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Range Similarity and Satisfaction Measures

for Buyers and Sellers in e-Marketplaces

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Abstract. Price is the omnipresent factor in decision making of buyers and sellers when trading products in real and virtual marketplaces. However, since a fixed price can easily lead to unsuccessful negotiations, market players in practice often have price ranges in mind, which reflect possible negotiation concessions when finding potential buyer-seller matches. In this paper, we propose a price-range similarity measure that computes price-range overlaps based on buyers' maximum and sellers' minimum prices. We also propose two measures for computing a notion of satisfaction for buyers and sellers that is additionally based on their published prices. Our price-range similarity measure and the measures for satisfaction provide ranked seller/buyer lists for buyers, sellers, and the match-maker in an e-marketplace. These measures extend our earlier similarity algorithm towards a priced product/service compatibility measure for match-making between buyers and sellers.

Keywords: price, similarity, satisfaction, buyer, seller, semantic matching.

1 INTRODUCTION

On-line shopping is very common for buyers nowadays. For example, e-Bay (http://www.ebay.com) lists the details (price, payment, shipping, etc.) of particular products that are sought by buyers. For buying a specific product, buyers usually want to compare prices from various sellers in order to make decisions. Therefore, among the various product attributes, the price, having the greatest effect on buyers' and sellers' decision-making, is arguably the most important attribute.

To flexibly achieve successful transactions, buyers (usually) and sellers (often) have price ranges in their minds. While the buyer will not tell a seller, upfront, the maximum price (s)he would be willing to pay, a match-making engine should be made aware of it to avoid unrealistic buyer-seller pairings. Conversely, the seller will hide the minimum price to a buyer until the latest moment in the negotiation phase, but the match-maker should use it for reasonable pairings. Providing a modular (price-)range extension to the similarity engine of the AgentMatcher architecture [Boley et al. 2005], we focus on the match-making phase here. An application of the AgentMatcher architecture is our Teclantic portal (http://teclantic.cs.unb.ca) which matches projects according to the project profiles.

In the price-comparison problem proposed in [Chan et al. 2002], a buyer is provided with products such that each has the lowest price that falls into his/her price ranges (minimum and maximum). However, there is a problem with this approach when the price is less than the minimum price of the buyer's quoted price range: the interpretation of a buyer's non-zero minimum price is not clear, e.g. does it mean if (s)he could not *imagine* the product to be cheaper or would not *want* a cheaper product. The consequence might be that a buyer overspends on a product of given quality.

Some earlier systems that have provided the functionality of price comparison are BizRate [BizRate], DealTime [DealTime], MySimon [MySimon], PriceScan [PriceScan], and PriceWatch [PriceWatch]. They allow buyers to specify price ranges and then display possible products within such a range from various vendors. There are two disadvantages of these kinds of price-comparison systems. First, the systems only search corresponding products that fall into buyers' price ranges, but do not provide intelligent recommendations. Second, only one party, the buyer, is active in seeking sellers. In such a buyer-centric e-marketplace, the one-way interaction between buyers and sellers restricts sellers to find appropriate buyers. The e-marketplace embodied in MARI [Tewari et al. 2002] aims to solve these two problems. It classifies product attributes as fixed and flexible. Fixed attributes have predefined permissible values and flexible attributes associate with ranges values. For fixed attributes, it only checks if the transaction party qualifies the specified values of those attributes. However, for flexible attributes, it values corresponding ranges by utility functions. The matching cost for a buyer and a seller is computed according to their valued ranges of flexible attributes. Price is not classified as flexible in this system and thus it does not affect the final matching cost.

Automated negotiation also makes use of a similarity measure [Faratin et al. 2002] to approximate the preference structures between negotiators. The similarity between two contracts which contain quantitative and qualitative decision variables is an integration of the pair-wise similarities over the values of a set of decision variables for a given domain. Our tree similarity algorithm [Bhavsar et al. 2004] recursively computes the intermediate subtree similarity values for the overall similarity computation between a buyer and a seller tree. Prices ranges represented by leaf nodes are appropriately located in the tree (see subsection 2.2). The prices in [Faratin et al. 2002] are considered as a quantitative decision variable whose similarity is computed by a linear function. However, they are represented as fixed prices rather than price ranges. Thus, the corresponding price similarity cannot express the potential overlap between a buyer's and a seller's maximum, minimum and published prices existing in their minds.

In this paper, we propose a similarity measure to find the overlaps of buyer/seller price ranges for their semantic matching. We treat prices as ranges which are composed of minimum, published and maximum prices specified by buyers and sellers. Furthermore, we propose measures for satisfaction of buyers and sellers based on these price ranges. Our price-range similarity measure and the measures for satisfaction provide a ranked list of buyers (sellers) to each of the sellers (buyers). These measures can be embedded into our earlier similarity algorithm [Bhavsar et al. 2004] as a subfunction to obtain overall similarity measure or can be used independently when the price is the only decisive factor for decision-making.

This paper is organized as follows. In the following section, we describe how we represent price ranges for buyers and sellers. Two sample trees that embed price ranges are also shown here. Section 3 derives our price-range similarity measure and satisfaction measures based on seven case studies. The analysis of our proposed measures with examples is provided in Section 4. Concluding remarks are given in Section 5.

2 PRICE RANGES FOR BUYERS/SELLERS

We use arc-labeled and arc-weighted trees [Bhavsar et al. 2004， Yang et al. 2005] to represent product descriptions of buyers/sellers. The attribute "price range" and its corresponding values are represented as arc labels and node labels, respectively, in our trees.

