
Customer Oriented Product Selection using Fuzzy approach

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ABSTRACT

Decision making problem is the process of finding the best option from all the feasible alternatives. In the paper proposed, multiple attribute decision making model using fuzzy approach is suggested to select a product when multiple alternatives having multiple attributes available to the customer in the market. Linguistic quantifiers are used in the article to estimate rank and weight of the attributes in terms of triangular or trapezoidal fuzzy numbers as required by customer preference and satisfaction level. A case study is used to illustrate the procedure of the proposed approach at the end of the paper.

Keywords: Fuzzy Sets, Product features, Membership function, Linguistic quantifiers, Customer satisfaction level

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INTRODUCTION

In traditional or even online customer is considered to be the King of the Market. "It is the customer who determines what a business is" (peter, 1977)^[1]. Customer likes to have the fullest satisfaction on all the desired attributes of the products. However, the product attributes are in general conflicting, non-commensurable and fuzzy in nature and it is very difficult to satisfy all of them simultaneously. In this situation, a customer makes effort to satisfy most of the attributes rather than all of them.

Crisp set is inadequate in day to day real life of vagueness, imprecise and ambiguous information due to these realization evolution of fuzzy logic occur. Fuzzy Logic was introduced in 1965 by Lofti A Zadeh, professor of computer science as a mathematical way of representing impreciseness of vagueness in everyday life. MCDM (Multiple Criteria Decision Making) refer to the ranking, selecting, prioritizing a alternatives under multiple conflicting criteria (Fenton, 2006)^[2].

Fuzzy Logic is a multivalued logic that allows intermediate values to be defined between conventional evaluation like true/false, yes/no, high/low. Fuzzy Logic provide a simple way to arrive at a definite conclusion based upon vague, ambiguous, imprecise information. The multi level fuzzy logic model developed by fuzzy logics is based on the weight-age and ranking with establishment of benchmark and finally gives the result by fuzzy decision making. Bellman,

Zadeh and Zimmerman introduced fuzzy sets in to the field of MCDM to arrive at a definite conclusion based upon vague, ambiguous, imprecise information.

LITERATURE REVIEW

Multi criteria decision making methods are used to take decisions when a number of multiple, usually conflicting criteria are present in any decision making scenario (Zionts, 1988)^[3]. Any problem has multiple objectives or attributes. The area of multiple-criteria decision-making has grown significantly in recent past (Hwang and Lin 1987, Munda 1995, Asgharpour 1998)^{[4][5][6]}. Generally, this area consists of two major fields:

1) Multiple-Objective Decision-Making (MODM) (Michnik and Trzaskalik 2002)^[7], works on continuous decision spaces, primarily on mathematical programming with several objective functions.

2) Multiple-Attribute Decision-Making (MADM) (Yoon and Hwang 1995)^[8], focuses on problems with discrete decision spaces. MADM methods choose an optimal alternative from a set of alternatives with respect to several evaluation attributes with different weights.

Multi attribute decision making is best suited for selection or evaluation problem whereas multi objective decision making is best suited for operation design problems. Customers' imprecise judgments are treated in terms of fuzzy logic and their compromising attitudes are handled by linguistic quantifiers. Multi criteria decision making has been one of the fastest growing areas during the last decade depending on the changing in the business sector. The decision maker must identify or generate the objectives or attributes for a problem (Chuu, 2004)^[9].

Techniques for the evaluation of a decision-making support methods base including methods such as the Simple Additive Weighting – SAW (Churchman and Ackoff, 1954; Tvaronaviciene et al., 2008)^{[10][11]}, TOPSIS – Technique for Order Preference by Similarity to Ideal Solution (Hwang and Yoon, 1981; Zavadskas et al., 2006)^{[12][13]}, COPRAS – Complex Proportional Assessment (Zavadskas and Kaklauskas, 1996; Kaklauskas et al., 2006; Zavadskas et al., 2007b)^{[14][15][16]}, fuzzy COPRAS (Zavadskas and Antuchevičienė, 2007)^[17], MOORA – Multi-Objective Optimization on basis of Ratio Analysis (Brauers and Zavadskas, 2006; Brauers et al., 2008; Kalibatas and Turskis, 2008)^{[18][19][20]}, ELECTRE – Elimination and Choice Translating Reality (Roy, 1991)^[21], Game theory methods (Peldschus and Zavadskas, 2005)^[22] and etc. Latest development in the area of MCDM is the Evidential Reasoning (ER) approach (Yang and Xu 2000, Yang 2001; Yang and Singh, 1994)^{[23][24][25]}.

