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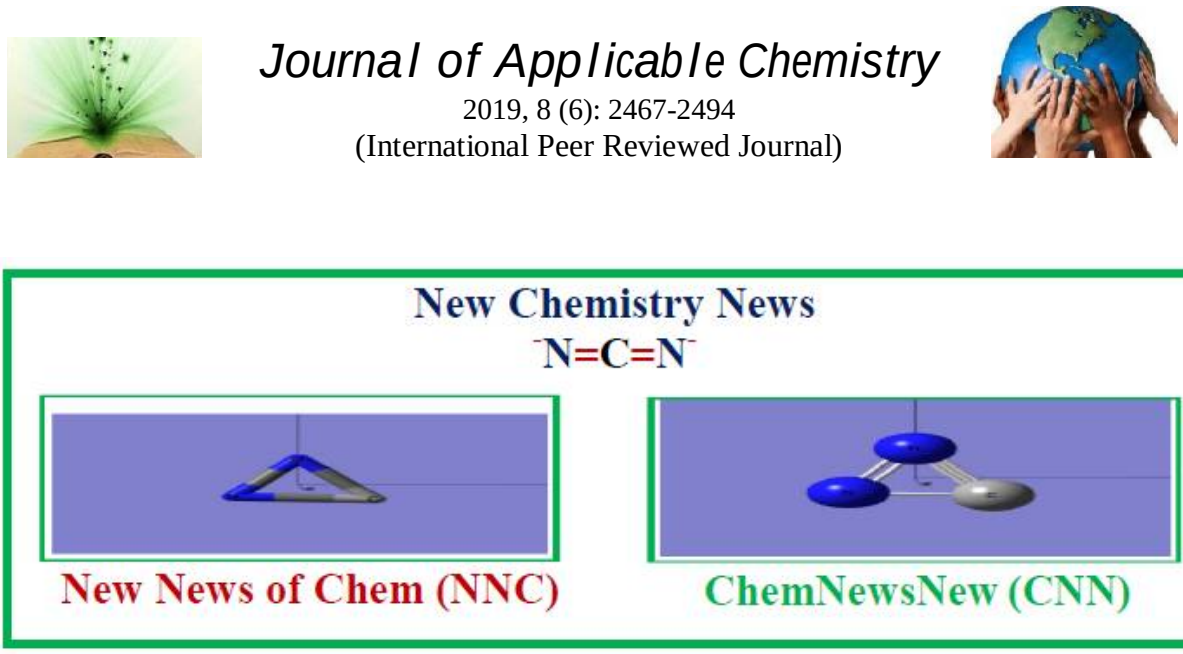

Rough Sets

SXR (Structure Activity Relationships)

Method	Rough sets	**Task.Chem**	3D-SAR
Compounds	Antibiotics N1-site substituted fluoroquinolones	**Methods.CQC**	Semi-empirical methods o AM1 o MNDO3
Compared with	o PCA o PLS o ANN	**X**	Condition attributes
Goal	▪ Resistance mechanism of fluoroquinolones ▪ Development of new fluoroquinolones	**Y**	Biological activity

The application of rough sets in SAR analysis of N1-site substituted fluoroquinolones	Chemometrics and Intelligent Laboratory Systems, 87(2007)155-160, doi.org/10.1016/j.chemolab.2006.11.005
Hao Liu and Bingren Xiang and Lingbo Qu	

RoughSets--RoughSets--RoughSets--RoughSets--RoughSets–RoughSets-

Method	Roughsets	**Used for**	Smallest set of condition attributes
Task.Chem	SXR	**Discipline**	Antifungal imidazolium compounds
Compounds	Quaternary imidazolium	**Outcome**	Supporting decisions concerning synthesis of new antifungal imidazolium compounds

Rough Sets in the Analysis of the Structure–Activity Relationships of Antifungal Imidazolium Compounds	Journal of Pharmaceutical Sciences,84(1995)243-248, doi.org/10.1002/jps.2600840225
Jerzy Krysiński	

RoughSets--RoughSets--RoughSets--RoughSets--RoughSets--RoughSets

Method	o Ordinary Least Squares o Sparse SPLS o Elastic Net o Least Absolute Shrinkage and Selection Operator (Lasso) regression coupled to o Rough Set ; PCA	**Applications**	Solar cell
Task. Math	classification	**Task. Chem**	QSAR
Goal	Bandgap prediction	**Compounds**	200 Chalcopyrite

Informatics-aided bandgap engineering for solar materials	Computational Materials Science, 83(2014)185-195, doi.org/10.1016/j.commatsci.2013.10.016
Partha Dey and Joe Bible and Somnath Datta and Scott Broderick and Jacek Jasinski and Mahendra Sunkara and Madhu Menon and Krishna Rajan	

RoughSets--RoughSets--RoughSets--RoughSets--RoughSets--RoughSets

Method	Rough set	**Applications**	Algae Populations Estimation
Task. Chem	SXR	**Goal**	Chemical response = fn (chemical structure)
Compounds	o (Alkoxymethyl)dodecyldimethylammonium o (Cycloalkoxymethyl)dodecyldimethylammonium o (Alkylthiomethyl)dodecyldimethylarnmonium o (Alkoxymethyl)dimethyloctylammonium o (Cycloalkoxymethyl)dimethyloctylammonium o (Alkylthiomethyl)dimethyloctylammonium chlorides		

Synthesis and antimicrobial activities of new quats	European Journal of Medicinal Chemistry, 32(1997) 661-668, doi.org/10.1016/S0223-5234(97)83292-8
A Skrzypczak and B Brycki and I Mirska and J Pernak	

RoughSets--RoughSets--RoughSets--RoughSets--RoughSets--RoughSets

Method	**Rough Set**	**Data**	o Chemical data o Inexact, uncertain, or vague
Task. Math	Classification	**Task. Chem**	QSAR

Rough sets theory	Chemometrics and Intelligent Laboratory Systems, 47(1999)1-16, doi.org/10.1016/S0169-7439(98)00200-7
B. Walczak and D.L. Massart	

RoughSets-- RoughSets-- RoughSets-- RoughSets-- RoughSets-- RoughSets—

NN + Expert system

Method,Math	Rough set	**Hybrid.Method**	Rough neural expert systems
Method flow	o Pre-processing rough engine o Pre-processor for neural networks within the architecture o Rough neural inference engine o Added to the architecture to build a new structure of inference engine		

Rough neural expert systems	Expert Systems with Applications, 18(2000)87-99,doi.org/10.1016/S0957-4174(99)00055-X
M.E. Yahia and R. Mahmod and N. Sulaiman and F. Ahmad	

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Intelligent information extraction

Method,Math	Rough set	**Taskappln**	Intelligent information retrieval
Data	Collections of documents	**Compared with**	Boolean, Vector, Fuzzy models of information retrieval

Intelligent information retrieval using rough set approximations	Information Processing & Management, 25(1989)347-361, doi.org/10.1016/0306-4573(89)90064-2
Padmini Srinivasan	

