EVALUATING THE IMPACT OF VARIOUS PARAMETERS ON UNCERTAINTY OF MEASUREMENT USING ANALYTIC HIERARCHY PROCESS

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Abstract -. *In many engineering applications the final decision is based on the evaluation of a number of alternatives in terms of a number of criteria. This problem may become a very difficult one when the data are qualitative and difficult to be quantified. The Analytic Hierarchy Process (AHP) is an effective approach in dealing with this kind of decision problems. AHP is a decision making process which finds out a proper decision using a systematic method. For finding the decision data is needed and it is collected using a questionnaire method. The measurements are inseparable part of our life. In each and every field, whether it is laboratory or industry measurements are to be taken. Measured values are never perfect. So the reliability of measurement result is important aspect for the measurement. There are various factors which affect the result of measurement and needed to be determined. This paper examines some of the practical and computational issues involved when the AHP method is used in determining the impact of qualitative factors on uncertainty of measurement.*

Keywords: Multi criteria decision making, Analytical hierarchical process, pairwise comparison, uncertainty of measurement.

1. INTRODUCTION

The Analytic Hierarchy Process (AHP) is a multi-criteria decision-making approach and was introduced by Saaty (1977 and 1994). The AHP has attracted the interest of many researchers mainly due to the nice mathematical properties of the method and the fact that the required input data are rather easy to obtain. The AHP is a decision support tool which can be used to solve complex decision problems. It uses a multi-level hierarchical structure of objectives, criteria, sub criteria, and alternatives. The pertinent data are derived by using a set of pair wise comparisons. These comparisons are used to obtain the weights of importance of the decision criteria, and the relative performance measures of the alternatives in terms of each individual decision criterion. As an illustrative application consider the case of measurement uncertainty. There are various qualitative and quantitative factors which affect the result of measurement. Effect of quantitative factors is quiet easy to calculate. But for the factors like training, knowledge, experience, of the operator no quantitative data is available. So to determine the impact of such parameters on measurement of uncertainty is challenging. As these factors are equally important the AHP is used.

2. HOW TO USE AHP

2.1 Steps for AHP

- State the objectives
- Define the criteria
- Pick the alternatives
- determine the ranking of criteria using judgement
- doing pairwise comparison and forming matrix
- finding eigenvector after solving matrix
- repeating the procedure for alternatives

2.2 How it is applied in case of measurement of uncertainty

There are various quantitative factors which affect the measurement causes uncertainty in results. These factors are calculated using standard procedures available. But foe qualitative data no such standard procedure is available. So AHP is applied for finding the impact of such parameters.

2.2.1 State the objective

The objective is to find the impact of qualitative factors on uncertainty of measurement.

2.2.2 Define the criteria

Criteria used are expert person providing training, knowledge and experience, level of training, knowledge and experience provided and the time span for which training, knowledge and experience is provided.

2.2.3 Pick the alternatives

In this paper the quantitative factors considered are training of operator ,knowledge provided to operator, experience provided to operator. These are alternatives.

2.2.4 Determine the Ranking of Criteria

Expert person is 3 times as important as time span
Expert person is 4 times as important as level
Time span is 2 times as important as level

2.2.4.1 Pair wise Comparison

Using abbreviations **E** for Expert person, **T** for Time span and **L** for Level

	E	T	L
E	1/1	3/1	4/1
T	1/3	1/1	2/1
L	1/4	1/2	1/1

	E	T	L
E	1.0000	3.0000	4.0000
T	0.3333	1.0000	2.0000
L	0.2500	0.5000	1.0000

2.2.4.2 Finding Eigenvector

1) Squaring the above matrix

	E	T	L
E	2.9000	8.0000	1.7500
T	1.1000	2.9000	0.6500
L	5.2000	14.0000	3.0000

2) Sum the rows

	E	T	L
E	2.9000	8.0000	1.7500 = 12.6500
T	1.1000	2.9000	0.6500 = 4.6500
L	5.2000	14.0000	3.0000 = 22.2000

Row total= 12.65+4.65+22.2= 39.5000

3) Normalizing by dividing the row sum by row total
The result is eigenvector

Expert Person:	**0.3202**	second most important
Time Span:	**0.1177**	least important
Level:	**0.5620**	Most important

