Neutrosophic Sets and Systems, Vol. 49, 2022
University of New Mexico

A Maple Code to Perform Operations on Single Valued Neutrosophic Matrices

Said Broumi[1,2], Mohamed Bisher Zeina[3], M. Lathamaheswari[4], Assia Bakali[5], Mohamed Talea[6]

[1,6] Laboratory of Information Processing, Faculty of Science Ben M'Sik, University Hassan II, B.P 7955, Sidi Othman, Casablanca, Morocco, broumisaid78@gmail.com, taleamohamed@yahoo.fr

[2]Regional Center for the Professions of Education and Training (C.R.M.E.F), Casablanca-Settat,

[3]Department of Mathematical Statistics, Faculty of Science, University of Aleppo, Aleppo, Syria; bisher.zeina@gmail.com

[4] Department of Mathematics, Hindustan Institute of Technology and Science; lathamax@gmail.com

[5] Ecole Royale Navale, Boulevard Sour Jdid, B.P 16303 Casablanca, Morocco, assiabakali@yahoo.fr

* Correspondence: broumisaid78@gmail.com

Abstract: In this paper, we present a maple programming code that helps useres and scientific researchers to input single valued neutrosophic matrices, checks whether inputted matrix is single valued neutrosohic matrix, finds the complement of a single valued neutrosophic matrix, calculates score matrix, accuracy matrix and certainty matrix, finds the union and intersection of two single valued neutrosophic matrices, finds addition and product of two single valued neutrosophic matrices, also finds transpose of single valued neutrosophic matrix. This code is very important and useful in decision making problems that depend on single valued neutrosophic data.

Keywords: Maple language; neutrosophic set; operations of matrices; single valued neutrosophic sets

1. Introduction

The idea of fuzzy set was introduced by Zadeh where every element has a degree of membership[1]. In [2], as a generalization of fuzzy set, Atanassov introduced intuitionistic fuzzy set with two degrees for each element namely degree of membership nad degree of non-memebrship. Henceforth, Smarandache introduced neutrosophic set which is based on three independent degrees namely truth membership, indeterminate membership and falsity membership [4]. Single valued and interval valued neutrosophic sets and numbers have many applications in many branches of science including pure mathematics, linear algebra, statistics, probability, operations research, etc., as they are fruitfully address uncertainities as a single numer and interval numbers in the unit interval [0,1] as well [9, 12-13]. Neutrosopihic matrices, a development of neutrosophic theory, are used to deal with uncertainties and have beautiful operations which are very useful in decision making [16]. Many researchers have been presented packages and programming codes to deal with single valued neutrosophic numbers. Various engineering and scientific problems can be solved by linear methods, ut non-trivial examples of these problems may require large amounts of memory to represent and even large amounts of computing time to solve. Memory demands of large arrays can be reduced by partitioning those arrays into smaller sections of processing and loading a few of those sections from disk into virtual memory as they are only needed. Using this way, the computation can run smaller and faster in a time-saved environment. Maple contributes, a good prototyping environment for addressing this problem [3]. Resultant matrices can be obtained by using Macaulay2 and Maple [5]. The Maple package called conley has been introduced in [6], to compute connection and C-connection matrices. Some of the definite integrals involving Residue theory has been evaluated using Maple code in [7]. In [8], special types of Maple codes namely Tan method maple code, Tanh method maple code, Sech method maple code, Cot method maple code and Coth method maple code have been introduced. In [10], Maple code of the cubic algorithm has been proposed for obtaining optimized result of multiobjective decision making problem with box constaints. Practical explanation of SCAToolbox is given in [11]. Minimum arc length of an intuitionistic fuzzy hyperpath is determined using Maple in [14]. In [15], some of the new operations on single-valued neutrosophic matrices have been proposed and applied in a decision making problem. A new Python toolbox for single valued neutrosophic matrices has been proposed in [16]. Orthogonal basis for a set of vectors or a matrix using Householder transformations has been constructed where only rational computtaions required with rational output using Maple in [17]. A Maple package for the symbolic computation of Drazin matrices with multivariate transcendental functions has been introduced in [18]. The approximate value of two Taylor series for the real or complex valued functions of a single variable has been obtained using Maple in [19] where the Maple implementation was stable and effective in evaluating blends using linear-cost Horner form. Maple DEtools have been introduced in [20]. A variety of approaches to study formal multivariate power series and univariate polynomials over such series was provided as a multivariate power series. Its implementation based on idle evaluation techniques and takes advantage of Maple aspect for object oriented programming [21]. The determinant and adjoint of neutrosophic matrix have been determined in [22]. Most of the jobs and proofs of Euclidean geometry can easily be carried out without sine and cosine functions and without introducing differential calculus as well. Using Maple, this concept has been accomplished in [23]. Complex neutrosophic soft matrices were introduced and some of the basic operations namely, complement, union and intersection on these matrices have been presented. Also, a novel algorithm has been developed using complex neutrosophic soft matrices and applied in signal processing [24]. Representation of neutrosophic matrices defined over a neutrosophic field using neutrosophic linear transformation between neutrosophic vector spaces and it was concluded that, every neutrosophic matrix can be represented uniquely by a neutrosophic linear transformation [25]. Neutrosophic matrices are widely used to handle with especially computer science problems in which the inputs are neutrosophic numbers. This kind of matrices and its properties have been proposed in [26]. A Maple package has been introduced for performing the operations on single-valued trapezoidal neutrosophic numbers using (α,β,γ)-cuts [27].The interrelation between the motion parameters and the configuration elements has been investigated by performing 6-degree-of-freedom simulations of the Autorotative flight of Maple seeds [28]. Selected tools offered by Maple and used support contributed by Maplesoft.Inc for professional and modern implementation in the field of scientific computation, modeling and visualizations in economics is mapped in [29]. In this paper, we presented a maple code that deals with single valued neutrosophic matrices which have many applications in various fields of science specially decision making. This code allows users and researchers to do many operations on single valued neutrosophic matrices like addition, product, union, intersection, transpose, etc. The rest of the paper is organized as follows. In section 2, background of single valued neutrosoohic sets and its operations have been presented for better understanding of the present work. In section 3, single valued matrix operatons have been computed using Maple programming. In section 4, conclusion of the present work is given with future directon.

