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Research Article

Effective Fuzzy Soft Set Theory and Its Applications

Shawkat Alkhazaleh

Shawkat Alkhazaleh Department of Mathematics, Faculty of Science and Information Technology, Jadara University, Irbid, Jordan

Correspondence should be addressed to Shawkat Alkhazaleh; shmk79@gmail.com

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Fuzzy soft set is the most powerful and effective extension of soft sets which deals with parameterized values of the alternative. It is an extended model of soft set and a new mathematical tool that has great advantages in dealing with uncertain information and is proposed by combining soft sets and fuzzy sets. Many fuzzy decision making algorithms based on fuzzy soft sets were given. However, these do not consider the external effective on the decision it depends on the parameters without considering any external effective. In order to solve these problems, in this paper, we introduce the concept of effective fuzzy soft set and its operation and study some of its properties. We also give an application of this concept in decision making (DM) problem. Finally, we give an application of this theory to medical diagnosis (MD) and exhibit the technique with a hypothetical case study.

1. Introduction

Currently, many researchers try to find suitable solutions to some uncertainty in mathematics that the classical methods cannot solve it since the classical methods cannot solve all the uncertainty decision making problems in economy, engineering, medicine, and others. Fuzzy set is one of these solutions defined by Zadeh as new mathematical tool [1] which was published in 1965. Molodtsove [2] defined one of the most important solutions as a general mathematical tool for dealing with uncertain, fuzzy, not clearly defined objects which is a soft set theory where Maji et al. [3] went deep into the study of this theory through defining some operations such as AND, OR, union, and intersection. Then, Maji and Roy [4] apply a soft sets theory to find a solution for some decision making problems using rough mathematics. In 2008, Majumdar and Samanta [5] proposed some similarity measures between soft sets and gave an application of these similarities to solve DM problems, and then Kharal and Ahmad [6] defined new definitions and applications on the similarity measure between soft sets. In 2001, as a combination between fuzzy and soft sets, Maji et al. [7] proposed a theory of fuzzy soft set and many researchers have studied this concept and its properties with applications such as Roy and Maji [8], in 2007, and Feng et al. [9]. Chaudhuri and De [10] gave an attention on soft relation and fuzzy soft relation and they used these concepts to solve some of the decision making problems. On the other hand, Majumdar and Samanta [11] in 2010 presented generalised fuzzy soft sets theory and studied some of its properties and their applications in DM problems and MD problems. Çağman et al. [12] proposed a new DM method by using a theory of fuzzy parameterized fuzzy soft sets and they also in 2011 [13] proposed a DM method based on fuzzy parameterized-soft sets theory. Alkhazaleh et al. [14] and as a combination between soft multiset [15] and fuzzy set defined the concept of fuzzy soft multiset with its application in DM. They also generalised the concepts of fuzzy parameterized fuzzy soft set (FPFSS) to fuzzy parameterized interval-valued fuzzy soft set (FPIVFSS) [16] and FPFSS to possibility fuzzy soft set [17] and gave some applications in DM and MD problems. One of the most important concepts related to soft set is soft expert set defined by Alkhazaleh and Salleh [18] which is generalised later by the same authors to fuzzy soft expert set theory [19] and they also presented the applications of these two theories in DM and MD problems. Certainty and coverage of a parameter defined by Renukadevi and Sangeetha in 2020 [20] as a new concept are related to the soft set and they presented a new approach using the certainty of a parameter to solve a DM problem over the soft universe. Debnath in his paper in 2021 [21] proposed a fuzzy hypersoft set as a combination between fuzzy set and hypersoft set. The adaptability of this hypothesis is to handle the parameterized issues of instability as more as compared to fuzzy soft set. In 2021, Phaengtan et. al. [22] defined partial averages of fuzzy soft sets and presented a new algorithm for solving some DM problems based on partial averages. Furthermore, they also showed that this algorithm is practical for solving DM problems. Močkoř and Hurtík in 2021 [23] defined fuzzy soft relations and introduced the fuzzy soft approximation of fuzzy soft sets related to this relation. They also used fuzzy soft approximations in selective color segmentation problem, where authoritative and fully automated methods do not yet exist. They proposed three novel hybrid models and presented some properties of these models and defined multi-(Q, N)−soft rough approximation operators in terms of multi-(Q, N)−soft relations. For more information, see [24, 25].

When studying soft sets and their applications, all researchers deal with the parameters and the universal set, ignoring external effective that may affect their decisions. In this research, we will study for the first time the extent of the effect of external effectiveness on soft sets and on the outcome of decisions issued by these sets. Firstly, we define the concept of effective fuzzy soft set (EFRSS) and some definitions related to this concept are given and we use these definitions to solve DM problems by giving a new algorithm. A medical diagnosis method (MD) is established for EFSS setting using similarity measures. Lastly, a numerical example is given to demonstrate the possible application of similarity measures in (MD).

2. Preliminary

In this section, we review some definitions relevant to this work. The soft set defined by Molodtsov can be expressed as the following: let U be a set of universe, E be a set of parameters, and $P(U)$ denote the power set of U and $A \subseteq E$.

Definition 1 (see [2]). A pair (F, A) is called a *soft set* over U, where F is a mapping

$$F\colon A \longrightarrow P(U). \tag{1}$$

Reference [7] generalised soft set of [2] to fuzzy soft set. In this section, we will review some definitions and properties related to fuzzy soft set theory, which we will use in our work. The following definitions and propositions are due to [7].

Definition 2. Let U be an initial universal set, E be a set of parameters, and I^U be the power set of fuzzy set of U. Let $A \subseteq E$ and (F, E) is a pair called a fuzzy soft set over U where F is a mapping given by

$$F\colon A \longrightarrow I^U. \tag{2}$$

Definition 3. The union of two fuzzy soft sets (F, A) and (G, B) over a common universe U is the fuzzy soft set (H, C) where $C = A \cup B$, and $\forall \varepsilon \in C$,

$$H(\varepsilon) = \begin{cases} F(\varepsilon), & \text{if } \varepsilon \in A - B, \\ G(\varepsilon), & \text{if } \varepsilon \in B - A, \\ (F(\varepsilon), G(\varepsilon)), & \text{if } \varepsilon \in A \cap B, \end{cases} \tag{3}$$

where s is any s-norm.

Definition 4. The intersection of two fuzzy soft sets (F, A) and (G, B) over a common universe U is the fuzzy soft set (H, C) where $C = A \cup B$, and $\forall \varepsilon \in C$,

$$H(\varepsilon) = \begin{cases} F(\varepsilon), & \text{if } \varepsilon \in A - B, \\ G(\varepsilon), & \text{if } \varepsilon \in B - A, \\ t(F(\varepsilon), G(\varepsilon)), & \text{if } \varepsilon \in A \cap B, \end{cases} \tag{4}$$

where t is any t-norm.

3. Effective Fuzzy Soft Set (EFSS)

In this section, we generalise the concept of fuzzy soft sets as introduced by Maji et al. [7]. In our generalisation of fuzzy soft set, an effective set is applied with the parameterization of fuzzy sets while defining a fuzzy soft set. Let us start with definitions of effective set and effect scale, respectively, which are introduced for the first time.

