Utilization of Rough Sets Method with Optimization Genetic Algorithms in Heart Failure Cases

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Abstract. Rough Set is a machine learning method capable of analyzing dataset uncertainty to determine essential object attributes. At the same time, genetic algorithms can solve estimates for optimization and search problems. Therefore, this study aims to extract information from the rough set method with genetic algorithm parameters using the Rosetta application in heart failure ca. The research dataset was a collection of Clinical Heart Failure Record Data obtained from the UCI machine learning repository. There are 13 attributes contained in the dataset. Still, two features are removed, namely sex and time. It becomes 11 to reduce the amount of time and memory needed and make data easier to visualize, and help reduce irrelevant features. This research produces eight reducts and 77 rules based on the 20 sample data used. This study concludes that the use of genetic algorithm parameters can optimize the standard rough set method in generating rules.

1. Introducing

art failure is one of the most common reasons for peo over 60 to be hospitalized [1]. This disease is the leading cause of increased mortality worldwide, with about 50% of patients dying within five years of being diagnosed with heart failure, which exceeds cancer [2]. So it is not surprising that the number of heart failure patients continues to increase worldwide [3], mainly if things such as hypertension, diabetes and obesity cann be controlled properly [4]. This paper will classify and predict patients with heart failure using a machine learning algorithm. Machine learning algorithms can be used to optimize computer or system per mance based on pre-existing sample data [5]. There are seven steps in machine learning, including collecting data, preparing input data, analyzing input data, human involvement, training, testing and using them. Machine Learning (ML) is one part of the artificial intelligence algorithm [6]. Many machine learning methods are often used to solve computing problems [7]. Machine learning algorithms have brought about significant changes in the AI field. Machine learning especially supports human discernment [8]. Among some of the well-known machine learning algorithms include: rough set [9], Support vector machine [10], naive bayes algorithm [11], logistic regression [12], KNN [13], decision tree [14], random forest [15], boosted tree [16], etc.

This paper will discuss using the Rough Set method, which will be optimized using genetic algorithms. The rough set is a mathematical technique developed by Pawlak and used for data

classification analysis in table form [17], and extracting ambiguity in exchange for the boundary of membership values [18]. This method is efficient for handling uncertain information [19]. The Rough set method is excellent when used in the field of artificial intelligence, as it can be applied as a component of a hybrid solution in data mining and machine learning [20]. Meanwhile, the genetic algorithm can represent the optimization problem as a set of variables. In the genetic algorithm, each issue will be optimized according to the chromosome of each gene based on the problem variable [21]. Many studies discuss Rough Sets and genetic algorithms to solve many problems, including research that presents a method of evaluating rock slope stability in freeze-thaw mountains combined with hierarchical analysis, rough sets, and genetic algorithms. This study used a dataset of Fifty stone road slopes in the Taishun area, China, which were selected as examples. The results and conclusions obtained from this study are that combining rough set theory, analytical process hierarchy and genetic algorithms with reduced evaluation knowledge and approximate reasoning, default reasoning can improve the intelligence of predictive accuracy of rock slope instability in frozen-thaw mountains [22]. Furthermore, catastrophe classification study on the analysis of medical rescue methods based on rough sets and genetic algorithms. In this paper, Medical characteristics triggered by different forms of sudden disasters are used as benchmarks in this paper to create a table of medical disaster rescue decisions based on the rough set theory. Then, using genetic algorithms, the general points of different disaster medical features are analyzed, resulting in several disaster classifications. The available features and characteristics of the disaster medical rescue personality operation are investigated, and based on the disaster classification features, formal guidelines for medical emergency rescue management are proposed. These findings help the creation of traditional disaster response classifications, plans, and rescue operations on a theoretical level [23]. Following that, research proposes a high-dimensional reduction function model in medical images based on the precision of rough set variables and genetic algorithms by adding values, loosening the rigid inclusion of the method for conventional rough sets, and designing three types of experiments by constructing decision knowledge tables from PET/CT features for ROI lung tumors. The high-dimensional feature selection algorithm based on genetic algorithms and variable precision rough set can solve the multi-objective optimization problem well, according to these experiments [24].