2. Background and Single Valued Neutrosophic Sets

In this section, we will discuss some definitions regarding neutrosophic sets, single valued neutrosophic sets, the set-theoretic operators on single valued neutrosophic set, which will be used in the rest of the paper. However, for details on the single valued neutrosophic sets, one can see(Smarandache,1998,Wang et al, 2014**,** Zhang et al, 2014).

2.1. Definition [4]:Suppose ξ be an universal set. The neutrosophic set A on the universal set ξ categorized in to three membership functions called the true T_A(x), indeterminate I_A(x) and false F_A(x) contained in real standard or non-standard subset of]-0, 1+[respectively.

$$-0 \leq \sup T_A(x) + \sup I_A(x) + \sup F_A(x) \leq 3+ \quad (1)$$

2.2. Definition [12]:suppose ξ be a space of points (objects)with a generic element in ξ denoted by x. A single valued neutrosophic set (SVNS) A in ξ is characterized by truth-membership function T_A, indeterminacy-membership functionI_A, andfalsity-membershipfunctionF_A. Foreachpoint x ∈ ξ, $T_A(x)$, $I_A(x)$, $F_A(x) \in [0,1]$.

$$A_{\mathrm{SVNS}} = \{\langle T_A(x), I_A(x), F_A(x)\rangle : \mathrm{x} \in \xi\}$$

$$\text{with} \quad 0 \leq T_A(x)+I_A(x)+F_A(x) \leq 3 \quad (2)$$

2.3. Definition [12] : Suppose two interval valued neutrosophic sets

$$A_{\mathrm{SVNS}} = \{\langle T_A(x), I_A(x), F_A(x)\rangle : \mathrm{x} \in \xi\}$$

and

$$B_{\mathrm{SVNS}} = \{\langle T_B(x), I_B(x), F_B(x)\rangle : \mathrm{x} \in \xi\}$$

the set-theoretic operators on the interval neutrosophic set are defined as follow.

1. An single valued neutrosophic set A is contained in another single valued neutrosophic set B, $A_{SVNS} \subseteq B_{SVNS}$, if and only if

   $T_A(x) \leq T_B(x)$,

   $I_A(x) \geq I_B(x)$,

   $F_A(x) \geq F_B(x)$, for all $x \in \xi$.

2. Two singlevalued neutrosophic sets A and B are equal, written as $A_{SVNS} = B_{SVNS}$, if and only if A $\subseteq$ B and B $\subseteq$ A, i.e.

   $T_A(x) = T_B(x)$,

   $I_A(x) = I_B(x)$,

   $F_A(x) = F_B(x)$,

for all $x \in \xi$.

3. A single neutrosophic set A is empty if and only if

   $T_A(x) = 0$,$I_A(x) = 1$ and$F_A(x) = 0$,for all $x \in \xi$.

   The complement of a single neutrosophic set A is denoted by A^c and is defined by

   $A_{SVNS}{}^c = \{x, [F_A(x)], [1 - I_A(x),], [T_A(x),] : x \in X\}$,

for all x in ξ.

4. The intersection of two singlevalued neutrosophic sets A and B is a singlevalued neutrosophic set$A \cap B$defined as follow

$$A_{SVNS} \cap B_{SVNS} = \{\langle x, [T_A(x) \wedge T_B(x)], [I_A(x) \vee I_B(x)], [F_A(x) \vee F_B(x)] \rangle : x \in \xi\}, \text{for all } x \text{ in } \xi. \quad (3)$$

5. The union of two single valued neutrosophic sets A and B is a single valued neutrosophic set $A_{IVNS} \cup B_{SVNS}$defined as follow:

$$A_{SVNS} \cup B_{SVNS} = \left\{ \langle \begin{matrix} x, [T_A^L(x) \vee T_B^L(x), T_A^U(x) \vee T_B^U(x)], \\ [I_A^L(x) \wedge I_B^L(x), I_A^U(x) \wedge I_B^U(x)], \\ [F_A^L(x) \wedge F_B^L(x), F_A^U(x) \wedge F_B^U(x)] \end{matrix} \rangle : x \in \xi \right\}, \text{for all } x \text{ in } \xi. \quad (4)$$

6. The difference of two single valued neutrosophic sets A and B is single valued neutrosophic set $A_{SVNS} \ominus B_{SVNS}$defined as follow: $A \ominus B$=<$[T_{A\ominus B}, T^U_{A\ominus B}]$, $[I_{A\ominus B}, I^U_{A\ominus B}]$, $[F_{A\ominus B}, F^U_{A\ominus B}]$ (5)

where

$T_{A\ominus B}$=min$(T_A(x), F_B(x))$,

$I_{A\ominus_2 B}$= $\max(I_A(x), 1 - I_B(x))$,

$F_{A\ominus_2 B}$=$\max(F_A(x), T_B(x))$,

[15] introduced a new difference operation for the single valued neutrosophic sets as follow:

A$\ominus_2$B=<$T_{A\ominus_2 B}$, $I_{A\ominus_2 B}$, $F_{A\ominus_2 B}$]> (6)

where

$T_{A\ominus_2 B}$=$T_A(x) - F_B(x)$,

$I_{A\ominus_2 B}$= $\max(I_A(x), I_B(x))$,

$F_{A\ominus_2 B}$=$F_A(x) - T_B(x)$,

for all x in ξ.

