Agent Planning, Models, Virtual Haptic Computing, and Visual Ontology

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Abstract. The paper is a basis for multiagent visual computing with the Morph Gentzen logic. A basis to VR computing, computational illusion, and virtual ontology is presented. The IM_BID model is introduced for planning, spatial computing, and visual ontology. Visual intelligent objects are applied with virtual intelligent trees to carry on visual planning. New KR techniques are presented with generic diagrams and appllied to define computable models. The IM Morph Gentzen Logic for computing for multimedia are new projects with important computing applications. The basic principles are a mathematical logic where a Gentzen or natural deduction systems is defined by taking arbitrary structures and multimedia objects coded by diagram functions.The techniques can be applied to arbitrary structures definable by infinitary languages. Multimedia objects are viewed as syntactic objects defined by functions, to which the deductive system is applied.

1. Introduction

Agent computing models are introduced with an intelligent multimedia dimension. An overview to a practical agent computing model based on beliefs, intentions, and desire is presented and possible augmentation to intelligent multimedia is explored. Genesereth-Nilsson [17] presents agent architectures as follows. Dynamics and situation compatibility in introduced as a structural way to compute and compare epistemic states. Worlds, epistemics, and cognition for androids are introduced with precise statements. The foundations are applied to present a brief on Computational Illusion, affective computing, and Virtual Reality. KR for AI Worlds, and Computable Worlds are presented with diagrams [7]. A preview to computational epistemology and concept descriptions is introduced. Deduction models and perceptual computing is presented with a new perspective. Intelligent multimedia interfaces are an important component to the practical computational aspects. Visual context and objects are presented with multiagent intelligent multimedia. Visual context abstraction and meta-contextual reasoning is introduced as a new field. Multiagent visual multi-board planning is introduced as a basis to intelligent multimedia with applications to spatial computing.

2. The Agent Models and Desire

Let us start with the popular agent computing model the Beliefs, Desire, and Intentions, henceforth abbreviated as the BID model (Brazier-Truer et.al.[1,6]. BID is a generic agent computing model specified within the declarative compositional modeling framework for multi-agent systems, DESIRE. The model, a refinement of a generic agent model, explicitly specifies motivational attitudes and the static and dynamic relations between motivational attitudes. Desires, goals, intentions, commitments, plans, and their relations are modeled. Different notions of strong and weak agency are presented at (Wooldridge and Jennings, 1995) [3]. (Velde and Perram, 1996) [10] distinguished big and small agents. To apply agent computing with intelligent multimedia some specific roles and models have to be presented for agents. The BID model has emerged for a "rational agent": a rational agent described using cognitive notions such as beliefs, desires and intentions. Beliefs, intentions, and commitments play a crucial role in determining how rational agents will act. Beliefs, capabilities, choices, and commitments are the parameters making component agents specific. The above are applied to model and to specify mental attitudes (Shoham, 1991-1993) [46], Rao and Georgeff, 1991[20], Cohen and Levesque, 1990, Dunin-Keplicz and Verbrugge, 1996 . A generic BID agent model in the multiagent framework DESIRE is presented towards a specific agent model. The main emphasis is on static and dynamic relations between mental attitudes, which are of importance for cooperative agents. DESIRE is the framework for design, and the specification of interacting reasoning components is a framework for modeling, specifying and implementing multi-agent systems, see (Brazier, Dunin-Keplicz, Jennings, and Treur, 1995, 1996; Dunin-Keplicz and Treur, 1995). Within the framework, complex processes are designed as compositional architectures consisting of interacting task-based hierarchically structured components. The interaction between components, and between components and the external world is explicitly specified. Components can be primitive reasoning components using a knowledge base, but may also be subsystems which are capable of performing tasks using methods as diverse as decision theory, neural networks, and genetic algorithms. As the framework inherently supports interaction between components, multi-agent systems are naturally specified in DESIRE by modeling agents as components that can be implemented applying author's 1993-1999.

2.1 Mental Attitudes

Agents are assumed to have the four properties required for the weak notion of agency described in (Wooldridge and Jennings, 1995). Thus, agents must maintain interaction with their environment, for example observing and performing actions in the world: reactivity; be able to take the initiative: pro-activeness; be able to perform social actions like communication, social ability; operate without the direct intervention of other (possibly human) agents: autonomy. Four main categories of mental attitudes are studied in the AI literature: informational, motivational, social and emotional attitudes. The focus is on motivational attitudes, although other aspects are marginally considered. In (Shoham and Cousins, 1994) [43], motivational attitudes are partitioned into the following categories: goal, want, desire, preference, wish, choice, intention, commitment, and plan. Individual agents are assumed to have intentions and commitments both with respect to goals and with respect to plans. A generic classification of an agent's attitudes is defined as follows: Informational attitudes: Knowledge; Beliefs.

