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Multi-Hierarchical Representation of Large-Scale Space

Applications to Mobile Robots

by

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TABLE OF CONTENTS

Chapter 1. Introduction 1
1.1. Abstraction and Hierarchies of Abstraction 1
1.2. Multiple Abstraction and the Task-Driven Paradigm 3
1.3. Contents of this Book 7

Chapter 2. Hierarchies of Abstraction in Literature 9
2.1. Large-Scale Space Modeling 9
2.2. Artificial Intelligence 12
2.3. Cognitive Science 13
2.4. Other Areas 14

Chapter 3. A Formal Model of Multiple Abstraction 17
3.1. Motivation 17
3.2. Formalization of the Plain Graph Model 19
3.2.1. Basic Definitions 19
3.2.2. The Set of Costs 20
Optimality of Costs 21
3.2.3. Paths 21
3.2.4. Path Searching in Plain Graphs 23
Other Path Searching Schemes 25
3.2.5. NP-Completeness in Plain Graphs 27
3.3. Formalization of the Hierarchical Graph Model 28
3.3.1. Definitions Concerning Hierarchical Concepts 28
3.3.2. Definitions Concerning Nodes 29
Abstraction Function for Nodes 30
Chains of Abstraction 31
Clusters and Subgraphs 31
Annotations 32
3.3.3. Definitions Concerning Arcs 33
Abstraction Function for Arcs 33
Classification of Arcs 34
Annotations 35
Cost Intervals 35
Different Hierarchical Levels to See the Same Information 37

3.3.4. Paths in AH-graphs 38
Abstracting Paths 39
Refining Paths 40
3.3.5. Classes of Hierarchical Graphs 41
Connected AH-graphs 41
AH-graphs with and without Forgetfulness 41
Complete AH-graphs 42
3.4. Formalization of the Multihierarchical Graph Model 42
3.4.1. General Definitions 43
3.4.2. Multihierarchies 43
3.4.3. Abstraction Paths in Multihierarchies 46
3.4.4. Labelled Multi-AH-graphs 47
3.5. Some implementation Issues of the Multi-AH-graph Model 48
3.5.1. Automatic Construction of the Multi-AH-graph Model 48
Automatic Clustering 49
Automatic Relations 50
Automatic Optimization of Multihierarchies 51
3.5.2. Storage Issues 52
3.5.3. Validating the Model 53
3.5.4. Isomorphism Implementation 54
Implementation of H-isomorphism 61
H-isomorphism in Multihierarchies with Several Ground Levels 65
Relation Between Isomorphism and H-isomorphism 65
When Does H-Isomorphism Imply Conventional Isomorphism? 66
When Does Conventional Isomorphism Imply H-Isomorphism? 67
3.6. Summary 68

Chapter 4. Hierarchical Path Search 71
4.1. Hierarchical Path Search in Single Hierarchies 72
4.2. Algorithms for Hierarchical Path Search 73
Classic Refinement 73
Path Marking 74
Alternating Opportunism 74
Left-Wedge 74
Mixed Methods 74
4.3. Pros and Cons of Hierarchical Path Search 75
4.3.1. Problem Dependency 75
4.3.2. Sub-Optimality 76
4.3.3. Bad Clustering 77
4.3.4. Hierarchical Backtracking 78
4.4. Hierarchical Path Search in AH-graphs 80

4.4.1. A General Hierarchical Path Search Algorithm 83
4.4.2. More Specific Hierarchical Path Search Algorithms 88
4.5. Optimality of Hierarchical Path Search in AH-graphs 89
4.5.1. Optimality of Paths in Algorithms Without Materialization of Costs 90
4.5.2. Optimality of Paths in Algorithms With Materialization of Costs 92
4.5.3. Some Conclusions on the Optimality of Hierarchical Path Search in AH-graphs 94
4.6. Computational Cost of Hierarchical Path Search 94
4.7. Classification of Search Problems 95
4.8. Goodness of Hierarchical Path Search 98
4.9. Hierarchical Path Search in Multiple Hierarchies 98
4.9.1. Solving a Single Search Problem in a Multihierarchy 99
Experiments 100
4.9.2. Solving Multiple Search Problems in a Multihierarchy 103
Experiments 106
4.9.3. Multiple Representations in a Multihierarchy 107
4.10. Summary 111

