Camera Based Swarm Tracking and Virtual Pheromone System

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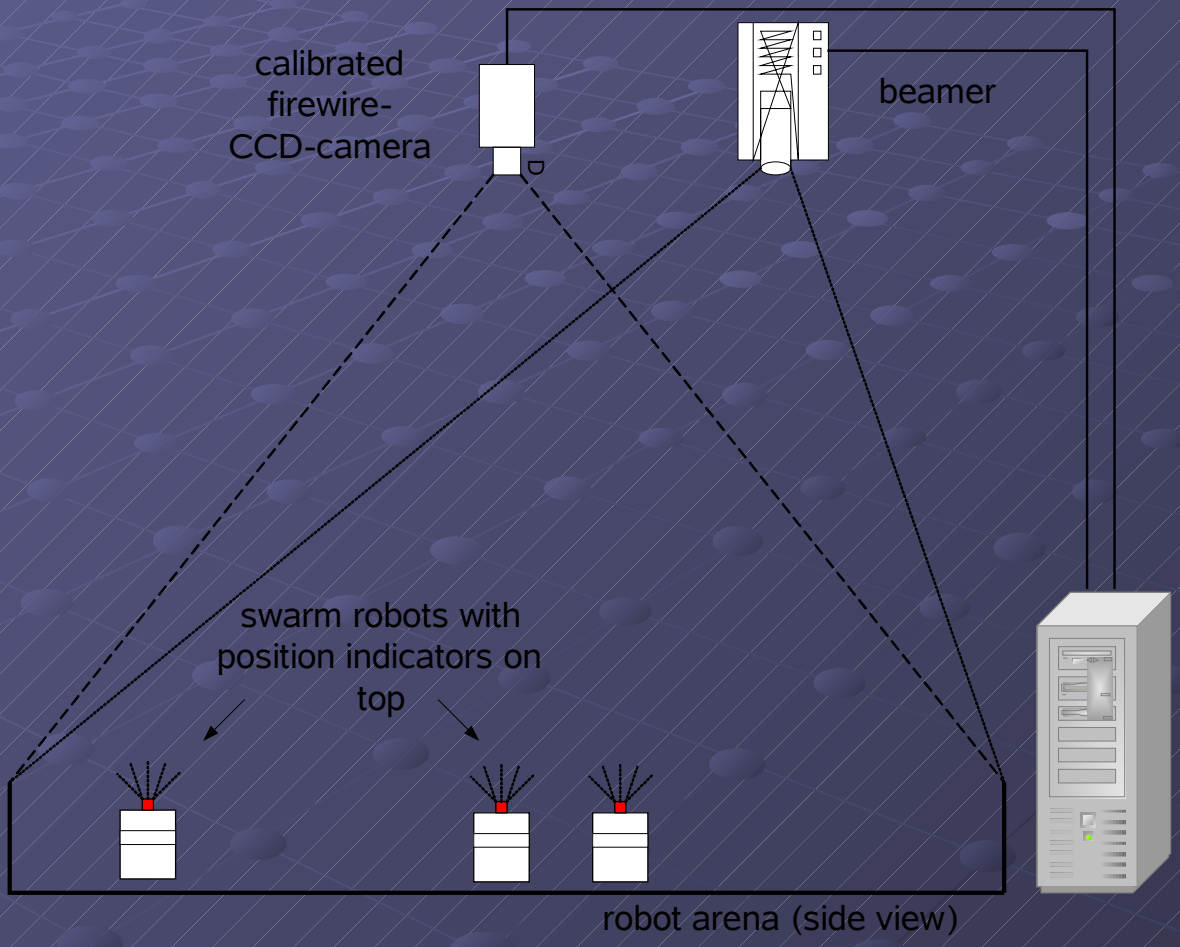
Schematical configuration

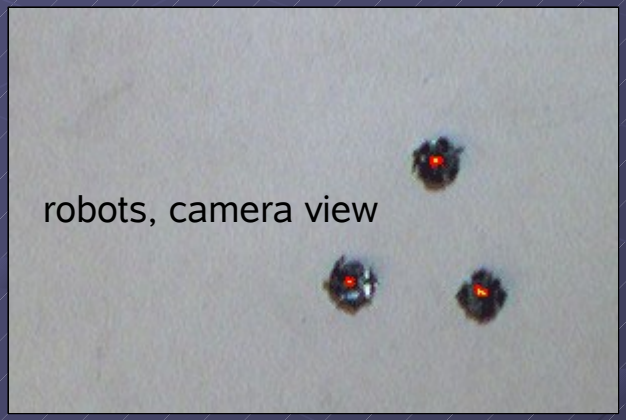


Aims of the system

- Robot detection and tracking:
  - robots are unambiguous identified and tracked
- Virtual pheromone system:
  - recognizion of pheromone emission
    = detection of optical signal from the robots
  - projection of those virtual pheromones to the arena
- Data collection:
  - various data is gathered by the program, e.g.
    - positions
    - speed
    - movements
  - whole session can be recorded to an .avi-file