Based on previous studies, this paper proposes using the Rough Set method with genetic algorithm optimization for the classification and prediction of patients with heart failure. Because the rough set method has weaknesses, including producing too many rules if enough attributes from the dataset are used [25], and genetic algorithms are able to optimize the resulting rules.

2. Method

2.1. Sample Data

The research dataset was a collection of Clinical Heart Failure Record Data obtained from the UCI machine learning repository [26]. The data contains 299 records and 13 attributes (age, anaemia, creatinine _phosphokinase, diabetes, ejection_fraction, high_blood_pressure, platelets, serum_creatinine, serum_sodium, sex, smoking, time, and Death_Event as target attributes).

Table 1. Heart Failure Clinical Record Data

No	Age	Anaemia	Creatinine Phosphokinase	Diabetes	Ejection Fraction	High Blood Pressure	Platelets	Serum Creatinine	Serum Sodium	Sex	Smoking	Time	DEATH EVENT
1	75	0	582	0	20	1	265000	1,9	130	1	0	4	1
2	55	0	7861	0	38	0	263358	1,1	136	1	0	6	1
3	65	0	146	0	20	0	162000	1,3	129	1	1	7	1
4	50	1	111	0	20	0	210000	1,9	137	1	0	7	1
5	65	1	160	1	20	0	327000	2,7	116	0	0	8	1
…	…	…	…	…	…	…	…	…	…	…	…	…	…
295	62	0	61	1	38	1	155000	1,1	143	1	1	270	0
296	55	0	1820	0	38	0	270000	1,2	139	0	0	271	0
297	45	0	2060	1	60	0	742000	0,8	138	0	0	278	0
298	45	0	2413	0	38	0	140000	1,4	140	1	1	280	0
299	50	0	196	0	45	0	395000	1,6	136	1	1	285	0

This study only took 20 sample data which would then be processed using the Rough Set method and genetic algorithms. Of the 13 attributes contained in the dataset, two features were removed, namely, sex and time, because they were considered not too important so that they became 11 attributes (10 condition attributes and one decision attribute) to reduce the amount of time and memory needed, and make the data easier to visualize and helps reduce irrelevant features. Age will be grouped into six sections as is often used in the health section (40-49 years: group 1, 50-59 years: group 2, 60-69 years: group 3, 70-79 years: group 4, 80-89 years: group 5, and > 90 years: group 6) [27]. Attribute of Creatinine_phosphokinase attribute will be changed to normal (1) if the value is 10 to 120 micrograms per litre (mcg / L); otherwise, it is abnormal (2) [28]. Atribut of ejection_fraction juga akan diganti nilai nya menjadi range 1-4. 50-70% = Normal (1), 40-49% = Slightly below normal (2), 35-39% = Moderately below normal (3) and Less 35% = Severely below normal (4) [29][30]. Attribute Platelets will also be converted into six categories. Normal platelets → 150.000 - 450.000 µl (1), mild thrombocytopenia → 100.000 - 149.000 µl (2), moderate thrombocytopenia → 75.000 - 99.000 µl (3), thrombocytosis > 450.000 µl (4), critical thrombocytopenia < 50.000 µl (5) and severe thrombocytopenia → 50.000 - 74.000 µl (6) [31]. The serum creatinine records were converted into 2 groups: 0,5 - 1,35 (Normal) = 1, > 1,35 (Abnormal) = 2 [32]. The serum_sodium attribute is changed to Normal (1) → 135-145/147 mEq/L and other than that Abnormal (2) [33].

2.2. Eligibility Criteria Analysis

The condition attributes used in the study were Age, Anaemia, Creatinine Phosphokinase, Diabetes, Ejection Fraction, High Blood Pressure, Platelets, Serum Creatinine, Serum Sodium, and Smoking. Meanwhile, the attribute of the decision is DEATH EVENT. The following is a list of features used in determining cases of heart failure.

