UNIVERSITY OF ZAGREB
CENTRE FOR COMPUTER VISION WORKSHOP 2012

Overhead camera feedback control of multiple terrestrial vehicles in a suburban environment

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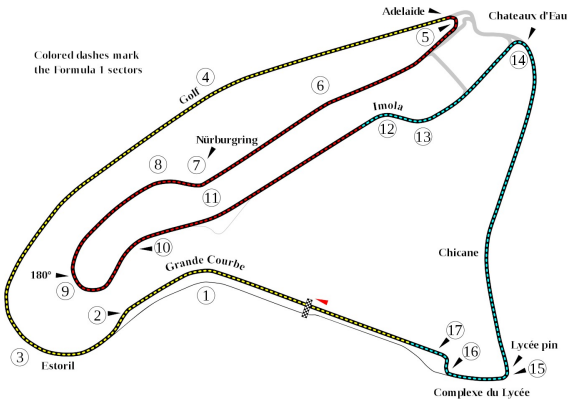
PROBLEM: to control vehicles in a suburb

(a) Carcassonne?

(b) the virtual moat!

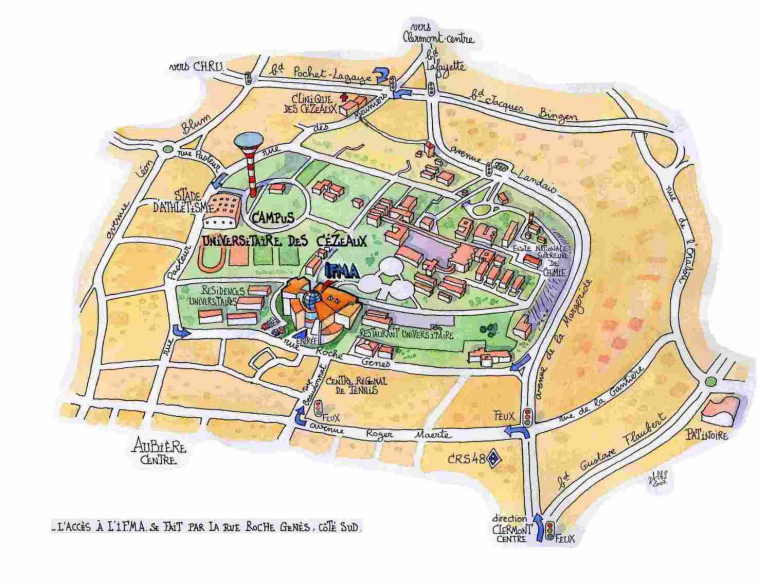


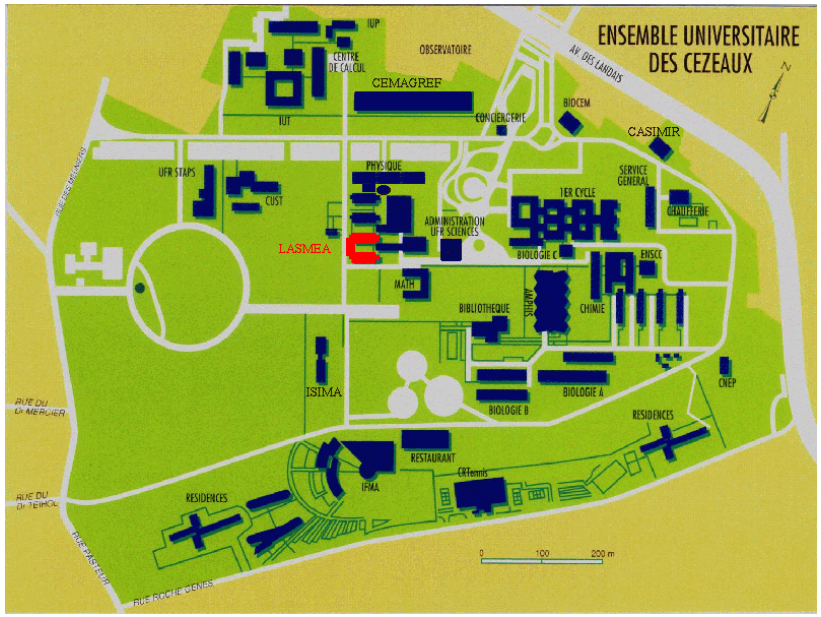
(c) a race track?

