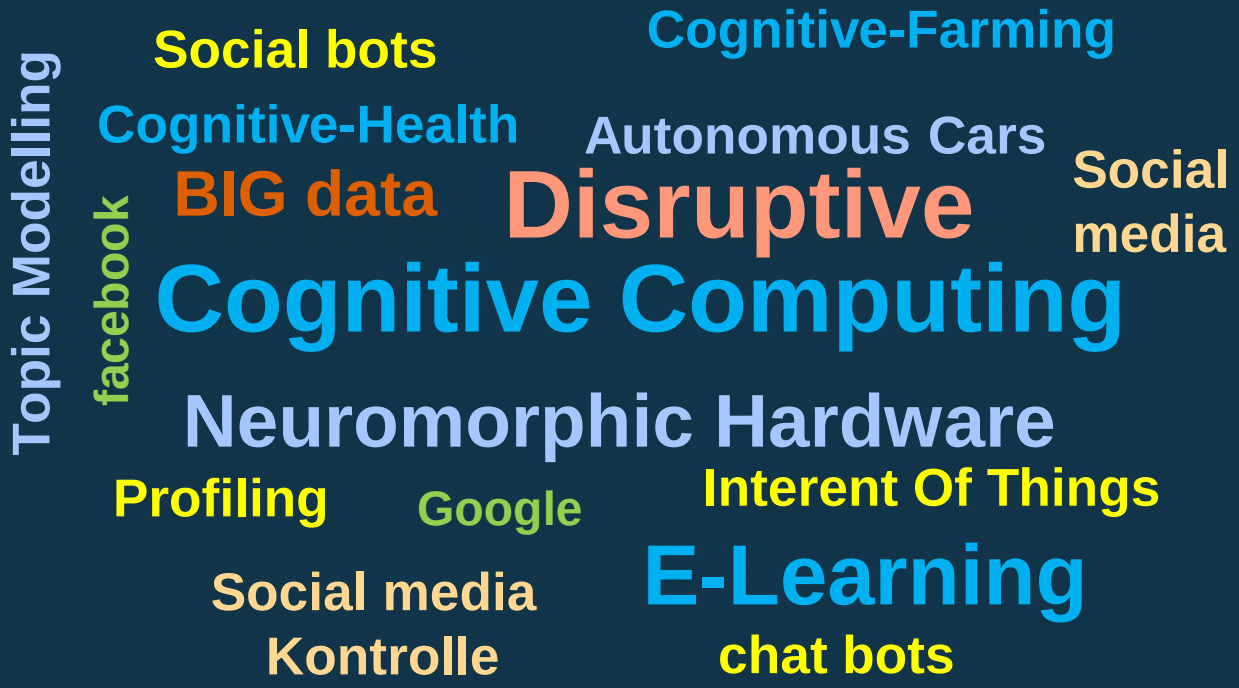
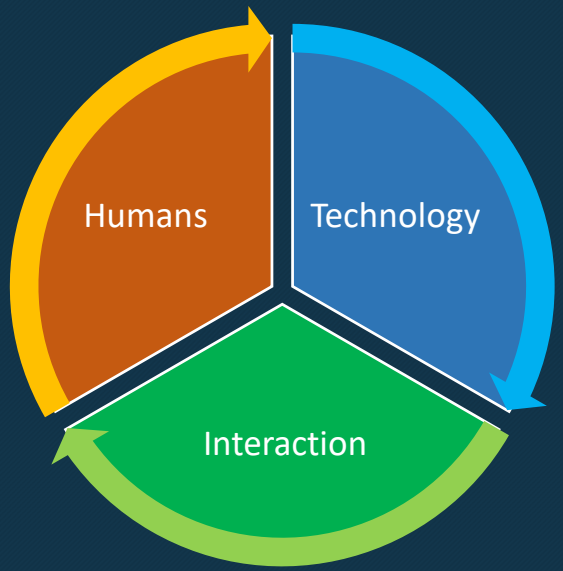
Institute of Cognitive Science

UNIVERSITÄT OSNABRÜCK



Cognitive Computing – (The new AI)



Symbiotic fusion of the intelligent system, the user, and the expert.

Dialog between machine and human (natural language, intuitive graphics, and gestures)

The machine is the super assistant that enables the human to make truly intelligent decisions in complex scenarios.

Institute of Cognitive Science

At the core of Cognitive Computing since 15 years

10 full professors

~ 600 BSc
~ 200 MSc
~ 45 PhD students

Institute of Cognitive Science

Cognitive Computing to predict and manage infectious outbreaks

Prof. Dr. Gordon Pipa, Osnabruck University

Prof. Dr. Kai-Uwe Kühnberger, Osnabruck University

Prof. Dr. Dr. Bertram Scheller, University Hospital Frankfurt

UNIVERSITÄTS KLINIKUM FRANKFURT
GOETHE-UNIVERSITÄT

Relevance of Cognitive Computing

Institute of Cognitive Science

„For the ***Robert Koch Institute*** the machine learning and cognitive computing are very important topics for the future. The project ***flu-prediction*** of university Osnabrück demonstrates and highlights the huge potential of these technologies for public health“