Table 2. Attributes Used

Criteria	Data Class Type	Data Class Used
Age	Nominal	1, 2, 3, 4, 5, 6
Anaemia	Nominal	0, 1
Creatinine_Phosphokinase	Nominal	1, 2
Diabetes	Nominal	0, 1
Ejection_Fraction	Nominal	1, 2, 3, 4
High_Blood_Pressure	Nominal	0, 1
Platelets	Nominal	1, 2, 3, 4, 5, 6
Serum_Creatinine	Nominal	1, 2
Serum_Sodium	Nominal	1, 2
Smoking	Nominal	0, 1
DEATH_EVENT	Nominal	0, 1

2.3. Research procedure

The procedure of the Rough Set method with the optimization of genetic algorithm parameters can be represented as shown in Figure 1.

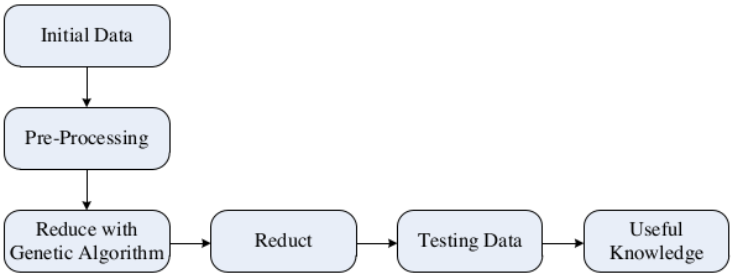


Figure 1. Prosedur Rough Set [34]

Initial Data in Figure 1 describes data input stages for patients with heart failure as many as 20 records. At this stage, the data obtained is still in the form of original data, and data has not been sorted; after that, then proceed to the Pre-Processing stage. The Pre-Processing stage is carried out to eliminate problems that can interfere with the results of the data process, because sometimes in the data, various issues can interfere with the results of the process of extracting information from the data itself, such as missing values, redundant data, outliers, or data formats. Incompatible with the system. In this case, the sex and time attributes are omitted. Besides, the record for the age attribute was changed to a value of 1-6, Creatinine_phosphokinase was changed to a value of 1 and 2, ejection_fraction to a value of 1-4, Platelets was changed to a value of 1-6, serum creatinine was altered to 1 and 2 and serum_sodium was also changed to a value of 1 and 2.

Furthermore, this data is processed using the Rosetta application. The next step is to carry out the reduction process by using the rough set method from the table that has been inputted with the genetic algorithm parameters to produce reducts. The decision rules were then concluded based on this Reduct process. The next stage is testing a sample of heart failure patient data using Rosetta's tools to produce proper knowledge based on the data that has been tested.

3. Results and Discussion

Analysis result are in the form of an explanation of the Rough Set method's problem-solving algorithm with the optimization of the genetic algorithm based on Figure 1, which has been presented previously.

3.1. Initial Data

nitial data were obtained from table 1 (sample heart failure patient data). This data still needs to be sorted to get the appropriate attributes so that it can be processed to the next stage.

3.2. Pre-Processing

Pre-Processing of Samples Data on heart failure patients were performed to remove attributes deemed unnecessary, such as sex and time, and classify age, creatinine_phosphokinase, ejection_fraction, platelets, serum creatinine and serum_sodium to a value of 1-6. The results of pre-processing data for heart failure patients can be seen in table 3. Then the data from the pre-processing results were entered into Rosetta's tools.

Heart_Failure

	Age	Anaemia	Creatinine_phosphokinase	Diabetes	Ejection_fraction	High_blood_pressure	Platelets	Serum_creatinine	Serum_sodium	Smoking	DEATH_EVENT
1	4	0	2	0	4	1	1	2	2	0	**1**
2	2	0	2	0	3	0	1	1	1	0	**1**
3	3	0	2	0	4	0	1	1	2	1	**1**
4	2	1	1	0	4	0	1	2	1	0	**1**
5	3	1	2	1	4	0	1	2	2	0	**1**
6	6	1	1	0	2	1	1	2	2	1	**1**
7	3	1	2	1	1	0	4	1	2	1	**1**
8	4	1	1	0	3	1	1	2	2	1	**1**
9	5	1	2	0	3	1	1	2	2	1	**1**
10	4	1	2	0	4	0	2	1	1	0	**1**
11	3	0	2	0	1	0	1	2	1	0	**1**
12	3	0	2	0	4	1	1	1	1	1	**1**
13	1	1	2	0	4	0	2	1	1	0	**1**
14	2	1	2	0	3	1	1	1	1	0	**1**
15	1	1	1	0	4	1	1	1	1	0	**0**
16	5	1	2	0	1	0	5	1	1	0	**1**
17	1	0	2	0	4	0	1	1	2	0	**1**
18	5	1	2	0	3	0	1	1	1	0	**1**
19	1	1	2	1	1	0	3	2	2	0	**1**
20	4	1	2	0	4	1	1	1	1	0	**1**

