Journal Template File

Taylor & Francis
Taylor & Francis Group

The Application of Topological Concepts to the Investigation of COVID-19 (Modified) Symptoms

Ali Abd Alhussein Zyarah*
Iraqi Ministry of Education
General Directorate of Education for the Holy Karbala
Karbala, Iraq.

Zahrah Ismael Salman§
University of Missan
College of Basic Education
Department of Mathematics
Iraq.

Mohammed Baqer Hashim al Hakeem ‡
Iraqi Ministry of Education
General Directorate of Education for the Holy Karbala
Karbala, Iraq.

Noora A.Al-Mothafar [4]
University of Baghdad
College of Science
Department of Biology
Baghdad, Iraq.

Ahmed Hadi Hussain [5]
University of Babylon
College of Engineering Al-Musayab
Department of Energy Engineering
Babil, Iraq.

Abstract
We examine 10 hypothetical patients suffering from some of the symptoms of COVID 19 (Modified) using topological concepts on topological spaces created from equality and similarity interactions and our information system. This is determined by the degree of accuracy obtained by weighing the value of the lower and upper figures. In practice, this approach has become clearer.

Keywords: *topology, Roughsets,similarity, accuracy,lower and upperapproximation.*

**E-mail:* aliziara107@gmail.com
§*E-mail:* zismeal@gmail.com
‡ *E-mail:* mbhmsc2015110@gmail.com
5 E-mail: met.ahmed.hadi@uobabylon.edu.iq

1. Introduction

Thepresent era is marked by a proliferation of computers capable of collecting vast amounts of data on any subject, and this knowledge enables you to make an informed decision. Now we needto develop mathematical techniques for this data that will aid in its analysis and extraction of knowledge [1, 2].

It is now distinguished by a huge number of computers capable of gathering vast amounts of data on any topic. You can make a decision based on this data. We'll need to build mathematical techniques to help us interpret and derive data from this data.

Topologicaluses of thetheory of material transition through topological techniques in science and technology earned the Nobel Prize in Physics in 2016 [11]. The Roughsettheory, which is focused on topological concepts, is among the most popular mathematical techniques [3]. The idea of approximate sets was proposed by Pawlak [2]. Roughly set theory has been the technique of data base mining or information discovery in relation to information bases since the beginning [4, 5]. The fundamental premise of theroughset approach is that lowering the degree of data accuracy makes the data model more accessible. Awareness, according to anthropology, is the capacity to classify. Heretofore, Pawlak [2] used an equivalence relationship, which was thought to be a significant constraint, so studies preferred to use an uneven relationship.

Inthis article, we use similarity relationships tofind and evaluate object neighborhoods, measure the degree of association of features with statistical data, and use this credentialing to extract effective features [6]. In this article, we will discuss some of the effects of respiratory system inflammation, and a variety of cases of inflammation resulting from the simple treatment of chronic conditions such as asthma and pneumonia, whom the patient suffers from all over his life. Covid-19 and Covid-19(Modified) are two respiratory conditions which are harder to control and can be lethal. Thedegree of association between patients and symptoms of respiratory tract inflammation and other symptoms that are more linked to respiratory tract disorders is investigated in this paper using interior and closure topological concepts.

2. Preliminaries

Therequirement to describe subsets of a universeset within terms of equivalence classes of adivision of that universe set motivates and use of rough set theory. Thedivision of equivalence classes is regarded as a topologicalspace. S = (U, B, D) is an information structure in which U, B, and D are finite, nonempty sets. U stands for universesets, B for Attributes, and D for Attribute Instances. In addition, equivalence classes are denoted by $R_u, u \in U$ and R_x is denoted by in conjunction with D of attribute B.

Definition (2.1)[3]:Let A be asubset of atopologicalspace (X,τ), theunion of allopen setscontained in A iscalled theinterior of aset A and denoted by int(A) or A°. Theinterior of aset A isthelargest openset contained in A i.e., $A^\circ = \{U \subseteq X : U \subseteq A, U \in \tau\}$, U is openset. Theintersection ofall closedsets containing A is called theclosure of aset A anddenotedby cl(A) or $\overline{A}$, i.e,. $\overline{A} = \{F \subseteq X : A \subseteq F, F \in \tau^c\}$, where F isthe closedset.

Definition (2.2) [2]: Supposethat weare givenknowledgebase $I = (U, R)$, witheachsubset $X \subseteq U$ and anequivalencerelation $R \in IND(I)$, weassociate twosubsets:

$\underline{P(X)} = \bigcup\{u \in U : R_u \subseteq R_X\}$ and $\overline{P(X)} = \bigcup\{u \in U : R_u \cap R_X \neq \phi\}$.

