IMPLEMENTATION OF DISTANCE BASED APPROACH METHOD
IN
MULTI CRITERIA DECISION MAKING
(DEFENCE RESEARCH AND DEVELOPMENT ORGANISATION, NEW DELHI)

A PROJECT REPORT

Under the guidance of

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Submitted by

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BONAFIED CERTIFICATE

Certified that this project report **"IMPLEMENTATION OF DISTANCE BASED APPROACH METHOD IN MULTI CRITERIA DECISION MAKING"** is the bonafide work of **"ADITYA MATHUR"** who carried out the project work under my supervision.

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ACKNOWLEDGEMENT

It was a great privilege for me to get my training in Defence Terrain Research Laboratory (DTRL) of Defence Research and Development Organisation under the guidance of Mr. Anil K.Goswami.

The report describes the training that I underwent, in the month of June 2107 to August 2017 at DTRL under DRDO. It was completed keeping in mind the course curriculum as per the university requirements.

I would like to express my sincere gratitude to all the people who have helped and supported me throughout. I am deeply indebted to my project supervisor Mr. Anil K.Goswami and other faculty members from DTRL for organizing my training programme, efficiently and providing me with valuable resources and also for their cooperation and willingness to share their expertise and knowledge and to devote their precious time to discuss related topics.

The help and co-operation extended by the staff of DRDO is fully acknowledged. I thoroughly enjoyed my entire training programme and would like to thank everyone at DTRL for their guidance and support.

ABSTRACT

In our day to day life we come across situations in which we have a number of choices available in front of us and it is difficult to choose among them on the basis of a single criterion. Different alternatives have different attributes related to them so it is important for the decision maker to weigh all the alternatives and come up with a common index on the basis of which he can compare his alternatives. In this report, to encounter with such problems, Distance Based Approach method is implemented in multi criteria decision making process to come up with the best alternative. The Distance Based Method is used to solve the real life problems.

ORGANIZATION ASSOCIATED WITH THE PROJECT

The Defence Research and Development Organisation (DRDO) is an agency of the Republic of India, charged with the military's research and development, headquartered in New Delhi, India. It was formed in 1958 by the merger of the Technical Development Establishment and the Directorate of Technical Development and Production with the Defence Science Organisation with the following aims :-

1. To create scientific temperament and environment among scientists of DRDO through close interactions among themselves.
2. To promote intellectual activities of science and technology by the way of conducting seminars, debates, lectures, conferences, symposia etc by inviting eminent experts of both national and international repute from various disciplines.
3. To create awareness among the scientists regarding latest developments in various fields of science and technology.
4. To promote reading habits and library culture among scientists by disseminating scientific and technical information relevant to their work.
5. To exchange scientific ideas among fellow scientists.

VISION OF DRDO

The vision of Defence Research and Development Organisation is as follows:-

“To make India prosperous by establishing world class science and technology base and provide our Defence Services decisive edge by equipping them with internationally competitive systems and solutions.”

MISSION OF DRDO

Mission of Defence Research and Development Organisation are as follow :-

1. Design, develop and lead to production state-of-the-art sensors, weapon systems, platforms and allied equipment for our Defence Services.
2. Provide technological solutions to the Services to optimize combat effectiveness and to promote well-being of troops.
3. Develop infrastructure and committed quality manpower and build strong indigenous technology base.

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CHAPTER 1: INTRODUCTION

INTRODUCTION

PROJECT OVERVIEW:

In our daily life we come across many decision like choosing which route to take to go to work or what to eat for lunch etc and all this decision are based on certain criteria. Making a choice about a certain thing can be very difficult sometimes or sometimes even impossible because we have a variety of choices and we make our choices based on different criteria having some positive and some negative attributes. We make our choices by comparing and ranking objects according to criteria defined by us, such as while purchasing a car one may look through various properties of the car like itscomfort level, cost, top speed, mileage and many other features and after that he/she make his/her choice depending on what is most important for him/her. The process by which one rank and compare different alternatives is known as "Multi Criteria Decision Making/Analysis". It has been recognized as an efficient statistical method in which one can combine different indices of various criteria for all the choices available to him/her into a single feasible data which can help in comparing and ranking the objects. A typical MCDM problem has a series of alternatives with different criteria which have to be compared using different methods and then the alternatives have to be ranked.

MCDM is concerned with structuring and solving decision and planning problems involving multiple criteria. The purpose is to support decision-makers facing such problems. Typically, there does not exist a unique optimal solution for such problems and it is necessary to use decision-maker's preferences to differentiate between solutions. A typical MCDM problem can be mainly classified into two type that are as follow:-

1. Multi-Criteria design problems:-The alternatives here are not explicitly known and can be infinite in number or are very typically large in number if countable.
2. Multi-Criteria evaluation problems:-Here the number of alternatives is finite and are clearly known at the beginning of the solution process.

The various steps involved in a MCDM problem are: -

1. The system relations attributes are obtained that relate the system capability to reach the goals.
2. Various alternatives are then generated to reach the goal.
3. The performance function of these alternatives for every criterion available is obtained.

4. Applying the chosen method of MCDM to solve for the best alternative among the available ones.
5. Accepting the best alternative available to reach the goal.
6. If our aim is not fulfilled we gather more data about the model and go for next iteration of the MCDM process.

PURPOSE OF THE PROJECT:

The purpose of this project is as follows:-

1. To understand the concept of Multi Criteria Decision Making.
2. To learn about the Distance Based Method and its implementation.
3. To implement the Distance Based Approach method in decision making analysis.

CHAPTER 2: LITERATURE SURVEY

LITERATURE SURVEY

Distance Based Approach Method:

The DBA method involves the defining of the optimal state of the overall objective, and specifying the ideally good values of attributes that are involved in the process. The optimal state of the objective is shown by the optimum model, the OPTIMAL. The vector OP, is the set of "optimum" simultaneous attributes values. In an n-dimensional space, the vector OP is called the Optimal Point. For practical purposes, the optimal good value for attributes is defined as the best values which exist within the range of values of attributes. The OPTIMAL, then, is simply the ALTERNATIVE that has all the best values of attributes.