7. The scalar multiplication of single valued neutrosophic set A is $A_{SVNS}.a$, defined as follow

$A_{SVNS}.a = \{\langle x, \min(T_A^L(x).a, 1), \min(I_A^L(x).a, 1), \min(F_A^L(x).a, 1)\rangle : x \in \xi\}$for all x ∈ ξ, a ∈ R+.

8. The scalar division of single neutrosophic set A is A_{SVNS}/adefined as follow

$$A_{IVNS}/a == \{\langle x, \min(T_A^L(x)/ a, 1), \min(I_A^L(x)/ a, 1), \min(F_A^L(x)/a, 1)\rangle : x \in \xi\}$$

for all x ∈ ξ, $a \in R^+$

the convenient method for comparing single valued neutrosophic and interval valued neutrosophic numbers can be done by using score function.

2.4 Definition [22]: Suppose A be an interval neutrosophic numberA_{IVNN}, the score function is defined as follow :

$\tilde{S}_{IVNN}(x)$=$\frac{T_A^L(x)+T_A^U(x)+4-I_A^L(x)-I_A^U(x)-F_A^L(x)-F_A^U(x)}{6}$ (7)

$\tilde{S}_{SVNN}(x)$=$\frac{2+T_A(x)-I_A(x)-F_A(x)}{3}$

$\tilde{A}_{IVNN}(x)$=$\frac{T_A^L(x)+T_A^U(x)-F_A^L(x)-F_A^U(x)}{2}$

$\tilde{A}_{SVNN}(x)$=$T_A(x) - F_A(x)$

$\tilde{C}_{IVNN}(x)$=$\frac{T_A^L(x)+T_A^U(x)}{2}$

$\tilde{C}_{SVNN}(x)$=$T_A(x)$

2.5 Definition [12]:A single valued valued neutrosophic matrix(SVNM) of order m$\times$ n is defined as

A_{SVNM}=$[< a_{ij}, a_{ij_T}, a_{ij_I}, a_{ij_F} >]_{\mathrm{m}\times\,\mathrm{n}}$ where

a_{ij_T} is the membership value of element a_{ij} in A.

a_{ij_I} is the indeterminate-membership value of element a_{ij} in A.

$a^{L}_{ij_F}$ is the non- membership value of element a_{ij} in A.

For simplicity, we write A as

$$A_{\mathrm{SVNM}}= [< a_{ij_T}, a_{ij_I}, a_{ij_F} >]_{\mathrm{m}\times\,\mathrm{n}} \quad (8)$$

3. Computing the Single Valued Neutrosophic Matrix Operations using Maple Language

In this section, the Maple program is developed for inputting the single valued neutrosophic matrices as follows:

3.1. Inputting SVNM to Maple

Here, for inputting SVNM to Maple, simply call the function SVNMInput(m,n) where m, n are numbers of rows and columns respectively and the code is described as follows:

```
interface(warnlevel=0):with(Maplets[Elements]):with(Maplets):
SVNMInput:=proc(m::integer,n::integer)
local mat:=Matrix(m,n);
for i from 1 to m by 1 do
for j from 1 to n by 1 do
truth:=Maplet(InputDialog['x'](cat("Enter truth of element
",i,",",j),'onapprove'=Shutdown(['x']),'oncancel'=Shutdown()));
truth:=parse(op(Display(truth)));
indeterminacy:=Maplet(InputDialog['x'](cat("Enter indeterminacy of element
",i,",",j),'onapprove'=Shutdown(['x']),'oncancel'=Shutdown()));
indeterminacy:=parse(op(Display(indeterminacy)));
falsity:=Maplet(InputDialog['x'](cat("Enter falsity of element
",i,",",j),'onapprove'=Shutdown(['x']),'oncancel'=Shutdown()));
falsity:=parse(op(Display(falsity)));
mat(i,j):=convert([truth,indeterminacy,falsity],string);
end do;
end do;
mat;
```

```
end proc:
```

3.1.1. Checking the matrix is SVNM or not

To generate the Maple program for deciding if a given matrix (say mat) is single valued neutrosophic matrix or not, simply call the function **SVNMChecking (mat)** is defined as follow:

```
SVNMChecking:=proc(mat)
IsMembership:=proc(num)
if num<0 or num>1 then return false else return true end if;
end proc:
m,n:=LinearAlgebra[Dimension](mat);
result:=true;
for i from 1 to m by 1 do
for j from 1 to n by 1 do
x:=parse(mat(i,j));
truth:=x[1];
indeterminacy:=x[2];
falsity:=x[3];
result:= IsMembership(x[1]) and IsMembership(x[2]) and IsMembership(x[3]);
if not result then break; end if;
end do;
if not result then break; end if;
end do;
if result then cat("your matrix is a single valued neutrosophic matrix") else cat("your matrix is not a single valued neutrosophic matrix") end if;
end proc:
```

Example 1. In this example we evaluate the checking the matrix is SVNM or not of the single valued neutrosophic matrix E of order 4X4:

E=

$$\begin{pmatrix} <.5,.7,.2> & <.4,.4,.5> & <.7,.7,.5> & <.1,.5,.7> \\ <.9,.7,.5> & <.7,.6,.8> & <.9,.4,.6> & <.5,.2,.7> \\ <.9,.4,.2,> & <.2,.2,.2> & <.9,.5,.5> & <.7,.5,.3> \\ <.9,.7,.2,> & <.3,.5,.2> & <.5,.4,.5> & <.2,.4,.8> \end{pmatrix}$$

The single valued neutrosophic matrix E can be inputted in Maple code like this:

E:=SVNMInput(4,4);

Then an input box dialogue is going to appear and lead you how to input elements.

