Introduction to Pattern Recognition

WS 13/14

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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)
  - Tue 10:15 – 11:30 (0.68)
  - Wed 10:15 – 11:30 (0.68)
  - Elli Angelopoulou
  - elli@i5.cs.fau.de

- Exercises (1 SWS - 2.5 ECTS)
  - Wed 14:15 – 15:45 (02.134) **or**
  - Fri 10:15 – 11:45 (00.151)
  - 45 minute session
  - Simone Gaffling
  - simone.gaffling@cs.fau.de

- Exercises are application-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

Additional Material for IntroPR

- When applicable, printed slides will be made available through the web.
- The videotaped lectures from Winter Semester 2012 are available at **video.cs.fau.de**
- You are still expected to take notes yourself.
- Slides and notes do not replace the textbooks (see next slide).
- Most of the slides can be understood only with the additional explanation provided during the lecture and through the use of additional material from textbooks.

PR Reading Material:

- Recommended Textbooks:

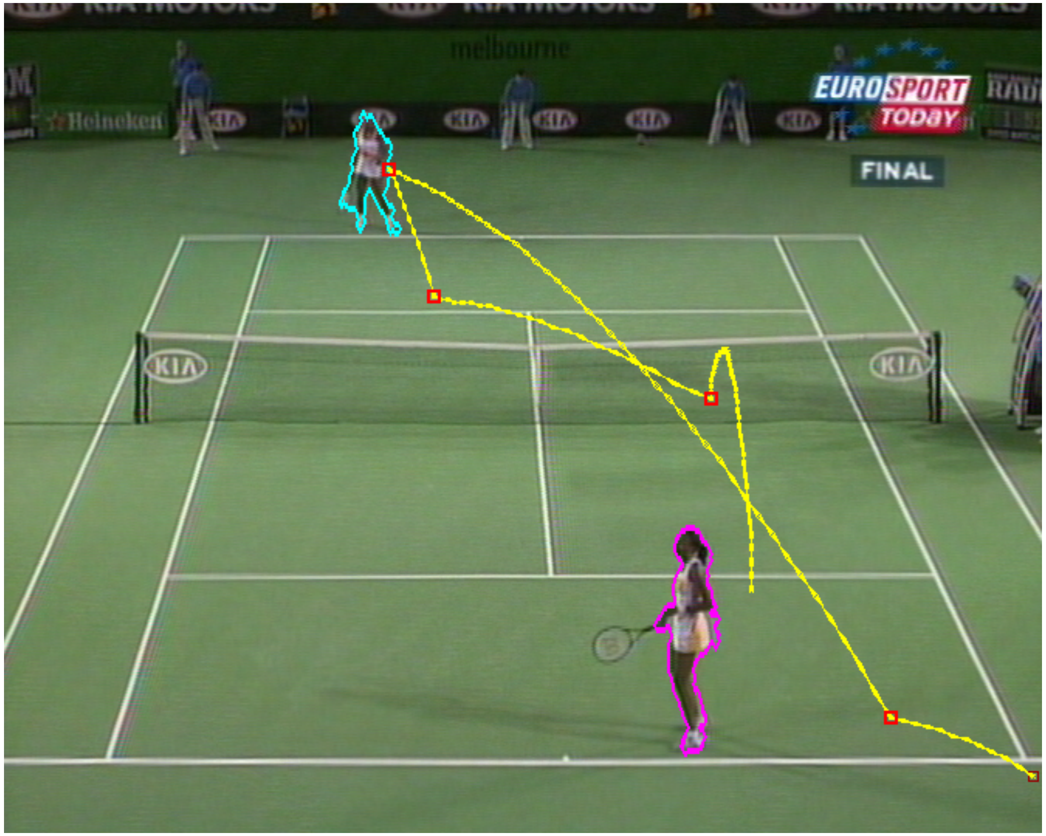
[1] H. Niemann. *Klassifikation von Mustern*. Springer, Berlin, Heidelberg, 1983. Second expanded edition available via Internet:
http://www5.informatik.uni-erlangen.de/en/our-team/niemann-heinrich

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

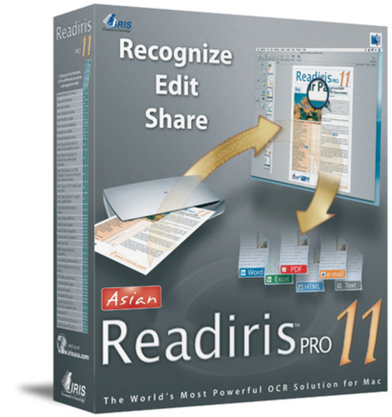
[3] R. Duda, P. Hart, D. Stork, *Pattern Classification*, 2nd ed., Wiley Interscience, 2001.