According to Sharma et al., (2015), it is very unlikely that a certain ALTERNATIVE has the best values for all attributes. Instead, a variety of alternatives may be used to simulate the optimal state. For this reason, the OPTIMAL is not to be considered as feasible alternatives, but it is used only as reference to which other alternatives are quantitatively compared. The numerical difference resulting from comparison represents the effectiveness of alternatives to achieve the optimal state of the objective function. Hence, here, the decision problem is to find a feasible solution which is as close as possible to the optimal point. The objective function for finding such a solution can be formulated as:

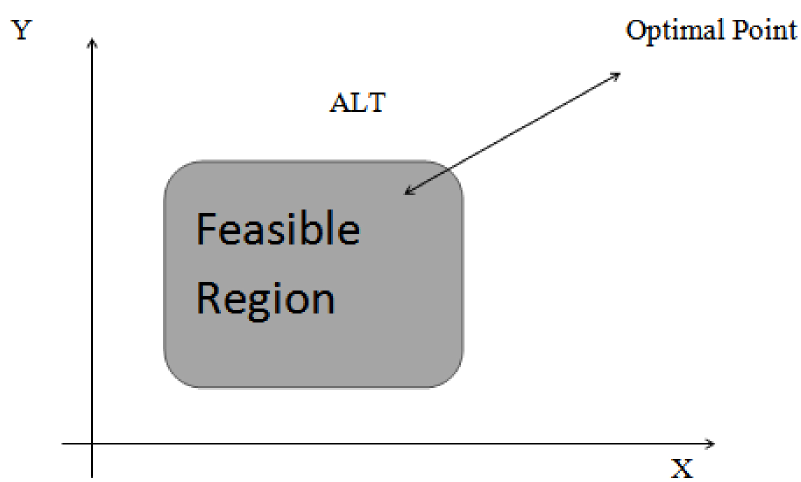


Figure 1: Finding a feasible solution

$$\text{Minimize } \delta\{\text{Alt}(x), \text{OPTIMAL}\}$$

Subject to xCX

Where {Alt(x)}, and δ represent aSRGMalternative in the n-dimensional space, and the distance from the optimal point, respectively. Thus the problem, and its solutions depend on the choice of optimal point, OPTIMAL, and the distance metric, δ, used in the model. In two dimensional spaces, this solution function can be illustrated as in the figure below, where OP is the optimal point.

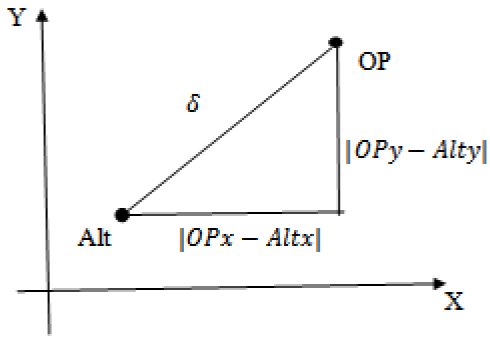


Figure 2: Calculation of distance between each alternative and optimal state

The Distance Based Approach method determines the point in the Feasible Region which is "the closest" to the optimal point, and is graphically explained in Fig. 3 for two dimensional cases. Note that the lines $(\mathrm{Alt} - \mathrm{OP})x$ and $(\mathrm{Alt} - \mathrm{OP})y$ are parallel to X and Y axis respectively. Therefore, $(\mathrm{Alt} - \mathrm{OP})x = |\mathrm{OPx} - \mathrm{Altx}|$and $(\mathrm{Alt} - \mathrm{OP})y = |\mathrm{OPy} - \mathrm{Alty}|$. Based on Pythagoras theorem, in two dimensional space, δ is

Equation 1:

$$\delta = [(\mathrm{OPx} - \mathrm{Altx})^2 + (\mathrm{OPy} - \mathrm{Alty})^2]^{1/2}$$

In general terms, the "distance δ" can be formulated as:

Equation 2:

$$\delta = [\sum (\mathrm{OP_{ij}} - \mathrm{Alt_{ij}})^2]^{1/2}$$

Where i= 1,2,3,..n = alternatives, and j = 1,2,3,…m = selection criteria.

For implementation, let us assume we have complete set of alternatives consisting of 1,2,3,4,…n Alternatives and 1,2,3,4,….m selection Criteria corresponding to each alternative, $\mathrm{Alt}_1(\mathrm{r}_{11}, \mathrm{r}_{12}, .., \mathrm{r}_{1\mathrm{m}}), \mathrm{Alt}_2(\mathrm{r}_{21}, \mathrm{r}_{22}, .., \mathrm{r}_{2\mathrm{m}}), .. \mathrm{Alt}_\mathrm{n}(\mathrm{r}_{\mathrm{n}1}, \mathrm{r}_{\mathrm{n}2}, .., \mathrm{r}_{\mathrm{nm}})$, and OPTIMAL $(\mathrm{r}_{\mathrm{b}1}, \mathrm{r}_{\mathrm{b}2}, \dots\dots, \mathrm{r}_{\mathrm{bm}})$ where $\mathrm{r}_{\mathrm{bm}} =$ the best value of attribute 'm'. The whole set of alternatives can be expressed by the matrix,

Equation 3:

$$[\mathrm{r}] = \begin{bmatrix} \mathrm{r}_{11} & \cdots & \mathrm{r}_{1\mathrm{m}} \\ \vdots & \ddots & \vdots \\ \mathrm{r}_{\mathrm{n}1} & \cdots & \mathrm{r}_{\mathrm{nm}} \end{bmatrix}$$

$$\mathrm{r}_{\mathrm{b}1} \dots \dots .. \mathrm{r}_{\mathrm{bm}}$$

Thus, in this matrix, a vector in an m-dimensional space represents every alternative. To ease the process, and in the same time to eliminate the influence of different units of measurement, the matrix is standardized using the following equations,

Equation 4:Element of standardized matrix

$$\mathrm{Z}_{\mathrm{ij}} = \frac{\mathrm{r}_{\mathrm{ij}} - \bar{\mathrm{r}}_\mathrm{j}}{\mathrm{S}_\mathrm{j}}$$

Equation 5:Average value of each criteria:

$$\text{Here}, \bar{\mathrm{r}}_\mathrm{j} = \frac{1}{\mathrm{n}} \sum_{\mathrm{i}=1}^{\mathrm{n}} \mathrm{r}_{\mathrm{ij}} \text{ , and}$$

Equation 6:Standard Deviation of each criteria:

$$\mathrm{S}_\mathrm{j} = [\frac{1}{\mathrm{n}} \sum_{\mathrm{i}=1}^{\mathrm{n}} (\mathrm{r}_{\mathrm{ij}} - \bar{\mathrm{r}}_\mathrm{j})^{\,2}]^{\,1/2}$$

$\overline{r}_j$ and Sj represent the average value, and the standard deviation of each criteria for all alternatives, m and n represent the number of different Criteria and the number of Alternatives, respectively. Using the above equations Equation 4, Equation 5, Equation 6 the matrix in Equation 3 is reduced to,

Equation 7: Standardized matrix:

$$[Z_{std}] = \begin{bmatrix} Z_{11} & \cdots & Z_{1m} \\ \vdots & \ddots & \vdots \\ Z_{n1} & \cdots & Z_{nm} \end{bmatrix}$$

Now, the next step is to obtain the difference from each alternative to the reference point, the OPTIMAL, by subtracting each element of the optimal set by a corresponding element in the alternative set. This results in another interim matrix is

Equation 8: Difference matrix

$$[Z_{dis}] = \begin{bmatrix} Z_{OP1} - Z_{11} & \cdots & Z_{OPm} - Z_{1m} \\ \vdots & \ddots & \vdots \\ Z_{OP1} - Z_{n1} & \cdots & Z_{OPm} - Z_{nm} \end{bmatrix}$$

Now, the Euclidean composite distance, CD, between each alternative to optimal state, OPTIMAL, is give in the form

Equation 9: Euclidean composite distance between each alternative to optimal state

$$CD_{OP-Alt} = [\sum_{j=1}^{m} (Z_{OPj} - Z_{ij})^{2}]^{1/2}$$

Within any given set of Alternatives, this distance of each alternative to every other is obviously a composite distance. In other words, it can be referred to as the mathematical expression of several distances on each attribute in which different Alternatives can be compared.