RoughSets--RoughSets--RoughSets--RoughSets--RoughSets—RoughSets

ToxiciTy effecTs

Method	o Rough sets
	o Optimized
	  o W algorithm
	  o SVM
		Data	Imbalanced dataset

Task. Math	Optimization Classification	*Task.sub.*	- Toxicity effects biotransformed hepatic drugs
Compounds	553 drugs that biotransformed in liver	**X**	31 Chemical descriptors

Method flow

1) Selection of most discriminative subset of features with rough set
   + Classification time Reduction
   + Improved classification performance
2) Different sampling methods to solve imbalanced dataset
   o Random Under-Sampling, Random Over-Sampling
   o Synthetic Minority Oversampling Technique (SMOTE)
     o BorderLine SMOTE
     o Safe Level SMOTE
3) Classification of an unknown drug into toxic or non-toxic by SVM

Classification of toxicity effects of biotransformed hepatic drugs using whale optimized support vector machines	Journal of Biomedical Informatics, 68(2017)132-149, doi.org/10.1016/j.jbi.2017.03.002
Alaa Tharwat and Yasmine S. Moemen and Aboul Ella Hassanien	

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Method	o RoughSet	**Task**	o Toxicity effects assessment
Compounds	553 biotransformed hepatic drugs four toxic effects, namely, mutagenic, tumorigenic, irritant and reproductive effects	**X**	o 31 Chemical descriptors
Task. Math	Classification	**Model**	o Neutrosophic Rule-based Classification System (NRCS) o Genetic NRCS
FOM	🕮 Sensitivity (89–93%) 🕮 Specificity (91–97%) 🕮 GM (90–94%)		

Neutrosophic rule-based prediction system for toxicity effects assessment of biotransformed hepatic drugs	Expert Systems with Applications, 121(2019)142-157, doi.org/10.1016/j.eswa.2018.12.014
Sameh H. Basha and Alaa Tharwat and Areeg Abdalla and Aboul Ella Hassanien	

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Method	Sine-Cosine Algorithm (SCA) + Rough Set	**Task. Math**	Multi-objective feature selection
Task.	Toxicity risks evaluation	**Compounds**	Biotransformed 5909 FDA drugs
		descriptors	33 Chemical

Toxicity risks evaluation of unknown FDA biotransformed drugs based on a multi-objective feature selection approach	Applied Soft Computing,(2019) 105509, doi.org/10.1016/j.asoc.2019.105509
Mohamed Abd Elaziz and Yasmine S. Moemen and Aboul Ella Hassanien and Shengwu Xiong	

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Medical diagnosis

Method	o Tolerance Rough Set o Firefly alg	**Task Math**	o Supervised Classification o Feature selection
Feature (X)	o Shape o Intensity o Texture based	**Applications**	MRI brain tumor image
compared with	o Artificial Bee Colony (ABC) o Cuckoo Search Algorithm (CSA) o Supervised Tolerance Rough Set–PSO based Relative Reduct (STRSPSO-RR) o Supervised Tolerance Rough Set–PSO based Quick Reduct (STRSPSO-QR)		

Hybrid Tolerance Rough Set–Firefly based supervised feature selection for MRI brain tumor image classification	Applied Soft Computing, 46(2016)639-651,doi.org/10.1016/j.asoc.2016.03.014
Jothi G. and Hannah Inbarani H.	

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Method	Intuitionistic fuzzy sets rough sets	**taskappln**	MRI -- brain images
Intuitionistic fuzzy roughness measure	Automated method to determine the initial values of cluster centroid	**Intuitionistic fuzzy histon**	Upper approximation of rough set
		Fuzzy histogram	lower approximation of rough set
Intuitionistic fuzzy complement function	Takes into account + Inhomogeneity in intensity + Noise in brain MR images		

Segmentation of brain MR images using rough set based intuitionistic fuzzy clustering	Biocybernetics and Biomedical Engineering, 36(2016)413-426, doi.org/10.1016/j.bbe.2016.01.001
Yogita K. Dubey and Miind M. Mushrif and Kajal Mitra	

RoughSets--RoughSets--RoughSets--RoughSets--RoughSets--RoughSets

Method	o Rough set theory o Genetic algorithm	**X**	Multiple tumor markers with multiple cutoff values
Task.	Diagnosis	**Disease**	Colorectal cancer

An algorithm designed for improving diagnostic efficiency by setting multi-cut off values of multiple tumor markers	Expert Systems with Applications, 39(2012)5784-5791, doi.org/10.1016/j.eswa.2011.11.089
Qiang Su and Jinghua Shi and Ping Gu and Gang Huang and Yan Zhu	

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Method,Math	Rough Sets	**DataSets**	Medical database
Method flow	🕮 Characterization of decision attributes for given classes 🕮 Hierarchy for given classes calculated 🕮 Rules for each hierarchical level are induced from data 🕮 For each class, rules for all the hierarchical levels are integrated into one rule + Induced rules correctly represent experts' decision processes		

Rule Induction with Grouping Target Concepts based on Rough Sets	Electronic Notes in Theoretical Computer Science, 82(2003)286-297, doi.org/10.1016/S1571-0661(04)80726-6
Shusaku Tsumoto	
Padmini Srinivasan and Miguel E Ruiz and Donald H Kraft and Jianhua Chen	

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Method,Math	Rough set	**Applicaton**	Representing and reasoning with incomplete / uncertain knowledge
Task.Discipline	Medical	**Taskappln**	Prognosis of cardiac (Scintigraphic scan)test

Modelling prognostic power of cardiac tests using rough sets	Artificial Intelligence in Medicine, 15(1999)167 – 191, doi.org/10.1016/S0933-3657(98)00051-7
Jan Komorowski and Aleksander Øhrn	

RoughSets--RoughSets--RoughSets--RoughSets--RoughSets--RoughSets

Method,Math	Rough set	**Taskappln**	Medical data
Task Math	Classification	**Goal**	Approximate analysis of data

Rough classification	International Journal of Human-Computer Studies,51(1999)369-383, doi.org/10.1006/ijhc.1983.0315
ZDZISŁAW PAWLAK	

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Method	Rough set	To select important features	
	Mahalanobis distance	To distinguish the pattern of OSA (Obstructive sleep apnea)	
Data	o 62 subjects with disease o 24 subjects non-disease	**Methods. compared**	▪ Logistic regression ▪ Artificial neural networks ▪ Support vector machine ▪ C45 decision tree
Task Math	Pattern recognition	**Task Medical**	Diagnosis OSA

The application of rough set and Mahalanobis distance to enhance the quality of OSA diagnosis

Expert Systems with Applications, 38(2011)7828-7836, doi.org/10.1016/j.eswa.2010.12.122