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 image processing, computer vision, speech processing and digital sports.

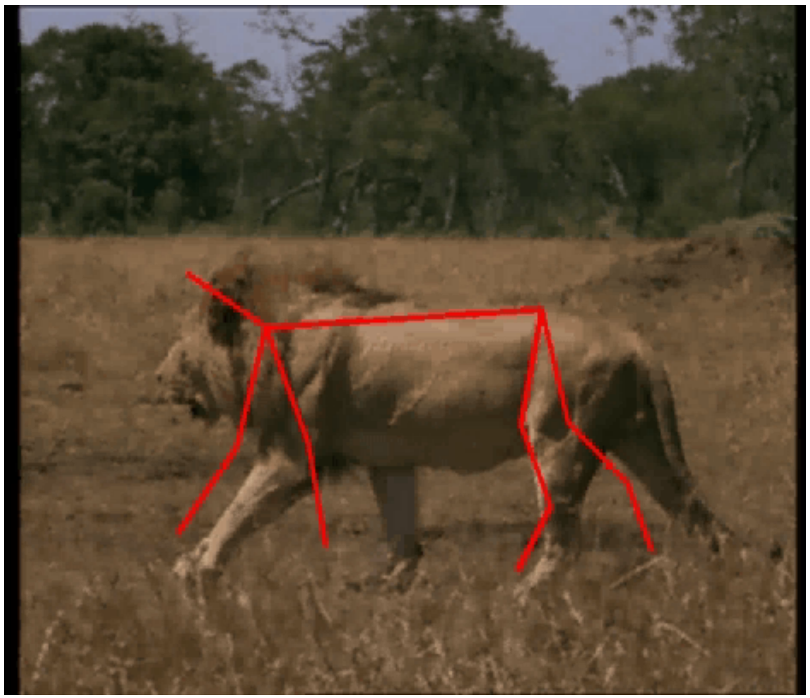
Signal Acquisition

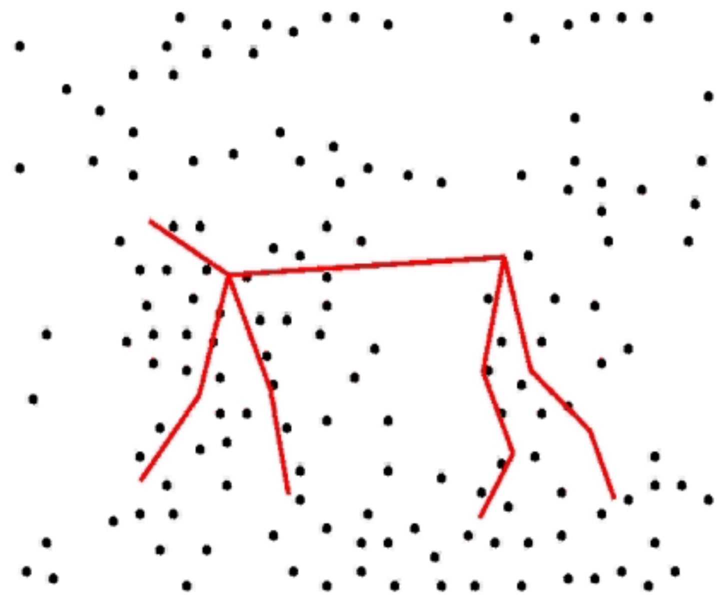
- Depending on the application we can use different types of sensors to acquire data:
  - microphones
  - cameras
  - Xrays, MRIs, CTs, ultrasound
  - GPS sensors, gyroscopes
  - heartrate monitors, perspiration sensors, blood pressure sensors
  - ….
- Once the type of sensor is selected, choosing a 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



