Introduction to Pattern Recognition

WS 10/11

Dr. Elli Angelopoulou

Lehrstuhl für Mustererkennung (Informatik 5)

Friedrich-Alexander-Universität Erlangen-Nürnberg

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Overview

- Administrative information
- A short journey through

  Introduction to Pattern Recognition

- Pattern Recognition in practice

Introduction to Pattern Recognition (IntroPR)

- Lecture (3 SWS - 5 ECTS)
  - Mon 10:15 – 11:45 (0.68)
  - Tue 14:00 – 14:45 (H10)
  - Elli Angelopoulou
  - elli@i5.informatik.uni-erlangen.de
- Exercises (1 SWS - 2.5 ECTS)
  - Mon 16:00 – 16:45 (09.150)
  - Wed 16:00 – 16:45 (09.150)
  - Christian Riess
  - christian.riess@informatik.uni-erlangen.de
- New: Exercises will be more applied oriented

Intro PR - Exams

Certificates

- Oral exam at the end of the semester
- Graded certificate *(benoteter Schein)* or exam through the *Prüfungsamt*
  - 7.5 ECTS - 30 min. oral exam on lecture **and** exercises
  - 5 ECTS - 30 min. oral exam on lecture material only
- Pass/Fail certificate *(unbenoteter Schein)*
  - 7.5 ECTS - 30 min. oral exam on lecture **and** exercises
  - 5 ECTS - 30 min. oral exam on lecture material only

PR Reading Material:

- When applicable, printed slides will be made available through the web.
- You are still expected to take notes yourself.
- Slides and notes do not replace the textbook.
- Most of the slides can be understood only with the additional explanation during the lecture and using additional material from textbooks.

- Textbooks:

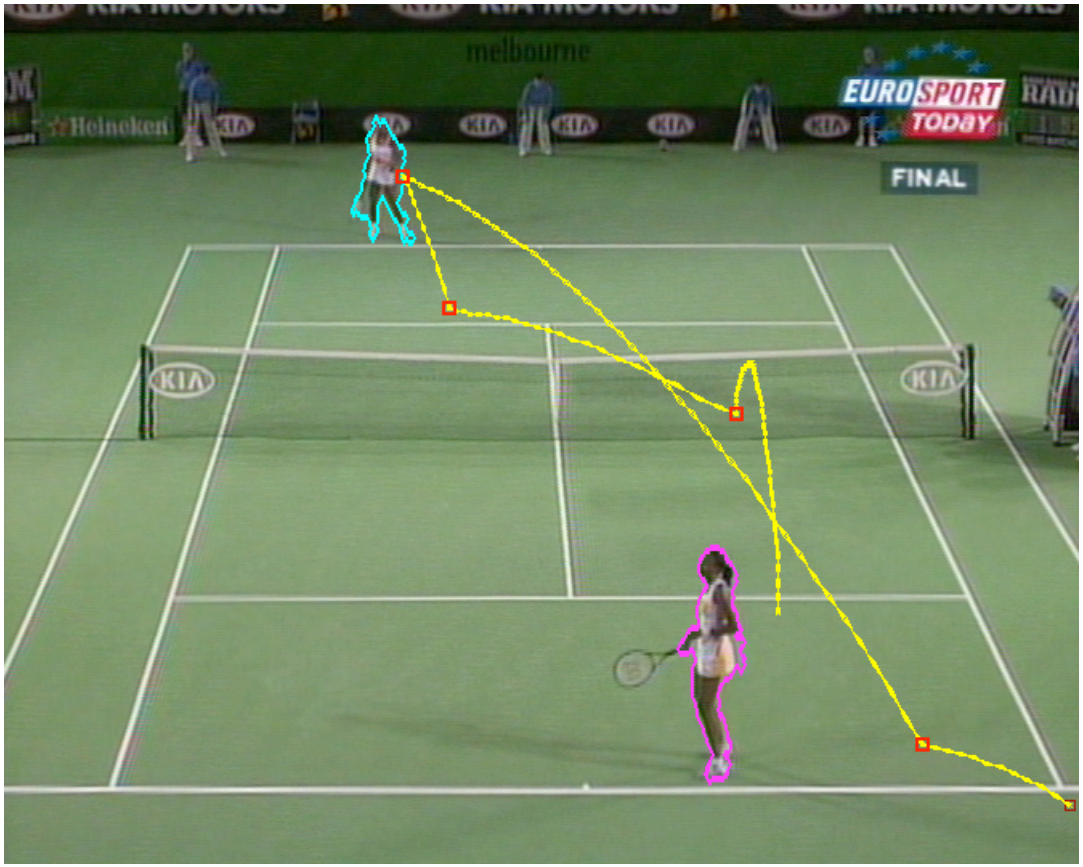
[1] H. Niemann. *Klassifikation von Mustern*. Springer, Berlin, Heidelberg, 1983.
Second expanded edition available via Internet:
http://www5.informatik.uni-erlangen.de/en/our-team/niemann-heinrich