Cheng and Mon, 1994^[26] propose a new algorithm for evaluating weapon systems by the Analytical Hierarchy Process (AHP) based on fuzzy scales. Altrock and Krause, 1994^[27] present a fuzzy multi-criteria decision-making system for optimizing the design process of truck components, such as gear boxes, axes or steering. Chang and Chen, 1994^[28] discuss the potential application of FMCDM techniques in the selection of technology transfer strategies in the area of biotechnology management.

SUGGESTED PRODUCT SELECTION METHODOLOGY

The approach illustrated in the paper defines a decision calculus that requires information on the ranking of preferences and importance weights, (Yager, 1981)^[29]. Lets us assume that n product are available in the market $P = \{P_1, P_2, P_3, \dots, P_n\}$ and r attributes $O = \{O_1, O_2, O_3, \dots, O_r\}$. Let O_i indicate the i^{th} attributes, then degree of membership of product P in O_i denoted by $\mu_{O_i}(P)$, is the degree to which product P satisfies the criteria specified for this attributes. Now we find a decision function which satisfies all the decision attributes (i.e. objectives).

Decision function given by the intersection of all the attributes sets,

$$D = O_1 \cap O_2 \cap \dots \cap O_r \quad \dots (1)$$

The grade of membership that the decision function D has for each product P is given by

$$\mu_D(P) = \min(\mu_{O_1}(P), \mu_{O_2}(P), \dots, \mu_{O_r}(P)) \quad \dots (2)$$

Optimum decision P^* will be,

$$\mu_D(P^*) = \max_{P \in P} \{\mu_D(P)\} \quad \dots (3)$$

A Set of preference (B) attached to each attribute to quantify the decision makers feeling about the influence that each objective should have on the chosen product.

Let the parameter, b_i , be contained on the set of preference $\{B\}$ where $i = 1, 2, 3, \dots, r$.

Now D, Decision function involving attributes and preference

$$D = M(O_1, b_1) \cap M(O_2, b_2) \cap \dots \cap M(O_r, b_r) \quad \dots (4)$$

The Decision measure for a particular product P can be replaced with a classical implication of the form.

$$M(O_i(a), b_i) = b_i \rightarrow (O_i(P)) = \bar{b}_i \cup O_i(P) \quad \dots (5)$$

Decision model will be the joint intersection of r decision measures.

$$D = \bigcap_{i=1}^r (\bar{b}_i \cup O_i) \quad \dots (6)$$

And the optimum solution P^* is the alternative that maximize D.

Let $S_i = \bar{b}_i \cup O_i$

$$\text{hence, } \mu_{S_i}(P^*) = \max[\mu_{\bar{b}_i}(P), \mu_{O_i}(P)] \quad \dots (7)$$

$$\mu_D(P^*) = \max_{P \in P} \left[\min \{ \mu_{s_1}(P), \mu_{s_2}(P), \dots, \mu_{s_r}(P) \} \right] \dots (8)$$

CASE STUDY

A vendor of laptop computers need to determine the best product for a customer based on his or her preferences. This vendor has four product alternatives to offer the customer. The vendor objective is to define the product that is closest to the customer preference. The product was evaluated by considering the five features. F_1 – speed, F_2 –price, F_3 – weight, F_4 –colour, F_5 – brand .

The features are allotted the preference value as per the customer choice given in the table No.1. Features of the product is represented by the normal fuzzy number as shown in the appendix 1. The case study is taken from the Selection of Product based on Customer Preference Applying Fuzzy Logic, Marco Barajas^[30] and Bruno Agard, Proceeding of IDMME-Virtual Concept 2008.

Table No. 1: Customer Features Preference (Priority level)

Features (F_i)	C_1	C_2	C_3
F_1 - Speed	HI	I	HI
F_2 – Price	I	HI	NI
F_3 – Weight	M	I	I
F_4 – Colour	LI	M	HI
F_5 – Brand	NI	LI	I

C_1, C_2, C_3 represent Customer 1 2 and 3

HI denote highly important, preference value 1.0. Fuzzy representation (6 9 10 10).

I denote important, preference value 0.8. Fuzzy representation (5 6 8 9).

M denote medium level, preference value 0.5. Fuzzy representation (4 5 5 6).

LI denote low importance, preference value 0.2. Fuzzy representation (1 2 4 5).

NI denote not important, preference value 0.0. Fuzzy representation (0 1 1 4).

Table No. 2: Feature Evaluation of the Product (Characteristic of the products) Attribute Product	Speed	Price	Weight	Colour	Brand
P_1	(0 2 5)	(2 2 8 8)	(1 4 6 9)	(2 6 9)	(2 6 8 10)
P_2	(4 5 8 9)	(4 5 8)	(4 4 8 8)	(3 4 5)	(0 2 4 5)
P_3	(0 3 4 6)	(5 7 8 9)	(4 4 7 7)	(5 7 9)	(2 5 8)
P_4	(5 7 8 9)	(0 3 6)	(2 4 7 10)	(4 4 8 8)	(3 5 7)

Here, the paper proposed ranking order of the products according to the customer 1 preference.

