

Introduction to Pattern Recognition

WS 11/12



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Lehrstuhl für Mustererkennung (Informatik 5)

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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 12:15 – 13:30 (0.68)
 - Wed 12:15 – 13:30 (0.68)
 - Elli Angelopoulou
 - elli@i5.cs.fau.de

- **Exercises (1 SWS - 2.5 ECTS)**
 - Wed 8:15 – 9:45 (E 1.12)
 - Thu 8:15 – 9:45 (E 1.12)
 - Christian Riess
 - riess@i5.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 2010 are available at StudOn under Inf5 (Mustererkennung).
- 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>

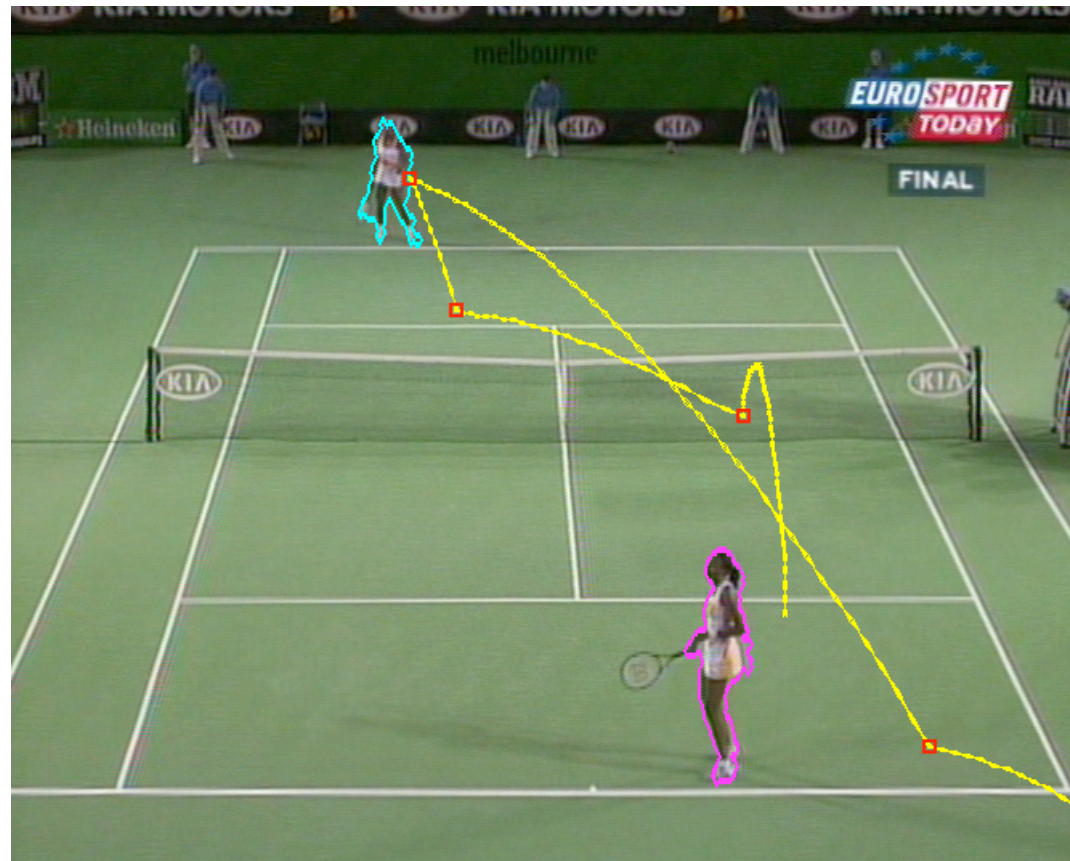
[2] S. Theodoridis and K. Koutroumbas, *Pattern Recognition*, 4th ed. Academic Press, 2009.

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

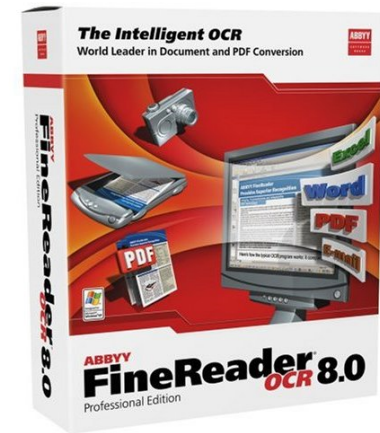
What is Pattern Recognition?