CHAPTER 3: METHODOLOGY

METHODOLOGY

Block Diagram:

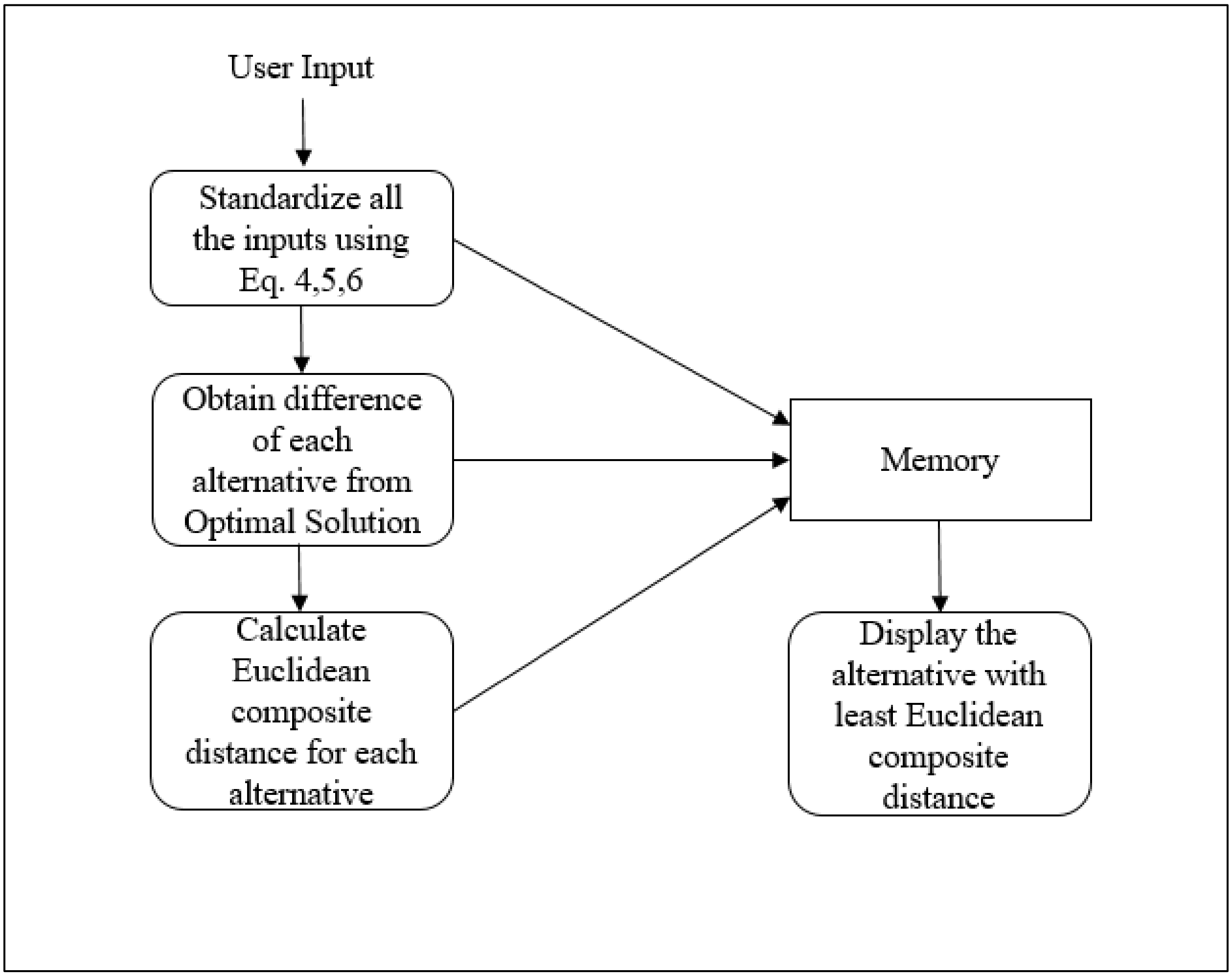


Figure 3: Block Diagram for implementation of DBA method

As shown in the block diagram above, the input given by user i.e. the value of each criteria for each alternative is first converted into standardized units as each criteria may have different unit of measurement and is stored into memory. After converting each value into standard form, the distance of each alternative from the Optimal Solution is calculated depending upon the criteria provided by the user and the calculated difference for each value is stored into memory. Next, the Euclidean composite distance is calculated for each alternative and the alternative that is closest to the Optimal Solution i.e. the alternative with least Euclidean composite distance is chosen as the best possible alternative from the given set.

Flowchart:

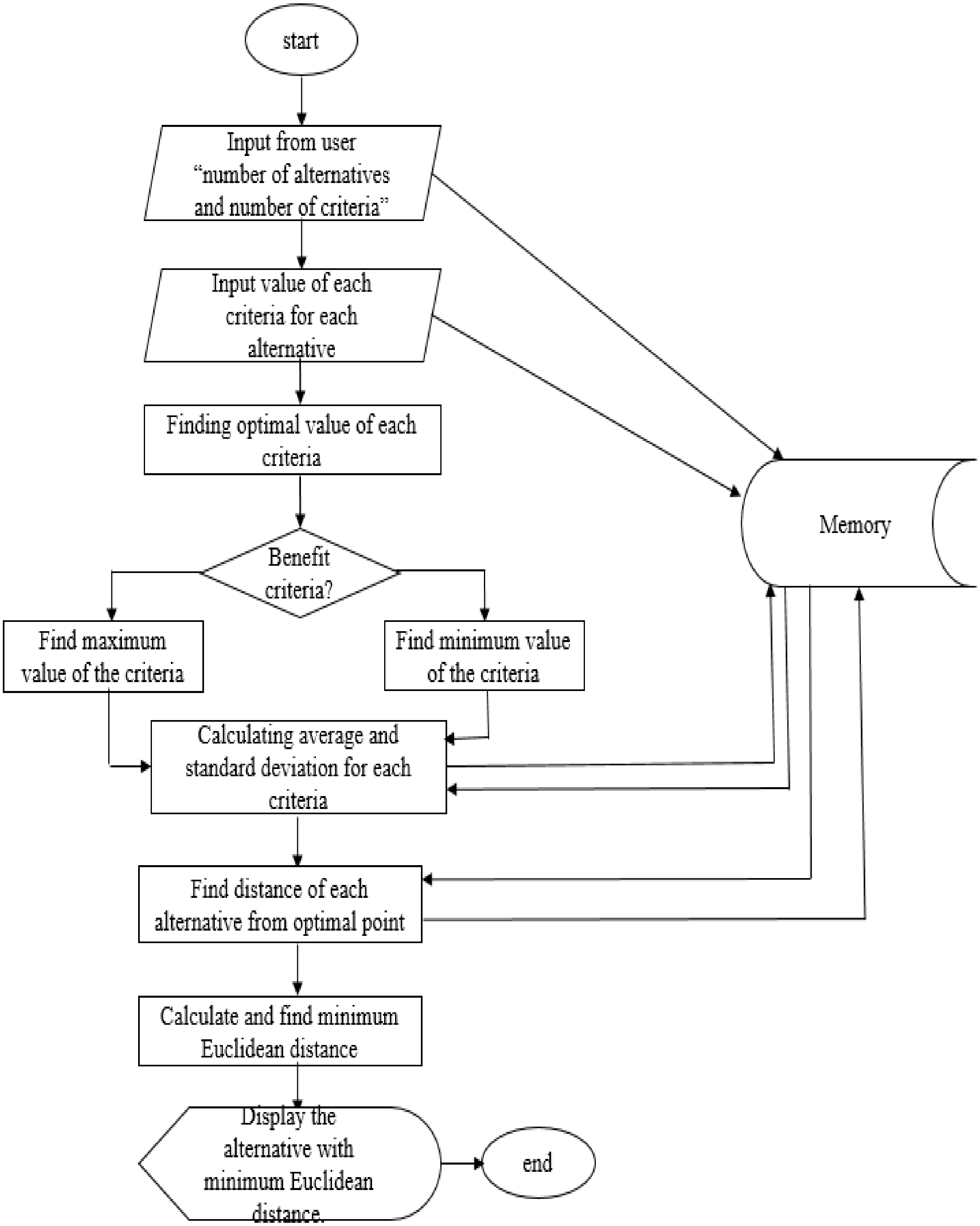


Figure 4: Flow chart for programming used

Algorithm:

Step 01: Start.

Step 02: Declare variable row and col.

Step 03: Read for number of alternatives and number of criteria and store it in variable row and col respectively.

Step 4: Read value for each criteria for each alternative and store the values in a matrix of dimension row x col.

Step 05: For j=0, Repeat while j<col

If benefit criteria, then

Find maximum value of the criteria.

Else,

Find minimum value of criteria.

[end of If-Else]

Increment j

[end of loop of Step 5]

Step 06: Calculating the average and standard deviation value for each criteria.

Step 07: Normalize each value of matrix using equation 4, 5 and 6

Step 08: For i=0, Repeat while i<row

For j=0, Repeat while j<col

standardizeValue[i][j]=(value[i][j]-avgValue[j])/stdDeviation[j]

Increment j

[end of inner loop]

Increment i

[end of outer loop]

[end of loop in Step 8]

Step 09: [Calculating distance of each alternative from optimal point]

For i=0, Repeat while i<row

For j=0, Repeat while j<col

If benefit criteria, then

disvalue[i][j]=optimalValue[j]-standardizedValue[i][j]

Else

disvalue[i][j]=standardizedValue[i][j]-optimalValue[j]

[end of If-Else]

[end of inner loop]

[end of outer loop]

Step 10: [Calculating Euclidean composite distance]

For i=0, Repeat whilei<row

Declare variable sumOfRowSqr=0

For j=0, Repeat while j<col

sumOfRowSqr=sumOfRowSqr+(disValue[i][j]*disValue[i][j]);

[end of inner loop]

Store value of distance for the i^{th} criteria.

[end of outer loop]

Step 11: Calculate the minimum Euclidean composite distance.

Step 12: Display the alternative with the least Euclidean distance.

Step 13: End.

CHAPTER 4: RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

TEST CASES

The objective of these problems is to determine the best alternative depending upon various attributes. In the following examples we use different scenario to find the best alternative.

Problem 1:-**Warehouse Selection Problem**

A certain company has to make a new warehouse to keep their goods, there are three options to choose from i.e. are location A, location B, location C and also there are different criteria that are to keep in wind while deciding on a location. The criteria are Price for the building of warehouse, Distance from the company, Labor required to maintain the warehouse and Wages of the labor. The required data is given in the table below on the scale of (0-100).