Table No. 3: Membership Function for the Customer 1

	P ₁	P ₂	P ₃	P ₄
Speed	0.0	0.75	0.0	0.75
Price	1.0	0.75	1.0	0.25
Weight	1.0	1.0	1.0	1.0
Colour	0.75	1.0	0.0	1.0
Brand	0.33	0.8	0.4	0.2

The value of the membership function is obtained from the intersection of the curve of customer priority level and product characteristic as shown in the appendix No. 1 Figure No. 1 show the membership value of all the products for the customer 1

The conclusion is drawn from the Venn diagram given in the appendix 1 that as per preference of customer 1 only product 2 and product 4 satisfy the required criteria, and product 2 dominant the product 4 in case of price and brand. So the choice is product 2. The measures/result obtain from the Venn diagram is not certain when the number of attribute and alternative is more. So this paper also proposed a methodology of MODM (Multiple Objective Decision Making) which is simple and valid for any number of attributes and alternatives.

$$P' = \{P_1, P_2, P_3, P_4\}$$

$$O = \{\text{Speed, Price, Weight, Colour, Brand}\}$$

$$B = \{b_1, b_2, b_3, b_4, b_5\}$$

All the products are rates with respect to the objectives. These rating are fuzzy sets expressed in Zadeh's notation (Zadeh, 1965)^[31].

$$O_1 = \{0.0/P_1 + 0.75/P_2 + 0.0/P_3 + 0.75/P_4\}$$

$$O_2 = \{1.0/P_1 + 0.75/P_2 + 1.0/P_3 + 0.25/P_4\}$$

$$O_3 = \{1.0/P_1 + 1.0/P_2 + 1.0/P_3 + 1.0/P_4\}$$

$$O_4 = \{0.75/P_1 + 1.0/P_2 + 0.0/P_3 + 1.0/P_4\}$$

$$O_5 = \{0.33/P_1 + 0.8/P_2 + 0.4/P_3 + 0.2/P_4\}$$

Membership Function for each product wrt the objective according to the table No. 3

Customer 1 lists the preferences as given in the table No. 1 for each of the five objectives. Customer priority is in the order of Speed, Price, Weight, Colour, Brand.

Preference for each of the three objectives:

$$b_1 = 1.0 \quad b_2 = 0.8 \quad b_3 = 0.5 \quad b_4 = 0.2 \quad b_5 = 0.0$$

All the operation on the fuzzy set is performed according to the Zadeh's notation and standard fuzzy operation.

$$\bar{b}_1 = 0.0 \quad \bar{b}_2 = 0.2 \quad \bar{b}_3 = 0.5 \quad \bar{b}_4 = 0.8 \quad \bar{b}_5 = 1.0$$

Decision measures are calculated for each alternatives according to the equation No. 6 which is formulated in the table No. 4

$$D^* = \max \{D(P_1), \dots, D(P_8)\}$$

Table No.4 : Decision measures of the product

Products	$\bigcap_{i=1}^r (\bar{b}_i \cup O_i)$
D(P ₁)	0.0
D(P ₂)	0.8
D(P ₃)	0.0
D(P ₄)	0.2

Table No.5: Final ranking of the product

Products (alternatives)	Suggested Rank
P ₂	I
P ₄	II
P ₁ , P ₃	III

Table No. 6: Membership Function for the Customer 2

	P ₁	P ₂	P ₃	P ₄
Speed	0.0	1.0	0.35	1.0
Price	0.65	0.35	0.6	0.0
Weight	1.0	1.0	1.0	0.5
Colour	1.0	0.5	0.35	1.0
Brand	0.6	1.0	0.8	0.65

Table No. 7: Membership Function for the Customer 3

	P ₁	P ₂	P ₃	P ₄
Speed	0.0	0.75	0.0	0.78
Price	0.65	0.0	0.0	0.67
Weight	1.0	1.0	1.0	0.5
Colour	0.45	0.0	0.6	0.65
Brand	1.0	0.0	0.78	0.67

The conclusion is drawn from the Venn diagram given in the appendix 1 that as per preference of customer 2 only product 2 and product 3 satisfy the required criteria, and product 2 dominant the product 3 in case of speed, colour and brand, only product 3 dominant the product 2 in the feature of price. So the choice is product 2.

The conclusion is drawn from the Venn diagram given in the appendix 1 that as per preference of customer 3 only product 4 satisfy the required criteria. So the choice is product 4.