Definition 5. An effective set is a fuzzy set Λ in a universe of discourse A where Λ is a function $\Lambda\colon A \longrightarrow [0, 1]$. A is the set of effective parameters that may change the membership values by making positive effect (or no effect) on values of memberships after applying it and defined as follows:

$$\Lambda = \{\langle a, \delta_\Lambda(a)\rangle\colon a \in A\}. \tag{5}$$

Definition 6. Let U be an initial universal set, E be a set of parameters, A be a set of effective parameters, and Λ be the effective set over A. Let I^U denote all fuzzy subsets of U; a pair $(F, E)_\Lambda$ is called an effective fuzzy soft set (EFSS in short) over U where F is a mapping given by

$$F\colon E \longrightarrow I^U, \tag{6}$$

defined as follows:

$$F(e_i)_\Lambda = \left\{\frac{x_j}{\mu_U(x_j)_\Lambda}\colon x_j \in U, e_i \in E\right\}, \tag{7}$$

where $\forall a_k \in A$,

$$\mu_U(x_j)_\Lambda = \begin{cases} \mu_U(x_j) + \left[\dfrac{(1-\mu_U(x_j))\sum_k \delta_{\Lambda_{x_j}}(a_k)}{|A|}\right], & \text{if } \mu_U(x_j) \in (0,1), \\ \mu_U(x_j), & \text{O.W.} \end{cases} \quad (8)$$

Example 1. Let $U = \{x_1, x_2, x_3\}$ be a set of universe. Let $E = \{e_1, e_2, e_3, e_4, e_5, e_6\}$ be a set of parameters and let $A = \{a_1, a_2, a_3, a_4\}$ be a set of effective parameters. Suppose that the effective set over A for all $\{x_1, x_2, x_3\}$ is given by expert as follows:

$$\begin{aligned} \Lambda(x_1) &= \left\{\frac{a_1}{0.8}, \frac{a_2}{1}, \frac{a_3}{0}, \frac{a_4}{0.2}\right\}, \\ \Lambda(x_2) &= \left\{\frac{a_1}{0.4}, \frac{a_2}{0.5}, \frac{a_3}{0}, \frac{a_4}{0.8}\right\}, \\ \Lambda(x_3) &= \left\{\frac{a_1}{1}, \frac{a_2}{1}, \frac{a_3}{0.7}, \frac{a_4}{0.6}\right\}. \end{aligned} \quad (9)$$

Let the fuzzy soft set F be defined as follows:

$$\begin{aligned} F(e_1) &= \left\{\frac{x_1}{0.3}, \frac{x_2}{0.7}, \frac{x_3}{0.5}\right\}, \\ F(e_2) &= \left\{\frac{x_1}{0.5}, \frac{x_2}{0.6}, \frac{x_3}{0.6}\right\}, \\ F(e_3) &= \left\{\frac{x_1}{0.7}, \frac{x_2}{0.6}, \frac{x_3}{0.5}\right\}, \\ F(e_4) &= \left\{\frac{x_1}{0.8}, \frac{x_2}{0.4}, \frac{x_3}{0.4}\right\}, \\ F(e_5) &= \left\{\frac{x_1}{0.6}, \frac{x_2}{0.9}, \frac{x_3}{0.3}\right\}, \\ F(e_6) &= \left\{\frac{x_1}{0.2}, \frac{x_2}{0.4}, \frac{x_3}{0.7}\right\}. \end{aligned} \quad (10)$$

After applying Definition 6 on F, we obtain the following:

$$F_\Lambda(e_1) = \left\{\frac{x_1}{0.3 + 0.7[(0.8+1+0+0.2)/4]}, \frac{x_2}{0.7 + 0.3[(4+0.5+0+0.8)/4]}, \frac{x_3}{0.5 + 0.5[(1+1+0.7+0.6)/4]}\right\}. \quad (11)$$

Then, we have $F_\Lambda(e_1) = \{x_1/0.65, x_2/0.83, x_3/0.91\}$.

By using the same method, we get the following EFSS:

$$\begin{aligned} (F_\Lambda, E) = \Bigg\{ &\left(e_1, \left\{\frac{x_1}{0.65}, \frac{x_2}{0.83}, \frac{x_3}{0.91}\right\}\right), \left(e_2, \left\{\frac{x_1}{0.75}, \frac{x_2}{0.77}, \frac{x_3}{0.93}\right\}\right), \left(e_3, \left\{\frac{x_1}{0.85}, \frac{x_2}{0.77}, \frac{x_3}{0.91}\right\}\right), \left(e_4, \left\{\frac{x_1}{0.9}, \frac{x_2}{0.66}, \frac{x_3}{0.9}\right\}\right), \\ &\left(e_5, \left\{\frac{x_1}{0.8}, \frac{x_2}{0.94}, \frac{x_3}{0.88}\right\}\right), \left(e_6, \left\{\frac{x_1}{0.6}, \frac{x_2}{0.66}, \frac{x_3}{0.95}\right\}\right)\Bigg\}. \end{aligned} \quad (12)$$

Definition 7. The union and intersection of two effective sets Λ' and Λ'' over the set of effective parameters A is the effective set Λ_s and Λ_t, respectively, where s is any s-norm and t is any t-norm.

Definition 8. The complement of effective set Λ over the set of effective parameters A is the effective set Λ^c where c is any fuzzy complement.

Definition 9. The $\Lambda_{\text{complement}}$ of the EFSS (F_Λ, E) is the EFSS (F_{Λ^c}, E), where Λ^c is any fuzzy complement of Λ.

Here, we keep the fuzzy soft set F as is and find the fuzzy complement of the effective set Λ, and then we apply equation (6) to get a new EFSS.

Definition 10. The $\text{Soft}_{\text{complement}}$ of the EFSS (F_Λ, E) is the EFSS (F^c_Λ, E), where F^c is the fuzzy soft complement of F.

Here, we find the fuzzy soft complement of F which is F^c and keep the effective set Λ as is, then we apply equation (6) to get a new EFSS.

Definition 11. The $\text{Total}_{\text{complement}}$ of the EFSS (F_Λ, E) is the EFSS $(F^c_{\Lambda^c}, E)$, where F^c is the fuzzy soft complement of F and Λ^c is any fuzzy complement of Λ.

Here, we find the fuzzy soft complement of F which is F^c and the fuzzy complement of the effective set Λ which is Λ^c, then we apply Definition 6 to get a new EFSS.

Example 2. Consider Example 1. Let

$$\begin{aligned}
\Lambda(x_1) &= \left\{\frac{a_1}{0.8}, \frac{a_2}{1}, \frac{a_3}{0}, \frac{a_4}{0.2}\right\},\\
\Lambda(x_2) &= \left\{\frac{a_1}{0.4}, \frac{a_2}{0.5}, \frac{a_3}{0}, \frac{a_4}{0.8}\right\},\\
\Lambda(x_3) &= \left\{\frac{a_1}{1}, \frac{a_2}{1}, \frac{a_3}{0.7}, \frac{a_4}{0.6}\right\}.
\end{aligned} \tag{13}$$

By using the basic fuzzy complement of effective set Λ, we get the following effective set Λ^c:

$$\begin{aligned}
\Lambda^c(x_1) &= \left\{\frac{a_1}{0.2}, \frac{a_2}{0}, \frac{a_3}{1}, \frac{a_4}{0.8}\right\},\\
\Lambda^c(x_2) &= \left\{\frac{a_1}{0.6}, \frac{a_2}{0.5}, \frac{a_3}{1}, \frac{a_4}{0.2}\right\},\\
\Lambda^c(x_3) &= \left\{\frac{a_1}{0}, \frac{a_2}{0}, \frac{a_3}{0.3}, \frac{a_4}{0.4}\right\}.
\end{aligned} \tag{14}$$

