TABLE OF CONTENTS

Chapters	Titles	Page No.
	Certificate	**ii**
	Declaration By the Candidate	**iii**
	Copyright Transfer Certificate	**iv**
	Acknowledgements	**v-vii**
	Table of Contents	**viii-xii**
	List of Figures	**xiii-xvii**
	List of Tables	**xviii-xix**
	Abbreviations	**xx-xxi**
	Preface	**xxii-xxix**
Chapters-1	**Introduction and Literature Survey**	**1-36**
	1.1. Introduction	1-2
	1.2. VOCs/Gas/Odor Sensing	2-10
	1.2.1. The Evolution of Gas Sensing	2-3
	1.2.2. Gas Chromatography-Mass Spectrometry (GC-MS)	4-5
	1.2.3. Mammalian Olfactory System	5-6
	1.2.4. Artificial Olfaction and Electronic-nose (E-Nose)	7-8
	1.2.5. Application of E-nose for Air-Borne Hazard Detection	9-10
	1.3. Recent Advancements	10-28
	1.3.1. Sensor Technology	11-17
	1.3.2. Tin-Oxide MOX-based Gas Sensor Array	18-20
	1.3.3. Sensor's Signal Processing	20-27
	1.3.3.1. Analysis of Space Transformation	20-23
	1.3.3.2. Classifiers	23-27
	1.3.4. Networks of E-Noses	27-28
	1.4. Contextual Review of Previous Work	28-35
	1.5. Definition of the Problems	35-36
Chapter-2	**Materials, Methods and Technology Background**	**37-80**
	2.1 General Experimental Setup	38-51
	2.1.1 Sensors, Devices and Microcontrollers as Used	39-49
	2.1.1.1 Tin-oxide MOX-based Gas Sensors	39-41

	2.1.1.2 PM Sensor	41-43
	2.1.1.3 DHT 22	43-44
	2.1.1.4 ESP32	44-45
	2.1.1.5 Arduino Uno	45-46
	2.1.1.6 Regulator	46
	2.1.1.7 DC-DC Buck Converter	46-47
	2.1.1.8 Voltage-Divider Circuit	47-48
	2.1.1.9 Gas Chamber	48-49
	2.1.2 Gas Sensor Array Responses	49-51
	2.1.2.1 Signature Patterns from Non-selective Gas Sensors	51
	2.2 Experimental Data Collection and Storing Process (Data Acquisition System)	52-57
	2.2.1 Cyber-physical System (CPS)	53-54
	2.2.2 Amazon Web Services (AWS)	54-55
	2.2.3 Visual Studio Code (VS code)	55
	2.2.4 Arduino IDE	55-56
	2.2.5 LoRa	56-57
	2.2.5.1 Working Principle of LoRa	57
	2.3 The Dataset	58-61
	2.3.1 The Dataset I (Smart Home)	58
	2.3.2 The Dataset II (Fire Hazard Detection and Mapping)	58-59
	2.3.3 The Dataset III (Pollution Hazard-Using LoRa Module)	59-60
	2.3.4 The Dataset IV (Disinfectants Detection and Monitoring)	60
	2.3.5 The Dataset V (Health Hazard)	61
	2.4 Data Pre-Processing Techniques	61-66
	2.4.1 Independent Component Analysis (ICA)	62-63
	2.4.2 Standardised Linear Discriminant Analysis (SLDA)	63-65
	2.4.3 Kernel Principal Component Analysis (KPCA)	65
	2.4.4 Standardised Principal Component Analysis (SPCA)	65-66
	2.5 The concept of Analysis Space Transformation and Cluster formation	66