Table No. 8: Decision measures of the product according to the Customer preference 2 & 3

Product	Customer 2	Customer 3
D(P ₁)	0.2	0.0
D(P ₂)	1.0	0.0
D(P ₃)	0.6	0.0
D(P ₄)	0.0	0.7

Table No. 9: Product selection for each customer

Customers	Best product alternative
C ₁	P ₂
C ₂	P ₂
C ₃	P ₄

In the proposed methodology all the product are selected as per the customer choice and also ranks the product in case when the decision measures are equal for two or more products whereas in the paper from where case study is taken result is affected by fuzzy indifference degree.

Figure No. 1 membership value of all products for the customer 1

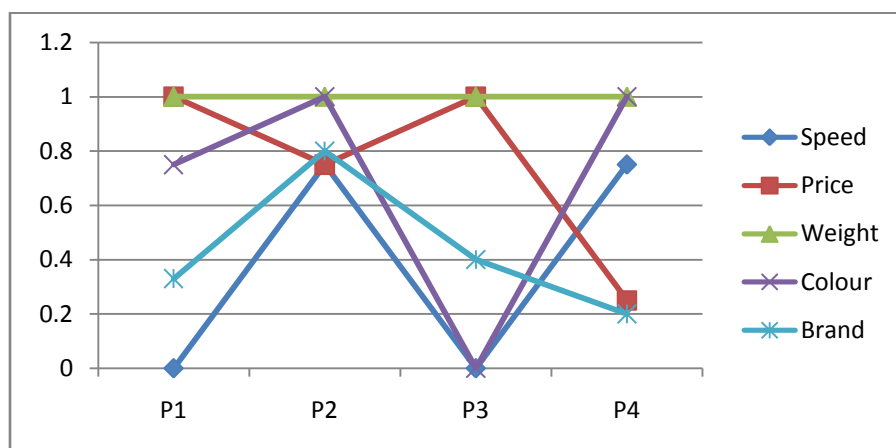


Figure No. 2 membership value of all products for the customer 2

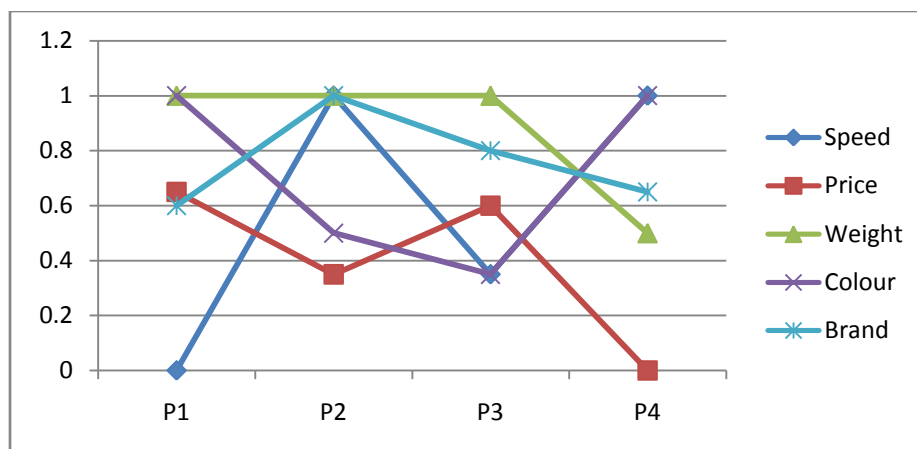
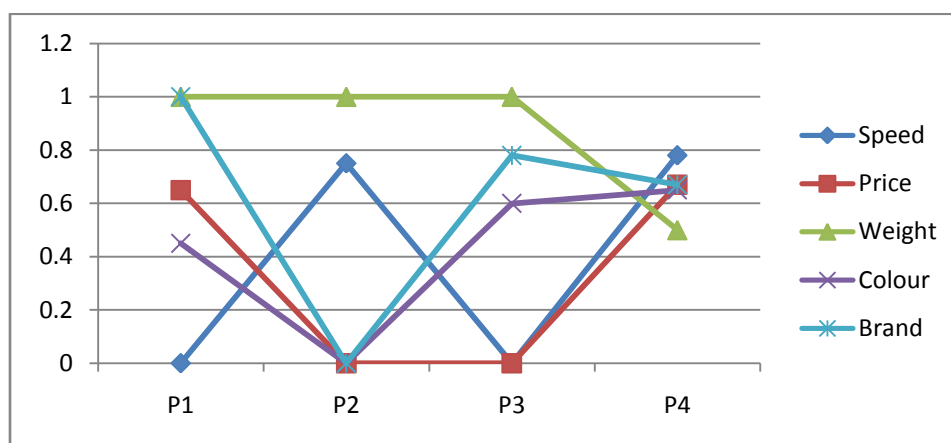


Figure No. 3 membership value of all products for the customer 3



CONCLUSION

Comparing the alternative is the key of making the decision. In the case of conflicting alternatives, a decision maker must also consider imprecise or ambiguous data which is significantly help in problem solving. Multiple attribute decision making model is considered as one of the critical decision making process to choose a product, therefore a fuzzy approach capable of capturing vagueness associated with subjective perception of decision makers has been proposed. Although case studies concentrate on laptop selection, the methodology is applicable to any problem solving practice if the criteria and alternatives are defined properly. The result obtained from proposed approach is fast and simple with all the products ranked according to the preference required by the customers. In rare case, when the attributes of two products are nearly same then product select at the same rank.

