Big Brother Logic: Reasoning about Agents Equipped with Surveillance Cameras in the Plane

(Demonstration)

Tristan Charrier
ENS Rennes
IRISA, France
tristan.charrier@eleves.ens-rennes.fr

Florent Ouchet
ENS Rennes, France
ouchet@ens-rennes.fr

Francois Schwarzentruber
ENS Rennes
IRISA, France
schwarze@ens-rennes.fr

ABSTRACT

We consider multi-agent scenarios where each agent controls a surveillance camera positioned in the plane, with fixed position and angle of view, but rotating freely. The agents can thus observe the surroundings and each other. They can also reason about each other's observation abilities and knowledge derived from these observations.

In this demonstration, cameras are located in the plane. The user can interact with the cameras, check epistemic properties and announce formulas. The camera can also turn in order to satisfy an epistemic property.

1. INTRODUCTION

Modeling and study of multi-agent systems that involve intelligent agents combining perceptual and reasoning abilities is a major field of research and applications of AI. In particular, in camera surveillance, we want to check some properties as:

1. camera a_1 knows that camera a_3 sees the intruder b or camera a_2 knows that camera a_3 sees the intruder b (this is called distributed knowledge about a_1 and a_2 that camera a_3 sees the intruder b);
2. camera a_1 knows that camera a_2 knows that camera a_1 knows etc. that camera a_3 sees the intruder b (this is called common knowledge about a_1 and a_2 that camera a_3 sees the intruder b).

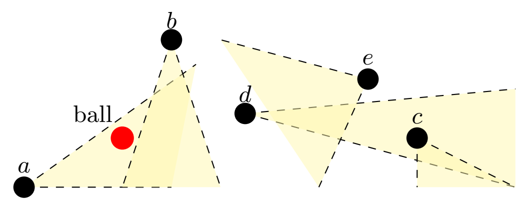
First we describe the demonstration. Then we recall the variant of epistemic modal logic used here. This is maybe the first real demonstration involving epistemic modal logic.

2. DEMONSTRATION

2.1 Overview

We propose to dispose cameras on a table (some of them have hats) and a red ball representing the intruder. The system can then check properties on the current situation (model checking) or automatically turn the cameras for satisfying a given formula (satisfiability problem). In particular, we are able to simulate the muddy children puzzle and the prisonners' puzzle.The reader can find information about the demonstration here:

`http://people.irisa.fr/Francois.Schwarzentruber/publications/AAMAS2014_demo`



2.2 Interactive aspects

During the demonstration, the user can interact with the system in five possible ways:

1. She can turn the cameras by hand;
2. She can move the red ball;
3. She can add/remove hats to cameras;
4. She can enter a property to check in epistemic modal logic described in the next section;
5. After the positions of the cameras are fixed, the position of the ball is fixed and the hats are fixed, she can make public announcements of a property ϕ.

The interaction is divided in two phases:

	1	2	3	4	5
Initialization phase	X	X	X	X	
Communication phase				X	X

2.3 Technical details

A camera is built up with:

- A position-controled actuator (Robotis Dynamixel RX24F or equivalent);
- A webcam (C310 HD Webcam Usb 2.0, 1280x720 pixels).

A serial converter interface connects the actuators to the computer.

2.4 Architecture

In real life, cameras are *autonomous*: if a camera a_1 sees another camera a_2, a_1 should be able to infer the direction of view of a_2 from the image returned by the webcam of a_1.

