Methods of Artificial Intelligence

Week 1: Introduction

UNIVERSITÄT OSNABRÜCK

Overview

- Organization
  - Course Organization
  - Textbooks
  - Course Topics
- Recent Developments in AI
  - Agent View, Games, Architectures, Semantic Web, Neural-Symbolic Integration
- AI at the IKW
  - Examples
- Organization once more again

Methods of AI: WS 2017/2018

- Contact information:
  - Kai-Uwe Kühnberger: kkuehnbe@uos.de
  - Nico Potyka: npotyka@uni-osnabrueck.de
- Times and rooms:
  - Lecture: Monday 12:00 – 14:00 room 93/E31
  - Lecture: Tuesday 12:00 – 14:00 room 93/E31
- Tutorials:
  - Two tutorials will take place
  - Tutorial 1: Wednesday 12:00-14:00, room tba
    Tutorial 2: Friday 14:00 – 16:00, room tba
- Tutors
  - Johannes Schrumpf: jschrumpf@uni-osnabrueck.de
  - Anton Laukemper: alaukemper@uni-osnabrueck.de

Methods of AI: WS 2017/2018

- Intended Audience:
  - Cognitive Science Bachelor students
  - Cognitive Science Master students
  - Others?
  - Who did attend the “Introduction to AI and Logic Programming course”?
- If you want to participate in this course, please sign-up using the StudIP tool for the two courses:
  - Lecture & Practice course (e.g. uploaded slides from the lectures can be found here, exams will be written here)
  - Tutorial (papers for presentations can be found here)
    - You can sign-up for building work groups soon.

Course Organization

- What you need to do to get a certificate:
  - Midterm examination (25%)
  - Final examination (35%)
  - Programming project (20%)
    - Consists of two parts
      Part I: Implement a grid world environment
      Part II: Implement a reinforcement learner in grid world
  - Presentation & Short online quizzes using StudIP (20%)
    - One presentation in a group should be given in the tutorial (graded)
    - Approx. 10 times during the semester there will be some online quizzes that can be solved at home (not graded)
    - Requirement: each student needs to solve 50% of the problems correctly
    - Some of the quiz problems will appear in the exams
- Each achievement needs to be passed in order to get a certificate.

Course Organization

- **Organization schedule**
  - **This week:** No tutorials will take place during the first week of the semester.
  - **This week:** sign-up for working groups using StudIP “MAI (Tutorial)”; group slots will be provided in StudIP
  - **This week:** candidate papers for paper presentations will be uploaded in StudIP (Tutorial Wiki). Please have a look at the papers during the next weekend.
  - **Next week:** preferences for paper presentations due. Please, e-mail a preference list of three papers per group to jschrumpf@uni-osnabrueck.de

Tentative Schedule of this Course

1.	23.10.2017	Introduction
	Part I: Foundations & Planning	
2.	30.10.2017	Local Search
3.	06.11.2017	Constraint Satisfaction Problems Advanced
4.	13.11.2017	Theorem Proving Advanced
5.	20.11.2017	Planning
	Part II: Reasoning & Learning	
6.	27.11.2017	Knowledge Representation
7.	04.12.2017	Midterm
8.	11.12.2017	Reasoning over Space and Time
	18.12.2017	Uncertain Reasoning and Learning Basics
9.	08.01.2018	ML 1: SVMs and Random Forests
10.	15.01.2018	ML 2: Reinforcement Learning
	Part III: Cognitive Architectures & Games	
11.	22.01.2018	Cognitive Architectures
12.	29.01.2018	Games Advanced
13.	05.01.2018	Repetition
14.	06.02.2018	Final Exam

Textbook

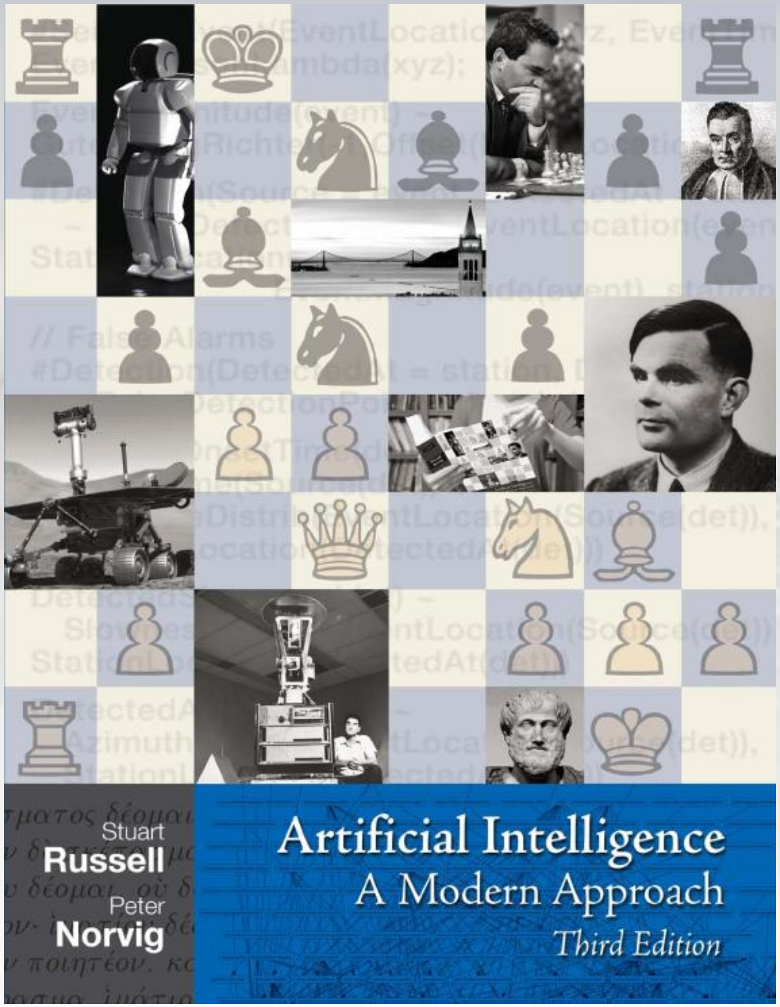
Stuart Russell & Peter Norvig

Artificial Intelligence: A Modern Approach

[without exaggeration *the* AI textbook]

Prentice-Hall, 2010

http://aima.cs.berkeley.edu/



More Textbooks

- **Artificial intelligence : a new synthesis** / Nils J. Nilsson, San Francisco, Calif.: Kaufmann, 1998. - XXI, 513 S. ; ISBN 1558604677
- **Artificial intelligence** / Patrick Henry Winston. - 3rd. ed., reprinted with corr. Reading, Mass. [u.a.]: Addison-Wesley, 1993. - XXV, 737 S.; ISBN 0201533774
- **Artificial intelligence** / Elaine Rich; Kevin Knight. - 2. ed. New York [u.a.]: McGraw-Hill, 1991. - XVII, 621 S.; ISBN 0070522634
- **Handbuch der künstlichen Intelligenz** / edited by Görz, Schneeberger, Schmid - 5. Aufl. Oldenbourg, 2013.

The *Methods of AI* Course

- Is the Methods of AI course a typical AI course?
  - Yes, with an emphasis on methodological issues and cognitive aspects.
  - The course will give a broad overview of topics and research questions in AI.
  - What you will not learn is a specialization in and an in-depths examination of a very narrow field in AI.
  - Some potentially interesting topics will not be discussed (like computer vision, neural learning etc.), because you can find specialized courses for such topics.

Comparison to Topics at IJCAI 2016

- Topics of the International Joint Conference on Artificial Intelligence 2016 (Topics marked with * will be discussed to a certain extent in this course)
  - Agent-Based and Multiagent Systems (cf. seminar on Multiagent systems)
  - *Combinatorial & Heuristic Search
  - *Constraints & Satisfiability
  - *Knowledge Representation, Reasoning, and Logic
  - *Machine Learning
  - *Multidisciplinary Topics and Applications
  - Natural Language Processing (cf. computational linguistics)
  - *Planning and Scheduling
  - Robotics and Vision (cf. Lectures of the computer vision group)
  - *Uncertainty in AI
  - *AI and the Web

Recent Developments in AI

AlphaGo and more…

Artificial Intelligence

http://www.youtube.com/watch?v= WFR3lOm_xhE

Mobile devices

Smart home: Heating, Lighting, Entertainment, Security, Shades etc.

Autonomous Google car

Autonomous Daimler truck

Google’s Big Dog, Honda’s Asimo,

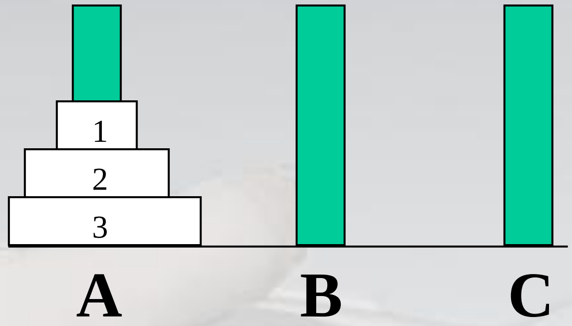
NSA headquarters

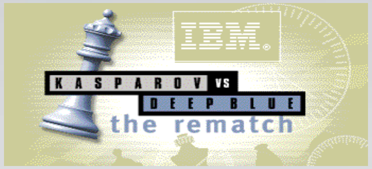
Artificial Intelligence

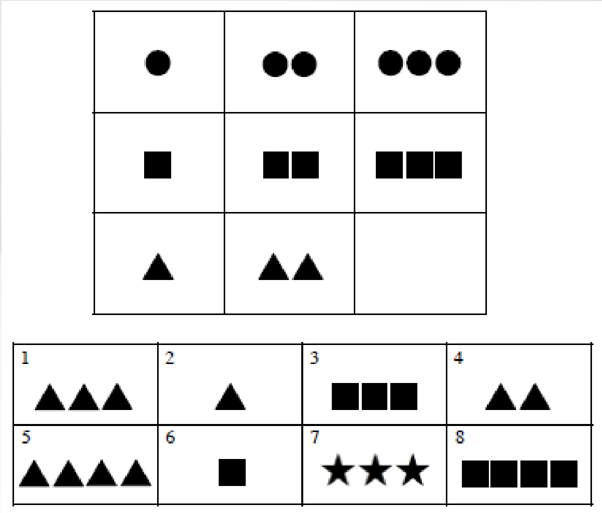
Carl Sandburg‘s poem Fog:

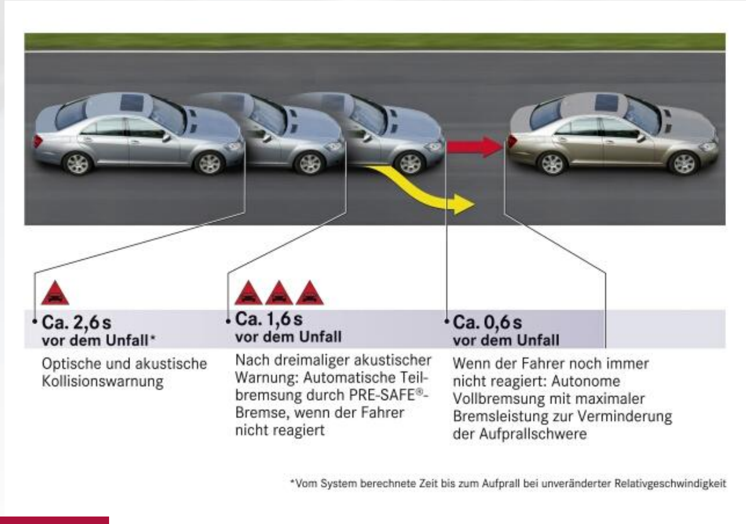
The fog comes
on little cat feet.

It sits looking
over harbor and city
on silent haunches
and then moves on.