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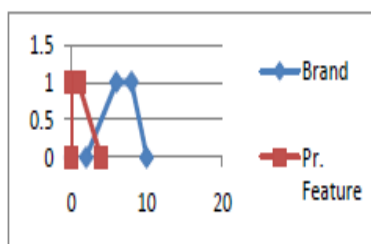
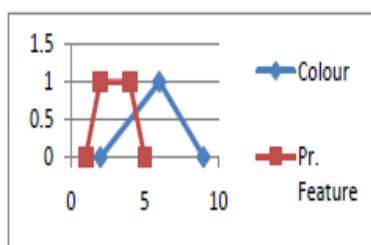
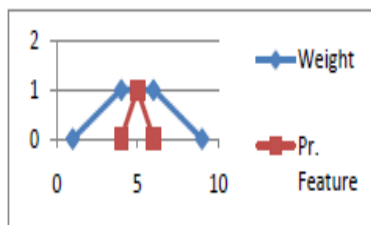
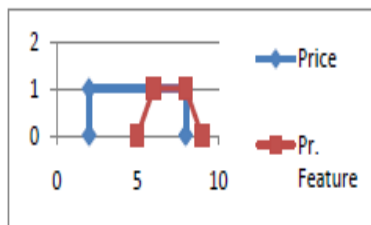
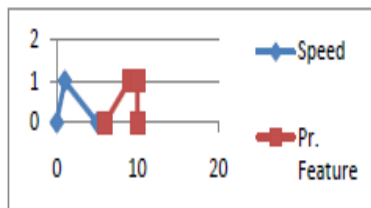
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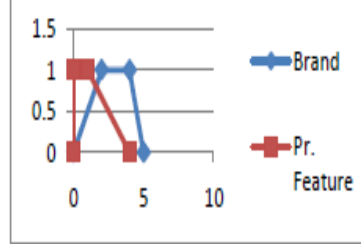
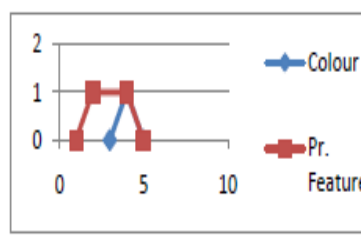
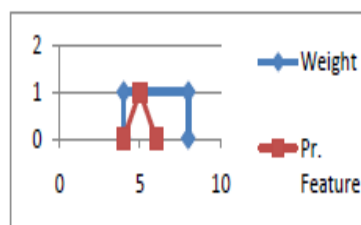
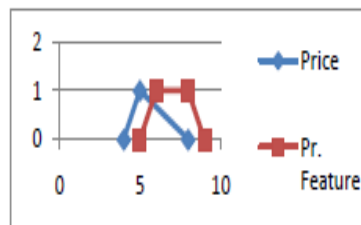
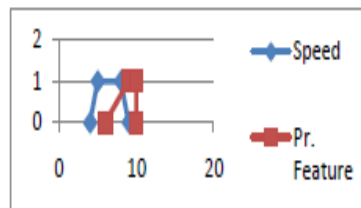
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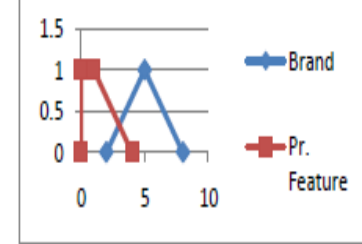
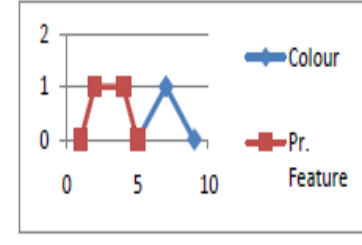
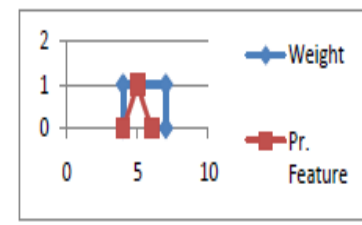
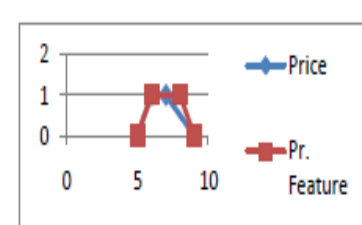
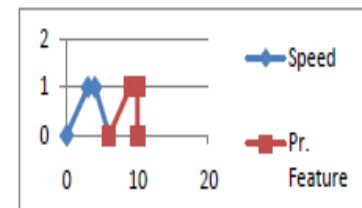
Appendix 1, Customer 1 Product 1