1. Motivational attitudes: Desires; Intentions- Intended goals and Intended plans.
2. Commitments: Committed goals and Committed plans

In planning, see section 6, the weakest motivational attitude might be desire: reflecting yearning, wish and want. An agent may harbor desires which are impossible to achieve. Desires may be ordered according to preferences and, as modeled in this paper, they are the only motivational attitudes subject to inconsistency. At some point an agent must just settle on a limited number of intended goals, i.e., chosen desires.

2.2 Specifying BID Agents

The BID-architectures upon which specifications for compositional multi-agent systems are based are the result of analysis of the tasks performed by individual agents and groups of agents. Task (de)compositions include specifications of interaction between subtasks at each level within a task (de)composition, making it possible to explicitly model tasks which entail interaction between agents. The formal compositional framework for modeling multi-agent tasks DESIRE is introduced here. The following aspects are modeled and specified: (1) A task (de)composition,(2) information exchange, (3) sequencing of (sub)tasks, (4) subtask delegation, (5) knowledge structures. Information required/produced by a (sub)task is defined by input and output signatures of a component. The signatures used to name the information are defined in a predicate logic with a hierarchically ordered sort structure (order-sorted predicate logic). Units of information are represented by the ground atoms defined in the signature. The role information plays within reasoning is indicated by the level of an atom within a signature: different (meta) levels may be distinguished. In a two-level situation the lowest level is termed object-level information, and the second level meta-level information. Some specifics and a mathematical basis to such models with agent signatures might be obtained from (Nourani 1996a) [44] where the notion had been introduced since 1994. Meta-level information contains information about object-level information and reasoning processes; for example, for which atoms the values are still unknown (epistemic information). The generic model and specifications of an agent described above, can be refined to a generic model of a rational BID-agent capable of explicit reasoning about its beliefs, desires, goals and commitments.

3.Epistemitcs

3.1 Worlds and A Robot's Touch

Starting with the issues raised by Heidegger in 1935-36, and notion of "What is a thing" as put forth in (Heidegger 63). The author’s was presented with such challenges to computing applications with philosophical epistemics, while visiting INRIA, Paris around 1992. His reaction was to start with "first principles", not touching such difficult areas of philosophy and phenomenology, and only present views to what they could imply for the metamathematics of AI. However, since the author’s techniques were intended for AI computations and reasoning, rather than knowledge representation from observations, as it is the case in (Didday 90), Heidegger's definitions had to be taken further. The common point of interest is symbolic knowledge representation. However, the research directions are two essentially orthogonal, but not contradicting, views to knowledge representation.

3.2 Computational Illusion and Virtual Reality

Let us call “der Vielleicht Vorhandenen” objects that are only ‘Perhaps Computable,’ and therefore might be a computational illusion. That is the robot’s senses are not always real. The important problem is to be able to define worlds minimally to have computable representations with mathematical logic thus the ability to make definitive statements. Heidegger's Die Frage nach dem Ding will prove to be a blessing in disguise. Could it have computing applications to things without. Heidegger had defined three sorts of things. 1- Things in the sense of being "within reach", des Vorhandenen. 2. Things which "unify" things of the first kind, or are reflections on, resolution and actions. 3. Things of kind 1 or 2 and also any kind of things which are not nothing. To define logic applicable to planning for robots reaching for objects, the der Vielliecht Vorhandenen computational linguistics game is defined. To start, let us explore Heidegger's views of the "des Vorhandenen", having to do with what object is within "reach" in a real sense. In AI and computing applications notion of des Vorhandnen is not absolute. As an AI world develops the objects that have names in the world are at times des Vorhandnen and as defined by a principle of Parsimony only des Vorhandnen in an infinitary sense of logic (Nourani 1984,91) [32]. The logical representation for reaching the object might be infinitary only. The phenomenological problem from the robot's standpoint is to acquire a decidable descriptive computation [30] for the problem domain. Thus what is intended to be reached can stay always out of reach in a practical sense, unless it is at least what I call der Vielliecht Vorhandenen . The computing issues are the artificial intelligence computation and representation of real objects. That is, we can make use of symbolic computation to be able to "get at" a real object. At times, however, only infinite computations could define real world objects. For example, there is a symbolic computation for an infinite ordinal, by an infinite sequence of successor operations on 0. Furthermore, the present notion of der Vielliecht Vorhandenen is not intend to be the sense in which a robot cannot reach a particular object. The intent is that the language could have names for which the corresponding thing is not obvious in the AI world and there is incomplete information until at some point the world is defined enough that there is a thing corresponding to a name, or that at least there is a thing by comprehension, which only then becomes des Vorhandnen as the AI world is further defined or rearranged. These issues are examined in the computational context in the sections below. For example, the der Vielleicht Vorhandenen game has a winning strategy if the world descriptions by generic diagrams define the world enough to have a computation sequence to reach for an intended object. This implies there must be a decidable descriptive computation (Nourani 1994,96) for the world applied. The immediate linguistics example of these concepts from natural languages is a German child's language in which to "vor" and "handenen" are some corresponding things in the child's language world and mind, but "vorhandenen" is not a thing in that child's world and only becomes a thing as the linguistics world is further defined for the child.

