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Studies on The Covid-19 Pandemic Disease using Rough Set Theoretic Approach

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ABSTRACT
Rough Set Theory (RST) is new mathematical techniques. This technique approach to ambiguity that is due to the lack of information about some elements of the universe discourse. RST is very wide diversity of approaches like as medical sciences, artificial intelligence (AI), cognitive sciences, data mining, control and linguistics, information analysis, especially in machine learning, engineering, banking, financial and market analysis, expert systems, approximate reasoning, knowledge discovery and pattern recognition, pharmacology and other. This task used strength, certainty factor, and coverage factor of the decision rule represents a though flow of the corresponding branch. The proposed work we sort out major symptoms of COVID-19 disease affected by several people using rough set theory.
Keywords: *RST, Certainty, Coverage, Symptoms, Rule, COVID-19.*

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INTRODUCTION

Rough Set Theory (RST) was first introduced by Z. Pawlak [1,2] as a means to analyze vague or imprecise descriptions of items. RST is new mathematical approach to vagueness that is due to the lack of information about some elements of the universe discourse. It is formal theory derived from fundamental research on logical properties of information systems. The notation of a set is a fundamental concept for the whole of contemporary mathematics and set theory introduced by Georg Cantor in 1883 is undoubtedly a milestone in the development of modern mathematical thinking.

The connection of rough set theory and many other theories have been clarified and the concept of rough set theory and fuzzy set were different to refer various aspects of imprecision [3-5].. The rough theory has attracted many researchers and practitioners all over the world, who contributed essentially to its developments and applications. Rough set theory has a close connection with many other theories. It has been proposed for a very wide variety of applications in cognitive sciences. The main idea of rough set theory corresponds to the lower approximations and upper approximations. The lower approximation of a set involves of all elements that surely belong to the set and the upper approximation of the set constitutes of all elements that possibly belong to the set. Boundary region is a difference between upper and lower approximation [6-9].

It involves all elements that cannot be classified uniquely to the set or its complement by using available information system. Thus any rough set in contrast to a crisp set has nonempty boundary region. In this task we discussed indiscernibility, approximation and membership function, strength of decision rule, certainty factor of the decision rule and coverage factor of the decision rule represent a though flow of the corresponding branch.

Information System

For the sake of simplicity, we first introduce the proposed approach intuitively, by means simple Information System (tutorial examples). Data are found presented as a table, columns of which are labeled by Symptoms (Attributes), rows by objects of interest and entries of the table are attribute values. In a table containing information about COVID-19 patients suffering from certain symptoms (attributes) of a patients. The following attributes F, C, Ch., CP, DB, H, MA, RN, ST, T say as Fever, Cough, Chills, Chest Pain, Difficulty in Breathing, Headache, Muscle Aches, Runny Nose, Sore Throat, Tiredness or Fatigue. Information System presented data about patients as shown in Table 1.

Table 1: Symptoms Data

CASE	Symptoms (Attributes)										COVID - 19 Test
	F	C	Ch.	CP	DB	H	MA	RN	ST	T	
P_1	High	Y	Y	Y	Y	Y	N	Y	Y	Y	**+**
P_2	Normal	Y	Y	N	N	N	N	Y	N	N	**-**
P_3	Very- High	Y	Y	N	Y	Y	N	Y	Y	Y	**+**
P_4	Normal	Y	Y	N	N	Y	N	Y	N	Y	**-**
P_5	High	N	Y	N	N	N	N	Y	Y	Y	**-**
P_6	Very- High	Y	Y	Y	Y	Y	Y	Y	Y	N	**+**
P_7	High	Y	Y	N	N	Y	N	N	N	Y	**-**
P_8	Very- High	N	N	N	Y	Y	Y	Y	Y	Y	**+**
P_9	Normal	Y	N	N	N	N	N	N	N	Y	**-**

Indiscernibility

Information function defined as $\rho : U \times A \rightarrow V$. Assume that two finite (nonempty) sets, U and A, where U is the universe of discourse (number of patients), and A set of Attributes, i.e., to every attribute a $\in A$, we associate a set V_a , of its values called the domain of a. The pair $S = (U, A)$ will be called an information system. Any subset B of A determines a binary relation I_B on U, which will be called an indiscernibility relation, and is defined as follows: x I_B y if and only if a (x) = a (y) for every a $\in A$, where a(x) denotes the value of attribute a for element x, that is relation between two or more objects where all the values are identical in the relation between to a subset of considerable attributes. Using indiscernibility relation to which is an equivalence relation induces a partitioning of the universe and subsets that are most found of interest have the same value of the decision attributes. In final set of indiscernibility relation is

$$IND(\{F, C, Ch., CP, DB, H, MA, RN, ST,T\}) =\{\{P_1\}\{P_2\}\{P_3\}\{P_4\}\{P_5\}\{P_6\}\{P_7\}\{P_8\}\{P_9\}\}$$

Attributes (Dispensable or Indispensable)