- 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 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
 -

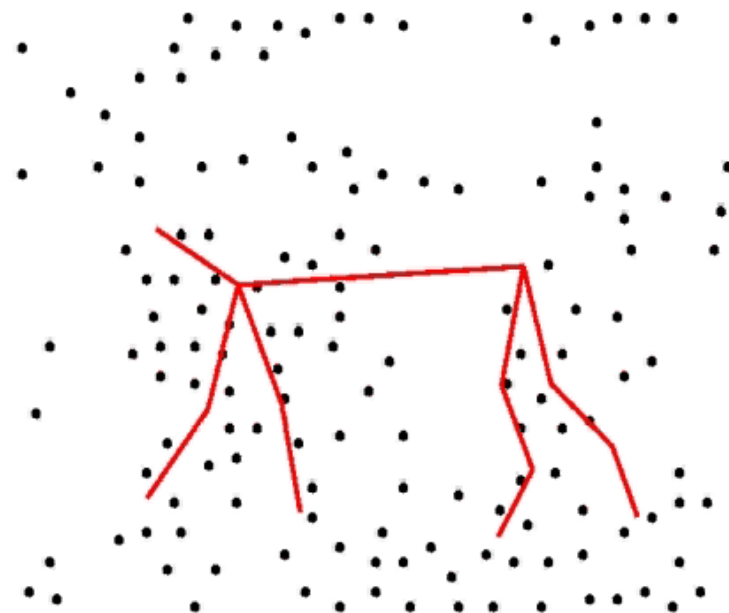
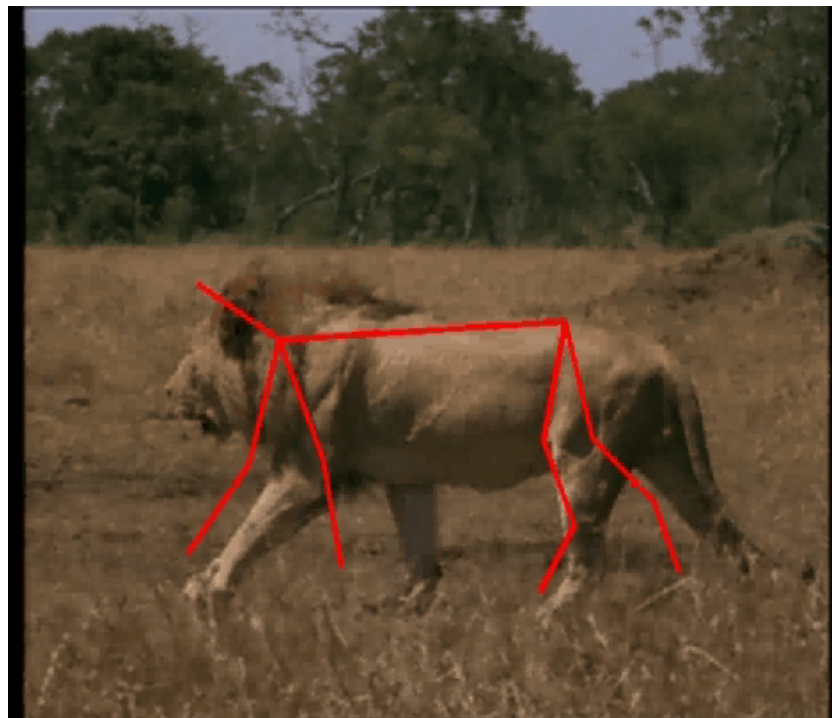
- Once the type of sensor is selected, choosing a particular model can have a significant impact on the overall performance of our PR system:
 - noise levels
 - data acquisition speed
 - amount of collected information
 - built-in preprocessing