ROBERT KOCH INSTITUT

Assessment by
Prof. Dr. Lothar H. Wieler
President of the
Robert Koch Institute

www.flu-prediction.com

Institute of Cognitive Science

Influenza matters

Prediction is important

Delayed and too little data

Data science methods

Social media analysis

Watson as medical expert

Cognitive Computing

flu prediction

A one year project by a core team of three master's students

www.flu-prediction.com

Institute of Cognitive Science

Influenza matters

Prediction is important

Delayed and too little data

Data science methods

Social media analysis

Watson as medical expert

Better prediction

Fully informed user

www.flu-prediction.com

Institute of Cognitive Science

Influenza matters

Prediction is important

Delayed and too little data

Data science methods

Social media analysis

Watson as medical expert

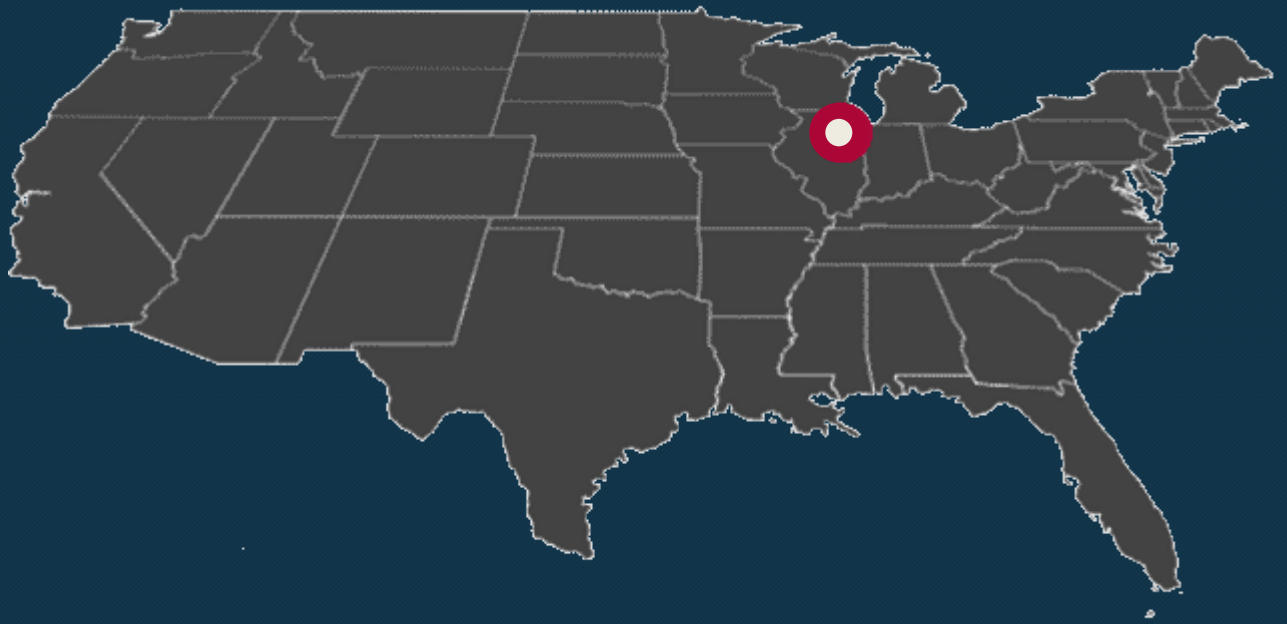
Better prediction

Fully informed user

Structured Causal Models

flu prediction

Institute of Cognitive Science



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

Structured Causal Models

flu prediction

Institute of Cognitive Science

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

Structured Causal Models

flu prediction

Institute of Cognitive Science

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

Structured Causal Models

flu prediction

Institute of Cognitive Science

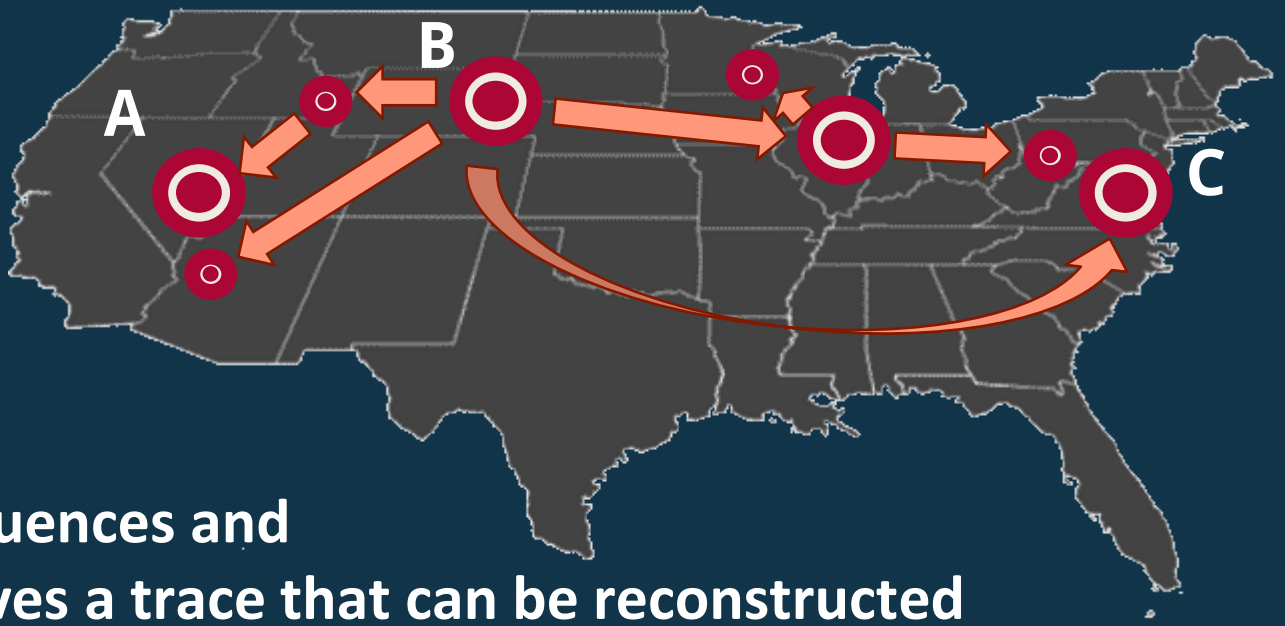
Direction and speed of spread NEEDS to be identified from data

U.S. Outpatient Influenza-like Illness Surveillance Network (ILINet)

Identify Causal Interactions

flu prediction

Institute of Cognitive Science



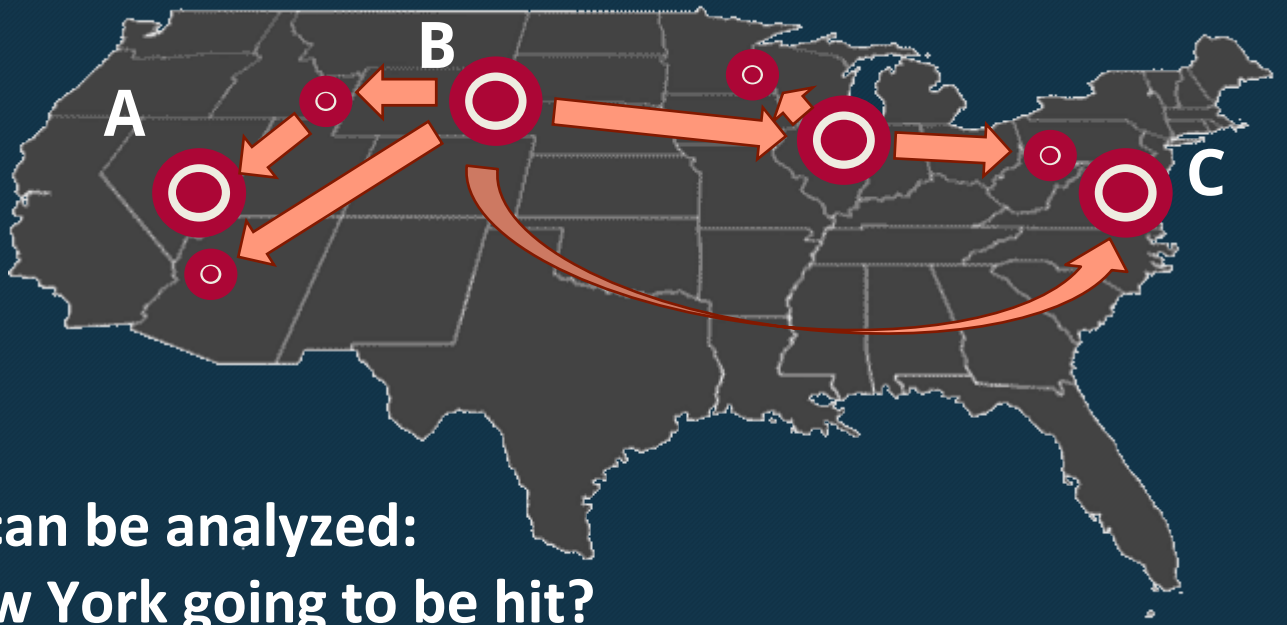
A driver influences and thereby leaves a trace that can be reconstructed

- Schumacher et al. (2015) - A Statistical Framework to Infer Delay and Direction of Information …
- Sugihara et al. (2012) - Detecting Causality in Complex Ecosystems

Identify Causal Interactions

flu prediction

Institute of Cognitive Science



The model can be analyzed:
When is New York going to be hit?

- Schumacher et al. (2015) - A Statistical Framework to Infer Delay and Direction of Information …
- Sugihara et al. (2012) - Detecting Causality in Complex Ecosystems

www.flu-prediction.com

Institute of Cognitive Science

Influenza matters

Prediction is important

Delayed and too little data

Data science methods

Social media analysis

Watson as medical expert

Better prediction

Fully informed user

Social Media

flu prediction

Institute of Cognitive Science

Twitter activity (geo tag + Tweet)

Unstructured Data from 500 Mil tweets a day !

