NuSec Nuclear Security Science Network

UNIVERSITY OF SURREY

NuSec Summer Placement 2021
Creating a Scintillator Selection Tool Using Fuzzy Logic

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Research Interests | *Shenton-Taylor*

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Artificial intelligence to support global nuclear security.

Radiation Portal Screening	Treaty Controlled Item Verification	Urban infrastructure threat protection	Nuclear Decommissioning	Primary and Secondary Inspection	Environmental Monitoring

Optimised Detection | Optimised Data Analytics | Appropriate End User Deployment

Artificial Intelligence Supported Decisions

Wavelet Analysis | Genetic Algorithms | Fuzzy Logic | Neural Networks | Convex Partition Method

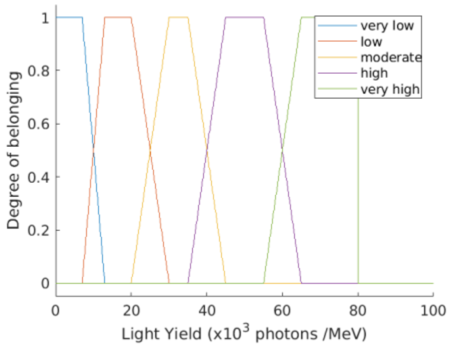
Current / Recent Projects

Recent & Current Projects, Shenton-Taylor

Artificial Intelligence to support Global Nuclear Security

Projects	Optimised Detection	Enhanced Data Analytics	End User Deployment	Funding
Fuzzy Logic to optimise scintillator selection	■		■	NuSec 2021
Genetic Algorithm optimised Wavelets to resolve overlapping spectral features.		■		TRANSCEND
Neutral Network for automatic radioisotope identification		■		TRANSCEND
Convex Partition Method for optimised radioisotope search			■	AWE Collaboration
Intelligent sensor placement for radiation detection; static and mobile.	■		■	Surrey
Fuzzy Logic for informed risk management.			■	Surrey

Input parameters with a degree of membership



Manufactures classify scintillator performance on different scales.

Provides an opportunity to **quantify expert judgement.**

1

Fuzzification of multiple input parameters

TABLE I. Parameter Weightings (on a scale of 1-10) for Applications of Scintillating Materials

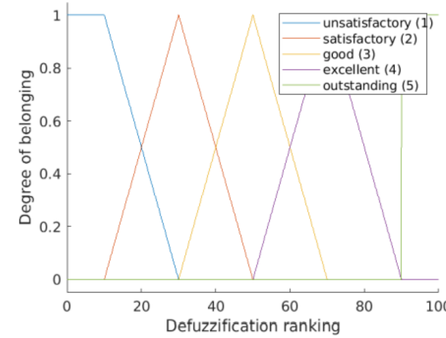
Application	Light Yield	Density	Decay Time	Energy Resolution
PET [11] [12] [3]	10	10	-	-
CT [3]	10	10	3	-
Environmental Monitoring [9]	10	10	-	10
Teaching Laboratory[a] [13]	1	1	1	10
High Energy Particle Detectors [3]	3	10	10	-
Astrophysics [3]	5	-	5	10
Spectrometry of Low Energy γ Quanta [3]	10	-	-	10

[a] The cost of the scintillator was of particular importance to this application.

User defined weighting of input parameter significance; can tailor to end application.

2

Defuzzification to crisp numeric output



This project **applied a Graphical Trapezoidal** approach for defuzzification.

3

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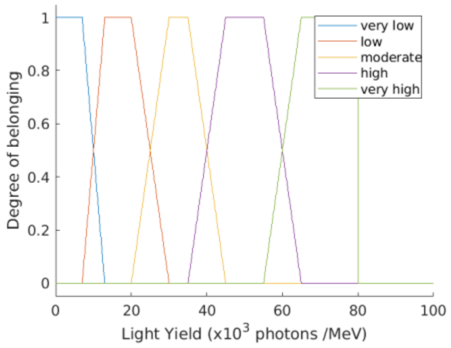
Input parameters with a degree of membership



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Provides an opportunity to **quantify expert judgement.**

1

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Developed approach to move scintillator properties into fuzzy logic 'degree of membership' inputs.

Future PhD

- Optimise initial parameter classification; the degree of membership categories.
- Assess further the impact of parameter weighting.
- Increase the number of parameters considered, both scintillator performance parameters & end use deployed constraints.

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2

NuSec 2021 Summer Pilot

Combined, via simply logic fuzzification rules, input parameters of light yield, density, decay time and energy resolution.

Future PhD

- Optimise the inclusion of end user deployment constraints; could be added with the fuzzy logic framework or as boundary conditions.
- Alter the weighting applied to the input parameters.
- Consider fuzzification approach; i.e. T-Norm, S-Norm operators.

Apply a Genetic Algorithm to assess the importance of scintillator parameters within the model.

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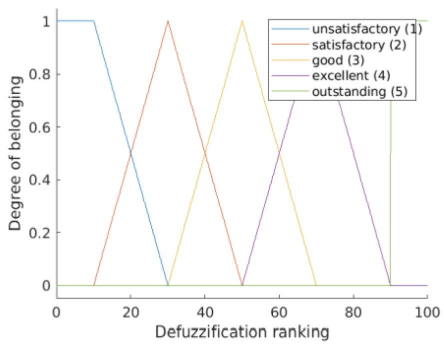
Defuzzification to crisp numeric output



This project **applied a Graphical Trapezoidal** approach for defuzzification.

3

NuSec 2021 Summer Pilot

Applied graphical trapezium method to return a single rating for each scintillator material & compared with test cases.

Future PhD

- Assess against a larger range of test cases.
- Optimise the defuzzification method (weighted fuzzy mean, centre of gravity etc).

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Thank you to NuSec for funding the pilot project.
We are now actively seeking funds to move into a PhD studentship.