



**KTH Computer Science  
and Communication**

# **Learning from Structures for Long Term Autonomous Robots**

AKSHAYA THIPPUR SRIDATTA

Doctoral Thesis  
Stockholm, Sweden 2020

TRITA-CSC-XXXXX  
ISSN-XXXXXXXXXX  
ISRN-KTH/CSC/XXXX  
ISBN XXXXXXXXXXXXX

Robotics, Perception and Learning  
School of Computer Science and Communication  
KTH Royal Institute of Technology  
SE-100 44 Stockholm, Sweden

Copyright © 2020 by Akshaya Thippur Sridatta except where otherwise stated.

Tryck: Universitetsservice US-AB 2020

**Abstract**

Here is my Abstract

**Sammanfattning**

The Swedish Abstract

## **Acknowledgments**

Thank everyone here

# Contents

<b>Contents</b>	<b>v</b>
1 On the structures in our universe . . . . .	1
2 Where is structure? . . . . .	1
3 Why care for structure? . . . . .	1
4 Machine Learning: Attention to structures . . . . .	1
<b>1 Finding Structure</b>	
<b>Towards Spatial Relationships: KTH-3D-Total Dataset</b>	<b>3</b>
1 Long-term observations of human indoor environments . . . . .	3
2 RELATED WORK . . . . .	3
3 Interesting surfaces - Why desks? . . . . .	3
4 KTH Long Term Dataset . . . . .	3
5 Matterport Dataset . . . . .	3
6 KTH 3D Total Dataset . . . . .	3
7 Spatial Relations: Language of Spatial Structures . . . . .	3
8 TODO . . . . .	3
<b>2 Describing Spatial Structure</b>	
<b>Qualitative and Quantitative Spatial Relations</b>	<b>5</b>
1 Spatial Relations - Intro . . . . .	5
2 RELATED WORKS . . . . .	5
3 Spatial Relations for our problem . . . . .	5
4 Task description - object recognition . . . . .	5
5 INSERT PAPER - AAAI QSR . . . . .	5
6 Spatial Relations recommendations . . . . .	5
7 SR for STRANDS? . . . . .	5
8 INSERT PAPER - IROS QSR . . . . .	6
<b>3 Designing Spatial Relations</b>	
<b>Joint Object Classification with Intrinsic Frame of Reference</b>	
<b>Calculi IFRC</b>	<b>7</b>
1 What kind of spatial relations to design? . . . . .	7
2 Why IFRC? . . . . .	7

3	INSERT PAPER- IFRC . . . . .	7
4	Discussion . . . . .	7
<b>4</b>	<b>Object Estimation</b>	
	<b>Bayesian Optimisation based Multiple Instance Estimation</b>	<b>9</b>
1	Difficulties of Object Estimation . . . . .	9
2	RELATED WORKS - Object Estimation . . . . .	9
3	INSERT PAPER – Bayesian Optimisation for Object Estimation . . . . .	9
4	Discussion . . . . .	9
<b>5</b>	<b>Making the Environment Continuous</b>	
	<b>Finite Mixture Models for Stochastic Kronecker Graphs</b>	<b>11</b>
1	Environment Recognition . . . . .	11
2	Kronecker graph theory . . . . .	11
3	Related works for large network analysis . . . . .	11
4	INSERT PAPER - FMM for SKG . . . . .	11
5	Discussion on generative model . . . . .	11
6	TODO . . . . .	11
<b>6</b>	<b>Deep Learning and Demo</b>	
	<b>Possible chapter</b>	<b>13</b>
1	DNN problem formulations . . . . .	13
2	Parallels to graph neural networks . . . . .	13
3	SORHACK Demo . . . . .	13
4	Further challenges . . . . .	14
5	TODO . . . . .	14
<b>7</b>	<b>Final Discussion</b>	<b>15</b>

# Introduction

- 1 On the structures in our universe**
- 2 Where is structure?**
- 3 Why care for structure?**
- 4 Machine Learning: Attention to structures**