Sample Tweets from 29/09/16

Institute of Cognitive Science

chaos tK @WhosChaos ·
Really hope I'm not getting the **flu** 🤒

himself worried

Kim @nanosounds
Anyone had any experience of getting better from **flu**,then getting worse?I was up and about yesterday, but today I'm exhausted and **sick** again

herself sick

Rob Sinclair @RSinclairAuthor
It's that time of the year again...the school/nursery **flu** merry-go-round - both boys **sick** tonight! 😂 See you on the other side in April...

familiy is sick

Halen Sumner @haysum10
The Centenary **flu** has started making its way around campus. For those who don't wish to die: cover yo mouth, wash yo hands, & shun the **sick**

friends are sick

Close the Gap by Fusing Data

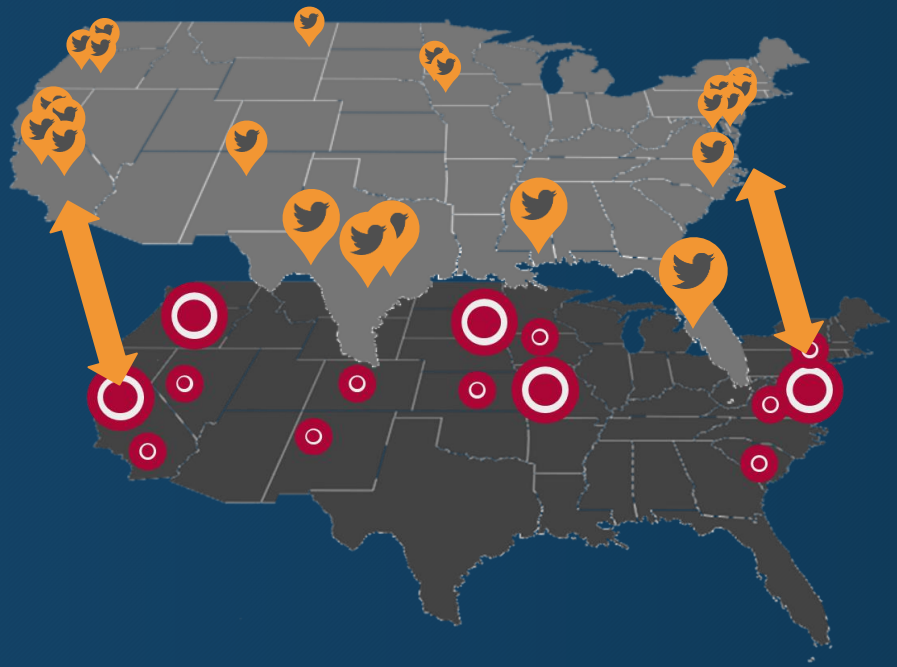
flu prediction

Institute of Cognitive Science

Realtime fuzzy social media

+

Slow but reliable CDC data



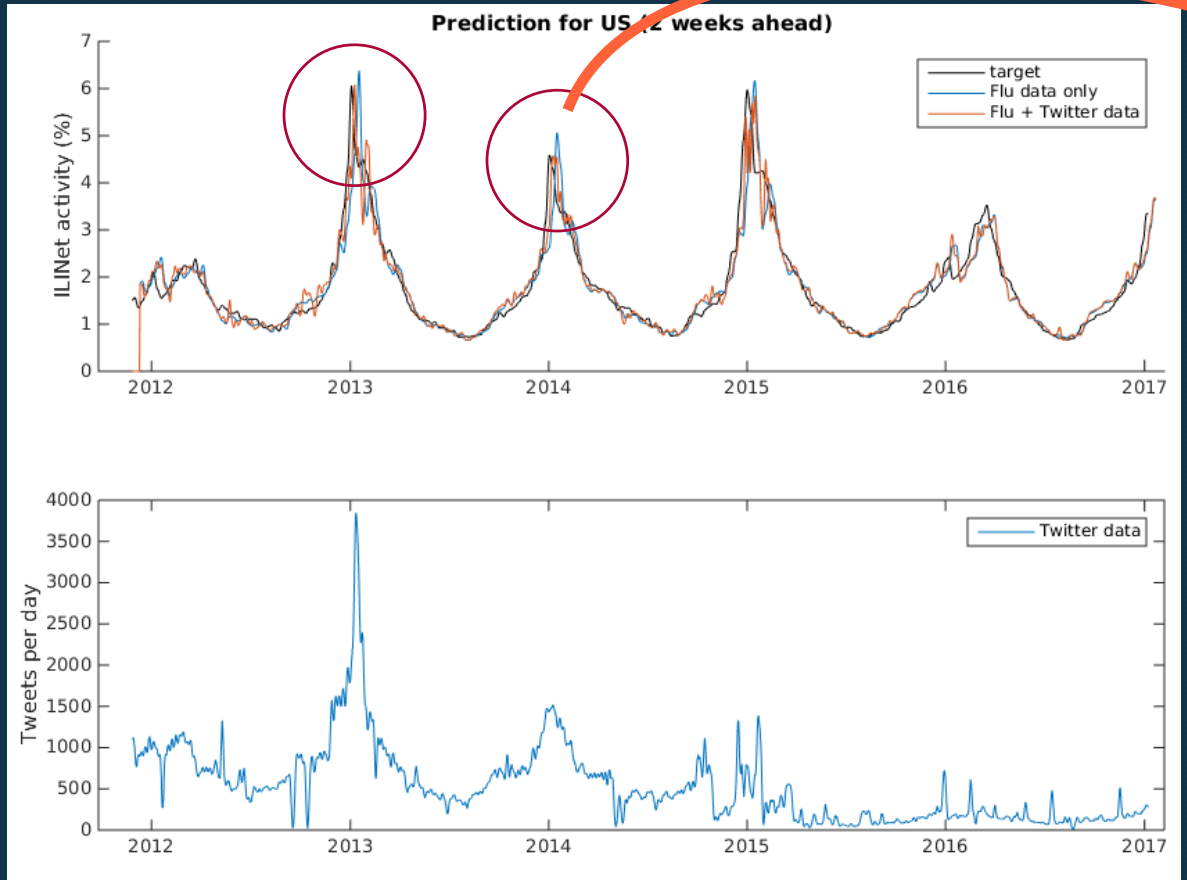
Twitter activity (geo tag + Tweet)