2.1 Representations and Semantics of Price-Range

In most on-line systems that advertise products, a buyer needs to fill out an on-screen form to specify the particular product(s) that (s)he wants to buy. The systems then provide buyer detailed descriptions of the product(s). For various product attributes in the on-screen form, price range (maximum and minimum prices) plays a leading role for the success of transaction.

However, in some cases (e.g., used-car buying/selling), sellers also seek buyers to find a good deal. In a common e-marketplace, both buyers and sellers explicitly provide a published price that might be negotiable. However, they never disclose their private prices (i.e., the maximum price for the buyer and the minimum price for the seller) to each other. In a buyer-seller matching system, the match-maker such as AgentMatcher [Boley et al. 2005] matches buyers and sellers based on their published and private prices to calculate their similarity values. It is natural that a buyer wants to buy a product as cheap as possible; on the other hand, a seller always wants to sell it as expensive as possible to obtain more benefit. Therefore, if a buyer specifies his published price as "\$40", we can assume that (s)he is also interested in those products that are cheaper than "\$40". And for a seller, (s)he will never refuse to consider the offers that are higher than his/her published price. However, in practice, it is quite common that both buyers and sellers would like to concede to some extent. So, buyers often have maximum and sellers have minimum prices in their minds.

In this paper, a price range such as <\$40, \$50] for a buyer indicates that (s)he would like to buy the product for \$40 or even cheaper and the maximum price (s)he can accept is \$50. The price range, say [\$30, \$70>, for a seller reveals that (s)he would like to sell a product at \$70 or even higher but (s)he can accept a price as low as \$30.

Figure 1 should go here or around

We use B_{pub} and B_{max} to represent the published and maximum prices of buyers and S_{pub} and S_{min} for the published and minimum prices of sellers. B_{max} will always be equal to or greater than B_{pub} and S_{min} be equal to or less than S_{pub}. If we use r_1 and r_2 to represent the price ranges for a buyer b and a seller s, then $r_1 = \langle B_{pub}, B_{max}]$ and $r_2 = [S_{min}, S_{pub}\rangle$, respectively. When $B_{pub} = B_{max}$ or $S_{min} = S_{pub}$, it means that the buyer or the seller will not concede in his/her future negotiation. In Fig. 1, we show an example of the price ranges of a buyer and a seller. Buyer and seller prices are shown on the "*Price*" axis. Some example values are shown in brackets. Since negative prices are meaningless, all prices are equal to or greater than \$0. Therefore, the buyer is satisfied with the prices below his/her published price (B_{pub}). This is shown by a curve with a left arrow. Symmetrically, the seller is satisfied with prices above his/her published price (S_{pub}) and we show it by a curve with a right arrow. Based on our real life experiences, we easily know that the transaction can take place within the grey range [S_{min}, B_{max}] (in this case, [\$30, \$50]). It is obvious that the bigger the grey range (buy/seller price-ranges overlap), the bigger the distance of S_{min} and B_{max} ; and thus the more successful their transaction and consequently, the more similar their price ranges.

2.2 Price Ranges in Trees

The core of the similarity engine embedded in our AgentMatcher [Boley et al. 2005] architecture is our weighted-tree similarity algorithm [Bhavsar et al. 2004] for buyer-seller matching [Bircher 2003, Sycara et al. 2003]. Product attributes and corresponding values are respectively incorporated into weighted trees as arc labels and node labels underneath. However, we only conducted exact string matching for values with "price" attribute which results in non-semantic similarity values. For example, for a buyer who wants to buy a product for \$50 and a seller who sells at \$51, the similarity value 0.0 is not reasonable because they have quite close offers.

Fig. 2 shows two example trees describing used cars from a buyer and a seller. Attribute "Price range" and its corresponding value (e.g., <\$40, \$50]) are now arc label and node label. We also allow buyers and sellers to specify an importance value for each attribute.

Figure 2 should go here or around

The similarity of two whole trees is recursively obtained by computing intermediate similarity values of each pair of subtrees. As it is not the main focus of this paper, please refer to [Bhavsar et al. 2004] for more details on our tree similarity measure. Here, we present our similarity measure on nodes (e.g. "<\$40, \$50]" vs. "[\$30, \$70>") under "Price range" arc-label.

3 RANGE SIMILARITY AND SATISFACTION MEASURES

In a real market, buyers and sellers publish their prices of some products they want to buy and sell, but do not disclose their private prices (S_{min} and B_{max}) to each other. However, in an e-Marketplace, a match-maker system such as our AgentMatcher [Bhavsar et al. 2004] works as a mediator, and both buyers and sellers provide their published and private prices to the mediator to determine the possible matching by calculating their similarity values. In this section, we present the similarity measure for buyers' and sellers' price ranges based on their range overlaps. We propose a satisfaction measure for buyers and sellers in the case that the AgentMatcher knows both their private and published prices. Another satisfaction measure is presented in this paper when both buyers and sellers hide their private prices. These measures are proposed by case studies on price range overlaps. There are at most seven possible cases of buyer-seller price range overlapping. For each case, we illustrate the three measures in the following order.