Chapter 5. Automatic Generation of Multiple Hierarchies of Abstraction 115
5.1. Task-Driven Automatic Construction of Hierarchies 115
5.1.1. The Task-Driven Paradigm for Multiple Hierarchy Construction 116
5.1.2. Obtaining Hierarchical Information 117
5.1.3. Problems of the Task-Driven Paradigm 119
5.1.4. Utility of the Task-Driven Paradigm 121
5.2. Overview of CLAUDIA 123
5.3. The Ground Information Interface (GI^2) 125
5.3.1. Information Provided by the GI^2 125
Ground Concepts 126
Ground Relations 126
5.3.2. Implementation Issues of the GI^2 127
Complex Relations 127
Percept Equality 128
Forgetfulness / Reinforcement of Ground Information 129
5.4. The Abstraction Construction and Optimization Subsystem (ACO) 129
5.4.1. The Clustering Module 129
OEET (Optimality Edge Elimination Test) Algorithm 130
OSHA (Optimal Search Hierarchy Approach) Algorithm 130
Seed-Size Algorithm 130
Cohesion Forces Algorithm 131
Partition Enumeration Algorithm 132
Approximation Algorithms to NP-Complete Clustering Problems 133
5.4.2. The Single-Hierarchy Constructor Module 135

Type of the Arcs 136
Label of the Hierarchy in the Multihierarchy 136
Parameters for H-Isomorphism Detection 136
Procedures for Abstracting Annotations 137
5.4.3. The Multihierarchy Optimizer Module 142
5.4.3.1. A Definition of the "Goodness" of a Multihierarchy 144
Agent, Environment, and Task Define "Goodness" 144
Classification of Search Problems 145
Prediction of the Computational Cost of Solving a Search Problem 146
Calculating the Goodness of a Multihierarchy 148
5.4.3.2. The Space of Multihierarchies 150
Exploring the Neighbours of a Multihierarchy 152
Utility of the Hierarchies of a Multihierarchy 153
5.4.3.3. Algorithms for Multihierarchy Optimization 154
Optimization of Multihierarchies by Hill-Climbing 154
Generation of the Neighbours of a Multihierarchy 156
Other Techniques for the Optimization of Multihierarchies 159
5.5. Evaluation of the Automatic Multiple Abstraction System 161
5.6. Summary 168

Chapter 6. Multiple Hierarchies of Abstraction for Mobile Robots 171
6.1. Large-Scale Space Modeling for Mobile Robots 171
6.2. A Mobile Robot with a Model of Large-Scale Space 174
6.3. Formalizing the Connection Between CLAUDIA and the SSH 188
6.3.1. The Spatial Semantic Hierarchy 189
Formalizing Regions at the SSH Topological Level 193
6.3.2. Connecting the SSH Topological Level to CLAUDIA 199
6.4. Summary 202

Chapter 7. Conclusions 203

Appendix A. NP-Completeness Overview 209

Appendix B. Algorithm for Hierarchical Path Search 213

Appendix C. The Cohesion Forces Clustering Algorithm 221

Appendix D. The OEET Clustering Algorithm 225
D.1. Introduction 225
D.2. The OEET Algorithm 226
D.2.1. First Stage: Retrieving Path Information 229

D.2.2. Second Stage: Arc-Elimination Test and Arc-Erasing Process 230
BEHAVIOUR OF THE OPTIMAL PATHS 231
BEHAVIOUR OF THE NON-OPTIMAL PATHS 232

Appendix E. Computational Cost of Hierarchical Path Search 245
E.1. Computational Cost in Hierarchies with Two Hierarchical Levels 246
E.2. Computational Cost in Hierarchies with More Than Two Hierarchical Levels 252

Appendix F. Sufficient Condition for Optimality When There is No Materialization of Costs 255
F.1. When the Cost of Refining Paths is a Constant 256
F.2. When the Cost of Refining Paths is Bounded by the Costs of the Arcs 257