Table 1: Dataset of Problem 1

Location	Price	Distance	Labor	Wages
A	50	28	17	15
B	11	5	68	61
C	38	65	13	22

Input given by user for number of alternatives and number of criteria,

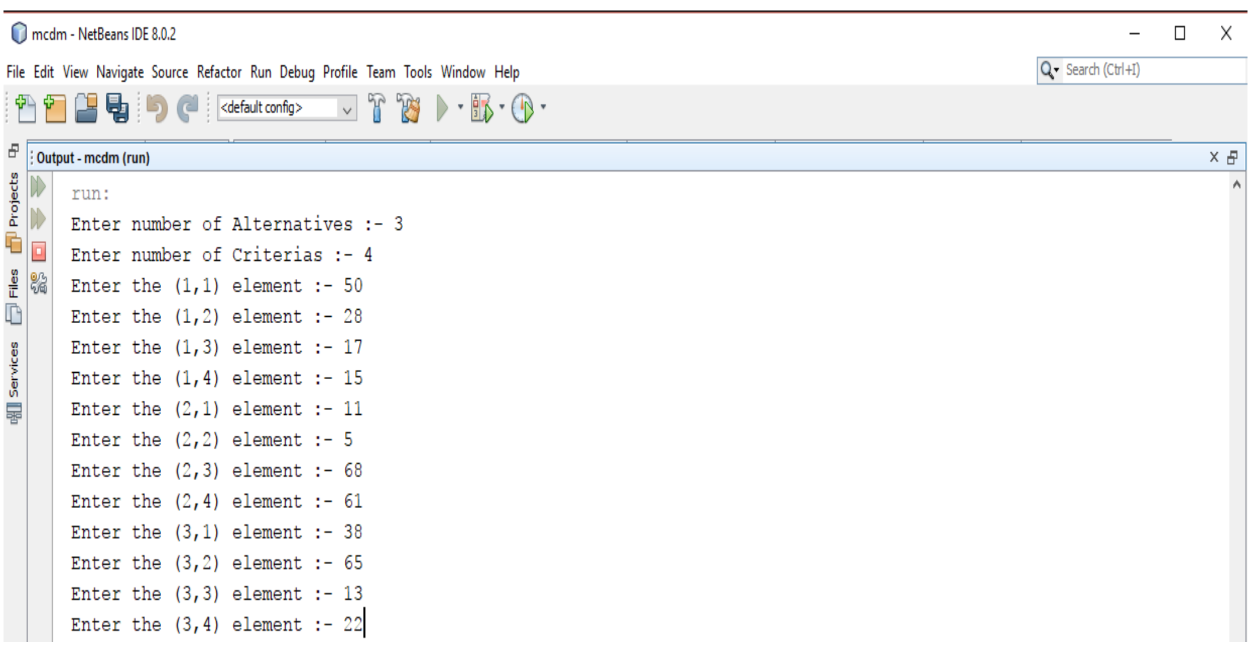


Figure 5: Input given by user for Problem 1

Now, using Equation 4, Equation 5, Equation 6 we got the standardized matrix as,

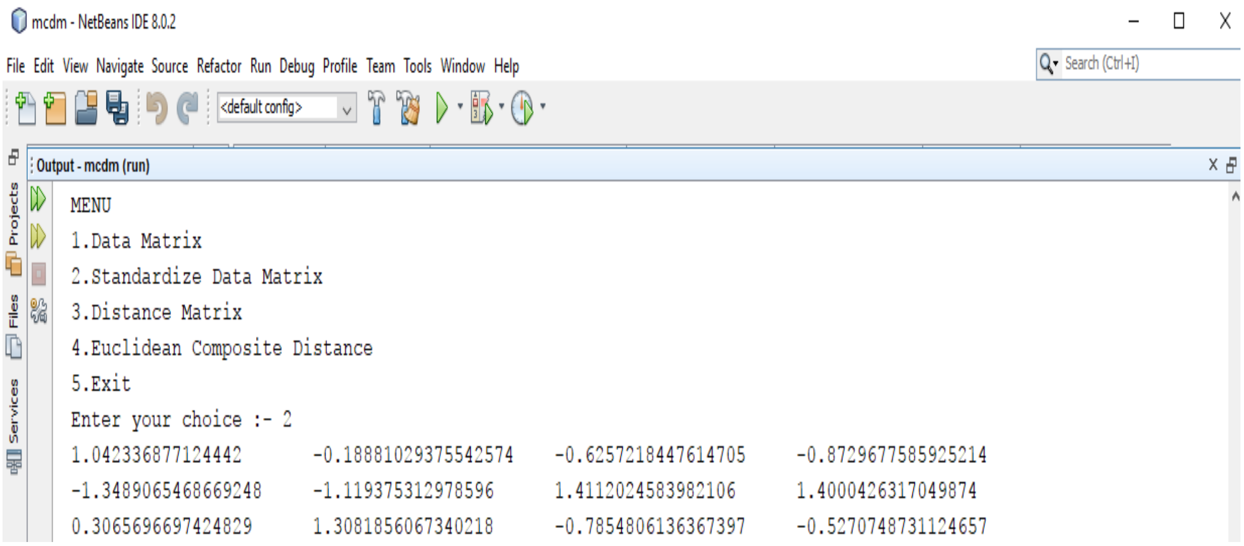
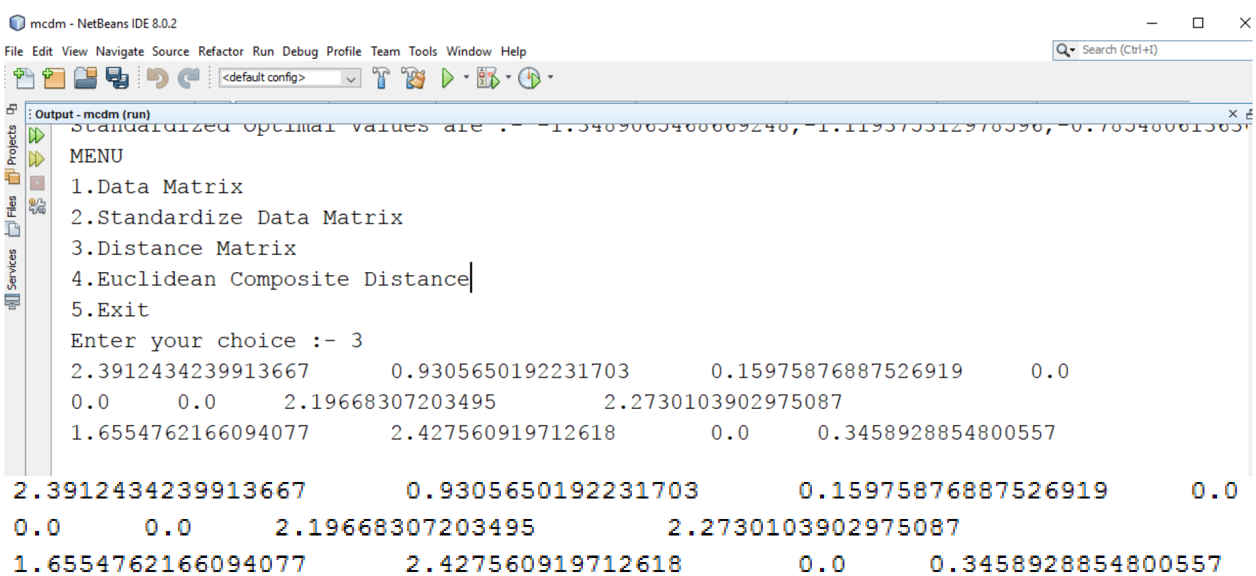

```
MENU
1.Data Matrix
2.Standardize Data Matrix
3.Distance Matrix
4.Euclidean Composite Distance
5.Exit
Enter your choice :- 2
1.042336877124442     -0.18881029375542574     -0.6257218447614705     -0.8729677585925214
-1.3489065468669248   -1.119375312978596       1.4112024583982106      1.4000426317049874
0.3065696697424829    1.3081856067340218       -0.7854806136367397     -0.5270748731124657
```

Figure 6: Standardized Matrix for Problem 1

Using Equation 8 we get the distance matrix as,


```
MENU
1.Data Matrix
2.Standardize Data Matrix
3.Distance Matrix
4.Euclidean Composite Distance
5.Exit
Enter your choice :- 3
2.3912434239913667    0.9305650192231703    0.15975876887526919    0.0
0.0    0.0    2.19668307203495    2.2730103902975087
1.6554762166094077    2.427560919712618    0.0    0.3458928854800557
```

```
2.3912434239913667    0.9305650192231703    0.15975876887526919    0.0
0.0    0.0    2.19668307203495    2.2730103902975087
1.6554762166094077    2.427560919712618    0.0    0.3458928854800557
```

Figure 7: Distance of each attribute from optimal state for Problem 1

After calculating the Euclidean Composite Distance using Equation 9, we get Location A as the best alternative as shown below in Figure 5

