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1. Project description

Automated surveillance of different environments through cooperating mobile agents (robots) is among the most urgent and promising topics in multi-robot research.

In the past decade criminal and terroristic developments have led to a tremendous interest in automated surveillance systems as a means to improve security and safety.

In recent years there has been a rapidly growing interest in using teams of mobile agents (surface robots, flying robots, etc.) for automatically surveilling environments of different type and complexity. This interest is mainly motivated by the broad spectrum of potential civilian, industrial and military applications of multi-robot surveillance systems. Examples of such applications are the protection of safety-critical technical infrastructures, the safeguarding of country borders, and the monitoring of high-risk regions and danger zones which cannot be entered by humans in the case of a nuclear incident, a bio-hazard or a military conflict. Because of this broad application range, today mobile surveillance is considered as an urgent and promising field of research in various disciplines such as artificial intelligence and robotics.

Two interrelated key components of every multi-agent surveillance system are environmental *exploration* and *coverage*. The term "exploration" refers to the discovery of all traversable regions of the environment through one or several agents. The term "coverage" refers to the maximization of the total area covered by the sensors of the involved robots (within a certain time window). In a sense, exploration may be viewed as the initial phase of coverage. Both exploration and coverage typically rely on the following basic activities: map building, (self-)localization, environmental partitioning, path planning, and intruder detection and tracking. Not all of these basic activities are equally relevant for different surveillance tasks. Moreover, surveillance scenarios can differ in a number of characteristics such as: the shape, dynamics and predictability of the environment, the number of involved agents, the agents' sensing abilities (sensor ranges, and view angles), the agents' communication abilities (local versus global), the agents' movement speed, the organization of the agents (e.g., peers versus hierarchical structure), reliability of the agents, the agent's cognitive abilities (learning and planning), the degree of homogeneity/heterogeneity of the agents, the costs of moving around, and so forth.

This project consists of three phases:

During the **first phase** (block) relevant literature is investigated and a map builder is implemented. This map builder allows the user to define the space / terrain / complex to be surveilled. Furthermore, the implementation of the simulation of the world the agents operate in is started. As a deliverable a map editor and a simulation environment where (possibly unintelligent) agents can walk about is expected, though this environment will be a "working version". Obviously, you are free to do more.

During the **second phase** the (intelligent) surveillance agents (SAs) are implemented. It is suffices if all agents have the same control strategy. Next, an intruder is included. The

SAs should "discover" this intruder and then track it or surround it. The deliverable is a fully operational simulation environment with at least one type of intelligent SA and an intruder agent.

During the **third phase** research is done with the system. Here a lot of options are open.

Examples of possible research issues (w.r.t. both exploration and coverage) are:

- What are the consequences of constraints on the perception (e.g. local variance of visibility) of the agents or constraints on the (range / radius of) communication between agents?
- What are the consequences of restrictions on the speed or acceleration of the SAs or the intruder?
- What impact does communication among the agents have? What should agents communicate?
- Sensitivity analysis: e.g.: What is the influence of the number of SAs on the performance?
- Can you (gradually) make the intruder more intelligent? How does the system respond to this? Is it possible to make the system adaptive?
- What happens when multiple intruders are introduced?
- What is the fault tolerance / robustness of the system, or its scalability?
- Which group has the best intruder or SAs.

2. The setting

This section describes the properties of the World the agents operate in.

2.1 Velocities

Both the surveillance robots as the intruders have a base speed of 1.4 m/s. The intruder can make a 5 second sprint at 3 m/s after having at least 10 seconds of rest.
Both can't turn faster than 180 degrees/second and may do this while walking. One can't turn more than 10 degrees while in a sprint

2.2 Visual capabilities

The surveillance robots have a visual range of 6 meters and the intruders have a visual range of 7.5 meters, both with a 45 degrees viewing angle. The surveillance robots can be on a sentry tower, changing the visual range between 2 and 15 meters (hence no sight at close range) with a 30 degree viewing angle. Entering/leaving the tower costs 3 second of blindness, deafness and immobility. Obviously, a guard in a sentry tower can sound the alarm.
If you turn more than 45 degrees/second you don't see anything for the turning time plus half a second.
In case an agent is settled for more than 10 seconds in an area with decreased visual range, others can only see him within 1 meter distance.