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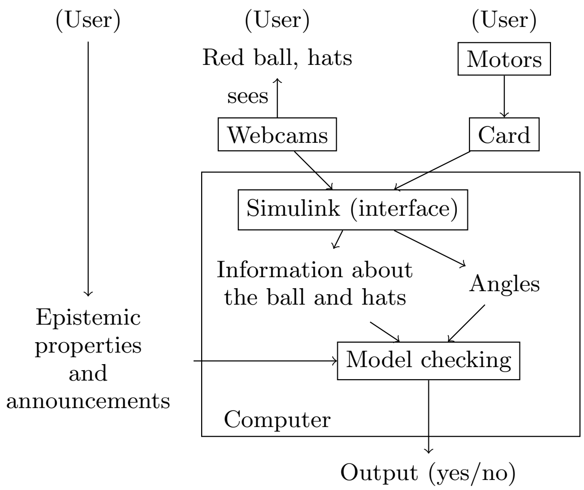
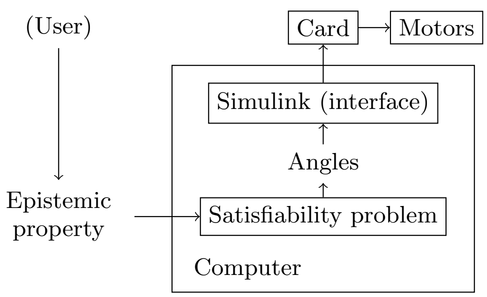
Here, in this demonstration, the system will not have a distributed architecture. For technical reasons, the knowledge of the cameras is computed externally by the computer that has access to the directions of view of all the cameras.

Nevertheless, the position of the ball and hats are inferred from images returned by the webcam. The following diagram shows the architecture around the model checking procedure:



On the contrary, the satisfiability problem procedure will modify the angles of the cameras in order to satisfy a specification. The following diagram shows the architecture around the procedure for solving the satisfiability problem:



3. EPISTEMIC MODAL LOGIC

We recall the framework that is presented in more details in [1].

3.1 Language

Formulas are built up from the following primitives: The set of well-formed formulas we can check is given by the following BNF:

$a_1 \triangleright a_2$	camera a_1 sees camera a_2
$a \triangleright b$	camera a sees the red ball b
hat_a	camera a wears a hat
$\neg\phi$	ϕ is false
$\phi \vee \psi$	ϕ or ψ
$\mathsf{K}_a\phi$	camera a knows ϕ
$\mathsf{C}_J\phi$	cameras in J commonly know that ϕ

The semantics is given in terms of a Kripke model M_0 made up of all possible angle assignments to the cameras. For more information about the semantics, the reader may refer to [1].

3.2 Model checking

The positions of the cameras are fixed and we first compute the so-called *vision sets*, that is, for a given camera a, the set of all possible sets of cameras that a can see.

The model checking is implemented as follows: from the vision sets and the set of cameras that see the red ball, we browse the inferred Kripke model on the fly and we evaluate the formula. For more information about the model checking procedure, the reader may refer to [1].

About public announcements.

At the beginning of the demonstration, the model is M_0, w where w is the actual world. Then, the user can announce a true formula ϕ in the current situation. The current model M is replaced by the updated model M^ϕ that is the subgraph of M made up of the worlds u such that $M, u \models \phi$ [2]. The algorithm is an adaptation of the algorithm of model checking for a variant of this framework [3].

3.3 Satisfiability problem

The satisfiability problem consists in turning the cameras so that a given property is satisfied. We here restrict the language by avoiding constructions $a \triangleright b$ since we can not move the ball. For more information about the procedure for the satisfiability problem, the reader may refer to [1].

4. CONCLUSION

In this demonstration, we argue the feasibility of using epistemic modal logic to specify a system of cameras and to check properties.

Up to now, we have two phases during the interaction: the initialisation phase and the communication phase. The intialisation phase is made up of ontic actions whereas the communication phase is made up of pure communicative actions. In order to being able to mix ontic and communicative actions, we plan to allow use revision instead of public announcement and belief instead of knowledge. Another future work consist in handling mobile agents. Efficient algorithms for such features are not yet completely established. As a long-term project, we plan to build a logical framework for planning involving temporal and epistemic properties (that is, epistemic properties may be invariants, objectives etc.).

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5. REFERENCES

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