

# Contents

<b>Contents</b>	<b>vii</b>
<b>List of Figures</b>	<b>ix</b>
<b>List of Tables</b>	<b>x</b>
<b>1 Introduction</b>	<b>1</b>
1.1 Motivation . . . . .	1
1.2 Objective . . . . .	1
1.3 Contribution of the thesis . . . . .	2
1.4 Chapters . . . . .	2
<b>2 Literature Review</b>	<b>3</b>
2.1 Rehabilitation Robotics and Assistive Technology . . . . .	3
2.2 Intelligent Wheelchair . . . . .	3
2.3 Human Robot Interaction . . . . .	4
2.4 Robotic Paradigms . . . . .	5
2.5 Cognitive Architecture . . . . .	5
2.6 Collaborative Control & Related Research . . . . .	6
2.6.1 Why Collaborative Control . . . . .	7
2.7 Memory and learning . . . . .	7
2.8 Knowledge Representation and FOL . . . . .	10
2.9 Robotic Software Framework and Simulation . . . . .	10
2.9.1 Robotic Control Framework . . . . .	10
2.9.2 Robotic Simulation . . . . .	11
<b>3 Cognitive Collaborative Architecture</b>	<b>13</b>
3.1 Introduction . . . . .	13

3.2	Cognitive Collaborative Architecture . . . . .	13
3.2.1	User Interface Layer . . . . .	13
3.2.2	Superior Control Layer . . . . .	14
3.2.3	Local Control Layer . . . . .	15
3.3	Margin Based Obstacle Avoidance Algorithm . . . . .	16
<b>4</b>	<b>Formalization of CCA</b>	<b>17</b>
4.1	Time . . . . .	17
4.2	Space . . . . .	17
4.3	Space-Time . . . . .	18
4.4	Relative Position . . . . .	18
4.5	Action & Plan . . . . .	18
4.6	Modes & Operations . . . . .	18
4.7	CCA . . . . .	19
<b>5</b>	<b>CCA within ROS-USARSim</b>	<b>23</b>
5.1	USARsim . . . . .	23
5.2	System Setup . . . . .	23
5.3	Simulation of CCA . . . . .	24
5.3.1	Generating A Virtual environment . . . . .	24
5.3.2	Spawning a P3AT Robot . . . . .	25
5.3.3	Bring up the Implemented CCA as ROS-node . . . . .	26
<b>6</b>	<b>Evaluation</b>	<b>28</b>
6.1	Evaluation . . . . .	28
6.1.1	Evaluation of Obstacle Avoidance Experiment . . . . .	28
6.1.2	Evaluation Based on Total Finish Time . . . . .	29
6.1.3	Evaluation of Adapting Human Strategy . . . . .	30
6.1.4	Evaluation of Smooth Negotiation . . . . .	31
6.1.5	Without Assistance Vs With Assistance . . . . .	31
	<b>Bibliography</b>	<b>35</b>

# List of Figures

2.1	Types of Human Memory: Diagram by Luke Mastin . . . . .	8
3.1	Cognitive Collaborative Architecture . . . . .	14
3.2	Three Different Cases for MOOA . . . . .	16
4.1	Structure of spatial Semantics . . . . .	21
5.1	System setup for CCA . . . . .	24
5.2	Simulated Environment in USARSim and its equivalent map Gen- erated by SLAM in ROS . . . . .	25
5.3	All the nodes working together for CCA (Detailed View) . . . . .	27
6.1	Users Drive time withing safety margin . . . . .	29
6.2	Percentage of users drive time within margin . . . . .	29
6.3	Percentage of users drive time within margin . . . . .	30
6.4	figure(a):wall follow , figure(b):Center Point , figure(c):Least angle with Goal . . . . .	30
6.5	smooth path instead of a sharp turn during negotiation . . . . .	31
6.6	Driving time comparison with or without assistance of Participants of having low cognitive score . . . . .	32
6.7	Driving time comparison with or without assistance of Participants of having high cognitive score . . . . .	32
.8	Experimental setup . . . . .	34

# List of Tables

2.1	YARP Vs ROS . . . . .	11
2.2	USARSim Vs other simulators . . . . .	12
3.1	Context switching criteria & corresponding action between states	16