Let $S = (U, A)$ be an information system, $B \subseteq A$ and let a $\in B$. Then we say that 'a is dispensable in B if $IND_s\ (B) = IND_s\ (B - \{a\})$' Otherwise 'a' is indispensable in B. In given information system dispensable attributes is Chest Pain (CP), Headache (H), Muscle Aches (MA), Runny Nose (RN) and indispensable attribute is Cough (C), Chills (Ch.), Difficulty Breathing (DB), Fever (F), Sore Throat (ST), Tiredness or Fatigue (T).

Reduct: Any subset B' Reduct of B is called reduct of B if B' is independent and

$$IND_s\ (B') = IND_s\ (B).$$

In given information systems reduct is F, C, Ch., DB, ST, T.

Core: Let B be a subset of A. The core of C is the set of all indispensable attributes of B

$$\text{core}\ (C) = \cap\ \text{core}\ (B)$$

The core of given information system is Chills.

In rough set easily identified partial or total dependencies in data and reducing the original data in Table 2.

CASE	Symptoms (Attributes)					COVID -19 Test
	F	Ch.	DB	ST	T	
P_1	High	Y	Y	Y	Y	**+**
P_2	Normal	Y	N	N	N	**-**
P_3	Very -High	Y	Y	Y	Y	**+**
P_4	Normal	Y	N	N	Y	**-**
P_5	High	N	N	Y	Y	**-**
P_6	Very-High	Y	Y	Y	N	**+**
P_7	High	Y	N	N	Y	**-**
P_8	Very-High	N	Y	Y	Y	**+**
P_9	Normal	N	N	N	Y	**-**

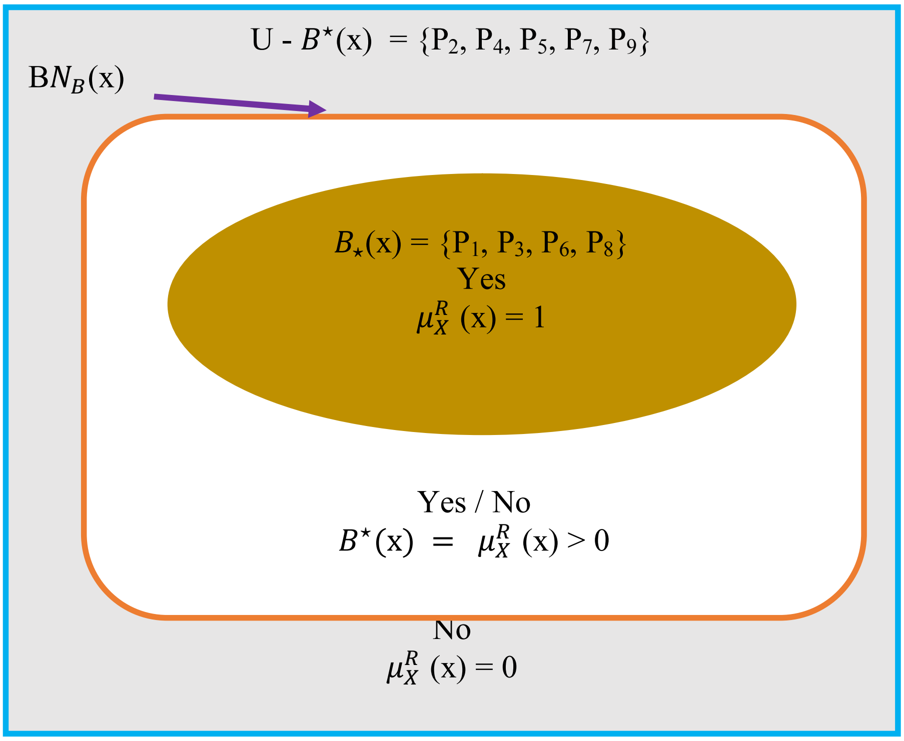
Table 2

This means that the classification defined by equivalence relation Fever, Cough, Chills, Chest Pain, Difficulty Breathing, Headache, Muscle Aches, Runny Nose, Sore Throat and Tiredness is a same as the classification defined by Fever, Cough, Chills, Difficulty Breathing, Sore Throat and Tiredness.