The result of checking the matrix is SVNM or not E can be obtained by the call of the command SVNMChecking (E);

And the result will be:

"your matrix is a single valued neutrosophic matrix"

3.2. Determining complement of single valued neutrosophic matrix

For a given SVNM A= $[< T_{ij}, I_{ij}, F_{ij} >]_{m\times n}$, the complement of A is defined as follow:

A^c= $[< \{1\} - T_{ij}, \{1\} - I_{ij}, \{-1\} - F_{ij}]_{m\times n}$ (9)

A^c= $[< F_{ij}, \{1\} - I_{ij}, T_{ij},]_{m\times n}$ (10)

To generate the Maple program for finding complement of single valued neutrosophic matrix, simple call of the function**SVNMCompelementOf1 (mat)** is defined as follow:

The function SVNMCompelementOf1 (mat) the below returns the complement matrix of a given single valued neutrosophic matrix mat for (9).

```
SVNMCompelementOf1:=proc(mat::Matrix)
temp:=LinearAlgebra[Copy](mat);
m,n:=LinearAlgebra[Dimension](temp);
for i from 1 to m by 1 do
for j from 1 to n by 1 do
x:=parse(temp(i,j));
truth:=1-x[1];
indeterminacy:=1-x[2];
```

```
falsity:=1-x[3];

temp(i,j):=convert([truth,indeterminacy,falsity],string);

end do;

end do;

temp;

end proc:
```

Example 2. Evaluate the complement of matrix E in example 1.

So, the complement of single valued neutrosophic matrix E is portrayed as follow:

$$E^c = \begin{pmatrix} <.5,.3,.8> & <.6,.6,.5> & <.3,.3,.5> & <.9,.5,.3> \\ <.1,.3,.5> & <.3,.4,.2> & <.1,.6,.4> & <.5,.8,.3> \\ <.1,.6,.8> & <.8,.8,.8> & <.1,.5,.5> & <.3,.5,.7> \\ <.1,.3,.8,> & <.7,.5,.8> & <.5,.6,.5> & <.8,.6,.2> \end{pmatrix}$$

The result of the complement of single valued neutrosophic matrix E can be obtained by the call of the command SVNMCompelementOf1(E);

SVNMCompelementOf1(E);

$$\begin{bmatrix} "[.5, .3, .8]" & "[.6, .6, .5]" & "[.3, .3, .5]" & "[.9, .5, .3]" \\ "[.1, .3, .5]" & "[.3, .4, .2]" & "[.1, .6, .4]" & "[.5, .8, .3]" \\ "[.1, .6, .8]" & "[.8, .8, .8]" & "[.1, .5, .5]" & "[.3, .5, .7]" \\ "[.1, .3, .8]" & "[.7, .5, .8]" & "[.5, .6, .5]" & "[.8, .6, .2]" \end{bmatrix}$$

The function SVNMCompelementOf2(A) the below returns the complement matrix of a given single valued neutrosophic matrix A for (10).

```
SVNMCompelementOf2:=proc(mat::Matrix)

temp:=LinearAlgebra[Copy](mat);

m,n:=LinearAlgebra[Dimension](temp);

for i from 1 to m by 1 do

for j from 1 to n by 1 do

x:=parse(temp(i,j));

truth:=x[3];

indeterminacy:=1-x[2];
```

```
falsity:=x[1];
temp(i,j):=convert([truth,indeterminacy,falsity],string);
end do;
end do;
temp;
end proc:
```

The single valued neutrosophic matrix A is a simple example, one can create his/her SVNM and try it into the function **SVNMCompelementOf1** ( ); or **SVNMCompelementOf2** ( );

3.3. Determining the score, accuracy and certainty matrices of single valued neutrosophic matrix

To generate the Maple program for obtaining the score matrix, accuracy of single valued neutrosophic matrix, simple call of the functions**ScoreMatrix( )**, **AccuracyMatrix ( )** and **CertaintyMatrix ( )** are defined as follow:

```
ScoreMatrix:=proc(mat::Matrix)
m,n:=LinearAlgebra[Dimension](mat);
scoreMat:=Matrix(m,n);
fori from 1 to m by 1 do
for j from 1 to n by 1 do
x:=parse(mat(i,j));
score:=(2+x[1]-x[2]-x[3])/3;
scoreMat(i,j):=score;
end do;
end do;
scoreMat;
endproc:
AccuracyMatrix:=proc(mat::Matrix)
m,n:=LinearAlgebra[Dimension](mat);
aMat:=Matrix(m,n);
fori from 1 to m by 1 do
for j from 1 to n by 1 do
```

```
x:=parse(mat(i,j));
a:=x[1]-x[3];
aMat(i,j):=a;
end do;
end do;
aMat;
endproc:
CertaintyMatrix:=proc(mat::Matrix)
m,n:=LinearAlgebra[Dimension](mat);
cMat:=Matrix(m,n);
fori from 1 to m by 1 do
for j from 1 to n by 1 do
x:=parse(mat(i,j));
c:=x[1];
cMat(i,j):=c;
end do;
end do;
cMat;
endproc:
```

3.4. Computing union of two single valued neutrosophic matrices

The union of two single valued neutrosophic matrices A and Bis defined as follow:

$$A \cup B = C = [< c_{ij_T}, c_{ij_I}, c_{ij_F} >]_{\mathrm{m\times n}} \quad (11)$$

where

$c_{ij_T} = a_{ij_T} \vee b_{ij_T}$,

$c_{ij_I} = a_{ij_I} \wedge b_{ij_I}$,

$c_{ij_F} = a_{ij_F} \wedge b_{ij_F}$

The union of two single valued neutrosophic matrices can be determined using the Maple program with simple call of the following function**Union(A, B)** is described as follows:

```
Union:=proc(mat1::Matrix,mat2::Matrix)

m1,n1:=LinearAlgebra[Dimension](mat1);

m2,n2:=LinearAlgebra[Dimension](mat2);

if (n1=n2) and (m1=m2) then

m:=m1;n:=n1;

unionMat:=Matrix(m,n);

for i from 1 to m by 1 do

for j from 1 to n by 1 do

x:=parse(mat1(i,j));

y:=parse(mat2(i,j));

truth:=max(x[1],y[1]);

indeterminacy:=min(x[2],y[2]);

falsity:=min(x[3],y[3]);

unionMat(i,j):=convert([truth,indeterminacy,falsity],string);

end do;

end do;

unionMat;

else

print("dimension of given matrices must be equal!");

end if;

end proc:
```

