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A Maple Code to Perform Operations on Single Valued Neutrosophic Matrices

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Abstract: In this paper, we present a maple programming code that helps users and scientific researchers to input single valued neutrosophic matrices, checks whether inputted matrix is single valued neutrosophic 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 and degree of non-membership. 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 uncertainties as a single number and interval numbers in the unit interval [0,1] as well [9, 12-13]. Neutrosophic 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 neutrosophic sets and its operations have been presented for better understanding of the present work. In section 3, single valued matrix operators have been computed using Maple programming. In section 4, conclusion of the present work is given with future direction.

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.

$$-0 \leq \sup T_A(x) + \sup I_A(x) + \sup F_A(x) \leq 3 \tag{1}$$

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 function I_A , and falsity-membership function F_A . For each point $x \in \xi$, $T_A(x), I_A(x), F_A(x) \in [0, 1]$.

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

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

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

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

and

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

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

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

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

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

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

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

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

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

5. The union of two single valued neutrosophic sets A and B is a single valued neutrosophic set $A \cup B$ defined as follow:

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

6. The difference of two single valued neutrosophic sets A and B is single valued neutrosophic

$$\text{set } A_{SVNS} \ominus B_{SVNS} \text{ defined as follow: } A \ominus B = \langle [T_{A \ominus B}, T_{A \ominus B}^U], [I_{A \ominus B}, I_{A \ominus B}^U], [F_{A \ominus B}, F_{A \ominus B}^U] \rangle \quad (5)$$

where

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

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

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

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

$$A \ominus_2 B = \langle T_{A \ominus_2 B}, I_{A \ominus_2 B}, F_{A \ominus_2 B} \rangle \tag{6}$$

where

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

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

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

for all x in ξ .

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

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

8. The scalar division of single 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 $x \in \xi, a \in R^+$

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 number A_{IVNN} , the score function is defined as follow :

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

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

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

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

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

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

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

$A_{SVNM} = [\langle a_{ij}, a_{ij_T}, a_{ij_I}, a_{ij_F} \rangle]_{m \times n}$ 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.

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

For simplicity, we write A as

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

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 SVNМ to Maple

Here, for inputting SVNМ to Maple, simply call the function SVNМInput(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=

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

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 SVNMM or not E can be obtained by the call of the command SVNMMChecking (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 SVNMM $A = [\langle T_{ij}, I_{ij}, F_{ij} \rangle]_{m \times n}$, the complement of A is defined as follow:

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

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

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 SVNMMCompelementOf1 (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:

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

The result of the complement of single valued neutrosophic matrix E can be obtained by the call of the command SVNMComplementOf1(E);

SVNMComplementOf1(E);

```
["[.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]" ]
```

The function SVNMComplementOf2(A) the below returns the complement matrix of a given single valued neutrosophic matrix A for (10).

```
SVNMComplementOf2:=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 SVNМ and try it into the function **SVNMComplementOf1 ()**; or **SVNMComplementOf2 ()**;

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 B is defined as follow:

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

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=

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

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

E:=SVNMInput(4,4);

F=

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

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 matrices is portrayed as follow

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

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:

$$A \cap B = D = \left[\langle d_{ijT}, d_{ijI}, d_{ijF} \rangle \right]_{m \times n} \quad (12)$$

where

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

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

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

To develop the Maple program to find the intersection of two single valued neutrosophic matrices, simple call of the function Intersection(,) 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

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

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:

$$A \oplus B = S = \left[\langle s_{ijT}, s_{ijI}, s_{ijF} \rangle \right]_{m \times n} \quad (13)$$

where

$$s_{ijT} = a_{ijT} + b_{ijT} - a_{ijT} \cdot b_{ijT},$$

$$s_{ijI} = a_{ijI} \cdot b_{ijI},$$

$$s_{ijF} = a_{ijF} \cdot b_{ijF},$$

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 matrices is portrayed as follow

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

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:

$$A \odot B = R = [\langle r_{ijT}, r_{ijI}, r_{ijF} \rangle]_{m \times n} \tag{14}$$

where

$$r_{ijT} = a_{ijT} \cdot b_{ijT},$$

$$r_{ijI} = a_{ijI} + b_{ijI} - a_{ijI} \cdot b_{ijI},$$

$$r_{ijF} = a_{ijF} + b_{ijF} - a_{ijF} \cdot b_{ijF},$$

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

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

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=

$$\begin{bmatrix} ".15, .82, .44]" & ".4e-1, .52, .85]" & ".21, .76, .80]" & ".2e-1, .55, .79]" \\ ".18, .76, .85]" & ".21, .80, .92]" & ".54, .70, .76]" & ".15, .52, .82]" \\ ".45, .58, .28]" & ".10, .52, .44]" & ".45, .90, .80]" & ".28, .80, .65]" \\ ".54, .73, .76]" & ".12, .80, .52]" & ".20, .94, .65]" & ".8e-1, .70, .88]" \end{bmatrix}$$

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=

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

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

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

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)
elif numelems(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;

```

```

        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 neutrosophic matrix F of order 4×4 by 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.

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