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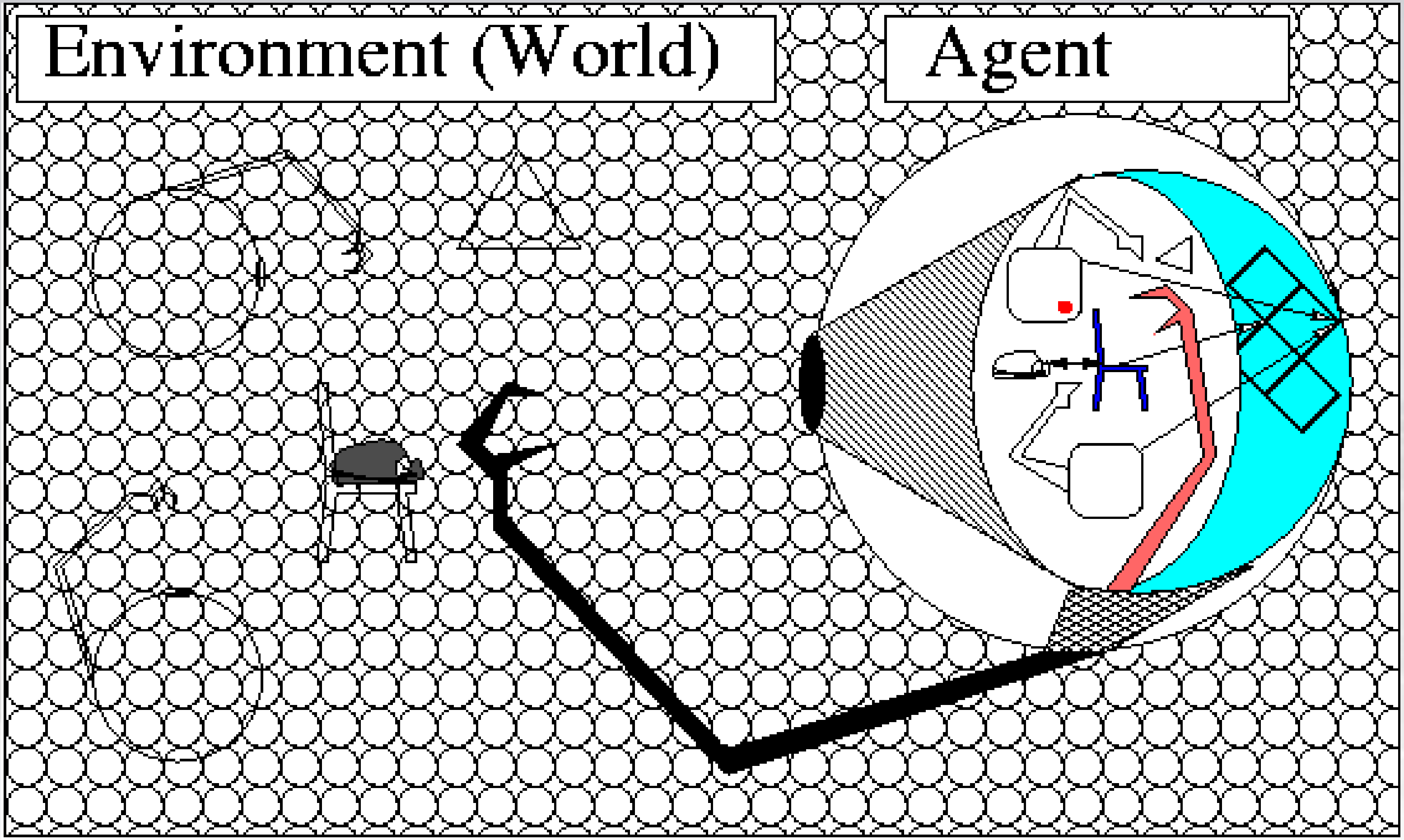
The Agent View of AI



Agent View: Autonomous Cars

Result of this endeavor:

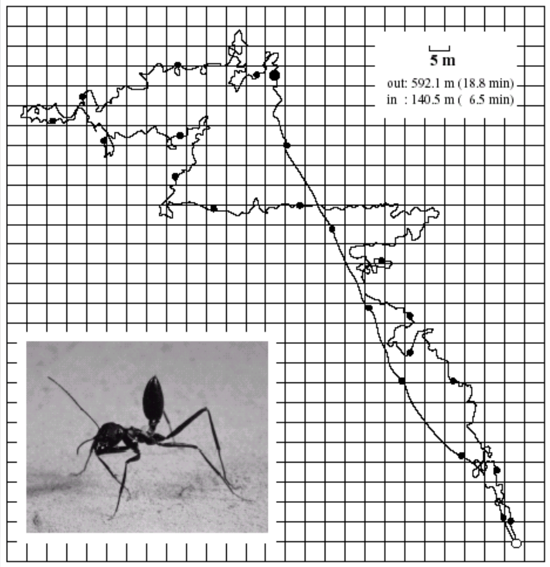

Autonomous Google car


Autonomous Daimler truck

- Example 1: Autonomous agents / robotics
- Winner of the Grand Challenge 2005
  - Sebastian Thrun (former Director of the AI Lab in Stanford)
  - Prize money: $ 2.000.000
  - Sponsor: DARPA (Defense Advanced Research Projects Agency)
  - http://www.youtube.com/watch?v=2gQ3P5BpLjQ
  - Modern versions of autonomous cars exist for more or less all major car producers and several internet companies

Agent View: New AI

- Example 2: Dimitrios Lambrinos et al. (University of Zürich) worked on a robot model of orientation of the desert ant Cataglyphis …



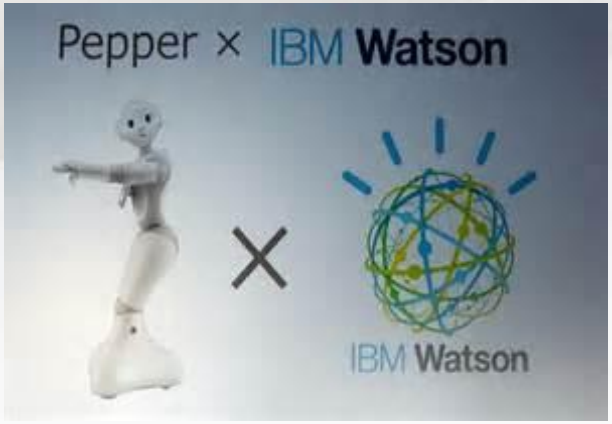
- The ant and the robot show a similar orientation behavior in the Sahara environment based on polarized light and landmarks.
- Modern versions of New AI ideas are often used in Cognitive Robotics

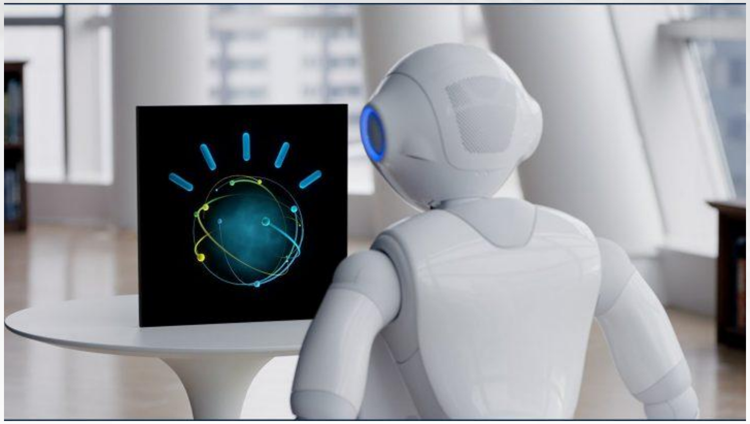
Agent View: Humanoid Robots

Example 3: Watson & Pepper at CES 2016

https://www.youtube.com/watch?v=xvajAkUh6UE

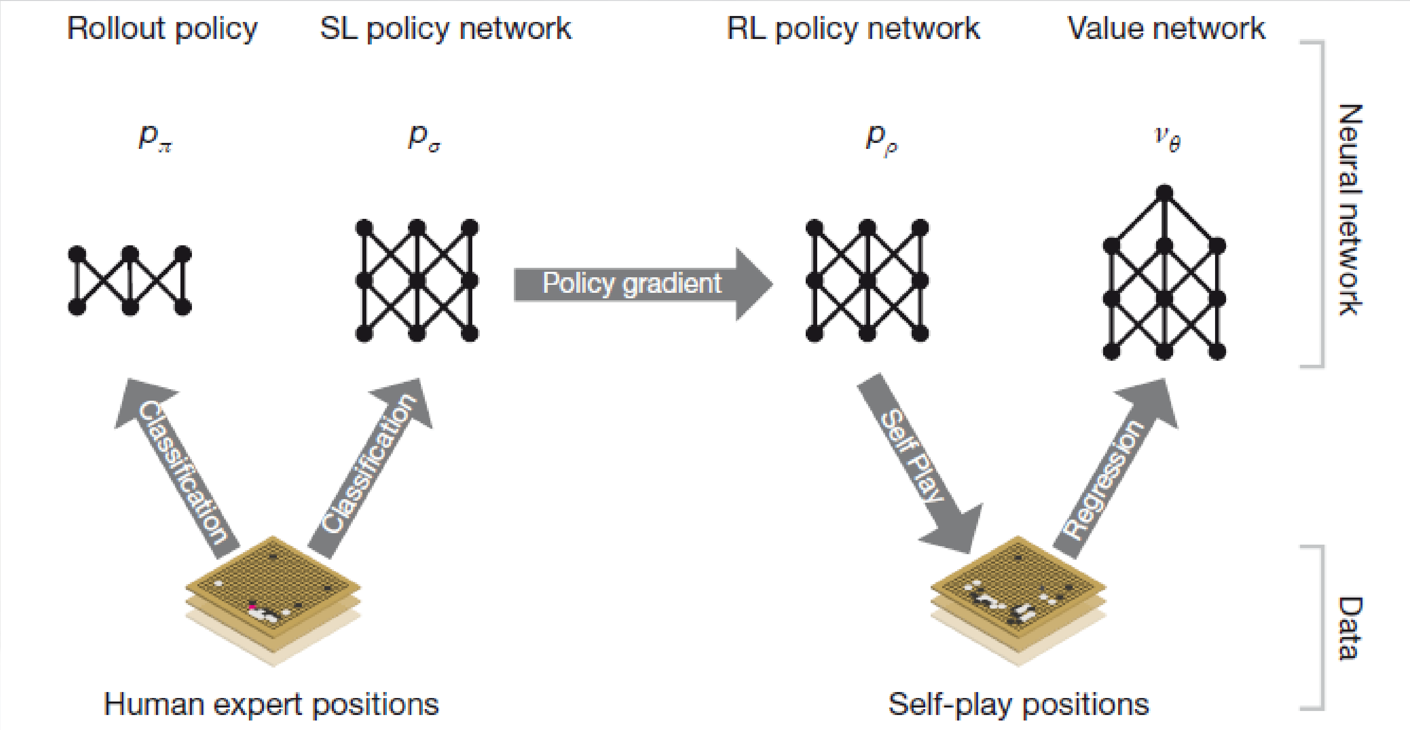
There is currently a study project running “Data Analytics and Question Answering…” that is trying to train Pepper as an e-tutor.





Game Playing: AlphaGo

Example 4: Deepmind’s AlphaGo (Game Playing)



Silver et al. (2016), Nature

Game Playing: Jeopardy!

Example 5: Real-Time Game Shows

Watson Jeopardy!

https://www.youtube.com/watch?v=WFR3lOm_xhE

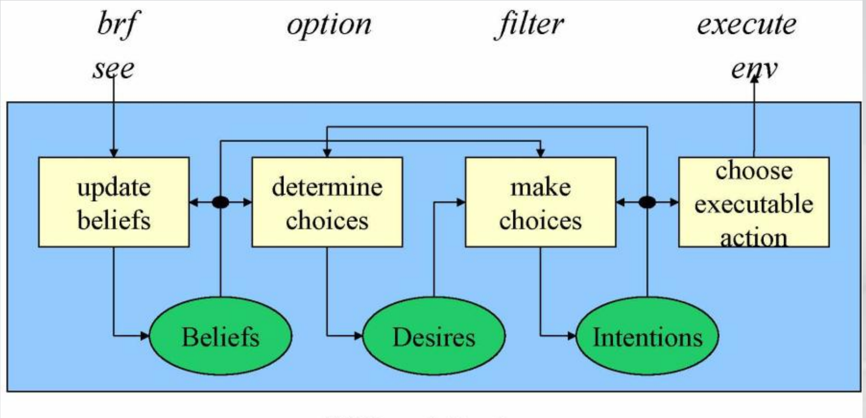
Game Playing: Poker

- Example 6: Texas Hold ´Em Poker is solved
- 2015 Poker was solved for a restricted version
- 2017 Poker was solved for the unrestricted version

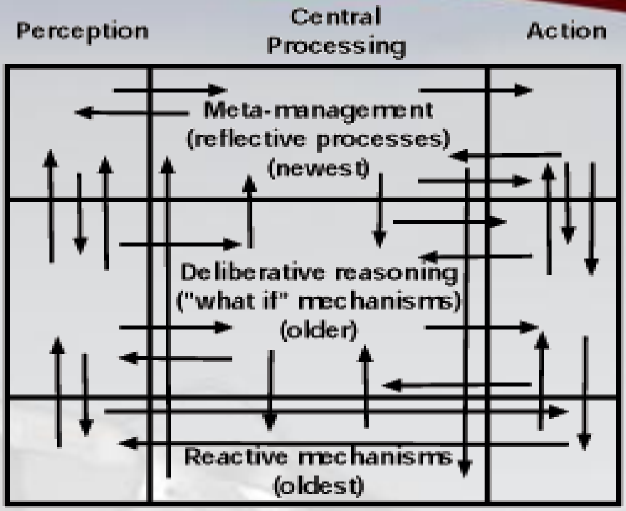
- Some concepts used in poker
  - Nash equilibrium
  - Algorithms for computing the Nash equilibirum
  - At least in one approach deep learning is used (DeepStack)