Example 3. Here, union of two single valued neutrosophic matrices E and F of order 4X4 has been obtained:

E=

$$\begin{pmatrix} <.5,.7,.2> & <.4,.4,.5> & <.7,.7,.5> & <.1,.5,.7> \\ <.9,.7,.5> & <.7,.6,.8> & <.9,.4,.6> & <.5,.2,.7> \\ <.9,.4,.2,> & <.2,.2,.2> & <.9,.5,.5> & <.7,.5,.3> \\ <.9,.7,.2,> & <.3,.5,.2> & <.5,.4,.5> & <.2,.4,.8> \end{pmatrix}$$

The single valued neutrosophic matrix E can be inputted in Maple code like this:

E:=SVNMInput(4,4);

F=

$$\begin{pmatrix} < .3, .4, .3 > & < .1, .2, .7 > & < .3, .2, .6 > & < .2, .1, .3 > \\ < .2, .2, .7 > & < .3, .5, .6 > & < .6, .5, .4, > & < .3, .4, .4 > \\ < .5, .3, .1 > & < .5, .4, .3 > & < .5, .8, .6 > & < .4, .6, .5 > \\ < .6, .1, .7 > & < .4, .6, .4 > & < .4, .9, .3 > & < .4, .5, .4 > \end{pmatrix}$$

The single valued neutrosophic matrix F can be inputted in Maple code like this:

F:=SVNMInput(4,4);

So, the union matrix of two single valued neutrosophic matricesis portrayed as follow

$$E_{SVNM} \cup F_{SVNM} = \begin{pmatrix} < .5, .4, .2 > & < .4, .2, .5 > & < .7, .2, .5 > & < .2, .1, .3 > \\ < .9, .2, .5 > & < .7, .5, .6 > & < .9, .4, .4 > & < .5, .2, .4 > \\ < .9, .3, .1 > & < .5, .2, .2 > & < .9, .5, .5 > & < .7, .5, .3 > \\ < .9, .1, .2, > & < .4, .5, .2 > & < .5, .4, .3 > & < .4, .4, .4 > \end{pmatrix}$$

The result of union matrix of two single valued neutrosophic matrices E and F can be obtained by the call of the command Union (E, F):

Union(E, F);

$$\begin{bmatrix} "[.5, .4, .2]" & "[.4, .2, .5]" & "[.7, .2, .5]" & "[.2, .1, .3]" \\ "[.9, .2, .5]" & "[.7, .5, .6]" & "[.9, .4, .4]" & "[.5, .2, .4]" \\ "[.9, .3, .1]" & "[.5, .2, .2]" & "[.9, .5, .5]" & "[.7, .5, .3]" \\ "[.9, .1, .2]" & "[.4, .5, .2]" & "[.5, .4, .3]" & "[.4, .4, .4]" \end{bmatrix}$$

3.5. Computing intersection of two single valued neutrosophic matrices

The union of two single valued neutrosophic matrices A and B is defined as follow:

$A \cap B = D = \left[< d_{ij_T}, d_{ij_I}, d_{ij_F} >\right]_{\mathrm{m\times n}}$ (12)

where

$d_{ij_T} = a_{ij_T} \wedge b_{ij_T},$

$d_{ij_I} = a_{ij_I} \vee b_{ij_I},$

$d_{ij_F} = a_{ij_F} \vee b_{ij_F},$

To develop the Maple program to find the intersection of two single valued neutrosophic matrices, simple call of the functionIntersection(,) is defined in the following manner.

```
Intersection:=proc(mat1::Matrix,mat2::Matrix)

m1,n1:=LinearAlgebra[Dimension](mat1);
```

```
m2,n2:=LinearAlgebra[Dimension](mat2);
if (n1=n2) and (m1=m2) then
m:=m1;n:=n1;
intersectMat:=Matrix(m,n);
for i from 1 to m by 1 do
for j from 1 to n by 1 do
x:=parse(mat1(i,j));
y:=parse(mat2(i,j));
truth:=min(x[1],y[1]);
indeterminacy:=max(x[2],y[2]);
falsity:=max(x[3],y[3]);
intersectMat(i,j):=convert([truth,indeterminacy,falsity],string);
end do;
end do;
intersectMat;
else
print("dimension of given matrices must be equal!");
end if;
end proc:
```

Example 4. Here, the intersection of two single valued neutrosophic matrices E and F of order 4X4 which are presented in example 3 is

So, the intersection matrix of two single valued neutrosophic matrices is portrayed as follow

$$E_{SVNM} \cap F_{SVNM} = \begin{pmatrix} <.3,.7,.3> & <.1,.4,.7> & <.3,.7,.6> & <.1,.5,.7> \\ <.2,.7,.7> & <.3,.6,.8> & <.6,.5,.6> & <.3,.4,.7> \\ <.5,.4,.2> & <.2,.4,.3> & <.5,.8,.6> & <.4,.6,.5> \\ <.6,.7,.7> & <.3,.6,.4> & <.4,.9,.5> & <.2,.5,.8> \end{pmatrix}$$

The result of intersection matrix of two single valued neutrosophic matrices E and F can be obtained by the call of the command Intersection (E, F):

Intersection (E, F)

$$\begin{bmatrix} "[.3, .7, .3]" & "[.1, .4, .7]" & "[.3, .7, .6]" & "[.1, .5, .7]" \\ "[.2, .7, .7]" & "[.3, .6, .8]" & "[.6, .5, .6]" & "[.3, .4, .7]" \\ "[.5, .4, .2]" & "[.2, .4, .3]" & "[.5, .8, .6]" & "[.4, .6, .5]" \\ "[.6, .7, .7]" & "[.3, .6, .4]" & "[.4, .9, .5]" & "[.2, .5, .8]" \end{bmatrix}$$