Also, let

$$\begin{aligned}
F(e_1) &= \left\{\frac{x_1}{0.3}, \frac{x_2}{0.7}, \frac{x_3}{0.5}\right\},\\
F(e_2) &= \left\{\frac{x_1}{0.5}, \frac{x_2}{0.6}, \frac{x_3}{0.6}\right\},\\
F(e_3) &= \left\{\frac{x_1}{0.7}, \frac{x_2}{0.6}, \frac{x_3}{0.5}\right\},\\
F(e_4) &= \left\{\frac{x_1}{0.8}, \frac{x_2}{0.4}, \frac{x_3}{0.4}\right\},\\
F(e_5) &= \left\{\frac{x_1}{0.6}, \frac{x_2}{0.9}, \frac{x_3}{0.3}\right\},\\
F(e_6) &= \left\{\frac{x_1}{0.2}, \frac{x_2}{0.4}, \frac{x_3}{0.7}\right\},
\end{aligned} \tag{15}$$

be the fuzzy soft set, and by using the fuzzy soft complement over F, we have the following fuzzy soft set:

$$\begin{aligned}
F^c(e_1) &= \left\{\frac{x_1}{0.7}, \frac{x_2}{0.3}, \frac{x_3}{0.5}\right\},\\
F^c(e_2) &= \left\{\frac{x_1}{0.5}, \frac{x_2}{0.4}, \frac{x_3}{0.4}\right\},\\
F^c(e_3) &= \left\{\frac{x_1}{0.3}, \frac{x_2}{0.6}, \frac{x_3}{0.5}\right\},\\
F^c(e_4) &= \left\{\frac{x_1}{0.2}, \frac{x_2}{0.6}, \frac{x_3}{0.6}\right\},\\
F^c(e_5) &= \left\{\frac{x_1}{0.6}, \frac{x_2}{0.9}, \frac{x_3}{0.3}\right\},\\
F^c(e_6) &= \left\{\frac{x_1}{0.2}, \frac{x_2}{0.6}, \frac{x_3}{0.6}\right\}.
\end{aligned} \tag{16}$$

By using Definitions 9, 10, and 11 with applying Definition 6, we obtain the following $Total_{complement}$, $\Lambda_{complement}$, and $Soft_{complement}$, respectively:

$$\begin{aligned}
(F^c_{\Lambda^c}, E) = \Bigg\{&\left(e_1, \left\{\frac{x_1}{0.85}, \frac{x_2}{0.7}, \frac{x_3}{0.59}\right\}\right), \left(e_2, \left\{\frac{x_1}{0.75}, \frac{x_2}{0.75}, \frac{x_3}{0.5}\right\}\right), \left(e_3, \left\{\frac{x_1}{0.65}, \frac{x_2}{0.63}, \frac{x_3}{0.59}\right\}\right), \left(e_4, \left\{\frac{x_1}{0.6}, \frac{x_2}{0.83}, \frac{x_3}{0.67}\right\}\right),\\
&\left(e_5, \left\{\frac{x_1}{0.8}, \frac{x_2}{0.95}, \frac{x_3}{0.43}\right\}\right), \left(e_6, \left\{\frac{x_1}{0.6}, \frac{x_2}{0.83}, \frac{x_3}{0.47}\right\}\right)\Bigg\},\\
(F_{\Lambda^c}, E) = \Bigg\{&\left(e_1, \left\{\frac{x_1}{0.65}, \frac{x_2}{0.87}, \frac{x_3}{0.59}\right\}\right), \left(e_2, \left\{\frac{x_1}{0.75}, \frac{x_2}{0.83}, \frac{x_3}{0.67}\right\}\right), \left(e_3, \left\{\frac{x_1}{0.85}, \frac{x_2}{0.83}, \frac{x_3}{0.59}\right\}\right), \left(e_4, \left\{\frac{x_1}{0.9}, \frac{x_2}{0.75}, \frac{x_3}{0.5}\right\}\right),\\
&\left(e_5, \left\{\frac{x_1}{0.8}, \frac{x_2}{0.96}, \frac{x_3}{0.43}\right\}\right), \left(e_6, \left\{\frac{x_1}{0.6}, \frac{x_2}{0.75}, \frac{x_3}{0.75}\right\}\right)\Bigg\}.
\end{aligned} \tag{17}$$

Definition 12. The union of two EFSSs $(F_{\Lambda'}, E_1)$ and $(G_{\Lambda''}, E_2)$ over a common universe U is the EFSS (H_{Λ_s}, E) where $E = E_1 \cup E_2$ and $\forall v \in E$,

$$H_{\Lambda_s}(v) = \begin{cases} F_{\Lambda_s}(v), & \text{if } v \in E_1 - E_2, \\ G_{\Lambda_s}(v), & \text{if } v \in E_2 - E_1, \\ (F \cup G)_{\Lambda_s}(v), & \text{if } v \in E_1 \cap E_2, \end{cases} \tag{18}$$

where s is any s-norm and H is the fuzzy soft union between F and G.

The idea of this union is to create a new effective set Λ_s resulting from the union of Λ' and Λ'' and then apply this set to the fuzzy soft set H, resulting from the union of F and G by using Definition 6.

Example 3. Consider Example 1. Let

$$\begin{aligned} \Lambda'(x_1) &= \left\{\frac{a_1}{0.8}, \frac{a_2}{1}, \frac{a_3}{0}, \frac{a_4}{0.2}\right\}, \\ \Lambda'(x_2) &= \left\{\frac{a_1}{0.4}, \frac{a_2}{0.5}, \frac{a_3}{0}, \frac{a_4}{0.8}\right\}, \\ \Lambda'(x_3) &= \left\{\frac{a_1}{1}, \frac{a_2}{1}, \frac{a_3}{0.7}, \frac{a_4}{0.6}\right\}, \\ \Lambda''(x_1) &= \left\{\frac{a_1}{0.7}, \frac{a_2}{0.8}, \frac{a_3}{0.2}, \frac{a_4}{0.2}\right\}, \\ \Lambda''(x_2) &= \left\{\frac{a_1}{0.4}, \frac{a_2}{0.6}, \frac{a_3}{0.1}, \frac{a_4}{0.8}\right\}, \\ \Lambda''(x_3) &= \left\{\frac{a_1}{0.9}, \frac{a_2}{0.8}, \frac{a_3}{0.8}, \frac{a_4}{0.7}\right\}, \end{aligned} \tag{19}$$

be any two effective sets given by two different experts. Also, let

$$(F, E_1) = \left\{\left(e_1, \left\{\frac{x_1}{0.8}, \frac{x_2}{0.6}, \frac{x_3}{0.9}\right\}\right), \left(e_3, \left\{\frac{x_1}{0.5}, \frac{x_2}{0.7}, \frac{x_3}{0.8}\right\}\right), \left(e_4, \left\{\frac{x_1}{0.6}, \frac{x_2}{0.7}, \frac{x_3}{0.8}\right\}\right), \left(e_6, \left\{\frac{x_1}{0.6}, \frac{x_2}{0.6}, \frac{x_3}{0.9}\right\}\right)\right\}, \tag{20}$$

be a fuzzy soft set over $E_1 \subset E$, and let

$$(G, E_2) = \left\{\left(e_1, \left\{\frac{x_1}{0.7}, \frac{x_2}{0.7}, \frac{x_3}{0.8}\right\}\right), \left(e_2, \left\{\frac{x_1}{0.8}, \frac{x_2}{0.6}, \frac{x_3}{0.4}\right\}\right), \left(e_3, \left\{\frac{x_1}{0.5}, \frac{x_2}{0.7}, \frac{x_3}{0.8}\right\}\right), \left(e_4, \left\{\frac{x_1}{0.7}, \frac{x_2}{0.6}, \frac{x_3}{0.9}\right\}\right), \left(e_5, \left\{\frac{x_1}{0.4}, \frac{x_2}{0.5}, \frac{x_3}{0.7}\right\}\right)\right\}, \tag{21}$$

be a fuzzy soft set over $E_2 \subset E$.