Figure 2. Heart failure patient data samples that have been entered into the Rosetta application

3.3. Reduce

At this stage, Reduce is selected using the rough set method with genetic algorithm parameters..

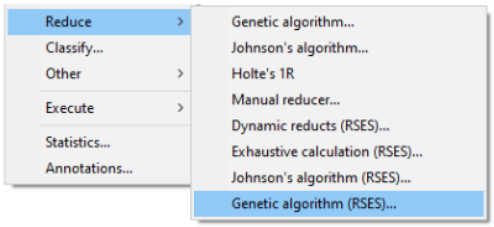
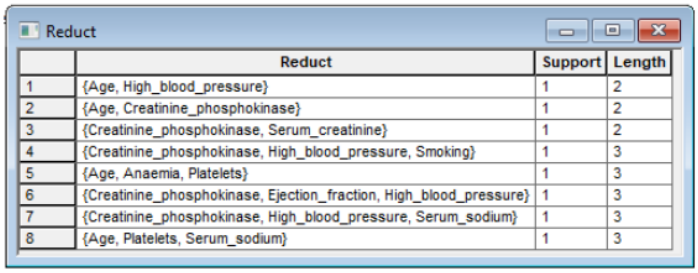


Figure 3. Rough Set Method Reduce Process with Genetic Algorithm Parameters

3.4. Reduct

Reduct results will appear after the Reduce process is complete.



	Reduct	Support	Length
1	{Age, High_blood_pressure}	1	2
2	{Age, Creatinine_phosphokinase}	1	2
3	{Creatinine_phosphokinase, Serum_creatinine}	1	2
4	{Creatinine_phosphokinase, High_blood_pressure, Smoking}	1	3
5	{Age, Anaemia, Platelets}	1	3
6	{Creatinine_phosphokinase, Ejection_fraction, High_blood_pressure}	1	3
7	{Creatinine_phosphokinase, High_blood_pressure, Serum_sodium}	1	3
8	{Age, Platelets, Serum_sodium}	1	3

Figure 4. Reduct Results

The reductions that have been done have resulted in 8 Reducts, namely: {Age, High_blood_pressure}, {Age, Creatinine_phosphokinase), {Creatinine_phosphokinase, Serum_creatinine}, {Creatinine_phosphokinase, High_blood_pressure, Smoking}, {Age, Anemia, Platelets, Ejection_fraction, }, {Creatinine_phosphokinase, High_blood_pressure, Serum_sodium} and {Age, Platelets, Serum_sodium}.

3.5. Testing Data

The steps taken after the reduct process is complete is data testing. Data testing is carried out to obtain generate rules, which can be seen in Figure 5.