3.3 Deduction Models and Perceptual Computing

Models uphold to a deductive closure of the axioms modeled and some rules of inference, depending on the theory. By the definition of a diagram they are a set of atomic and negated atomic sentences. Hence a diagram can be considered as a basis for defining model, provided we can by algebraic extension, define the truth value of arbitrary formulas instantiated with arbitrary terms. Thus all compound sentences build out of atomic sentences then could be assigned a truth value, handing over a model. It might be illuminating to compare the G-diagram techniques and computational epistemology to the (Konolige 1984) [24] starting with the consequential closure problem for artificial intelligence and the possible worlds. What Konolige starts with is the infeasibility premise for consequential closure, i.e. the assumption that an agent knows all logical consequences of his beliefs. The deductive model is defined for situations where belief derivation is logically incomplete. The area had been voiced since (Fodor 75) and (Moore 80). Konolige applies a model where beliefs are expressions in the agent's "mind" and the agent reasons about them by manipulating syntactic objects. When the process of belief derivation is logically incomplete, the deduction model does not have the property of the consequential closure. Konolige defines a saturated deduction model and claims a correspondence property: For every modal logic of belief based on Kripke possible world models, there exists a corresponding deduction model logic family with an equivalent saturated logic. The G-diagrams are defined for incomplete KR, modalities, and model set correspondence. What computational epistemology defines is a model theoretic technique whereby without the consequential closure property requirements on agents a model-theoretic completeness can be ascertained via nondeterministic diagrams. The author defined specific modal diagrams for computational linguistics models [27,29].

4.AffectiveComputing

(Picard 1999) [14] assertions indicate not all modules is a designed AI system might pay attention to emotions, or to have emotional components. Some modules are useful rigid tools, and it is fine to keep them that way. However, there are situations where the human-machine interaction could be improved by having machines naturally adapt to their users. Affective computing expands human-computer interaction by including emotional communication together with appropriate means of handling affective information. Neurological studies indicate that the role of emotion in human cognition is essential; emotions are not a luxury. Instead, emotions play a critical role in rational decision-making, in perception, in human interaction, and in human intelligence. These facts, combined with abilities computers are acquiring in expressing and recognizing affect, open new areas for research. The key issues in "affective computing," (Picard 1999a) [14] computing that relates to, arises from, or deliberately influences emotions. New models are suggested for computer recognition of human emotion, and both theoretical and practical applications are described for learning, human-computer interaction, perceptual information retrieval, creative arts and entertainment, human health, and machine intelligence. Scientists have discovered many surprising roles played by human emotion - especially in cognitive processes such as perception, decision making, memory judgment, and more. Human intelligence includes emotional intelligence, especially the ability to a accurately recognize and express affective information. Picard suggests that affective intelligence, the communication and management of affective information in human/computer interaction, is a key link that is missing in telepresence environments and other technologies that mediate human-human communication. (Picard-Cosier 1997) [25] discusses new research in affective intelligence, and how it can impact upon and enhance the communication process, allowing the delivery of the more natural interaction that is critical or a true telepresence.

5.Planning

The visual field is represented by visual objects connected with agents carrying information amongst objects about the field, and carried onto intelligent trees for computation. Intelligent trees compute the spatial field information with the diagram functions. The trees defined have function names corresponding to computing agents. Multiagent spatial vision techniques are introduced in (Nourani 1998) . The duality for our problem solving paradigm (Nourani 1991a,95a,95b) is generalized to be symmetric by the present paper to formulate Double Vision Computing. The basic technique is that of viewing the world as many possible worlds with agents at each world that compliment one another in problem solving by cooperating. An asymmetric view of the application of this computing paradigm as presented by the author and the basic techniques were proposed for various AI systems(Nourani1991a).