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

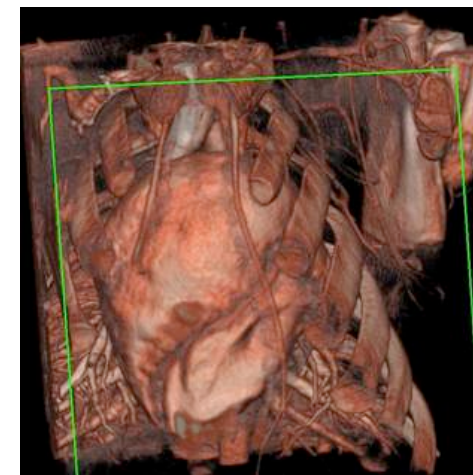
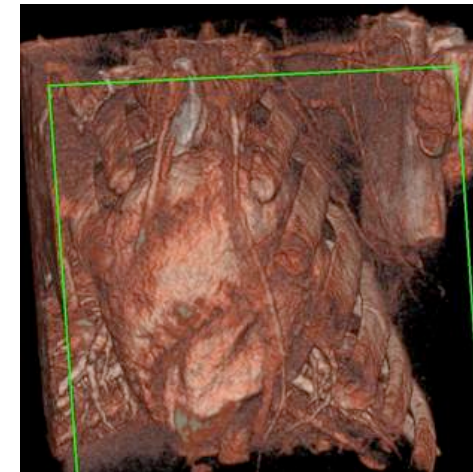
Challenges – Medical Image Processing



- Need for accuracy
- Thorough evaluation



Coronary tree extraction



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

Challenges – Speech Recognition



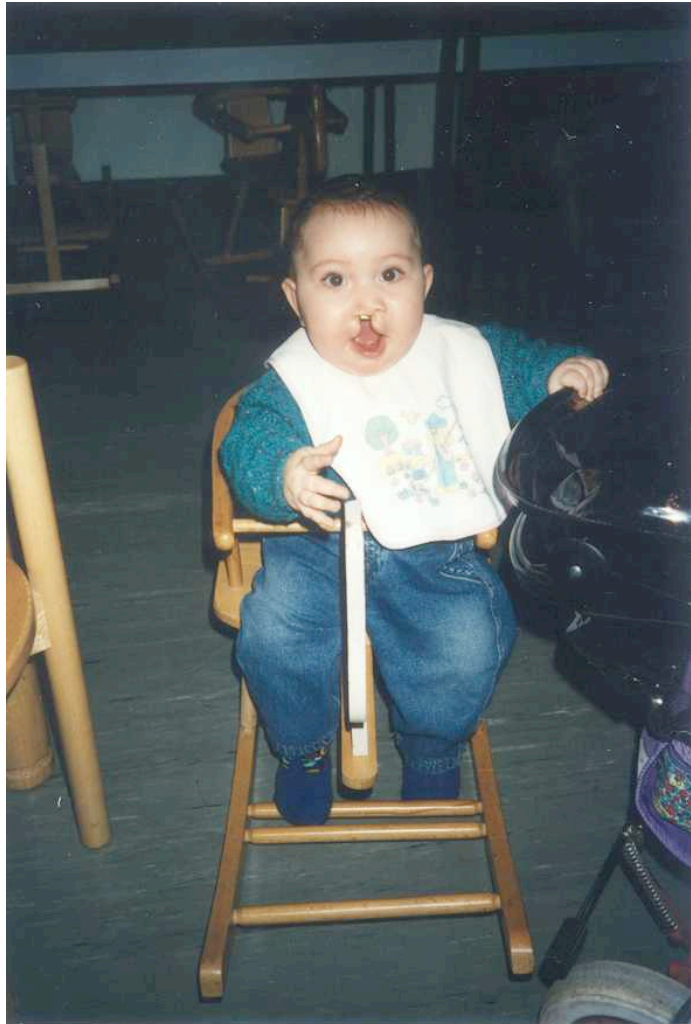
- Why is speech recognition so difficult:
 - Ambiguities (here vs. hear)
 - Emotions
 - Non-distinctive articulation
 - Accents/Dialects
 - Technical problems (microphones, encoding, ...)

Also:

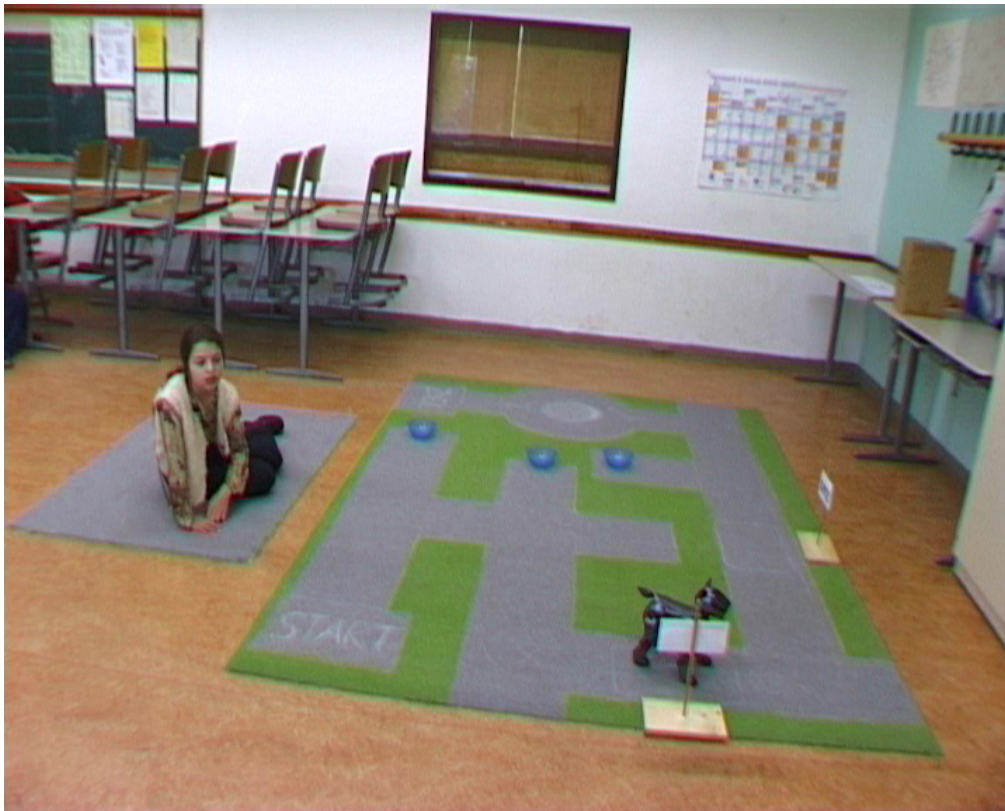
- Diseases of the oral apparatus



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
 <*is> 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...)



