Oberseminar Lehrstuhl für Grundlagen der Künstlichen Intelligenz

Feldberg-Hebelhof

Abstracts of Presentations

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March 30-31, 2006

Contents

1 Heterogeneous Verification of Composition Tables

Stefan Wölfl

In the domain of qualitative constraint reasoning, a subfield of AI which has evolved in the last 25 years, a large number of calculi for efficient reasoning about spatial and temporal entities have been developed. Qualitative reasoning aims at describing the common-sense background knowledge on which our human perspective on the physical reality is based. The calculi, that is, formal languages and reasoning techniques, developed in this research area are of special interest for all application fields that rely on human-machine interaction in static or dynamically changing spatial environments.

Reasoning techniques developed for these constraint calculi crucially rely on their respective composition tables. However, quite often these composition tables are developed in an "ut figura docet"-like manner and hence they are prone to errors. In view of possible safety critical applications it is desirable to formally verify these composition tables, which in general is hard, since the semantics of qualitative calculi usually depends on higher-order constructs such as sets. In my talk I will present a heterogeneous proof method that allows for combining higher-order proof assistance systems (such as Isabelle) with automatic (first order) reasoners (e. g., SPASS). The benefit of this method is that the number of proof obligations that need to be proven by hand with a semi-automatic reasoner can be minimized to an acceptable level.

2 ATL-Modelchecking

Micha Altmeyer

Temporale Handlungslogiken stellen einen interessanten Ansatz dar, Multi-Agenten-Systeme in einer präzisen Weise zu spezifizieren und hinsichtlich bestimmter Eigenschaften zu prüfen. Hier zu erwähnen ist insbesondere die Multi-Agenten-Logik ATL, die die im Bereich des Model-Checkings dominante Logik CTL in naheliegender Weise für Multi-Agenten-Systeme adaptiert. Alur stellt nun einen Algorithmus vor, der das Model-Checking für ATL durchführt. Ziel der Studienarbeit war es, diesen Algorithmus für sogenannte Moore-synchrone Agentensysteme zu implementieren. Anhand eines einfachen Multi-Agenten-Szenarios soll die Implementation vorgestellt werden und ein Einblick in die Theorie gegeben werden.

Literatur: Rajeev Alur and Thomas A. Henzinger and Orna Kupferman: "Alternating-Time Temporal Logic", Lecture Notes in Computer Science Vol. 1536, 23–60, 1998.

3 Combining Topological and Directional Information: First Results

Sanjiang Li

Representing and reasoning about spatial information is important in artificial intelligence and geographical information science. Relations between spatial entities are the most important kind of spatial information. Most current formalisms of spatial relations focus on single aspect of space. This contrasts sharply with real world applications where several aspects are usually involved together. In this talk we propose a qualitative calculus that combines a simple direction relation model with the well-known topological RCC5 model. We show by construction that consistency of atomic constraint networks can be decided in polynomial time.

Keywords: Qualitative Spatial Reasoning; topological relations; direction relations; consistency.

4 A computational model for reasoning with spatial models

Marco Ragni

A computational model for spatial-relational reasoning by means of mental models is presented. According to the mental models theory (MMT), humans reason by constructing, inspecting, and validating mental models of the state of affairs described in the premises. The mental models machine (MMM) consists of a spatial array and a spatial focus that places objects in the array, manipulates the position of objects, and inspects the array to find spatial relations that are not given in the premises. The MMM results in a computational complexity measure that relies on the number of "cognitive units" necessary for each operation in the array. Many of the experimental findings concerning the difficulty of spatial relational reasoning can be explained by this complexity measure.

5 Reasoning in Calculi for Networks

Alexander Scivos

When reasoning in refined calculi for networks, the solvability of a constraint satisfaction problem may depend on single points, i. e. a submodel is in some cases no longer a model of the CSP. This causes a decrease in the amount and size of tractable subclasses which means that the traditional idea of restricting to tractable subclasses of an RA is more limited in practical cases. Instead, a structure-based approach of ensuring polynomial-time decidability of CSPs is motivated and explained, along with a proof that this approach works in the case given.

6 Cheap, Mobile And Autonomous Rescue Robots

Alexander Kleiner

Rescue Robotics is a newly emerging field dealing with systems that support first response units in disaster missions. Especially autonomous mobile robots can be a highly valuable for urban search and rescue (USAR). They can be used to inspect places inaccessible for humans due to hostile environmental conditions, such as collapsing structures, hazardous chemicals, and fire. Moreover, they can support the coordinated and efficient search of victims within unknown terrain.

RoboCup is an international research and education initiative. It is an attempt to foster AI and intelligent robotics research by providing a standard problem where a wide range of technologies can be integrated and examined. RoboCupRescue is since 2000 a regular part of RoboCup with a constantly increasing number of teams from different countries applying for participating in the competition. The competition is based on reference Test Arenas, which are provided by the National Institute of Standards and Technology (NIST). These arenas, modeled from buildings in various stages of collapse, allow objective performance evaluation of robots as they perform a variety of USAR.

