Incorporating Game-theoretic Rough Sets in Web-based Medical Decision Support Systems

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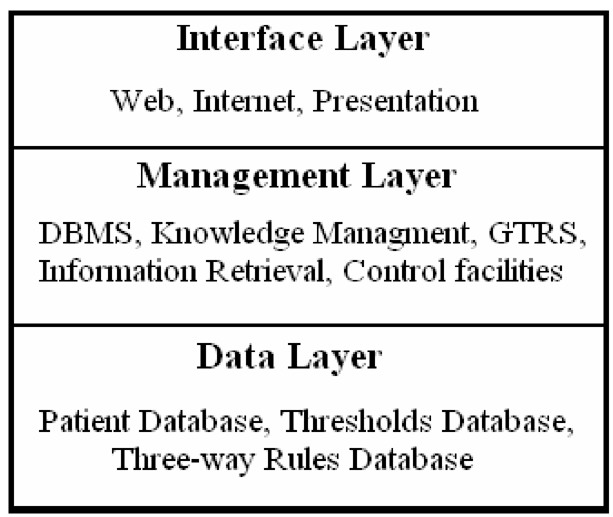
Abstract

Web-based support systems (WSS) assist human activities with the modern Web technology. We focus on decision making in Web-based medical decision support systems (WMDSS). The game-theoretic rough sets (GTRS) which is a recent development in rough sets is studied for this purpose. It is suggested that the GTRS may be a useful alternative for providing ternary decisions support in WMDSS.

Motivation

Uncertainty is a critical issue that affects medical decision making. A ternary decision making approach is commonly employed to reduce the effects of uncertainty. Considering treatment decisions, a pair of thresholds is defined to determine three types of decisions, e.g., treatment, no treatment and delay treatment. A key issue is the determination of thresholds by realizing the optimization of one or more characteristics of decision making. The GTRS can play a role here.

Conceptual Model of WMDSS with GTRS



Game-theoretic Rough Set Model

GTRS provides a threshold determination approach by implementing a game between multiple decision making aspects. Ternary decisions for an object *x* to be in concept *C* based on (α, β) thresholds are made according to the following rules.

Acceptance: If the evidence of *x* to be in *C* is greater then level α,

Rejection: If the evidence of *x* to be in *C* is lesser then level α,

Deferment*:* If the evidence of x to be in is between the two levels.

The major components in GTRS are,

Players: represents multiple criteria for evaluating the quality of decision making such as accuracy, generality or precision.

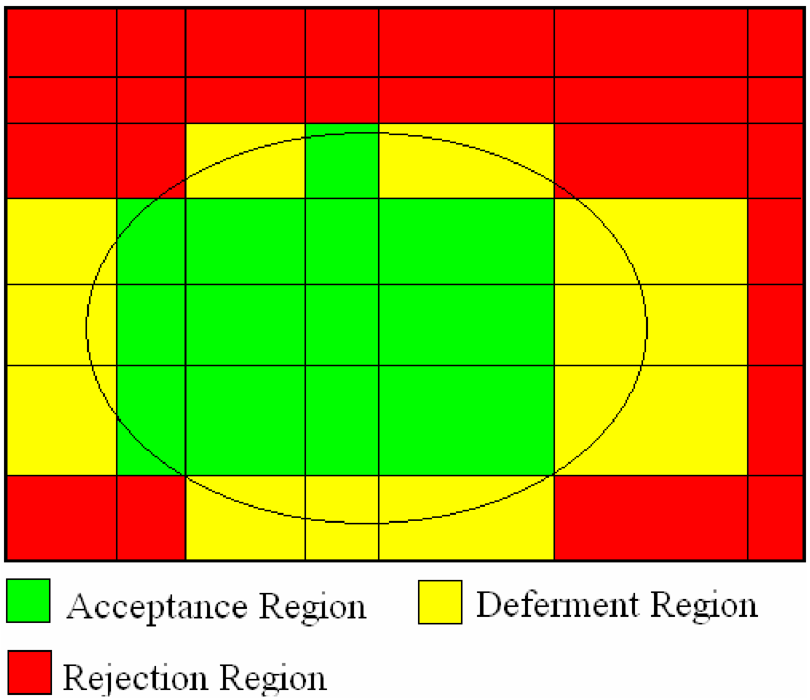
Strategies: different (α, β) thresholds levels that affects the criteria in some order.

Payoff functions: evaluations based on considered criteria by realizing different modification of thresholds, for instance,