1) The AgentMatcher [Bhavsar et al. 2004] computes the similarity values and recommends a ranked list of buyers (sellers) to sellers (buyers) according to their similarity values. It knows buyers' and sellers' published prices and their corresponding private prices. Buyers and sellers never reveal their private prices to each other. The similarity values presented to them by the system only show the ratio of their price-range overlaps and the overall price range in the whole e-Marketplace. The AgentMatcher never give any hints that how much the buyer and the seller may concede in their future negotiation. The price-range similarity is represented as $Sim(r_1, r_2)$ where r_1, r_2 are price ranges of buyer b and seller s, respectively.
2) The AgentMatcher has buyers' and sellers' published and private prices. It provides each buyer (seller) another ranked list of sellers (buyers) according to the buyer's (seller's) level of satisfaction. We denote the satisfaction of a buyer and a seller from the perspective of AgentMatcher as $\hat{S}at^b$ and $\hat{S}at^s$, respectively.
3) We simulate the real-life market where buyers and sellers only provide their published prices and hide their private prices in an e-Marketplace. We provide each buyer (seller) yet another ranked list of sellers (buyers) based on the buyer's (seller's) level of satisfaction. We denote the satisfaction of a buyer and a seller as Sat^b and Sat^s, respectively.

Case 1

Figure 3 should go here or around

In Fig. 3, a buyer's published price is greater than or equal to that of seller's ($S_{pub} \leqslant B_{pub}$). Therefore, both of them are pleased with the transaction. We do not need to take into account S_{min} and B_{max} specified by the seller and the buyer because $[S_{pub}, B_{pub}]$ is the only range within which both the buyer and the seller are satisfied. Therefore, in this case, we have $Sim(r_1, r_2) = 1.0$, $\hat{S}at^b = 1.0$, $\hat{S}at^s = 1.0$, $Sat^b = 1.0$, and $Sat^s = 1.0$.

From Case 2 to 7, there is no overlap between a buyer's and a seller's published prices (i.e., $B_{pub} < S_{pub}$). Therefore, successful transactions can only take place if one or both of them are willing to concede.

Case 2

Figure 4 should go here or around

Both B_{max} and S_{min} stay in [B_{pub}, S_{pub}] but $B_{max} < S_{min}$ (Fig. 4). So, although both the buyer's and seller's prices are negotiable, they still do not have any overlap between their price ranges. In this case, we have $Sim(r_1, r_2)$ = 0.0, $\hat{S}at^b$ =0.0, $\hat{S}at^s$ =0.0, Sat^b =0.0, and Sat^s =0.0.

From Case 3 to 6, there is an overlap between buy/seller price ranges since $S_{min} < B_{max}$ always holds. Successful transactions only take place within the overlap range [S_{min}, B_{max}]. It is intuitive that the bigger the distance between S_{min} and B_{max}, the more chances for their successful transaction and thus the more similar their price ranges. However, the satisfaction for buyers and sellers are also decided by other factors which are discussed later. We define the price-range similarity as

$$Sim(r_1, r_2) = d(B_{max}, S_{min}) \tag{1}$$

where, $d(B_{max}, S_{min})$ is the distance of B_{max} and S_{min}.

We compute $d(B_{max}, S_{min})$ by $\frac{B_{max} - S_{min}}{\text{MAX} - \text{MIN}}$ [Wilson and Martinez 1997] and thus Eq. (1) is changed into

$$Sim(r_1, r_2) = \frac{B_{max} - S_{min}}{\text{MAX} - \text{MIN}} \tag{2}$$

where, for a specific product (e.g., used book), MAX and MIN are the maximum and minimum prices among all buyers and sellers in an e-Marketplace. Here, we consider the values of MAX and MIN in the market are \$95 and \$5, respectively, for the following cases.

Case 3

Figure 5 should go here or around

Case 3 represents one special case that S_{min}=B_{max} that is shown in Fig. 5. It might happen that the buyer's maximum price is the same as the seller's minimum price. In practice, transactions in such a case tend to fail. Only when both buyers and sellers concede toward their price limits then the transactions could be successful. However, if we use Eq. (2), we obtain similarity 0.0 which is not reasonable since price ranges of the buyer and seller still have one common point overlapping. We expect a similarity value that is small but greater than 0.0.

We denote the smallest financial unit as μ (e.g., for the currency in dollars, it is 1 cent). This implies that the minimum difference between two different prices is μ . So, if two price ranges have different values of S_{min} and B_{max}, their similarity $Sim(r_1, r_2)$ must be equal to or greater than $\frac{\mu}{\text{MAX}-\text{MIN}}$.

Thus, we consider the difference for identical S_{min} and B_{max} as $\mu/2$. And consequently, we get their price-range similarity

$$Sim(r_1, r_2) = \frac{\mu/2}{\text{MAX}-\text{MIN}} \tag{3}$$

This value is a number that is greater than 0.0, but smaller than any cases when $S_{min}<B_{max}$.

We explain satisfaction measures in the following more general cases. In Case 3, if we keep B_{max} unchanged (\$60) but continuously move S_{min} to its left (e.g., \$40), the overlap between the buyer's and seller's price ranges becomes bigger and bigger. Intuitively, we should get greater and greater similarity values. As an opposite case is that we continuously move B_{max} to its right while keep S_{min} unchanged. These cases are illustrated as follows.

Case 4

Figure 6 should go here or around

The Case 4 in Fig. 6 shows that $B_{pub} < S_{min} < B_{max}$. Therefore, both B_{max} and S_{min} stay within [B_{pub}, S_{pub}]. In this case, both the buyer and the seller have to concede to a price in the range [S_{min}, B_{max}] for a successful transaction.

1) Eq. (2) is employed and the value of $Sim(r_1, r_2)$ of this example is 0.2222.