During the last three years a significant boost in the performance of the participating teams could be registered. In contrary to the very beginning, rescue robots nowadays are capable of reliably detecting victims, mapping an unknown and unstructured environment (likewise in 2D or 3D), and overcoming obstacles, such as ramps, stairs, and fields of arbitrarily arranged pieces of wood. Whereas before these tasks could only be carried out by teleoperation, i.e. under supervision of a human operator, research nowadays also focuses on the aspect of autonomy, i.e. the development of robots that search for victims without any human control. This talk provides an overview on the approach of the team "RescueRobots Freiburg", winner of the "Best in Class Autonomy" award at the RoboCupRescue competition in Osaka 2005. It will basically be shown how low-cost hardware, e.g. home-made or R/C toy-based robot platforms, can successfully be utilized for the autonomous exploration and mapping of unknown terrain. Furthermore a novel method for RFID technology-based exploration and Simultaneous Localization And Mapping (SLAM), and a system for reliable victim detection will be introduced.

7 Structure recognition within 3D data based on Markov Random Fields (MRFs)

Rainer Kümmerle

This student thesis deals with the problem of object recognition within 3D scan data based on Markov Random Fields (MRFs). The 3D Data is acquired using a laser scanner and is represented as a pointcloud. By extracting plain surfaces it is possible to extract various features, that are used as input for the Markov Random Field. Training the Markov Random Field with Maximum Margin Estimation yields promising results, so that it is possible to recognize the existing objects.

8 Reinforcement Learning for action selection of a rescue robot

Bastian Steder

In this work reinforcement learning is introduced and it will be illustrated, how a robocup rescue robot was given the possibilities to overcome bigger obstacles and to drive up ramps autonomously. For this, the sensors and the hardware in general were modified and handcoded skills were combined with reinforcement learning. Within two concrete tasks, the learning aptitude was tested on the real robot and the results show, that the concept works.

9 Examination of different methods for Visual Odometry

Christian Dornhege

This student thesis deals with visual odometry, i.e. the robot's position estimation based on visual data. A simple approach, that takes the robot's kinematic model into account, is pursued. It is based on the tracking of features between frames utilizing a KLT feature tracker and afterwards classifying these features into different classes of movement using a voting scheme. Results show that the odometry derived from this system is of similar quality compared to wheeled odometry on flat surfaces, but the system is also capable of generating movement estimates on obstacles as e.g. pallets and ramps.

10 An Integration of Manipulation and Action Planning

Sebastian Trüg

The most common approach to manipulation planning is to create a manipulation graph which connects valid free grasp positions. The manipulation graph, however, does not explicitely include the notion of regrasping an object in order to change the grasp pose. Thus, in order to allow as free a handling of the grasp poses as possible, classical domain-independent action planning techniques are used. To keep the symbolical domain as simple as possible the problem is decomposed into the sometimes expensive constraint checking and effect calculation based on the full domain knowledge including geometric information on the one hand, and the purely symbolic planning process on the other. On the technical side this requires the introduction of "procedural attachments" in the PDDL.

11 Erfüllbarkeitsbasierte Handlungsplanung mit temporal erweiterten Zielen

Robert Mattmüller

Handlungsplanung mit temporal erweiterten Zielen ist eine echte Verallgemeinerung klassischer Handlungsplanung, die es nicht nur erlaubt, bestimmte Eigenschaften eines Zielzustandes, sondern der gesamten Planausführung, wie etwa Sicherheitseigenschaften, zu spezifizieren. Es wird ein Verfahren zur Lösung solcher Planungsaufgaben vorgestellt, das auf einer Reduktion auf das aussagenlogische Erfüllbarkeitsproblem basiert.

Dabei werden der Zustandsraum der Planungsaufgabe und die temporallogische Spezifikation (als LTL-Formel) der gewünschten Eigenschaft des Ausführungspfades eines Planes für aufsteigende Planlängen in aussagenlogische Formeln übersetzt, die resultierenden Formeln auf Erfüllbarkeit geprüft und gegebenenfalls aus einer erfüllenden Belegung ein Plan extrahiert.

Durch das Hinzufügen geeigneter Konjunktionsglieder zu der aussagenlogischen Übersetzung kann man parallele Pläne erzeugen und dadurch unter Umständen die Effizienz des Planers erhöhen. In ersten Experimenten waren die von einem Planer, der parallele Pläne zulässt, erzeugten Lösungen immer höchstens so lang wie die von einem entsprechenden sequentiellen Planer erzeugten Pläne, häufig waren sie auch um einige Schritte kürzer. Auch die Laufzeiten des eingesetzten SAT-Solvers auf den erzeugten aussagenlogischen Formeln waren im parallelen Fall meist geringer als im sequentiellen.