References 261

Index 273

LIST OF FIGURES

1.1. Example of hierarchy of abstractions created in one's mind 2

3.1. Example of plain multigraphs with three different types of arcs 20
3.2. Examples of paths in a plain multigraph 21
3.3. Example of DAM / DAG 22
3.4. Two AH-graphs of four and three hierarchical levels, respectively 29
3.5. Example of clusters and subgraphs 32
3.6. Examples of external and internal graphs 35
3.7. Examples of cost intervals and their properties 36
3.8. Cycles may arise in simple paths when they are abstracted 40
3.9. Examples of different types of AH-graphs 42
3.10. A multihierarchy for modeling two conceptions of the countries of Europe 45
3.11. Typical example of multihierarchy 46
3.12. Example of a labelled Multi-AH-graph 48
3.13. Three isomorphic plain graphs 55
3.14. Induction of clusterings through a hierarchical graph 57
3.15. Illustration of the theorem Y of h-isomorphism 57
3.16. Illustration of the theorem D of h-isomorphism 59
3.17. Illustration of the theorem M of h-isomorphism 60
3.18. Pseudocode of the algorithm to find a common antecessor of two hierarchical levels 62
3.19. Pseudocode of the algorithm that implements function "Alpha" 63
3.20. Pseudocode of the algorithm for clustering equivalence 64
3.21. Illustration of the cases where h-isomorphism implies isomorphism 67
3.22. Counterexample for the implication isomorphism -> h-isomorphism 68

4.1. Illustration of the process of refining a node of a path 79
4.2. Recursive hierarchical path search algorithm in pseudocode 81
4.3. Illustration of the pyramid of search of a search problem, and its contour 84
4.4. Status of the generic hierarchical path search algorithm 85
4.5. Zones of the pyramid of search for the generic path search algorithm 86
4.6. Hierarchical path search algorithm in forgetfulnessless, connected AH-graphs, in pseudocode 88
4.7. Plain graph structures that permit clusterings that preserve the SCO 90
4.8. Computational cost comparison in several hierarchical path search methods 102

4.9. Optimality of paths comparison in several hierarchical path search methods 103
4.10. A common hierarchical level in a multiple search problem 105
4.11. Definition of ground cluster 106
4.12. Environment where an office-delivery robot operates 108
4.13. Different hierarchies constructed for the office-delivery robot 109-110

5.1. Flow of information between the world, an agent, and CLAUDIA 123
5.2. Components of the abstraction and optimization subsystem of CLAUDIA 124
5.3. Examples of gestalt relations between percepts 128
5.4. Estimates of the redundancy of some clustering algorithms 134
5.5. Example of structured environment where a robot navigates 137
5.6. Perceptual shots of the navigation environment and the ground level generated from them by the GI² of CLAUDIA 137-142
5.7. Clustering of the navigation environment generated for the first hierarchical level of the Multi-AH-graph 142
5.8. Clustering of the navigation environment generated for the second hierarchical level of the Multi-AH-graph 143
5.9. Classification of search problems for the path planning application of CLAUDIA 146
5.10. Illustration of the influence of the arrangement of values of the variables of a function in an optimization method based on exploration of neighbours 151
5.11. Illustration of the procedure for generation of neighbour multihierarchies 153
5.12. Hill-climbing algorithm used by CLAUDIA for optimization of multihierarchies, in pseudocode 155
5.13. Neighbour multihierarchies generated by the optimizer of CLAUDIA 157
5.14. Two of the three plain graphs used for evaluation of CLAUDIA 162
5.15. Example of multihierarchy obtained by optimization 168

6.1. The mobile robot RAM-2 174
6.2. Software architecture of the application designed in NEXUS for RAM-2 176
6.3. Image taken from the real environment where RAM-2 navigates, and a portion of the floor plant and 2D global maps generated by the Map Builder module 180
6.4. Floor plant of the entire building where RAM-2 navigates 181
6.5. Simplified floor plant of the environment where RAM-2 navigates, and the plain graph constructed by the GI² 182
6.6. First hierarchical level of the initial multihierarchy constructed for RAM-2 183
6.7.a. First hierarchical level of the final multihierarchy constructed for RAM-2 177
6.7.b. Second hierarchical level of the final multihierarchy constructed for RAM-2 184
6.7.c. Third hierarchical level of the final multihierarchy constructed for RAM-2 185
6.8.a. Ground level received by the optimizer and complete initial multihierarchy constructed for RAM-2 187

6.8.b. First hierarchical level of the final multihierarchy constructed for RAM-2 187
6.9. Complete final multihierarchy constructed for RAM-2 188
6.10. Distinct representations of the Spatial Semantic Hierarchy (SSH) 191
6.11. Application of the SSH to a simulated mobile robot 192
6.12. Illustration of the process of "lifting" a path in the SSH 195
6.13. AH-graph obtained by connecting the SSH topological level to CLAUDIA 198
6.14. Plain graph obtained by CLAUDIA from the connection to the SSH 201