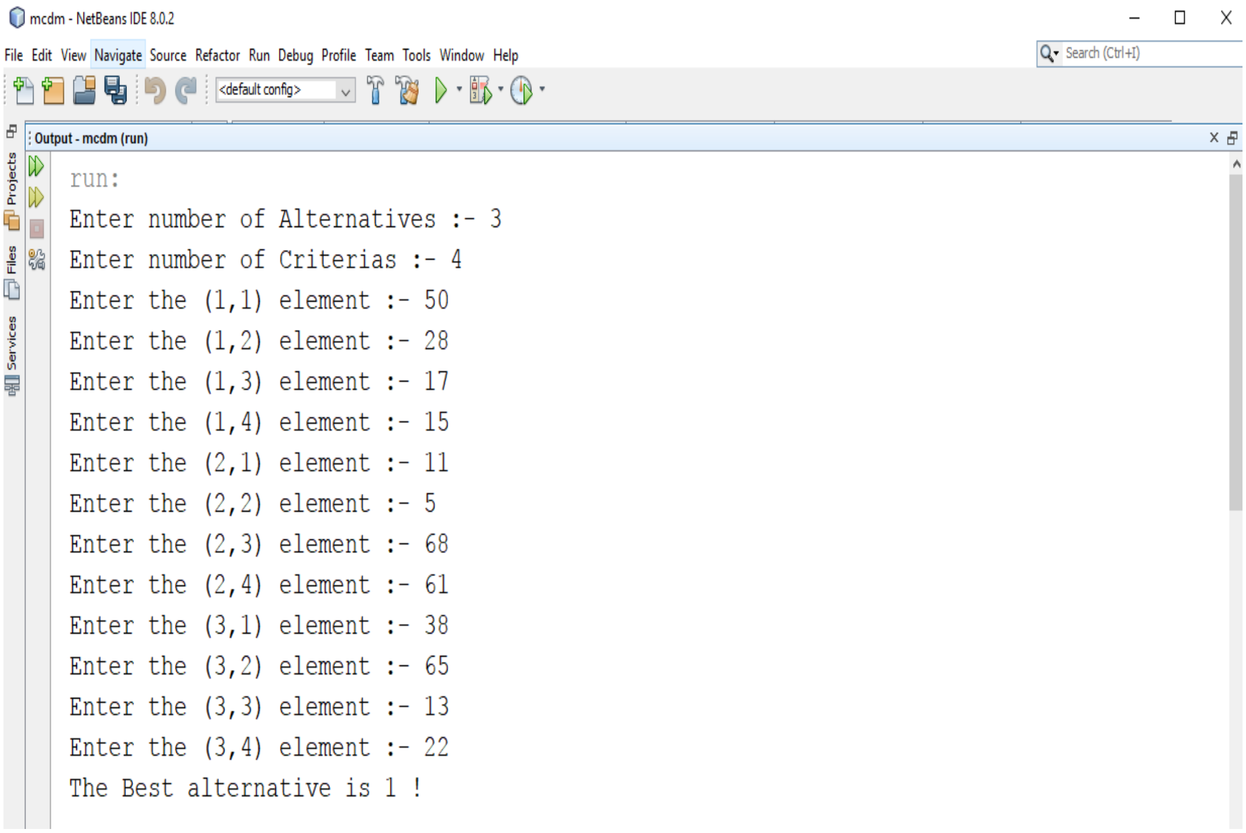


Figure 8: Result of Problem 1

Problem 2:- Fighter Aircraft Selection Problem

A certain nation wants to buy Fighter Aircrafts and there are four alternatives from where it can choose to buy. The criteria required while making a purchase are X1:Max Speed (mach number), X2:Ferry Range(nautical miles), X3:Max Payload(lbs), X4:Cost(million dollars),X5:Reliability(on scale of 0-100), X6:Maneuverability(on scale of 0-100). In the discussed problem all the criteria are benefit criteria except Cost. The required data is given in the table below.

Table 2: Dataset of Problem 2

Alternative	X1	X2	X3	X4	X5	X6
A1	2	1500	20000	5.5	50	100
A2	2.5	2700	18000	6.5	25	50
A3	1.8	2000	21000	4.5	100	100
A4	2.2	1800	20000	5	50	50

Input given by user for number of alternatives and criteria according to fiven problem,