[2] S. Theodoridis and K. Koutroumbas, *Pattern Recognition*, 4th ed. Academic Press, 2009.

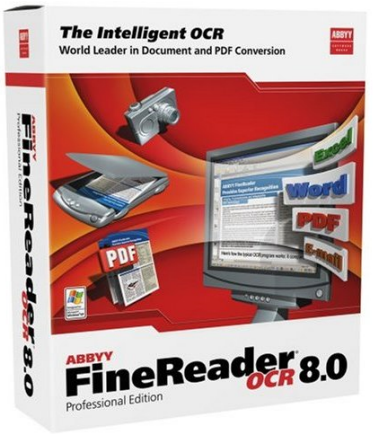
[3] R. Duda, P. Hart, D. Stork, *Pattern Classification*, 2nd ed., Wiley Interscience, 2001.

What is Pattern Recognition?

- Pattern Recognition involves the design of systems which (semi) automatically recognize patterns in sensed data.



Pattern Recognition in Everyday Life



Components of a Pattern Recognition System

- Sensor
  - Collect information
  - Camera, microphone, sonar, X-ray machine
- Preprocessing
  - Remove noise from the collected information
  - Bring data in a standardized format
- Extract Features
  - Compute numeric or symbolic information from the „raw" collected data
  - Selection of appropriate features has great impact on the success of a PR system
- Classification
  - Main recognition step
  - Machine learning (supervised or unsupervised)

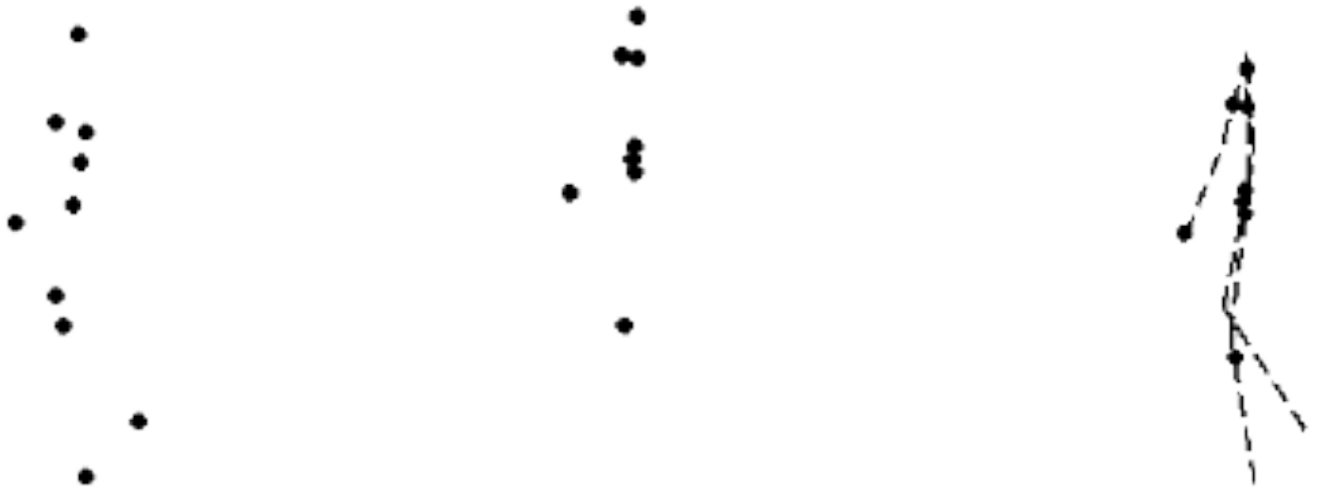
Pattern Recognition Topics

- Signal Acquisition
- Preprocessing
- Feature Extraction
- Feature Reduction
- Classification (continued in PR and PA)
- Pattern recognition is at the borderline between computer science and electrical engineering
- Topics of pattern recognition in Erlangen: medical applications, computer vision, speech recognition and digital sports