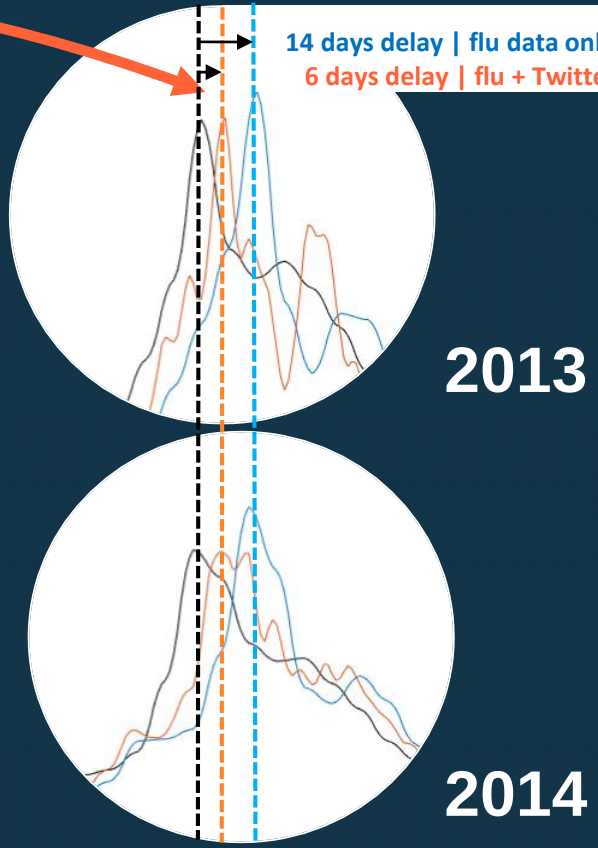
CDC – delayed influenza data

Use the best from both worlds to improve prediction

Delay Reduction with Twitter Data

Institute of Cognitive Science





www.flu-prediction.com

Institute of Cognitive Science

Influenza matters

Prediction is important

Delayed and too little data

Data science methods

Social media analysis

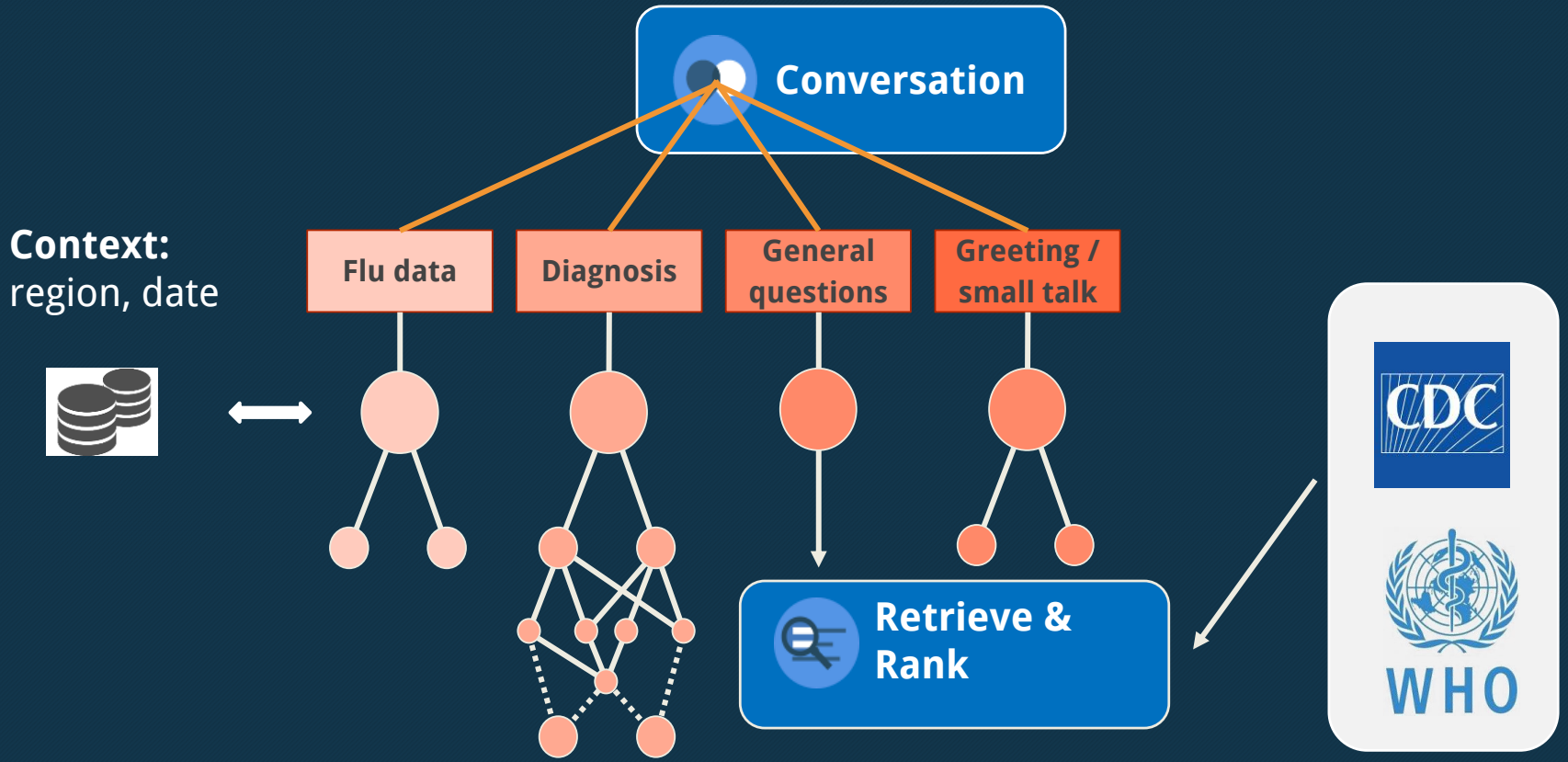
Watson as medical expert

Better prediction

Fully informed user

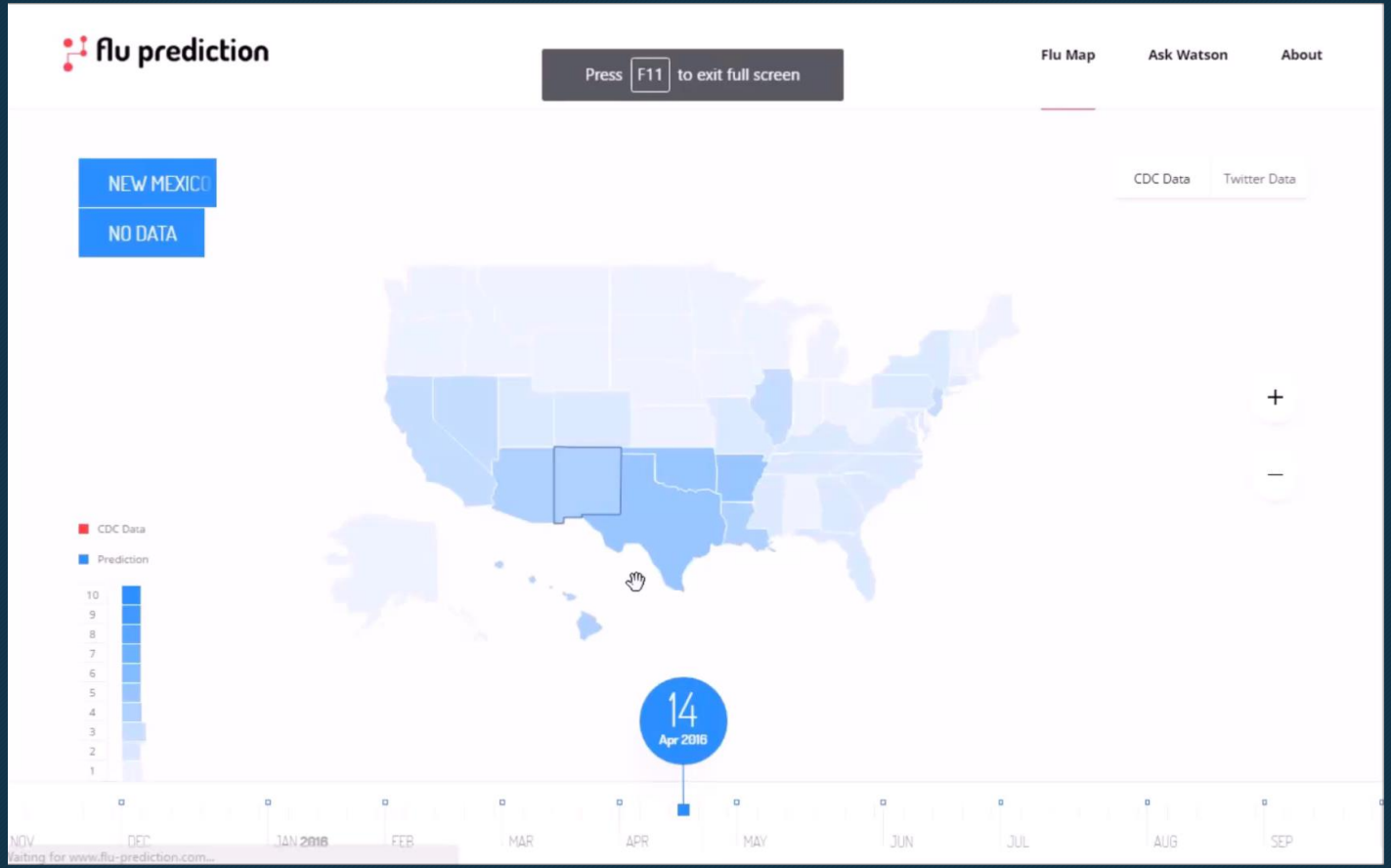
Cognitive Computing: Natural Language + Data Science

