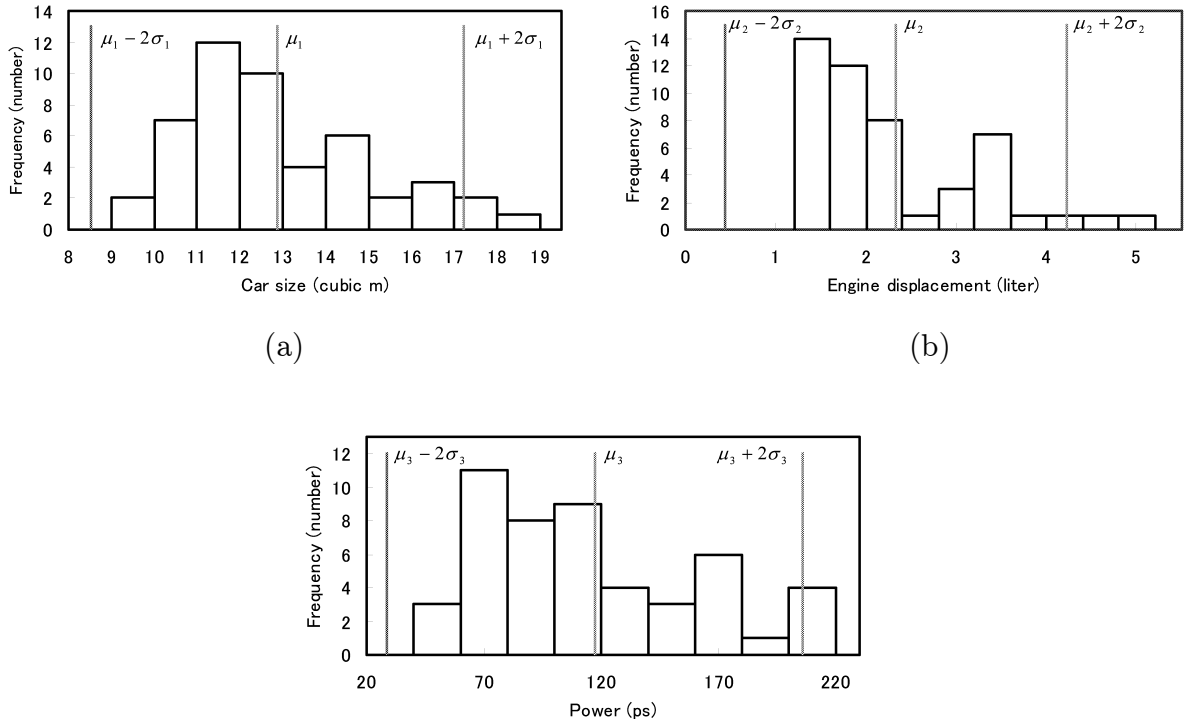


FIGURE 1. The histograms. (a) The car size ($\mu_1$ =12.9, $\mu_1$-2$\sigma_1$ =8.5, $\mu_1$+2$\sigma_1$ =17.2), (b) The engine displacement ($\mu_2$ =2.3, $\mu_2$-2$\sigma_2$ =0.4, $\mu_2$+2$\sigma_2$ =4.2), (c) The Maximum power ($\mu_3$ =117, $\mu_3$-2$\sigma_3$ =29, $\mu_3$+2$\sigma_3$ =206).

$$A = \mu - 2\sigma \tag{1}$$

$$B = \mu + 2\sigma \tag{2}$$

where $\mu$ and $\sigma$ are average and standard deviations of a data $x_i$ ($i = 1, 2, \ldots, n$), respectively. These are shown as follows:

$$\mu = \frac{1}{n}\sum_{i=1}^{n} x_i, \tag{3}$$

$$\sigma = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \mu)^2}, \tag{4}$$

Figure 1 show the histograms for the car size, the engine displacement, and the power. Here, $\mu_1, \mu_2$ and $\mu_3$ are averages deviations of the data, $\sigma_1, \sigma_2$ and $\sigma_3$ are standard deviations of the data. These data are tendencies to low or small. It seems that the light motor vehicles are manufactured by TOYOTA.

Figure 2 show the membership functions for the car size, the engine displacement, and the power. We assigned five membership functions for each item, which are likely to be asked in the questionnaires. The values of membership functions which selected the menu at the proposal tool indicate the equality each data.