Signal Acquisition

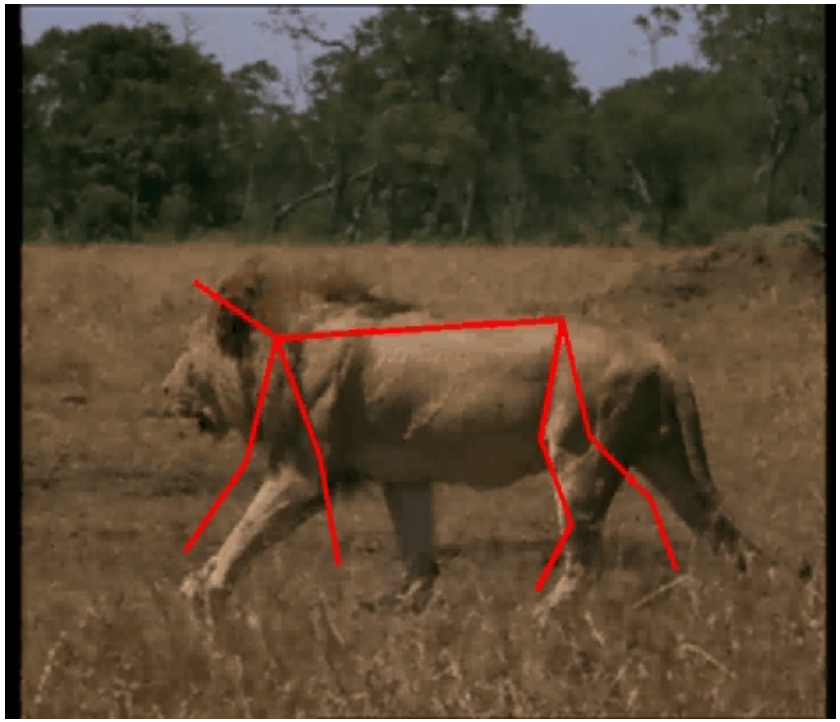
- Depending on the application we can use different types of sensors to acquire data:
  - microphones
  - cameras
  - Xrays, MRIs, CTs, ultrasound
  - GPS sensors, gyroscopes
  - heartrate monitors, perspiration sensors, blood pressure sensors
  - ….
- Once the type of sensor is selected, choosing a particular model can have a significant impact on the overall performance of our PR system:
  - noise levels
  - data acquisition speed
  - amount of collected information
  - built-in preprocessing

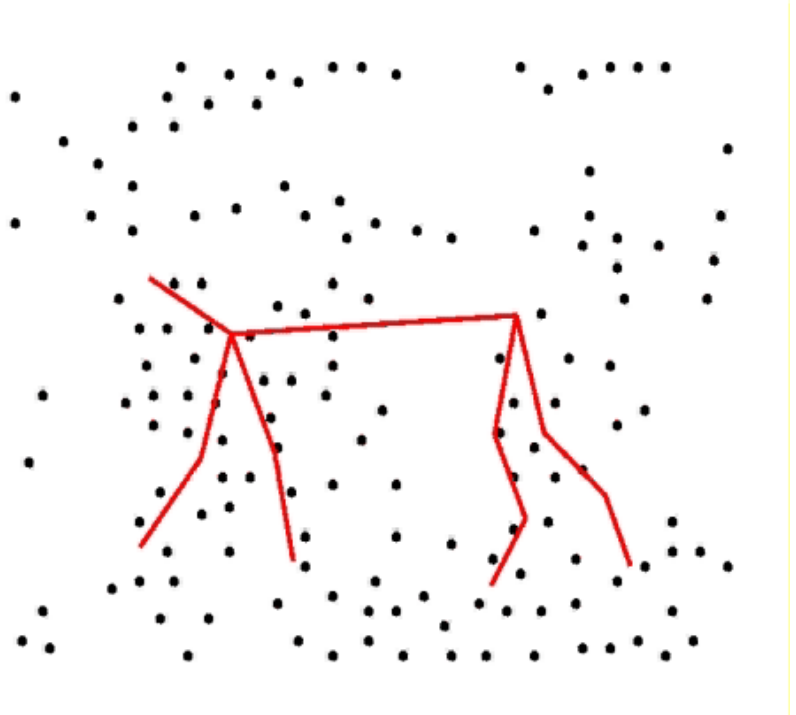
Feature Extraction/Selection



- Are point features sufficient for object recognition?