3.6. Computing addition operation of two single valued neutrosophic matrices.

The addition of two single valued neutrosophic matrices A and B is defined as follow:

$$A \oplus B = S = \left[< s_{ij_T}, s_{ij_I}, s_{ij_F} >\right]_{\mathrm{m\times n}} \quad (13)$$

where

$s_{ij_T} = a_{ij_T} + b_{ij_T} - a_{ij_T}.b_{ij_T},$

$s_{ij_I} = a_{ij_I}.b_{ij_I},$

$s_{ij_F} = a_{ij_F}.b_{ij_F},$

To generate the Maple program for obtaining the addition of two single valued neutrosophic matrices, simple call of the function **Addition (A, B)**is defined as follow:

```
Addition:=proc(mat1::Matrix,mat2::Matrix)
m1,n1:=LinearAlgebra[Dimension](mat1);
m2,n2:=LinearAlgebra[Dimension](mat2);
if (n1=n2) and (m1=m2) then
m:=m1;n:=n1;
addMat:=Matrix(m,n);
for i from 1 to m by 1 do
for j from 1 to n by 1 do
x:=parse(mat1(i,j));
y:=parse(mat2(i,j));
truth:=x[1]+y[1]-x[1]*y[1];
indeterminacy:=x[2]*y[2];
falsity:=x[3]*y[3];
addMat(i,j):=convert([truth,indeterminacy,falsity],string);
end do;
end do;
```

```
addMat;
else
print("dimension of given matrices must be equal!");
end if;
end proc:
```

Example 5. In this example we evaluate the addition of the two single valued neutrosophic matrices E and F of order 4X4 presented in example 3:

So, the addition matrix of two single valued neutrosophic matricesis portrayed as follow

$$C_{SVNM} \oplus D_{SVNM} = \begin{pmatrix} <.65,.28,.06 > & <.46,.08,.35> & <.79,.14,.30> & <.28,.05,.21> \\ <.92,.14,.35> & <.79,.30,.48> & <.96,.20,.24> & <.65,.08,.28> \\ <.65,.12,.02> & <.60,.08,.06> & <.95,.40,.30> & <.82,.30,.15> \\ <.96,.07,.14> & <.58,.30,.08> & <.70,.36,.15> & <.52,.20,.3> \end{pmatrix}$$

The result of addition matrix of two single valued neutrosophic matrices E and F can be obtained by the call of the command addition (E, F):

```
Addition(E,F);
```

"[.65, .28, .6e-1]"	"[.46, .8e-1, .35]"	"[.79, .14, .30]"	"[.28, .5e-1, .21]"
"[.92, .14, .35]"	"[.79, .30, .48]"	"[.96, .20, .24]"	"[.65, .8e-1, .28]"
"[.95, .12, .2e-1]"	"[.60, .8e-1, .6e-1]"	"[.95, .40, .30]"	"[.82, .30, .15]"
"[.96, .7e-1, .14]"	"[.58, .30, .8e-1]"	"[.70, .36, .15]"	"[.52, .20, .32]"

3.7. Computing product of two single valued neutrosophic matrices

The product of two single valued neutrosophic matrices A and B is defined as follow:

$$A \odot B = R = [< r_{ij_T}, r_{ij_I}, r_{ij_F} >]_{m\times n} \qquad (14)$$

where

$r_{ij_T} = a_{ij_T} . b_{ij_T},$

$r_{ij_I} = a_{ij_I} + b_{ij_I} - a_{ij_I} . b_{ij_I},$

$r_{ij_F} = a_{ij_F} + b_{ij_F} - a_{ij_F} . b_{ij_F},$

To generate the Maple program for finding the product operation of two single valued neutrosophic matrices, simple call of the function **Product (A, B)** is defined as follow:

```
Prod:=proc(mat1::Matrix,mat2::Matrix)
```

```
m1,n1:=LinearAlgebra[Dimension](mat1);
m2,n2:=LinearAlgebra[Dimension](mat2);
if (n1=n2) and (m1=m2) then
m:=m1;n:=n1;
prodMat:=Matrix(m,n);
for i from 1 to m by 1 do
for j from 1 to n by 1 do
x:=parse(mat1(i,j));
y:=parse(mat2(i,j));
truth:=x[1]*y[1];
indeterminacy:=x[2]+y[2]-x[2]*y[2];
falsity:=x[3]+y[3]-x[3]*y[3];
prodMat(i,j):=convert([truth,indeterminacy,falsity],string);
end do;
end do;
prodMat;
else
print("dimension of given matrices must be equal!");
end if;
end proc:
```

Example 6. In this example we evaluate the product of the two single valued neutrosophic matrices E and F of order 4X4 presented in example 3:

So, theproduct matrix of two single valued neutrosophic matricesis portrayed as follow

$$E_{SVNM} \odot F_{SVNM} = \begin{pmatrix} <.15,.82,.44> & <.04,.52,.85> & <.21,.76,.80> & <.02,.55,.79> \\ <.18,.76,.85> & <.21,.80,.92> & <.54,.70,.76> & <.15,.52,.82> \\ <.45,.58,.28> & <.10,.52,.44> & <.45,.90,.80> & <.28,.80,.65> \\ <.54,.73,.76> & <.12,.80,.52> & <.20,.94,.65> & <.08,.70,.88> \end{pmatrix}$$

The result of product matrix of two single valued neutrosophic matrices E and F can be obtained by the call of the command Product (E, F):

Product(E, F);