12 Metric Localization with SIFT Features using a Single Camera

Maren Bennewitz

The Scale Invariant Feature Transform (SIFT) has become a popular feature extractor for vision-based applications. It has been successfully applied to metric localization and mapping using stereo vision and omnivision. In this paper, we present an approach to Monte-Carlo localization using SIFT features for mobile robots equipped with a single perspective camera. First, we acquire a 2D grid map of the environment that contains the visual features. To come up with a compact environmental model, we appropriately down-sample the number of features in the final map. During localization, we cluster close-by particles and estimate for each cluster the set of potentially visible features in the map using ray-casting. These relevant map features are then compared to the features extracted from the current image. The observation model used to evaluate the individual particles considers the difference between the measured and the expected angle of similar features. In real-world experiments, we demonstrate that our technique is able to accurately track the position of a mobile robot. Moreover, we present experiments illustrating that a robot equipped with a different type of camera can use the same map of SIFT features for localization.

13 Goal Oriented Extensive Games

Vittorio Amos Ziparo

In this talk we present a framework for MultiAgent planning where heterogeneous self-interested agents, which inhabit a partially observable strategic environment, pursue possibly conflicting goals. We base our framework on Extensive Games: a Game Theoretic tool for analyzing the behavior of interacting agents. Compared to other approaches, we try to narrow down the sources of uncertainty to the actions performed by other agents. Moreover, communication is an integral part of the model and allows reasoning of distributed knowledge and action synchronization.

14 Learning Methods for the Table Soccer Robots

Dapeng Zhang

Learning is indispensable for intelligence agents to improve themselves. In this talk, the possible learning methods for our table soccer robots are proposed. As the first step, a tablesoccer-game recorder is going to be constructed by rebuilding a regular game table, which makes the learning tasks much easier. Based on the recorded data, sequence learning could be employed for the recognition and prediction of the actions of human players. The temporal dependencies among the position of the ball and the movements of the different rods can be explored. Module-based MDPs could be used for high-level decision.

15 Continual Planning and Acting in Dynamic Multiagent Environments

Michael Brenner

Multiagent systems (MAS) are usually highly dynamic and only partially observable for individual agents. With individual knowledge being strongly limited, classical conditional or stochastical planning algorithms become prohibitively hard to use in MAS. Moreover, agents planning their actions should also be able to consider other agents' goals and actions, and to interact with them. In this talk, we describe a multiagent planning formalism that allows to represent and reason about these aspects of MAS. Building on the formalism, we decribe a new continual planning technique called "Planning with Assertions" (PwA). It avoids the compututational blow-up of considering all possible contingencies at planning time. Instead, PwA deliberately postpones parts of the planning process to later stages in the plan-act-monitor cycle and automatically determines when to toggle between these stages.

To evaluate MA planning techniques and architectures, we have developed a generic simulation environment into which specific domains can be loaded and which intelligent agents can interact with. Using this simulation, we have evaluated several agent architectures using PwA with different sensing capabilities, memory capacities, and degrees of cooperation. Our experiments show that, using continual planning techniques, deliberate action planning can be used efficiently even in complex multiagent environments.

16 Approximation Properties of Planning Benchmarks

Malte Helmert

For many classical planning domains, the computational complexity of non-optimal and optimal planning is known. However, little is known about the area in between the two extremes of finding *some* plan and finding *optimal* plans. To remedy this disagreeable state of affairs, my talk provides a complete classification of the propositional domains from the first four International Planning Competitions and a wide variety of related optimization problems with respect to the well-known approximation classes **PO**, **FPTAS**, **PTAS**, **APX**, **poly-APX**, **exp-APX** and **EXPO**. A brief introduction to the theory of approximation algorithms is provided.

17 Representing a Propositional Formula as *one* Linear Pseudo-Boolean Constraint

Jan-Georg Smaus

A *linear pseudo-Boolean constraint* (LPB) is an expression of the form $a_1 \cdot l_1 + \ldots + a_m \cdot l_m \geq d$, where each l_i is a *literal* (it assumes the value 1 or 0 depending on whether a propositional variable x_i is true or false) and the $a_1, \ldots, a_m, d$ are natural numbers. The formalism can be viewed as a generalisation of a propositional clause. It has been said that LPBs can be used to represent Boolean functions more compactly than the well-known *conjunctive* or *disjunctive* normal forms. In this paper, we address the question: *how much* more compactly? We compare the expressiveness of a single LPB to that of related formalisms, and we give a statement that outlines how the problem of computing an LPB representation of a given CNF or DNF might be solved recursively. However, there is currently still a missing link for this to be a full algorithm.