Recognition based on Point Features





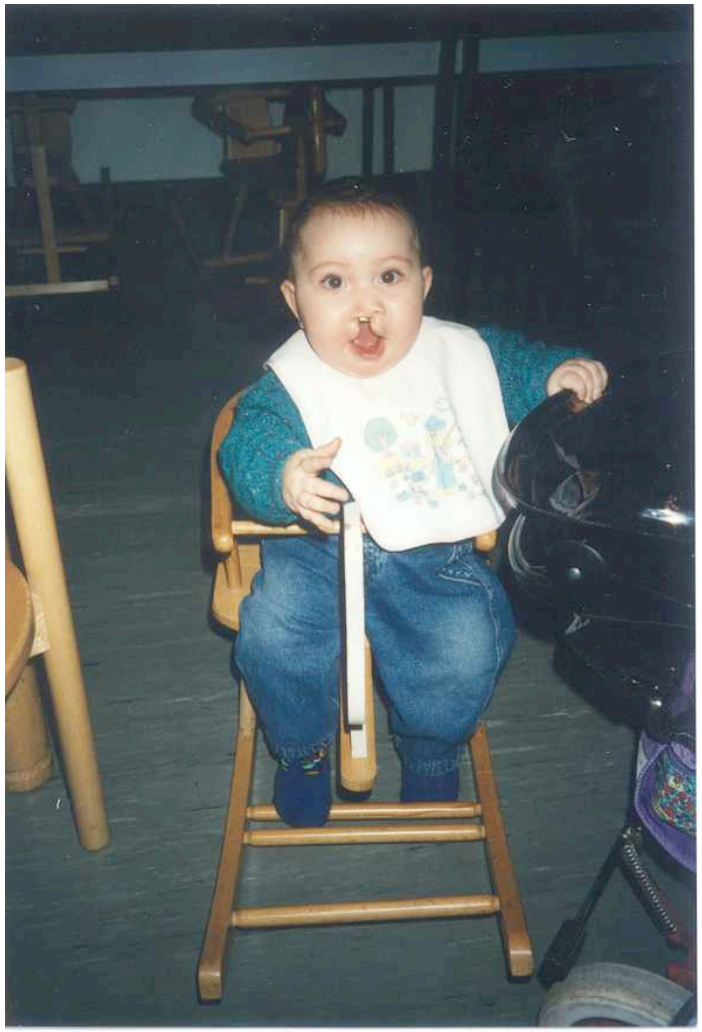
Videoclips courtesy of Ruixuan Wang, Wee Kheng Leow and Hon Wai Leong,
“3D-2D Spatiotemporal Registration for Sports Motion Analysis”, CVPR 2008

Challenges – Speech Recognition

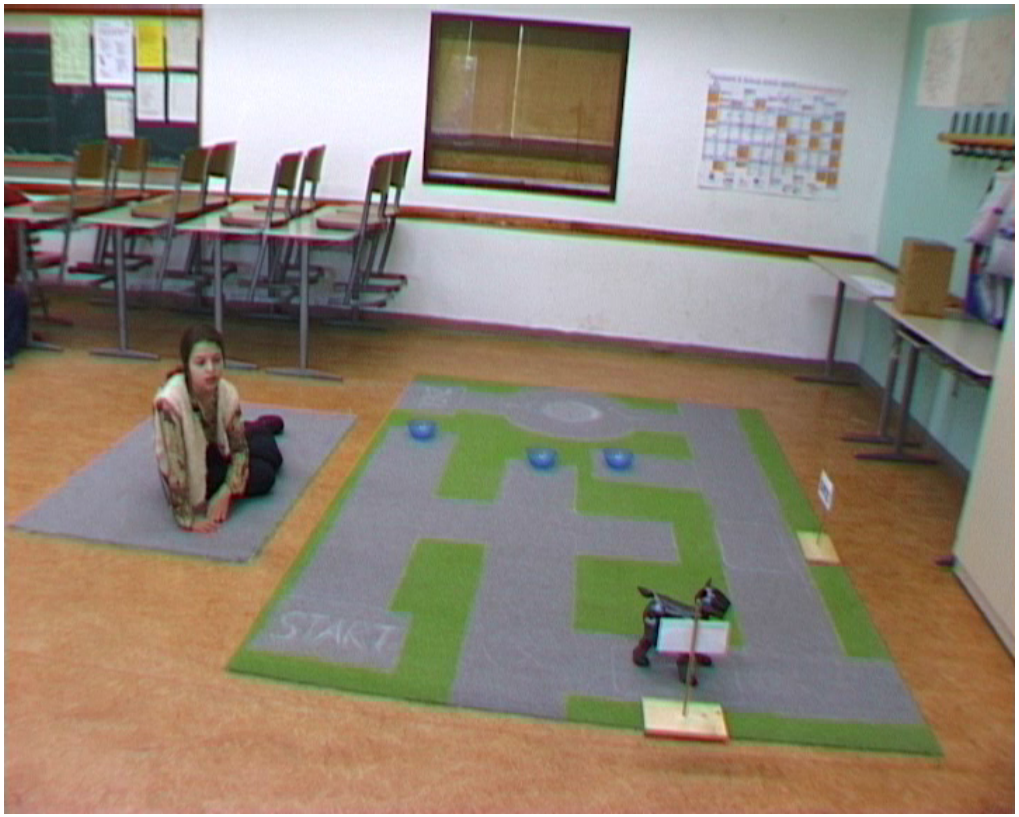
- Why is speech recognition so difficult:
  - Ambiguities
  - Emotions
  - Nondistinctive articulation
  - Accents/Dialects
  - Technical problems (microphones, encoding, …)