Set Approximations

Let $L = (U, A)$ and $B \subseteq A$, $X \subseteq U$. Approximate X using only the information contained in B as B-Lower approximation $B_{\star}(x)$ and B-Upper approximation $B^{\star}(x)$ of X as

Lower approximation: $B_{\star}(x) = \{x \mid [x]_B \subseteq X\}$
Using information system, $B_{\star}(x) = \{P_1, P_3, P_6, P_8\}$, since P_1, P_3, P_6, and P_8 patients affected by COVID-19.
Upper approximation: $B^{\star}(x) = \{x \mid [x]_B \cap X \neq \emptyset\}$
Using information system, $B^{\star}(x) = \{P_1, P_3, P_6, P_8\}$
Boundary region of approximation
Using information System we get
B **- Boundary region of** ***X*****:** $BN_B(X) = B^{\star}(x) - B_{\star}(x) = \emptyset$
B **- outside of the region of** ***X:*** $U - B^{\star}(x) = \{P_2, P_4, P_5, P_7, P_9\}$, the patients P_2, P_4, P_5, P_7, and P_9 are not affected by COVID-19.



Information Systems and Decision Rules
Every decision table describes decisions (activities, outcomes etc.) determined, when some conditions are satisfied. We describe decision rule as follows
Let $S = (U, P, D)$ be a decision table. Every $x \in U$ finding a sequence of $p_1(x), p_2(x), \ldots, p_r(x).\ d_1(x), d_2(x), \ldots, d_n(x)$. The above sequence known as decision rule induced by $x \in S$ and it denoted by $P \rightarrow_x D$. The number $supp_x(P, D) = |P(x) \cap D(x)|$ is known as support of the decision rule $P \rightarrow_x D$ and the number $\sigma_x(P, D) = \frac{supp_x(P,D)}{|U|}$ represent as strength of the decision rule $P \rightarrow_x D$ we associate the certainty factor of the decision rule as $cert_x(P, D) = \frac{supp_x(P,D)}{|P(x)|}$, and we use coverage factor of the decision rule defined as $cov_x(P, D) = \frac{supp_x(P,D)}{|D(x)|}$

Decision Tables and Flow Graphs
Every decision table we associate a flow graph i.e. a directed, connected, acyclic graph defined as follows: to every decision rule $P \rightarrow_x D$ we assign a directed branch x connecting the input node $P(x)$ and output node $D(x)$. Strength, certainty and coverage of the decision rule represent a though flow of the corresponding branch.
Decision Algorithm: The following decision algorithm associated with below table

a) *if (covid-19 symptoms (high-fever, chills, difficulty breathing, sore throat, tiredness), yes) and (age, middle man) then (covid-19 test,* **+***).*
b) *if (covid-19 symptoms (normal-fever, chills-yes, difficulty breathing-no, sore throat-no, tiredness-no), no) and (age, middle man) then (covid-19 test,* **-***)*
c) *if (covid-19 symptoms (very high-fever, chills, difficulty breathing, sore throat, tiredness), yes) and (age, middle women) then (covid-19 test,* **+***).*
d) *if (covid-19 symptoms (normal-fever, chills-yes, difficulty breathing-no, sore throat-no, tiredness-yes), no) and (age, middle women) then (covid-19 test,* **-***)*

e) *if* (*covid-19 symptoms* (*high-fever, chills-no, difficulty breathing-no, sore throat-yes, tiredness-yes*), *no*) *and* (*age, old man*) *then* (*covid-19 test,* **-**)
f) *if* (*covid-19 symptoms* (*very high-fever, chills-yes, difficulty breathing-yes, sore throat-yes, tiredness-no*), *yes*) *and* (*age, old man*) *then* (*covid-19 test,* **+**)
g) *if* (*covid-19 symptoms* (*high-fever, chills-yes, difficulty breathing-no, sore throat-no, tiredness-yes*), *no*) *and* (*age, young man*) *then* (*covid-19 test,* **-**)
h) *if* (*covid-19 symptoms* (*very high-fever, chills-no, difficulty breathing-yes, sore throat-yes, tiredness-yes*), *yes*) *and* (*age, old women*) *then* (*covid-19 test,* **+**)
i) *if* (*covid-19 symptoms* (*normal-fever, chills-no, difficulty breathing-no, sore throat-no, tiredness-yes*), *no*) *and* (*age, old women*) *then* (*covid-19 test,* **-**)