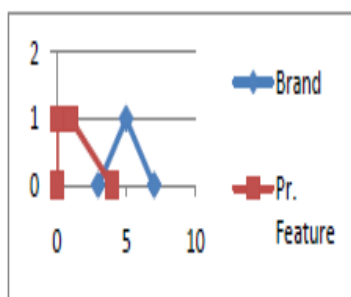
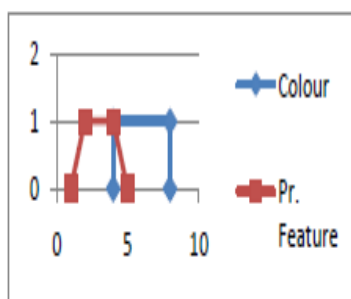
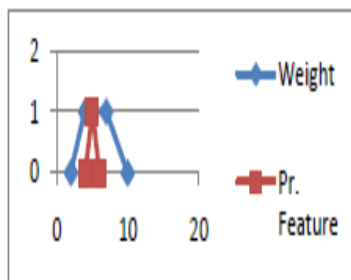
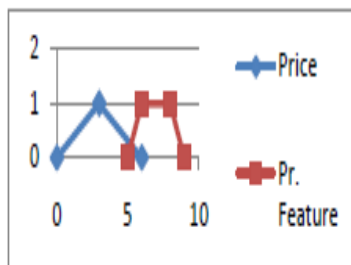
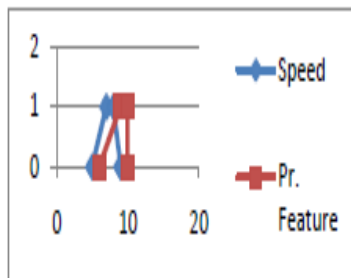
Customer 1 Product 2



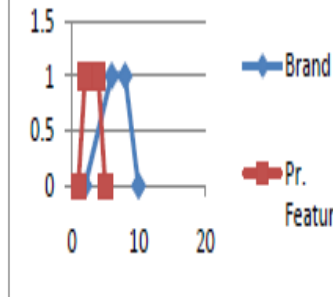
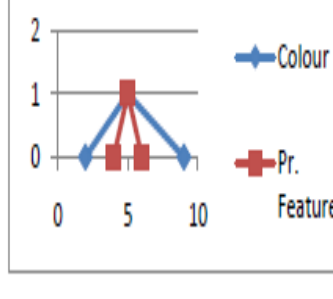
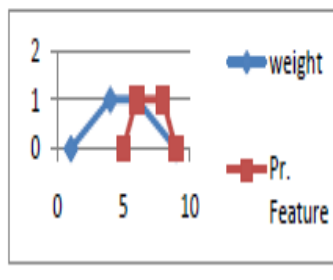
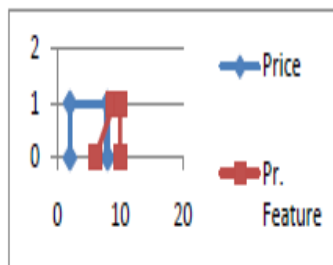
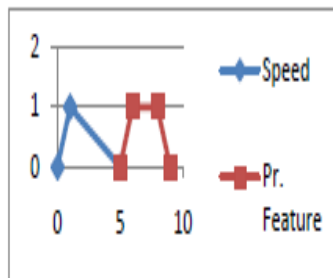
Customer 1 Product 3



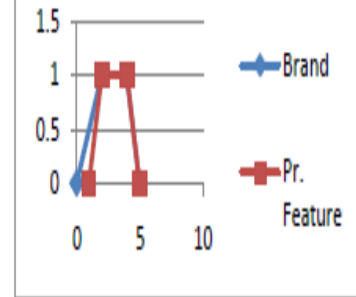
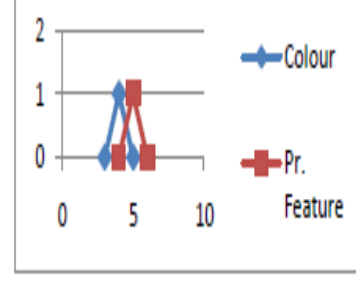
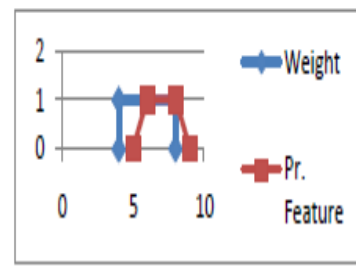
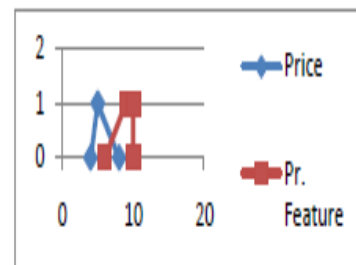
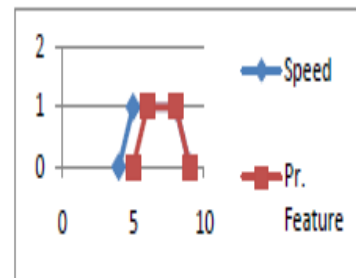
Customer 1 Product 4