  Also:
  - Diseases of oral apparatus

Nasalization



Spontaneous Child Speech



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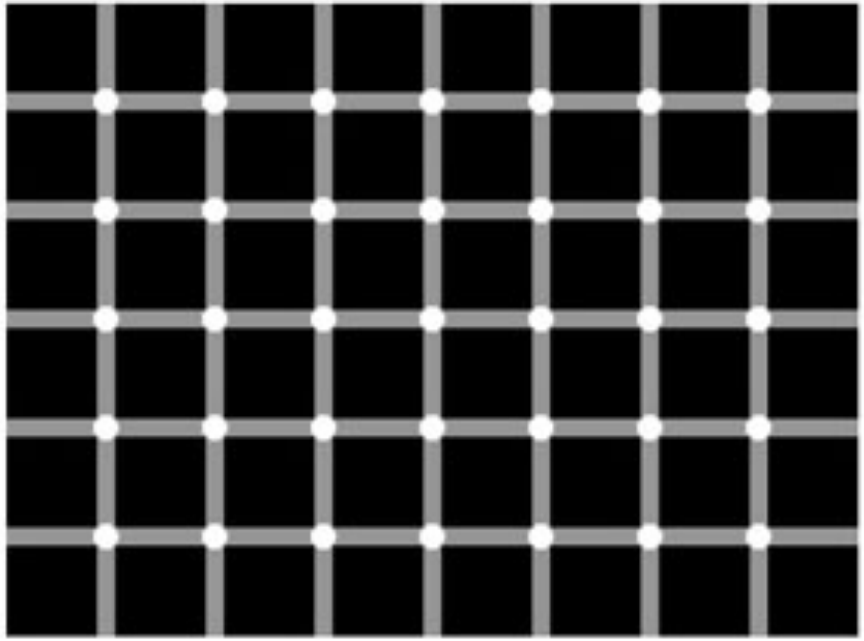
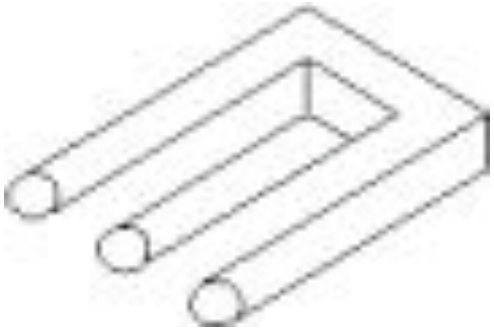
Challenges – Computer Vision