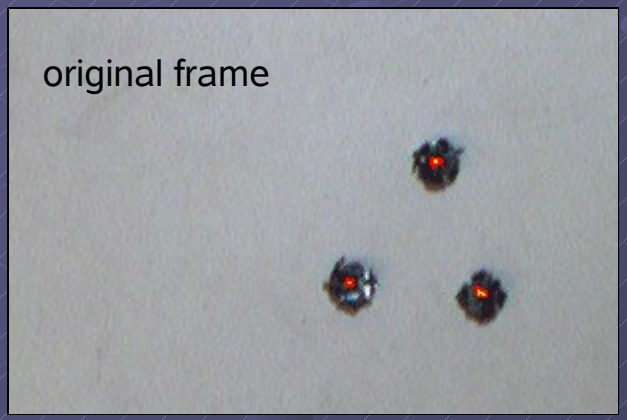
The tracking procedure

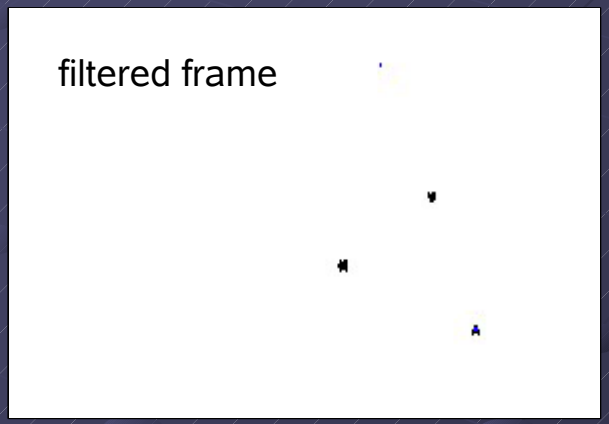
- Short overview:
  - robots have special LEDs on top
  - program identifies those LEDs as robots via
    - auto detection
    - manual selection (mouse clicks)
  - program tracks the motions of every single robot



The tracking procedure

- First step: Image preprocessing
  - frame grabbing from camera
  - conversion from RGB to HSV colorspace (easier filtering)
  - color filter: leaves only the interesting detail, the LEDs