Pa-Chun Wang and Chao-Ton Su and Kun-Huang Chen and Ning-Hung Chen

RoughSets-- RoughSets-- RoughSets-- RoughSets-- RoughSets—RoughSets

Method,Math	RoughSet		
Task Math	Classification	**Taskappln**	Patients of duodenal ulcer

Sensitivity analysis of rough classification

International Journal of Man-Machine Studies, 32(1990)693-705, doi.org/10.1016/S0020-7373(05)80108-7

Krzysztof Słowiński and Roman Słowiński

RoughSets--RoughSets--RoughSets--RoughSets--RoughSets--RoughSets

Method,Math	Fuzzy rough sets	**Taskappln**	Feature selection
Task Math	Fuzzy pattern recognition	**Compared with**	Expert opinion
Discipline	Medical	**DataSets**	Hypoxic resistance of a patient (blood pressure during a barocamera examination)

Fuzzy rough sets: Application to feature selection

Fuzzy Sets and Systems, 51(1992)147-153, doi.org/10.1016/0165-0114(92)90187-9

Ludmila Ilieva Kuncheva

RoughSets--RoughSets--RoughSets--RoughSets--RoughSets--RoughSets

Method	✔ Fuzzy sets ✔ Neural networks ✔ Genetic algorithms ✔ Rough sets ✔ Swarm intelligence	**Goal**	▪ Diagnosis ▪ Prognosis ▪ Treatment planning
Probes.instrument	Radiographic imaging o Computed tomography (CT) o Positron emission tomography (PET) o Magnetic resonance imaging (MRI)	**Disease**	Cancer ▪ Brain ▪ Breast ▪ Prostate ▪ Skin ▪ Lung ▪ Liver
Task	Medical image analysis		

Medical image analysis for cancer management in natural computing framework	Information Sciences, 306(2015)111-131, doi.org/10.1016/j.ins.2015.02.015
Sushmita Mitra and B. Uma Shankar	

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Method	Bitopological rough approximations	**Application**	Medical data

Bitopological rough approximations with medical applications	Journal of King Saud University – Science, 22(2010)177-183, doi.org/10.1016/j.jksus.2010.04.010
A.S. Salama	

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Method,Math	Rough sets	**Task**	Outlier detection
DataSets	UCI data set o Wisconsin Breast Cancer o Lymphography o Annealing data	**Methods.compared**	NED, IE, SEQ, FindCBLOF, DIS, KNN
Method flow	Rough set-based methods (classical) - Applicable only to categorical data; o **Remedy:** neighborhood rough sets applicable to numericdata, heterogeneous data ▪ Outlier detection restricted to numeric data • **Remedy**:neighborhood information entropy		

NED	Neighborhood detection	
IE	Information entropy-based detection	with rough sets
SEQ	Sequence-based detection	with rough sets
Find-CBLOF	Finding cluster-based	local outlier factor

DIS	Distance-based detection	
KNN	K-nearest neighbor method	
NIEOD	Neighborhood information entropy-based outlier detection	

Hybrid data-driven outlier detection based on neighborhood information entropy and its developmental measures	Expert Systems with Applications, 122(2018)243-257, doi.org/10.1016/j.eswa.2018.06.013
Zhong Yuan and Xianyong Zhang and Shan Feng	

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Method	Covering-based fuzzy rough set models	**Applications**	Medical diagnosis biomedicine
Task Math	Outlier detection	**Hybrid.method**	Fuzzy neighborhood operators + fuzzy rough set
Data	5520 bone transplant replacement materials (from Johnson & Johnson China Ltd)	**X**	For tissues in body o No chemical activity o No carcinogenicity processability sterility o Anti-infectivity o Good reactivity

	o **Method Acronym**	**Method**
Compared with	o WAA	Weighted arithmetic average operato
	o OWA	Ordered weighted averaging operator
	o OWGA	Ordered weighted geometric mean operator
	o PROMEE II	Preference Ranking Organization METHod for Enrichment Evaluation
	o TOPSIS	Technique for order preference by similarityideal solution

TOPSIS method based on a fuzzy covering approximation space: An application to biological nano-materials selection	Information Sciences, 502(2019)297-329, doi.org/10.1016/j.ins.2019.06.043
Kai Zhang and Jianming Zhan and Yiyu Yao	

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Method,Math	o Multigranulation fuzzy decision-theoretic rough set o Rough set over two universes o Fuzzy rough set o Decision-theoretic rough set	**Hybrid. method**	Fusion of ▪ Multigranulation rough set method + ▪ Three-way decision-making
Goal	Three-way group decision	**Task.appln**	Medical diagnosis

Three-way group decision making based on multigranulation fuzzy decision-theoretic rough set over two universes	International Journal of Approximate Reasoning, 81(2017)87-102, doi.org/10.1016/j.ijar.2016.11.001
Bingzhen Sun and Weimin Ma and Xia Xiao	

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Method	Variable precision rough set	**Task Math**	Clustering
Discipline	Medical diagnosis	**Task.appln**	Student's anxiety

Applying variable precision rough set model for clustering student suffering study's anxiety	Expert Systems with Applications, 39(2012)452-459, doi.org/10.1016/j.eswa.2011.07.036
Iwan Tri Riyadi Yanto and Prima Vitasari and Tutut Herawan and Mustafa Mat Deris	

RoughSets--RoughSets--RoughSets--RoughSets--RoughSets--RoughSets

Method	o Rough – Granular Computing o Rough Mereology	**Task Math**	Knowledge discovery models
	o ANN o Genetic Algorithm	**Task.appln**	Medical classification
Datasets	o Coronary Heart Disease o Hepatitis C Virus	**Goal**	o To extract main medical indicators o To reduce misdiagnosis rates o to improve decision-making

Rough – Granular Computing knowledge discovery models for medical classification	Egyptian Informatics Journal, 17(2016)265-272, doi.org/10.1016/j.eij.2016.01.001
Mohammed M. Eissa and Mohammed Elmogy and Mohammed Hashem	

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MRI --- Brain

Method	o Rough-Fuzzy C-Means o Patch based K-means	**Task. Medical**	MRI Brain Tumor Segmentation
Task. Math	Pattern recognition	**FOM**	Accuracy(RFCM) >> [Hard C-means ; Fuzzy C-means]

MRI Brain Tumor Segmentation and Analysis using Rough-Fuzzy C-Means and Shape Based Properties	Journal of King Saud University - Computer and Information Sciences, (2018), doi.org/10.1016/j.jksuci.2018.11.001
Abhishek Bal and Minakshi Banerjee and Amlan Chakrabarti and Punit Sharma	

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Mammograms + Classification +NN

Method,Math	o Rough set o NNs
Task	Automatic analysis of mammograms

DataSets	Training o 222 random images MIAS (Mammographic Image Analysis Society)	**Testing** o 100 random images from MIAS o 100 random images from the independent BancoWeb database
Method flow	o Serial of image pre-processing o Segmentation techniques, 2D median filtering, seeded region growing (SRG) image contrast enhancement, deletion of radiopaque artifacts, elimination of projection of the pectoral muscle from a digitalized mammogram o Rough-set approach: image texture-feature based classification method o ANN: classification of a mammogram [normal; benign lump; malignant tumor;]	