Cognitive Architectures

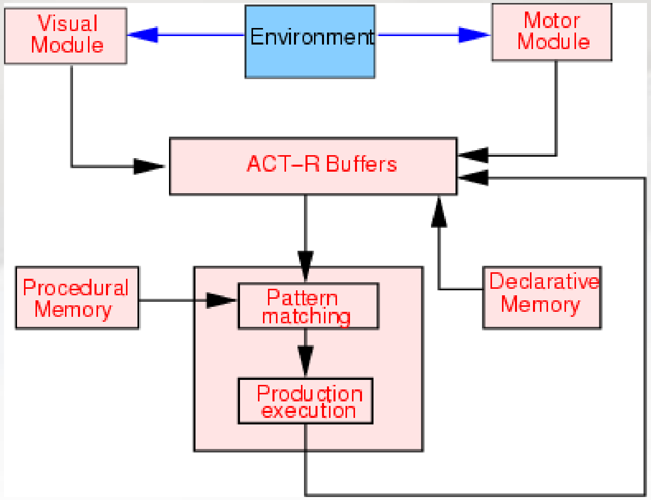
Example 7: Cognitive Architectures



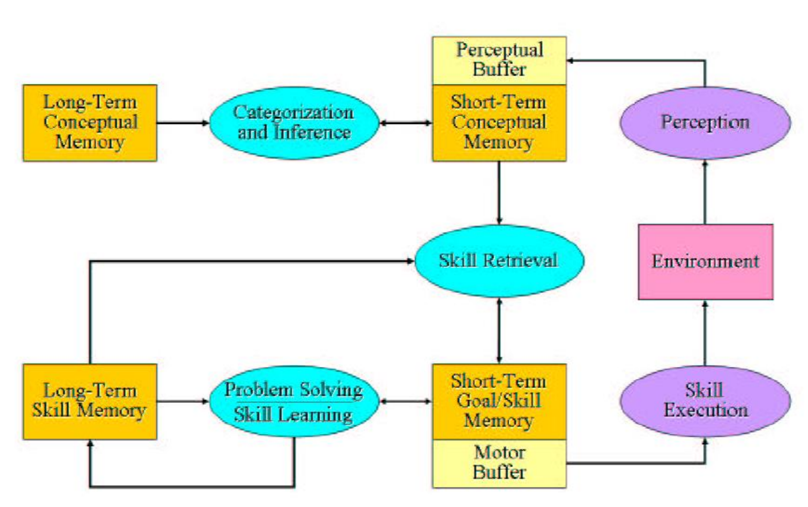
BDI architecture



Subsumption architecture



ACT-R



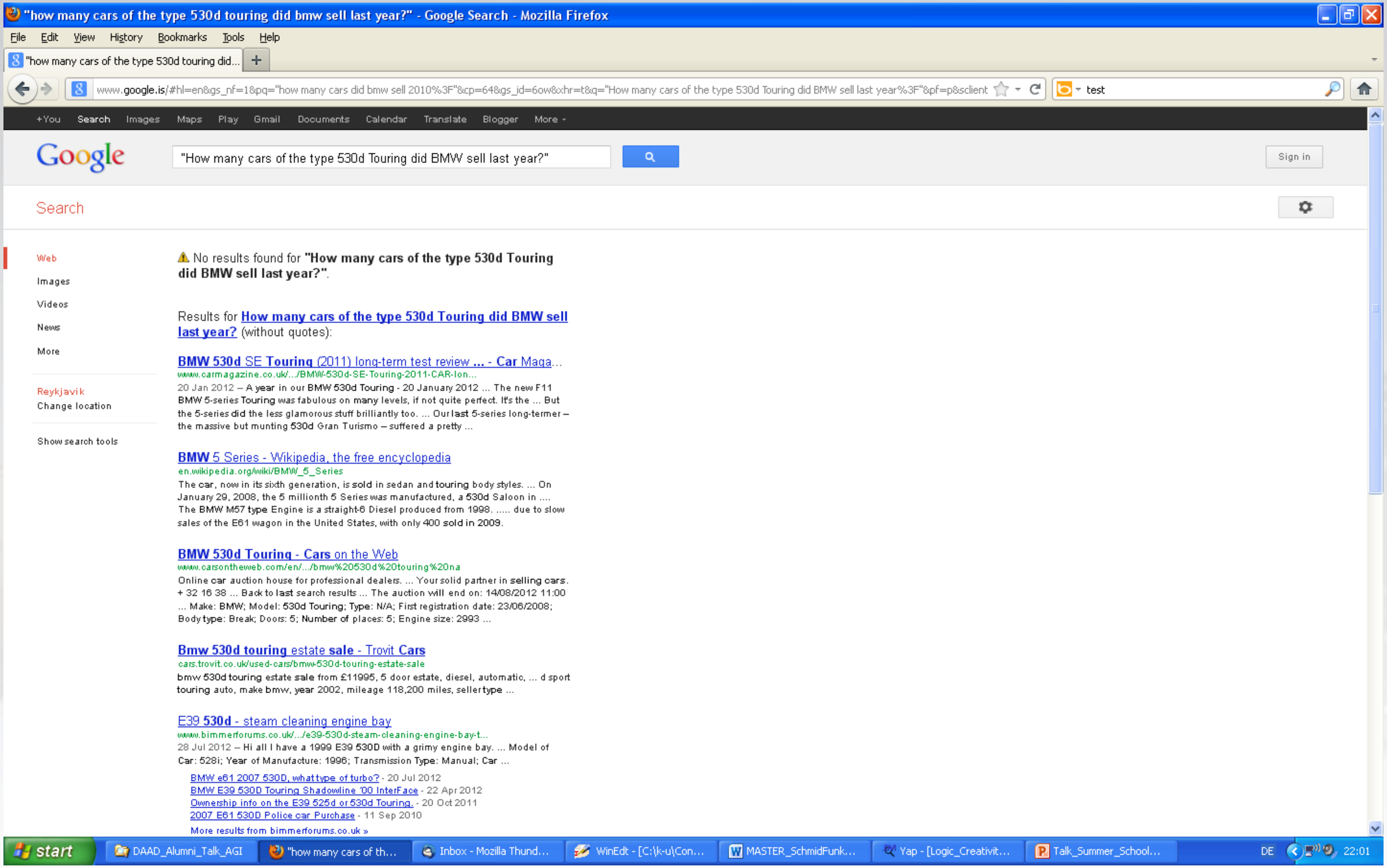
ICARUS Architecture

Semantic Web

Example 8: Semantic web

- Query: “How many cars of the type 530d Touring did BMW sell last year?”
  - Search engines output many (irrelevant) pages, but no answer to this question.
  - Search engines do not understand such questions. They do only know what statistically users assess as being interesting.

Semantic Web



Neural-Symbolic Distinction

Example 9: Neural-Symbolic Integration

- Neural approaches
  - Good in / for:
    - Learning from noisy data.
    - Handling inconsistencies (robust)
    - Modeling lower cognitive abilities (perception, motor control etc.)
  - Bad in:
    - Deductions, theorem proving
    - Planning
    - Problem solving
    - Generating recursively new representations
- Symbolic approaches
  - Good in / for:
    - Deductions, theorem proving
    - Planning
    - Problem solving
    - Generating recursively new representations
  - Bad in:
    - Learning from noisy data
    - Resolving inconsistencies (non-robust)
    - Modeling lower cognitive abilities (perception, motor control etc.)

Neural-Symbolic Distinction

- From a methodological perspective:
  - Neural networks use homogeneous data structures as input (vectors of real numbers $\boldsymbol{x} \in \mathbb{R}^n$) for learning and cannot represent easily complex data structures. Analytic methods need to be applied.
  - Symbolic approaches use complex data structures for manipulation. Usually logical / algebraic methods are used.
- If it is true that there is a not-trivial gap between neuro-inspired and symbolic approaches, what are techniques for a neuro-symbolic integration?
  - How is it possible to train NNs with complex data structures?
  - How is it possible to extract rules from trained NNs?

AI from Different Perspectives

- **First perspective**
  - AI as an engineering science
    - Example: Automatic sorting of letters in the post office, i.e. recognizing handwritten addresses
    - Example: Building assistant systems for cars
- **Second perspective**
  - AI as a cognitive science modeling animal (human) behavior
    - Example: Modeling natural language
  - In contrast to AI that models usually competence (example above), cognitive psychology usually models performance!
- **Third perspective**
  - AI as the answer to the questions „What is intelligence?“ and „What is a simulation of intelligent behavior?“
    - Connection to philosophy
    - Are there „natural laws“ of intelligence?

Models for AI Research

Increasing Degree of Abstraction

Wang (2008) distinguishes 5 types of AI research:

1. Defining AI by structure
   Model “**brain-like**” **structures** (e.g. NNs, artificial brains)
2. Defining AI by behavior
   Model **behavior** of natural agents (e.g. ACT-R)
3. Defining AI by capability
   Focus on **hard problems** (for humans) and applications (e.g. Cyc, Deep Blue)
4. Defining AI by function
   Model **functions** mapping an input to some output (e.g. search, planning)
5. Defining AI by principle
   Intelligence as the **best solution** given bounded rationality/optimality (e.g. NARS)

Different Levels of Description

AI at the IKW

Examples of Topics of Interest

Example 1: Analogies (Idea)

Idea: analogies and concept blending can be used to explain several abilities we would call creative.

Metaphors:

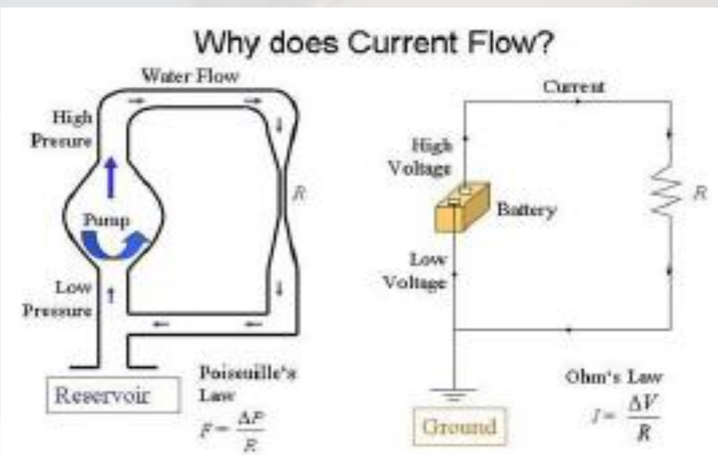
“Gills are the lungs of fish.”

“Electrons are the planets of the nucleus.”

„Juliet is the sun.”

According to Lakoff & Núñez (2000) mathematics origins from concrete domains of human activity (mathematical metaphors)

motion along a path	arithmetic
acts of moving along the path	arith. operations
a point location on the path	result of an operation; number
origin; beginning of the path	zero
unit location, a point location distinct from the origin	one
further from the origin than	greater
closer to the origin than	less
moving away from the origin a distance	addition
moving toward the origin a distance	subtraction



Analogies in the Physics Domain

Technical Concepts

Example 1: Analogies (HDTP)

Heuristic-Driven Theory Projection (HDTP)

Input:
first-order
theories

Process
select terms / predicates / formulas (heuristics)
select best generalization (heuristics)
project formulas, if they are not associated yet

Output:
generalized
theory

Generalization

mass(X) > mass(Y)

dist(X, Y) > 0

F (X , Y) > 0

Source

mass(s) > mass(p)

dist(s, p) > 0

gravity(s, p) > 0

Target

mass(n) > mass(e)

dist(e, n) > 0

coulomb(n, e) > 0

Gust, Kühnberger, Schmid (2006), TCS

Example 1: Analogies (HDTP)

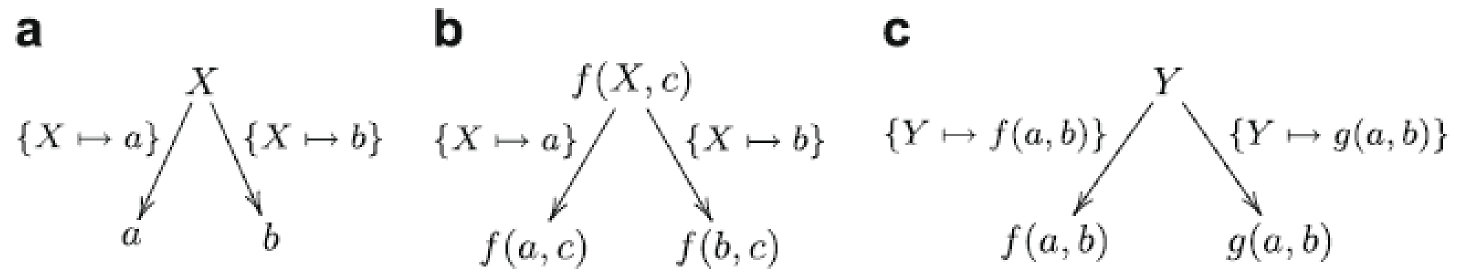


Fig. 3. Plotkin's first-order anti-unification.