Institute of Cognitive Science



flu prediction

Institute of Cognitive Science



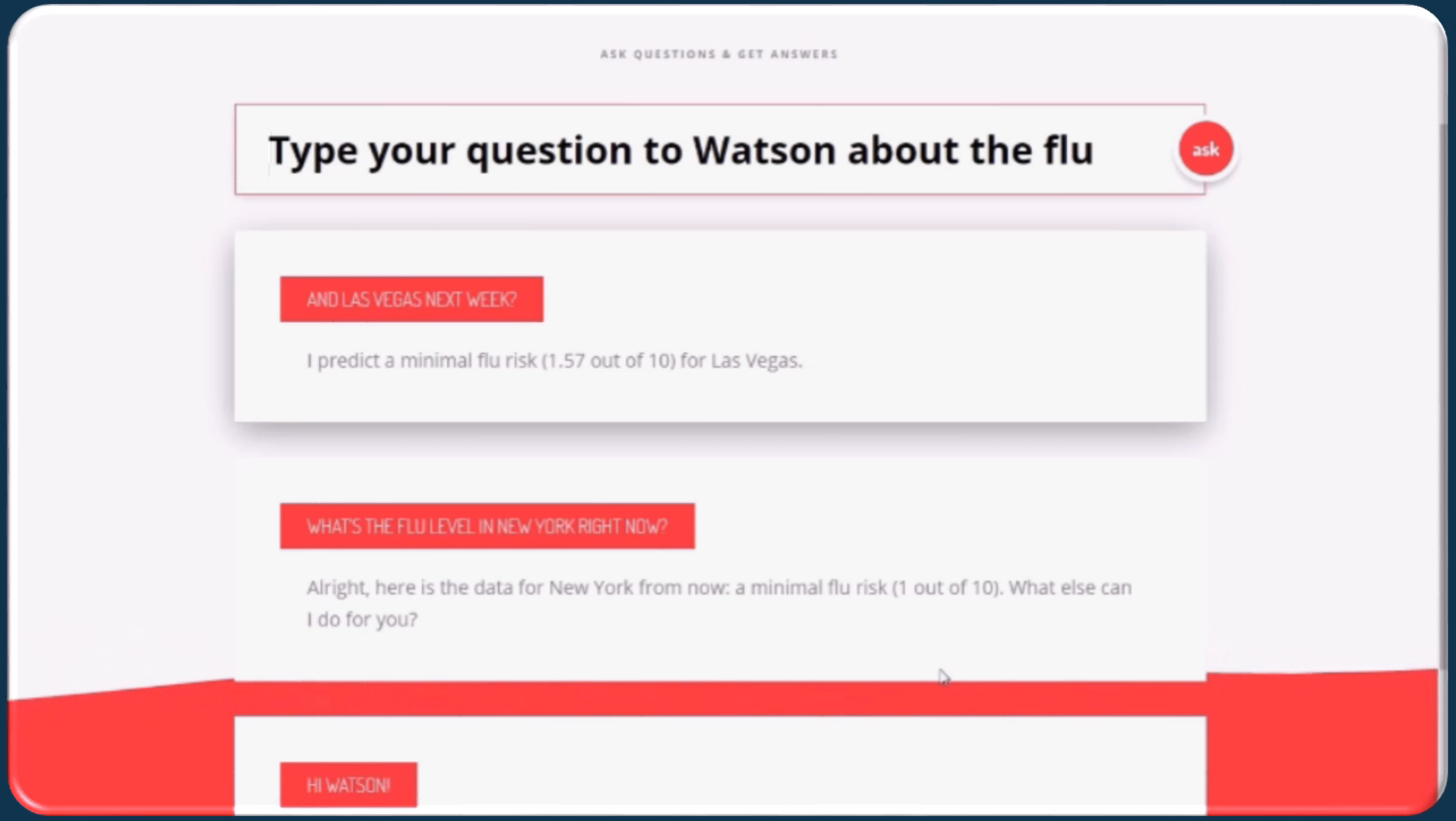
Supported by:

IBM Academic Initiative

IBM Bluemix™

Speak with Watson Flu

Institute of Cognitive Science



Supported by:

IBM Academic Initiative

IBM Bluemix™

Summary

flu prediction

Institute of Cognitive Science

Data science methods

- Data science allows identification of very complex causal relations

Social media analysis

- Combine social media with other conventional data to get the best of both worlds → realtime and reliable

Watson as expert

- Use unstructered data to learn relationships

Institute of Cognitive Science

ALP – Mobile Cloud Diagonsis

Prof. Dr. Gordon Pipa, Osnabruck University

Prof. Dr. Dr. Bertram Scheller, University Hospital Frankfurt

UNIVERSITÄTS KLINIKUM FRANKFURT
GOETHE-UNIVERSITÄT

ALP: A Proposal for the use case epilepsy

Institute of Cognitive Science

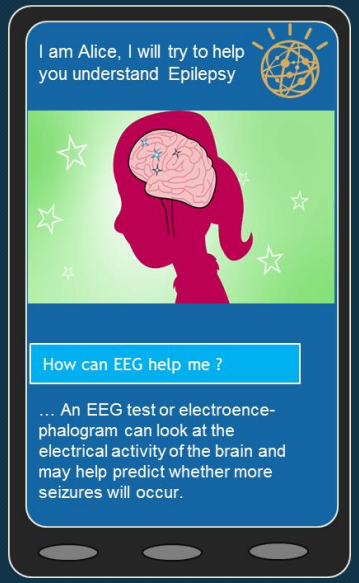
- 50 million people worldwide, with 80% in developing regions
- There, mostly older AEDs are administered by non-physician health care workers (~10$ a month)
- Sustainable service since the social and economic problems outweigh investment for treatment by far

→ The crucial step is the diagnosis and crowd support by experts

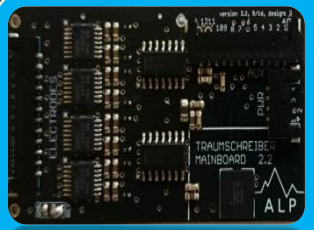
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2912535/
https://www.youtube.com/watch?v=lhC0zCcUV3E

ALP: A CLOUD IOT/AI System for treating epilepsy

Institute of Cognitive Science



IoT



EEG using mobil phones

Cloud Services for

- Artificial Intelligence
- Distributing Data
- Managing Human Resources, Patients, and Devices

ALP: A CLOUD IOT/AI System for treating epilepsy

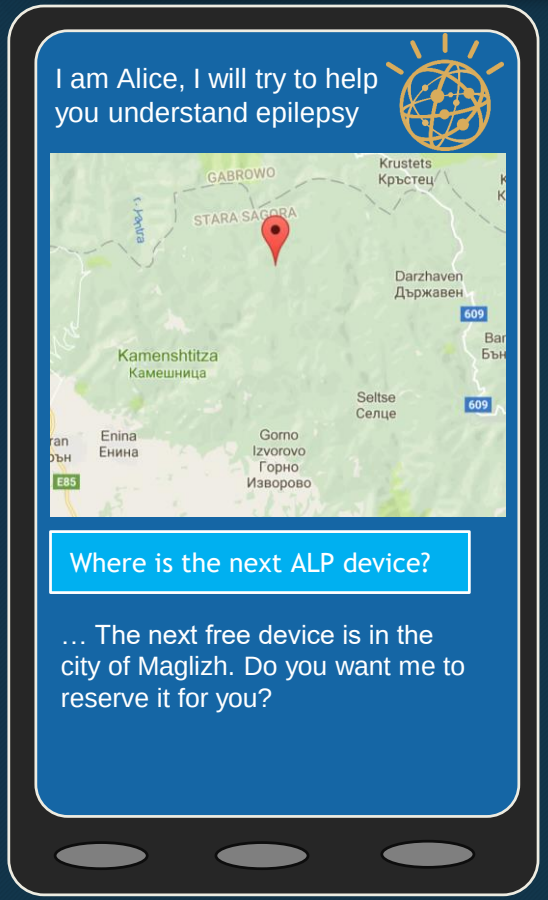
Institute of Cognitive Science

- Simple App for generating awareness and informing patients and relatives in spoken natural language

https://www.youtube.com/watch?v=LS4_jwVY3mc
from Epilepsy Action. The UK's leading epilepsy charity

ALP: A CLOUD IOT/AI System for treating epilepsy

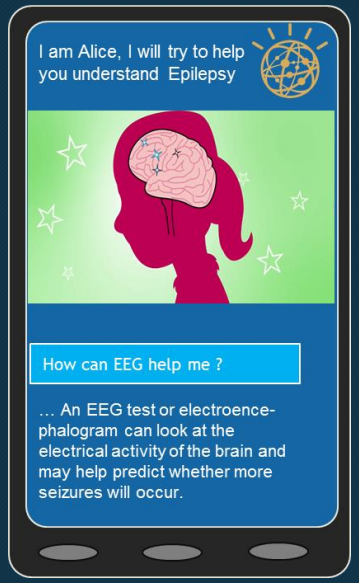
Institute of Cognitive Science



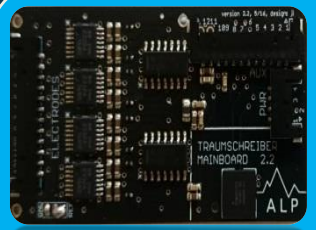
- It helps in locating ALP crowd EEG devices
- It establishes a network of patients and medical care