Decision Table:

Case	COVID -19 Symptoms	Age	Sex	COVID -19 Test	support
P_1	Yes	middle	man	**+**	280
P_2	No	middle	man	**-**	40
P_3	Yes	middle	women	**+**	250
P_4	No	middle	women	**-**	60
P_5	No	old	man	**-**	30
P_6	Yes	old	man	**+**	350
P_7	No	young	man	**-**	40
P_8	Yes	old	women	**+**	300
P_9	No	old	women	**-**	50

Strength, Certainty and Coverage Factors:

The Strength, Certainty and Coverage Factors for decision table as follows

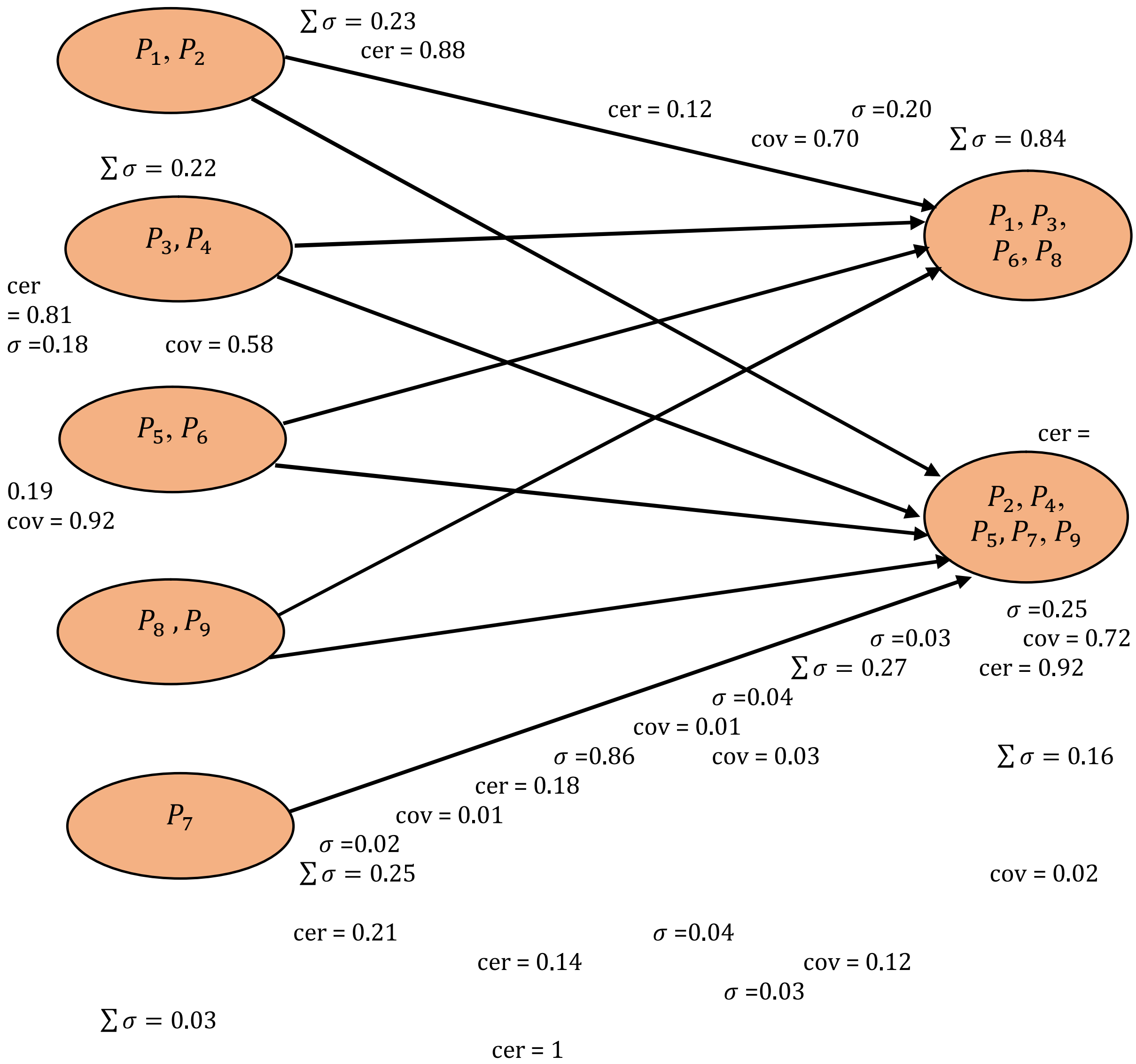
Case	Strength	Certainty	Coverage
P_1	0.20	0.88	0.70
P_2	0.03	0.12	0.01
P_3	0.18	0.81	0.58
P_4	0.04	0.19	0.03
P_5	0.02	0.18	0.01
P_6	0.25	0.92	0.92
P_7	0.03	1	0.12
P_8	0.21	0.86	0.72
P_9	0.04	0.14	0.02