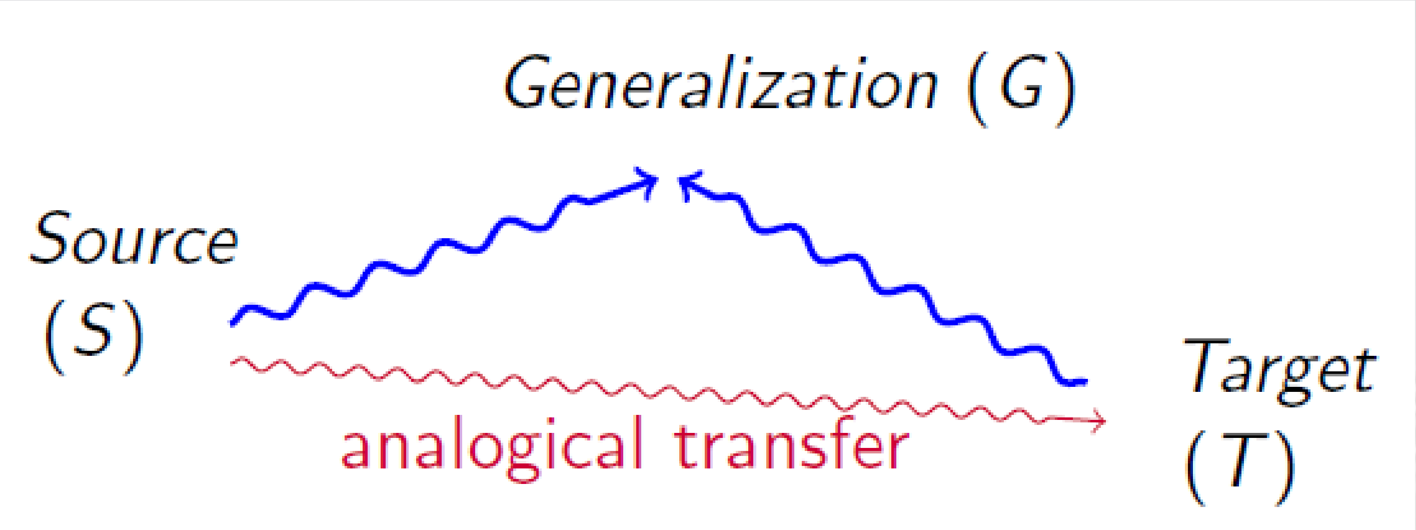
Anti-unification was introduced as a dual construction to unification by Gordon Plotkin (Plotkin, 1970).

Anti-unification constructs a generalization of two terms by using substitutions.

HDTP uses a restricted form of higher-order anti-unification

Schwering et al. (2009), CogSys

Example 1: Analogies (HDTP)



Input:

first-order theories

Process

select terms / predicates / formulas (heuristics)
select best generalization (heuristics)
project formulas, if they are not associated yet

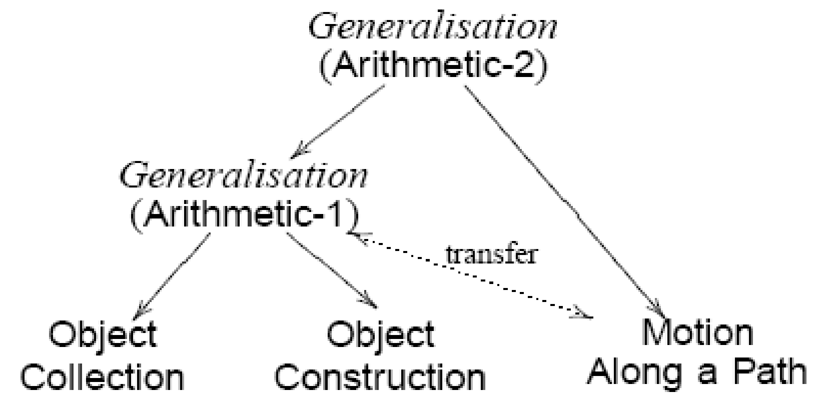
Output:
generalized theory

Example 1: Analogies (Lakoff's Metaphors)

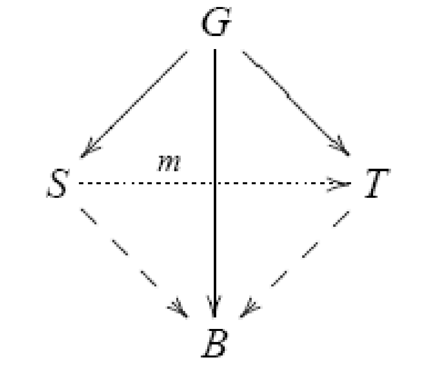
motion along a path	arithmetic
acts of moving along the path	arith. operations
a point location on the path	result of an operation; number
origin; beginning of the path	zero
unit location, a point location distinct from the origin	one
further from the origin than	greater
closer to the origin than	less
moving away from the origin a distance	addition
moving toward the origin a distance	subtraction

Again Lakoff & Núñez (2000): mathematics origins from concrete domains of human activity (mathematical metaphors)

A natural idea is to use the analogy engine HDTP to compute mathematical metaphors that are grounded in concrete domains of human activity.



HDTP's view of blending



Example 1: Analogies (Lakoff's Metaphors)

Generalisation (Arithmetic-2)

$\sigma_1: \forall V_1,V_2 : G(V_1,V_2) \rightarrow L(V_2,V_1)$
$\sigma_2: \forall V_1,V_2,V_3 : P(V_1,V_2,V_3) \rightarrow M(V_3,V_2,V_1)$
$\sigma_3: \forall V_1,V_2,V_3,V_4 : (A(V_1,V_2) \wedge P(V_2,V_3,V_4)) \rightarrow G(V_4,V_1)$
$\sigma_4: \forall V_1,V_2 : S(V_1) \rightarrow (\neg Q(V_2) \rightarrow \neg G(V_1,V_2))$

$\kappa_1: G \longrightarrow bigger$
$\kappa_2: L \longrightarrow smaller$
$\kappa_3: A \longrightarrow align$
$\kappa_4: Q \longrightarrow false$

Generalisation (Arithmetic-1)

$\rho_1: \forall V_1,V_2 : bigger(V_1,V_2) \rightarrow smaller(V_2,V_1)$
$\rho_2: \forall V_1,V_2,V_3 : P(V_1,V_2,V_3) \rightarrow M(V_3,V_2,V_1)$
$\rho_3: \forall V_1,V_2,V_3,V_4 : (align(V_1,V_2) \wedge P(V_2,V_3,V_4)) \rightarrow bigger(V_4,V_1)$
$\rho_4: \forall V_1,V_2 : S(V_1) \rightarrow \neg bigger(V_1,V_2)$

$\mu_1: P \longrightarrow putTogether$
$\mu_2: M \longrightarrow takeAway$
$\mu_3: S \longrightarrow smallestCollection$

$\lambda_1: P \longrightarrow combine$
$\lambda_2: M \longrightarrow split$
$\lambda_3: S \longrightarrow smallestWholeObject$

Object Collection

$\alpha_1: \forall C_1,C_2 : bigger(C_1,C_2) \rightarrow smaller(C_2,C_1)$
$\alpha_2: \forall C_1,C_2,C_3 : putTogether(C_1,C_2,C_3) \rightarrow takeAway(C_3,C_2,C_1)$
$\alpha_3: \forall C_1,C_2,C_3,C_4 : (align(C_1,C_2) \wedge putTogether(C_2,C_3,C_4)) \rightarrow bigger(C_4,C_1)$
$\alpha_4: \forall C_1,C_2 : smallestCollection(C_1) \rightarrow \neg bigger(C_1,C_2)$

Object Construction

$\beta_1: \forall O_1,O_2 : bigger(O_1,O_2) \rightarrow smaller(O_2,O_1)$
$\beta_2: \forall O_1,O_2,O_3 : combine(O_1,O_2,O_3) \rightarrow split(O_3,O_2,O_1)$
$\beta_3: \forall O_1,O_2,O_3,O_4 : (align(O_1,O_2) \wedge combine(O_2,O_3,O_4)) \rightarrow bigger(O_4,O_1)$
$\beta_4: \forall O_1,O_2 : smallestWholeObject(O_1) \rightarrow \neg bigger(O_1,O_2)$

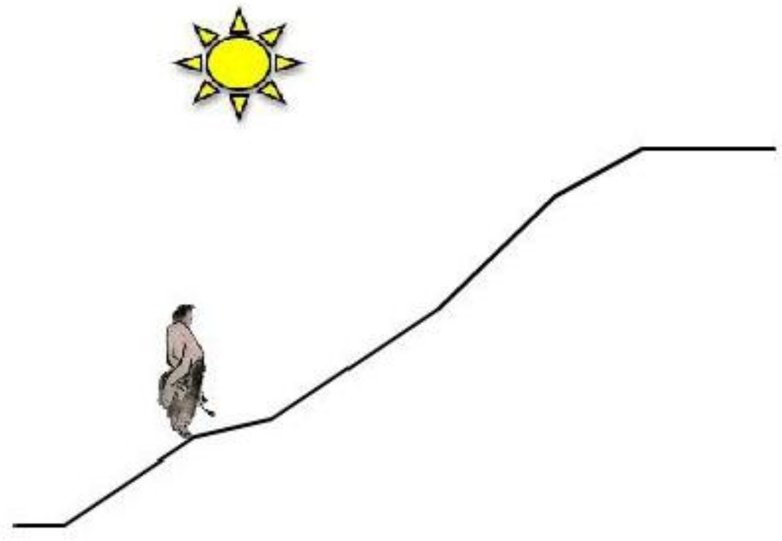
$\tau_1: G(V_1,V_2) \longrightarrow furtherFromOrigin(V_1,V_2,Path)$
$\tau_2: L(V_1,V_2) \longrightarrow closerToOrigin(V_1,V_2,Path)$
$\tau_3: P(V_1,V_2,V_3) \longrightarrow moveAwayFromOrigin(V_1,V_2,V_3,Path)$
$\tau_4: M(V_1,V_2,V_3) \longrightarrow moveTowardsOrigin(V_1,V_2,V_3,Path)$
$\tau_5: A \longrightarrow true$
$\tau_6: S \longrightarrow closestToOrigin$
$\tau_7: Q(V_1) \longrightarrow origin(V_1,Path)$

Motion Along A Path

$\gamma_1: \forall P_1,P_2,Path : furtherFromOrigin(P_1,P_2,Path) \rightarrow closerToOrigin(P_2,P_1,Path)$
$\gamma_2: \forall P_1,P_2,P_3,Path : moveAwayFrom(P_1,P_2,P_3,Path) \rightarrow moveTowardsOrigin(P_1,P_2,P_3,Path)$
$\gamma_3: \forall P_1,P_2,P_3,P_4,Path : moveAwayFromOrigin(P_2,P_3,P_4,Path) \rightarrow furtherFromOrigin(P_4,P_1,Path)$
$\gamma_4: \forall P_1,P_2,Path : closestToOrigin(P_1) \rightarrow (\neg origin(P_2,Path) \rightarrow \neg furtherFromOrigin(P_1,P_2,Path))$
$\gamma_5: \forall P_1,Origin,Path : moveTowardsOrigin(P_1,P_1,Origin,Path) \rightarrow origin(Origin,Path)$

Guhe, Pease, Smaill, Schmid, Gust, Kühnberger, Krumnack (2010), CogSci'10

Example 2: Conceptual Blending

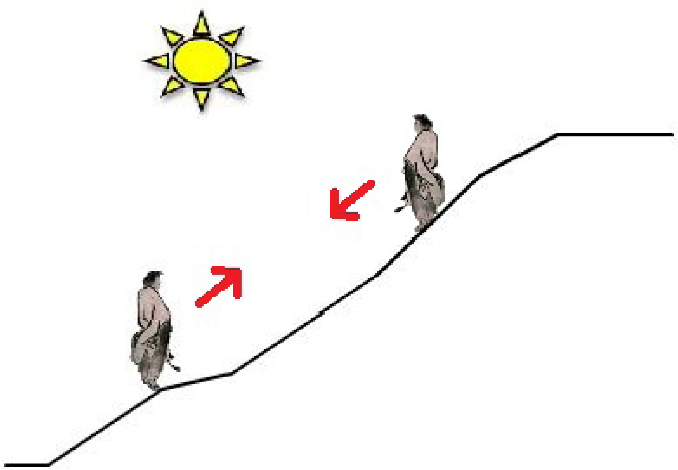


The Riddle of the Buddhist Monk: A Buddhist monk begins at dawn one day walking up a mountain, reaches the top at sunset, meditates at the top overnight until, at dawn, he begins to walk back to the foot of the mountain, which he reaches at sunset. Make no assumptions about his starting or stopping or about his pace during the trips. Riddle: is there a place on the path which the monk occupies at the same hour of the day on the two trips?

Example 2: Conceptual Blending

Solution:

imagine both journeys taking place on the same day!