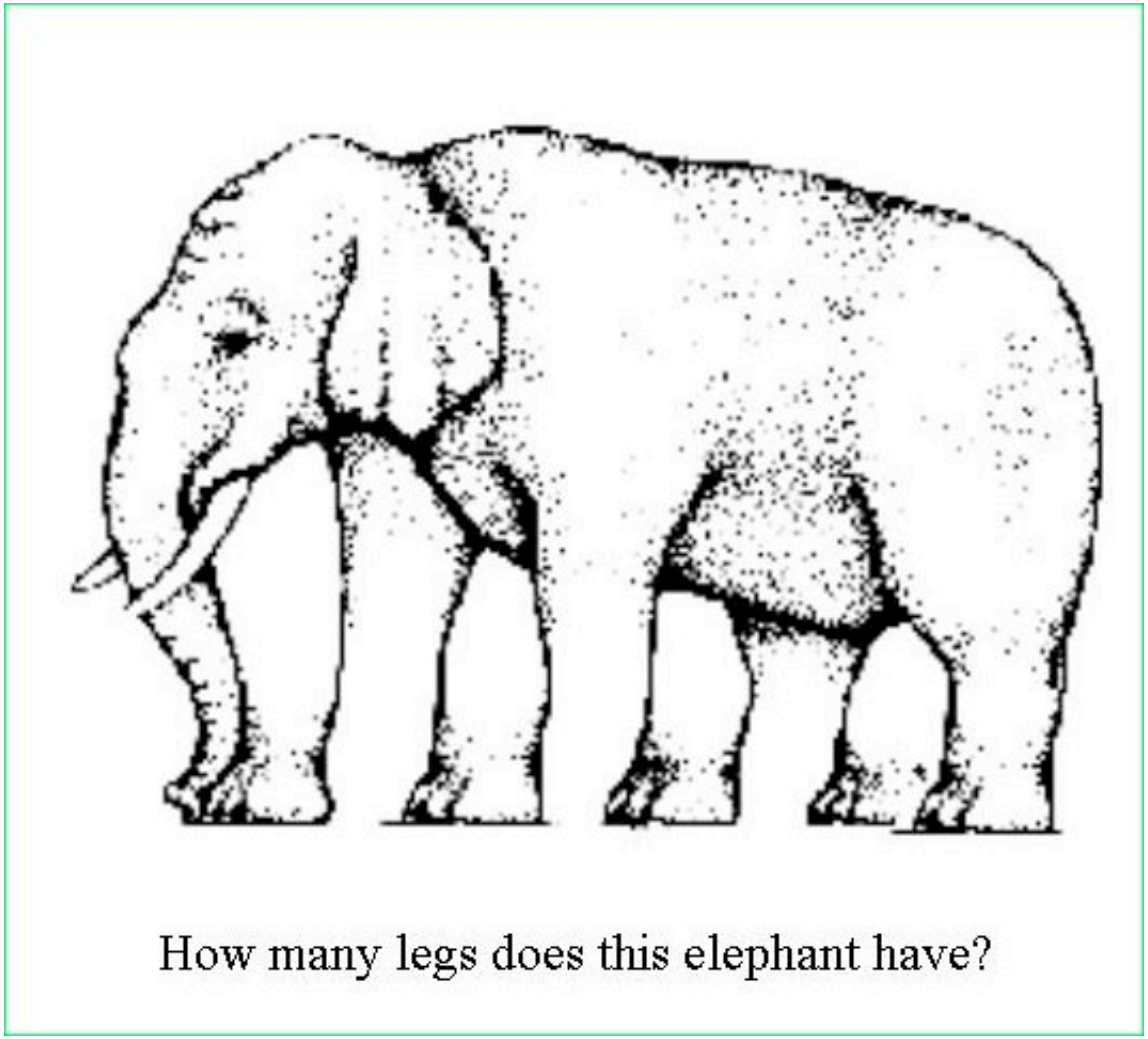
- Why is computer vision so difficult:
  - Ambiguities
  - Implicit knowledge
  - Prior information
  - Technical problems (noise, limited data, encoding...)

Influence of Entire Image



Implicit Knowledge





Is it Hopeless?

- We have a structured way of processing incoming signals (sound, light, etc.) in order to identify what is being conveyed by that signal.
- This framework (the Pattern Recognition pipeline) is general and can be applied to a variety of situations.
- There are many challenges.
- Can such a general framework be effective?

DARPA Grand Challenge

- A prize competition for driverless (autonomous) cars organized by DARPA (Defense Advanced Research Project Agency), the research oprganization of the USA Department of Defense.