5.1TheIM_BIDModel

The co-operative problem solving paradigms have been applied ever since the AI methods put forth by Hays-Roth et.al. [14,35]. The muliagent multi-board techniques are due to the author (Nourani 1995a). The BID model has to be enhanced to be applicable to intelligent multimedia. Let us start with an example multi-board model where there multiagnt computations based on many boards, where the boards corresponds to either virtual possible worlds or to alternate visual views to the world, or to the knowledge and active databases. The board notion is a generalization of the Blackboard problem solving model (Hays-Roth 1985), (Nii 1986). The blackboard model consists of a global database called the blackboard and logically independent sources of knowledge called the knowledge sources. Agents can cooperate on a board with very specific engagement rules not to tangle the board nor the agents. The multiagent multi-board model, henceforth abbreviates as MB, is a virtual platform to an intelligent multimedia BID agent computing model. We are faced with designing a system consisting of the pair <IM-BID,MB>, where IM-BID is a multiagent multimedia computing paradigm where the agents are based on the BID model. The agents with motivational attitudes model is based on some of the assumptions described as follows. Agents are assumed to have the extra property of rationality: they must be able to generate goals and act rationally to achieve them, namely planning, replanting, and plan execution. Moreover, an agent's activities are described using mentalistic notions usually applied to humans. To start with the way the mentalistic attitudes are modulated is not attained by the BID model. It takes the structural IM-BID to start it. The preceding sections on visual context and epistemics have brought forth the difficulties in tackling the area with a simple agent computing model. The BID model does not imply that computer systems are believed to actually "have" beliefs and intentions, but that these notions are believed to be useful in modeling and specifying the behavior required to build effective multi-agent systems. The first BID assumption is that motivational attitudes, such as beliefs, desires, intentions and commitments are defined as reflective statements about the agent itself and about the agent in relation to other agents and the world. At BID the functional or logical relations between motivational attitudes and between motivational attitudes and informational attitudes are expressed as meta-knowledge, which may be used to perform meta-reasoning resulting in further conclusions about motivational attitudes. If we were to plan with BID with intelligent multimedia the logical relations might have to be amongst worlds forming the attitudes and event combinations. For example, in a simple instantiation of the BID model, beliefs can be inferred from meta-knowledge that any observed fact is a believed fact and that any fact communicated by a trustworthy agent is a believed fact. With IM_BID, the observed facts are believed facts only when a conjunction of certain worlds views and evens are in effect and physically logically visible to the windows in effect. Since planning with IM_BID is at times with the window visible agent groups, communicating, as two androids might, with facial gestures, for example (Picard 1998). In virtual or the "real-world" AI epistemics, we have to note what the positivists had told us some years ago: the apparent necessary facts might be only tautologies and might not amount to anything to the point at the specifics. Philosophers have been faced with challenges on the nature of absoulte and the Kantian epistemtics (Kant 1990) [25], (Nourani 1999a) [45] for years. It might all come to terms with empirical facts and possible worlds when it comes to real applications. A second BID assumption is that information is classified according to its source: internal information, observation, communication, deduction, assumption making. Information is explicitly labeled with these sources. Both informational attitudes (such as beliefs) and motivational attitudes (such as desires) depend on these sources of information. Explicit representations of the dependencies between attitudes and their sources are used when update or revision is required. A third assumption is that the dynamics of the processes involved are explicitly modeled. A fourth assumption is that the model presented is generic, in the sense that the explicit meta-knowledge required to reason about motivational and informational attitudes has been left unspecified. A fifth assumption is that intentions and commitments are defined with respect to both goals and plans. An agent accepts commitments towards himself as well as towards others (social commitments). For example, a model might be defined where a agent determines which goals it intends to fulfill, and commits to a selected subset of these goals. Similarly, an agent can determine which plans it intends to perform, and commits to selected subset of these plans. There are two component: goal_determination and plan_determination.