# **Chapter 1**

## **Finding Structure**

### **Towards Spatial Relationships: KTH-3D-Total Dataset**

**1 Long-term observations of human indoor environments**

**2 RELATED WORK**

**3 Interesting surfaces - Why desks?**

**4 KTH Long Term Dataset**

**5 Matterport Dataset**

**6 KTH 3D Total Dataset**

**6.1 Need and construction**

**6.2 Noticing Spatial structures**

**6.3 INSERT PAPER KTH 3D TOTAL**

**7 Spatial Relations: Language of Spatial Structures**

**8 TODO**

- See if you can convert Matterport pointclouds into 2D projections
- Matterport arXiv paper and hosting?
- KTH 3D Total hosting



## **Chapter 2**

# **Describing Spatial Structure**

### **Qualitative and Quantitative Spatial Relations**

#### **1 Spatial Relations - Intro**

- why use it?
- language and description
- compression - topological descriptions
- mapping and directions

#### **2 RELATED WORKS**

#### **3 Spatial Relations for our problem**

#### **4 Task description - object recognition**

Talk about aiding the vision system and why? Extrinsic cues.

#### **5 INSERT PAPER - AAAI QSR**

#### **6 Spatial Relations recommendations**

Take the discussion section from paper and elaborate. When to use what SR and why should QSRs be measureable?

#### **7 SR for STRANDS?**

How to go forward from this analysis?

6 *CHAPTER 2. DESCRIBING SPATIAL STRUCTURE*  
*QUALITATIVE AND QUANTITATIVE SPATIAL RELATIONS*

**8 INSERT PAPER - IROS QSR**

Discuss practical issues

## **Chapter 3**

# **Designing Spatial Relations**

**Joint Object Classification with Intrinsic Frame of Reference Calculi**

**IFRC**

**1 What kind of spatial relations to design?**

**2 Why IFRC?**

TODO: Insert the linguistic experiment data. Conclusions drawn from it – elaborate.

**3 INSERT PAPER- IFRC**

**4 Discussion**

Difficulties of Joint Object Classification.

Elaborate discussion of joint object classification with IFRC. What can be improved?  
What are the pitfalls?



## **Chapter 4**

# **Object Estimation**

### **Bayesian Optimisation based Multiple Instance Estimation**

#### **1 Difficulties of Object Estimation**

- Multiple instances
- Only extrinsic features
- small data
- multiple instances – explain different location hits

#### **2 RELATED WORKS - Object Estimation**

Focus: Non parametric methods for Object Estimation

#### **3 INSERT PAPER – Bayesian Optimisation for Object Estimation**

#### **4 Discussion**





## Chapter 5

# Making the Environment Continuous

### Finite Mixture Models for Stochastic Kronecker Graphs

#### 1 Environment Recognition

- Why constrain to objects?
- Generalise to all kinds of environments. Football scenes, Chess boards, Crime scenes
- Key points - large network graphs
- Use large networks to analyse
- place in this context environment recognition in office places
- elaborate on nodes, graph construction, edges what ARE nodes in interpretation.

#### 2 Kronecker graph theory

#### 3 Related works for large network analysis

#### 4 INSERT PAPER - FMM for SKG

#### 5 Discussion on generative model

What are the main takeaways from the generative model?

#### 6 TODO

- convert couple scenes into large networks for examples - run inference experiments



## Chapter 6

# Deep Learning and Demo

### Possible chapter

#### 1 DNN problem formulations

- Bar code type of problem
- fly on object type of problem - Who am I?
- In painting
- Include IFRC data as metadata

Why not deep learning explored? Model importance for interpretability. Data constraints. Data feeding constraints.

#### 2 Parallels to graph neural networks

refer to work from Talukdar tutorial

#### 3 SORHACK Demo

Possible to include this chapter 4

##### 3.1 Problem statement

- motivation
- resources
- hidden object estimation

success measurement. Precision Recall why not used? Refer papers - Sanne Elena

#### **4 Further challenges**

problems with object identification with integration to vision system.

#### **5 TODO**

- Report? arXiv paper on system integration?
- Make up the video

## **Chapter 7**

# **Final Discussion**

Discussion