- there must be a meeting point
- there *is* a place the monk occupies at the same time on both journeys

→ solution by **blending** separate up- and downward journeys of the monk into one simultaneous journey

→ newly emerged structure: monk encountering himself, leads to solution

Example 2: Conceptual Blending

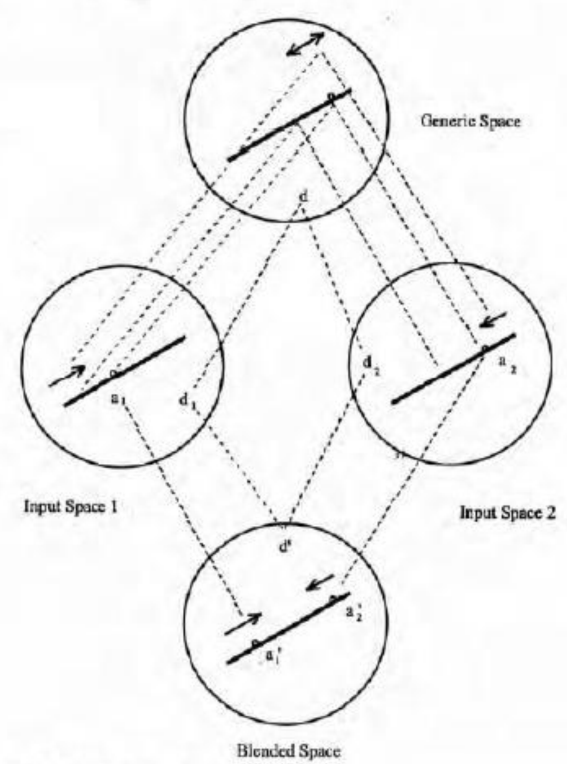


FIGURE 3.4 BLENDED SPACE

- **generic space**: mental space containing communalities of input spaces
- **blend**: selective projection and fusion of structures from input spaces

→ resulting in new **emergent structures**:

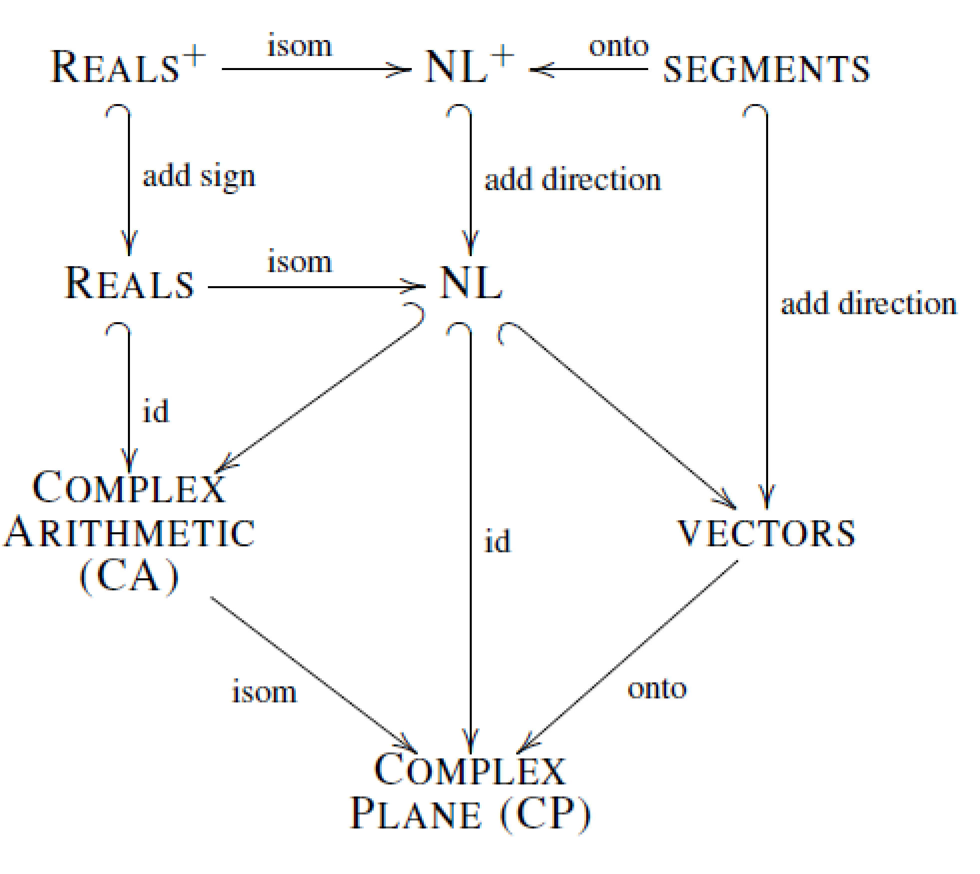
- *composition* of elements → new relations
- *completion* (with background knowledge) → new structures
- *elaboration* ("running" of the blend)

Example 2: Conceptual Blending (Argand's Complex Plane)

Argand discovered the complex plane as a geometric interpretation of complex numbers in 1806 (Argand, 1813).

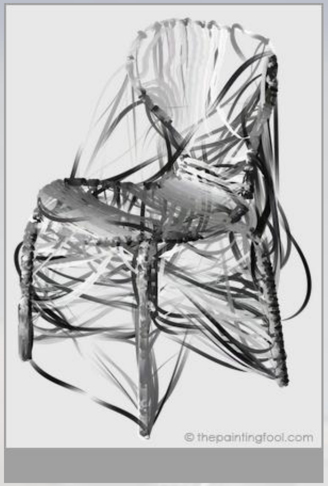
This discovery is rather explicitly described by the mathematician.

A formalized version of concept blending can be used to compute the blend space.



Martinez et al. (2012), Springer

Example 3: Computational Creativity



The Painting Fool

- Some examples of computationally composed (generated) music can be found on Youtube:
  - EMI System by David Cope
- On the left: Painting Fool, a computer artist: a creative program generating paintings & Exhibition.

Example 3: Computational Creativity

There are many possibilities to harmonize a piece of music.

Blending different harmonization styles with a melody adds interesting aspects to a piece of music: Here is Beethoven's famous "Ode to Joy" in two types of harmonization.

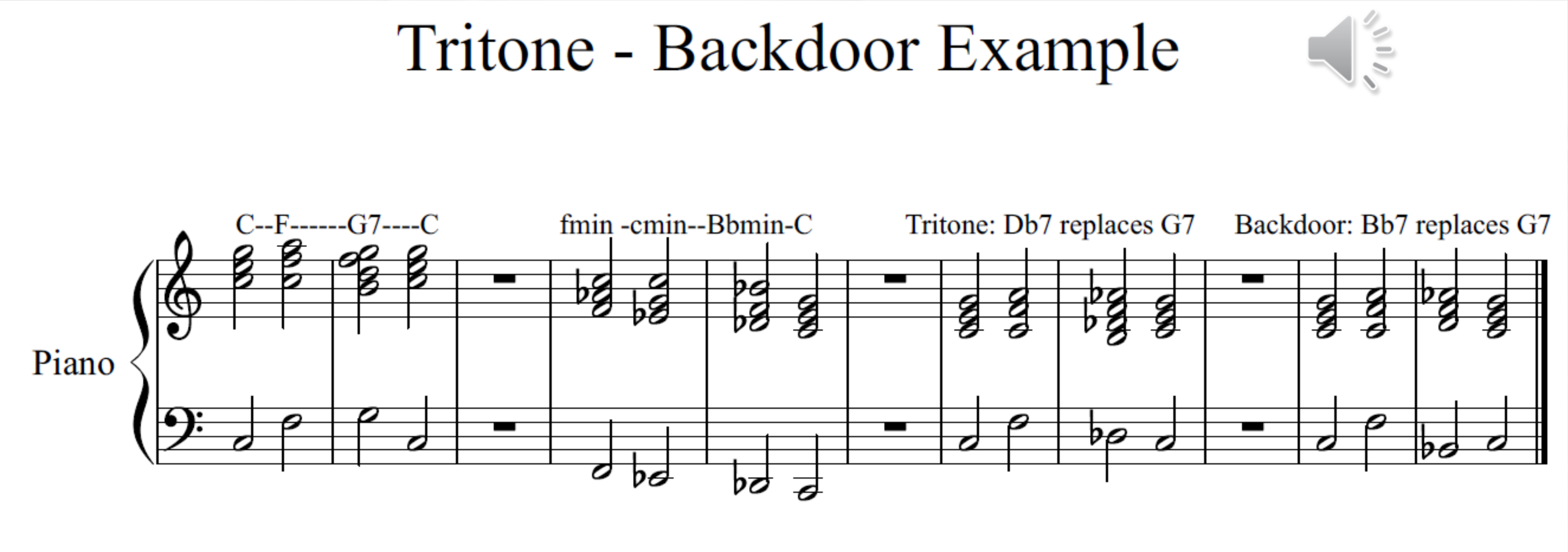
Example 3: Computational Creativity

But even with the probably most often used chord progression in popular music, the theme sounds kind of ok: vi – ii – V – I (continue from the beginning).

Example 3: Computational Creativity

An example concerns the blending of cadences.

Tritone substitution and backdoor progression are Jazz chord progressions, whereas the perfect cadence and the phrygian cadence existed already for hundreds of years.

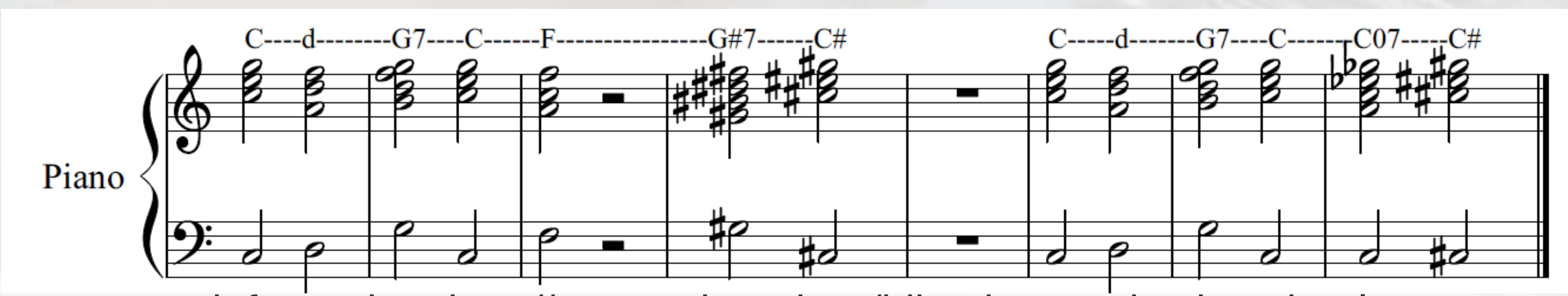


Eppe et al. (2015); IJCAI

Example 3: Computational Creativity

Another form of cadence blending is cross-fading chord progressions of different idioms in a smooth manner.

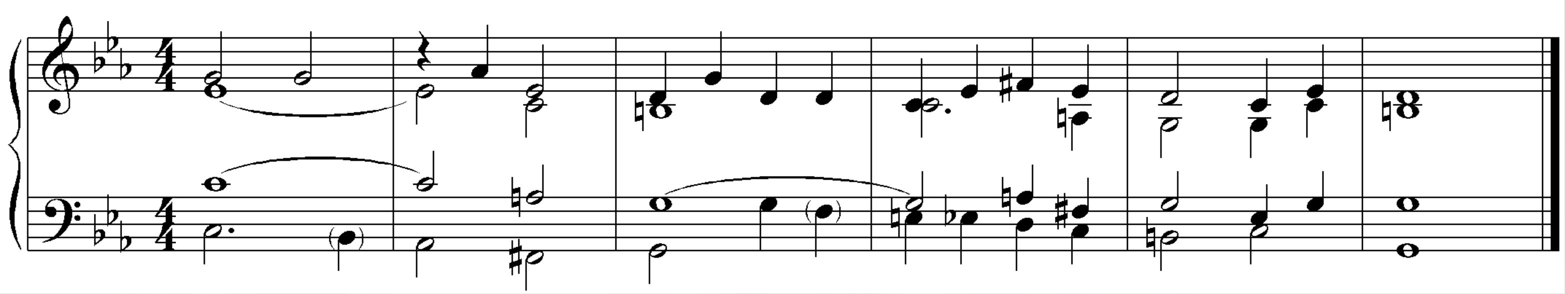
Assume a sequence C – Dmin – G7 – C – F and a sequence G#7 – C# is given. A transition from F to G#7 is hard, if the key is C. But by blending F and G#7 to a C˚7 (diminished dominant seventh chord), this might be possible.