2.2.5 Determine the Ranking of Alternatives

2.2.5.1 Pair wise Comparison on the basis of Expert person

Using abbreviations **T** for Training, **K** for knowledge and **E** for experience

	T	K	E
T	1/1	3/1	4/1
K	1/3	1/1	2/1
E	1/4	1/2	1/1

	T	K	E
T	1.0000	3.0000	4.0000
K	0.3333	1.0000	2.0000
E	0.2500	0.5000	1.0000

2.2.5.1.1 Finding Eigenvector

1) Squaring the above matrix

	T	K	E
T	2.9000	8.0000	14.0000
K	1.1000	2.9000	5.2000
E	0.6500	1.7500	3.0000

2) Sum the rows

	T	K	E
T	2.9000	8.0000	14.0000 = 24.9000
K	1.1000	2.9000	5.2000 = 9.2000
E	0.6500	1.7500	3.0000 = 5.40000

Row total= 24.9 + 9.2 +5.4= 39.5

2.2.5.1.2 Normalizing by dividing the row sum by row total

The result is eigenvector

Training **0.6303**
Knowledge **0.2329**
Experience **0.1367**

2.2.5.2 Pair comparison on the basis of Time Span

Using abbreviations **T** for Training, **K** for knowledge and **E** for experience

	T	K	E
T	1/1	3/1	1/2
K	1/3	1/1	1/4
E	2/1	4/1	1/1

	T	K	E
T	1.0000	3.0000	0.5000
K	0.3333	1.0000	0.2500
E	2.0000	4.0000	1.0000

2.2.5.2.1 Finding Eigenvector

1) Squaring the above matrix

	T	K	E
T	2.9000	8.0000	1.7500
K	1.1600	2.9000	0.6500
E	5.2000	14.0000	3.0000

2) Sum the rows

	T	K	E
T	2.9000	8.0000	1.7500 = 12.6500
K	1.1000	2.9000	0.6500 = 4.6500
E	5.2000	14.0000	3.0000 = 22.2000

Row total= 12.65+4.65+22.2= 39.5000

2.2.5.2.2 Normalizing by dividing the row sum by row total

The result is eigenvector

Training **0.3202**

Knowledge **0.1177**

Experience **0.5620**

2.2.5.3 Pair wise comparison on the basis of Level

Using abbreviations **T** for Training, **K** for knowledge and **E** for experience

	T	K	E
T	1/1	1/2	1/3
K	2/1	1/1	1/4
E	3/1	4/1	1/1

	T	K	E
T	1.0000	0.5000	0.3333
K	2.0000	1.0000	0.2500
E	3.0000	4.0000	1.0000

2.2.5.3.1 Finding Eigenvector

1) Squaring the above matrix

	T	K	E
T	2.9000	2.3200	0.7850
K	4.7500	3.0000	1.1600
E	14.0000	9.5000	2.9000

2) Sum the rows

	T	K	E
T	2.9000	2.3200	0.7850 = 6.0050
K	4.7500	3.0000	1.1600 = 8.9100
E	14.0000	9.5000	2.9000 = 26.4000

Row total= 6.005 +8.91 +26.4 = 41.3150

2.2.5.3.2 Normalizing by dividing the row sum by row total

The result is eigenvector

Training **0.4150**

Knowledge **0.2156**

Experience **0.6389**

2.2.6 Finding final solution

Training	0.6303	0.3202	0.4150		0.3202	**E**
Knowledge	0.1177	0.2329	0.2156	*	0.1177	**T**
Experience	0.5620	0.1367	0.6389		0.5620	**L**

The result is 0.4726
0.1863
0.5549

2.3 RESULT

The impact of Experience, Training and Knowledge on Uncertainty of measurement is 0.5549, 0.4726 and 0.1863

2.4 CONCLUSION

The analytical Hierarchical method here calculates the impact of various qualitative factors on measurement uncertainty in a systematic way. The Experience has the highest impact on measurement uncertainty. Second factor is Training and Knowledge is the last factor in the race. By giving proper training to the operator the impact can be reduced. This helps in reducing the overall measurement uncertainty.

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