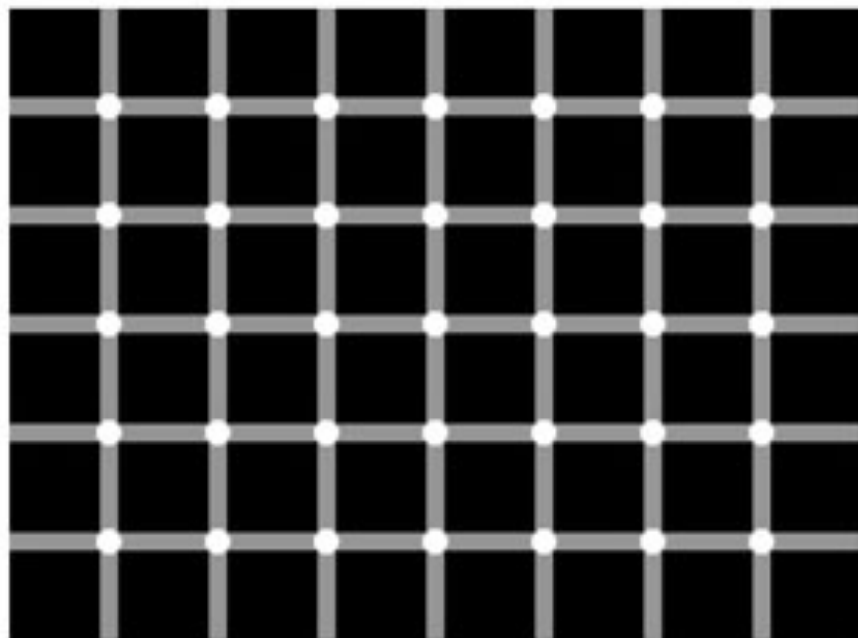
BEFORE 6 BEERS



AFTER 6 BEERS

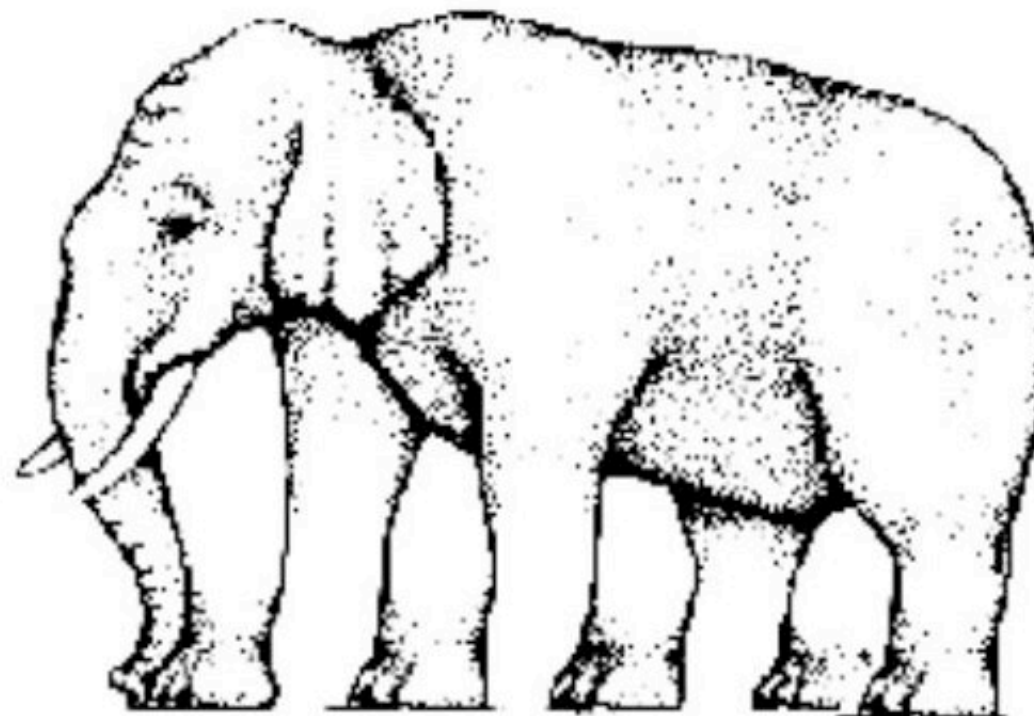
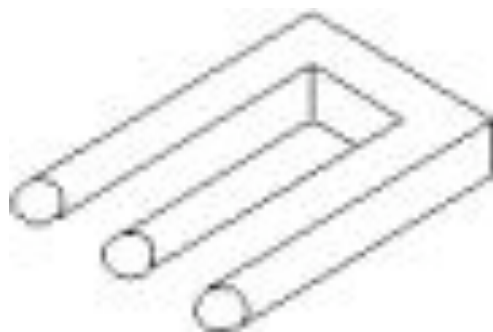


Influence of Entire Image





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 organization of the USA Department of Defense.