	2.5.1 K-Fold Cross-Validation Process	67
	2.5.2 Introduction to different Classification Algorithms	67
	2.5.2.1 K-nearest neighbors (KNN)	67-68
	2.5.2.2 Logistic Regression (LR)	68-69
	2.5.2.3 Stochastic Gradient Descent (SGD)	69
	2.5.2.4 Decision-Tree-Based Techniques	69-70
	2.5.2.5 Naïve Bayes (NB)	70-71
	2.5.2.6 Support Vector Machine (SVM)	71-73
	2.5.2.7 Recursive Discriminant Analysis (RDA)	73-74
	2.5.2.8 Random Forest (RF) Classifier	74-76
	2.5.2.9 Adaboost Classifier	76-77
	2.5.2.10 XGBoost Classifier	77-78
	2.5.2.11 Multilayer Perceptron (MLP) Classifier	78-80
Chapter-3	**Analysis Space Transformation Based Electronic Nose for Efficient Detection and Monitoring of Volatile Organic Compounds, Gases/Odors in Smart Homes**	**81-100**
	3.1 Introduction	81-86
	3.2 Materials and Methods	87-95
	3.2.1 The High Performance – Gas Sensor System (HP-GSS) and Data Acquisition	87-90
	3.2.2 The Concept and Approaches for Analysis Space Transformation	90-92
	3.2.3 Quantitative Details of the SPCA Transformed Sensor Array Responses	92-93
	3.2.4 Design of Classifiers using the SPCA Transformed Sensor Array Responses	94-95
	3.2.5 The Proposed Modular Architecture	95
	3.3 Results and Discussion	96-100
	3.3.1 Laminar Air Flow Using the Variable Speed of the Exhaust	96
	3.3.2 Performance Analysis	96-98
	3.3.3 Quantitative Analysis of the Results	98-100
Chapter-4	**ID2S4FH: A Novel Framework of Intelligent Decision Support System for Fire Hazards**	**101-122**

	4.1 Introduction	101-108
	4.2 Materials and Methods	108-117
	4.2.1 The Design Concept	109-110
	4.2.2 The Prototype	110-112
	4.2.3 The Experiment	112-114
	4.2.4 The Dataset	114-115
	4.2.5 Contextual Background of Data Pre-Processing and Classifiers	115-117
	4.3 Results and Discussion	118-122
	4.3.1 VOCs/Gases/Odors Sensor Response Patterns	118-119
	4.3.2 Efficacy of the Analysis Space Transformation Approach	119-120
	4.3.3 Performance of the IDSS Classifier for classifying the Fire Classes	120-122
Chapter-5	**An IoT-Enabled E-Nose for Airborne Pollution Hazards Detection and Monitoring of Airborne Pollution Hazards Using LoRa Network Protocol**	**123-145**
	5.1 Introduction	123-128
	5.1.1 Motivation and Contributions	127-128
	5.2 Materials and Methods	128-142
	5.2.1 The contextual background of N-IGSS	129-130
	5.2.2 The Gas Sensor Node Prototype	130-133
	5.2.3 Experimental setup	133-135
	5.2.4 Contextual Background of Analysis Space Transformation	135-142
	5.2.4.1 Data Pre-processing	135-138
	5.2.4.2 Design of the Classifiers	138-142
	5.3 Results and Discussions	142-145
	5.3.1 The LoRa Network Link Performance	142
	5.3.2 Performance of the Proposed N-IGSS for Air-borne Pollution Hazard Detection	142-145
Chapter-6	**IoT-IGSS: Real-Time Detection of VOCs in Household Disinfectants using IoT-enabled Intelligent Gas Sensor System**	**146-164**
	6.1 Introduction	146-151
	6.1.1 Motivation and Contribution	150-151
	6.2 Materials and Methods	151-159

	6.2.1 The Design Concept of HP-IGSS	151-152
	6.2.2 The prototype designs	153-154
	6.2.3 The Experimental Details	154-155
	6.2.4 Contextual Background of Analysis Space Transformation Method	155-159
	6.2.4.1 Data pre-processing	155-156
	6.2.4.2 Design of classifiers	156-159
	6.3 Results and Discussions	159-164
Chapter-7	**Cloud-Connected Intelligent Gas Sensor System for Qualitative Estimation of Blood Glucose Level Through Analysis of Exhaled Breath VOCs**	**165-185**
	7.1 Introduction	165-170
	7.2 Materials and Methods	170-183
	7.2.1 The Design Concept of CC-IGSS	170-172
	7.2.2 The Prototype Design	173-175
	7.2.3 The Experiment	175-176
	7.2.4 Conceptual Background of Data Preprocessing and Classifiers	176-183
	7.2.4.1 Data Preprocessing	177-178
	7.2.4.2 The Classifiers	178-183
	7.3 Results and Discussions	183-185
	7.3.1 Sensor Response Patterns of Breath Samples	183-184
	7.3.2 Performance of Classifier for Classifying the BGL Classes	184-185
Chapter-8	**Summary, Conclusions and Scope of Future Work**	**186-191**
	8.1 Summary	186-189
	8.2 Conclusions	190
	8.3 Scope of Future Work	191
	References	**192-213**
	List of Publications	**214**