Twoapproximations $\overline{P(X)}$ and $\underline{P(X)}$ calledthe upperapproximation and lowerapproximationof X respectively. Also, theaccuracy of theapproximation is definedby

$\alpha(X) = \dfrac{\left|\underline{P(X)}\right|}{\left|\overline{P(X)}\right|}$, $0 \leq \alpha(X) \leq 1$. If aset X withaccuracy equalto 1 is crisp, otherwise X isrough.

Definition (2.3) [6]: For each $A \subseteq B$, therelation $RA \subseteq U \times U$ defined

$xR_A y = \dfrac{\left|\sum_{i=1}^{5} (b(x_i) = a(y_i))\right|}{5}$, where $|.|$ isthe cardinalityof A also $a, b \in U$ and x_i, y_i denotedtothe similarsymptoms.

Inthispaper $U = \{u_1, u_2, u_3, u_4, u_5, u_6, u_7, u_8, u_9, u_{10}\}$ ispatients, $B = \{X, Y, Z, T, W\}$ issymptoms of inflammationof respiratorysystem and D is classify ofsymptoms as inapplication down.

3. Relation-Generated Topological Spaces

We look at facts from ten hypothetical patients that have arespiratory disease who are experiencing thefollowing symptoms: trouble breathing, high temperature, cough, muscle pain, and loss of smell and taste, which is the greatest sign of infection. We use the symbol $\{u_1, u_2, u_3, u_4, u_5, u_6, u_7, u_8, u_9, u_{10}\}$ to represent the ten patients, as well as the following symbols to represent symptoms:

1. The symbol X represents the symptom of breathing trouble, and is graded as a heavy case X_α, a mild case X_β, or a plain case X_γ.

2. Symptom temperature by thesymbol Y, whereitisclassified into veryhightemperature Y_α, hightemperature Y_β and simpletemperature Y_γ.

3. Cough is represented by the symbol Z, and it is divided into three types: dry coughing Z_α, cough with mucus Z_β, and attic cough Z_γ.

4. Symptommusclepain by thesymbol *T*, and it is divided into three categories: heavy pain T_α, mild pain T_β and plain pain T_γ.

5. Symptomlossof thesense ofsmellandtaste by thesymbol W, whereitis classifiedinto Lossof thesense of smellandtaste W_α, Lossofsenseofsmell W_β and Lossofsense oftaste W_γ.

Table 1: Informationsystem

	X	Y	Z	T	W
u_1	X_β	Y_β	Z_β	T_β	W_β
u_2	X_γ	Y_γ	Z_β	T_γ	W_β
u_3	X_β	Y_β	Z_β	T_α	W_α
u_4	X_β	Y_β	Z_α	T_γ	W_α
u_5	X_β	Y_α	Z_α	T_γ	W_β
u_6	X_α	Y_β	Z_α	T_β	W_α
u_7	X_α	Y_β	Z_α	T_γ	W_α
u_8	X_α	Y_β	Z_γ	T_α	W_γ
u_9	X_γ	Y_α	Z_γ	T_β	W_γ
u_{10}	X_γ	Y_α	Z_γ	T_α	W_γ

Part 1: And according to Pawlak method, we create patient classes R_u based on prior symptoms, while patient classes are created based on the fair distribution of all symptoms, calculated based on the following class:

$$R_U = \left\{ \{u_1\},\{u_2\},\{u_3\},\{u_4\},\{u_5\},\{u_6\}, \{u_7\},\{u_8\},\{u_9\},\{u_{10}\}\right\}$$

In the following scenarios, we explain the aforementioned symptoms using a table 1:

Case 1:

The class of symptom R_X trouble breathing occurs in table 1, which includes three groups of patients based on their pain:

$$X_\gamma = \{u_2,u_9,u_{10}\}, X_\beta = \{u_1,u_3,u_4,u_5\}, X_\alpha = \{u_6,u_7,u_8\}$$

Similarly, the types of other conditions such as temperature, cough, muscle pain, and lack of smell and taste appear in table 1. It contains the following sets based on symptom situation: It displays the following patient types, R_Y, R_Z, R_T and R_W contains the following sets based on symptom situation:

$$Y_\gamma = \{u_2,u_3\}, Y_\beta = \{u_1,u_4,u_6,u_7,u_8\}, Y_\alpha = \{u_5,u_9,u_{10}\}$$

$$Z_\gamma = \{u_8,u_9,u_{10}\}, Z_\beta = \{u_1,u_2,u_3\}, Z_\alpha = \{u_4,u_5,u_6,u_7\}$$

$$T_\gamma = \{u_2,u_4,u_5,u_7\}, T_\beta = \{u_1,u_6,u_9\}, T_\alpha = \{u_3,u_8,u_{10}\}$$

$$W_\gamma = \{u_7,u_8,u_9,u_{10}\}, W_\beta = \{u_1,u_2,u_5\}, W_\alpha = \{u_3,u_4,u_6\}$$