5.3 VR Computing and Computational Illusion

The IM Morphed Computing Logic for computing for multimedia are new projects with important computing applications. The basic principles are a mathematical logic where a Gentzen[25] or natural deduction systems is defined by taking arbitrary structures and multimedia objects coded by diagram functions. Multimedia objects are viewed as syntactic objects defined by functions, to which the deductive system is applied. Thus we define a syntactic morphing to be a technique by which multimedia objects and hybrid pictures are homomorphically mapped via their defining functions to a new hybrid picture. The logical language has function names for hybrid pictures. The *MIM Morph Rule* - An object defined by the functional n-tuple <f1,...,fn> can be Morphed to an object defined by the functional n-tuple <h(f1),...,h(fn)>, provided h is a homomrphism of abstract agent signature structures [35]. The *MIM TransMorph Rules*- A set of rules whereby combining hybrid pictures p1,...,pn defines an Event {p1,p2,...,pn} with a consequent hybrid picture p. Thus the combination is an impetus event. A computational logic for intelligent languages is presented in brief with a soundness and completeness theorem in [28]. The preliminaries to VR computing logic are presented since Summer Logic Colloquium 1997, Prague.

Theorem 5.1 Soundness and Completeness- Morph Gentzen Logic is sound and complete. □

Proposition 5.1 Morph Gentzen and Intelligent languages provide a sound and complete logical basis toVR.□

A virtual tree, or virtual proof tree is a proof tree that is constructed with agent languages with free Skolem functions. In the present paper we also instantiate proof tree leaves with free Skolemized trees. Thus virtual trees are substituted for the leaves. In the present approach, as we shall further define, leaves could be virtual trees. By a virtual tree we intend a term made of constant symbols and Skolem functions terms A plan is a sequence of operations in the universe that could result in terms that instantiate the truth of the goal formulas in the universe. That is what goes on as far as the algebra of the model is concerned. It is a new view of planning prompted by our method of planning with GF-diagrams and free Skolemized trees. It is a model-theoretic view. The planning process at each stage can make use of diagrams by taking the free interpretation of the possible proof trees that correspond to each goal satisfiability. The techniques we have applied are to make use of the free Skolemized proof trees in representing plans in terms of generalized Skolem functions. In planning with G-diagrams that part of the plan that involves free Skolemized trees is carried along with the proof tree for a plan goal. Proofs can be abstracted by generalizing away from constants in the proof. Thus, such a generalized proof can be defined by a whole class of minimal diagrams. This process is usually realized via partial deduction, which can be regarded as the proof-theoretical way of abducing diagrams whose littorals are necessary conditions for the proof. By not requiring the proof-tree leaves to get instantiated with atomic formulas, we get a more general notion of a proof. The mathematical formalization that allows us to apply the method of free proof trees is further developed and applied to theorem proving. Existentially quantified diagrams carry a main deficit- the Skolemized formulas are not characterized. Hilbert's epsilon symbol may be applied to solve this problem. Now we present the notion of a predictive diagram and apply it to provide a model-theoretic characterization for PD and related proof trees. A predictive diagram for a theory T is a diagram D[M], where M is a model for T, and for any formula q in M, either the function f: q $\rightarrow$ {0,1} is defined, or there exists a formula p in D[M], such that T U {p} proves q; or that T proves q by minimal prediction. By viewing PD from predictive diagrams we could define models for PD from predictive diagrams- thus a model theoretic formulation for PD emerges. We then define Hilbert models to handle the proof-model problems further on. The idea is that if the free proof tree is constructed then the plan has a model in which the goals are satisfied. The model is the initial model of the AI world for which the free Skolemized trees were constructed. Thus we had stated the Free Proof Tree Sound Computing Theorem.

Theorem 5.2 For the virtual proof trees defined for a goal formula from the G-diagram there is a canonical model satisfying the goal formulas. It is the canonical model definable from the G-diagram.

Proof <overview> In planning with generic diagrams plan trees involving free Skolemized trees is carried along with the proof tree for a plan goal. The idea is that if the free proof tree is constructed then the plan has a model in which the goals are satisfied. Since the proof trees are either proving plan goals for formulas defined on the G-diagram, or are computing with Skolem functions defining the GF-diagram, the model defined by the G-diagram applies. The model is standard canonical to the proof.□

Theorem 5.3 The Hilbert's epsilon technique implies there is a virtual tree model M for the set of formulas such that we can take an existentially quantified formula w[X] and have it instantiated by a Skolem function which can answer the satisfiability question for the model.

Proof Follows from the definitions**.** □

6. Conclusions

A basis to haptic computing and visual ontology is presented applying multiagent computing, morph Gentzen logic, and the IM_BID model. Specific paradigms are introduced and mathematical conclusions are reached on the computational properties, visual ontology, and haptic computing pragmatics. Implications are that the techniques will allow us to mathematically structure the processes and achieve specific deductive goals.

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