For more information: http://ccm.web.auth.gr/idiomharmonisations.html

Eppe et al. (2015); IJCAI

Example 3: Computational Creativity



Beginning of Michelle by the Beatles automatically harmonized in **J.S.Bach's chorale** style

Beginning of Michelle by the Beatles automatically harmonized in **'classical' jazz** style

Example 4: Flu Prediction with Watson

Former study project of master students. Main contributors:
Hendrik Berkemeyer, Pascal Nieters, Histofor Lukanov

The study project was organized together with Gordon Pipa

Influenza matters

Prediction is important

Delayed and too few data

Data science methods

Social media analysis

Watson as medical expert

Cognitive Computing

Better prediction

Fully informed user

Example 4: Flu Prediction with Watson

- **Disease spreads locally and via transportation hubs**
- **Weather, vaccination, and seasonal events change spreading**

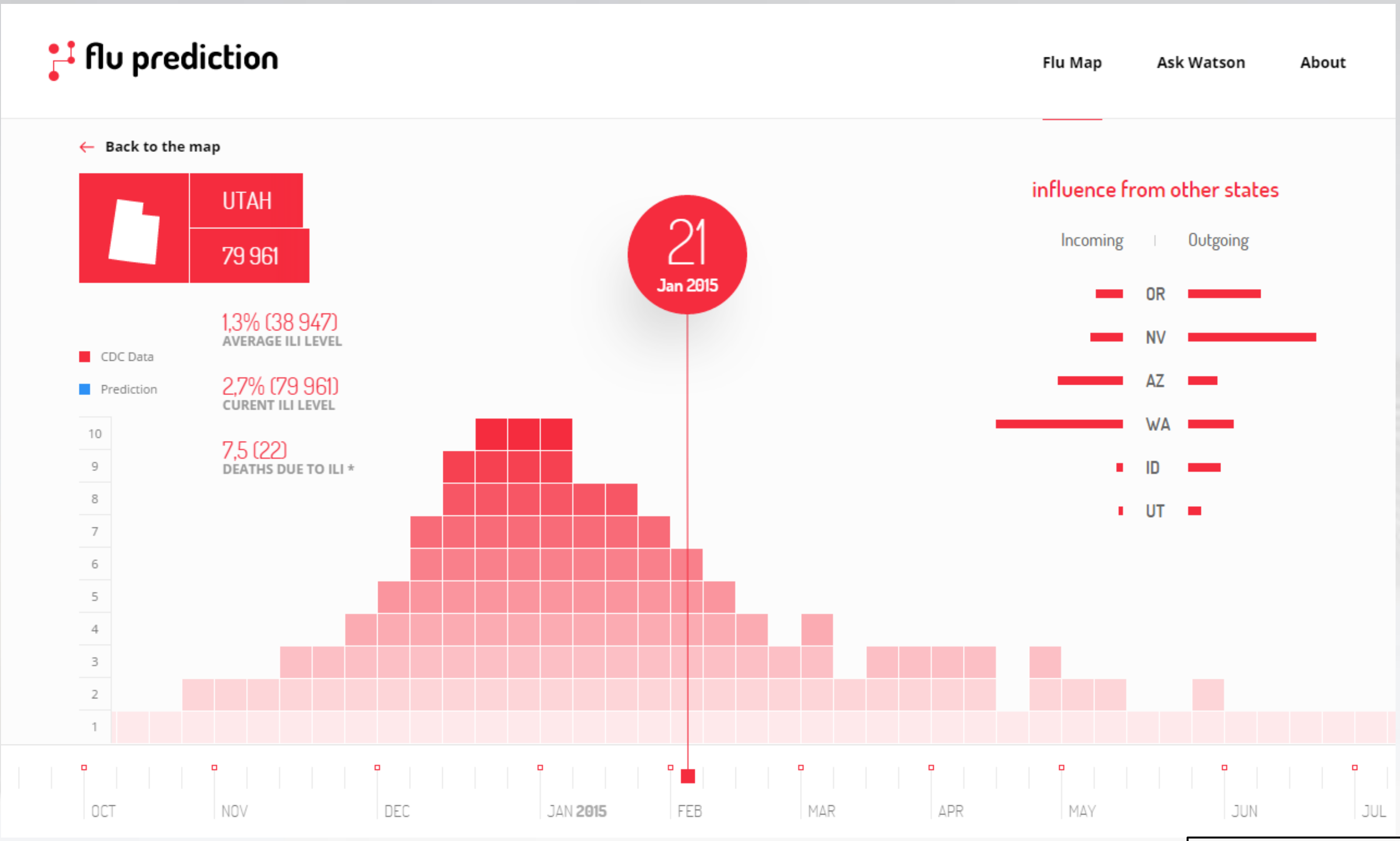
Example 4: Flu Prediction with Watson

- **Disease spreads locally and via transportation hubs**
- **Weather, vaccination, and seasonal events change spreading**

Example 4: Flu Prediction with Watson

- **Direction and speed of spread NEEDS to be identified from data**
- **A driver influences and thereby leaves a trace that can be reconstructed**

Example 4: Flu Prediction with Watson



IBM Bluemix™

www.flu-prediction.com

Example 4: Flu Prediction with Watson

Combine CDC data with social media data.

- Influenza matters
- Prediction is important
- Delayed and too few data

Cognitive Computing

- Data science methods
- Social media analysis
- Watson as medical expert

- Better prediction
- Fully informed user

Example 4: Flu Prediction with Watson

Twitter activity
(geo tag + tweet)

- **Twitter gives realtime and anytime available data**
- **IBM Insights contain tweets since 2014**

Example 4: Flu Prediction with Watson

Realtime fuzzy social media

+

Slow but relibale CDC data

Twitter activity (geo tag + tweet)

CDC – delayed influenca data

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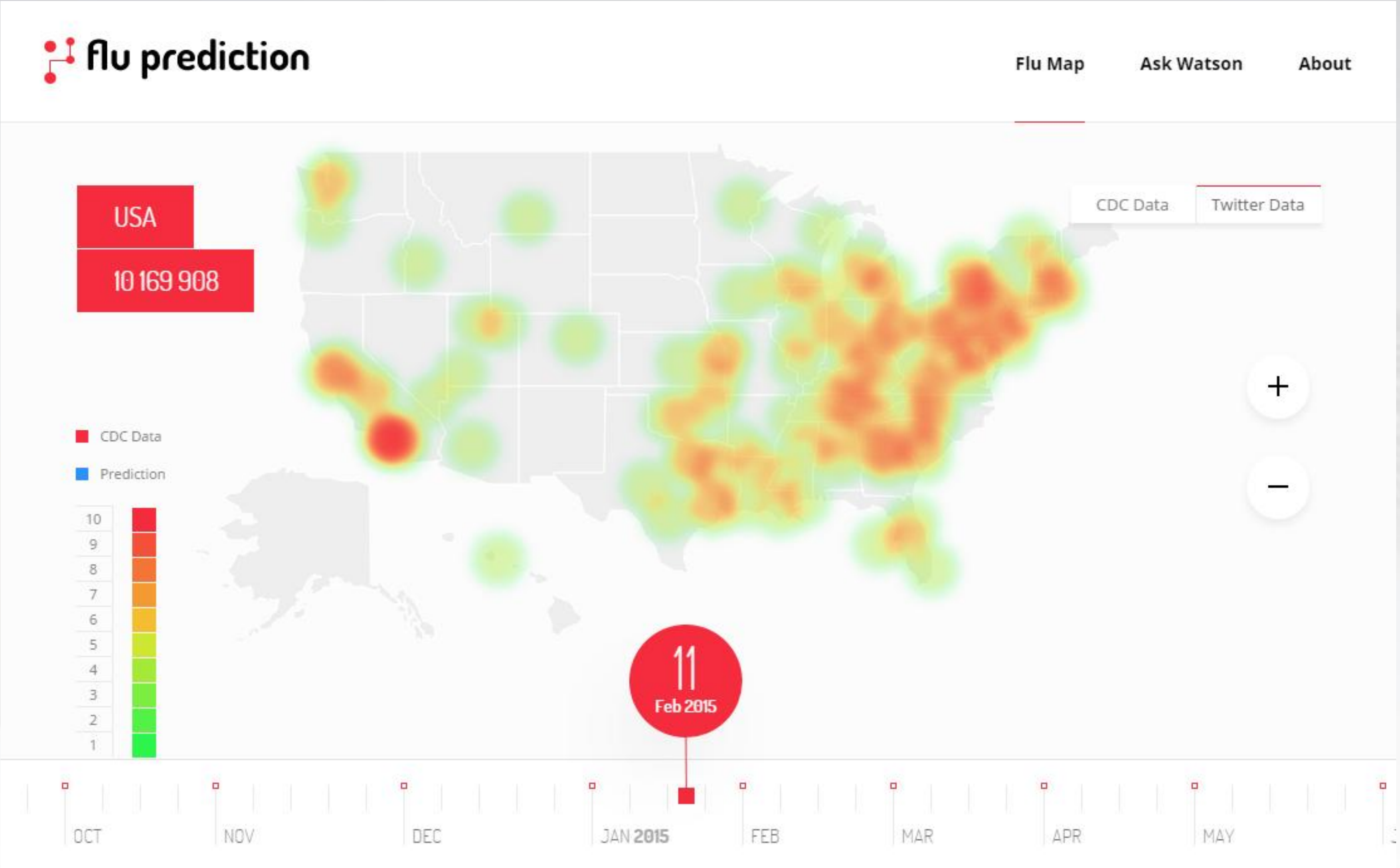
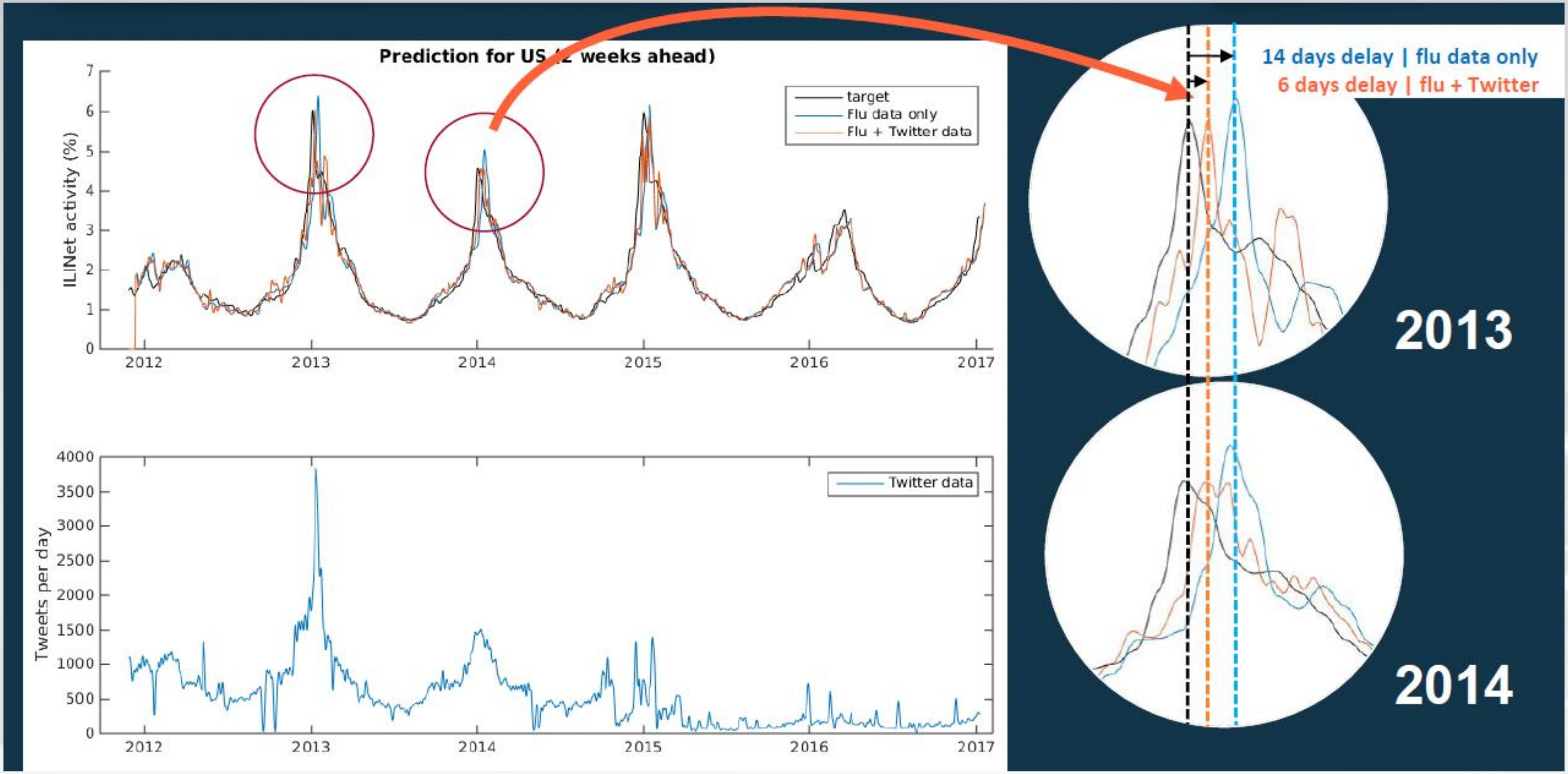
Example 4: Flu Prediction with Watson