ALP: A CLOUD IOT/AI System for treating epilepsy

Institute of Cognitive Science



IoT



EEG using mobil phones

Cloud services for

- Artificial Intelligence
- Distributing Data
- Managing Human Resources, Patients, and Devices

Cloud Doctor

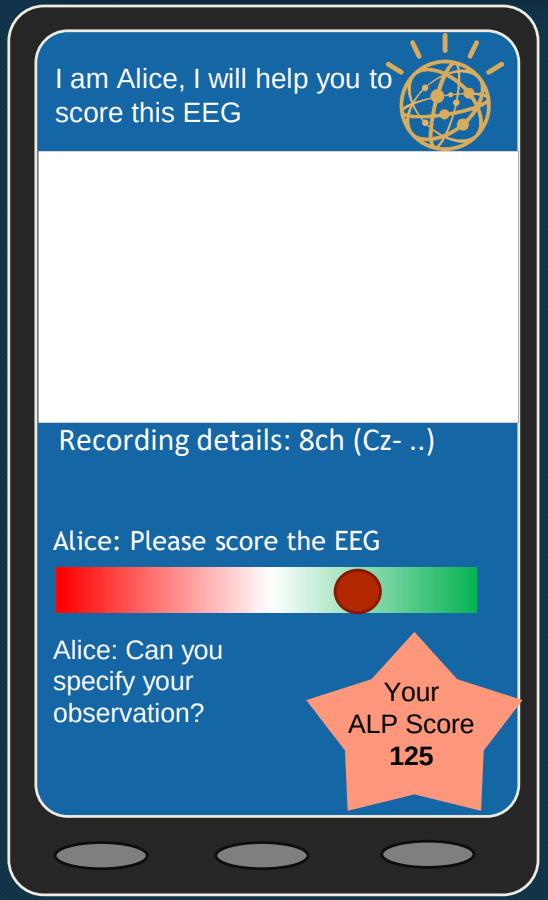
EEG will be scored automatically and by cloud doctors.

Treatment Support

Expert assessment by cloud doctors supports the local teams

ALP: A CLOUD IOT/AI System for treating epilepsy

Institute of Cognitive Science



- Simple App for CLOUD scoring the EEG and videos.
- AI to support treatment with recommendations
- Gamification for CLOUD doctors by ALP Score.

  (You contributed to helping 125 children already)

We need help in making our dream reality

Institute of Cognitive Science

ALP

Demonstrator

Charity organization

(STARTUP FUNDING NEEDED)

European research funding

CLOUD services (e.g. IBM)

Governmental support (e.g. Africa, EU)

Roll Out ALP Service

1st 10k Units

now

2018

2019

Institute of Cognitive Science

Copyright Detection

Prof. Dr. Gordon Pipa, Osnabruck University

Prof. Dr. Kai-Uwe Kühnberger, Osnabruck University

Big Data: §52a

+

+

Big Data

> 100.000 StudIP Documents

Many weak features

Machine learning

> 90% performance

> 90% performance

Roadmap:

In 2018 we will provide service for 10 universities nationwide based on an initiative of the Kultusminister-konferenz

Institute of Cognitive Science

Neuromorphic computing

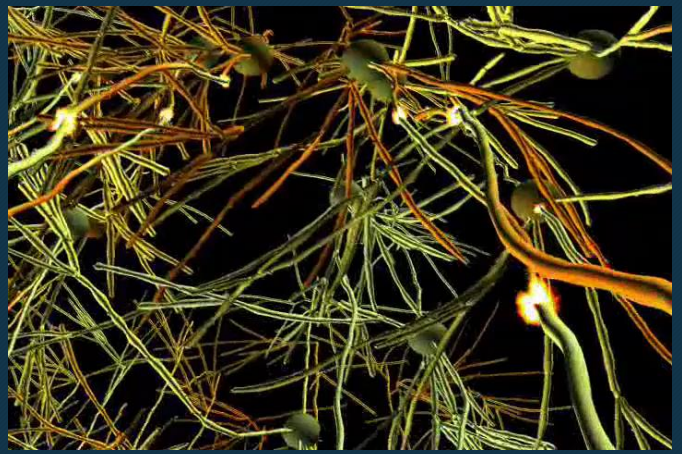
Prof. Dr. Gordon Pipa, Osnabruck University

Neuro-Inspired Hardware

Institute of Cognitive Science

- The cortex is structured canonically
- Cortex learns to process information based on self-organisation and reward based learning
- Cortical computing is robust

Neuronal Netzwork
(© EU Flagship Project HBP)

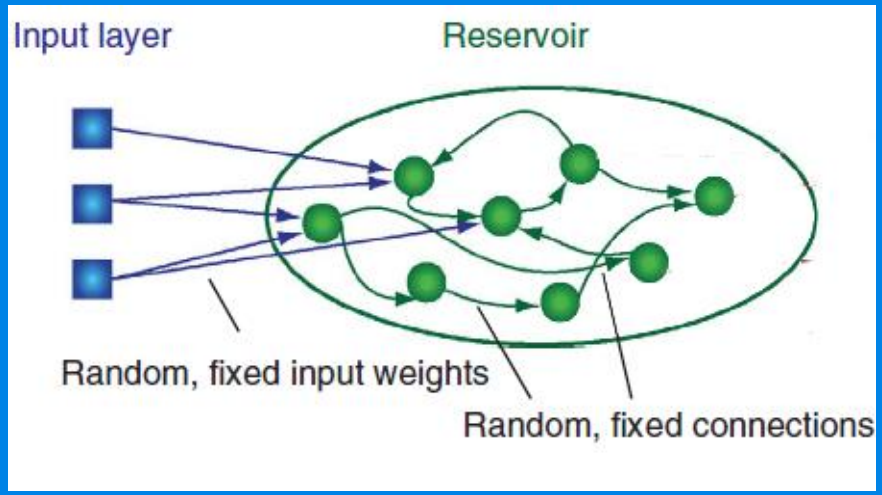


- Nieters, Leugering, Pipa, “Neuromorphic computation in multi-delay coupled models“, IBM Journal of Research (2017)
- Kovac, Koall, Pipa, Toutounji, “Persistent Memory in Single Node Delay-Coupled Reservoir Computing”, PloS one 11 (10), e0165170 (2016)
- Schumacher, Toutounji, Pipa, “An introduction to delay-coupled reservoir computing”, Artificial Neural Networks, 63-90 (2015)
- Aswolinskiy, Pipa, “RM-SORN: a reward-modulated self-organizing recurrent neural network“, Frontiers in computational neuroscience 9 (2015)
- Toutounji, Schumacher, Pipa, “Homeostatic plasticity for single node delay-coupled reservoir computing”, Neural computation (2015)
- Toutounji, Pipa, “Spatiotemporal computations of an excitable and plastic brain: …”, PLOS CB (2014)
- Lazar, Pipa. Triesch. “SORN: a self-organizing recurrent neural network”, Frontiers in computational neuroscience (2009)