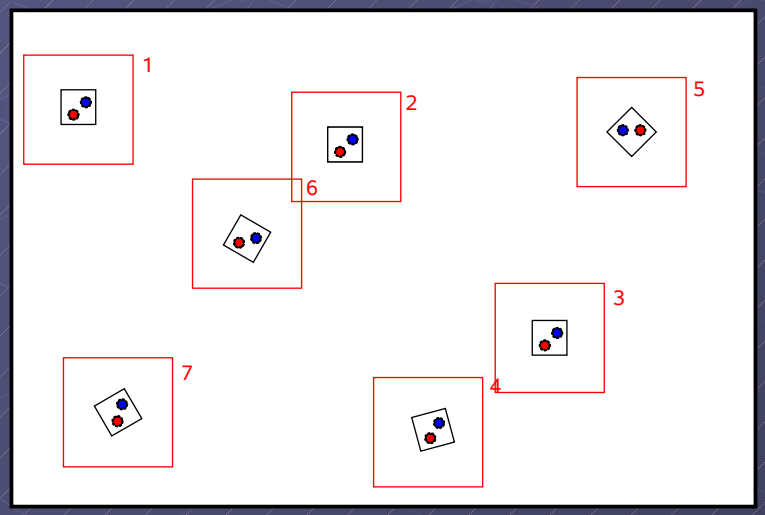


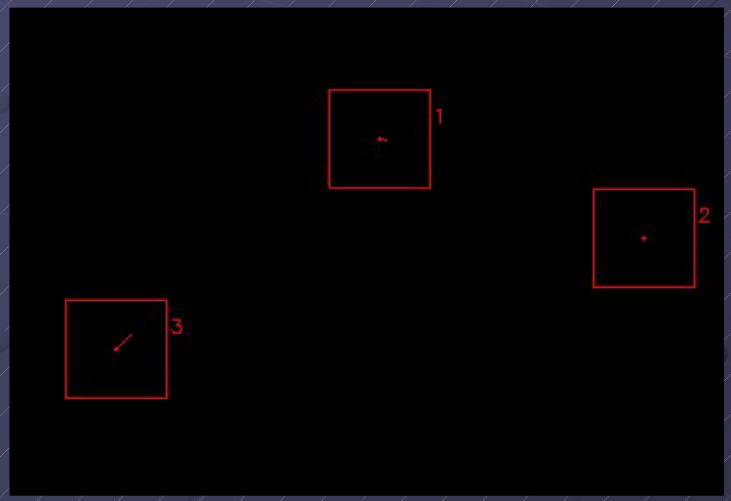


The tracking procedure

- Second step: Searching of ROIs
  - known parameters:
    - positions at the last detection (t-1)
    - estimated motion range/speed maximum
    - minimal distance between two position LEDs (given by chassis)

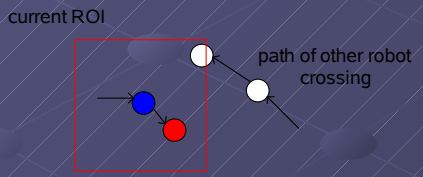
→ each robot is searched in a defined region-of-interest (ROI)



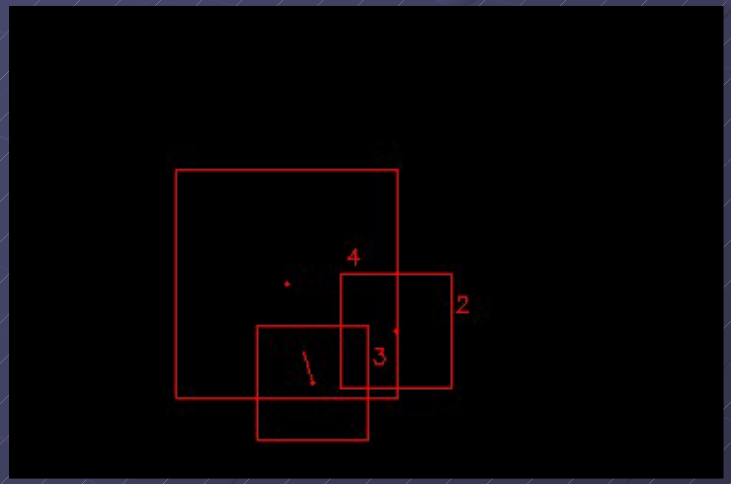


The tracking procedure

- Third step: Case differentiation
  - only one LED in current ROI: alright, that‘s the one
  - no LED in current ROI: enlarge ROI and search again, keep old position
  - more than one LED in current ROI:
    - comparision of propabilities given by the known parameters
    - the one with the highest propability wins