An automated confirmatory system for analysis of mammograms	Computer Methods and Programs in Biomedicine, 125(2016)134-144, doi.org/10.1016/j.cmpb.2015.09.019
W. Peng and R.V. Mayorga and E.M.A. Hussein	

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Post-operative Care

Method,Math	Rough sets	**Taskappln**	Total hip arthroplasty medical care staying length in hospital
DataSets	Experimental dataset (National Health Insurance Research Database, Taiwan) - Imbalanced class data		

Identifying the medical practice after total hip arthroplasty using an integrated hybrid approach	Computers in Biology and Medicine, 42(2012)826-840, doi.org/10.1016/j.compbiomed.2012.06.006
You-Shyang Chen and Ching-Hsue Cheng	

RoughSets--RoughSets--RoughSets--RoughSets--RoughSets--RoughSets

Method	Rough set theory (RST)	**TaskMedical**	Total knee arthroplasty
Method flow	o Screening of data by specialist o Feature selection • ANOVA • Proposed an integrated feature selection approach		

	o Data discretization & rule generation by RST

Discovering medical resource utilization in total knee arthroplasty (TKA) using rule-based method	Archives of Gerontology and Geriatrics, 55(2012)157-164, doi.org/10.1016/j.archger.2011.07.002
Min-Hsiung Wei and Ching-Hsue Cheng and Jhao-Yu Li	

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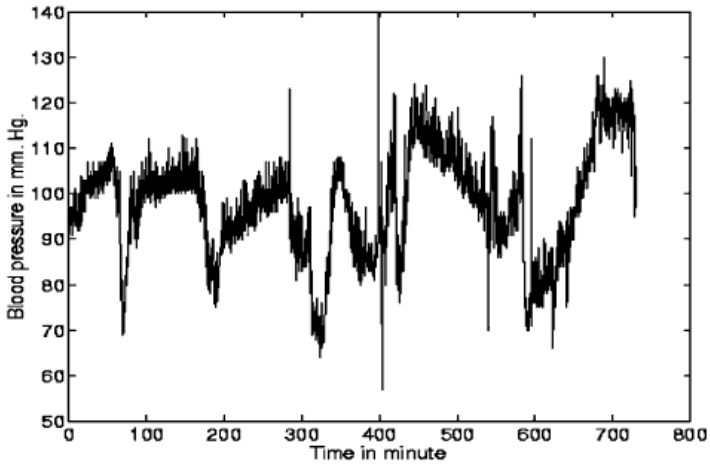
ICU-patients

Method,Math	Rough set theory Fuzzy-rough fractals	**Taskappln**	Medical time series
Datasets	ICU data sets	**FOM**	More rugged then Hurst exponent



Respiratory distress syndrome patient under mechanical ventilation
Systolic BP for every twelve seconds

Ruggedness measures of medical time series using fuzzy-rough sets and fractals	Pattern Recognition Letters, 27(2006)447-454,doi.org/10.1016/j.patrec.2005.09.007
Manish Sarkar	

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Medical Expert Systems

Method,Math	Rough set	**Task Math**	Classification
Method flow	**Automatic knowledge discovery from databases** o Rule induction system based on rough sets and attribute-oriented generalization: to extract diagnostic rules from a database of congenital		

	malformation o Induced knowledge is used to build an expert system for a differential diagnosis on congenital disorders o ES evaluated in an outpatient clinic → ES performs well as a medical expert → Useful for instruction tomedical residents

Knowledge discovery in clinical databases and evaluation of discovered knowledge in outpatient clinic	Information Sciences, 124(2000)125-137, doi.org/10.1016/S0020-0255(99)00065-1
Shusaku Tsumoto	

RoughSets--RoughSets--RoughSets--RoughSets--RoughSets--RoughSets

Method,Math	RoughSets	**Taskappln**	o Medical knowledge acquisition o Extraction of experts' decision rules
Method flow	o Characterization of decision attributes (given classes) is extracted from databases o Classes divided into several groups with respect to characterization o Characterization rules for each group and discrimination rules for each class in the group are induced o Two parts are integrated into one rule for each decision attribute		
	o Evaluated on medical databases, **Inference**: induced rules correctly represent experts' decision processes		
Knowledge bits	Rule induction methods - Cannot extract rulesrepresenting experts'result Induction methods - Induce probabilistic rules, the description length of which is too short, compared with the experts' rules decision processes Bayesian networks - Generates too lengthy rules		

Extraction of experts' decision rules from clinical databases using rough set model	Intelligent Data Analysis, 2(1998)215-227, doi.org/10.1016/S1088-467X(98)00025-0
Shusaku Tsumoto	

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Method,Math	Fuzzy rough sets	**DataSets**	Clinical databases
Taskfield	Automated extraction of medical expert system rules	**Output**	o Extracts classification rules + o Medical knowledge needed for diagnosis

Automated extraction of medical expert system rules from clinical databases based on rough set theory	Information Sciences, 112(1998)67-84, doi.org/10.1016/S0020-0255(98)10021-X
Shusaku Tsumoto	

Method,Math	▪ Generalized rough sets ▪ Fuzzy sets	**Task.application**	Medical Language Vocabulary mining in information

Vocabulary mining for information retrieval: rough sets and fuzzy sets	Information Processing & Management, 37(2001)15-38, doi.org/10.1016/S0306-4573(00)00014-5
Padmini Srinivasan and Miguel E Ruiz and Donald H Kraft and Jianhua Chen	

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Industry

Method	o Rough Sets	**Applications**	Decision-Making
Outcome	Rough Sets→Informal knowledge formalized based on "preferences" and "no preferences" of experts	**Data**	o High yield pulping process o Cheese production
Goal	Chemical and Biochemical Multicriteria Multi-objective Process Optimisation	**Discipline**	Environmental pollution

Decision-Making by Rough Sets Applied to Chemical and Biochemical Multicriteria Process Optimisation	IFAC Proceedings Volumes, 36(2003)215-220, doi.org/10.1016/S1474-6670(17)37720-0
J. Renaud and F. Fournier and J. Thiébault and R. Lanouette and K. Zaras and C. Fonteix	

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Method	**RoughSets** Dynamic-rough multiple objective programming (SD-RMOP) models	**Application**	To plan/develop natural gas industry operations
Location	Yangtze River in China	**Discipline**	Natural gas industry

On simulation and optimization of one natural gas industry system under the rough environment	Expert Systems with Applications, 37(2010)1854-1862, doi.org/10.1016/j.eswa.2009.07.022
Jiuping Xu and Rentao Dong and Desheng Dash Wu	