By using the basic fuzzy union (max), we have the following effective set:

$$\begin{aligned} \Lambda_s(x_1) &= \left\{\frac{a_1}{0.8}, \frac{a_2}{1}, \frac{a_3}{0.2}, \frac{a_4}{0.2}\right\}, \\ \Lambda_s(x_2) &= \left\{\frac{a_1}{0.4}, \frac{a_2}{0.6}, \frac{a_3}{0.1}, \frac{a_4}{0.8}\right\}, \\ \Lambda_s(x_3) &= \left\{\frac{a_1}{1}, \frac{a_2}{1}, \frac{a_3}{0.8}, \frac{a_4}{0.7}\right\}. \end{aligned} \tag{22}$$

Also, by using the basic fuzzy soft union, we have the following fuzzy soft set (H, E) (in this example $E = E_1 \cup E_2$):

$$(H,E)=\left\{\left(e_1,\left\{\frac{x_1}{0.8},\frac{x_2}{0.7},\frac{x_3}{0.9}\right\}\right),\left(e_2,\left\{\frac{x_1}{0.8},\frac{x_2}{0.6},\frac{x_3}{0.4}\right\}\right),\left(e_3,\left\{\frac{x_1}{0.5},\frac{x_2}{0.7},\frac{x_3}{0.8}\right\}\right),\left(e_4,\left\{\frac{x_1}{0.7},\frac{x_2}{0.7},\frac{x_3}{0.9}\right\}\right),\left(e_5,\left\{\frac{x_1}{0.4},\frac{x_2}{0.5},\frac{x_3}{0.7}\right\}\right),\left(e_6,\left\{\frac{x_1}{0.6},\frac{x_2}{0.6},\frac{x_3}{0.9}\right\}\right)\right\}. \tag{23}$$

Then, by using Definitions 12 and 6, we obtain the following EFSS (H_{Λ_s},E):

$$\left(H_{\Lambda_s},E\right)=\left\{\left(e_1,\left\{\frac{x_1}{0.99},\frac{x_2}{0.9},\frac{x_3}{0.99}\right\}\right),\left(e_2,\left\{\frac{x_1}{0.99},\frac{x_2}{0.88},\frac{x_3}{0.93}\right\}\right),\left(e_3,\left\{\frac{x_1}{0.78},\frac{x_2}{0.91},\frac{x_3}{0.98}\right\}\right),\left(e_4,\left\{\frac{x_1}{0.87},\frac{x_2}{0.9},\frac{x_3}{0.99}\right\}\right),\left(e_5,\left\{\frac{x_1}{0.77},\frac{x_2}{0.85},\frac{x_3}{0.96}\right\}\right),\left(e_6,\left\{\frac{x_1}{0.82},\frac{x_2}{0.88},\frac{x_3}{0.99}\right\}\right)\right\}. \tag{24}$$

Definition 13. The intersection of two EFSSs $(F_{\Lambda'},E_1)$ and $(G_{\Lambda''},E_2)$ over a common universe U is the EFSS (K_{Λ_t},E) where $E=E_1\cup E_2$ and $\forall v\in E$,

$$K_{\Lambda_s}(v)=\begin{cases}F_{\Lambda_t}(v), & \text{if } v\in E_1-E_2,\\ G_{\Lambda_t}(v), & \text{if } v\in E_2-E_1,\\ (F\cap G)_{\Lambda_t}(v), & \text{if } v\in E_1\cap E_2,\end{cases} \tag{25}$$

where t is any t-norm; K is the fuzzy soft intersection between F and G.

The idea of this intersection is to create a new effective set Λ_t resulting from the intersection of Λ' and Λ'' and then apply this set to the fuzzy soft set K resulting from the intersection of F and G by using Definition 6.

Example 4. Consider Example 3.

By using the basic fuzzy intersection (min), we have the following effective set:

$$\begin{aligned}\Lambda_t(x_1)&=\left\{\frac{a_1}{0.7},\frac{a_2}{0.8},\frac{a_3}{0},\frac{a_4}{0.2}\right\},\\ \Lambda_t(x_2)&=\left\{\frac{a_1}{0.4},\frac{a_2}{0.5},\frac{a_3}{0},\frac{a_4}{0.8}\right\},\\ \Lambda_t(x_3)&=\left\{\frac{a_1}{0.9},\frac{a_2}{0.8},\frac{a_3}{0.7},\frac{a_4}{0.6}\right\}.\end{aligned} \tag{26}$$

Also, by using the basic fuzzy soft intersection, we have the following fuzzy soft set (H,E) (in this example $E=E_1\cup E_2$):

$$(K,E)=\left\{\left(e_1,\left\{\frac{x_1}{0.7},\frac{x_2}{0.6},\frac{x_3}{0.8}\right\}\right),\left(e_2,\left\{\frac{x_1}{0.8},\frac{x_2}{0.6},\frac{x_3}{0.4}\right\}\right),\left(e_3,\left\{\frac{x_1}{0.5},\frac{x_2}{0.7},\frac{x_3}{0.8}\right\}\right),\left(e_4,\left\{\frac{x_1}{0.6},\frac{x_2}{0.6},\frac{x_3}{0.8}\right\}\right),\left(e_5,\left\{\frac{x_1}{0.4},\frac{x_2}{0.5},\frac{x_3}{0.7}\right\}\right),\left(e_6,\left\{\frac{x_1}{0.6},\frac{x_2}{0.6},\frac{x_3}{0.9}\right\}\right)\right\}. \tag{27}$$

Then, by using Definitions 13 and 6, we obtain the following EFSS (K_{Λ_t},E):

$$\left(K_{\Lambda_t},E\right)=\left\{\left(e_1,\left\{\frac{x_1}{0.83},\frac{x_2}{0.77},\frac{x_3}{0.95}\right\}\right),\left(e_2,\left\{\frac{x_1}{0.87},\frac{x_2}{0.77},\frac{x_3}{0.85}\right\}\right),\left(e_3,\left\{\frac{x_1}{0.72},\frac{x_2}{0.83},\frac{x_3}{0.95}\right\}\right),\left(e_4,\left\{\frac{x_1}{0.77},\frac{x_2}{0.77},\frac{x_3}{0.95}\right\}\right),\left(e_5,\left\{\frac{x_1}{0.66},\frac{x_2}{0.72},\frac{x_3}{0.93}\right\}\right),\left(e_6,\left\{\frac{x_1}{0.77},\frac{x_2}{0.77},\frac{x_3}{0.98}\right\}\right)\right\}. \tag{28}$$

4. An Effective Fuzzy Soft Set Theoretic Approach to Decision Making Problems

In this section, we give an effective fuzzy soft set theoretic approach to get a solution of decision making problem.