2) Although both the buyer's and the seller's published prices are outside of the range [S_{min}, B_{max}], they may still have satisfaction to some extent on their transaction after concession. We observe that the closer the values of B_{pub} and S_{min}, the smaller the concession is after the buyer's conceded price falls into [S_{min}, B_{max}]. And then, the buyer is more

satisfied with the transaction which implies higher buyer satisfaction. The size of the range [S_{min}, B_{max}] also affects the buyer's satisfaction. A bigger [S_{min}, B_{max}] implies a bigger negotiation space for the seller and thus decreases the buyer's satisfaction. Therefore, we conclude that, when B_{pub} is outside of [S_{min}, B_{max}], the satisfaction for him(her) is

$$\hat{S}at^{b} = \frac{B_{\max} - S_{\min}}{B_{\max} - B_{pub}} \qquad \text{if } B_{pub} < S_{min} < B_{max} \tag{4}$$

The buyer's satisfaction for the example in Fig.6 is 0.6667. We can explain the seller's satisfaction in a similar way i.e. the closer the values of S_{pub} and B_{max}, the chance of concession is smaller once the seller's conceded price falls within [S_{min}, B_{max}]. And then, the seller is more satisfied with the transaction which implies the seller's higher satisfaction. The size of [S_{min}, B_{max}] also affects the seller's satisfaction. A bigger [S_{min}, B_{max}] implies a bigger negotiation space for the buyer and thus decreases the seller's satisfaction. Eq. (5) illustrates how to compute the seller's satisfaction. The seller's satisfaction for the example in Fig.6 is 0.5.

$$\hat{S}at^{s} = \frac{B_{\max} - S_{\min}}{S_{pub} - S_{\min}} \qquad \text{if } S_{min} < B_{max} < S_{pub} \tag{5}$$

3) In this situation, we can only compute the buyer's (seller's) satisfaction based on his/her <B_{pub}, B_{max}] ([S_{min}, S_{pub}>) and the seller's (buyer's) published price S_{pub} (B_{pub}). However, in Fig.6, the S_{pub} and B_{pub} stay outside of the ranges <B_{pub}, B_{max}] and [S_{min}, S_{pub}>. Therefore, the buyer (seller) has no idea if the seller (buyer) would like to increase (decrease) his/her published price. Both he buyer's and seller's satisfaction Sat^{b} and Sat^{s} are assigned as 0.0.

Case 5

Figure 7 should go here or around

In Fig. 7, we still keep the unchanged B_{max} within [B_{pub}, S_{pub}] but allow S_{min} to be even equal to or less than B_{pub}. The buyer does not have to concede in his/her future negotiation since the seller would like to concede to a price below B_{pub}.

1) The buyer's and seller's successful transaction can only take place in [S_{min}, B_{max}]. So we still use Eq. (2) to get their similarity value $Sim(r_1, r_2) =$ 0.5.

2) Since S_{pub} is still outside of [S_{min}, B_{max}], we compute the seller's satisfaction by Eq. (5) and obtain 0.6923. Although the buyer's published price is within [S_{min}, B_{max}], (s)he still wants to buy the product as cheap as possible. However, his/her price cannot be less than the seller's bottom line i.e. S_{min}. Therefore, the bigger the interval between

S_{min} and B_{pub}, the bigger the negotiation space for the buyer and thus the bigger his/her satisfaction. The buyer's satisfaction depends on his/her published price within [S_{min}, B_{max}] and is described by Eq. (6). The buyer's satisfaction for the example in Fig.7 is 0.3333.

$$\hat{S}at^{b} = \frac{B_{pub} - S_{\min}}{B_{\max} - S_{\min}} \quad \text{if } S_{min} < B_{pub} < B_{max} \tag{6}$$

3) Since S_{pub} is still outside of [B_{pub}, B_{max}] like Case 4, the value of Sat^{b} is 0.0. However, B_{pub} is between [S_{min}, S_{pub}] which implies we can expect a satisfaction for the seller. It is obvious that, in [S_{min}, S_{pub}], the bigger the difference between B_{pub} and S_{min}, the higher the seller's satisfaction because (s)he has bigger negotiation space. We present the seller's satisfaction in Eq. (7). The seller satisfaction for the example in Fig.7 is 0.2308.

$$Sat^{s} = \frac{B_{pub} - S_{\min}}{S_{pub} - S_{\min}} \quad \text{if } S_{min} < B_{pub} < S_{pub} \tag{7}$$

Case 6

Figure 8 should go here or around

This case (Fig. 8) is symmetric to Case 5. S_{min} is within [B_{pub}, S_{pub}] and $B_{max}>S_{pub}$. The seller does not have to concede since the buyer concedes to a price above S_{pub}.

1) The buyer's and seller's successful transaction can only be in [S_{min}, B_{max}]. We obtain their similarity value $Sim(r_1, r_2) = 0.3333$ by Eq. (2).