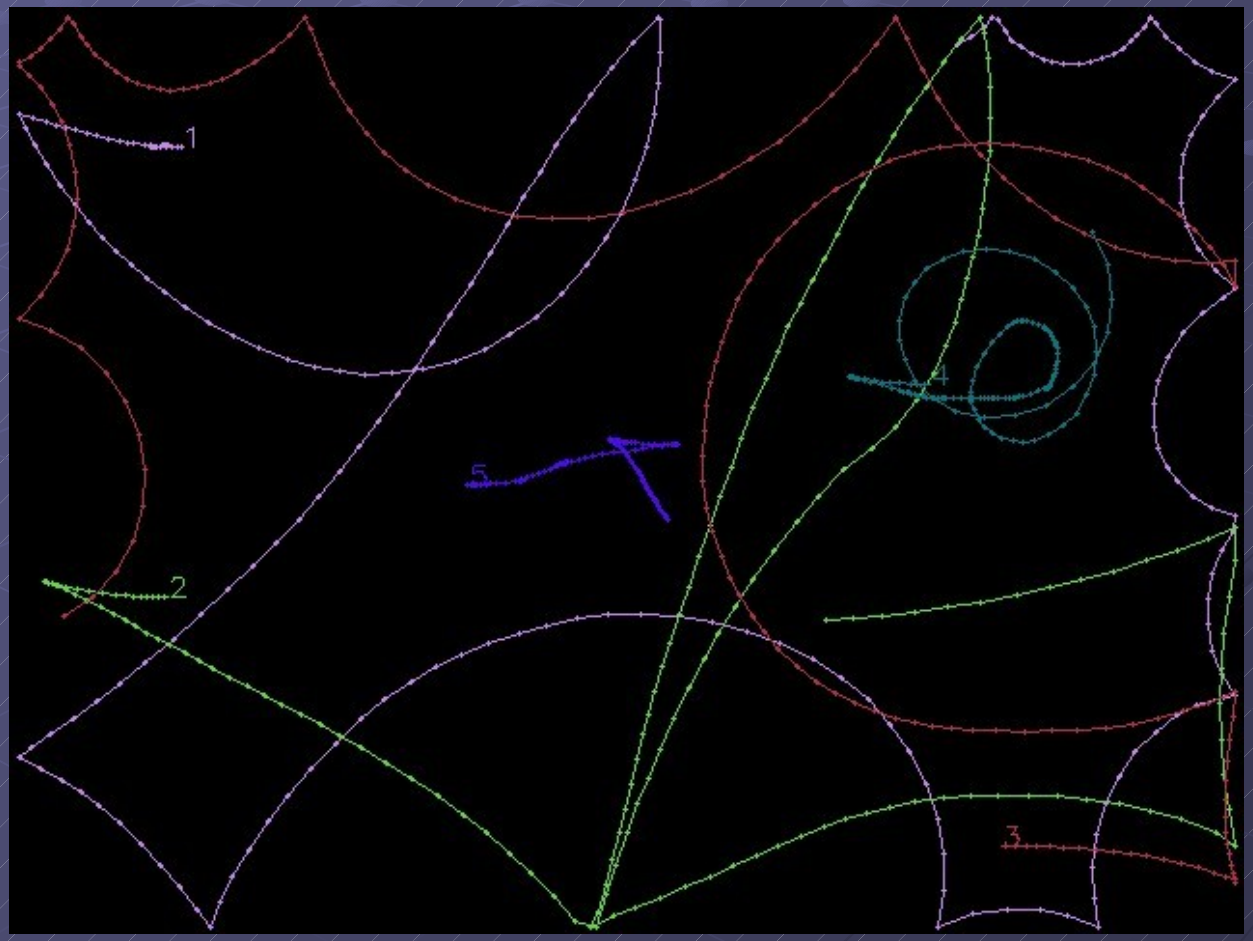


red: current position
blue: position at (t-1)