(d) a traffic island?

traffic island at Pavin

"Plate forme d'Auvergne pour les Vehicule Intelligent"[1] (flv)

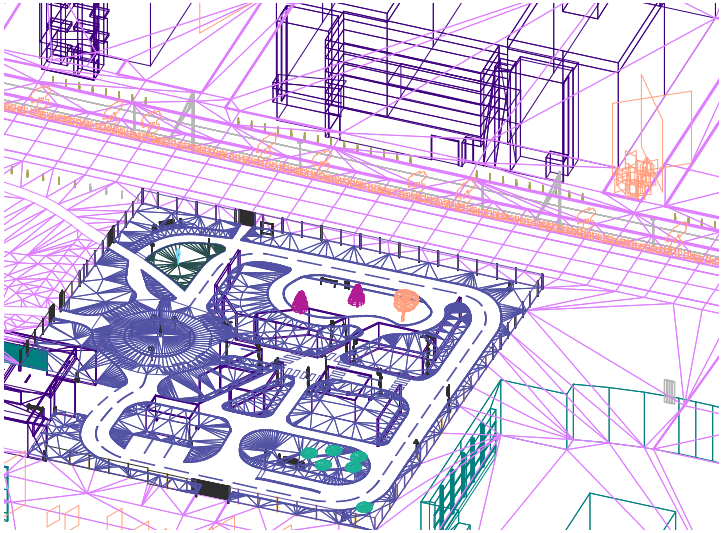




Institut Pascal (Clermont-Ferrand, France)

[1] PAVIN Principal Investigator: Jean-Pierre DERUTIN

traffic island at Pavin cont'd



Contributions of this work

- 'field robotic' implementation of visual feedback control
- extension of the limit-cycle method[2] to arbitrary closed curves

[2] to be described shortly

How to avoid (static) obstacles. . . like traffic islands

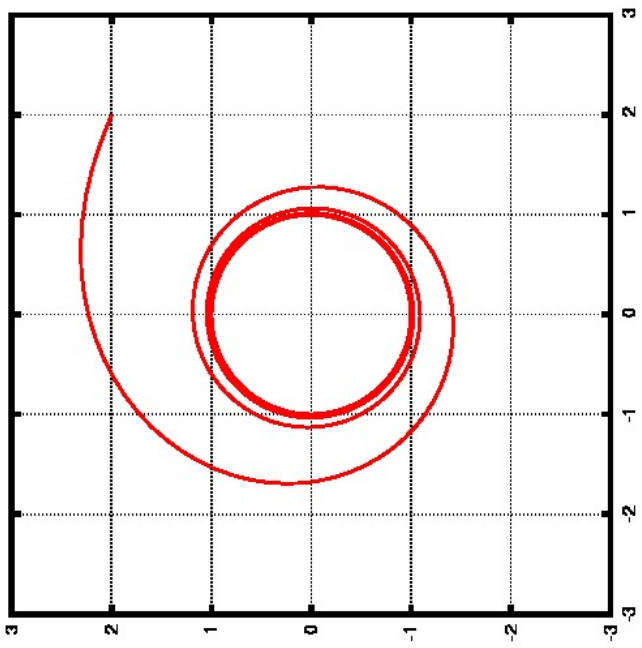
Prior art - at least three groups of path calculations:

- virtual electropotential field[3]
- virtual deformable zone[4]
- limit cycle method potential flow[5]

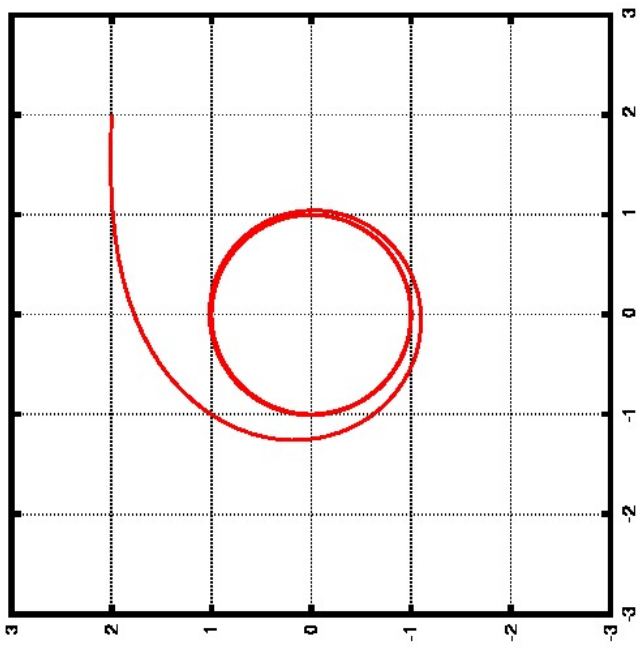
[3] Andrews & Hogan, Borenstein & Koren
[4] Zapata & Lepinay
[5] Benzerrouk, PhD 2011 UBP, §2.3.2; Adouane 2009