2) Since B_{pub} is outside of [S_{min}, B_{max}], we compute the buyer's satisfaction by Eq. (4) and obtain 0.9091. Although the seller's published price is within [S_{min}, B_{max}], (s)he still wants to sell the product as expensive as possible. However, his/her price cannot be greater than the buyer's bottom line B_{max}. Therefore, the bigger the interval between B_{max} and S_{pub}, the bigger the negotiation space for the seller and thus the bigger his/her satisfaction. The seller's satisfaction depends on his/her published price within [S_{min}, B_{max}] described by Eq. (8). The seller's satisfaction for the example in Fig.8 is 0.8333.

$$\hat{S}at^{s} = \frac{B_{\max} - S_{pub}}{B_{\max} - S_{\min}} \quad \text{if } S_{min} < S_{pub} < B_{max} \tag{8}$$

3) Since B_{pub} is outside of [S_{min}, S_{pub}] like Case 4, the value of Sat^s is 0.0. However, S_{pub} is between [B_{pub}, B_{max}] which implies we can expect a satisfaction for the buyer. It is obvious that, in the range [B_{pub}, B_{max}], the bigger the difference between S_{pub} and B_{max}, the higher is the buyer's satisfaction because (s)he has bigger negotiation space. We present the buyer's satisfaction in Eq. (9). The buyer satisfaction for the example in Fig.8 is 0.4545.

$$Sat^b = \frac{B_{\max} - S_{pub}}{B_{\max} - B_{pub}} \quad \text{if } B_{pub} < S_{pub} < B_{max} \tag{9}$$

Case 7

Figure 9 should go here or around

In this case (Fig. 9), both the buyer and the seller are willing to concede a lot compared to other cases. S_{min} is smaller than B_{pub} and B_{max} is greater than S_{pub}. This case covers the cases from 4 to 6. Either the buyer or the seller has to concede to a successful transaction. Therefore, we employ the equations explained above for the similarity and the satisfaction computation.

1) Using Eq. (2), we get $Sim(r_1, r_2) = 0.7778$.

2) Using Eq. (6) and (8), we obtain $\hat{S}at^b = 0.4286$ and $\hat{S}at^s = 0.3571$.

3) Using Eq. (9) and (7), we obtain Sat^b =0.875 and $Sat^s = 0.8571$.

4 ANALYSIS OF MEASURES WITH EXAMPLES

In this section, we summarize the seven cases shown in Section 3 and present the analysis of our price-range similarity and satisfaction measures with examples. All plots are generated by Matlab 6.5.

$$Sim(r_1, r_2) = \begin{cases} 1.0 & S_{pub} <= B_{pub} \\ \frac{B_{max} - S_{min}}{\text{MAX} - \text{MIN}} & B_{max} > S_{min} \\ \frac{\mu / 2}{\text{MAX} - \text{MIN}} & B_{max} = S_{min} \\ 0.0 & B_{max} < S_{min} \end{cases} \tag{10}$$

Eq. (10) is the price-range similarity function. We observe that, except those three special cases, the similarity of r_1 and r_2 is determined by the size of the interval of B_{max} and S_{min} and normalized by the difference of MAX and MIN.

Figure 10 should go here or around

Figure 10 shows the graph for $B_{max}>S_{min}$ in Eq. (10). We assume that the values of MAX and MIN are \$40 and \$0, respectively. The values of B_{max} and S_{min} vary in the interval [\$20, \$40] and [\$0, \$20], respectively. We see that the bigger the overlap of B_{max} and S_{min}, the higher their similarity value.

$$\hat{Sat}^b = \begin{cases} 1.0 & S_{pub}<=B_{pub} \\ \frac{B_{max}-S_{min}}{B_{max}-B_{pub}} & B_{pub}<S_{min}<B_{max} \\ \frac{B_{pub}-S_{min}}{B_{max}-S_{min}} & S_{min}\leq B_{pub}\leq B_{max} \\ \frac{\mu/2}{\mathrm{MAX}-\mathrm{MIN}} & B_{max}=S_{min} \\ 0.0 & B_{max}<S_{min} \end{cases} \tag{11}$$

Eq. (11) is the buyer's satisfaction function when sellers' private prices are provided to the AgentMatcher for the buyer satisfaction computation. Figure 11 corresponds to the case where $B_{pub}<S_{min}<B_{max}$. We allow B_{pub} and B_{max} to change in two intervals [\$0, \$29] and [\$30, \$40], respectively. S_{min} is fixed to \$30. Figure 12 shows the case for $S_{min}\leq B_{pub}\leq B_{max}$. Values of B_{pub} and B_{max} are in [\$5, \$10] and [\$10, \$40], respectively. The value of S_{min} is \$5. The trends in figures 11 and 12 conform to our case analysis in Section 3.

Figure 11 and 12 should go here or around

Eq. (12) is the seller's satisfaction function when buyers' private prices are provided to the AgentMatcher for the seller satisfaction computation. Figure 13 corresponds to the case where $S_{min}<B_{max}<S_{pub}$. We allow S_{min} and S_{pub} to change in two intervals [\$1, \$19] and [\$21, \$40], respectively. B_{max} is fixed to \$20. Figure 14 shows the case for $S_{min}\leq S_{pub}\leq B_{max}$. The values of S_{min} and S_{pub} are in [\$1, \$20] and [\$20, \$40], respectively. The value of B_{max} is \$20. The trends in figures 13 and 14 also conform to our case analysis in Section 3.

$$\hat{S}at^{s} = \begin{cases} 1.0 & S_{pub} <= B_{pub} \\ \frac{B_{max} - S_{min}}{S_{pub} - S_{min}} & S_{min} < B_{max} < S_{pub} \\ \frac{B_{max} - S_{pub}}{B_{max} - S_{min}} & S_{min} \le S_{pub} \le B_{max} \\ \frac{\mu / 2}{\mathrm{MAX} - \mathrm{MIN}} & B_{max} = S_{min} \\ 0.0 & B_{max} < S_{min} \end{cases} \tag{12}$$

Figure 13 and 14 should go here or around

Eq. (13) and (14) present the function of buyer's and seller's satisfaction, respectively, when buyers' and sellers' private prices are not provided for the seller and buyer satisfaction computation. Figure 15 shows the buyer satisfaction when $B_{pub}<S_{pub}<B_{max}$. The value ranges for B_{pub} and B_{max} are [$1, $9] and [$10, $40], respectively, and the value of S_{pub} is $10. We do not show the graph for Eq. (14) since it is similar to Figure 15.