RoughSets--RoughSets--RoughSets--RoughSets--RoughSets--RoughSets

Low carbon technology integration innovation assessment index review based on rough set theory – an evidence from construction industry in China	Journal of Cleaner Production, 126 (2016)88-96, doi.org/10.1016/j.jclepro.2016.03.035
Xiaodong Lai and Jixian Liu and Georgi Georgiev	

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Classification

Method	Dominance-based **Rough Sets**	**Method.math**	Stochastic Multi-Criteria Acceptability Analysis
Task. Math	Classification	**Task. Chem**	Silver nanoparticles synthesis processes
Model. Math	Improved gray incidence model + Comprehensive rough set weight model	**Discipline**	Green nanotechnology

Robustness analysis of a green chemistry-based model for the classification of silver nanoparticles synthesis processes	Journal of Cleaner Production, 162(2017)938-948, doi.org/10.1016/j.jclepro.2017.06.113
Marco Cinelli and Stuart R. Coles and Mallikarjuna N. Nadagouda and Jerzy Błaszczyński and Roman Słowiński and Rajender S. Varma and Kerry Kirwan	

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Method	Neighbourhood rough set theory	**Used for**	Hyperspectral band selection
Task. Math	Classification	***Task.sub.***	Effect of class noise
Goal	Soybean and maize classification		

Impact of class noise on performance of hyperspectral band selection based on neighborhood rough set theory	Chemometrics and Intelligent Laboratory Systems, 188(2019) 37-45, doi.org/10.1016/j.chemolab.2019.03.003
Yao Liu and Xiaoda Cao and Xiangli Meng and Tao Wu and Xiaozhen Yan and Qinghua Luo	

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Method	Rough sets	**Discipline Math**	o Computational intelligence o Clustering classification
Methods.AI	o Neural network o Restricted boltzmann machine o Deep belief network o Fuzzy logic o Rough sets o Evolutionary algorithm o Genetic algorithm o Swarm intelligence o Artificial immune system o Support vector machine	**Task.appln**	▪ Bioinformatics protein sequence classification ▪ Gene selection ▪ DNA fragment assembly ▪ Multiple sequence alignment ▪ Protein function prediction ▪ Protein structure

Computational intelligence techniques in bioinformatics	Computational Biology and Chemistry, 47(2013)37-47, doi.org/10.1016/j.compbiolchem.2013.04.007
Aboul Ella Hassanien and Eiman Tamah Al-Shammari and Neveen I. Ghali	

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Task math	Classification	**Data**	Microarray data
Neighborhood rough set	To select representative genes in each cluster	Affinity propagation clustering algorithm	To study impact of biological similarity on results

Classification by integrating plant stress response gene expression data with biological knowledge	Mathematical Biosciences, 266(2015)65-72, doi.org/10.1016/j.mbs.2015.06.005
Jun Meng and Rui Li and Yushi Luan	

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Method,Math	Rough-fuzzy based	**Categories of scene videos**	Animation OutletSports e-Learning Medical Weather Defense Economics Animal Planet Technology
Task Math	Categorization scene Classification		

Rough-fuzzy based scene categorization for text detection and recognition in video	Pattern Recognition, 80(2018)64-82,doi.org/10.1016/j.patcog.2018.02.014
Sangheeta Roy and Palaiahnakote Shivakumara and Namita Jain and Vijeta Khare and Anjan Dutta and Umapada Pal and Tong Lu	

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Method,Math	Dominance-based rough set approach Abc classification	**Task.appln**	Spare parts in industry
Task. Math	Classification	**Fom**	96% of spare parts correctly classified
DataSets	Data from a manufacturing company in China		
	Classification framework for spare parts management using the dominance-based rough set approach (DRSA) 1) Set of 'if–then' decision rules generated from historical data 2) Generated rules validated using automated and manual approaches, including cross-validation and feedback assessments		
Unique features	+ Learning-set based analysis approach + Uses multicriteria classification method (DRSA); + Validation of generated decision rules with multiple strategies		

Spare parts classification in industrial manufacturing using the dominance-based rough set approach	European Journal of Operational Research, 262(2017)1136-1163, doi.org/10.1016/j.ejor.2017.04.040
Qiwei Hu and Salem Chakhar and Sajid Siraj and Ashraf Labib	

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Method,Math	Rough set.Generalization	**Applications**	o Decision-making o Knowledge representation o Expert systems

Rough classification in incomplete information systems	Mathematical and Computer Modelling, 12(1989)1347-1357,doi.org/10.1016/0895-7177(89)90373-7
Roman Słowiński and Jerzy Stefanowski	

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Method.Math	o RST o Exhaustive Algorithm o Genetic Alg. o Covering Alg. o LEM2 alg.		
Task.Discipline	Telecommunication	**Subtask.Discipline**	Customer churn prediction
Task.Math.	Classification	**Subtask.Math**	Feature selection

Customer churn prediction in the telecommunication sector using a rough set approach	Neurocomputing,237(2017)242-254,doi.org/10.1016/j.neucom.2016.12.009
Adnan Amin and Sajid Anwar and Awais Adnan and Muhammad Nawaz and Khalid Alawfi and Amir Hussain and Kaizhu Huang	

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Article.type	Review	**Task. Math**	Classification
Method,Math	Rough set	**Task.appln**	Decision rules for boundary e-mail classification
Task.field	Spam filtering	**Compared with**	**Anti-spam filtering techniques** o Support vector machines o Adaboost o Bayes classifiers

Rough sets for spam filtering: Selecting appropriate decision rules for boundary e-mail classification	Applied Soft Computing, 12(2012)3671-3682, doi.org/10.1016/j.asoc.2012.05.024
Noemí Pérez-Díaz and David Ruano-Ordás and José R. Méndez and Juan F. Gálvez and Florentino Fdez-Riverola	

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Article.type	Review	**Data sets**	Five
Method,Math	Mahalanobis–Taguchi System via Rough Sets based Feature Selection	**Task. Math**	Classification
Method.flow	▶ Mahalanobis Taguchi System (MTS) used to classify data with dichotomous states or categories ▶ Rough Set Theory to develop Subset of System Variables and system classes		

Enhancement of Mahalanobis–Taguchi System via Rough Sets based Feature Selection	Expert Systems with Applications, 41(2014)8003-8015, doi.org/10.1016/j.eswa.2014.06.019
Ashif Sikandar Iquebal and Avishek Pal and Darek Ceglarek and Manoj Kumar Tiwari	

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Article.type	Review	**Task. Math**	Classification kernel-based
Method,Math	Fuzzy rough sets Vaguely quantified rough sets	**Task.math**	Fuzzy-rough nearest neighbor classification

Fuzzy nearest neighbor algorithms: Taxonomy, experimental analysis and prospects	Information Sciences, 260(2014)98-119,doi.org/10.1016/j.ins.2013.10.038
Joaquín Derrac and Salvador García and Francisco Herrera	

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Method	RoughSets	**Applications**	o Criminal detection o Chemical synthesis o Biological grafting

Def: In_class-bridge rule: Here, antecedent and consequent belong to different conceptual classes