The degree of association between all of the data and respiratory difficulties is $\alpha(X) = 1$. This indicates that the credentialing rate is100%. Wewill find the lower and upper approximation in patient classes for other symptoms such as fever Y, cough Z, muscle pain T, and lack of smell and taste W, and so we can find that the credentialing ratio of the total details and each of the other symptoms is 100%.

Case 2:

Table 1 indicates the equivalence class R_{XY} of patients with the symptoms XY of breathing difficulty X and temperature Y:

$$R_{XY} = \left\{\{u_1,u_4\},\{u_2\},\{u_3\},\{u_5\},\{u_6,u_7,u_8\},\{u_9,u_{10}\}\right\}$$

Now that we've found the lower and upper approximations, we'll have a 100% degree ofthe credentialing for all of the data on XY. Similarly, wefind thelower and upper approximation of patient classeswith *XZ, XT, XW, YZ , YT, YW , ZT , ZW , TW , XY Z, XYT, XYW , YZT , YZW, ZTW* and the degree of credentialing between both of them is 100%.

Part 2: The degree of similarities between patients is represented by a similarity matrix. We create the elements of this similarity matrix by adding the number of identical symptoms between each pair of patients and dividing it by the total number of symptoms; these elements are the degree of similarity. i.e.

The degree of similarities $= \frac{\left|\sum_{i=1}^{5} (b(x_i) = a(y_i))\right|}{5}$ The number 5 denotes the presence of Covid-19(Modified) disease symptoms.

$$\begin{bmatrix} 1 & \frac{3}{5} & \frac{3}{5} & \frac{2}{5} & \frac{3}{5} & \frac{1}{5} & \frac{1}{5} & \frac{1}{5} & \frac{1}{5} & 0 \\ \frac{3}{5} & 1 & \frac{3}{5} & 0 & \frac{2}{5} & 0 & 0 & 0 & \frac{1}{5} & \frac{1}{5} \\ \frac{3}{5} & \frac{3}{5} & 1 & \frac{2}{5} & \frac{2}{5} & \frac{1}{5} & 0 & 0 & 0 & 0 \\ \frac{2}{5} & 0 & \frac{2}{5} & 1 & \frac{2}{5} & \frac{4}{5} & \frac{3}{5} & \frac{1}{5} & 0 & 0 \\ \frac{3}{5} & \frac{2}{5} & \frac{2}{5} & \frac{2}{5} & 1 & \frac{1}{5} & \frac{1}{5} & 0 & \frac{1}{5} & \frac{1}{5} \\ \frac{1}{5} & 0 & \frac{1}{5} & \frac{4}{5} & \frac{1}{5} & 1 & \frac{4}{5} & \frac{2}{5} & 0 & 0 \\ \frac{1}{5} & 0 & 0 & \frac{3}{5} & \frac{1}{5} & \frac{4}{5} & 1 & \frac{3}{5} & \frac{1}{5} & \frac{1}{5} \\ \frac{1}{5} & 0 & 0 & \frac{1}{5} & 0 & \frac{2}{5} & \frac{3}{5} & 1 & \frac{3}{5} & \frac{3}{5} \\ 0 & \frac{1}{5} & 0 & 0 & \frac{1}{5} & 0 & \frac{1}{5} & \frac{3}{5} & 1 & 1 \\ 0 & \frac{1}{5} & 0 & 0 & \frac{1}{5} & 0 & \frac{1}{5} & \frac{3}{5} & 1 & 1 \end{bmatrix}$$

We included to classify patients based on their equals; now, weclassify patients basedon their degree of similarity $\frac{1}{5}$, so wehave the following topological approximation space based on degreeof similarity $\frac{1}{5}$:

$$R_{u_{(\frac{1}{5})}} = \{\{u_6, u_7, u_8\}, \{u_9, u_{10}\}, \{u_6\}, \{u_8\}, \{u_6, u_7, u_9, u_{10}\}, \{u_1, u_3, u_5\}, \{u_1, u_5, u_9, u_{10}\}, \{u_1, u_4\}, \{u_2, u_5, u_7\}\}$$

In the following instances, we will address these classes using table 1:

Case 1:

Table 1 from symptom breathing trouble X revealed that theclasses R_X include three groups of patients based on their discomfort. We now need to locate the lower and upper approximations in patientclasses $R_{u_{(\frac{1}{5})}}$ for classes R_X . Then, based on the degree of similarity $\frac{1}{5}$, the credentialing degree between total knowledge and symptom X is $\alpha(X)=\frac{9}{10}$, indicating that the credentialing ratio is 90%. In the same way, the credentialing ratio for symptom Y is 60%. Although Z has a 40% credentialing ratio, T has a 70% credentialing ratio, and W has a 40% credentialing ratio.