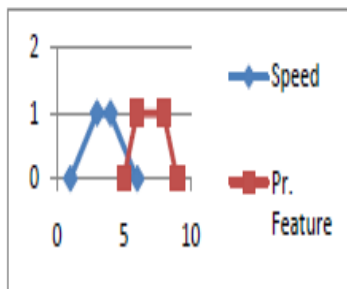
Customer 2 Product 1



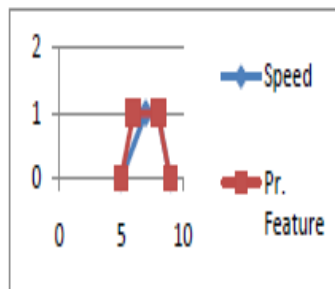
Customer 2 Product 2



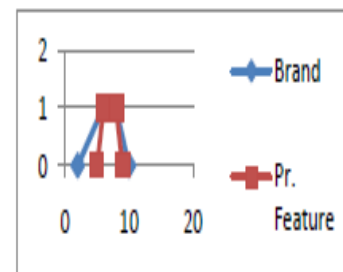
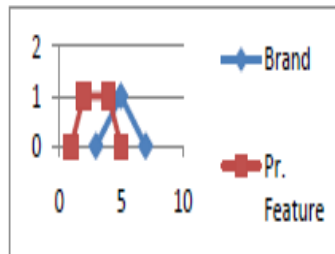
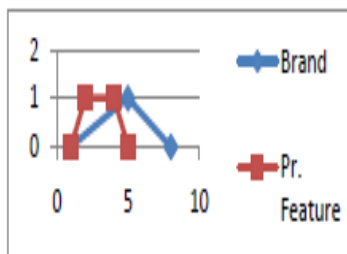
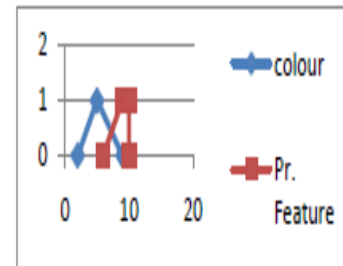
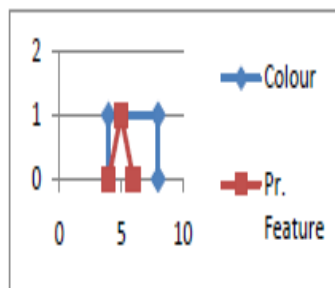
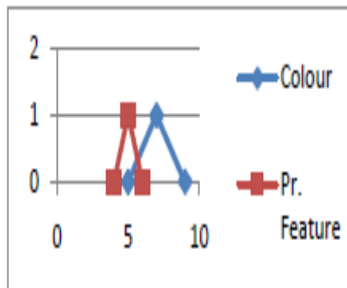
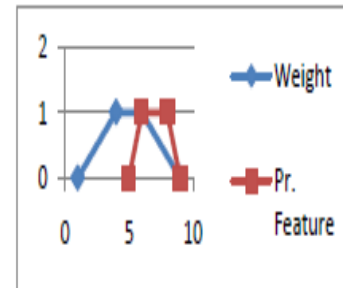
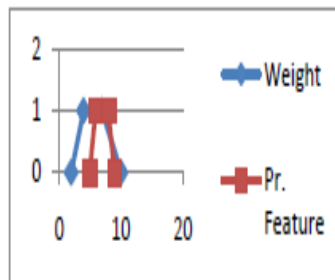
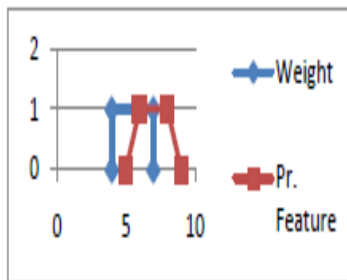
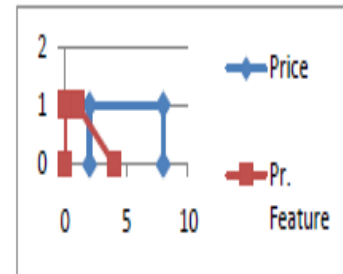
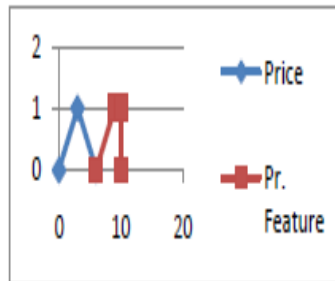
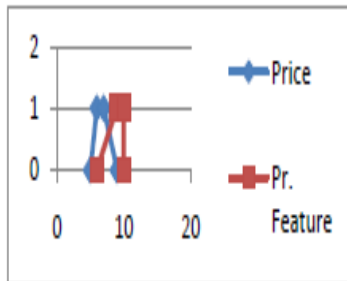
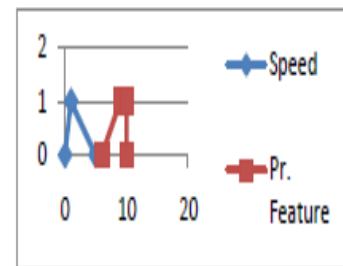
Customer 2 Product 3