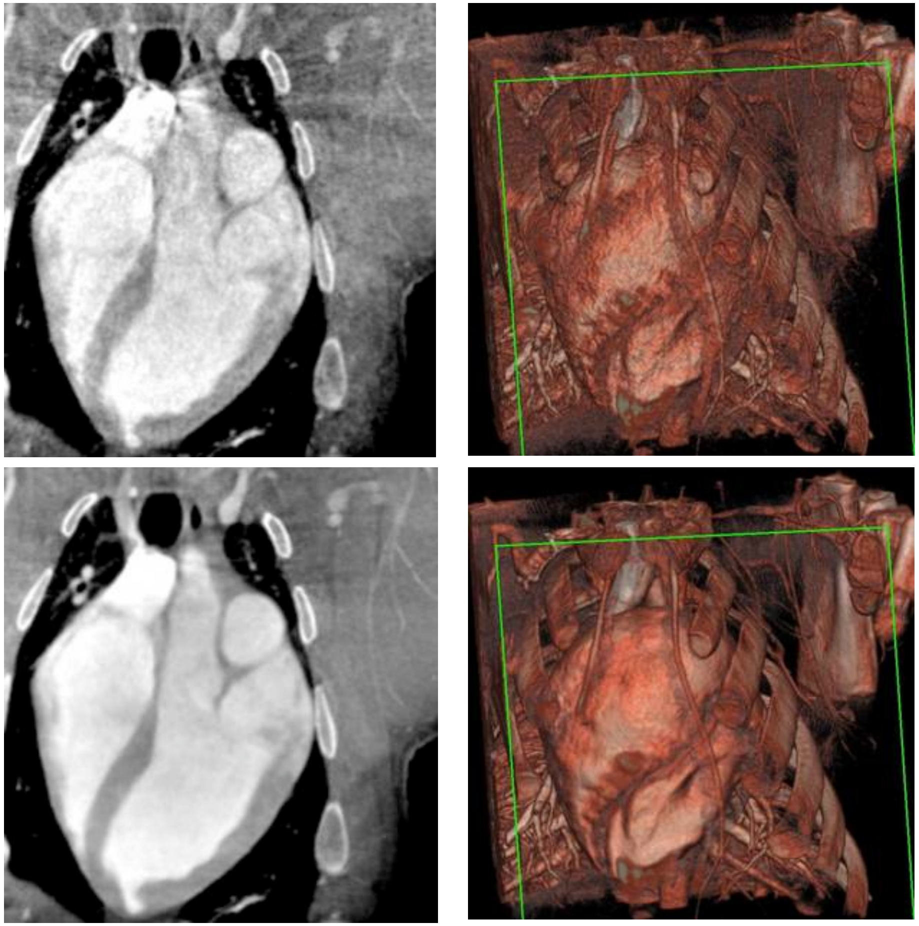


Videoclips courtesy of Ruixuan Wang, Wee Kheng Leow and Hon Wai Leong, "3D-2D Spatiotemporal Registration for Sports Motion Analysis", CVPR 2008