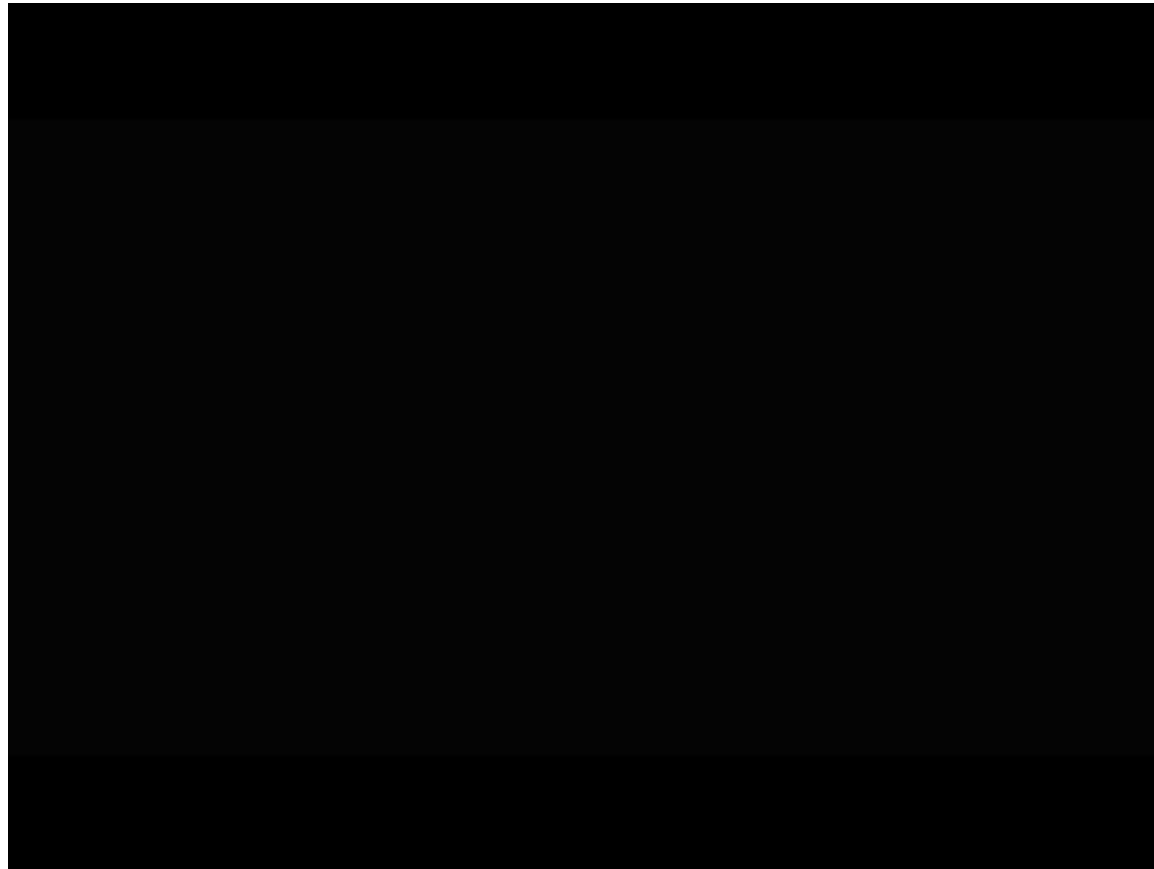
- „DARPA Grand Challenge“ of 2004 – Mojave Desert, CA, 240km
 - No competitor of the 21 participants finished the race
 - CMU won for completing the longest distance 11.78km

- „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

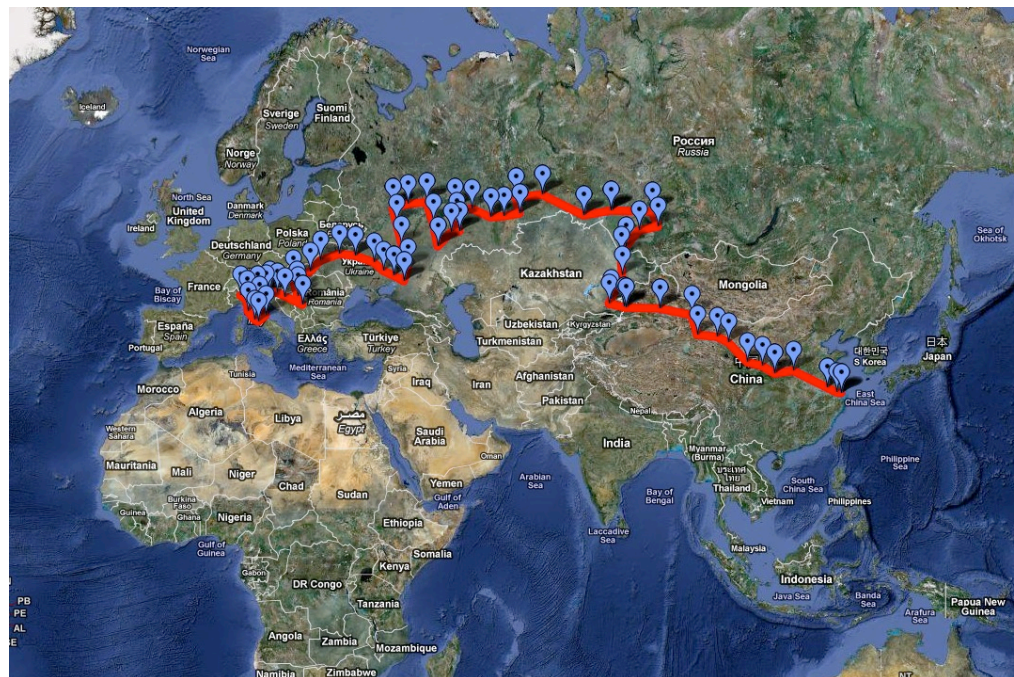
DARPA Urban Challenge Event





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)