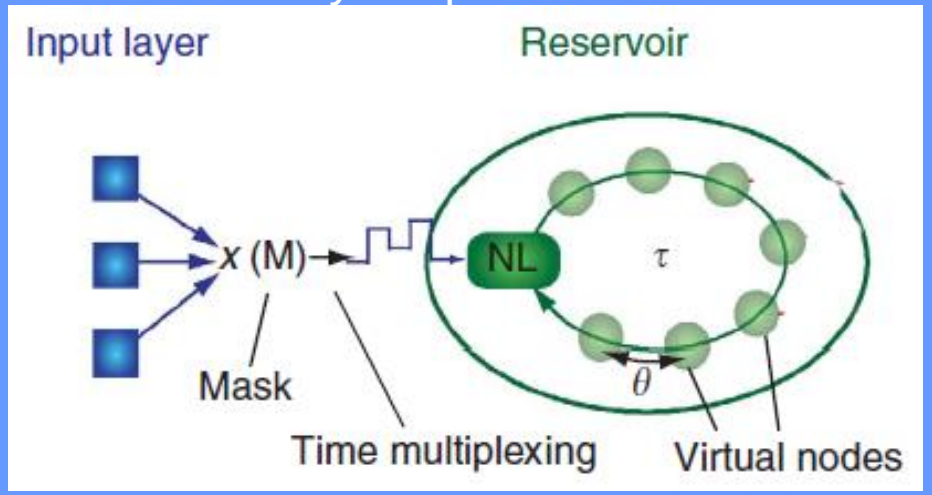
Delays render computation richer

Institute of Cognitive Science

Recurrent network reservoir



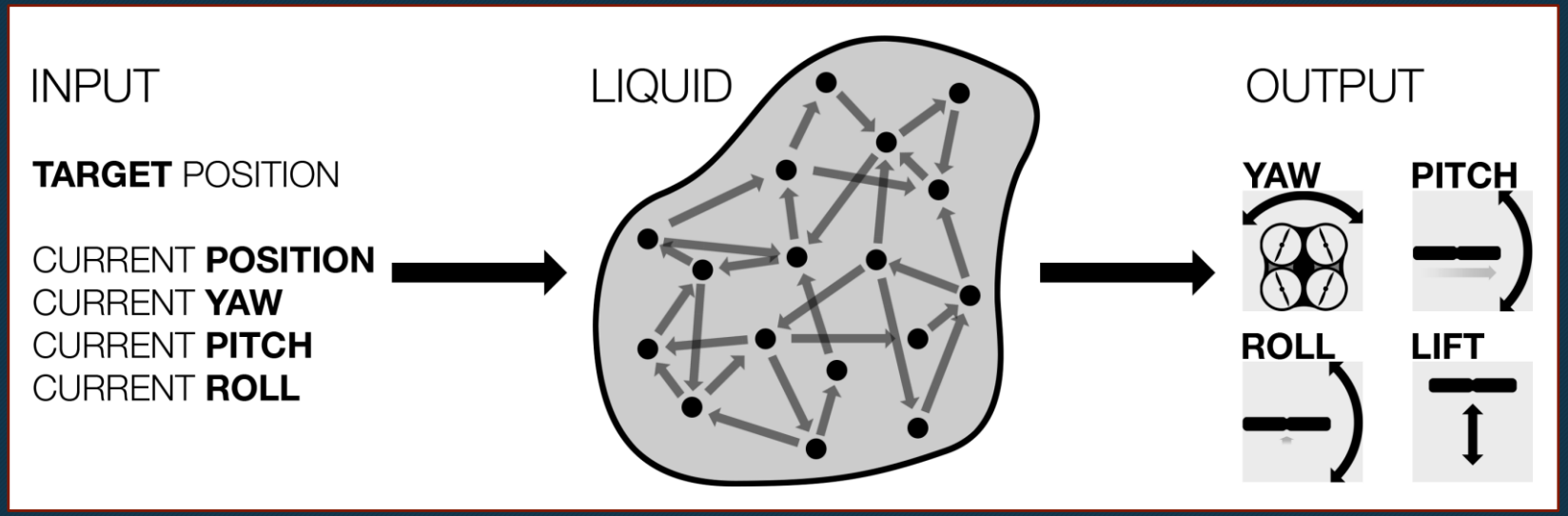
Delay coupled reservoir



- Nieters, Leugering, Pipa, “Neuromorphic computation in multi-delay coupled models“, IBM Journal of Research (2017)
- Kovac, Koall, Pipa, Toutounji, “Persistent Memory in Single Node Delay-Coupled Reservoir Computing”, PloS one 11 (10), e0165170 (2016)
- Schumacher, Toutounji, Pipa, “An introduction to delay-coupled reservoir computing”, Artificial Neural Networks, 63-90 (2015)
- Aswolinskiy, Pipa, “RM-SORN: a reward-modulated self-organizing recurrent neural network“, Frontiers in computational neuroscience 9 (2015)
- Toutounji, Schumacher, Pipa, “Homeostatic plasticity for single node delay-coupled reservoir computing”, Neural computation (2015)
- Toutounji, Pipa, “Spatiotemporal computations of an excitable and plastic brain: …”, PLOS CB (2014)
- Lazar, Pipa, Triesch, “SORN: a self-organizing recurrent neural network”, Frontiers in computational neuroscience (2009)

Neuro-Inspired Hardware

Institute of Cognitive Science



- Nieters, Leugering, Pipa, “Neuromorphic computation in multi-delay coupled models“, IBM Journal of Research (2017)
- Kovac, Koall, Pipa, Toutounji, “Persistent Memory in Single Node Delay-Coupled Reservoir Computing”, PloS one 11 (10), e0165170 (2016)
- Schumacher, Toutounji, Pipa, “An introduction to delay-coupled reservoir computing”, Artificial Neural Networks, 63-90 (2015)
- Aswolinskiy, Pipa, “RM-SORN: a reward-modulated self-organizing recurrent neural network“, Frontiers in computational neuroscience 9 (2015)
- Toutounji, Schumacher, Pipa, “Homeostatic plasticity for single node delay-coupled reservoir computing”, Neural computation (2015)
- Toutounji, Pipa, “Spatiotemporal computations of an excitable and plastic brain: …”, PLOS CB (2014)
- Lazar, Pipa, Triesch, “SORN: a self-organizing recurrent neural network”, Frontiers in computational neuroscience (2009)