Challenges – Medical Image Processing

- Need for accuracy
- Thorough evaluation

Coronary tree extraction



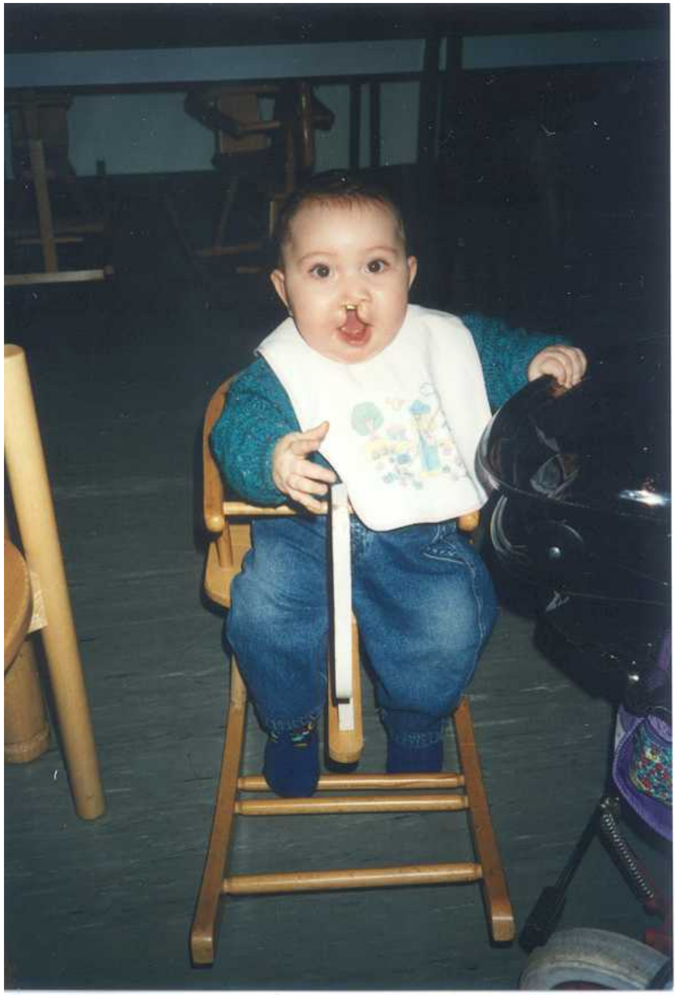
Correction for heartbeat motion using ECG (top) and just image data (bottom)

Challenges – Speech Recognition

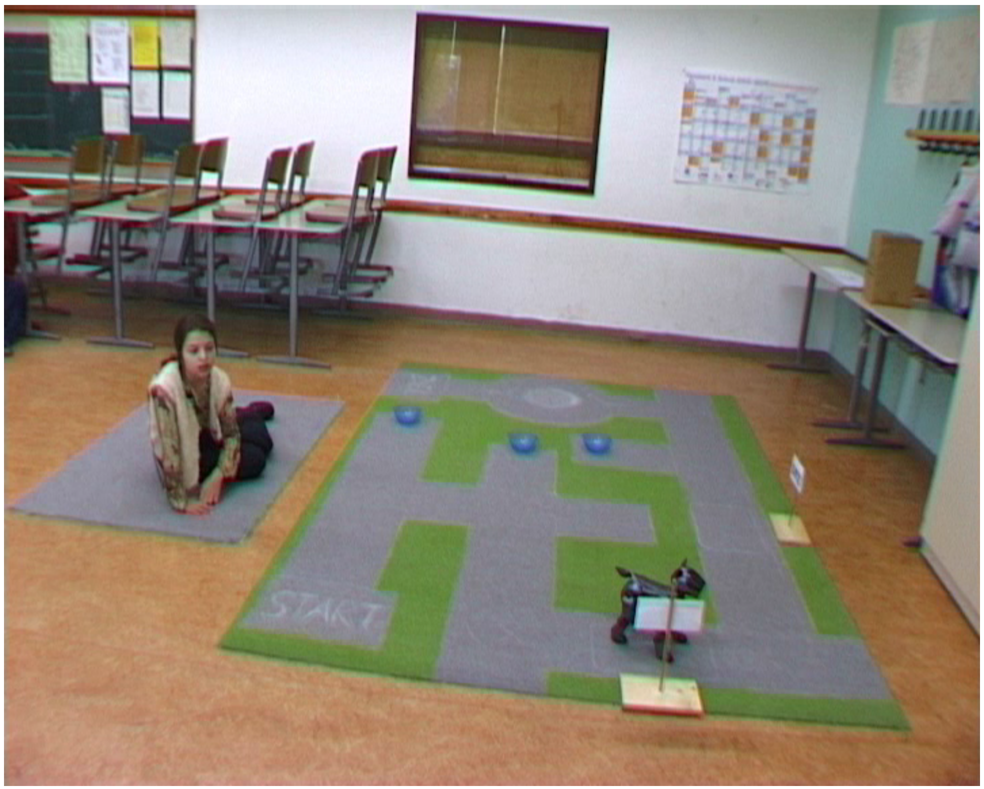
- Why is speech recognition so difficult:
  - Ambiguities (here vs. hear)
  - Emotions
  - Non-distinctive articulation
  - Accents/Dialects
  - Technical problems (microphones, encoding, …)