- o Generated from infrequent item sets
- o Measurement includes distance between conceptual classes and relation between the antecedents/consequents and their affiliated conceptual classes

Mining class-bridge rules based on rough sets	Expert Systems with Applications, 36(2009) 6453-6460, doi.org/10.1016/j.eswa.2008.07.044
Shichao Zhang and Feng Chen and Zhi Jin and Ruili Wang	

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Model. Math	o Improved gray incidence model + o Comprehensive rough set weight model	**Models.Phenonmemnon**	o Physical habitat o Chemical condition o Biotic structure

Task	River health assessment	X	11

River health assessment: Proposing a comprehensive model based on physical habitat, chemical condition and biotic structure	Ecological Indicators, 103(2019)446-460, doi.org/10.1016/j.ecolind.2019.04.013
Shuo Wang and Qian Zhang and Tao Yang and Liqi Zhang and Xiaoping Li and Jia Chen	

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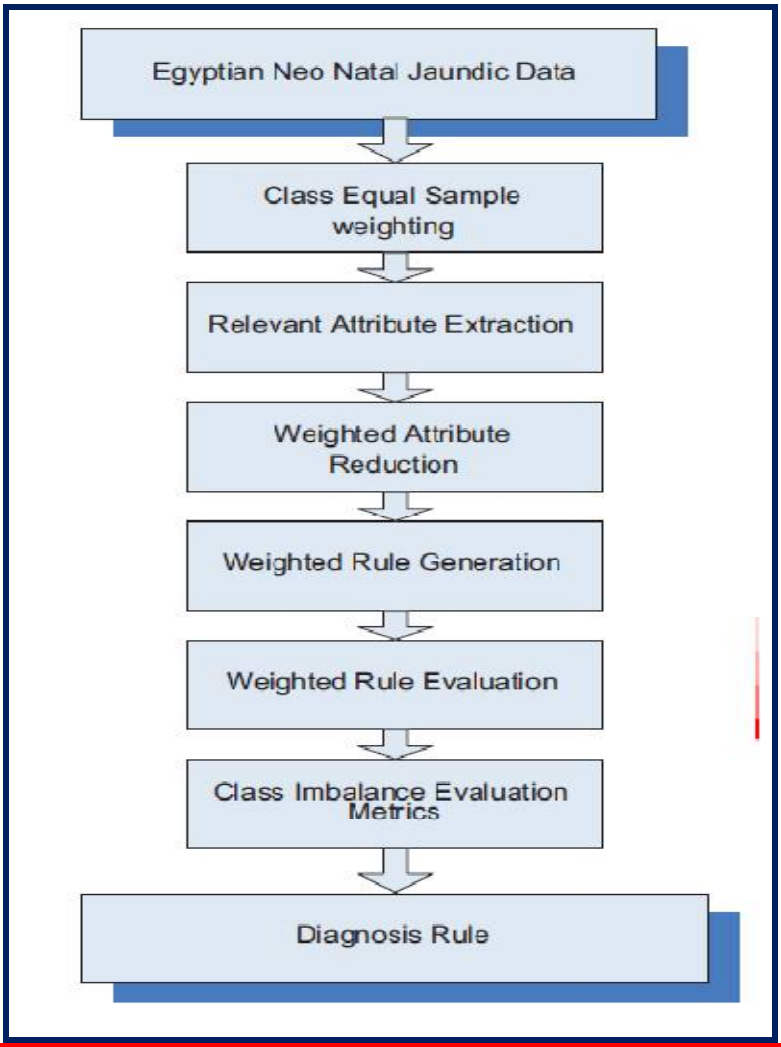
Method,Math	Weighted rough set	Task Math	Classification
Disease	Egyptian NeoNatal Jaundice	Compared with	Weighted SVM Decision tree



A new weighted rough set framework based classification for Egyptian NeoNatal Jaundice	Applied Soft Computing, 12(2012)999-1005, doi.org/10.1016/j.asoc.2011.11.025
Hala S. Own and Ajith Abraham	

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Method,Math	Rough set	**Taskappln**	Automated extraction of hierarchical decision rules
DataSets	Clinical databases	**Knowledge.bits**	Rule induction methods - Cannot extract rules Induction methods - Induce probabilistic rules - Description length too short Compared with the experts' rules Bayesian networks - Generates too lengthy rule

Automated extraction of hierarchical decision rules from clinical databases using rough set model	Expert Systems with Applications, 24(2003)189-197, doi.org/10.1016/S0957-4174(02)00142-2
Shusaku Tsumoto	

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Method,Math	Rough set theory + ABC analysis Integration	**Task.appln**	Supply chain of auto spare parts
Task.field	Forecast of demands of retailers (Iranian distributors)	**Goal**	Study of number of sold cars (mileages) vs spare parts

Integrating ABC analysis and rough set theory to control the inventories of distributor in the supply chain of auto spare parts	Computers & Industrial Engineering, 2019, doi.org/10.1016/j.cie.2019.01.047
Masoud Mehdizadeh	

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Method,Math	Rough set Parallel genetic algorithm	**X:**	Attribute subset selection
Task. Math	Large-scale decision systems	**Task.appln**	Intrusion detection in Computer networks

Towards scalable rough set based attribute subset selection for intrusion detection using parallel genetic algorithm in MapReduce	Simulation Modelling Practice and Theory, 64(2016)18-29, doi.org/10.1016/j.simpat.2016.01.010
El-Sayed M. El-Alfy and Mashaan A. Alshammari	

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Method,Math	Decision-theoretic rough set models	**Task.appln**	Three-way decisions sequential

Attribute reduction for sequential three-way decisions under dynamic granulation	International Journal of Approximate Reasoning, 85(2017)196-216, doi.org/10.1016/j.ijar.2017.03.009
Jin Qian and Chuangyin Dang and Xiaodong Yue and Nan Zhang	

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Method,Math	Filtration-rough set theory	**Task.appln**	Privacy Preserving in to select favorite products

Hybrid Filtrations Recommendation System based on Privacy Preserving in Edge Computing	Procedia Computer Science, 129(2018)407-409, doi.org/10.1016/j.procs.2018.03.016
Lina Ni and Hongdi Lin and Mengmeng Zhang and Jinquan Zhang	

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Pattern recognition

Method,Math	Rough set fuzzy set		
Task.appln	**Intelligent computing system** o Artificial intelligence o Machine learning o Statistical analysis o Fuzzy logic o Pattern recognition o Artificial neural networks	**Task. Math**	Pattern recognition

Intelligent computing system based on pattern recognition and data mining algorithms	Sustainable Computing: Informatics and Systems, 20(2018)192-202, doi.org/10.1016/j.suscom.2017.10.010
Junlin Zhang and Samuel Oluwarotimi Williams and Haoxiang Wang	

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Reviews

Article.type	Review	**Task**	Designing business intelligence systems
Method,Math	o Rough set theory o Inductive rule learning o Information retrieval	**DataSets**	Amazon.com, customers' Reviews on different products