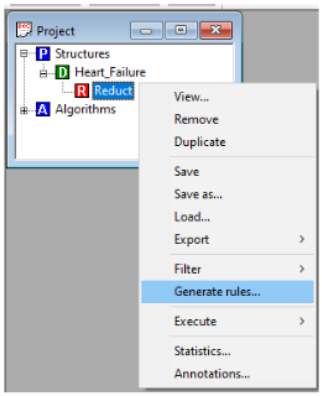
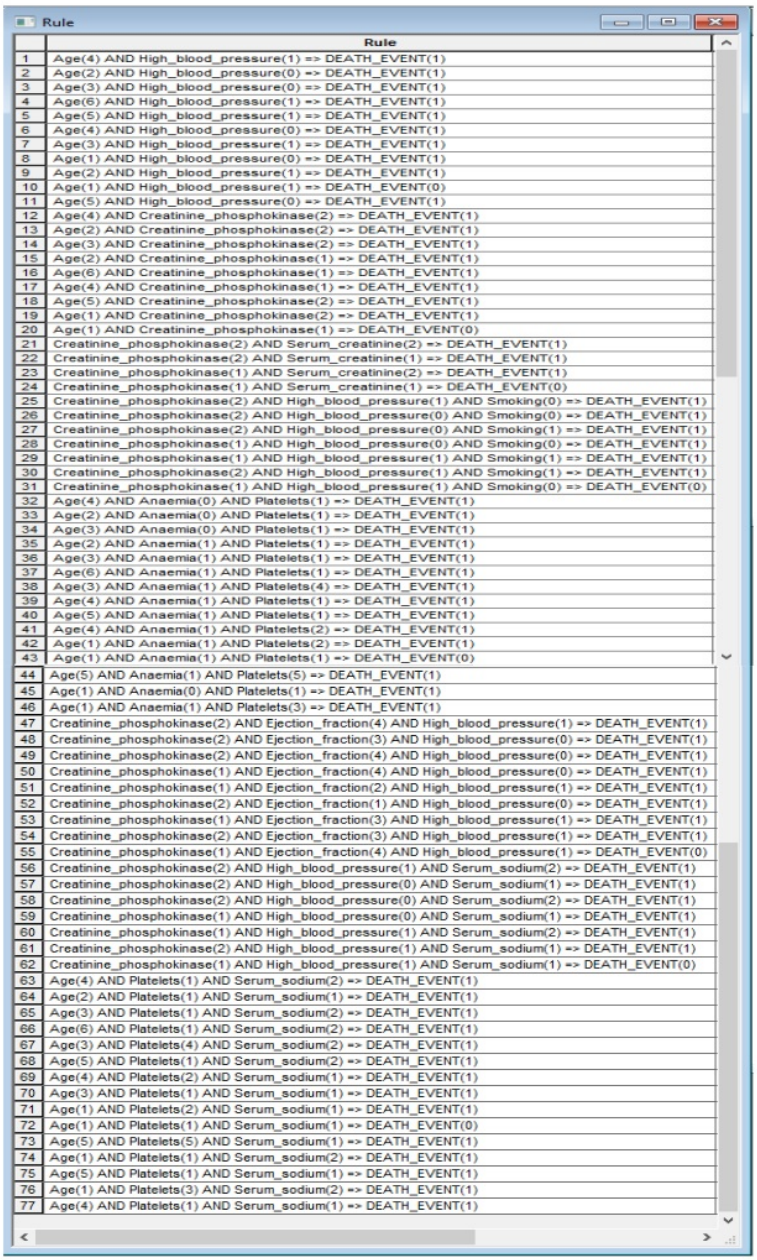


Figure 5. Generate Rules Process

3.6. Useful Knowledge

Reduct results obtained are used to produce Knowledge by referring to table 1. A decision System is an Information System that already has a decision or impact based on assumptions based on its attributes that meet the terms and conditions. The value of each existing result attribute comes from a sample of data that is converted into the eligibility criteria.