  Also:
  - Diseases of the oral apparatus

Cleft Palate



Spontaneous Child Speech

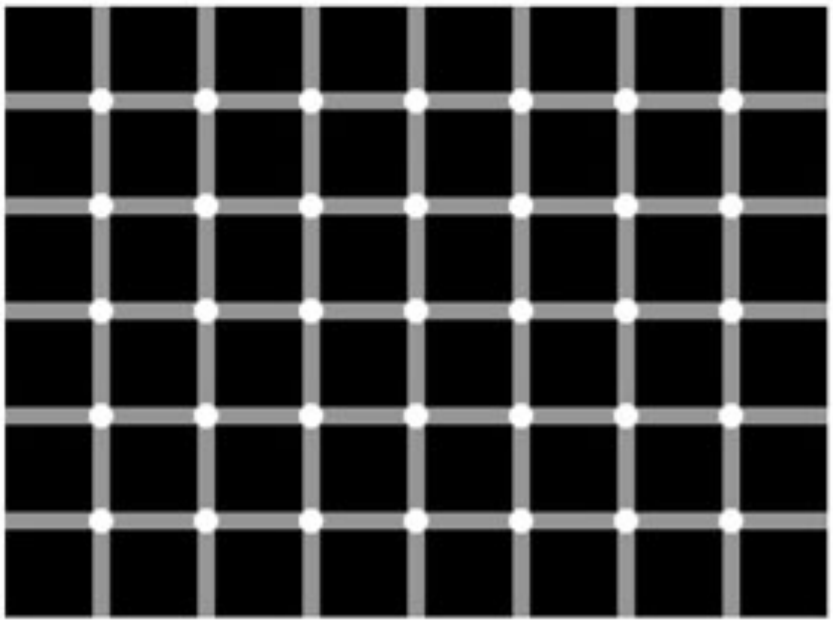


geradeaus Aibolein ja M fein M gut M
machst M du M *da M | *tz läufst du
mal bitte nach links | stopp E Aibo
stopp | nach links E umdrehen | nein M
<*ne> nein M <*ne> nein M <*ne>
so M weit M *simma M noch M nicht
M aufstehen M Schlafmütze M komm
M hoch M | ja M so M ist M es M
<*is> guter M Hund M lauf mal jetzt
nach links | nach links Aibo | Aibolein M
aufstehen M *son M sonst M werd' M
ich M böse M hoch E | nach A links A |
Aibo A nach A links A | Aibolein A ganz
A böser A Hund A jetzt A stehst A du A
auf A | hoch A | dreh dich ein bisschen
| ja M so ist es <*is> gut stopp Aibo
stopp | *tz lauf g'radeaus