Inverse Decision Algorithm:

The following inverse decision algorithm associated with above table

a) *if* (*covid-19 test,* **+**) *then* (*covid-19 symptoms* (*high-fever, chills, difficulty breathing, sore throat, tiredness*), *yes*) *and* (*age, middle man*).
b) *if* (*covid-19 test,* **-**) *then* (*covid-19 symptoms* (*normal-fever, chills-yes, difficulty breathing-no, sore throat-no, tiredness-no*), *no*) *and* (*age, middle man*).
c) *if* (*covid-19 test,* **+**) *then* (*covid-19 symptoms* (*very high-fever, chills, difficulty breathing, sore throat, tiredness*), *yes*) *and* (*age, middle women*).
d) *if* (*covid-19 test,* **-**) *then* (*covid-19 symptoms* (*normal-fever, chills-yes, difficulty breathing-no, sore throat-no, tiredness-yes*), *no*) *and* (*age, middle women*).
e) *if* (*covid-19 test,* **-**) *then* (*covid-19 symptoms* (*high-fever, chills-no, difficulty breathing-no, sore throat-yes, tiredness-yes*), *no*) *and* (*age, old man*).
f) *if* (*covid-19 test,* **+**) *then* (*covid-19 symptoms* (*very high-fever, chills-yes, difficulty breathing-yes, sore throat-yes, tiredness-no*), *yes*) *and* (*age, old man*).
g) *if* (*covid-19 test,* **-**) *then* (*covid-19 symptoms* (*high-fever, chills-yes, difficulty breathing-no, sore throat-no, tiredness-yes*), *no*) *and* (*age, young man*).
h) *if* (*covid-19 test,* **+**) *then* (*covid-19 symptoms* (*very high-fever, chills-no, difficulty breathing-yes, sore throat-yes, tiredness-yes*), *yes*) *and* (*age, old women*).
i) *if* (*covid-19 test,* **-**) *then* (*covid-19 symptoms* (*normal-fever, chills-no, difficulty breathing-no, sore throat-no, tiredness-yes*), *no*) *and* (*age, old women*).

Flow Graph: The flow graph for the decision algorithm is represented as below



CONCLUSION

The RST is new mathematical techniques for dealing with inexact, unclear knowledge. RST was provides powerful many interesting applications proposed for a very wide variety of applications. In COVID-19 affects different people in some symptoms such as Cough; Chills; Chest Pain; Difficulty in Breathing; Fever; Headache; Muscle Aches; Runny Nose; Sore Throat; Tiredness or Fatigue and so on. The proposed task we sort out major symptoms affected by several people using rough set theory. This task used strength, certainty factor, and coverage factor of the decision rule represents a though flow of the corresponding branch. The certainty factor of the decision rules to find out results: 88% middle-age man, 81% middle-age women, 92% old-age man, 86% old-age women have covid-19 symptoms, test positive, the average of 15% middle-age man and old-age man have covid-19 symptoms is not present, test negative, the average of 16.5% middle-age women and old-age women have covid-19 symptoms is not present, test negative and all healthy young man have covid-19 negative test and the coverage factors finding following test results: 70% middle-age man, 58% middle-age women, 92% old-age man, 72% old-age women have covid-19 symptoms, test positive, the average of 1% middle-age man and old-age man have covid-19 symptoms is not present, test negative, the average of 2.5% middle-age women and old-age women have covid-19 symptoms is not present, test negative. Using RST the result we got assures that the patients P_1, P_3, P_6, P_8 are surely affected by COVID-19 whereas other patients are not affected. This article helps the common people, reader, researcher to use his or her own imagination and knowledge about whether infected people may or may not develop mild to moderate illness and recover without hospitalization, otherwise seek immediate medical attention.

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