HYBRID-FUZZY TECHNIQUES WITH FLEXIBILITY AND ATTITUDINAL PARAMETERS FOR SUPPORTING EARLY PRODUCT DESIGN AND RELIABILITY MANAGEMENT

DANIEL OSEZUA AIKHUELE

DOCTOR OF PHILOSOPHY
(MANUFACTURING ENGINEERING)

UNIVERSITI MALAYSIA PAHANG
I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Doctor of Philosophy in Manufacturing Engineering.

(Supervisor’s Signature)

Full Name: Ir. Dr. Faiz Mohd Turan
Position: Senior Lecturer
Date: 
STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citation which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

_______________________________
(Student’s Signature)
Full Name : DANIEL OSEZUA AIKHUELE  
ID Number : PMF14005  
Date : 24 May 2017
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<tr>
<td>$\omega$</td>
<td>Attribute weight</td>
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<tr>
<td>$\mu_A$</td>
<td>Membership function of the fuzzy set $A$</td>
</tr>
<tr>
<td>$\nu_A$</td>
<td>Non-membership function of the fuzzy set $A$</td>
</tr>
<tr>
<td>$S(\hat{a})$</td>
<td>Score function</td>
</tr>
<tr>
<td>$H(\hat{a})$</td>
<td>Accuracy function</td>
</tr>
<tr>
<td>$S_e(A)$</td>
<td>Exponential score function</td>
</tr>
<tr>
<td>$ER(A)$</td>
<td>Exponential related function</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>Attitudinal parameter</td>
</tr>
<tr>
<td>$\lambda_c$</td>
<td>Flexibility and adjustability feature</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>Experts (DMs) associated weights vector</td>
</tr>
<tr>
<td>$R_{m\times n}(a_{ij})$</td>
<td>Intuitionistic fuzzy decision matrix</td>
</tr>
<tr>
<td>$ERM_{m\times n}$</td>
<td>Exponential related matrix</td>
</tr>
<tr>
<td>$\Omega^n$</td>
<td>The set of real numbers</td>
</tr>
<tr>
<td>$\otimes$</td>
<td>Circled time operator (multiplication sign)</td>
</tr>
<tr>
<td>$\forall i$</td>
<td>For all</td>
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<tr>
<td>AHP</td>
<td>Analytic Hierarchy Process</td>
</tr>
<tr>
<td>AI</td>
<td>Artificial Intelligence</td>
</tr>
<tr>
<td>CC</td>
<td>Closeness Coefficient</td>
</tr>
<tr>
<td>DEMATEL</td>
<td>Decision-making Trial and Evaluation Laboratory</td>
</tr>
<tr>
<td>DMs</td>
<td>Decision Makers</td>
</tr>
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<td>ER</td>
<td>Exponential Related function</td>
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<td>FMEA</td>
<td>Failure mode and effect analysis</td>
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<td>GTIFOWGA</td>
<td>Generalized Triangular Intuitionistic Fuzzy Ordered Weighted Geometric Averaging operator</td>
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<tr>
<td>GTIFGA</td>
<td>Generalized Triangular Intuitionistic Fuzzy Geometric Averaging operator</td>
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<td>IFE</td>
<td>Intuitionistic Fuzzy Entropy</td>
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<td>Intuitionistic Fuzzy Set</td>
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<tr>
<td>IFN</td>
<td>Intuitionistic Fuzzy Number</td>
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<tr>
<td>IFWG</td>
<td>Intuitionistic Fuzzy Weighted Geometric operator</td>
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<td>IFPIS</td>
<td>Intuitionistic Fuzzy Positive Ideal Solutions</td>
</tr>
<tr>
<td>IFNIS</td>
<td>Intuitionistic Fuzzy Negative Ideal Solutions</td>
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<tr>
<td>MADM</td>
<td>Multi-Attribute Decision Making</td>
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<td>MAGDM</td>
<td>Multi-Attribute Group Decision Making</td>
</tr>
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<td>NIFIGOWA</td>
<td>Normal Intuitionistic Fuzzy Induced Generalized Ordered Weighted Averaging operator</td>
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<tr>
<td>TOPSIS</td>
<td>Technique for Order Preference by Similarity to the Ideal Solution</td>
</tr>
<tr>
<td>TIFN</td>
<td>Triangular Intuitionistic Fuzzy Number</td>
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<tr>
<td>TIFWGA</td>
<td>Triangular Intuitionistic Fuzzy Weighted Geometric Averaging operator</td>
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<tr>
<td>TIFOWGA</td>
<td>Triangular Intuitionistic Fuzzy ordered weighted geometric averaging operator</td>
</tr>
<tr>
<td>TIFHWGA</td>
<td>Triangular Intuitionistic Fuzzy Hybrid Weighted Geometric Averaging operator</td>
</tr>
<tr>
<td>RPN</td>
<td>Risk Priority Number</td>
</tr>
<tr>
<td>RCF</td>
<td>Root Cause of Failure</td>
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<tr>
<td>VIKOR</td>
<td>VlseKriterijumska Optimizacija I Kompromisno Resenje</td>
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DEFINITION OF SOME KEY WORDS

Intuitionistic Fuzzy Sets: are sets whose elements have degrees of membership and non-membership. Intuitionistic fuzzy sets have been introduced by Krassimir Atanassov in 1986 as an extension of Lotfi Zadeh’s notion of fuzzy set, which itself extends the classical notion of a set. See details of the fuzzy set theory in APPENDIX 5.

Reliability: can be described as the probability that an item will continue to perform its intended function without failure for a specified period of time under stated conditions.

Product Reliability or Design for Reliability: describes the entire set of tools that support product and process design (typically from early in the concept stage all the way through to product obsolescence) to ensure that customer expectations for reliability are fully met throughout the life of the product with low overall life-cycle costs.

Multiple attribute decision making (MADM): MADM which is a sub-discipline of operation research, is concerns with problems of prioritizing, screening, ranking or selecting alternative(s) from among a finite set of candidates with multiple attributes, usually conflicting, by considering them simultaneously to select the best candidate (Braglia1 et al., 2003). Many of our everyday decision-making problems involve the consideration of multiple criteria or attributes. See details of the MADM in APPENDIX

Group decision-making (GDM): GDM is a situation where individuals are tasked to collectively make a choice from a list of alternatives with respect to some attributes. The GDM, for the purpose of this thesis, will be regarded as Multi-Attribute Group Decision Making (MAGDM).

TOPSIS: TOPSIS is a multi-attribute technique which is based on obtaining the alternative that approaches an ideal alternative, by considering the positive ideal alternative and the negative ideal alternative.

Reliability and validity in Research: Reliability and validity in research are two concepts that are important for defining and measuring bias and distortion, where Reliability refers to the extent to which research assessments are consistent, Validity refers to the accuracy of the research assessment.

Attitudinal Parameter: Attitudinal Parameter is the mathematic symbol used in this research study, to describe the emotional disposition of design stakeholders (decision-makers) when making decisions.

Product design: Product design is the translation of intellectual wisdom, requirements of the entrepreneurs, or needs of the consumers, into a specific product.