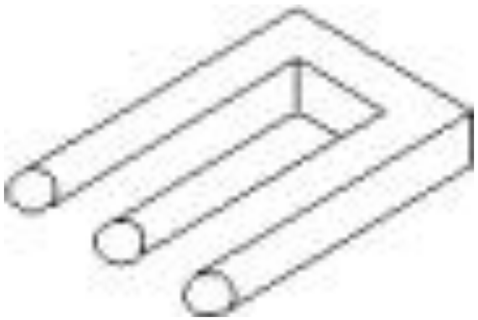
Challenges – Computer Vision

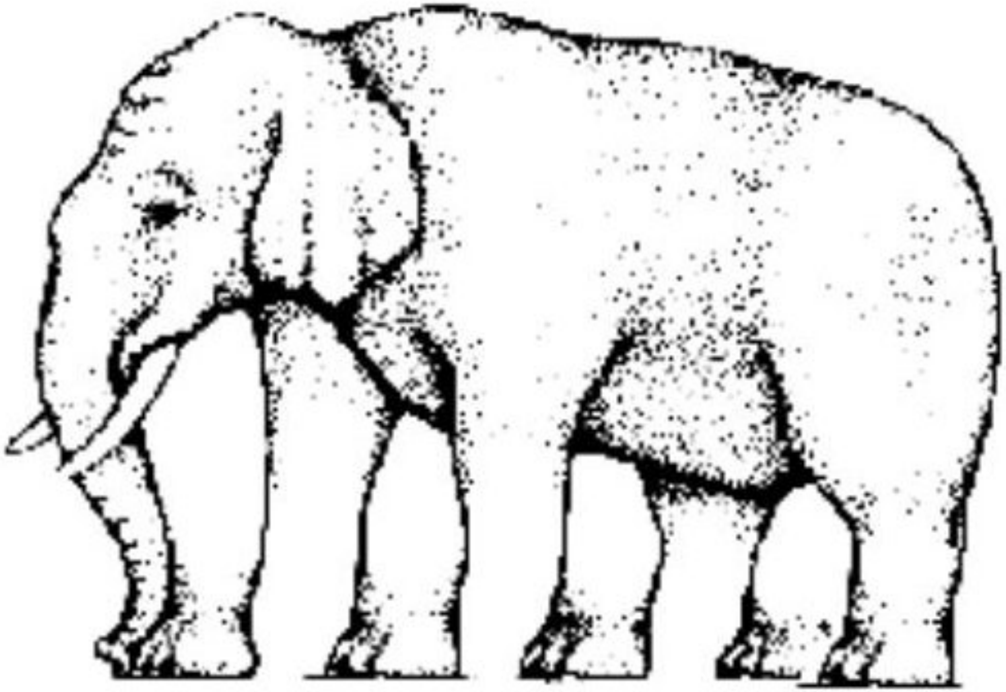
- Why is computer vision so difficult:
  - Ambiguities
  - Implicit knowledge
  - Prior information
  - Technical problems (noise, limited data, encoding...)

Influence of Entire Image



Implicit Knowledge





How many legs does this elephant have?

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
  - 22 out of the 23 participants surpassed the 11.78km distance.
  - 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

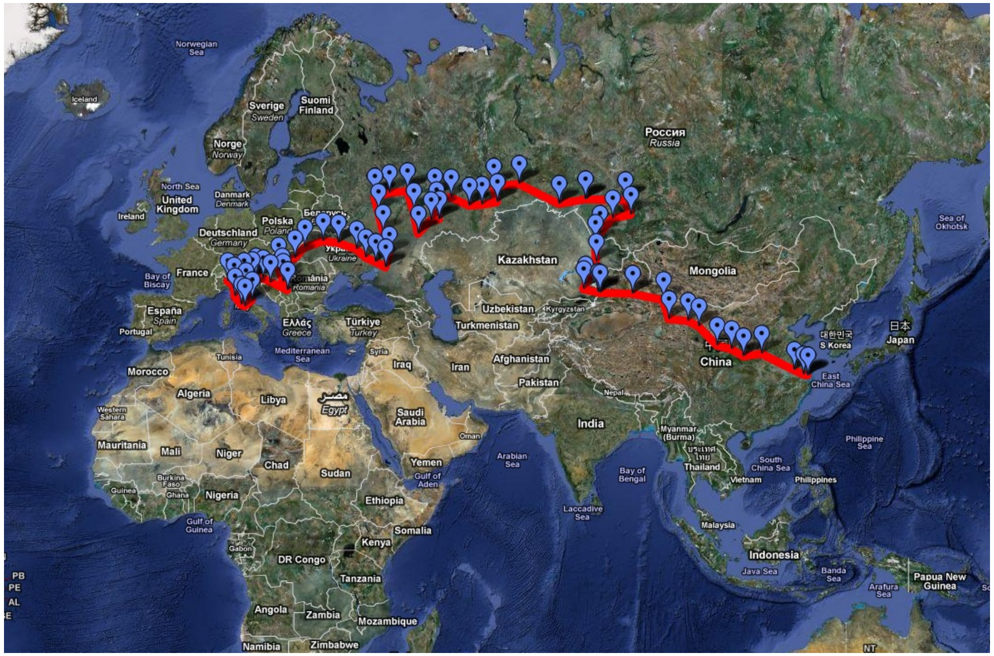
- Goal: Autonomous driving in an city setup
- Course:
  - 96km to be completed in less than 6hrs
  - Obey all traffic regulations
  - Handle obstacles and other cars on the road
  - Merge into traffic
- Day of Final Event: November 3, 2007
- Results:
  - 35 participants, 11 passed to the finals
  - 6 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