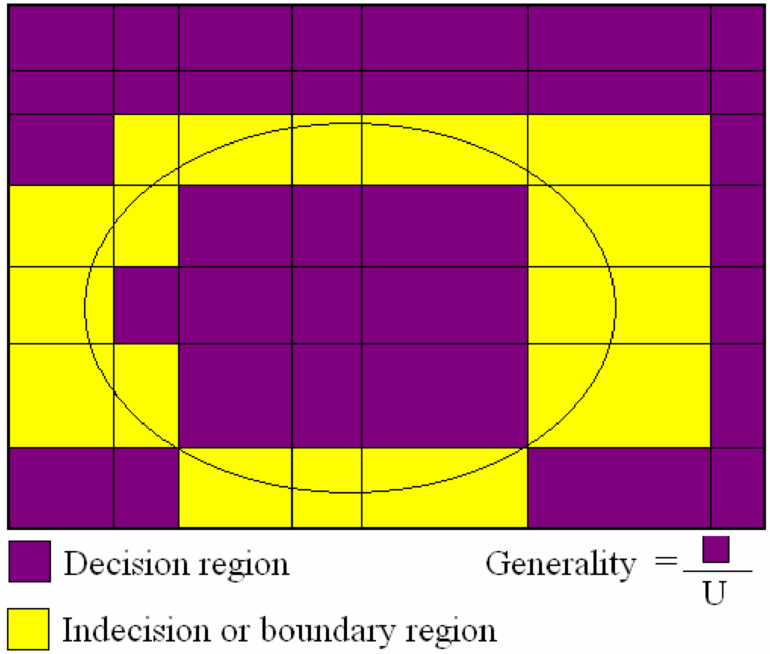
$$Accuracy(\alpha, \beta) = \frac{\text{correctly classified objects by using } (\alpha, \beta) \text{ levels}}{\text{classified objects by using } (\alpha, \beta) \text{ levels}}$$

$$Generality(\alpha, \beta) = \frac{\text{classified objects by using } (\alpha, \beta) \text{ levels}}{\text{total number of objects in U}}$$

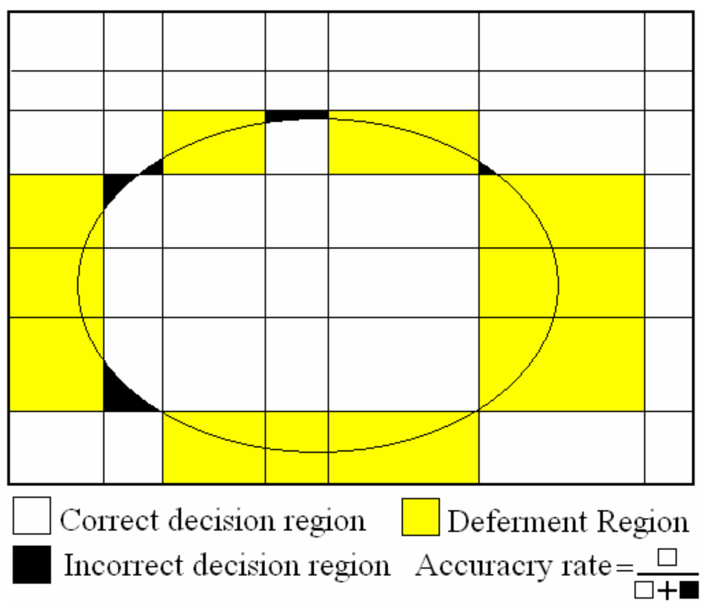
Visualizing Accuracy versus Generality Game



The decision regions based on particular (α, β) thresholds.



Increasing the generality would require to reduce the number of yellow blocks.



Increasing the accuracy would require to increase the number of yellow blocks.

Example: Applying GTRS for Making Treatment Decisions

Considering some sample information about patients with treatment decisions being made in the past.

Patient	S_1	S_2	S_3	Decision
P_1	1	1	1	Yes
P_2, P_3	1	1	0	Yes
P_4, P_5, P_6, P_7	1	0	1	Yes
P_8	1	0	1	No
P_9, P_{10}, P_{11}	0	1	1	Yes
P_{12}	0	1	1	No
P_{13}, P_{14}	0	1	0	Yes
P_{15}, P_{16}	0	1	0	No
P_{17}, P_{18}	0	0	1	No
P_{19}	0	0	1	Yes
$P_{20}, P_{21}, P_{22}, P_{23}$	1	0	0	No
P_{24}	1	0	0	Yes
P_{25}, P_{26}, P_{27}	0	0	0	No

The rows represent information about patients. The columns represent symptoms shown by patients. The decision attribute represent whether treatment was given.

Accuracy versus Generality of Decision Rules

A decision model with high accuracy may have lesser generality while a model with high generality may have a lower accuracy.

		Generality(α, β)		
		$s_1 = \alpha_\downarrow$ 25% dec. α	$s_2 = \beta_\uparrow$ 25% inc. β	$s_3 = \alpha_\downarrow\beta_\uparrow$ 25% (dec. α & inc. β)
Accuracy(α, β)	$s_1 = \alpha_\downarrow$ 25% dec. α	(0.79,0.7)	(0.85,0.74)	(0.79,0.88)
	$s_2 = \beta_\uparrow$ 25% inc. β	(0.85,0.74)	(0.90,0.41)	**(0.83,0.85)**
	$s_3 = \alpha_\downarrow\beta_\uparrow$ 25% (dec. α & inc. β)	(0.79,0.88)	(0.83,0.85)	(0.77,1.0)

The strategy profile (s_2,s_3) is the game solution, with the corresponding payoff pair (0.83,0.85). The threshold pair based on this solution is (α, β) = (0.75,0.5). This means that we can make 83% correct treatment decisions if our level of confidence for acceptance is greater than or equal to 0.75 and the level of confidence for rejection is lesser than or equal to 0.5. However, these decisions are applicable to 85% of the patients.

Conclusion

We explained the use of GTRS component in WMDSS to obtain ternary or three-way decisions. The GTRS can obtain the threshold parameters that define the three types of decisions by considering different decision making aspects. The importance of GTRS is that it considers multiple characteristics of decision making in a soft computing paradigm in order to determine effective thresholds.

References

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