Neuro-Inspired Hardware

Institute of Cognitive Science

1000 Nervenzellen (~vergleichbar mit dem Gehirn einer Medusa/Qualle)

Neuro-Inspired Hardware

Institute of Cognitive Science

1000 Nervenzellen (~vergleichbar mit dem Gehirn einer Medusa/Qualle)

Institute of Cognitive Science

Modelling Complex Human Behaviour for autonmous systems

Prof. Dr. Gordon Pipa, Osnabruck University

Prof. Dr. Peter König, Osnabruck University

Prof. Dr. Achim Stephan, Osnabruck University

Modellig Human Moral Behaviour

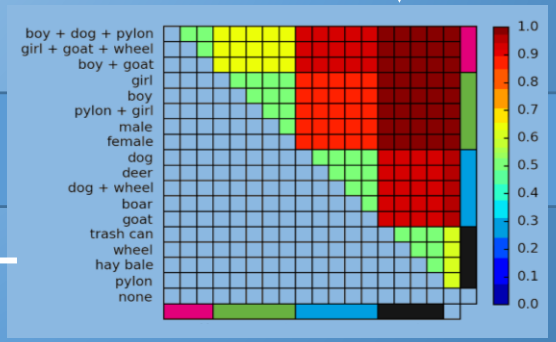
Institute of Cognitive Science

Value-of-life models approximate moral decisions

Human decisions in virtual reality

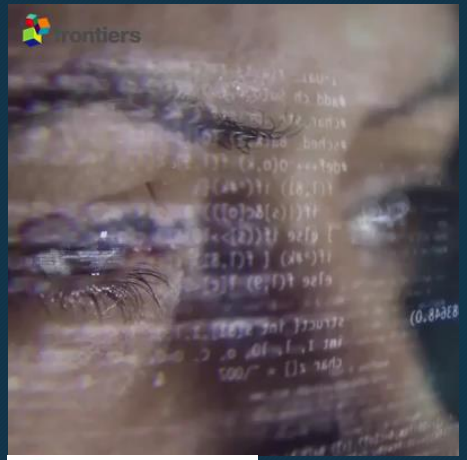
91.20%
Prediction accuracy

Probabilistic inference



Conceptualized models

Enabling algorithmic behavior of autonomous vehicles

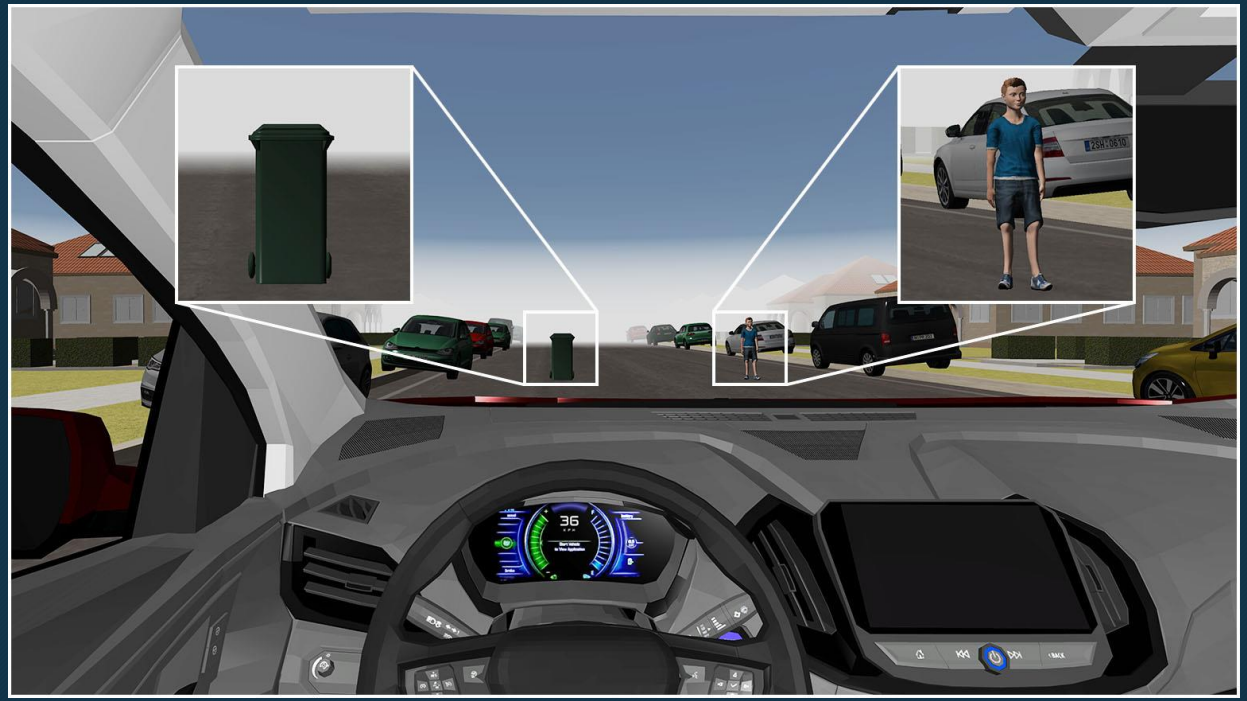


frontiers Blog

L.R. Sütfeld, R. Gast, P. König, G. Pipa, „Using Virtual Reality to Assess Ethical Decisions in Road Traffic Scenarios: Applicability of Value-of-Life-Based Models and Influences of Time Pressure", Front. Behav. Neurosci., 05 July 2017

The Moral/Ethical Turing Test

Institute of Cognitive Science



THE WALL STREET JOURNAL.

How New Technology is Illuminating a Classic Ethical Dilemma (June 8, 2016)

heise online

Autonome Autos können Ethik

Heise, 24 Jul 2017

Menschen handeln in Extremsituationen instinktiv. Dieses Handeln kann vor autonomen Autos simuliert werden, sagen Osnabrücker...

Daily Mail

News story from Daily Mail on Wednesday 05 July 2017

Daily Mail, 05 Jul 2017

Self-driving cars will soon be able to make snap life or death judgements in the event of deciding who to save in a collision...

- L.R. Sütfeld, R. Gast, P. König, G. Pipa, „Using Virtual Reality to Assess Ethical Decisions in Road Traffic Scenarios: Applicability of Value-of-Life-Based Models and Influences of Time Pressure", Front. Behav. Neurosci., 05 July 2017
- Skulmowski A, Bunge A, Kaspar K and Pipa G (2014) Forced-choice decision-making in modified trolley dilemma situations: a virtual reality and eye tracking study. *Front. Behav. Neurosci.* **8**:426. doi: 10.3389/fnbeh.2014.00426

The Moral/Ethical Turing Test

Institute of Cognitive Science

Institute of Cognitive Science

Join the Endeavor on Cognitive Computing

Prof. Dr. Gordon Pipa, Osnabruck University

Prof. Dr. Peter König, Osnabruck University

Prof. Dr. Achim Stephan, Osnabruck University

Education: BSc + MSc + PhD

Institute of Cognitive Science

KONSEKUTIVER BERUFSBEGLEITENDER MASTER IN *COGNITIVE SCIENCE*

Universität Osnabrück - Institut für Kognitionswissenschaft **Juni 2016**

Studienorganisation

Das berufsbegleitende Studium *Cognitive Science* kann in Blockwochen abgeleistet werden. Im Ergebnis sind die Studierenden im ersten, zweiten und dritten Semester jeweils zu ca. 50% ihrer Studienzeit in Osnabrück und zu ca. 50% ihrer Studienzeit bei PARTNER oder Kunden von PARTNER. Die Kurse werden basierend auf vorheriger Absprache mit den PARTNER Masterstudierenden geblockt angeboten.

Semester 1	**BW 1-2**	**PARTNER**			**BW 3-4**	**PARTNER**			**BW 5-6**
Dauer	**2W**	**3W**			**2W**	**3W**			**2W**
Semester 2	**BW 1-2**	**ST***	**PARTNER / ST***	**ST***	**PARTNER / ST**	**ST***	**PARTNER / ST**	**ST***	**BW 5-6**
Dauer	**2W**	**2T**		**3T**		**3T**		**2T**	**2W**
Semester 3	**BW 1-2**	**ST***	**PARTNER / ST***	**ST***	**PARTNER / ST**	**ST***	**PARTNER / ST**	**ST***	**BW 5-6**
Dauer	**2W**	**2T**		**3T**		**3T**		**2T**	**2W**
Semester 4	**Masterthese (6 Monate)**								

*ST: Studienprojektbezogene Arbeit. Kann bei PARTNER oder bei PARTNER-Kunden durchgeführt werden. Das Projekt wird durch die Lehrenden des Instituts für Kognitionswissenschaft begleitet. Dazu sind neben Online Tools 3 ST-Meetings pro Semester vorgesehen.

*BW: Blockwoche mit Blockunterricht in den jeweiligen Kursen.

Zentrum für Informationsmanagement und Virtuelle Lehre (virtUOS)

Alle Kurse des berufsbegleitenden Masterstudienganges werden überwiegend als Online-Vorlesung bzw. Online-Seminar mit elektronisch durchsuchbaren Slides und als druckbares Material online zur Verfügung stehen.

Thank you to my collaborators on these projects

Prof. Dr. Pipa
Neuroinformatik

Prof. Dr. Kühnberger
Künstliche Intelligenz

Prof. Dr. König
Neurobiopsychologie

Dr. Thelen
virtUOS & Computer science
Institute of Cognitive Science

Prof. Dr. Stephan
Philosophie des Geistes
und der Kognition

Prof. Dr. Dr. Scheller
Intensive Care, University
Hospital Frankfurt

Institute of
Cognitive Science

Institute of Cognitive Science (seit 2002)

9 Professoren

~ 650 BSc
~ 250 MSc
~ 50 PhD Studenten

2012-2014: 4,05 Mio. €
formelrelevante Drittmittel

Try It Yourself **www.flu-prediction.com**

You can download this talk from https://youtu.be/s_TDUjrti4w

flu prediction

IBM Academic Initiative

Institute of Cognitive Science

Prof. Dr. Gordon Pipa
Osnabrück University
gpipa@uos.de

Prof. Dr. Kühnberger
Osnabrück University

Prof. Dr. Dr. Scheller
University Hospital
Frankfurt