$$Sat^{b} = \begin{cases} 1.0 & S_{pub} <= B_{pub} \\ \frac{B_{max} - S_{pub}}{B_{max} - B_{pub}} & B_{pub} < S_{pub} < B_{max} \\ \frac{\mu / 2}{\mathrm{MAX} - \mathrm{MIN}} & B_{max} = S_{min} \\ 0.0 & B_{pub} < B_{max} < S_{pub} \text{ or } B_{max} < S_{min} \end{cases} \tag{13}$$

$$Sat^{s} = \begin{cases} 1.0 & S_{pub} <= B_{pub} \\ \frac{B_{pub} - S_{min}}{S_{pub} - S_{min}} & S_{min} < B_{pub} < S_{pub} \\ \frac{\mu / 2}{\mathrm{MAX} - \mathrm{MIN}} & B_{max} = S_{min} \\ 0.0 & B_{pub} < S_{min} < S_{pub} \text{ or } B_{max} < S_{min} \end{cases} \tag{14}$$

Figure 15 should go here or around

5 CONCLUSION

Price is a decisive product attribute for buyer-seller matching in e-marketplaces. Furthermore, prices in buyers' and sellers' minds might often range so as to concede to some extent. In this paper, we have proposed a price-range similarity measure for buyers and sellers. We have also proposed measures for computing satisfaction between buyers/sellers using those price ranges. This price-range similarity measure together with satisfaction measures can be used independently if the price comparison is the only target or can be embedded into other algorithms to obtain similarity values combining with other product attributes.

In our approach, we allow the buyer and the seller to specify their published prices so that both buyer and seller are satisfied when their published prices overlap. Buyer and seller can also respectively provide their maximum and minimum prices for the purpose of finding more promising sellers and buyers. Thus, we use price ranges $<B_{pub}, B_{max}]$ and $[S_{min}, S_{pub}>$ for the buyer and seller, respectively. Our price-range similarity measure computes buyers' and sellers' price-range similarities based on the semantics of their overlaps. The bigger the semantic overlaps, the more similar their price ranges, and the more likely successful transactions.

Our current AgentMatcher system provides three useful ranked lists of sellers (buyers) for a given buyer (seller). We have opted not to merge these lists into a single list. Finding a good merging function is a topic for future work.

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Figure list:

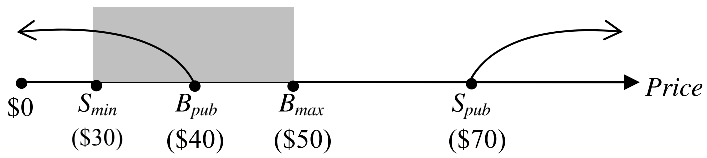

Fig. 1. An example of price range overlapping.

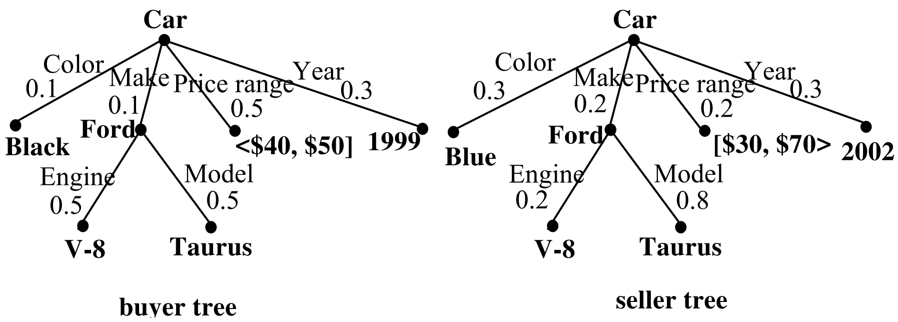

Fig. 2. Two example trees describing used cars.

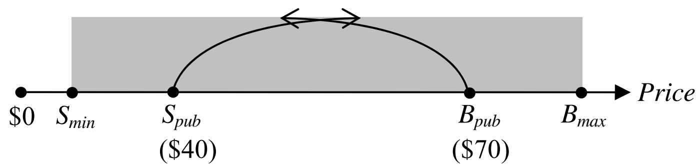

Fig. 3. Both buyer and seller do not concede for the transaction.

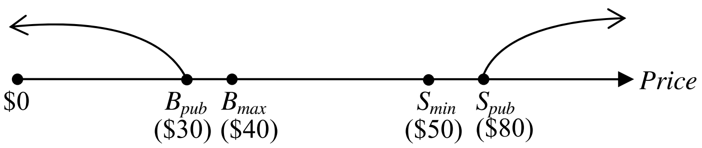

Fig. 4. Buyer's and seller's price ranges do not overlap even after concession.

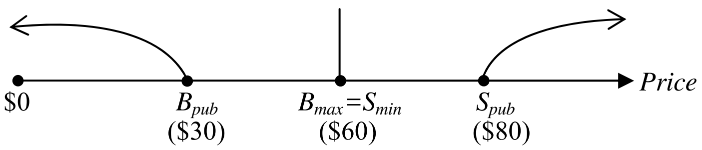

Fig. 5. Buyer and seller price ranges only have one point overlapping.