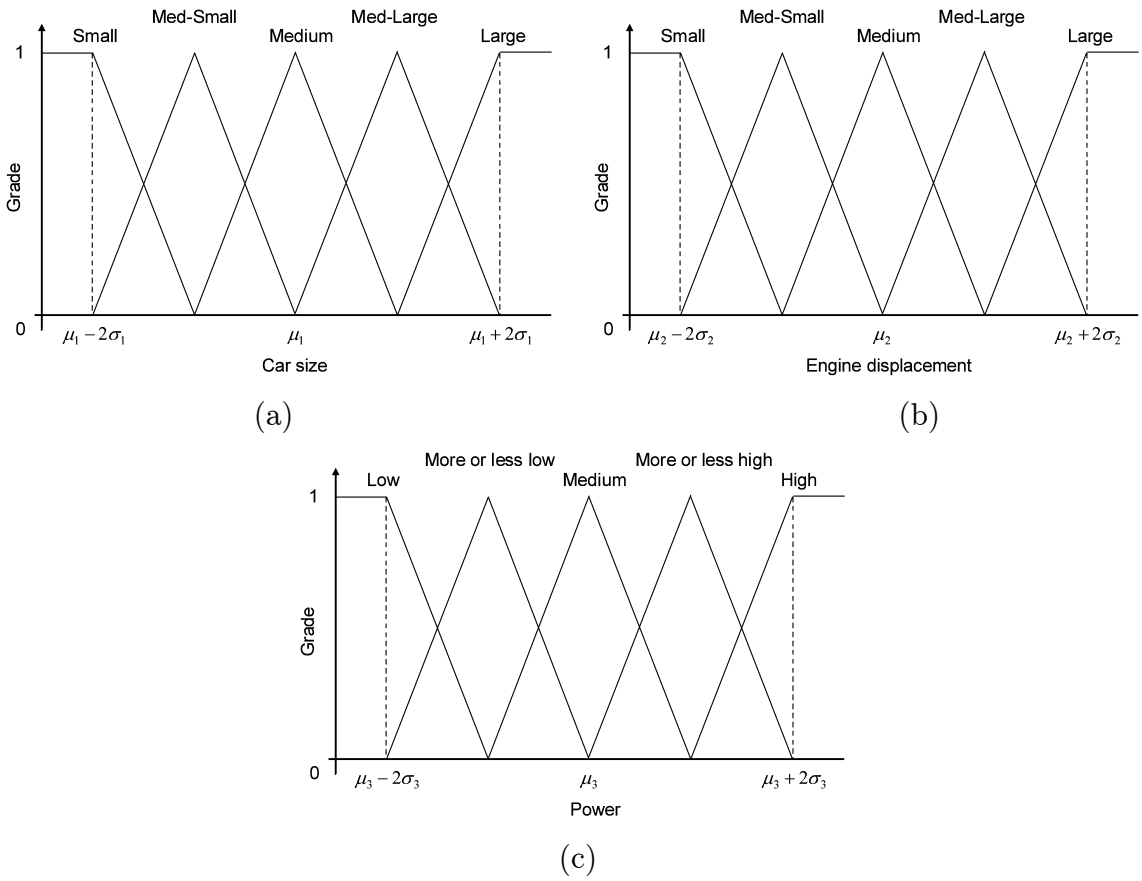


FIGURE 2. The membership functions. (a) The car size, (b) The engine displacement, (c) The Maximum power.

3. **Details of the Car Search System.** This chapter describes details of this study how to calculate the grade value for the membership function actually used, and explains the criteria of selecting items of the search form too.

3.1. **Processing flow and calculations.** In this section, the processing flow of proposed search system described as followed:

(1) Select elements from each item. Users can skip items they don't know well or are not interested etc.
(2) The grades of crisp sets and fuzzy sets are calculated as following.

Crisp set:

$$\alpha_c = \begin{cases} 1 \\ 0 \end{cases} \tag{5}$$

Fuzzy set:

$$\alpha_f = f_t(x), \tag{6}$$

where $f_t(x)$ is the triangle membership function in the previous chapter, and $k$ is the number of items crisp sets and fuzzy sets. These values indicate the equality the select element and each data.

(3) Calculations: Integrate the values of all crisp grades $\alpha_c$ and fuzzy grades $\alpha_f$. To avoid showing "Not Found", we adopt that each grade under 0.1 are changed to 0.1.
(4) The car models are shown in order, the highest integrated value of all grades on top.