2.3 Audio capabilities

Hearing something means that you are aware of an unknown sound in the actual direction with normal distributed uncertainty with a standard deviation of 10 degrees. So everything makes the same sound, hence you can't distinguish between guards, intruders and other sounds. Sounds thus only provide an awareness of a presence and costs.

One can hear each other depending on the other agent movement speed:

<0.5 m/s at 1 m

>0.5 m/s and < 1 m/s at 3 m

>1 m/s and < 2 m/s at 5 m

>2 m/s at 10 m

Audio is subject to noise hence for each $25m^2$ area there occurs a random noise at a random location according to a Poisson process of 0.1 occurrence per minute, which you can hear at 5m distance.

2.4 Communication

Each agent is able to communicate with other agents. Two types of communication are usually distinguished: *direct* communication (by sending messages to other agents), and *indirect* communication via the environment (by placing certain markers in the environment which can be sensed locally by the other agents). Indirect communication is also known as stigmergy-based or stigmergic or pheromone-based communication. We assume that the guards have up to five different types of markers available (e.g., markers of different color), where the meaning of the markers is not prespecified (i.e., it is up to you to assign meanings). The same is assumed for the intruders. Neither direct nor indirect communication is mandatory, that is, it is up to you to decide on using any of these two forms of communication to achieve coordination among the guards (respectively the intruders).

2.5 Victory

The intruder wins if he is 3 seconds in any of the target areas or visits the target area twice with a time difference of at least 3 seconds.

The guards win if the intruder is no more than 0.5 meter away and in sight.

For multiple intruders there are two modes: in the first mode all intruders need to complete their objectives to win; in the second mode any of the intruders need to complete its objective to win.

If an intruder flees through the entry point (3 sec delay for leaving) before making the target, it is a draw.

2.6 Performance Criteria

Different teams of guards perform differently. Usual performance criteria are:

- Time it takes to win. ("Time costs", unit of time costs: seconds)
- Sum of distances the guards had to move around before they win. ("Distance costs" or "movement costs", unit: meters)

- In the case of direct communication: number and accumulated size of messages the guards exchanged before winning. ("Direct communication costs", unit of message size: bytes)
- In the case of indirect communication: number of markers placed by the guards in the environment before winning. ("Indirect communication costs")

Note that a team of guards may perform excellently w.r.t. (e.g.) "time costs", but at the same time may perform poorly w.r.t. (e.g.) "direct communication costs".

2.7 Map

The map, i.e. the play field consists of non-overlapping rectangular areas, defined by top-left point, bottom-right point and type. The following five types of areas exist:

1. *Structures*
   One can't walk on structures and structures are visible from 10 meters away provided there is a line of sight. Structures can have doors and windows. Opening a closed door will take an intruder on average 12 seconds (normal distribution with std 2) to do it silently and 5 seconds to do it while producing a sound that can be detected at 5 meters. Going through a window takes 3 seconds with a sound detectable at 10 meters.
2. Target area for intruder.
   Unknown to guards
3. *Sentry towers*
   These are visible from 18 meters away, provided that you have sight, but for spotting whether these are manned, normal ranges apply
4. *Areas that decrease the visual range by 50%.*
   Think about trees and shades. When somebody is hiding there, the visual range even further decreases (see 2.2)
5. *Outer wall*
   The intruder may choose an entry point in the wall causing a sound that is detectable at 5m distance.

Since the guard towers' visual range cover a diameter of 30 meters, the map should be at least 200 by 200 meters to make it interesting

Examiners: Joel Karel, Jos Uiterwijk

5. Project assessment

The project period 1 will be concluded with a presentation of the results thus far. For the students this presentation means feedback on their interpretation of the project assignment, their conclusions and their planning for the next period. For the lecturers the presentations of period 1 enable them to judge if more information and tutoring is needed. At the end of period 3 the final presentation will take place in which the students communicate what their results and conclusions on the project assignment are. The presentations of the first and second phase and the final presentation have different weights in the total assessment of the block according to 1 : 1 : 4.