	Rule
1	Age(4) AND High_blood_pressure(1) => DEATH_EVENT(1)
2	Age(2) AND High_blood_pressure(0) => DEATH_EVENT(1)
3	Age(3) AND High_blood_pressure(0) => DEATH_EVENT(1)
4	Age(6) AND High_blood_pressure(1) => DEATH_EVENT(1)
5	Age(5) AND High_blood_pressure(1) => DEATH_EVENT(1)
6	Age(4) AND High_blood_pressure(0) => DEATH_EVENT(1)
7	Age(3) AND High_blood_pressure(1) => DEATH_EVENT(1)
8	Age(1) AND High_blood_pressure(0) => DEATH_EVENT(1)
9	Age(2) AND High_blood_pressure(1) => DEATH_EVENT(1)
10	Age(1) AND High_blood_pressure(1) => DEATH_EVENT(0)
11	Age(5) AND High_blood_pressure(0) => DEATH_EVENT(1)
12	Age(4) AND Creatinine_phosphokinase(2) => DEATH_EVENT(1)
13	Age(2) AND Creatinine_phosphokinase(2) => DEATH_EVENT(1)
14	Age(3) AND Creatinine_phosphokinase(2) => DEATH_EVENT(1)
15	Age(2) AND Creatinine_phosphokinase(1) => DEATH_EVENT(1)
16	Age(6) AND Creatinine_phosphokinase(1) => DEATH_EVENT(1)
17	Age(4) AND Creatinine_phosphokinase(1) => DEATH_EVENT(1)
18	Age(5) AND Creatinine_phosphokinase(2) => DEATH_EVENT(1)
19	Age(1) AND Creatinine_phosphokinase(2) => DEATH_EVENT(1)
20	Age(1) AND Creatinine_phosphokinase(1) => DEATH_EVENT(0)
21	Creatinine_phosphokinase(2) AND Serum_creatinine(2) => DEATH_EVENT(1)
22	Creatinine_phosphokinase(2) AND Serum_creatinine(1) => DEATH_EVENT(1)
23	Creatinine_phosphokinase(1) AND Serum_creatinine(2) => DEATH_EVENT(1)
24	Creatinine_phosphokinase(1) AND Serum_creatinine(1) => DEATH_EVENT(0)
25	Creatinine_phosphokinase(2) AND High_blood_pressure(1) AND Smoking(0) => DEATH_EVENT(1)
26	Creatinine_phosphokinase(2) AND High_blood_pressure(0) AND Smoking(0) => DEATH_EVENT(1)
27	Creatinine_phosphokinase(2) AND High_blood_pressure(0) AND Smoking(1) => DEATH_EVENT(1)
28	Creatinine_phosphokinase(1) AND High_blood_pressure(0) AND Smoking(0) => DEATH_EVENT(1)
29	Creatinine_phosphokinase(1) AND High_blood_pressure(1) AND Smoking(1) => DEATH_EVENT(1)
30	Creatinine_phosphokinase(2) AND High_blood_pressure(1) AND Smoking(1) => DEATH_EVENT(1)
31	Creatinine_phosphokinase(1) AND High_blood_pressure(1) AND Smoking(0) => DEATH_EVENT(0)
32	Age(4) AND Anaemia(0) AND Platelets(1) => DEATH_EVENT(1)
33	Age(2) AND Anaemia(0) AND Platelets(1) => DEATH_EVENT(1)
34	Age(3) AND Anaemia(0) AND Platelets(1) => DEATH_EVENT(1)
35	Age(2) AND Anaemia(1) AND Platelets(1) => DEATH_EVENT(1)
36	Age(3) AND Anaemia(1) AND Platelets(1) => DEATH_EVENT(1)
37	Age(6) AND Anaemia(1) AND Platelets(1) => DEATH_EVENT(1)
38	Age(3) AND Anaemia(1) AND Platelets(4) => DEATH_EVENT(1)
39	Age(4) AND Anaemia(1) AND Platelets(1) => DEATH_EVENT(1)
40	Age(5) AND Anaemia(1) AND Platelets(1) => DEATH_EVENT(1)
41	Age(4) AND Anaemia(1) AND Platelets(2) => DEATH_EVENT(1)
42	Age(1) AND Anaemia(1) AND Platelets(2) => DEATH_EVENT(1)
43	Age(1) AND Anaemia(1) AND Platelets(1) => DEATH_EVENT(0)
44	Age(5) AND Anaemia(1) AND Platelets(5) => DEATH_EVENT(1)
45	Age(1) AND Anaemia(0) AND Platelets(1) => DEATH_EVENT(1)
46	Age(1) AND Anaemia(1) AND Platelets(3) => DEATH_EVENT(1)
47	Creatinine_phosphokinase(2) AND Ejection_fraction(4) AND High_blood_pressure(1) => DEATH_EVENT(1)
48	Creatinine_phosphokinase(2) AND Ejection_fraction(3) AND High_blood_pressure(0) => DEATH_EVENT(1)
49	Creatinine_phosphokinase(2) AND Ejection_fraction(4) AND High_blood_pressure(0) => DEATH_EVENT(1)