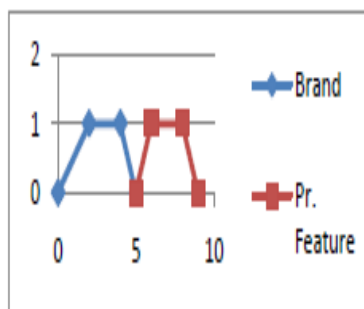
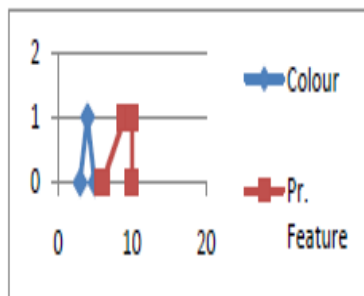
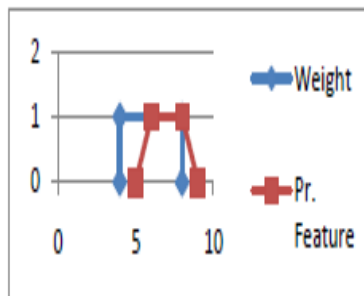
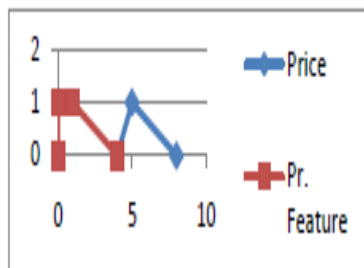
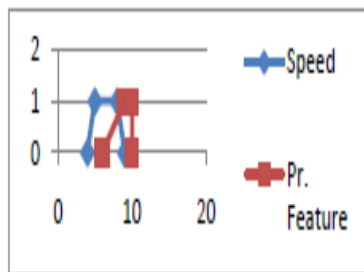
Customer 2 Product 4



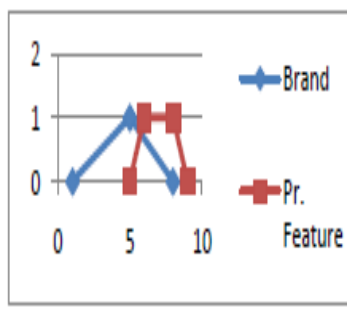
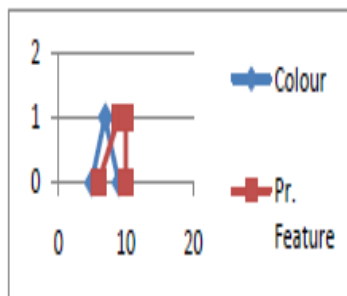
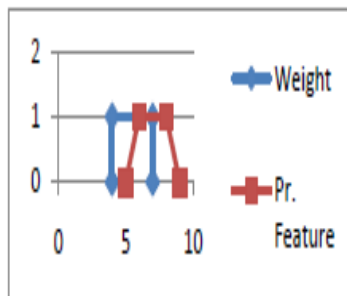
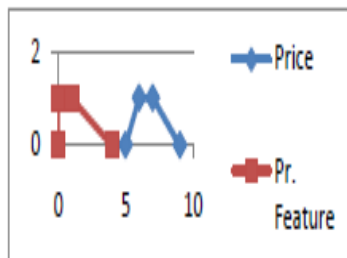
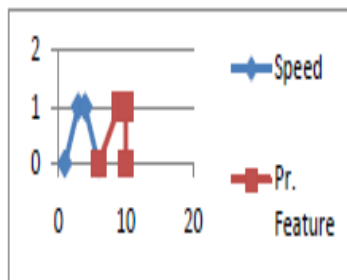
Customer 3 Product 1



Customer 3 Product 2



Customer 3 Product 3



Customer 3 Product 4