- „DARPA Grand Challenge" of 2004 – Mojave Desert, CA, 240km
  - No competitor of the 21 participants finished the race
  - CMU won for completing the longest distance 11.78km

- „DARPA Grand Challenge" of 2005 – Mojave Desert, CA, 212km on a wider road with fewer curves
  - 5 out of the 23 (22%) participants finished the race
  - 1st place: Stanford's „Stanley" (VW Touareg) after 6:54hrs of driving
  - 2nd place: CMU's „Sandstorm" at 7:05hrs
  - 3rd place: CMU's „Highlander" at 7:14hrs

DARPA Grand Challenge

DARPA Grand Challenge Bloopers

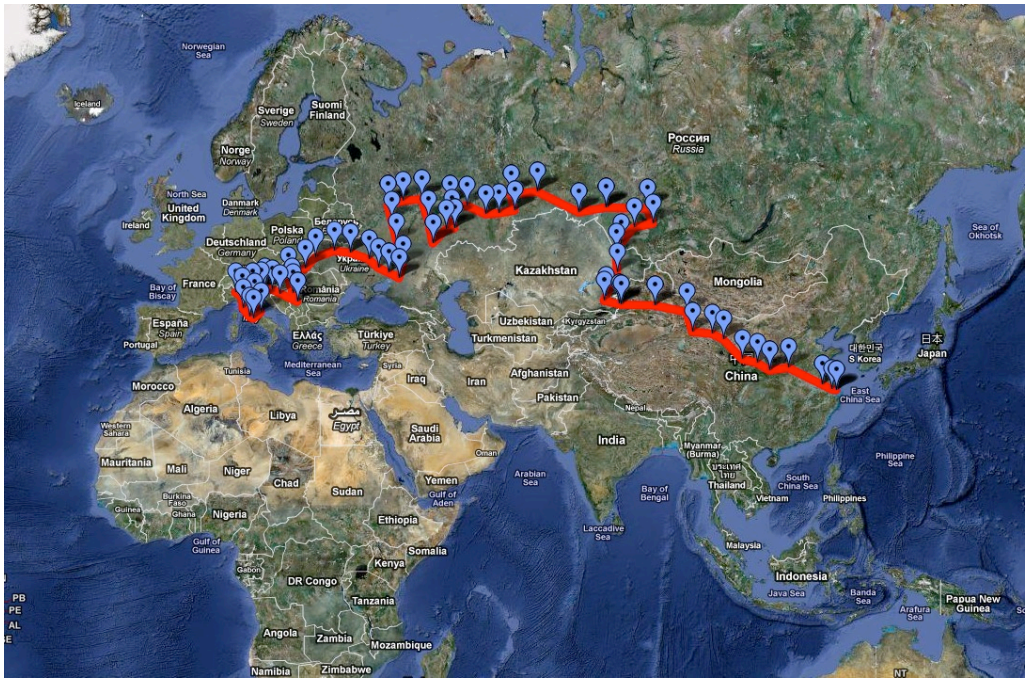
DARP Urban Challenge Event

- Goal: Autonomous driving in an city setup
- Course:
  - 96km to be completed in less than 6hrs
  - Obey all traffic regulations
  - Handle obstacles and other cars on the road
  - Merge into traffic
- Day of Final Event: November 3, 2007
- Results:
  - 35 participants, 11 passed to the finals
  - 6 out of 11 finalists (55% of finalists, 17% of participants) completed the course
  - 1st place: CMU (Chevy Tahoe) after 4:10hrs of driving
  - 2nd place: Stanford (Volkswagen Passat) at 4:29hrs
  - 3rd place: Virginia Tech at 4:36hrs
  - Followed by MIT, UPenn and Cornell

DARPA Urban Challenge Event

VisLab Intercontinental Challenge

- Goal: Autonomous driving from Parma, Italy to Shanghai, China
- Course:
  - 13,000km of regular roads
  - Estimated travel time approx. 3 months (20. Jul 2010, 28 Oct. 2010)
  - Electrical vehicles powered by solar energy



VisLab Intercontinental Challenge (2)

- Leader-Follower Model
  - First car drives autonomously **most** of the time. It collects a significant amount of data and performs tests on sensing, decision and control systems. Human **intervention is needed** for route selection and in critical situations.
  - The 2nd car automatically follows the route defined by the preceding vehicle. It is **100% autonomous**.
  - If the leader is visible, it follows it.
  - If the leader is not visible, it uses the GPS coordinates that the leader has determined as part of the route.
  - The follower uses local sensing to refine its position on the road, avoid obstacles and determine speed.

VisLab Intercontinental Challenge (3)

VisLab Intercontinental Challenge (4)

- As of Thursday 14. October 2010 (http://viac.vislab.it)