Limit cycle method - explained

easiest to describe with 2D pictures[6]:



(i) original

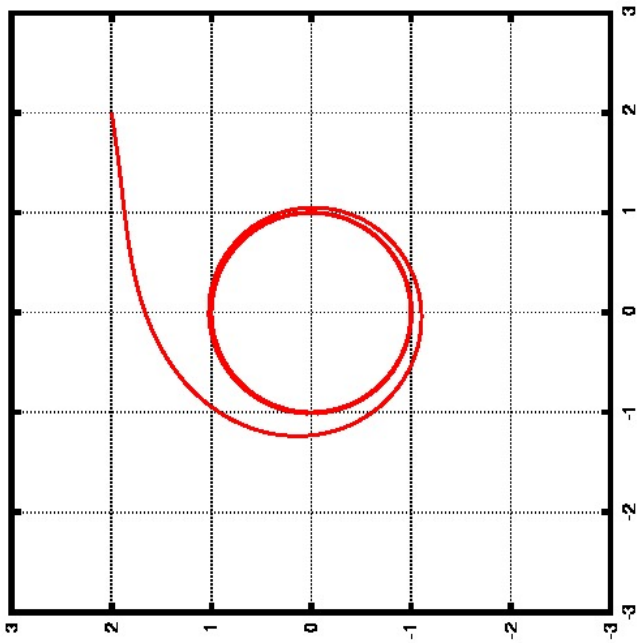


(j) better

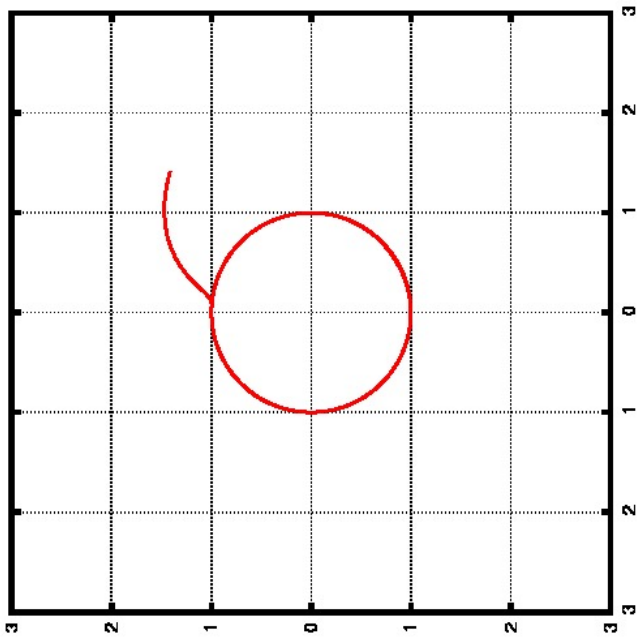
[6] look at start of path!

Limit cycle method - explained

place distorted vector diagram on plane of obstacle:



(k) best path?