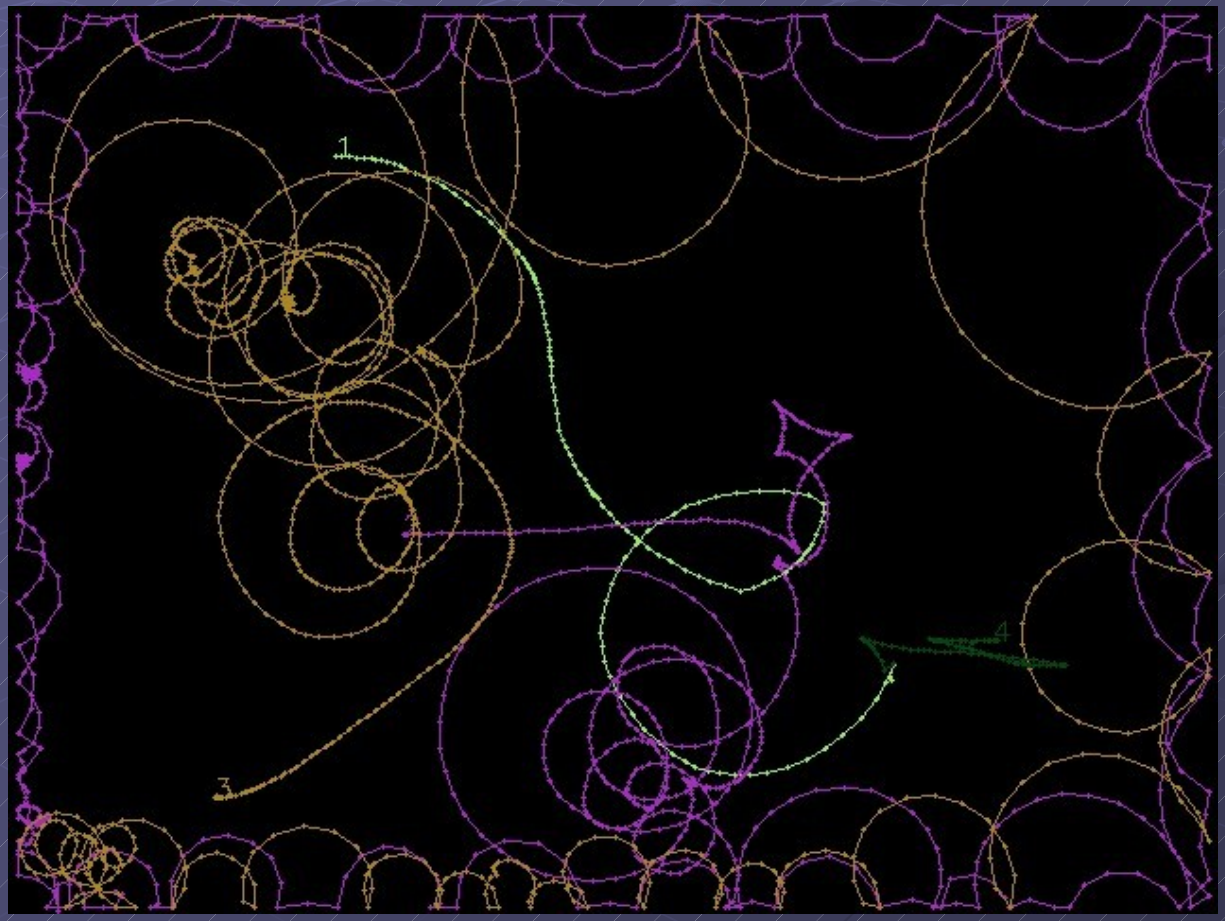
The tracking procedure

- Examples of graphical motion breakdown



The tracking procedure

- Examples of graphical motion breakdown



The virtual pheromone system

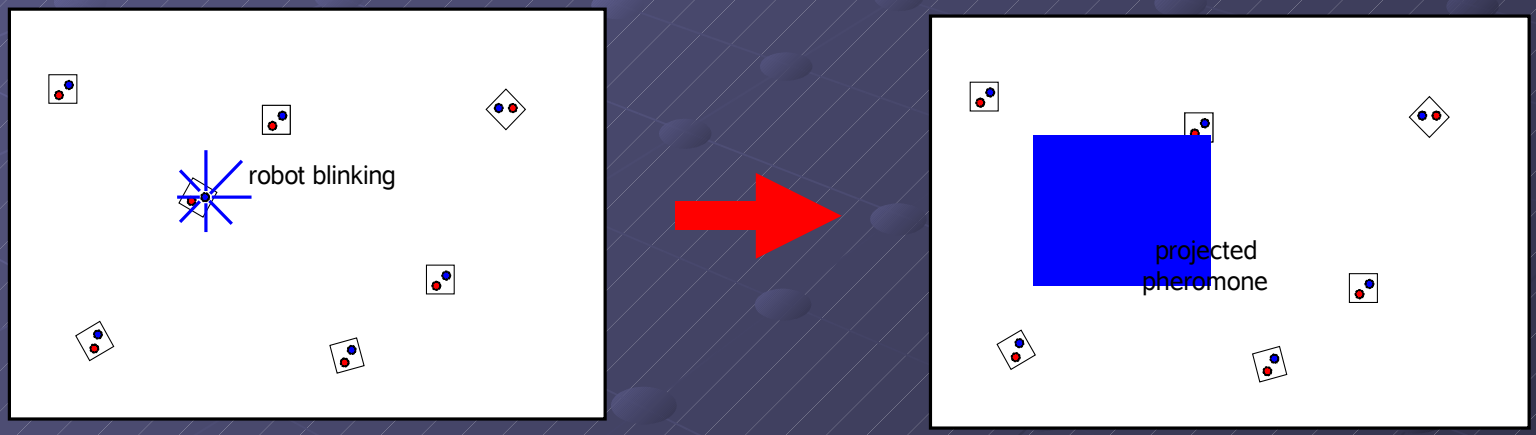
- Pheromone emission by robots:
  - 3 more LEDs in different colors than the position LED
  - emission of a specific pheromone = sending a special pattern
  - program detects color pattern the same way as the position LED:
    - color filter leaves only the LEDs
    - tracking algorithm gives positions and ROIs of the robots
    - the pheromone patterns can be read out of the ROIs

The virtual pheromone system

- Broadcasting of the emitted pheromone:
  - program knows position and type of pheromone:

    beamer projects the corresponding color to the region around the sending robot
  - other robots can detect the color/greyscale value with their fotodiodes

robot arena (top/camera view)



Sota/ToDo

- State of the art:
  - tracking procedure:
    - filtering and extraction of position LEDs working
    - tracking: working, but only tested with randomly generated „robot movements“ in the program, not with real robots
    - data storage in text files, images, .avi‘s; graphical motion breakdown possible
  - pheromone system:
    - problem: different LED colors have partly equal or very similar RGB/HSV-values
    - distinguishable, unambiguous signals for the pheromones needed
  - other features:
    - simulation mode, automatic white balance, usage of calibration data from file to get real world coordinates, etc