Toward Knowledge Propagation in an Omnidirectional Distributed Vision System

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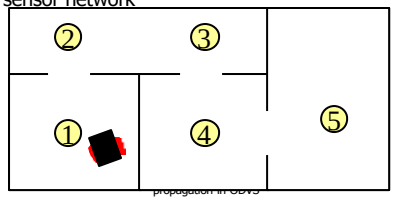
Presentation Outline

- Aim of the project
- Distributed Vision System
- Vision Agent Architecture
- Learning process
- Knowledge propagation
- Future Works

Aim of the Project

- To create a network of smart sensors able to navigate a blind service robot in an office like environment
- The robot is NOT autonomous, it is driven by the sensor network

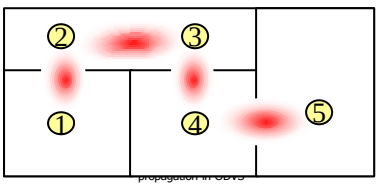


Difficulty?

- In order to navigate the robot, we need:
  - To calibrate all cameras in a common frame of reference
    (i.e. To find the mapping function between the image space and the world space)
- If the number of cameras is large this is impossible to do by hand

Proposed Solution

1. To have a network of smart sensors able to learn by observing the robot
2. To propagate the knowledge in the overlapping field of view of the sensors

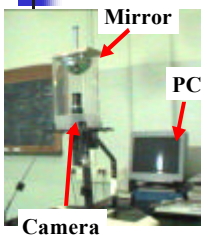


Sensor Network

- Uncalibrated sensors
- Heterogeneous Sensors
- Omnidirectional Vision Sensors

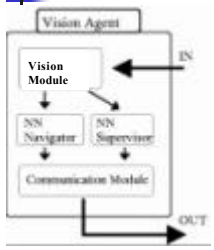
(Maybe existing camera network)

Vision Agent



- Smart Agent:
  - Autonomous
  - Able to learn
  - Able to cooperate
- VA communicates with other VAs via our middleware "ADE"

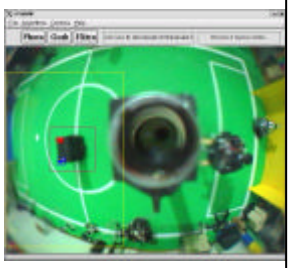
VA Architecture



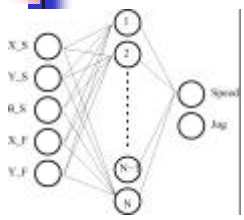
- Vision Module extracts robot pose from image
- Neural Net (Navigator) learns to control the robot
- Neural Net (Supervisor) learns to predict robot position
- Communication Module sends information to other VAs

Stage 1 - Learning Stage

- VA detects the initial robot pose
- Operator moves the robot by sending commands to the motors
- VA detects the final robot pose
- The Neural Nets are trained using the poses and the motors commands



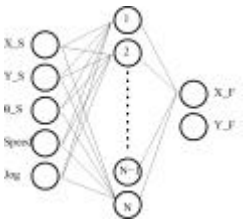
Navigator Net



- Input:
  - initial pose of the robot
  - final pose of the robot
- Output:
  - Translational speed (Speed)
  - Rotational Speed (Jog)
- Navigator learns which "speeds" to set on the motors to drive robot from starting position to final position

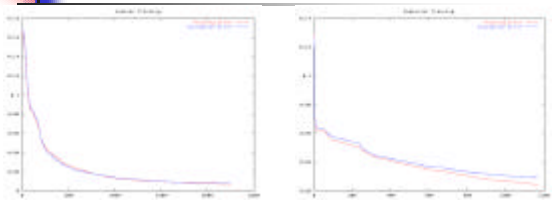
i.e. Navigator learns the mapping between the image space and the motor space

Supervisor Net



- Input:
  - initial pose of the robot
  - Speed & Jog
- Output:
  - Final pose of the robot
- Supervisor learns to predict the final robot position from the initial pose and the speed commands

Learning Process



Navigator Supervisor

Training and Validation error versus iteration using backpropagation

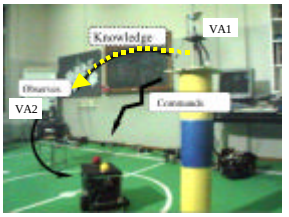
Stage 2 – Knowledge Propagation

- The knowledge acquired by the first VA cannot be used directly by the other VAs because:
  - Sensors are NOT calibrated (different heights, different vertical axis, etc.)
  - Sensors are heterogeneous (different cameras, different mirrors, etc.)
- Every VA will have its own mapping between image space and motor space
- To transmit the acquired knowledge we used

"implicit communication"

Implicit Communication

- VA1 learnt its own mapping
- VA1 moves the robot in the field of view of VA2
- VA2 observes the robot
- VA2 receives from VA1 the motor commands sent to the robot
- VA2 trains its own neural nets to build its own mapping



Knowledge Propagation

The bridge to propagate the knowledge in the network is the mobile robot

- VA_N generates examples for VA_{N+1} by:
  - moving the robot in the field of view of VA_{N+1}
  - transmitting the motor commands sent to the robot
- The knowledge acquired by VA1 is autonomously propagated up to VA_N

Omnidirectional Distributed Vision System

- When the knowledge is propagated to every VAs in the network
- Network is a kind of super-sensor for the robot
- We called it:
  - Omnidirectional Distributed Vision System

Implementation Problem

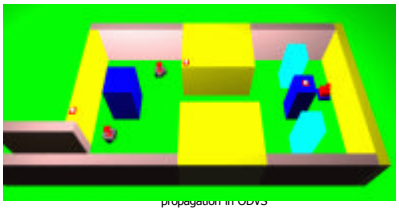
- The learning stage on the single VA is not robust enough
- We are investigating with:
  - more complex network topology
  - Different learning algorithms

A possible extension

- If we introduce different robots in the environment
- We need to train a different neural net for every robot
- This enables to recognise the robot by the network used to control it (remember Supervisor network)
- In a real environment, visual features are not so stable in order to recognise the robot

Future Works

- We wish to apply this system to
  Distributed Vision Systems for Surveillance

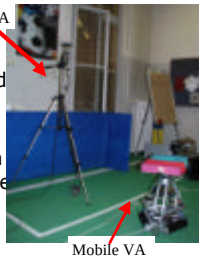


propagation in ODVS

Distributed Vision System for Surveillance (1)

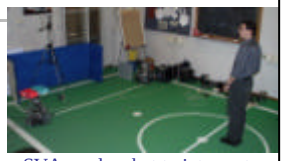
Composed of:

- Static VA
- Mobile VA mounted on board of a mobile robot
- We are studying cooperation between Static VA and Mobile VA



Distributed Vision System for Surveillance (2)

Static VA detects intruders



SVA sends robot to intercept intruders

Robot recognises intruders in the omnidirectional image and sends a picture of the intruder to the Static VA

Conclusions

- We proposed a new solution to the problem of calibrating a large number of camera to drive a mobile robot
- We proposed a solution to propagate the knowledge acquired by a VA to the other VAs in the network
- We are investigating to have a more robust learning of the single VA
- We presented current works on cooperation of heterogeneous VAs for a surveillance task