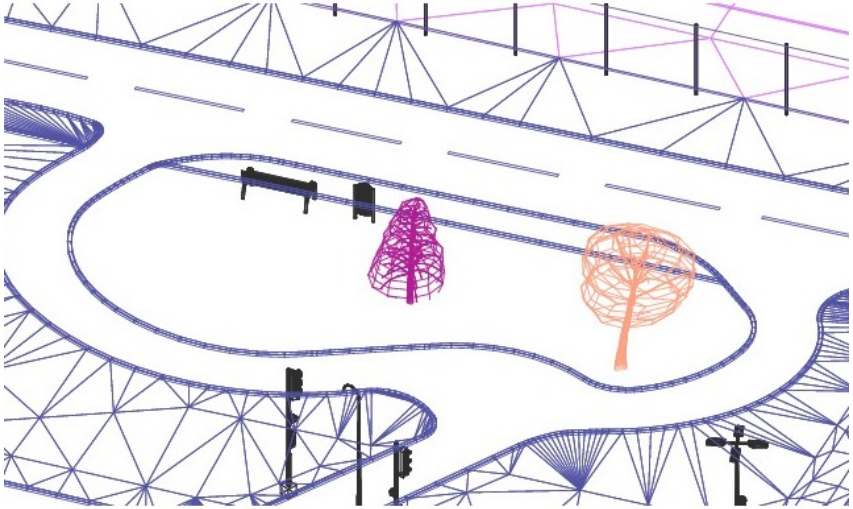
(l) how about this one?

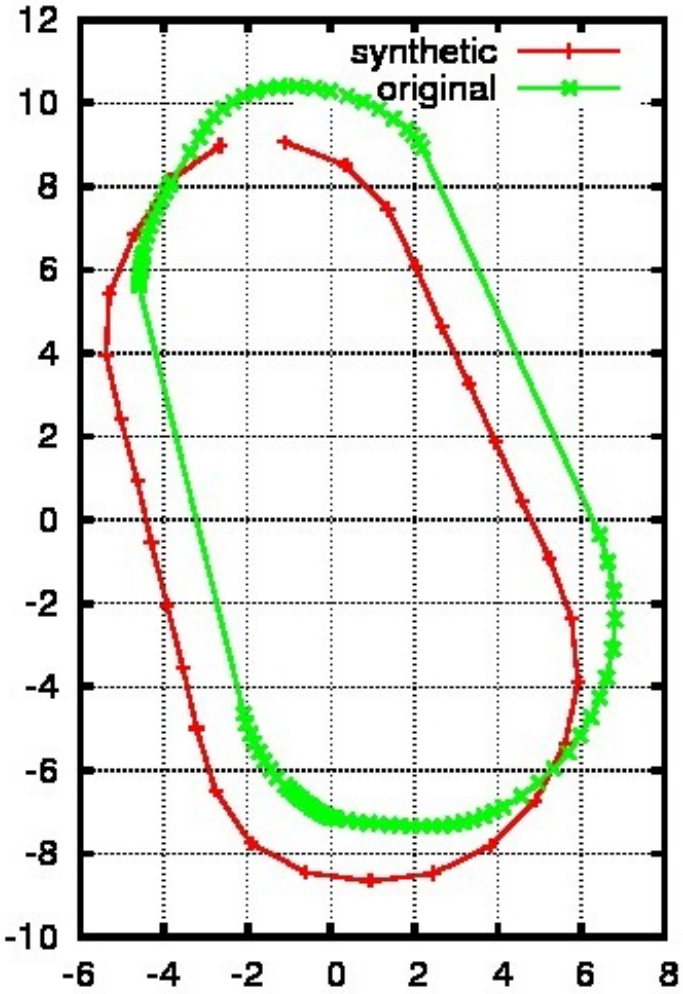
Subproblems!

- how to assemble 3D field coordinates
- how to reduce data from 3D to 2D?
- what is equation of plane?
- from assemblage of 3D points to ordered 2D polygon
- where is centre?
- how to represent irregular polygon with equispaced
- how to reduce the dimensionality of data[7]