Discovering business intelligence from online product reviews: A rule-induction framework	Expert Systems with Applications, 39(2012)11870-11879, doi.org/10.1016/j.eswa.2012.02.059
Wingyan Chung and Tzu-Liang (Bill) Tseng	

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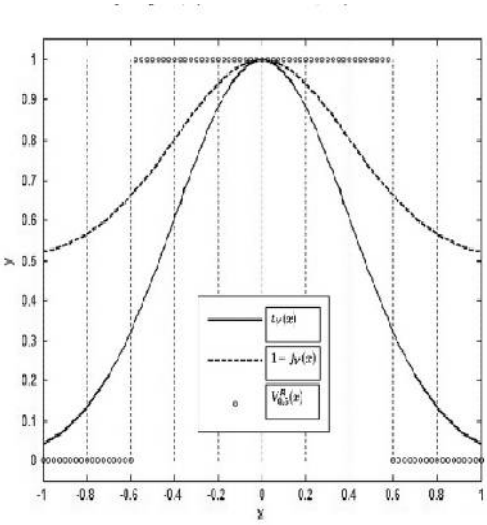
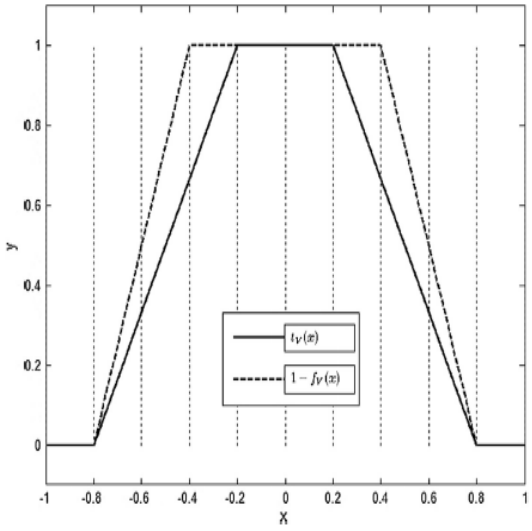
Method,Math	o Rough set; o vague set o 0.5-crisp set o Step-Vague Set	**Article.type**	Review

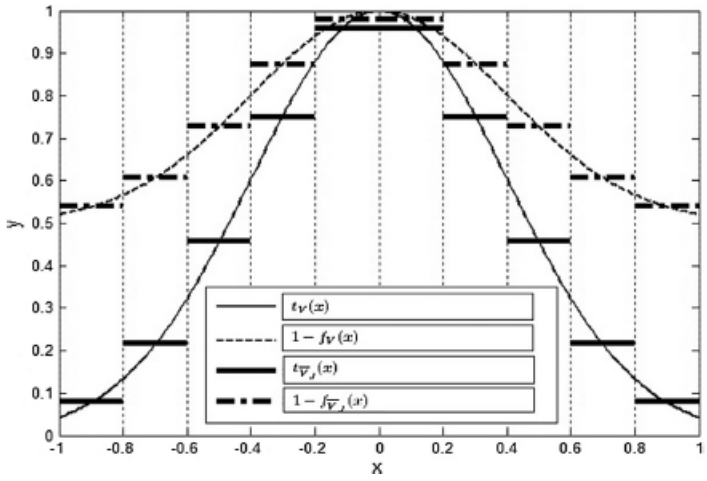
	o Average-step-vague set		
Task. Math	Approximation	**Task.appln**	Human cognitive mechanism



A vague set and its 0.5-crisp set.



Trapezoid vague set.



A vague set and its average-step-vague set.

The approximation set of a vague set in rough approximation space,	Information Sciences, 300 (2015) 1-19,doi.org/10.1016/j.ins.2014.12.023
Qinghua Zhang and Jin Wang and Guoyin Wang and Hong Yu	

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Article.type	Review	**Task.appln**	To discover fuzzy relationships in time series
Method,Math	Rough set theory	**Posive feature**	Dataset No prior knowledge

Extracting fuzzy relations in fuzzy time series model based on approximation concepts	Expert Systems with Applications, 38(2011)11624-11629, doi.org/10.1016/j.eswa.2011.03.040
Tung-Kuan Liu and Yeh-Peng Chen and Jyh-Horng Chou	

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Article.type	Review	**Method,Math**	Rough sets o Qualitative o Quantitative o Decision-theoretic o Probabilistic o Variable precision

Quantitative rough sets based on subsethood measures,	Information Sciences, 267 (2014)306-322,doi.org/10.1016/j.ins.2014.01.039
Yiyu Yao and Xiaofei Deng	

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Article.type	Review	**Task.appln**	Natural computing
Natural phenomena	Self-organization, self-repetition, self evaluation, Darwinian survival, granulationperception		
Nature inspiredcomputing	Artificial neural networks, fuzzy logic, rough sets, evolutionary algorithms, fractal geometry, DNA computing, granular or perception-based computing		

Natural computing: A problem solving paradigm with granular information processing	Applied Soft Computing, 13(2013)3944-3955,doi.org/10.1016/j.asoc.2013.06.026
Sankar K. Pal and Saroj K. Meher	

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Article.type	Review	**Method,Math**	rough sets
Task.appln	Supplier selection	Supplier categories Class 1 (excellent firms) Class 2 (common firms) class 3 (disappointed firms)	

A study of using RST to create the supplier selection model and decision-making rules	Expert Systems with Applications, 37(2010) 8284 – 8295, doi.org/10.1016/j.eswa.2010.05.056
Betty Chang and Hsu-Feng Hung	

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Article.type	Review	**Datasets**	UCI
Method,Math	Covering rough set	**Data**	Numerical Categorical

A novel method for attribute reduction of covering decision systems	Information Sciences, 254(2014)181-196, doi.org/10.1016/j.ins.2013.08.057
Changzhong Wang and Qiang He and Degang Chen and Qinghua Hu	

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Method,Math	Covering rough set	**Article.type**	Review
Software	R package	**Applications**	o Discretization o Feature selection o Instance selection o Rule induction o Nearest neighbor-based classifiers

Implementing algorithms of rough set theory and fuzzy rough set theory in the R package RoughSets	Information Sciences, 287(2014)68-89, doi.org/10.1016/j.ins.2014.07.029
Lala Septem Riza and Andrzej Janusz and Christoph Bergmeir and Chris Cornelis and Francisco Herrera and Dominik Śle¸zak and José Manuel Benítez	

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Article.type	Review	**Method,Math**	Covering rough sets

Covering based rough set approximations	Information Sciences, 200(2012)91-107, doi.org/10.1016/j.ins.2012.02.065
Yiyu Yao and Bingxue Yao	

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Article.type	Review	**Task.field**	Equilibria in game-theoretic

Interpretation of equilibria in game-theoretic rough sets	Information Sciences, 295(2015) 586-599, doi.org/10.1016/j.ins.2014.10.046
Nouman Azam and JingTao Yao	