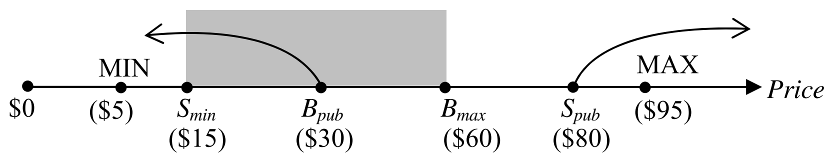

Fig. 6. Both the buyer and the seller have to concede but the transaction could happen

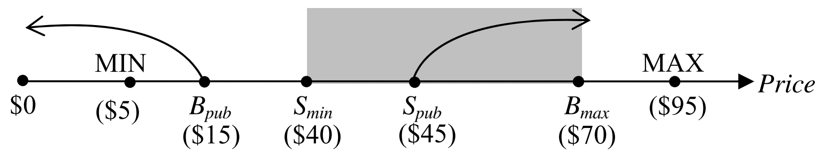

Fig. 7. Only the buyer does not have to concede for successful transaction

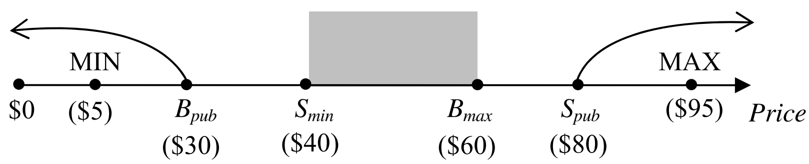

Fig. 8. Only seller does not have to concede for successful transaction

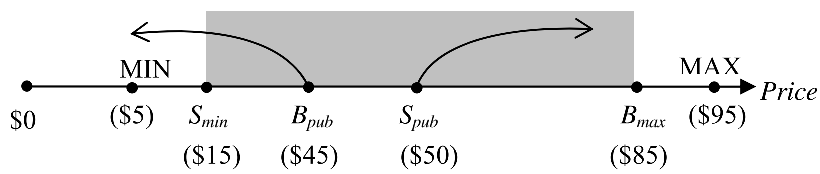

Fig. 9. Either the buyer or the seller has to concede for successful transaction

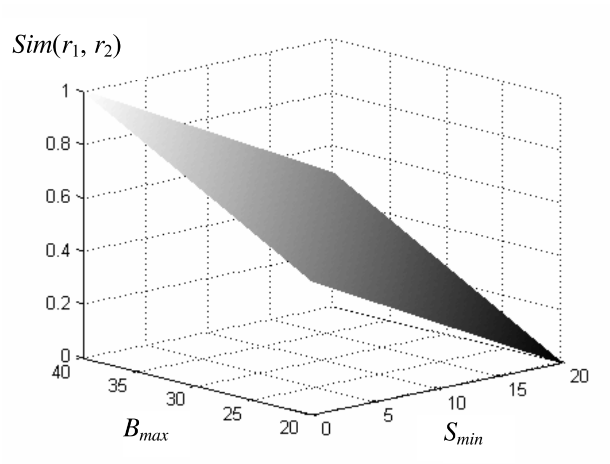

Fig. 10. Price range similarity between buyers and sellers.

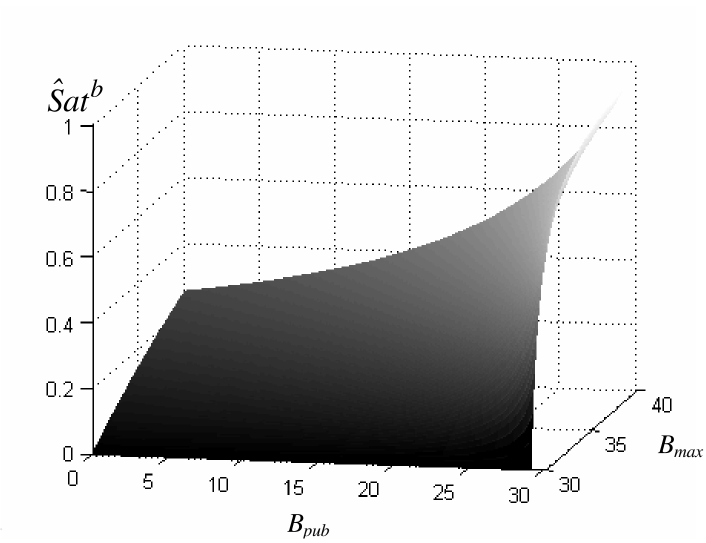

Fig. 11. Buyers' satisfaction degree when their published prices are beyond [S_{min}, B_{max}].

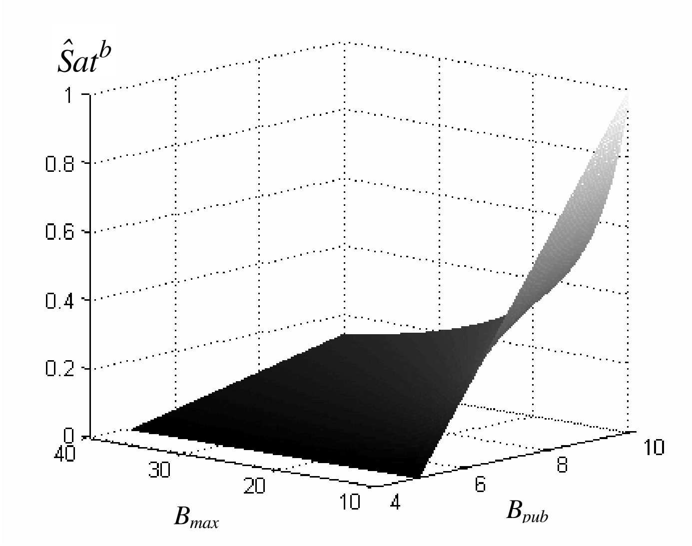

Fig. 12. Buyers' satisfaction degree when their published prices are within [S_{min}, B_{max}].