The final project result will be a group result unless a student hasn't shown enough attendance and participation. When a student has not participated enough, the examiner can decide to give him or her an additional assignment. The examiner can, in individual cases, decide to deviate from the group result in a positive or negative direction. Plagiarism is not allowed. If plagiarism is observed, sanctions will follow.

6. Project coordination

The examiners of project 2-2 are Joel Karel (joel.karel@maastrichtuniversity.nl) and Jos Uiterwijk (uiterwijk@maastrichtuniversity.nl). Jan Paredis (j.paredis@maastrichtuniversity.nl) is coordinating the project and tutoring the groups. Every week he will have a meeting with each project group.
For questions and remarks regarding the computers you can mail to: lo-fhs@ maastrichtuniversity.nl .General information, information on the courses and schedules is to be found on Blackboard.

7. Courses

Human-Computer Interaction & Social Media

Human-computer interaction (HCI) is the study of interaction between people (users) and computers. It is often regarded as the intersection of computer science, behavioural sciences, design and several other fields of study. Interaction between users and computers occurs at the user interface (or simply interface), which includes both software and hardware; for example, characters or objects displayed by software on a personal computer's monitor, input received from users via hardware peripherals such as keyboards and mice, and other user interactions with large-scale computerized systems such as aircraft and power plants. Social media are media for social interaction, using highly accessible and scalable communication techniques. Social media is the use of web-based and mobile technologies to turn communication into interactive dialogue. Examples of highly successful social media applications are Youtube, Facebook and Twitter.

Theoretical Computer Science

This course explores the theoretical underpinnings of computing by investigating algorithms and programs casted as language recognition problems. The influence of the theory on modern hardware and software system design is demonstrated. The following subjects will be treated: mathematical foundations, alphabets and languages, finite automata and regular languages, context-free languages and pushdown automata, Turing machines, acceptance and decidability, recursive functions and grammars, time complexity classes, NP problems, NP-completeness.

Mathematical Modeling

Mathematical modelling is of great importance for solving practical problems by casting them into a form suitable for the use of mathematical techniques.
In this course, a number of basic topics are discussed. First, attention is paid to a general methodology by means of the model cycle, which offers a systematic framework for mathematical modelling. Then we focus on some widely used model classes from engineering, in particular on the class of linear time-invariant dynamical models. These are described by linear difference equations (in discrete time) or linear differential equations (in continuous time). Alternative model descriptions that are discussed are transfer functions (in the frequency domain) obtained with the z-transform and the Laplace transform respectively; and state-space models, which may or may not involve canonical forms. Some further topics receiving attention are the concepts of stability, controllability and observability, Bode diagrams, the interconnection of subsystems, and the technique of pole placement by means of state feedback.
The subject matter is clarified through exercises and examples involving practical applications. Also, the software package Matlab and the control system toolbox are introduced, which offers a powerful instrument for analyzing linear dynamic models.

Project Skills 2.4

The subject of the training Interviewing is to formulate a goal for an interview. The students learn to transform this goal into different questions and to structure these questions into an interview in order to collect ideas or elicit knowledge. Different types of questions and interviews will be discussed and practised. The student will also reflect on nonverbal aspects of the interview situation. If possible, external clients will be interviewed and the information will be used for the project 2-2.