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Article.type	Review	**Task.appln**	Inexact, uncertain or vague knowledge in information systems

On axiomatic characterizations of three pairs of covering based approximation operators	Information Sciences, 180(2010)274-287, doi.org/10.1016/j.ins.2009.08.031
Yan-Lan Zhang and Jinjin Li and Wei-Zhi Wu	

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Method,Math	RoughSets	**Article.type**	Review
Task. Math	Information fusion methods o Multi-source o Multi-modality o Multi-scale o Multi-view	**Data.structure**	o Attributes o Rough approximations o Attribute reduction o Decision making

Information fusion in rough set theory : An overview	Information Fusion, 48(2019)107-118, doi.org/10.1016/j.inffus.2018.08.007
Wei Wei and Jiye Liang	

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Article.type	Review	**Data type**	Categorical data
Method,Math	o Ensemble based rough fuzzy clustering o Rough fuzzy clustering o Fusion rough set and fuzzy set theories	**Types roughnes**	▪ Semi rough ▪ Pure rough

Ensemble based rough fuzzy clustering for categorical data,	Knowledge-Based Systems, 77 (2015) 114-127, doi.org/10.1016/j.knosys.2015.01.008
Indrajit Saha and Jnanendra Prasad Sarkar and Ujjwal Maulik	

RoughSets--RoughSets--RoughSets--RoughSets--RoughSets–RoughSets

Article.type	Review	**Data sets**	Three
Method,Math	Generalized rough set models	**Basis**	Different non-equivalence relations

Generalized approximations defined by non-equivalence relations	Information Sciences, 193(2012)163-179, doi.org/10.1016/j.ins.2012.01.009
Lihe Guan and Guoyin Wang	

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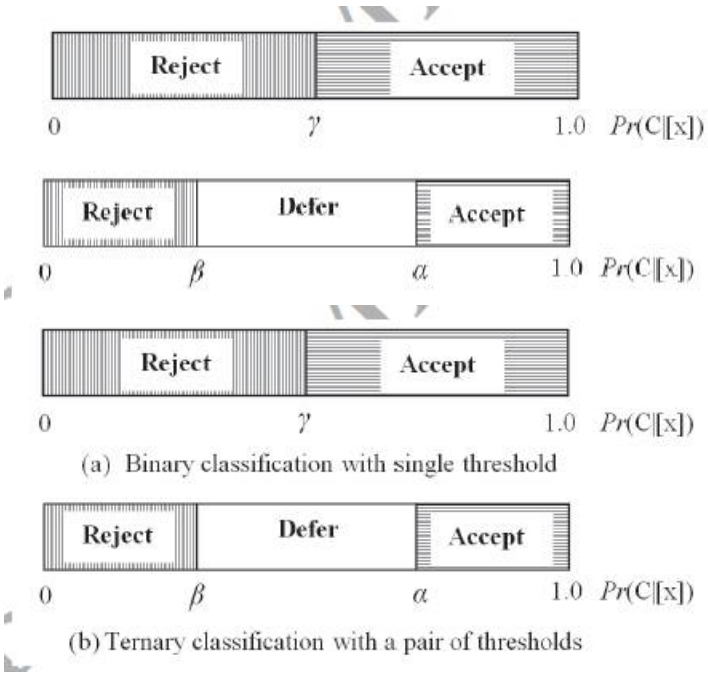
Method,Math	o Confirmation-theoretic rough sets o Decision-theoretic rough sets o Probabilistic rough sets		Review
	o Bayesian classification rough sets	Build from decision-theoretic rough set (DTRS)	
	o Bayesian confirmation rough sets	from parameterized rough set models	



Differences between binary ad ternary classifiers

Two Bayesian approaches to rough sets	European Journal of Operational Research,251(2016)904-917, doi.org/10.1016/j.ejor.2015.08.053
Yiyu Yao and Bing Zhou	

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Article.type	Review		
Task. Math	o Multiple discriminant analysis o Logistic regression o Artificial neural network o Support vector machines o Rough sets o Case based reasoning o Tree o Genetic algorithm	**Criteria**	▪ Accuracy ▪ Transparency ▪ Fully deterministic output ▪ Data size capability ▪ Data dispersion ▪ Variable selection method
DataSets	49 Journal articles published during years 2010 to2015	**Task.appln**	Bankruptcy prediction
Unique information	No single tool is predominantly better than other tools Many of the tools had been used with the wrong data conditions or for the wrong situation		

Systematic review of bankruptcy prediction models: Towards a framework for tool selection	Expert Systems with Applications, 94(2018)164-184, doi.org/10.1016/j.eswa.2017.10.040

Hafiz A. Alaka and Lukumon O. Oyedele and Hakeem A. Owolabi and Vikas Kumar and Saheed O. Ajayi and Olugbenga O. Akinade and Muhammad Bilal

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Article.type	Review		
Method,Math	o Variable precision rough sets o Type-1 variable precision multigranulation decision-theoretic fuzzy rough sets	**Task.appln**	Three-way decisions

Variable precision multigranulation decision-theoretic fuzzy rough sets	Knowledge-Based Systems, 91(2016)93-101, doi.org/10.1016/j.knosys.2015.10.007
Tao Feng and Ju-Sheng Mi	

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Article.type	Review	**Task.Math**	o Classification o Clustering
Method,Math	Rough set	**Goal**	o Information o Knowledge

Clustering	
o Credibilistic	o Hesitant fuzzy
o Evidential	o Interval-based fuzzy
o Neutrosophic	o Intuitionistic fuzzy
o Rough sets-	o Picture fuzzy
o Shadowed	o Type-2 fuzzy

Informational Paradigm, management of uncertainty and theoretical formalisms in the clustering framework: A review	Information Sciences, 400-401(2017)30-62, doi.org/10.1016/j.ins.2017.03.001
Pierpaolo D'Urso	

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Article.type	Review	**Method,Math**	Rough set model
Task. Math	Clustering	**Task.appln**	Three-way decisions: Ternary classification of data space (universe) into 1) Acceptance region, 2)Rejection region 3) Uncertainty region

Ranking interval sets based on inclusion measures and applications to three-way decisions	Knowledge-Based Systems, 91(2016)62-70, doi.org/10.1016/j.knosys.2015.07.025
Hong-Ying Zhang and Shu-Yun Yang and Jian-Min Ma	

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Article.type	Review	**DataSets**	UCI datasets (IRIS, Bupa, Glass ….)
Method,Math	Variable precision multigranulation decision-theoretic fuzzy rough sets	**Task.appln**	Three-way decisions

Uncertainty and reduction of variable precision multigranulation fuzzy rough sets based on three-way decisions	International Journal of Approximate Reasoning, 85(2017)36-58, doi.org/10.1016/j.ijar.2017.03.002
Tao Feng and Hui-Tao Fan and Ju-Sheng Mi	

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