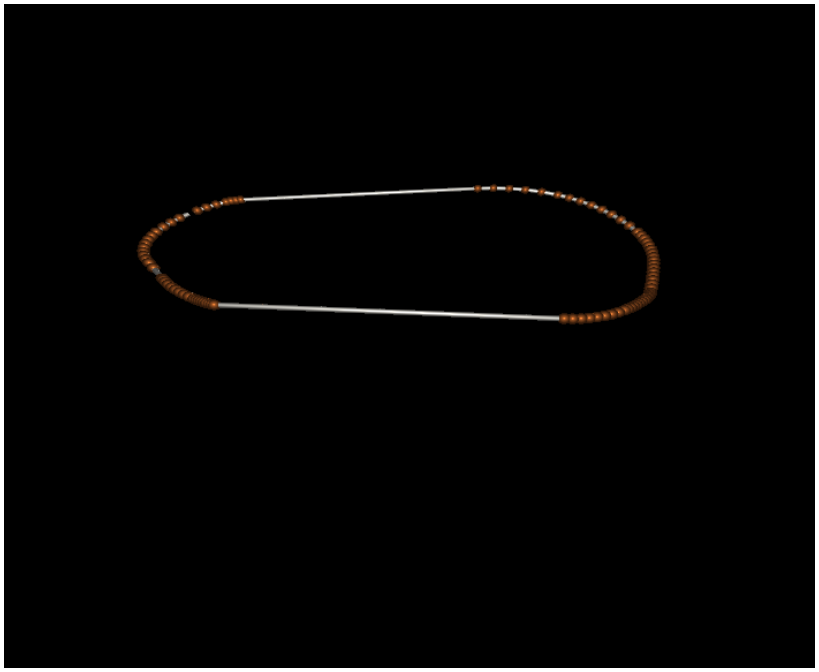
[7] (think real-time calculations!)

Convex polygon model seen here...

