

# Contents

<b>1</b>	<b>Introduction</b>	<b>12</b>
<b>2</b>	<b>Literature Review</b>	<b>14</b>
2.1	Qualitative Spatial Reasoning . . . . .	14
2.2	Qualitative Spatio-Temporal Reasoning . . . . .	17
2.3	Learning Spatio-Temporal Patterns within QSTR . . . . .	17
2.3.1	Qualitative abstractions of Patterns . . . . .	18
2.3.2	Probabilistic QSTR Approaches . . . . .	19
2.4	Description Logic . . . . .	20
2.4.1	Qualitative Spatio-Temporal Reasoning and Description Logic . . . . .	23
2.4.2	Description Logic and Probabilities . . . . .	23
2.5	Bayesian Network . . . . .	24
2.6	Bayesian Network and Description Logic . . . . .	26
<b>3</b>	<b>A Probabilistic QSTR Framework</b>	<b>29</b>
3.1	Qualitative Spatio-temporal Reasoning . . . . .	31
3.1.1	Direction Relations . . . . .	32
3.1.2	Orientation Relations . . . . .	34
3.2	Description Logic(DL) . . . . .	36
3.2.1	Syntax . . . . .	36
3.2.2	Semantics . . . . .	37
3.3	Bayesian Network(BN) . . . . .	45
3.4	Bayesian DL . . . . .	47
3.4.1	Syntax . . . . .	47
3.4.2	Semantics . . . . .	48
3.4.3	Semantic Properties . . . . .	50

<b>4 Reasoning Engine</b>	<b>52</b>
4.1 Reasoning Framework . . . . .	52
4.2 Module Descriptions and Algorithms . . . . .	53
4.2.1 QSTR Module . . . . .	54
4.2.2 DL Module . . . . .	54
4.2.3 BN Module . . . . .	56
4.2.4 BDL Module . . . . .	62
4.2.5 Pattern recognizer . . . . .	65
4.3 Illustrative Example . . . . .	68
<b>5 Discussion and Final Comments</b>	<b>74</b>

# List of Figures

2.1	Example of Role Assertions and Concept Assertions . . . . .	22
2.2	Example of a Bayesian Network . . . . .	26
2.3	Example of Combination of Network and DL . . . . .	27
3.1	The Schematic Probabilistic QSTR Framework . . . . .	30
3.2	The Direction Relations [From ( "A Qualitative Framework For Representation and Recognition of Motion Patterns" by Barua and Hazarika).] . . . . .	33
3.3	One Region Span [From ("A Qualitative Framework For Rep- resentation and Recognition of Motion Patterns" by Barua and Hazarika).] . . . . .	34
3.4	Two Region Span [From ("A Qualitative Framework For Rep- resentation and Recognition of Motion Patterns" by Barua and Hazarika) . . . . .	35
3.5	Three Region Span [From ("A Qualitative Framework For Representation and Recognition of Motion Patterns" by Barua and Hazarika). . . . .	35
3.6	Four Region Span [From ("A Qualitative Framework For Rep- resentation and Recognition of Motion Patterns" by Barua and Hazarika). . . . .	36
4.1	Reasoning Framework . . . . .	53
4.2	The Qualification Module . . . . .	54
4.3	DL Module . . . . .	55
4.4	BN Module . . . . .	57
4.5	LN for Role $R_O$ . . . . .	58
4.6	LN for Role $R_D$ . . . . .	59
4.7	BDL Module . . . . .	62
4.8	A Spatio-temporal data stream . . . . .	68

4.9	$\mathcal{L}$ of role $R_O$	71
4.10	$\mathcal{L}$ of role $R_D$	72

# List of Tables

3.1	Roles . . . . .	38
3.2	Concepts . . . . .	38
3.3	Spatial_Concepts . . . . .	38
3.4	Temporal_Concepts . . . . .	39
3.5	Spatio_Temporal_Concepts . . . . .	39

## List Of Symbols

---

$\mathcal{D}$	Spatio-temporal data stream
O	Orientation
D	Direction
<i>STDL</i>	Spatio-temporal description logic
<i>B-STDL</i>	Bayesian <i>STDL</i>
$\mathcal{L}$	Logical Bayesian Network
$P_r$	Probability of spatial relation of each episode.
ST	Spatio-temporal relation
S	Spatial relation
T	Tempoaryl Structure
$C_D$	Direction relations

---

---

$C_{D_1}$	Direction relations for a particular scenario
$C_O$	<i>Orientation relations</i>
$C_{O_1}$	Orientation relations for a particular scenario
$\mathfrak{I}$	Set of intervals
$E$	Episode
$S_1$	Scenario
$\mathfrak{S}\mathcal{C}$	Spatial concept
$\mathfrak{T}\mathcal{C}$	Temporal concept
$\mathfrak{S}\mathfrak{T}\mathcal{C}$	Spatio-temporal concept
$R_D$	Role for Direction
$R_O$	Role for Orientation
$\mathcal{D}$	Domain of objects/individuals
$\mathcal{C}$	Constant
$\mathcal{A}$	Atomic concepts
$\mathcal{R}$	Role

---

$\mathcal{J}$	Interpretation function
$\mathfrak{N}$	Non-logical symbols
LN	Logical Network
V	Vertices
$\mathcal{E}$	Edges
LN <sup>1</sup>	Logical Network for a particular scenario
V <sup>1</sup>	Vertices of Logical network for a particular scenario
$\mathcal{E}_1$	Edges of Logical network for a particular scenario
$\mathcal{T}$	True concept
$\mathcal{F}$	Pseudo concept
$\alpha$	Concept probability
$\mathfrak{o}$	No. of occurrences of a true concept in a scenario
$\mathbb{P}_{AB}$	Probabilistic Abox
$\mathbb{P}_{TB}$	Probabilistic Tbox
$\mathbb{P}_A$	Probabilistic Axioms



---

$\eta$	Probability of Probabilistic Axioms
$\mathbb{P}$	Probabilistic Patterns
$\mathbb{P}_F$	Probabilistic Fundamental Patterns
$\Psi$	Probability of Probabilistic Fundamental Pattern
$\mathbb{P}_B$	Probabilistic Basic Patterns
$\rho$	Probability of Probabilistic Basic Pattern
$\mathbb{P}_{NP}$	Probabilistic Neighboring Patterns
$\varphi$	Probability of Probabilistic Neighboring Pattern
$\mathfrak{M}$	Motion Pattern
$\Upsilon$	Probability of Composite pattern
$\mathfrak{I}$	Annotated Interpretation
$\mathfrak{P}$	Probabilistic Interpretation

---