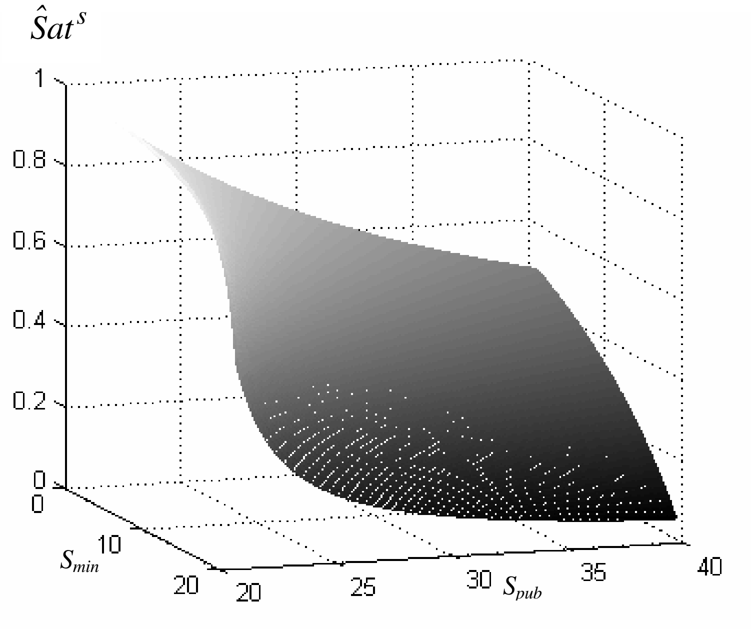

Fig. 13. Sellers' satisfaction degree when their published prices are beyond [S_{min}, B_{max}].

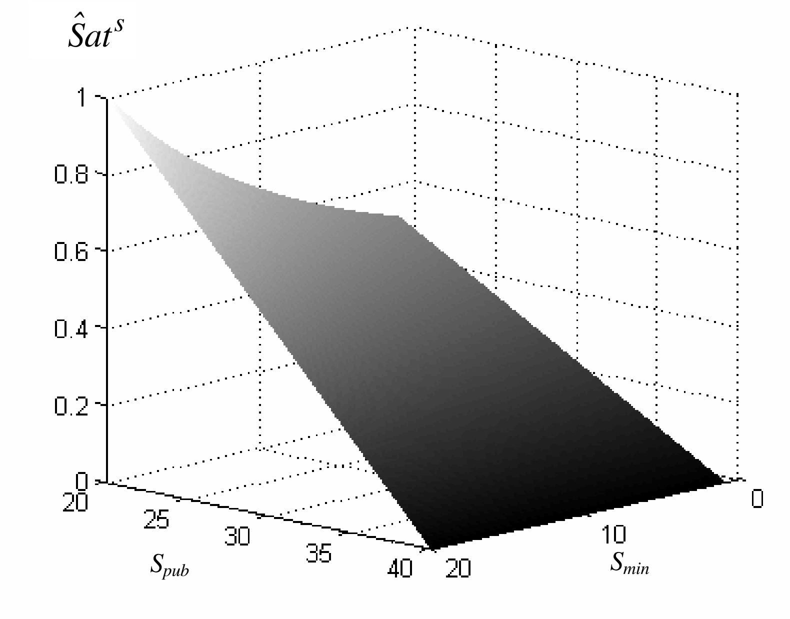

Fig. 14. Sellers' satisfaction degree when their published prices are within [S_{min}, B_{max}].

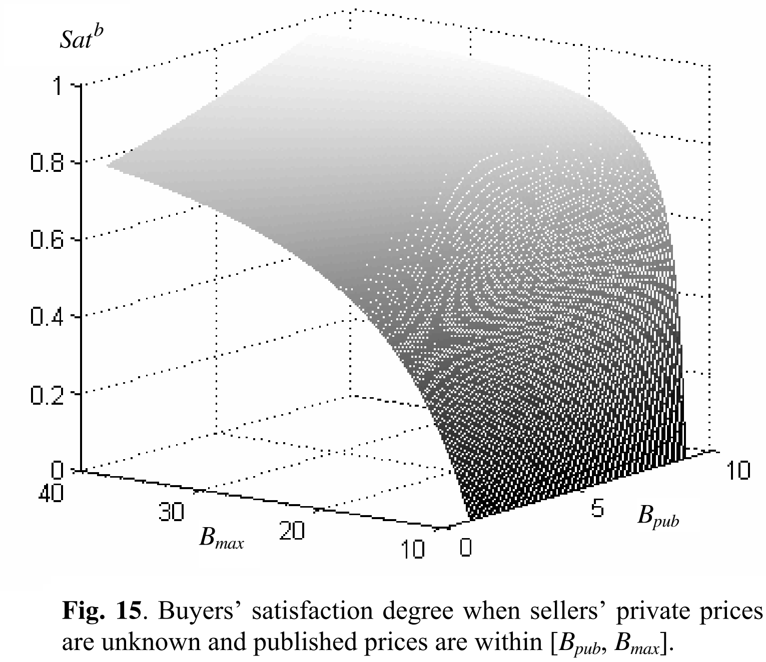

Fig. 15. Buyers' satisfaction degree when sellers' private prices are unknown and published prices are within [B_{pub}, B_{max}].