B.1. Dataflow diagram of the generic hierarchical path search algorithm 214
B.2. Dataflow diagram of the refinement routine 215
B.3. Dataflow diagram of the routine INIT_INFO 216
B.4. Dataflow diagram of the routine for finding the first refinable node 217
B.5. Dataflow diagram of the routine for updating the current hierarchical level 217
B.6. Dataflow diagram of the routine for finding the first entering subnode 218
B.7. Dataflow diagram of the routine for finding the first leaving subnode 218
B.8. Dataflow diagram of the routine for finding next leaving subnode 219
B.9. Dataflow diagram of the routine for finding next entering subnode 219
B.10. Dataflow diagram of the routine for backtracking between hierarchical levels 220

C.1. Examples of application of the cohesion forces algorithm 223
C.2. Example of calculation of the tension of a node in a cyclic graph 224

D.1. Control diagram of the OEET algorithm 228
D.2. Status stored by the OEET algorithm for a plain graph 229
D.3. Plain graph which the OEET algorithm clusterizes 233
D.4. Stages of the clustering performed by the OEET algorithm 235
D.5. Final clustering constructed by the OEET algorithm 236
D.6. A different clustering performed by the OEET algorithm 236
D.7. A clustering the does not preserve the SCO 237

E.1. 3D surface of the computational cost of hierarchical path search in AH-graphs with only 2 hierarchical levels 248
E.2. 3D surface of computational cost projected onto plane R=0 248
E.3. 3D surface of computational cost projected onto plane N=0 249
E.4. 3D derivative of the surface of computational cost 249
E.5. Zeroes of the derivative of the surface of computational cost 251

PREFACE

It has been stated in psychology that human brain arranges information in a way that improves efficiency in performing common tasks, for example, information about our spatial environment is conveniently structured for efficient route finding. On the other hand, in computational sciences, the use of *hierarchical* information is well known for reducing the complexity of solving problems.

This book studies hierarchical representations of large-scale space and presents a new model, called Multi-AH-graph, that uses multiple hierarchies of abstraction. It allows an agent to represent structural information acquired from the environment (elements such as objects, free space, etc., relations existing between them, such as proximity, similarity, etc. and other types of information, such as colors, shapes, etc). The Multi-AH-graph model extends a single hierarchy representation to a multiple hierarchy arrangement, which adapts better to a wider range of tasks, agents, and environments.

We also present a system called CLAUDIA, which is an implementation of the task-driven paradigm for automatic construction of multiple abstractions: a set of hierarchies of abstraction will be "good" for an agent if it can reduce the cost of planning and performing certain tasks of the agent in the agent's world. CLAUDIA constructs multiple hierarchies (Multi-AH-graphs) for a given triple *<agent,tasks,world>*, trying to optimize their "goodness".

The task-driven paradigm for construction of multiple abstraction requires CLAUDIA and the Multi-AH-graph model to be integrated in a real agent embedded in a real environment. Two mobile robotic frameworks have been tested: the mobile robot RAM-2 (in charge of delivering objects inside a building), and the Spatial Semantic Hierarchy (Kuipers, 2000).

CLAUDIA seems to be flexible enough to cope with any possible instantiation of the triple *<agent,tasks,world>*, becoming a general scheme where different procedures for acquiring hierarchical information can be integrated. In particular, some hints are given on the application of our system to areas of research such as computer vision, geographic information systems (GIS), communication networks, etc.

Other problems of interest are studied in the text, mainly graph isomorphism and path searching in hierarchical graphs.

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During summer 1998, Dr. Fernández was in a stay in the Computer Science Department of the University of Texas at Austin, with the Robotics Group directed by Prof. Benjamin J. Kuipers. The multiple abstraction model was originated in a inspiring talk with Prof. Kuipers in their robotics lab. Further collaboration with Emilio Remolina led to the formalization of the connection between the TOUR model and the Multi-AH-graphs. Thanks are due to all who made that stay possible and to be worth, in special to Prof. Kuipers.

Collaboration with Dr. Jose L. Pérez-de-la-Cruz, Dr. Lawrence Mandow, and Dr. Marlon Núñez, from the Computer Sciences Department of the University of Malaga was specially fruitful.

Several experiments were done with CLAUDIA and Multi-AH-graphs using the RAM-2 mobile platform, a robot designed and constructed in the Department of System Engineering and Automation of the University of Málaga. Thanks are due to all the department staff.

The feasibility of CLAUDIA to cope with a wide range of applications, in particular computer vision, was better understood under the work of Gregorio Ambrosio on stereo vision.

Finally, thanks are also due to all the anonymous referees who helped in improving the quality of the publications which this work is based on.