50	Creatinine_phosphokinase(1) AND Ejection_fraction(4) AND High_blood_pressure(0) => DEATH_EVENT(1)
51	Creatinine_phosphokinase(1) AND Ejection_fraction(2) AND High_blood_pressure(1) => DEATH_EVENT(1)
52	Creatinine_phosphokinase(2) AND Ejection_fraction(1) AND High_blood_pressure(0) => DEATH_EVENT(1)
53	Creatinine_phosphokinase(1) AND Ejection_fraction(3) AND High_blood_pressure(1) => DEATH_EVENT(1)
54	Creatinine_phosphokinase(2) AND Ejection_fraction(3) AND High_blood_pressure(1) => DEATH_EVENT(1)
55	Creatinine_phosphokinase(1) AND Ejection_fraction(4) AND High_blood_pressure(1) => DEATH_EVENT(0)
56	Creatinine_phosphokinase(2) AND High_blood_pressure(1) AND Serum_sodium(2) => DEATH_EVENT(1)
57	Creatinine_phosphokinase(2) AND High_blood_pressure(0) AND Serum_sodium(1) => DEATH_EVENT(1)
58	Creatinine_phosphokinase(2) AND High_blood_pressure(0) AND Serum_sodium(2) => DEATH_EVENT(1)
59	Creatinine_phosphokinase(1) AND High_blood_pressure(0) AND Serum_sodium(1) => DEATH_EVENT(1)
60	Creatinine_phosphokinase(1) AND High_blood_pressure(1) AND Serum_sodium(2) => DEATH_EVENT(1)
61	Creatinine_phosphokinase(2) AND High_blood_pressure(1) AND Serum_sodium(1) => DEATH_EVENT(1)
62	Creatinine_phosphokinase(1) AND High_blood_pressure(1) AND Serum_sodium(1) => DEATH_EVENT(0)
63	Age(4) AND Platelets(1) AND Serum_sodium(2) => DEATH_EVENT(1)
64	Age(2) AND Platelets(1) AND Serum_sodium(1) => DEATH_EVENT(1)
65	Age(3) AND Platelets(1) AND Serum_sodium(2) => DEATH_EVENT(1)
66	Age(6) AND Platelets(1) AND Serum_sodium(2) => DEATH_EVENT(1)
67	Age(3) AND Platelets(4) AND Serum_sodium(2) => DEATH_EVENT(1)
68	Age(5) AND Platelets(1) AND Serum_sodium(2) => DEATH_EVENT(1)
69	Age(4) AND Platelets(2) AND Serum_sodium(1) => DEATH_EVENT(1)
70	Age(3) AND Platelets(1) AND Serum_sodium(1) => DEATH_EVENT(1)
71	Age(1) AND Platelets(2) AND Serum_sodium(1) => DEATH_EVENT(1)
72	Age(1) AND Platelets(1) AND Serum_sodium(1) => DEATH_EVENT(0)
73	Age(5) AND Platelets(5) AND Serum_sodium(1) => DEATH_EVENT(1)
74	Age(1) AND Platelets(1) AND Serum_sodium(2) => DEATH_EVENT(1)
75	Age(5) AND Platelets(1) AND Serum_sodium(1) => DEATH_EVENT(1)
76	Age(1) AND Platelets(3) AND Serum_sodium(2) => DEATH_EVENT(1)
77	Age(4) AND Platelets(1) AND Serum_sodium(1) => DEATH_EVENT(1)

Figure 6. Useful Knowledge

Figure 6 is useful knowledge that yields 77 rules. After conducting the test, the results of the analysis can produce optimal decisions in predicting kidney failure patients who can experience death. The resulting choices are in the form of rules or rules patterns that are formed so that they become helpful information in decision making.

4. Conclusion

It can be concluded that the application of the Rough Set method with genetic algorithm parameters on the dataset of heart failure patients can produce more optimal rules than the standard rough set method. The Rough Set method with genetic algorithm parameters using Rosetta can create information to make more optimal decisions so that they can provide policies for patients with kidney failure. The use of the Rough Set method with genetic algorithm parameters in determining the death of kidney failure patients resulted in new knowledge, namely the possibility of death due to kidney failure; there are eight reducts with 77 rules.

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