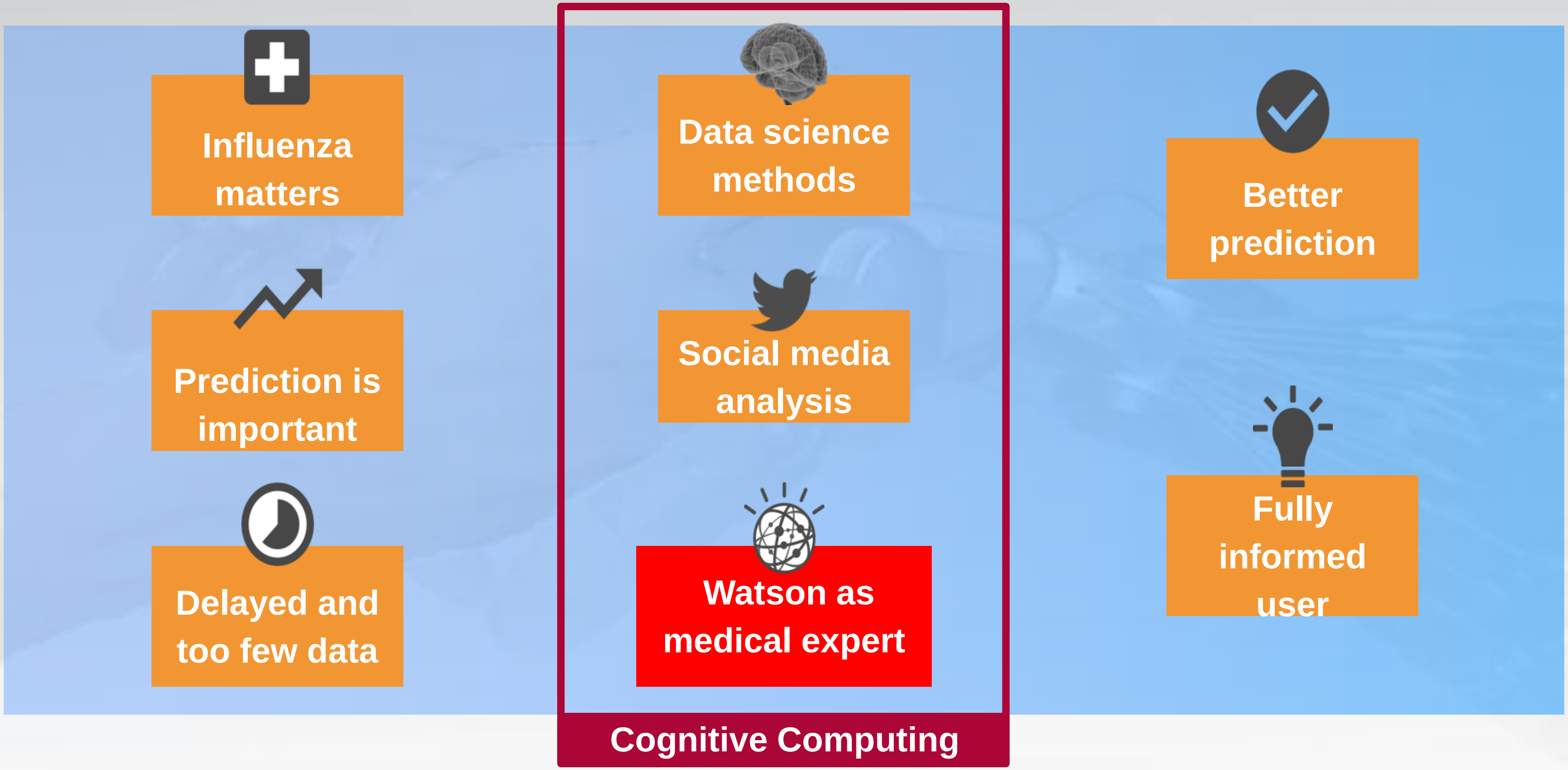
Supported by:

Example 4: Flu Prediction with Watson

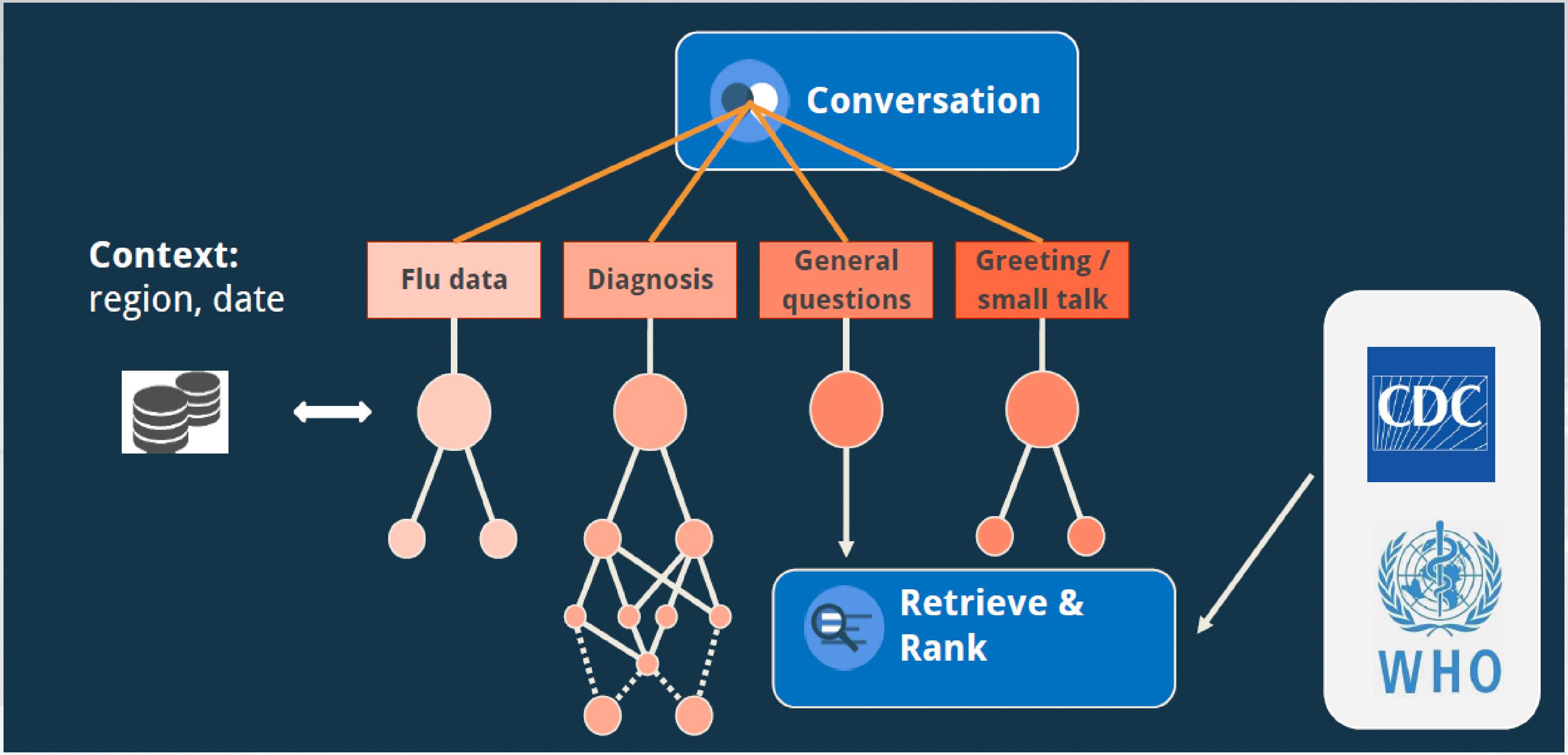


Example 4: Flu Prediction with Watson

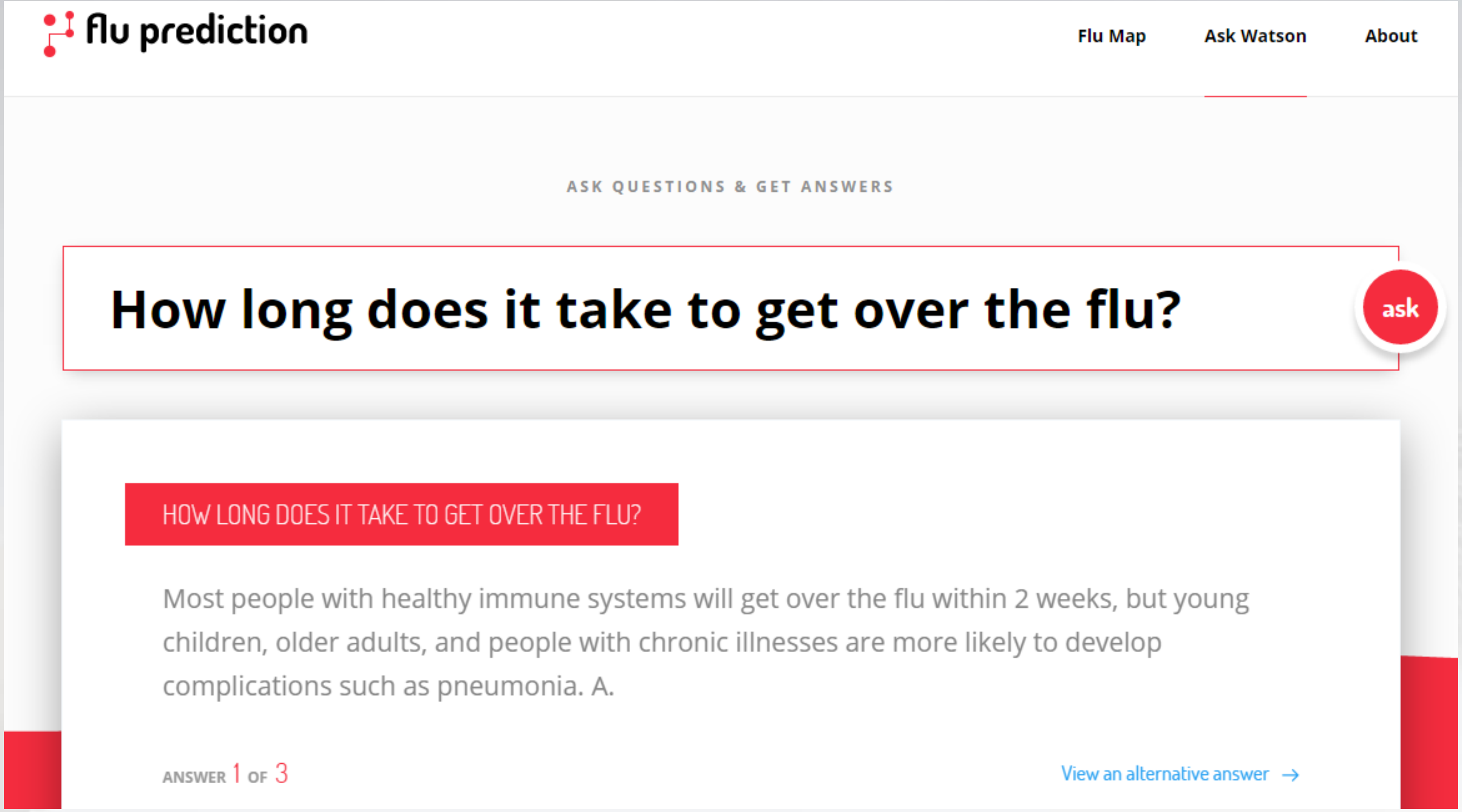
Combining CDC data with social media data in a project at the IKW



Example 4: Flu Prediction with Watson



Example 4: Flu Prediction with Watson



Supported by:

Example 5: MIA Study Project

- MIA study project
  - One-year study project of Master students of the IKW
  - Idea of the study project: Applying machine learning methods to hospital data
  - The first report of the project is currently written
  - The project is ongoing and will be continued in the winter term 2017/2018
  - Main contributors so far in the study project were:
    - Kai Fritsch, Carolin Gaß, Alexander Höreth, Inga Ibs, Ann-Christin Meisener, Tim Patzelt, Justin Shenk, Geeske Sieckmann, Andrea Suckro