You can watch this video at http://youtu.be/AABag3lLy5E

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, 26 Oct. 2010)
  - 4 electric vehicles powered by solar energy



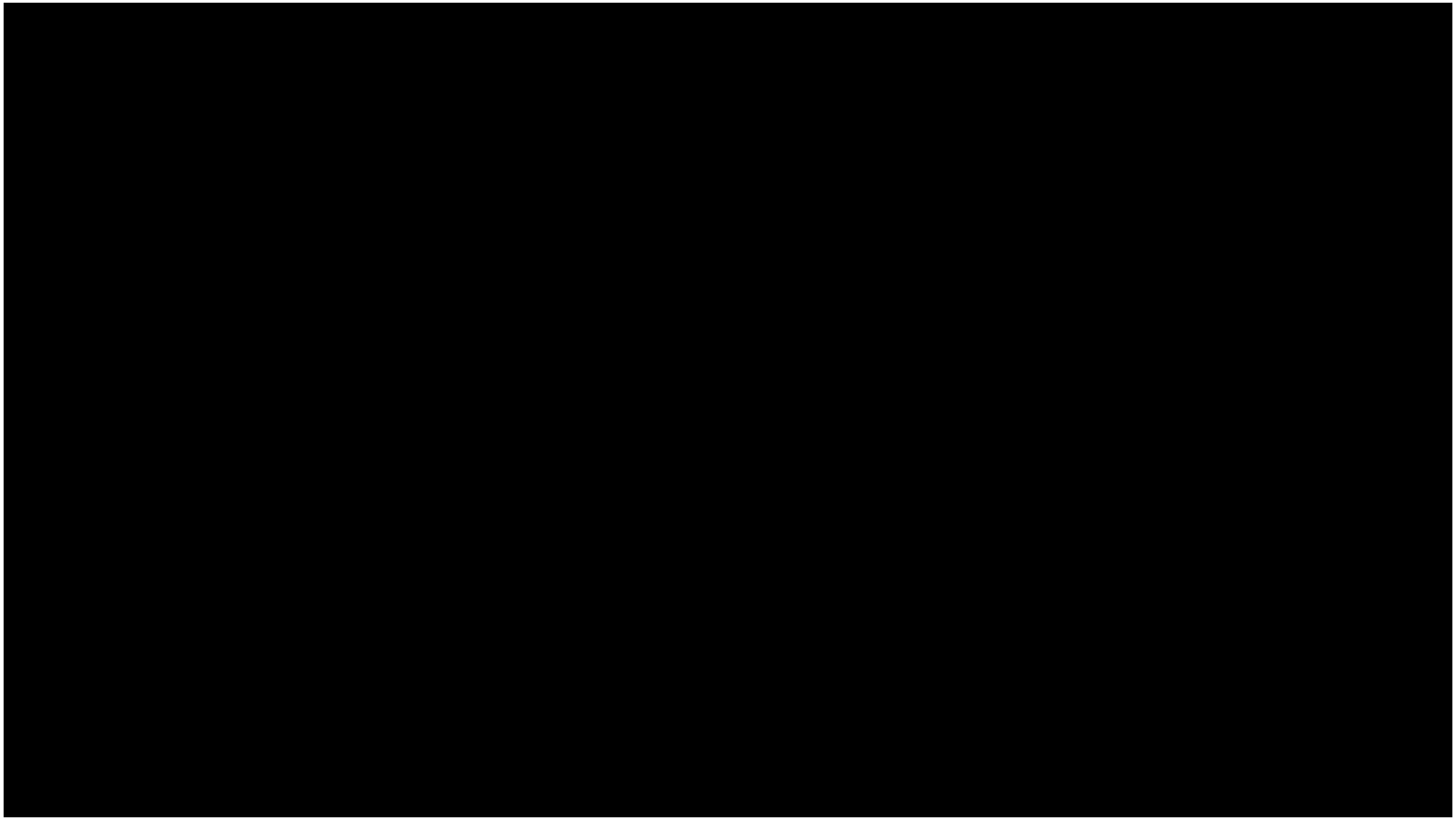
VisLab Intercontinental Challenge (2)

- 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 (3)

VisLab Latest Accomplishment



For additional videos and information check out

http://vislab.it/video/