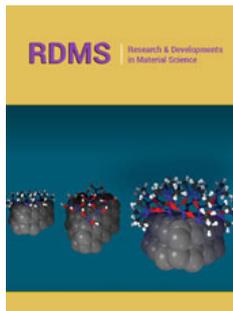


# Uncertainty Classification and Modelling

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## Abstract

Now a day's uncertainty plays crucial role in solving problems related to everyday life. It becomes integral part of research as general and particular to the fields which get affected due to negligence of uncertainty. since Uncertainty is integral part in science, modelling uncertainty is important to study. This paper discussed review on uncertainty modelling in details for Mathematical Mechanical Modelling (MMM) process, it includes classification of Uncertainty, types of Uncertainty and also researchers approach to deals with uncertainty. In recent days researchers are using different methodologies which quantify uncertainty, different researcher uses different techniques of uncertainty calculations. It is found by comparing different techniques those applications of fuzzy sets plays major role in uncertainty modelling. Research papers studied during this review shows almost 63.63% of researchers are using fuzzy set methods to handle uncertainty in real life applications. It concludes that MMM processes uncertainty can be handled with fuzzy sets.

**Keywords:** Mathematical mechanical modeling; Uncertainty; Fuzzy sets

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## Introduction

Purpose of designing a system is to manufacture the real system. Mathematical Mechanical Modeling (MMM) process designed for predicting the responses of the real system in its surrounding. Variations in responses are observed due to fluctuations in manufacturing process and configuration associated with the design system. MMM process of the design system, has parameters which can be uncertain. Uncertain parameters result in computational model uncertainties. Decision based on predictions from MMM process design should consider computational model uncertainties and model uncertainties. Uncertainty is a powerful aspect of simulations and highlighting it, directly increases the significance of a simulation [1]. Uncertainties in system at component level propagated to quantify level of reliability. Therefore, to identify all the uncertainties and treat them effectively to solve reliabilities in research studies and decision-making problems.

A systematic uncertainty analysis consists of the following discrete assessments:

- (1) Identification, evaluation and tabulation of contributors to uncertainty and their relative influences (sensitivity analysis).
- (2) Synthesis of primitive uncertainties to yield the corresponding uncertainty in the characteristic(s) of interest.
- (3) Implementation of methods and procedures for minimizing the effects of the primitive uncertainties, when possible

Not all forms of uncertainty can be predicted or corrected for, but it is reasonable to expect that situations like having fail would not bring the system to a halt [2]. E.g. Uncertainty in measurement can be analyzed with a denser sampling pattern to ensure a reliable assessment [3]. To come with the solutions for the challenges, the manufacturing industries should select appropriate manufacturing strategies, product designs, manufacturing processes, work piece, and tool materials, machinery, and equipment, and so on. The selection decisions are complex

due to uncertainties in decision making problems. Decision makers in the manufacturing sector frequently face the problem of assessing wide range of alternative options and selecting one based on a set of conflicting criteria. There are several types of uncertainties which arises in complex engineering design due to source of origin, it is very important to understand classification of uncertainties based on the source of origin.

### Classification of uncertainty

Uncertainty is classified in a broad way as shown in Table 1, it classified based on awareness of experts and context in which they arise classically. Further classified layer by layer uncertainties which exists with various types of occurrences and classified uncertainty based on understanding in complex engineering design.

**Table 1:** Classification of uncertainty.

| Sr. No. | Classification Based on                     | Classifications                   | Source                   | Meaning of types of Uncertainty   |
|---------|---|-----------------------------------|--------------------------|---|
| 1       | awareness of experts                        | <i>a. known unknowns</i>          | Classical Categorization | uncertainties that have the awareness of experts  |
|         |   | <i>b. unknown unknowns</i>        |                          | uncertainties which the experts are not aware of  |
| 2       | context in which they arise                 | <i>a. endogenous uncertainty</i>  | Classical Categorization | in contexts present inside an engineering complex system  |
|         |   | <i>b. exogenous uncertainties</i> |                          | in its environment  |
| 3       | uncertainty in five layers                  | <i>a. Nature Layer</i>            | New Approaches           | Layer regarding generalized uncertainty characteristics   |
|         |   | <i>b. Cause Layer</i>             |                          | Layer that defines uncertainties based on their source  |
|         |   | <i>c. Level Layer</i>             |                          | This layer classifies uncertainties regarding its severity  |
|         |   | <i>d. Manifestation Layer</i>     |                          | Deals with the point in the process where uncertainties occur   |
|         |   | <i>e. Expression Layer</i>        |                          | Layer that defines the treatment applied to the uncertainty   |
| 4       | understanding in complex engineering design | <i>a. Imprecision</i>             | New Approaches           | is associated mainly with early stage of the design process   |
|         |   | <i>b. Inconsistency</i>           |                          | arises in the presence of information ambiguities, information contradictions or model simplifications                      |
|         |   | <i>c. Inaccuracy</i>              |                          | arises primarily in early design stages where the lack of full knowledge or data leads to estimates that may contain errors |
|         |   | <i>d. Indecision</i>              |                          | is linked also with the abundance of solution and alternatives, and the tests conducted in early stages                     |
|         |   | <i>e. Instability</i>             |                          | may come from the lack of definition of requirements and specifications of the design process                               |

### Types of uncertainty Vs mathematical theories and methodologies

There are certain approaches to deal with uncertainty modeling, Table 2 shown above represents uncertainty modeling approaches and contribution of various researchers [4-24]. It shows that

random and fuzzy set approach is widely used for uncertainty modeling. Uncertainty problem can be solved by using FMCDM methods, for user preferred channel [25]. Fuzzy based uncertainty modeling is based on notion of belonging as it is depend on membership function, while use of probability distribution is based on frequency of occurrence [26].

**Table 2:** Uncertainty modeling approaches used by researchers.

| Category             | Approaches                          | Reference | Percentage |
|----------------------|-------------------------------------|-----------|------------|
| Uncertainty Modeling | Random and Fuzzy Sets               | [4-17]    | 63.63      |
|                      | Fuzzy Stochastic                    | [18,19]   | 9          |
|                      | FMEA integrated with Fuzzy and MCDM | [20]      | 4.5        |
|                      | Grey Theory                         | [21]      | 4.5        |
|                      | Knowledge management                | [4]       | 4.5        |
|                      | Differential Stochastic Calculus    | [22,23]   | 9          |
|                      | Probabilistic                       | [24]      | 4.5        |

## Conclusion

Detailed study of research papers on uncertainty modeling in Mathematical Mechanical Modeling (MMM) shows that researchers are inclined towards fuzzy sets utilization in their research. It was found that 63.63% of researcher from the paper studied shows application of fuzzy sets in uncertainty modeling, further researchers are finding different fuzzy techniques for uncertainty modeling to deal with uncertainty exactly.

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