Case 2:

The following are the classes R_{XY} of XY symptoms, as seen in table 1. When we combine thelower and upper approximations of patientclasses $R_{u_{(\frac{1}{5})}}$ with classes R_{XY} , we get the following:

$R_{XY}=\{\{u_1,u_4\},\{u_2\},\{u_3\},\{u_5\},\{u_6,u_7,u_8\},\{u_9,u_{10}\}\}$ and $\alpha(XY)=\frac{7}{10}$.

This equates to a 70% percent credentialing ratio R_{XZ} . Furthermore, the credentialing percentage of signs XZ is 40%. Similarly, the lower and upper approximation of patient classes with XW, YZ, YT, YW, ZT, ZW, TW, all have a 40% percent degree of similarity, with the exception of thelower and upper approximation of patient classes with XT, which has a 70% percent credentialing ratio.

Case 3:

The following classes R_{XYZ} of symptoms XYZ appear in table 1:

$R_{XYZ}=\{\{u_1\},\{u_2\},\{u_3\},\{u_4\},\{u_5\},\{u_6,u_7\},\{u_8\},\{u_9,u_{10}\}\}$

We get $\alpha(XYZ)=\frac{4}{10}$ by finding the lower and upper approximation of patientclasses $R_{u_{(\frac{1}{5})}}$. This implies that the credentialing ratio among both information and symptom XYZ is 40%, which is the same as the ratio for symptoms XYT, XYW, XZT, XZW, XWT, YZT, YZW, ZTW, and ZTW.

Case 4:

The following classes R_{XYZT} of symptoms XYZT appear in table 1:

$R_{XYZT}=\{\{u_6,u_7\},\{u_9,u_{10}\}\}$. We get $\alpha(XYZ)=\frac{3}{10}$ by finding the lower and upper approximation of patientclasses $R_{u_{(\frac{1}{5})}}$.

This implies that the credentialing ratio among both information and symptom XYZ is 40%, which is the same as the ratio for symptoms. This indicates that the credentialing ratio is 30%. Similarly, the credentialing ratio for the symptom XYZW is found to be 20%. YZTW has a 30% credentialing ratio, while XZTW has a 20% credentialing ratio.

References

1. Lellis Thivagar, M. and S. Priyalatha, *Medical diagnosis in a indiscernibility matrix based on nano topology.* Cogent mathematics, 2017. **4**(1): p. 1330180.
2. Pawlak, Z., *Rough sets.* International journal of computer & information sciences, 1982. **11**(5): p. 341-356.
3. Lashin, E., et al., *Rough set theory for topological spaces.* International Journal of Approximate Reasoning, 2005. **40**(1-2): p. 35-43.
4. Kozae, A., M. Elsafty, and M. Swealam, *Neighbourhood and reduction of knowledge.* AISS, 2012. **4**: p. 247-253.
5. Kang, X., et al., *Rough set model based on formal concept analysis.* Information Sciences, 2013. **222**: p. 611-625.
6. Alharthi, T. and M. Elsafty, *Attribute topologies based similarity.* Cogent Mathematics & Statistics, 2016. **3**(1): p. 1242291.
7. Zyarah, A.A.A. and N.S. Al-Mothafar, *On primary radical RΓ-submodules of RΓ-modules.* Journal of Discrete Mathematical Sciences and Cryptography, 2020. **23**(5): p. 1001-1007.
8. Zyarah, A.A.A. and N.S. Al-Mothafar, *Semiprime RΓ-Submodules of Multiplication RΓ-Modules.* Iraqi Journal of Science, 2020: p. 1104-1114.
9. Zyarah, A.A.A. and N.S. Al-Mothafar. *On S-Prime and S-Semiprime RΓ-Submodules of RΓ-Module*. in *Journal of Physics: Conference Series*. 2021. IOP Publishing.
10. Al-Mothafar, N.S. and A.A.A. Zyarah, *SEMI-PRIMARY RΓ-SUBMODULE OF MULTIPLICATION RΓ-MODULES.*