Definition 14 (see [8]). A comparison table is a square table with an equal number of rows and columns, both labelled by the object names $o_1,o_2,o_3,\ldots,o_n$ of the universe, and the entries are c_{ij}, $i,j=1,2,\ldots,n$, given by $c_{ij}=$ the number of parameters for which the membership value of o_i exceeds or is equal to the membership value of o_j.

4.1. Algorithm. Here, we give an algorithm as a modification of the algorithm given by Maji and Roy [8]. Then, we will compare between the original algorithm and the modified algorithm. Firstly, we present the algorithm given by Maji and Roy as follows: let (F, A), (G, B), and (H, C) be three fuzzy soft sets.

(1) Input (F, A), (G, B), and (H, C).
(2) Input the set of parameters P as observed by the observer.
(3) Compute the corresponding resultant fuzzy soft set (S, P) from (F, A), (G, B), and $((H, C)$ and place it in tabular form.
(4) Construct the comparison table of the fuzzy soft set (S, P) and compute r_i and t_i for $o_i, \forall i$.
(5) Compute the score of $o_i, \forall i$.
(6) The decision is S_k if $S_k = \max_i S_i$.
(7) If k has more than one value, then any one of o_k may be chosen.

Then, we give our algorithm as follows:

(1) Input the fuzzy soft sets (F, A) and (G, B).
(2) Input the effective sets of parameters $\mathbb{A}$.
(3) Input the effective sets Λ_F and Λ_G over $\mathbb{A}$ for the fuzzy soft sets (F, A) and (G, B), respectively.
(4) Compute the corresponding resultant EFSS F_{Λ_F} and G_{Λ_G}.
(5) Compute the corresponding resultant EFSS H_Λ from the EFFSs F_{Λ_F} and G_{Λ_G} and place it in tabular form.
(6) Construct the comparison table of the EFSS H_Λ and compute r_i and t_i for $o_i, \forall i$.
(7) Compute the score of $o_i, \forall i$.
(8) The decision is S_k if $S_k = \max_i S_i$.

4.2. Application in a Decision Making Problem. Let $U = \{x_1, x_2, x_3, x_4, x_5, x_6\}$ be a set of cars with the same model. This type of car is manufactured in four countries, and one of these factories is the main factory. Let $E = \{e_1, e_2, e_3, e_4, e_5, e_6\}$ be a set of parameters where e_1 = safety, e_2 = affordable, e_3 = maintenance, e_4 = comfortable, e_5 = performance, and e_6 = reliable. Let $A = \{a_1, a_2, a_3, a_4\}$ be a set of effective parameters where a_1 = all of its parts are made in the original factory, a_2 = it reassembled at the original factory, a_3 = never worked under car Apps, and a_4 = it was not owned by more than one person. Let the effective set over $A, \forall x_i \in U$ given by experts be as follows:

$$\begin{aligned}
\Lambda'(x_1) &= \left\{\frac{a_1}{0.8}, \frac{a_2}{1}, \frac{a_3}{0}, \frac{a_4}{0.2}\right\},\\
\Lambda'(x_2) &= \left\{\frac{a_1}{0.6}, \frac{a_2}{1}, \frac{a_3}{0.5}, \frac{a_4}{0.4}\right\},\\
\Lambda'(x_3) &= \left\{\frac{a_1}{0.2}, \frac{a_2}{0.3}, \frac{a_3}{0}, \frac{a_4}{0.3}\right\},\\
\Lambda'(x_4) &= \left\{\frac{a_1}{0.5}, \frac{a_2}{0.4}, \frac{a_3}{0.3}, \frac{a_4}{0.4}\right\},\\
\Lambda'(x_5) &= \left\{\frac{a_1}{0.7}, \frac{a_2}{0.7}, \frac{a_3}{0.5}, \frac{a_4}{0.8}\right\},\\
\Lambda'(x_6) &= \left\{\frac{a_1}{1}, \frac{a_2}{1}, \frac{a_3}{0.7}, \frac{a_4}{0.6}\right\},\\
\Lambda''(x_1) &= \left\{\frac{a_1}{0.6}, \frac{a_2}{1}, \frac{a_3}{0.1}, \frac{a_4}{0.3}\right\},\\
\Lambda''(x_2) &= \left\{\frac{a_1}{0.5}, \frac{a_2}{1}, \frac{a_3}{0.7}, \frac{a_4}{0.5}\right\},\\
\Lambda''(x_3) &= \left\{\frac{a_1}{0.3}, \frac{a_2}{0.4}, \frac{a_3}{0}, \frac{a_4}{0.4}\right\},\\
\Lambda''(x_4) &= \left\{\frac{a_1}{0.6}, \frac{a_2}{0.6}, \frac{a_3}{0.5}, \frac{a_4}{0.5}\right\},\\
\Lambda''(x_5) &= \left\{\frac{a_1}{0.7}, \frac{a_2}{0.8}, \frac{a_3}{0.4}, \frac{a_4}{0.6}\right\},\\
\Lambda''(x_6) &= \left\{\frac{a_1}{0.9}, \frac{a_2}{0.8}, \frac{a_3}{0.7}, \frac{a_4}{0.6}\right\}.
\end{aligned} \tag{29}$$

Also, let

$$\begin{aligned}
(F, E_1) = \Bigg\{&\left(e_1, \left\{\frac{x_1}{0.8}, \frac{x_2}{0.6}, \frac{x_3}{0.9}, \frac{x_4}{0.4}, \frac{x_5}{0.8}, \frac{x_6}{0.3}\right\}\right), \left(e_3, \left\{\frac{x_1}{0.5}, \frac{x_2}{0.7}, \frac{x_3}{0.8}, \frac{x_4}{0.6}, \frac{x_5}{0.7}, \frac{x_6}{0.8}\right\}\right), \left(e_4, \left\{\frac{x_1}{0.6}, \frac{x_2}{0.7}, \frac{x_3}{0.8}, \frac{x_4}{0.6}, \frac{x_5}{0.2}, \frac{x_6}{0.3}, \right\}\right),\\
&\cdot \left(e_6, \left\{\frac{x_1}{0.6}, \frac{x_2}{0.6}, \frac{x_3}{0.9}, \frac{x_4}{0.7}, \frac{x_5}{0.6}, \frac{x_6}{0.5}\right\}\right)\Bigg\},
\end{aligned} \tag{30}$$

be a fuzzy soft set over $E_1 \subset E$, and let

$$(G,E_2)=\left\{\left(e_1,\left\{\frac{x_1}{0.6},\frac{x_2}{0.5},\frac{x_3}{0.8},\frac{x_4}{0.3},\frac{x_5}{0.7},\frac{x_6}{0.4}\right\}\right),\left(e_2,\left\{\frac{x_1}{0.4},\frac{x_2}{0.5},\frac{x_3}{0.7},\frac{x_4}{0.4},\frac{x_5}{0.5},\frac{x_6}{0.5}\right\}\right),\left(e_3,\left\{\frac{x_1}{0.6},\frac{x_2}{0.8},\frac{x_3}{0.9},\frac{x_4}{0.6},\frac{x_5}{0.6},\frac{x_6}{0.7}\right\}\right),\right.$$
$$\left.\left(e_4,\left\{\frac{x_1}{0.6},\frac{x_2}{0.9},\frac{x_3}{0.7},\frac{x_4}{0.7},\frac{x_5}{0.4},\frac{x_6}{0.4}\right\}\right),\left(e_5,\left\{\frac{x_1}{0.8},\frac{x_2}{0.8},\frac{x_3}{0.9},\frac{x_4}{0.7},\frac{x_5}{0.5},\frac{x_6}{0.6}\right\}\right)\right\}, \tag{31}$$

be a fuzzy soft set over $E_2 \subset E$.