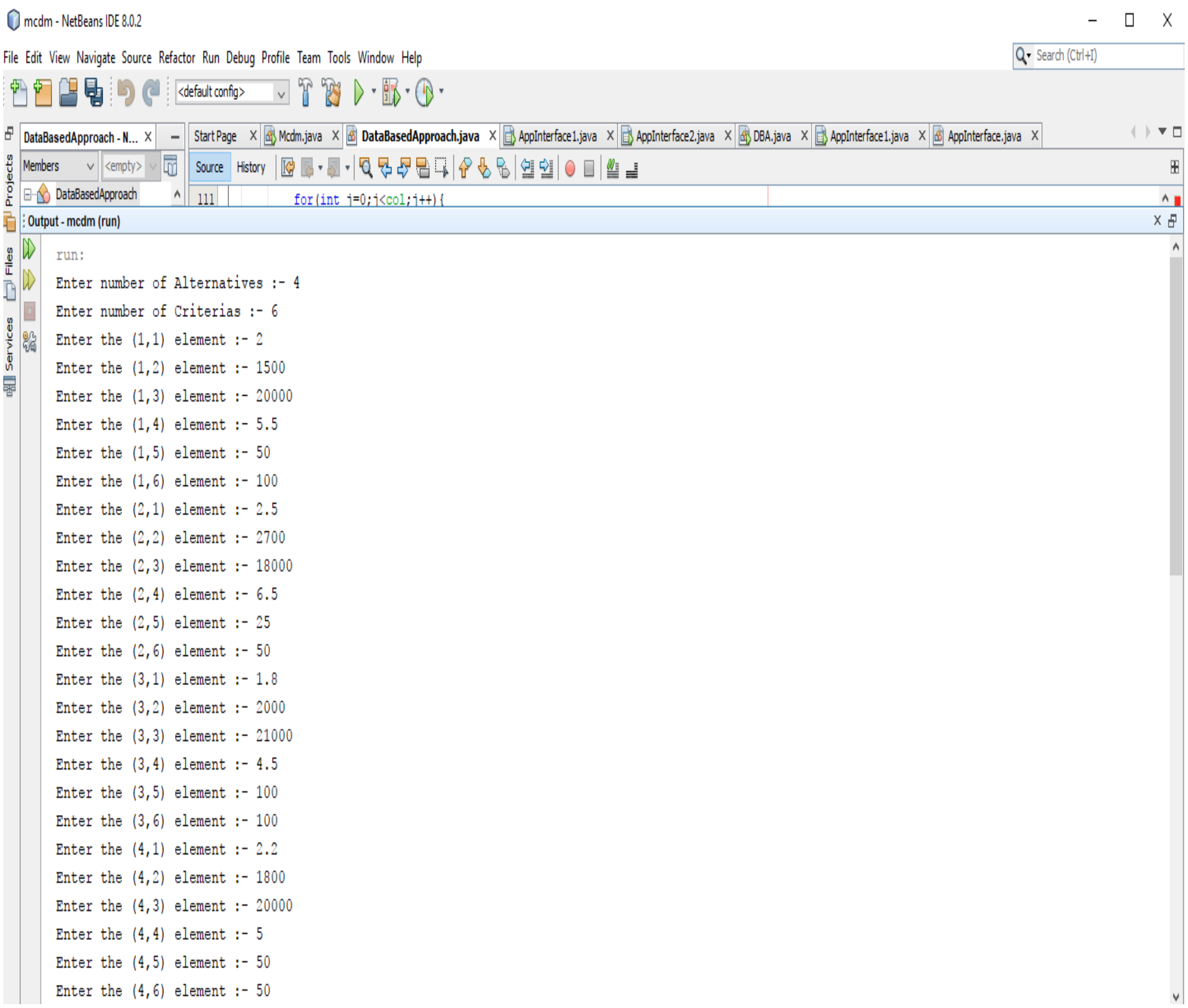


Figure 9: Input given by user for Problem 2

Using Equation 4, Equation 5, Equation 6 we get the standardized matrix as,

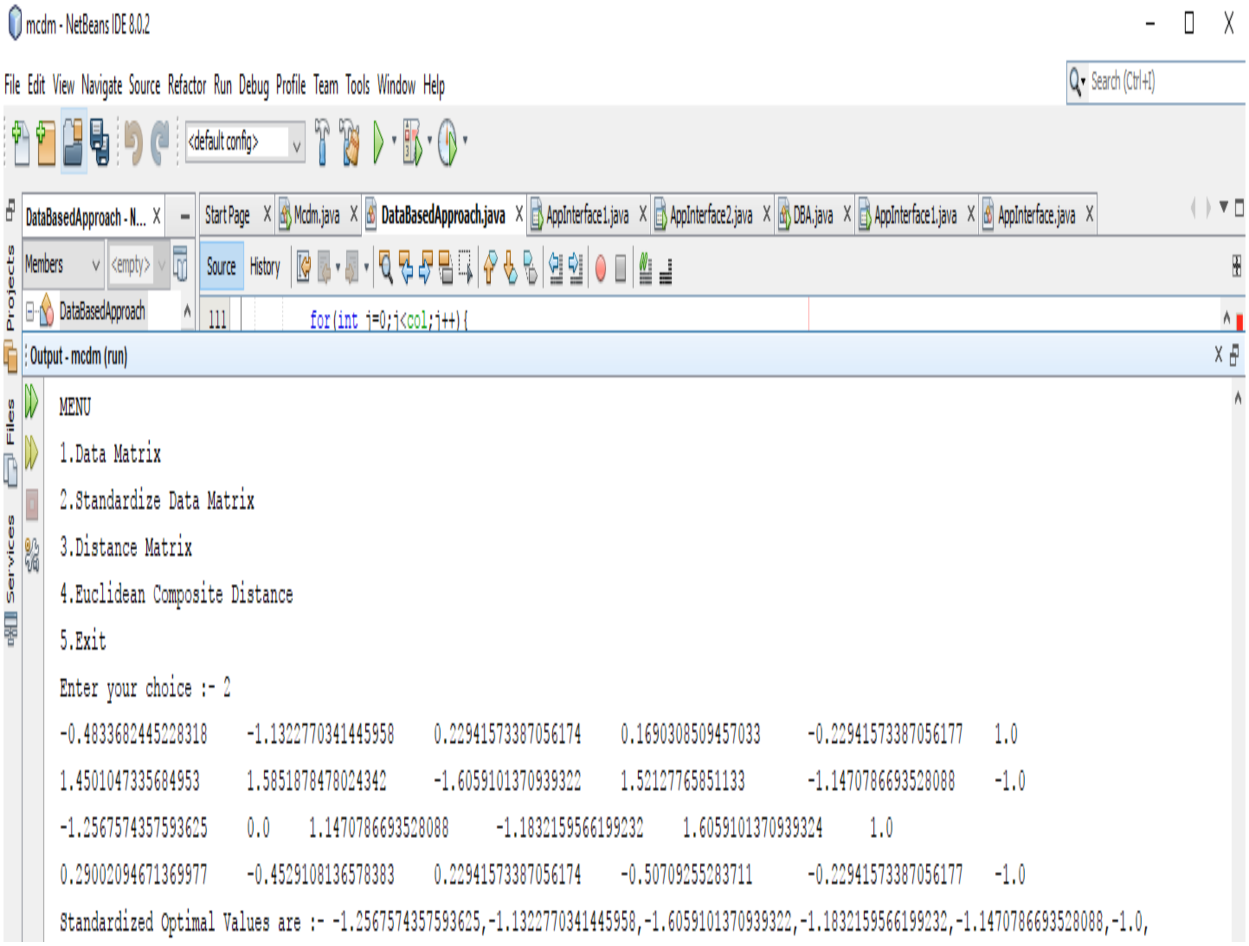


Figure 10: Standardized Matrix for Problem 2

Using Equation 8 we get the distance matrix as,

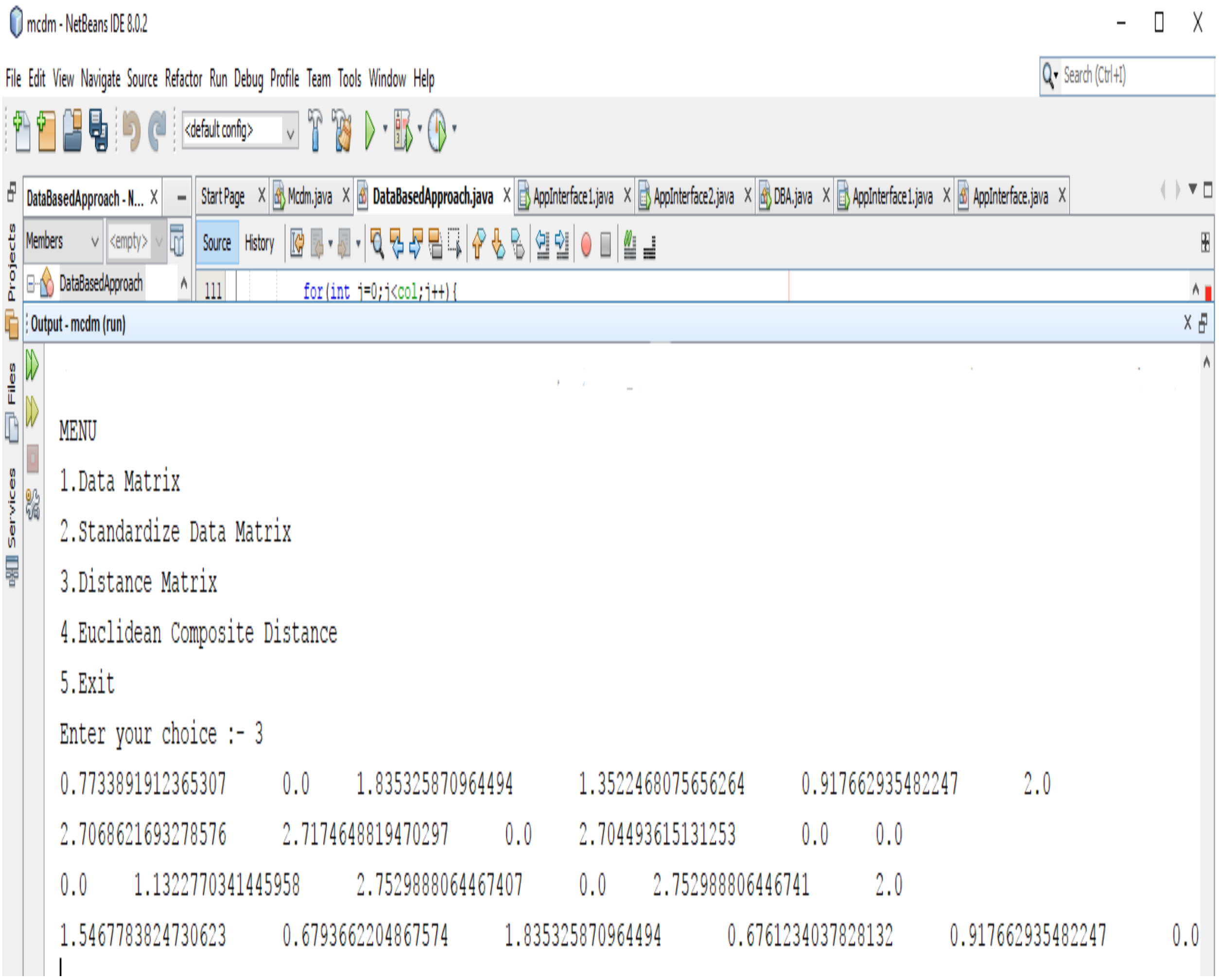


Figure 11: Distance of each attribute from optimal state for Problem 1

After calculating the Euclidean Composite Distance using Equation 9, we get Alternative 3 as the best alternative as shown below in Figure 8.

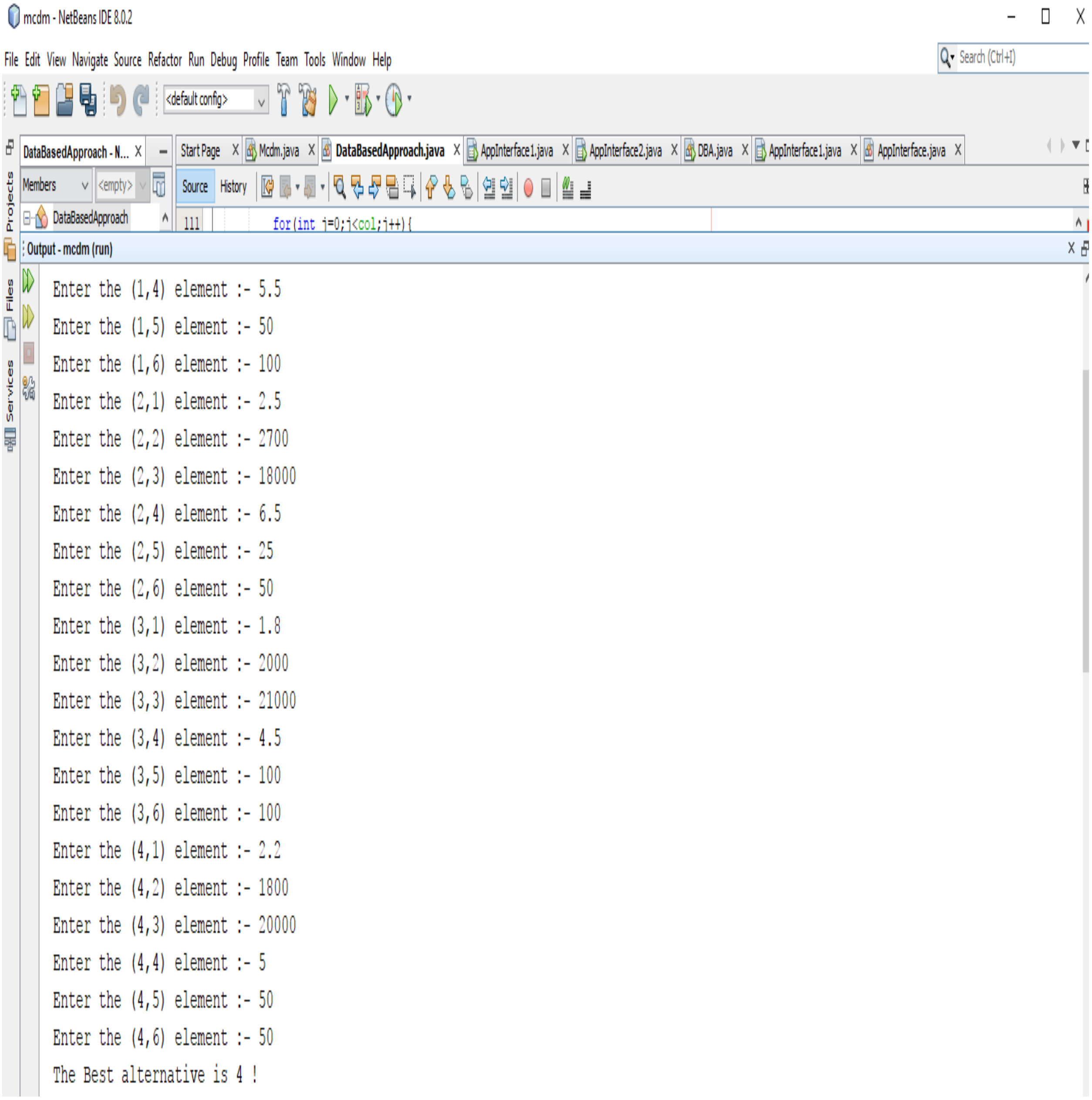


Figure 12: Result of Problem 2

CHAPTER 5: CONCLUSION

CONCLUSION

The training that I underwent at the Defence Research and Development Organization in the month of July - August, gave me an insight into the functioning of various units of DTRL. I learnt in depth about the concept of Multi Criteria Decision Making and Distance Based Approach.

As students of Computer Science Engineering, I got to observe practically, the equipment that I have only read about in textbooks till now and their functioning. This training has inspired me to excel in the field I have chosen, and has shown me that there is much scope in the future, which I as students can explore.

CHAPTER 6: REFERENCES

REFERENCES

Defence Research and Development Organisation. (2017, August 11). Vision & Mission .Retrieved from https://www.drdo.gov.in/drdo/English/index.jsp?pg=vision.jsp

Sharma, K., Garg, R., Nagpal, C. K., & Garg, R. K. (2010). Selection of optimal software reliability growth models using a distance based approach.*IEEE Transactions on Reliability*, *59*(2), 266-276.

Wikipedia: The free encyclopedia. (2017, August 12). Defence Research and Development Organisation. Retrieved from https://en.wikipedia.org/wiki/Defence_Research_and_Development_Organisation