Product=

"[.15, .82, .44]"	"[.4e-1, .52, .85]"	"[.21, .76, .80]"	"[.2e-1, .55, .79]"
"[.18, .76, .85]"	"[.21, .80, .92]"	"[.54, .70, .76]"	"[.15, .52, .82]"
"[.45, .58, .28]"	"[.10, .52, .44]"	"[.45, .90, .80]"	"[.28, .80, .65]"
"[.54, .73, .76]"	"[.12, .80, .52]"	"[.20, .94, .65]"	"[.8e-1, .70, .88]"

3.8. Computing transpose of single valued neutrosophic matrix

To generate the Maple program for finding the transpose of single valued neutrosophic matrix, simple call of the function **Transpose(A)** is defined as follow:

```
Transpose:=proc(mat::Matrix)
m,n:=LinearAlgebra[Dimension](mat);
temp:=Matrix(n,m);
for i from 1 to n by 1 do
for j from 1 to m by 1 do
temp(i,j):=mat(j,i);
end do;
end do;
temp;
end proc:
```

Example 7. In this example we evaluate the transpose of the single valued neutrosophic matrix E of order 4X4:

C=

$$\begin{pmatrix} <.5,.7,.2> & <.4,.4,.5> & <.7,.7,.5> & <.1,.5,.7> \\ <.9,.7,.5> & <.7,.6,.8> & <.9,.4,.6> & <.5,.2,.7> \\ <.9,.4,.2> & <.2,.2,.2> & <.9,.5,.5> & <.7,.5,.3> \\ <.9,.7,.2> & <.3,.5,.2> & <.5,.4,.5> & <.2,.4,.8> \end{pmatrix}$$

So, the transpose matrix of single valued neutrosophic matricesis portrayed as follow

$$C^T=\begin{pmatrix} <.5,.7,.2> & <.9,.7,.5> & <.9,.4,.2> & <.9,.7,.2> \\ <.4,.4,.5> & <.7,.6,.8> & <.2,.2,.2> & <.3,.5,.2> \\ <.7,.7,.5> & <.9,.4,.6> & <.9,.5,.5> & <.5,.4,.5> \\ <.1,.5,.7> & <.5,.2,.7> & <.7,.5,.3> & <.2,.4,.8> \end{pmatrix}$$

3.9. Computing determinant of single valued neutrosophic matrices

To generate the Maple program for finding the determinant of a single valued neutrosophic matrix, simply call this code, then call**det()**procedure:

```
AND:=proc(m1,m2)
n1:=parse(m1);
n2:=parse(m2);
if numelems(n1)<>3 then return convert(n2,string)
elifnumelems(n2)<>3   then return convert(n1,string)
else
t1:=n1[1];
i1:=n1[2];
f1:=n1[3];
t2:=n2[1];
i2:=n2[2];
f2:=n2[3];
t:=min(t1,t2);
i:=min(i1,i2);
f:=max(f1,f2);
return convert([t,i,f],string);
end if;
end proc:
OR:=proc(m1,m2)
n1:=parse(m1);
n2:=parse(m2);
```

```
if numelems(n1)<>3 then return convert(n2,string)
elifnumelems(n2)<>3   then return convert(n1,string)
else
t1:=n1[1];
i1:=n1[2];
f1:=n1[3];
t2:=n2[1];
i2:=n2[2];
f2:=n2[3];
t:=max(t1,t2);
i:=max(i1,i2);
f:=min(f1,f2);
return convert([t,i,f],string);
end if;
end proc:
subMat:=proc(mat,temp,p::integer ,q::integer ,n::integer)
   i:=1;j:=1;
   for row from 1 to n do
      for col from 1 to n do
         if row <> p and col <> q then
            temp(i,j) := mat(row,col);
            j:=j+1;
            if j = n then
               j := 1;
               i:=i+1;
            end if;
```

```
            end if;
        end do;
    end do;
end proc:
myDet:=proc(mat, n::integer)
    determinant:="[0]";
    if n = 1 then
        return mat(1,1);
    end if;
    if n = 2 then
        return OR(AND(mat(1,1) , mat(2,2)),AND(mat(1,2) , mat(2,1)));
    end if;
    for   i from 1 to n do
subMat(mat, temp, 1, i, n);
        determinant := OR(determinant,AND(mat(1,i),myDet(temp, n - 1)));
    end do;
    return determinant;
end proc:
det:=proc(mat::Matrix)
n:=LinearAlgebra[RowDimension](mat):
return myDet(mat,n);
end proc:
```

Example 8. In this example we evaluate the determinant of a single valued neutrosophicmatrixF of order 4X4by the call of the command det (F):

det (F)

"[.3, .4, .3]"

4. Conclusions

This paper proposed some new Maple programs for set-theoretic operations on single valued matrices. The package provides some programs such as complement, transpose, scalar multiplication of matrix, scalar division of matrix, computing the union, intersection addition, product, and difference and division operations for the single valued neutrosophic matrices. In future work, the interval valued neutrosophic matrices can be studied using Maple language.

Funding:
"This research received no external funding."

Acknowledgments:

The authors are very grateful to the chief editor and reviewers for their comments and suggestions, which is helpful in improving the paper.

Conflicts of Interest: "The authors declare no conflict of interest."

References:

[1] Zadeh, L. Fuzzy Sets. Information and Control, 1965, 8, 338-353.

[2] Atanassov, K. Intuitionistic Fuzzy Sets. Fuzzy Sets and Systems, 1986, 20, 87-96.

[3] Pinchback, R. Working with Large Matrices in Maple. In: Lee, T. (eds) Mathematical Computation with Maple V: Ideas and Applications. Birkhäuser, Boston, MA, 1993, https://doi.org/10.1007/978-1-4612-0351-3_8

[4] Smarandache, F. Neutrosophy. Neutrosophic Probability, Set, and Logic. ProQuest Information & Learning, Ann Arbor, Michigan, USA, 1998, 105 p.