Knowledge Management

The ability to manage knowledge has become increasingly important in today's knowledge economy. Knowledge is considered a valuable commodity, embedded in products and in the tacit knowledge of highly mobile individual employees. Knowledge Management represents a deliberate and systematic approach to cultivating and sharing an organisation's knowledge base. It is a highly multidisciplinary field that encompasses both information technology and intellectual capital. This course offers an overview of the field of Knowledge Management, providing both

a theoretical grounding and a pragmatic approach to applying key concepts. Drawing on ideas, tools, and techniques from such disciplines as sociology, cognitive science, organizational behavior, and information science, the course describes knowledge management theory and practice at the individual, community, and organizational levels.
The following areas will be addressed: an introduction to knowledge management; knowledge management models; capturing, sharing and applying knowledge; knowledge management tools; strategy, culture and organization. Questions to be discussed, are, among others: What is knowledge, and how may we apply knowledge as a production factor? What is a corporate knowledge infrastructure? How does one create a knowledge strategy? How can globally distributed knowledge be managed? What is the role of knowledge in outsourcing? What is the value of knowledge? What is the role of that IT in knowledge management? What are the strengths and weakness of deploying specific IT instruments in knowledge management processes?

Linear Programming
This course deals with one specific mathematical model: the linear programming model. This model has a wide range of practical applications, and is of interest to practitioners in operations research, statistics, economics, management and psychology. This, and the fact that good algorithms can solve huge linear programs, is reason for the considerable succes of this model. The theory of the course treats the simplex algorithm, duality theory, and sensitivity analysis. Many examples from practice illustrate the power of the model and teach the student the skill of modelling. Computer sessions teach the student how to solve linear programs with Matlab.

Mathematical Simulation
The area of mathematical simulation is concerned with studying processes and systems. Uncertainty can be an important factor and has to be modeled properly. After modeling a complex system, various scenarios can be simulated to gain insight. The results need to be properly interpreted and uncertainty has to be reduced. The modeling, implementation, analysis and technical aspects will be discussed as an introduction in this field. Emphasis will be on discrete event simulation.

Project Skills 2.5
The subject of the project skills training is Argumentation and Rhetoric. Several topics will be highlighted like logistics, argumentation for example critical reasoning and genres. The aims of logistics are to learn different techniques in building arguments, to identify applications across different genres, to write examples and to expand writing abilities. Furthermore, students learn to discover different types of argumentation and to review literature by several methods.

Appendices

Appendix A	Project evaluation Assessment Form
Appendix B	Criteria for assessing projects
Appendix C	Project groups, tutors and lecturers
Appendix D	Project meetings

Appendix A Project Evaluation Assessment Form

Date:	Project: 2-2
Student:	ID-number:
Project coordinator: J. Paredis	Number of the group:
Evaluator: J. Karel	Evaluator:
Evaluator: Jos Uiterwijk	
Evaluator:	

Assessment Product	factor x mark	Score
Form	1 x	
Contents	2 x	
Product mark		A =

Assessment Report	factor x mark	Score
Form	1 x	
Contents	2 x	
mark		B =

Assessment Presentation	factor x mark	Score
Form	1 x	
Contents	2 x	
Presentation mark		C =

GROUP MARK 2.6	(2A + 2B + C)/5	
FINAL MARK 2-2	2.4 + 2.4 + 4x2.6/6	

Attendance P-meetings	Sufficient?	Yes / No

Individual mark		
Signature Examiner:	Date:	

Appendix B Criteria for assessing projects

Product

form

well-structured, clarity, easy to read
user-friendly, easy input of data and parameters, good use of graphical possibilities, help facility, robustness (e.g. against deficient input)
manual, demo and/or other documentation

contents

functionality (has the solution been found?), efficiency (computational time needed)
range of applicability of the method(s) used
originality

form

cover, title page, table of contents, preface
summary
list of figures, list of abbreviations and symbols
problem description
structure of chapters and paragraphs, use of (sub) titles
introduction, conclusion
lay-out and spelling
references

contents

summary
introduction, problem description, structure
relevancy and complete reference of sources
background, history and importance of the problem
theoretical basis of the method, explanation of the theory used, description of alternative approaches, motivation for the chosen approach
program design
work plan
system validation, description of the test situation, test results, conclusions of the tests, final conclusions
overview of operational costs
adequate use of figures, tables, correct and adequate use of mathematics
explain abstract issues using simple illustrative examples
coherence of the arguments, well-written for the target audience

Presentation

form

introduction, title, names of project members, announcement of the structure of the presentation
contact with the public, audibility, attitude and behaviour
adequate use of audio-visual support

contents

problem statement, objectives of the project team, description of the problem
method of dealing with the problem
theoretical approach
explanation of experiments
results and conclusions
comprehensibility, quality of the argument(s), correct en adequate use of mathematics

Appendix C Project groups, tutors and lecturers

Here you will find an overview of the different roles and functions of those involved with project centred learning.