Now, let the parameter set $P = E$ be as observed by the observer. To using Maji and Roy algorithm, we firstly find (H, E) which is the union of (F, E_1) and (G, E_2) as follows:

$$(H,E)=\left\{\left(e_1,\left\{\frac{x_1}{0.8},\frac{x_2}{0.6},\frac{x_3}{0.9},\frac{x_4}{0.4},\frac{x_5}{0.8},\frac{x_6}{0.4}\right\}\right),\left(e_2,\left\{\frac{x_1}{0.4},\frac{x_2}{0.5},\frac{x_3}{0.7},\frac{x_4}{0.4},\frac{x_5}{0.5},\frac{x_6}{0.5}\right\}\right),\left(e_3,\left\{\frac{x_1}{0.6},\frac{x_2}{0.8},\frac{x_3}{0.9},\frac{x_4}{0.6},\frac{x_5}{0.7},\frac{x_6}{0.8}\right\}\right),\right.$$
$$\left.\left(e_4,\left\{\frac{x_1}{0.6},\frac{x_2}{0.9},\frac{x_3}{0.8},\frac{x_4}{0.7},\frac{x_5}{0.4},\frac{x_6}{0.4}\right\}\right),\left(e_5,\left\{\frac{x_1}{0.8},\frac{x_2}{0.8},\frac{x_3}{0.9},\frac{x_4}{0.7},\frac{x_5}{0.5},\frac{x_6}{0.6}\right\}\right),\left(e_6,\left\{\frac{x_1}{0.6},\frac{x_2}{0.6},\frac{x_3}{0.9},\frac{x_4}{0.7},\frac{x_5}{0.6},\frac{x_6}{0.5}\right\}\right)\right\}. \tag{32}$$

The tabular representation of resultant fuzzy soft set (H, E) will be, as in Table 1.

The comparison table of the above resultant fuzzy soft set is in Table 2.

Now, we compute the row-sum, column-sum, and the score for each o_i as shown in Table 3:

It is clear that our decision is to select Car 3 since the maximum score is 28, scored by x_3. To use our algorithm, firstly, we use the basic fuzzy union (max) to get the new effective set Λ_s from Λ' and Λ'' as follows:

$$\begin{aligned}
\Lambda_s(x_1)&=\left\{\frac{a_1}{0.8},\frac{a_2}{1},\frac{a_3}{0.1},\frac{a_4}{0.3}\right\},\\
\Lambda_s(x_2)&=\left\{\frac{a_1}{0.6},\frac{a_2}{1},\frac{a_3}{0.7},\frac{a_4}{0.5}\right\},\\
\Lambda_s(x_3)&=\left\{\frac{a_1}{0.3},\frac{a_2}{0.4},\frac{a_3}{0},\frac{a_4}{0.4}\right\},\\
\Lambda_s(x_4)&=\left\{\frac{a_1}{0.6},\frac{a_2}{0.6},\frac{a_3}{0.5},\frac{a_4}{0.5}\right\},\\
\Lambda_s(x_5)&=\left\{\frac{a_1}{0.7},\frac{a_2}{0.8},\frac{a_3}{0.5},\frac{a_4}{0.8}\right\},\\
\Lambda_s(x_6)&=\left\{\frac{a_1}{1},\frac{a_2}{1},\frac{a_3}{0.7},\frac{a_4}{0.6}\right\}.
\end{aligned} \tag{33}$$

Then, by using the FSS (H, E) as above, Definitions 12 and 6, we obtain the following EFSS (H_{Λ_s}, E):

$$(H,E)=\left\{\begin{array}{l}\left(e_1,\left\{\frac{x_1}{0.8},\frac{x_2}{0.6},\frac{x_3}{0.9},\frac{x_4}{0.4},\frac{x_5}{0.8},\frac{x_6}{0.4}\right\}\right),\left(e_2,\left\{\frac{x_1}{0.4},\frac{x_2}{0.5},\frac{x_3}{0.7},\frac{x_4}{0.4},\frac{x_5}{0.5},\frac{x_6}{0.5}\right\}\right),\left(e_3,\left\{\frac{x_1}{0.6},\frac{x_2}{0.8},\frac{x_3}{0.9},\frac{x_4}{0.6},\frac{x_5}{0.7},\frac{x_6}{0.8}\right\}\right),\\ \left(e_4,\left\{\frac{x_1}{0.6},\frac{x_2}{0.9},\frac{x_3}{0.8},\frac{x_4}{0.7},\frac{x_5}{0.4},\frac{x_6}{0.4}\right\}\right),\left(e_5,\left\{\frac{x_1}{0.8},\frac{x_2}{0.8},\frac{x_3}{0.9},\frac{x_4}{0.7},\frac{x_5}{0.5},\frac{x_6}{0.6}\right\}\right),\left(e_6,\left\{\frac{x_1}{0.6},\frac{x_2}{0.6},\frac{x_3}{0.9},\frac{x_4}{0.7},\frac{x_5}{0.6},\frac{x_6}{0.5}\right\}\right)\end{array}\right\}. \tag{34}$$

The tabular representation of resultant EFSS (H_{Λ_s}, E) will be as in Table 4.

The comparison table of the above resultant effective fuzzy soft set is in Table 5.

Now, we compute the row-sum, column-sum, and the score for each o_i as shown in Table 6.

It is clear that our decision is to select Car 6 since the maximum score is 17, scored by x_6, and by comparing with

Table 1: Tabular representation of (H, E).

U	e_1	e_2	e_3	e_4	e_5	e_6
x_1	0.8	0.4	0.6	0.6	0.8	0.6
x_2	0.6	0.5	0.8	0.9	0.8	0.6
x_3	0.9	0.7	0.9	0.8	0.9	0.9
x_4	0.4	0.4	0.6	0.7	0.7	0.7
x_5	0.8	0.5	0.7	0.4	0.5	0.6
x_6	0.4	0.5	0.8	0.4	0.6	0.5

Table 2: Comparison table of (H, E).

U	x_1	x_2	x_3	x_4	x_5	x_6
x_1	6	3	0	4	3	4
x_2	5	6	1	5	5	6
x_3	6	5	6	6	6	6
x_4	4	1	0	6	3	4
x_5	4	3	0	3	6	4
x_6	2	2	0	3	4	6

Table 3: o_i scores.

	Row-sum (r_i)	Column-sum (t_i)	Score (S_i)
x_1	20	27	−7
x_2	28	20	8
x_3	35	7	28
x_4	18	27	−9
x_5	20	27	−7
x_6	17	30	−13

Table 4: Tabular representation of (H_{Λ_s}, E).

U	e_1	e_2	e_3	e_4	e_5	e_6
x_1	0.91	0.73	0.82	0.82	0.91	0.82
x_2	0.88	0.85	0.94	0.97	0.94	0.88
x_3	0.93	0.78	0.93	0.86	0.93	0.93
x_4	0.73	0.73	0.82	0.87	0.82	0.87
x_5	0.94	0.85	0.91	0.82	0.85	0.88
x_6	0.9	0.92	0.97	0.9	0.93	0.92

Maji and Roy algorithm, we conclude that the effective set Λ_s made the change in decision from Car 3 to Car 6.