[5] Buse, L. Computing resultant matrices with Macaulay2 and Maple. [Research Report] RT-0280, INRIA. 2003, pp.33. ffinria-00069898f

[6] Barakat, M.; Robertz, D. Conley: Computing connection matrices in Maple. Journal of Symbolic Computation, 2009, 44(5):540-557.

[7] Bowman, K.O.; Shenton, L.R. Definite Integrals, Some involving Residue Theory Evaluated by The Maple Code. Far East Journal of Theoretical Statistics, 2010, 31(2):107-116.

[8] Davodi, A.G. Tan method maple code Tanh method maple code Sech method maple code Cot method maple code Coth method maple code, In project: Analytical solutions for nonlinear differential equations, 2010, DOI:10.13140/RG.2.2.13559.98727.

[9] Wang, H.; Smarandache, F.; Zhang, Y.; Sunderraman, R. Single Valued Neutrosophic Sets. Multispace and Multistructure, 2010, 4, 410-413.

[10] Delgado, P.M,; Galperin, E.A,; Jimenez, G.P. MAPLE Code of the cubic algorithm for multiobjective optimization with box constraints. Numerical Algebra, 2013, 3(3), 407-424.

[11] Natelie, B.; Dovlo, E. Maple code Demonstrating use of the SCAToolbox, 2014, DOI: 10.6084/M9.fighare.1247498.V1

[12] Zhang, H.Y.; Wang, J.Q.; Chen, X.H. Interval neutrosophic sets and their application in multi-criteria decision making problems. The Scientific World Journal, 2014, doi:10.1155/2014/645953

[13] http://fs.gallup.unm.edu/NSS/

[14] Barbacioru, Iuliana, C. Using Maple for determination minimum arc length of an intuitionistic fuzzy

hyperpath, Annals of 'ConstantinBrancusi' University of Targu-Jiu, Juridical Science Series,2016, 4, 81-85.

[15] Karaaslan, F.; Hayat, K. Some new operations on single-valued neutrosophic matrices and their applications in multi-criteria group decision making. Applied Intelligence, 2018, 48, 4594-4614. doi:10.1007/s10489-018-1226-y (2018).

[16] Broumi, S.; Topal, S.; Bakali, A.; Talea, M.; Smarandache, F. A novel python toolbox for single and interval-valued Neutrosophic matrices, 2020, doi: 10.4018/978-7998-2555-5.ch013.

[17] Couto, A.C.C.; Jeffrey, D.J. Using Maple to Make Manageable Matrices. In: Gerhard J., Kotsireas I. (eds) Maple in Mathematics Education and Research. MC 2019. Communications in Computer and Information Science, 2020, 1125. Springer, Cham. https://doi.org/10.1007/978-3-030-41258-6_16

[18] Caravantes, J.; Sendra, J.R.; Sendra, J. A Maple Package for the Symbolic Computation of Drazin Inverse Matrices with Multivariate Transcendental Functions Entries. In: Gerhard J., Kotsireas I. (eds) Maple in Mathematics Education and Research. MC 2019. Communications in Computer and Information Science, 2020, Volume 1125. Springer, Cham. https://doi.org/10.1007/978-3-030-41258-6_12

[19] Corless, R.M.; Postma, E.J. Blends in Maple, 2021, doi:10.1007/978-3-030-81698-8_12

[20] Gilbert, R.P.; Hsiao, G.C.; Ronkee, R. Introduction to the Maple DEtools, 2021, Doi: 10.1201/9781003175643-1

[21] Asadi, M.; Brandt, A;, Kazemi, M.; Moreno,M.M.; Postma, E.J.Multivariate Power Series in Maple. In: Corless R.M., Gerhard J., Kotsireas I.S. (eds) Maple in Mathematics Education and Research. MC 2020. Communications in Computer and Information Science, 2021; vol 1414. Springer, Cham. https://doi.org/10.1007/978-3-030-81698-8_4

[22] Karaaslan, F.; Hayat, K.; Jana, C. The Determinant and Adjoint of an Interval-Valued Neutrosophic Matrix. In book: Neutrosophic Operational Research, 2021, DOI:10.1007/978-3-030-57197-9_7

[23] Schramm, T. Rational Trigonometry Using Maple. In: Corless R.M., Gerhard J., Kotsireas I.S. (eds) Maple in Mathematics Education and Research. MC 2020. Communications in Computer and Information Science, 2021; Volume 1414. Springer, Cham. https://doi.org/10.1007/978-3-030-81698-8_24

[24] Madad, K.; Anis, S.; Bibi, K.; Iqbal, S; Smarandache, F. Complex Neutrosophic Soft Matrices Framework: An Application in Signal Processing. Journal of Mathematics, 2021, 16, 1-10.

[25] Abobala, M. On the Representation of Neutrosophic Matrices by Neutrosophic Linear Transformations. Journal of Mathematics, 2021, 1-5.DOI:10.1155/2021/5591576

[26] Ali, R. Neutrosophic Matrices and Their Properties, 2021, DOI: 10.13140/RG.2.2.26930.12481

[27] Mohamed, B.Z.; Omar Z.. Fatina, M.. Fatima, K.; Broumi, S. Operations on Single-Valued Trapezoidal Neutrosophic Numbers using (α,β,γ)-Cuts "Maple Package", International Journal of Neutrosophic Science, 2021, 15(2), 113-122 (doi : https://doi.org/10.54216/IJNS.150205).

[28] Kwon, B.G.; Sohn, M.H. Effects of the CG Positions on the Autorotative Flight of Maple Seeds. International Journal of Aeronautical and Space Sciences, 2022, https://doi.org/10.1007/s42405-021-00436-1

[29] Zuzana, C.Z.; Jiri, C.Z. Scientific Computing and Visualization with Maple in Economics and

Economic Research. International Journal of Economics and Statistics, 2022, 10, 73-79.

Received: Dec. 5, 2021. Accepted: April 3, 2022.