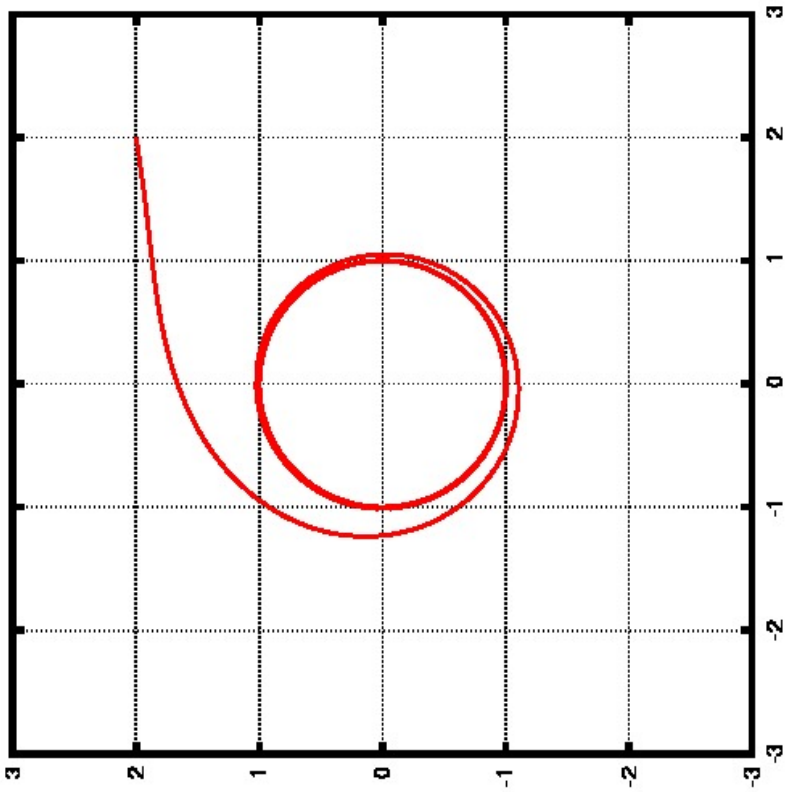


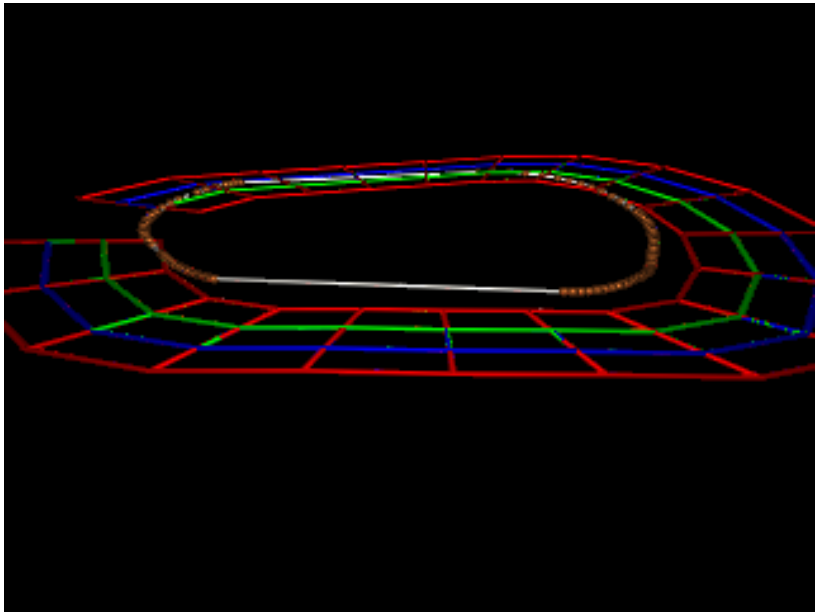


The camera perspective



Perspective with velocity field grid



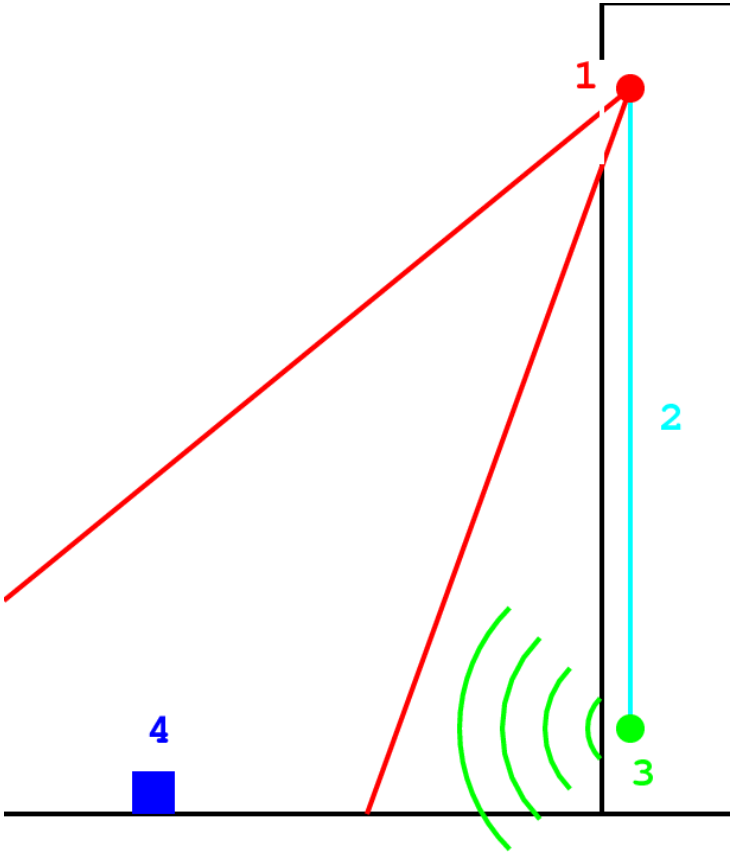


Why reduce to camera perspective?

- static field of vision (. . . for static cam)
- easy to compare what is and what should be (feedback!)
- planar environment reduces complexity of calculations
- simple calculations = real-time control laws
- don't like the GROOFV tune? change the music!
  - analogy to player piano
  - easy to add harmonies, behaviours
  - CW, CCW circulation?
  - different activities for different robots
  - partition space and/or time