5. Application of EFSS in Medical Diagnosis

There are many applications and theories that seek to facilitate the process of medical diagnosis, but each of these applications and theories take into account the symptoms that appear on the patient without looking at external effects that can change the diagnosis completely. In this section, we will try for the first time to find the closest diagnosis of the disease, depending on the symptoms and external effects.

Table 5: Comparison table of (H_{Λ_s}, E).

U	x_1	x_2	x_3	x_4	x_5	x_6
x_1	6	1	0	4	2	1
x_2	5	6	4	6	5	1
x_3	6	2	6	5	4	3
x_4	4	0	1	6	1	0
x_5	5	3	2	5	6	1
x_6	5	4	4	6	5	6

Table 6: o_i scores of (H_{Λ_s}, E).

	Row-sum (r_i)	Column-sum (t_i)	Score (S_i)
x_1	14	31	−17
x_2	27	16	11
x_3	26	17	9
x_4	12	32	−20
x_5	22	23	−1
x_6	30	13	17

Table 7: Patients daily activities and lives.

P	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9
p_1	Yes	Yes	No	Yes	Yes	No	No	No	Yes
p_2	No	No	Yes	No	Yes	No	Yes	Yes	Yes
p_3	Yes	No	No	No	No	Yes	Yes	No	No
p_4	No	No	No	Yes	Yes	No	No	Yes	No

Table 8: Parameters-diseases relation.

D	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	$\|A_j\|$
d_1	Yes	Yes	Yes	Yes	No	No	No	No	No	4
d_2	Yes	No	No	No	No	Yes	Yes	No	No	3
d_3	Yes	No	No	No	No	Yes	Yes	No	No	3
d_4	Yes	No	No	No	Yes	No	No	Yes	Yes	4

Table 9: Tabular representation of $\Lambda_{d_1}(p_i)$.

(p_i)	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	Sum
p_1d_1	1	1	0	1	0	0	0	0	0	3
p_2d_1	0	0	1	0	0	0	0	0	0	1
p_3d_1	1	0	0	0	0	0	0	0	0	1
p_4d_1	0	0	0	0	1	0	0	0	0	1

Assume that $P = \{p_1, p_2, p_3, p_4\}$ be a set of 4 patients in the hospital. The hospital diagnostic expert identified the following symptoms to find out what patients were suffering from:

$$S = \{s_1, s_2, s_3, s_4, s_5, s_6, s_7, s_8, s_9, s_{10}, s_{11}, s_{12}, s_{13}, s_{14}, s_{15}, s_{16}, s_{17}, s_{18}, s_{19}, s_{20}\}, \tag{35}$$

Table 10: Tabular representation of $\Lambda_{d_2}(p_i)$.

p_i	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	Sum
p_1d_2	1	0	0	0	0	0	0	0	0	1
p_2d_2	0	0	0	0	0	0	1	0	0	1
p_3d_2	1	0	0	0	0	1	1	0	0	3
p_4d_2	0	0	0	0	0	0	0	0	0	0

Table 11: Tabular representation of $\Lambda_{d_3}(p_i)$.

p_i	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	Sum
p_1d_3	1	0	0	0	0	0	0	0	0	1
p_2d_3	0	0	0	0	0	0	0	1	0	1
p_3d_3	1	0	0	0	0	1	1	0	0	3
p_4d_3	0	0	0	0	0	0	0	0	0	0

Table 12: Tabular representation of $\Lambda_{d_4}(p_i)$.

p_i	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	Sum
p_1d_4	1	0	0	0	1	0	0	0	1	3
p_2d_4	0	0	0	0	1	0	0	1	1	3
p_3d_4	1	0	0	0	0	0	0	0	0	1
p_4d_4	0	0	0	0	1	0	0	1	0	2

Table 13: Tabular representation of (F, S) part 1.

P	s_1	s_2	s_3	s_4	s_5	s_6	s_7	s_8	s_9	s_{10}
p_1	0.2	0.1	0.1	0.7	0.8	0.4	0	0	0.1	0
p_2	0.7	0.5	0.1	0	0.8	0.9	0.6	0.2	0.3	0
p_3	0.8	0.7	0.2	0	0.6	0.1	0.7	0	0.2	0
p_4	0.6	0.7	0.7	0.9	0.5	0.1	0.6	0.6	0.4	0.9

Table 14: Tabular representation of (F, S) part 2.

P	s_{11}	s_{12}	s_{13}	s_{14}	s_{15}	s_{16}	s_{17}	s_{18}	s_{19}	s_{20}
p_1	0.7	0.2	0.9	0.7	0.6	0.9	0	0.1	0.7	0.7
p_2	0.7	0.7	1	0.8	0	0	0.6	0.4	0.6	0
p_3	0.1	0	0.9	1	0.7	0	0.6	0.6	0.4	0
p_4	0.1	0.6	0.1	0.2	0	0.2	0	0	0	0

Table 15: Tabular representation of (G, S) (Part 1).

D	s_1	s_2	s_3	s_4	s_5	s_6	s_7	s_8	s_9	s_{10}
d_1	1	1	1	1	0.5	0	0.5	0.5	0.5	1
d_2	0	0	0	0.5	1	0.5	0	0	0	0
d_3	1	0.5	0	0	1	0	1	0	0	0
d_4	1	0.5	0	0	1	1	1	0	0	0

Table 16: Tabular representation of (G, S) (Part 2).

D	s_{11}	s_{12}	s_{13}	s_{14}	s_{15}	s_{16}	s_{17}	s_{18}	s_{19}	s_{20}
d_1	0	0.5	0	0	0	0	0	0	0	0
d_2	1	0	1	1	1	1	0	0	0.5	1
d_3	0	0	1	1	1	0	1	0.5	0.5	0
d_4	0.5	1	1	1	0	0	0.5	0.5	1	0

Table 17: Tabular representation of $(F_{\Lambda_{d_1}}, S)$ part 1.

P	s_1	s_2	s_3	s_4	s_5	s_6	s_7	s_8	s_9	s_{10}
p_1	0.8	0.76	0.76	0.93	0.95	0.85	0	0	0.76	0
p_2	0.76	0.63	0.33	0	0.85	0.93	0.7	0.4	0.48	0
p_3	0.85	0.76	0.4	0	0.7	0.33	0.76	0	0.4	0
p_4	0.7	0.76	0.76	0.93	0.63	0.33	0.7	0.7	0.55	0.93

Table 18: Tabular representation of $(F_{\Lambda_{d_1}}, S)$ (part 2).

P	s_{11}	s_{12}	s_{13}	s_{14}	s_{15}	s_{16}	s_{17}	s_{18}	s_{19}	s_{20}
p_1	0.93	0.8	0.98	0.93	0.9	0.98	0	0.76	0.93	0.93
p_2	0.76	0.76	1	0.85	0	0	0.7	0.55	0.7	0
p_3	0.33	0	0.93	1	0.76	0	0.7	0.7	0.55	0
p_4	0.33	0.7	0.33	0.4	0	0.4	0	0	0	0

Table 19: Tabular representation of $(F_{\Lambda_{d_2}}, S)$ (Part 1).