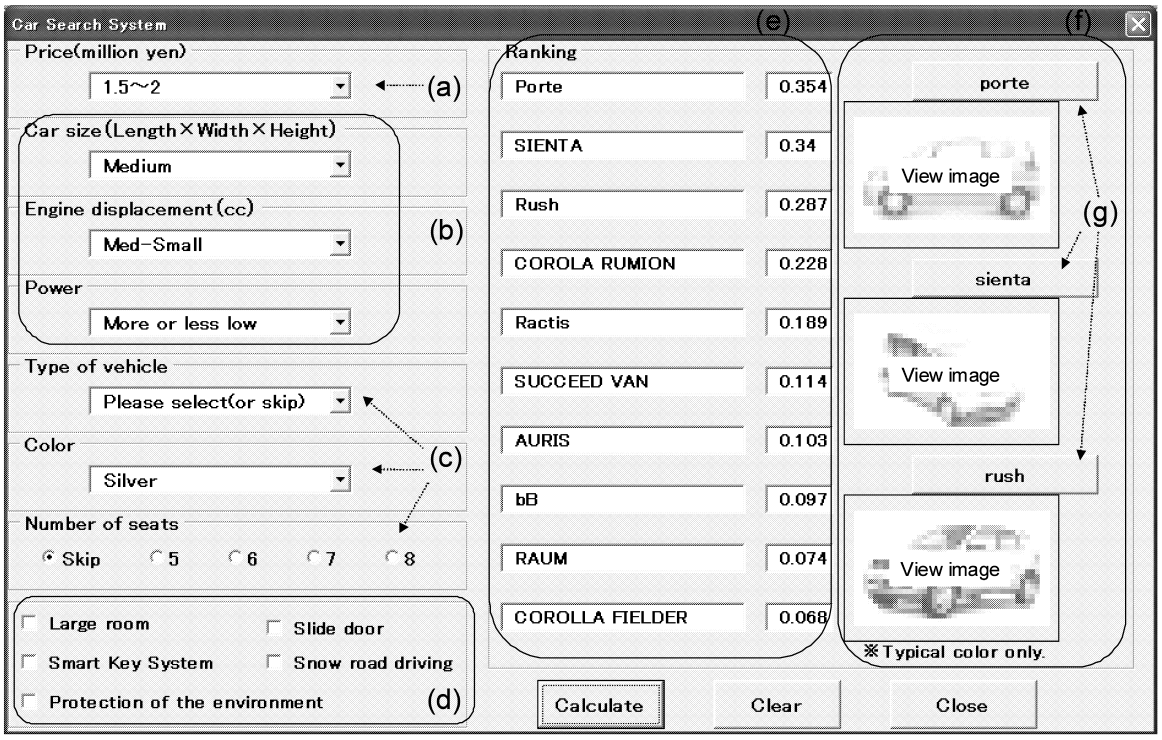


FIGURE 3. The GUI form of a practical car search system using fuzzy theory. (a) Menu for price (crisp set), (b) Menu for the car size, the engine displacement, and the power car size (fuzzy sets), (c) Menu for the type of vehicle, color, and number of seats (crisp sets), (d) Check box for particular uses, (e) Text boxes for display the ranking, (f) Image boxes for display the ranking, (g) Link button to web site.

3.2. **GUI form.** Figure 3 shows the proposed GUI form. The detail is as follows:

(a) The element of price is crisp set, which ranges from 1 million yen to ten million yen at interval of 0.5 million yen.
(b) Fuzzy items as stated in the previous chapter (the car size, the engine displacement, and the power).
(c) Each item is crisp sets. Type of vehicle: 2-Box car, sedan, wagon, etc. Color: White, Silver, Black, etc. Number of Seats: An item especially for large families.
(d) Check box for following particular uses. Large room (space): The cars of high ratio in the interior volume to the exterior volume. Slide door: The car which equipped with slide doors. Smart key system: The car which equipped with the keyless entry system. Snow road driving: The four-wheel drive system is included in the standard specification. Protection of the environment: Eco-friendly car which can reduce hazardous gas emission by more than 50
(e) The car search results are displayed here. Car types and model names at all grades are listed in order of highest match rate on top.
(f) Images of the top 3 are shown here.
(g) Buttons which link to the official web sites.

3.3. **An example and the result.** Figure 3 shows the result of an example which is shown in Table 1. Table 2 shows the selected car models and specs. The different types of vehicle can be selected, so it can be said that the proposed system is usefulness for supporting car purchasing for a person which doesn't know the type of vehicles. Users can get the information of the car models that only selected element of each items as if they ask casually someone who knows more about cars.

Table 1. An example of a select element

| Items | Elements |
|---|---|
| Price | 1.5-2.0 million yen |
| Car size | Medium |
| Engine displacement | Med-Small |
| Maximum power | More or less low |
| Type of vehicle | not selected |
| Color | Silver |
| Number of sheets | not selected |
| Check box for particular uses | not selected |

Table 2. The search result of an example

| Model name | Spec |
|---|---|
| Polte | 2-box type, 1496cc, 80ps |
| SIENTA | Minivan, 1496cc, 81ps |
| Rush | Sport utility vehicle, 1495cc, 80ps |

4. **Conclusion.** A supportive application for purchasing cars is created using fuzzy logic in this study. Even people who don't know well about cars can search a car with this supportive tool as if they ask casually someone who knows more about cars. Unspecific conditions are expressed by the fuzzy set, and the level matching the conditions are expressed by the grade values. The grade values against three items; the car size, the engine displacement, and the power are calculated to find adaptive level to all conditions. As a result the cars are shown in order, highest integrated value of all grades on top. Big reason for using fuzzy logic in this study is to express man's subjectivity and fuzziness, but the logic does not always fit to everyone because each person has different subjectivity. However by creating membership function using statistics and linear algebra, and by keeping on updating them can take up a fashion to approach the needs of users. Challenges for the future is to have questionnaires over the internet, and to adopt a system allowing to change membership function automatically to make the fuzzy set closer to the sense of users (the way of looking at things; such as "big" or "small" for example, depends on persons). In addition, an automatic data-updating system which cruises around the web is considered to be established, allowing reflecting the information from many car makers on car types, used cars, and even grades of each car type.

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