Apparatus - schematics

section view, facing North 45.75N, 3.11E



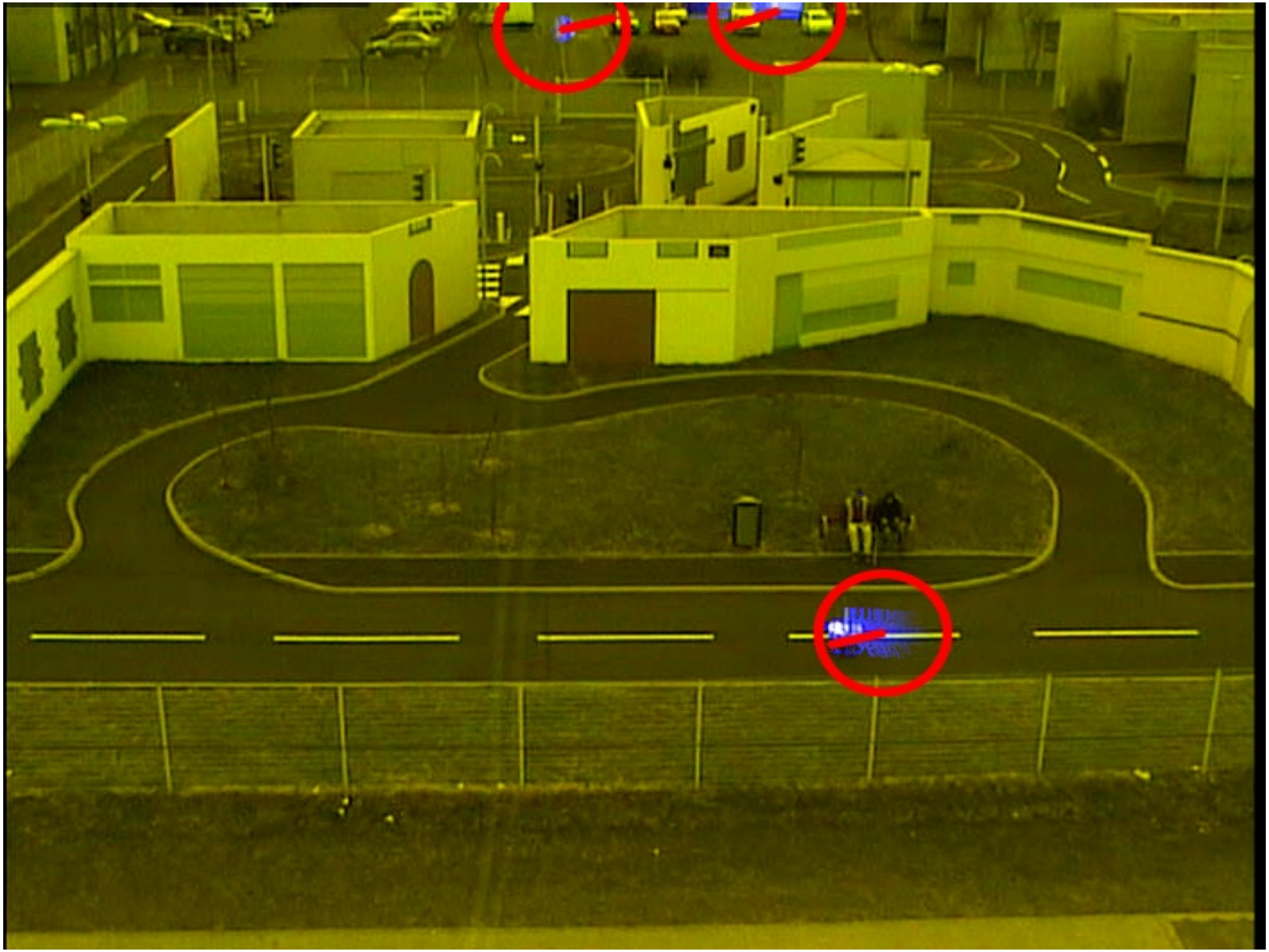
Apparatus - list

1. Computer vision system:
   - located on 3rd floor
   - firewire 400Mbit PCI
   - 1x Debian 'lenny' linux (vision)
   - OpenCV + friends image analysis
   - 100Mbit onboard ethernet
2. Wired network built infrastructure
3. Wireless bridge
   - WiFi node transceiver
   - located in LASMEA 0th floor garage
   - 25-50m distant from PAVIN site
4. Pioneer robot
   - 1x Debian 'lenny' linux controller (netbook)
   - WiFi receiver
   - USB/RS232 connector
   - and/or MobileSim software

Apparatus - list (+ digression)

- MobileSim software, Pioneer/ADEPT interchange
- MobileSim placed under GNU licence
- MobileSim skeleton enables 'Gazebo' simulator
- Gazebo = DARPA Robotics Challenge 'GFE[8] Simulator'
- Gazebo is built to run under Willow Garage ROS Linux
- see IEEE Spectrum article
- Willow Garage also hosts OpenCV

[8] Government Furnished Equipment



Conclusion

- discussed a functional solution for multiple robots to patrol a suburban environment with obstacles
- one overhead camera, commodity hardware
- your children will be able to learn this system by the age of 17

Future work

- algorithm: concave hull
- complete automation
  - for dynamic system
- medium-term 'vision'...
  - smart camera
  - mounted onto
  - autonomous helicopter
  - to supervise INTECO R-Jet?

Acknowledgements

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  - University of Zagreb
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  - Michel DHOME
  - Laurent MALATERRE

[9] Conseil National de Recherche Scientifique, France