Student:
Personal characteristics: autonomous, willing to take initiatives, adaptability, flexibility, capacity for improvisation, willing to cooperate.
Skills: oral presentation techniques, skills to negotiate, social skills; planning, organizing and coordinating activities and competent to apply knowledge.

Tasks:
There are several tasks within a project group.
Project leader:
monitors the process / progress
updates the planning
external communication
responsible for handing in the and product

Editor:
responsible for the
checks texts written by other team members
gives writing assignments
puts together the individual contributions resulting in a complete and coherent
administer of the literature for the

Presentation co-ordinator:
responsible for the presentation
tests the hardware used for the presentation
ensures coherence of the sheets and slides

Product co-ordinator:
assigns tasks with respect to the creation of the product
links the different modules of the product
manages the documentation, manual(s), diagrams
finishing touch
monitors progress of the product according to the design

Besides the functions above, students are assigned the responsibility for the input of the contents of the courses in the project.

The project groups, in the end, are responsible for the final results and the products. With each project general and specific learning goals can be discerned. The general goals are the same for each project to come. However, each time a higher level is expected. The following general goals are formulated by the educational board:

- Ability to apply knowledge and skills
- Ability to elicit relevant information in an efficient way
- Being able to cooperate in a project group
- Being able to structure meeting
- Being able to deliberate and negotiate with an external client
- Making and adjusting a planning and schedule
- Able to work under time pressure

- Able to give a presentation
- Able to write a project

The lecturers who are responsible for a specific project formulate the level of these more general goals by stating clear criteria.

The more specific goals are different for each project. These goals are content related and related to other educational activities in the block. The specific goals are formulated by those lecturers involved in the block. These goals are for example the application of specific theories, and methods and techniques on behalf of the project.

The role of a tutor is to keep a group on the right track in a non-directive way. He or she observes the process and progress of a group and may give suggestions to encourage the group.

The project coordinator
The project coordinator is responsible for the ins and outs of a project. Every week the coordinator has a meeting with each project group. Besides the project examiner the lecturers, involved in a block, also assess product, and presentation of each project group.

The lecturers are responsible for the professional knowledge. They will be available for consultation by the students during a project. Since the lecturers may act as a client for a project assignment, it is very important to approach them with your questions and ideas. The lecturers are being expected to question the students during their final presentations on domain related issues.

Appendix D Project meetings

The aim of a project meeting is to continuously track the state of the art of the project by looking backward and forward. Appointments made are checked, new appointments are made. Moreover, the feasibility of the planning will be checked. In case of deviations, an analysis of the situation will be made in order to trace the causes. Project meetings normally are scheduled on a fixed date and time. An agenda is available on each meeting. The chairman and secretary put up the agenda. Of each meeting minutes will be taken.

The agenda below can be seen as a standard agenda. This agenda, of course, can be changed, influenced by the project or specific situation.

1. Opening
2. Announcements
   a. by the group members
   b. by the tutor
3. Incoming/outgoing post or mail
4. Minutes last meeting (mention date of meeting)
5. State of the courses
6. State of the project
   a. planning
   b. correction of the planning
   c. discussion on the log book
   d. discussion on the results of a brainstorm session or of a sub group
7. Cooperation
8. Appointments
   a. tasks to be done
   b. organization of the work
   c. chairman and secretary next meeting; monitoring the log book
9. Any other business

The project leader is chairman. He or she takes care that everybody can participate, that the atmosphere in the group is safe and open, and that conclusions are drawn and decisions are made. Summarizing is an important skill for a chairman.

The secretary takes care of the minutes. He/she sends them at last one day before the next meeting to every group member and the tutor. The minutes have to be provided with date, group number and the names of those present and absent.