P	s_1	s_2	s_3	s_4	s_5	s_6	s_7	s_8	s_9	s_{10}
p_1	0.47	0.4	0.4	0.8	0.87	0.6	0	0	0.4	0
p_2	0.8	0.67	0.4	0	0.87	0.93	0.73	0.47	0.53	0
p_3	1	1	1	0	1	1	1	0	1	0
p_4	0.6	0.7	0.7	0.9	0.5	0.1	0.6	0.6	0.4	0.9

Table 20: Tabular representation of $(F_{\Lambda_{d_2}}, S)$ (Part 2).

P	s_{11}	s_{12}	s_{13}	s_{14}	s_{15}	s_{16}	s_{17}	s_{18}	s_{19}	s_{20}
p_1	0.8	0.47	0.93	0.8	0.73	0.93	0	0.4	0.8	0.8
p_2	1	1	1	1	0	0	1	1	1	0
p_3	0.1	0	0.9	1	0.7	0	0.6	0.6	0.4	0
p_4	0.1	0.6	0.1	0.2	0	0.2	0	0	0	0

Table 21: Tabular representation of $(F_{\Lambda_{d_3}}, S)$ (Part 1).

P	s_1	s_2	s_3	s_4	s_5	s_6	s_7	s_8	s_9	s_{10}
p_1	0.47	0.4	0.4	0.8	0.87	0.6	0	0	0.4	0
p_2	0.8	0.67	0.4	0	0.87	0.93	0.73	0.47	0.53	0
p_3	1	1	1	0	1	1	1	0	1	0
p_4	0.6	0.7	0.7	0.9	0.5	0.1	0.6	0.6	0.4	0.9

where s_1 = fever, s_2 = dry cough, s_3 = loose motion, s_4 = shortness of breath or difficulty breathing, s_5 = headache, s_6 = tiredness, s_7 = aches, s_8 = runny nose, s_9 = sore throat, s_{10} = severe pneumonia, s_{11} = rash, e_{12} = diarrhoea, s_{13} = bone and joint pain, s_{14} = nausea, s_{15} = vomiting, s_{16} = pain behind the eyes, s_{17} = chills, s_{18} = sweating, s_{19} = abdominal pain, ands_{20} = swollen glands. Also, let $D = \{d_1, d_2, d_3, d_4\}$ be a set of diseases such that d_1 = COVID-19, d_2 = dengue fever, d_3 = malaria, and d_4 = typhoid.

Suppose $A = \{a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8\}$ be a set of effective parameters, where a_1 = in the past two weeks, he visited a country in Europe, America, Africa, or East Asia, a_2 = he close contacted (less than 6 feet) with anyone who is suffering from COVID-19, a_3 = he works in medical centers, a_4 = he is working in large gatherings or using public

Table 22: Tabular representation of $(F_{\Lambda_{d_3}}, S)$ (Part 2).

P	s_{11}	s_{12}	s_{13}	s_{14}	s_{15}	s_{16}	s_{17}	s_{18}	s_{19}	s_{20}
p_1	0.8	0.47	0.93	0.8	0.73	0.93	0	0.4	0.8	0.8
p_2	1	1	1	1	0	0	1	1	1	0
p_3	0.1	0	0.9	1	0.7	0	0.6	0.6	0.4	0
p_4	0.1	0.6	0.1	0.2	0	0.2	0	0	0	0

Table 23: Tabular representation of $(F_{\Lambda_{d_4}}, S)$ (Part 1).

P	s_1	s_2	s_3	s_4	s_5	s_6	s_7	s_8	s_9	s_{10}
p_1	0.8	0.76	0.76	0.93	0.95	0.85	0	0	0.76	0
p_2	0.93	0.88	0.76	0	0.95	0.98	0.9	0.8	0.83	0
p_3	0.85	0.78	0.4	0	0.7	0.33	0.78	0	0.4	0
p_4	0.8	0.85	0.85	0.95	0.75	0.55	0.8	0.8	0.8	0.95

Table 24: Tabular representation of $(F_{\Lambda_{d_4}}, S)$ (Part 2).

P	s_{11}	s_{12}	s_{13}	s_{14}	s_{15}	s_{16}	s_{17}	s_{18}	s_{19}	s_{20}
p_1	0.7	0.2	0.9	0.7	0.6	0.9	0	0.1	0.7	0.7
p_2	0.93	0.93	1	0.95	0	0	0.9	0.85	0.9	0
p_3	0.33	0	0.93	1	0.78	0	0.7	0.7	0.55	0
p_4	0.55	0.8	0.55	0.6	0	0.6	0	0	0	0

transportation daily, a_5 = he is eating his food in the restaurant or eating fast food, a_6 = he was in an area with stagnant water, especially at dawn and dusk, a_7 = he used to sleep without a cover or mosquito net, a_8 = eating food that is raw or undercooked, and a_9 = eating foods and beverages purchased from street vendors. After talking with patients,

Table 25: $S(p_i, d_j)$.

	d_1	d_2	d_3	d_4	max
p_1	0.28	0.63	0.36	0.4	0.63
p_2	0.3	0.3	0.49	0.68	0.68
p_3	0.26	0.3	0.62	0.57	0.62
p_4	0.65	0.17	0.26	0.38	0.65

we found out the patients daily activities and lives, as in Table 7.

The relation between the above parameters and the given diseases is presented in Table 8.

By using the expertise of the medical team and the information in Tables 7 and 8, we construct the effective sets $\Lambda_{d_j}(p_i)$ for each patient with respect to the given diseases as the representation, Tables 9–12.

Now, suppose the tabular representation of (F, S) (patient symptom) given in Tables 13 and 14.

Also, the tabular representation of (G, S) (model symptom) is given in Tables 15 and 16.

w, we construct the EFSSs using Definition 6 and Tables 13 and 14, as given in Tables 17 and 24.

Finally, we compute the score table by finding the similarity between each row in Tables 17–24 with each row in Tables 15 and 16 and find the maximum value for each patient and the diseases related to these values. We use the following formula to find the similarity:

$$S\left(p_i, d_j\right) = \frac{\sum_l^{20}\left\{\min\left(F_{d_j}(p_i)(s_l), G\left(d_j\right)(s_l)\right)\right\}}{\sum_l^{20}\left\{\min\left(F_{d_j}(p_i)\left(s_j\right), G(d_k)\left(s_j\right)\right)\right\}}. \tag{36}$$

This step can be as follows:

$$S(p_1, d_1) = \frac{\min(0.8, 1) + \min(0.76, 1) + \cdots + \min(0.93, 0) + \min(0.93, 0)}{\max(0.8, 1) + \max(0.76, 1) + \cdots + \max(0.93, 0) + \max(0.93, 0)} = \frac{4.75}{16.7} = 0.28. \tag{37}$$

By similar calculations, consequently, we get the score table, as in Table 25.

It is clear from Table 25 that the first patient suffers from dengue fever, the second patient suffers from typhoid, the third patient suffers from malaria, and the fourth patient suffers from COVID-19

6. Conclusion

As a new tool dealing with uncertainty, we have introduced the effective fuzzy soft set theory which is more efficient and useful and studied some of its properties. We also defined basic operations on effective fuzzy soft sets, such as complement, union, and intersection. The theory has been applied to solve DM and MD problems. In future work, researchers can generalise this concept to interval-valued effective fuzzy soft set and they also can develop it to effective fuzzy soft expert set to give it more efficiency.

Data Availability

No data were used to support this study.

Conflicts of Interest

The author declares no conflicts of interest.

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