Example 5: MIA Study Project

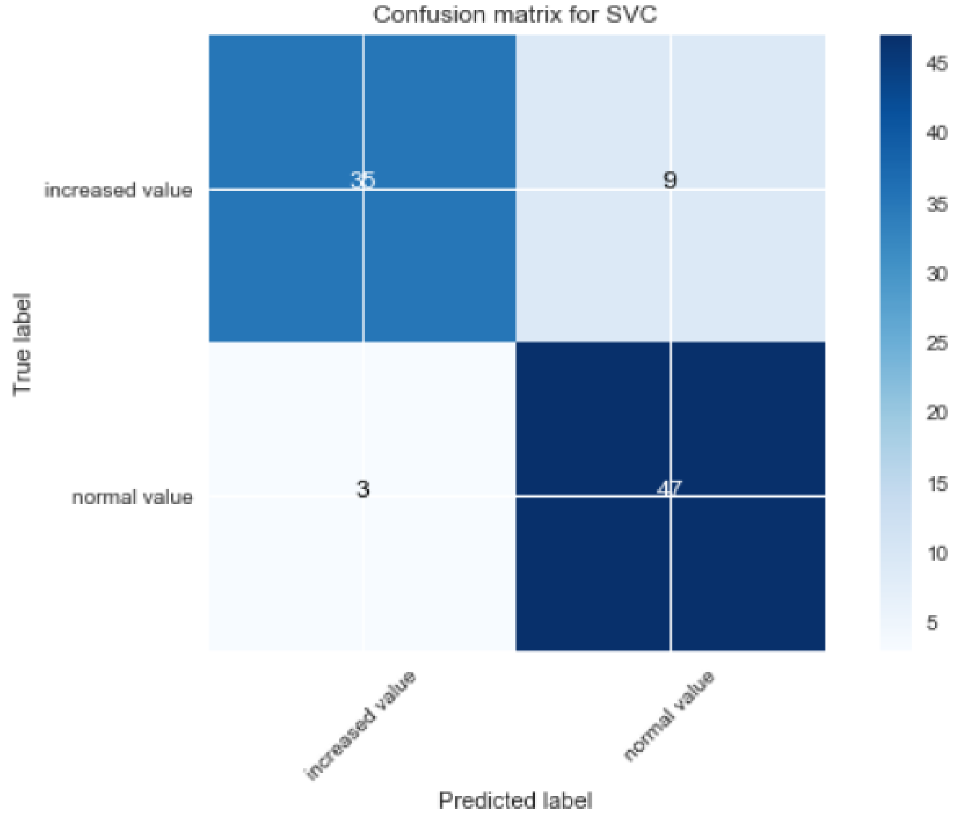
- Data
  - Provided by a Berlin-based company
  - Anonymous Data of 360,000 patient entries from 8 different hospitals
  - Types of available and anonymous data: age, gender, date of entrance and discharge, diagnosis, treatments etc.
    - Diagnosis and treatment is coded in ICD codes and OPS codes.
    - Additionally, lab tests were available.
- Practically addressed were the following questions:
  - Prediction of different ICD codes
  - Prediction of missing lab values

General Problem: Data was not as consistent as expected

Example 5: MIA Study Project

- Task: Predict critical values for patients concerning certain blood values.
- Confusion matrix: Ferritin results for balanced classes using a support vector machine.
- Other algorithms were tested for this prediction as well, e.g. random forests, neural networks...

0.79545455	0.20454545
0.06	0.94

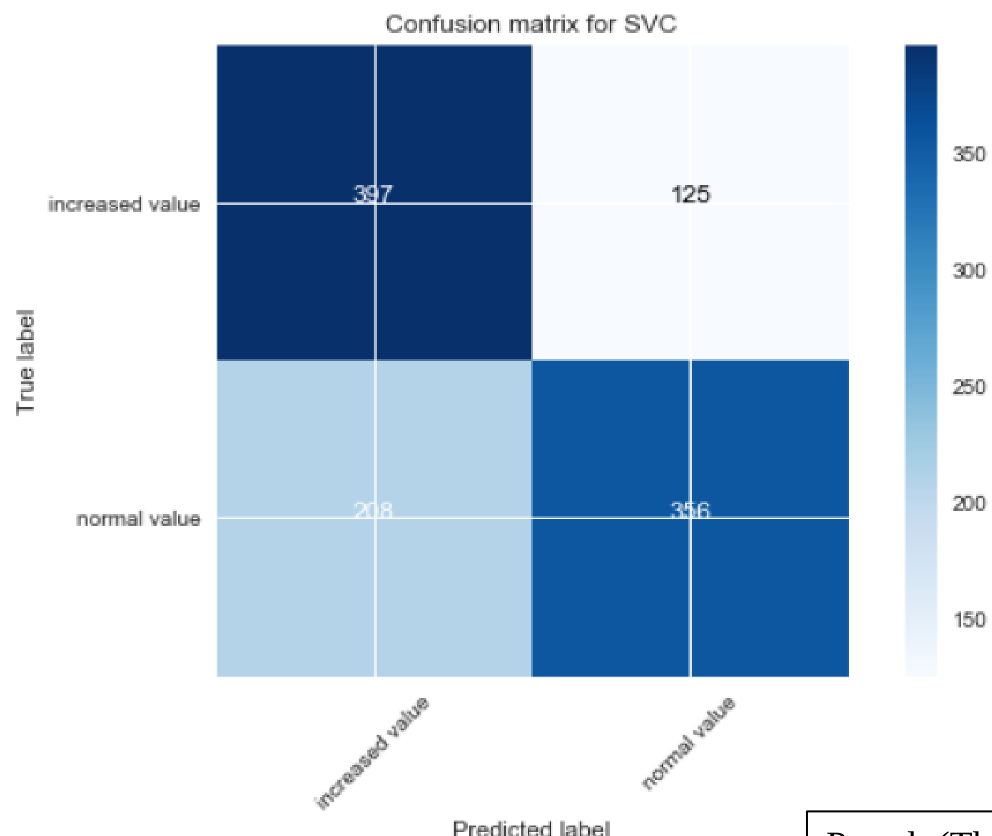


Patzelt (Thesis)

Example 5: MIA Study Project

- Task: Predict critical values for patients concerning certain blood values.
- HbA1c results for balanced classes using a support vector machine
- Results for random forests and neural networks were worse.

0.7605364	0.2394636
0.36879433	0.63120567



Patzelt (Thesis)

Example 5: MIA Study Project

- Task: Prediction of N17 (acute kidney failure)
- Methods used for ICD classification include
  - Logistic regression (LR)
  - Support Vector Machines (SVM)
  - Decision trees (DT)
  - Random forests (RF)
- Pre-processing: collect all data in the unified relational database, unify lab test identifiers (as above) and fix encoding problems (as above).
- **Problem: find task tailored subsets of data such that**
  - Only records with common features are used
  - Dropping erroneous records quite often results in small subsets. This leads to the challenge of limited and unbalanced datasets.

Example 5: MIA Study Project

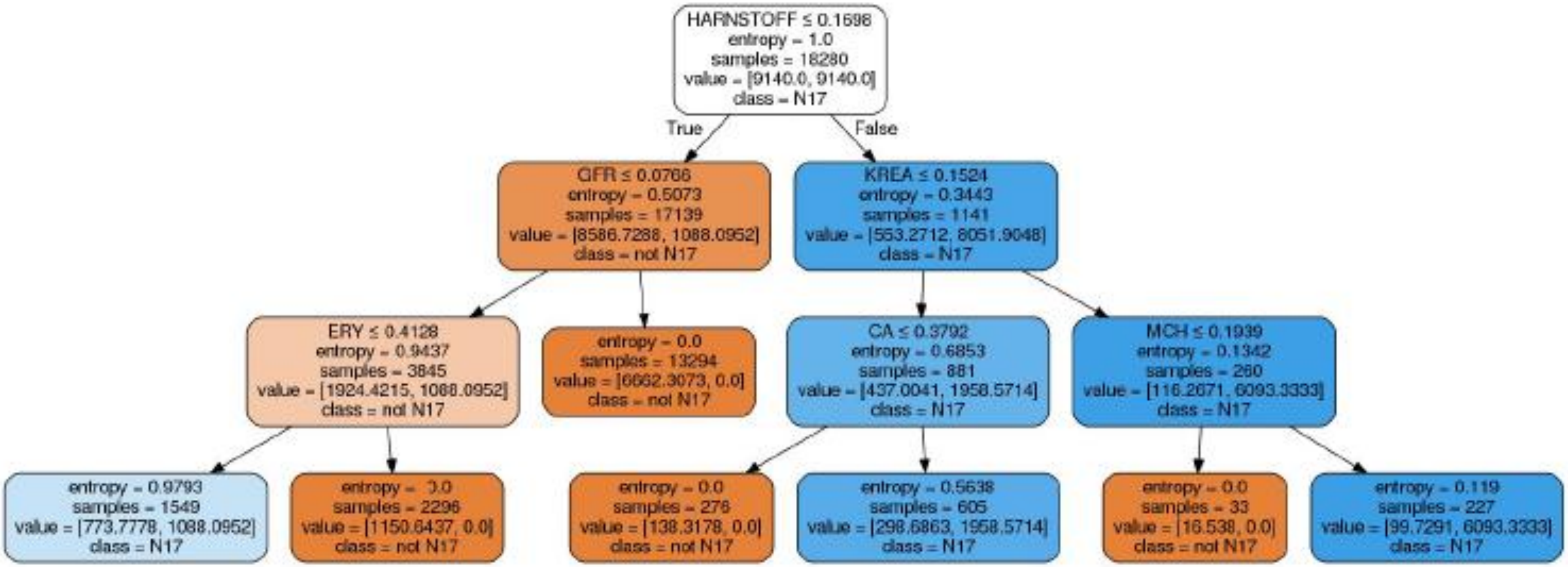


Figure 1. AKF Decision Tree

Ibs & Höreth, OCCAM 17

- Features that could be relevant for detecting N17 in a decision tree.
- **Problem: Feature selection (as above)**

Example 5: MIA Study Project

Scores	SVM	LR	DT	RF
True Positive	**0.866**	**0.881**	**0.851**	**0.805**
True Negative	0.925	0.927	0.882	0.957
False Positive	0.075	0.073	0.118	0.042
False Negative	**0.134**	**0.119**	**0.149**	**0.195**

Ibs & Höreth, OCCAM 17

- Results for predicting N17 (acute kidney failure) based on an appropriate feature set.
- Predictions of other ICD-Codes are sometimes more difficult, e.g. ICD code I10 (essential primary hypertension) shows around 0.24 false negatives for the best algorithm.

Example 6: Sketch Recognition

Cooperation with Ain Shams University (Cairo), German University in Cairo, and University of Münster

- Idea: build a sketch generating and recognition system
  - The basis are psychological experiments: how do subjects recognize sketches
  - Determine salient concepts used in recognition tasks
  - Learning basic elements of sketches and learning relations between interesting regions (both is learned by SVMs)
- First goal: system that recognizes online sketches while someone is drawing them

Example 7: Conceptual Spaces

- Lucas Bechberger’s PhD project

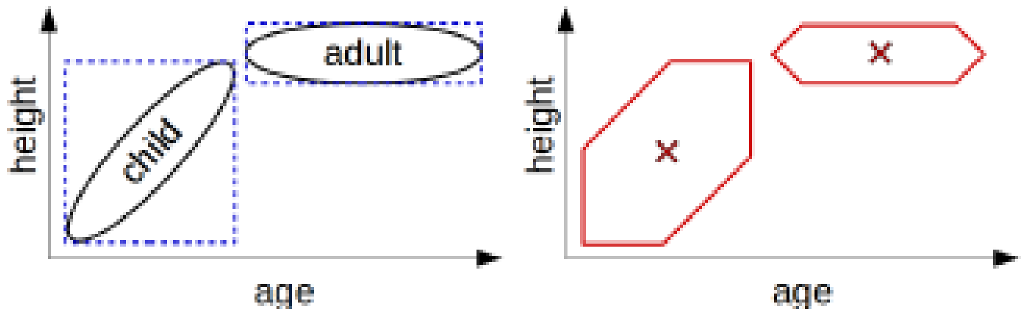


Fig. 1. Left: Intuitive way to define regions for the concepts of “adult” and “child” (solid) as well as representation by using convex sets (dashed). Right: Representation by using star-shaped sets with central points marked by crosses.

- Try to replace convexity property by a weaker property: here star-shapedness
- Task: Learn bottom-up by deep learning shapes in a conceptual space and lift this to a symbolic level

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Further Examples

- Example 8: Probabilistic Reasoning (Nico Potyka)
- Example 9: Document classification (student project together with Gordon Pipa & VirtUOS)
- Example 10: Bodily movement representations (Stefan Schneider)
- Example 11: Computational Approaches to Narratives and Story Telling (Leonid Berov)
  - Leonid is doing his PhD in the Institute for English and American Studies, but is associated with the IKW

AI and Cognitive Science

- **Claim:**
  - **All presented topics are motivated, inspired, driven by cognition or cognitive science related questions.**

Organization once more again

A Note on AI Module Examinations

- Preparing the research paper and giving a presentation about its content in the tutorials is a good training for an oral examination in AI
- We offer the following structure of an oral exam
  - 10-15 minutes presentation of a research paper (the student can suggest subfields of AI)
    - Comprehension
    - Embedding into the research area
    - Critical assessment
  - 15-20 minutes discussion. Topics:
    - Paper
    - The relation to AI
    - AI in general
    - The relation to Cognitive Science

A Note on AI Module Examinations

- What you definitely should NOT do:
  - Prepare only the paper
- What you should do:
  - Search the web for background knowledge
  - Search the web for related work
  - Do a really CRITICAL assessment
  - Prepare the background knowledge of AI as presented in this course!
- We expect that you have a broad knowledge of all the subfields of AI presented in this course

A Note on AI Module Examinations

- If you prepare an oral exam, 95% of the knowledge you learn will not be relevant for the exam.
- But you do not know which 5% you need and these 5% are crucial for the grade you get.
- The other 95% are not wasted! You will need them later in your (scientific) life.

A Note on AI Module Examinations

- You can prepare yourself for this type of examinations during this Methods of AI course in the tutorials:
  - You will have to prepare a research paper
  - Give a presentation (every one of the group must present something)
  - Moderate a discussion
- You should do this within a work group of three students

Thank you for your attention

Questions?