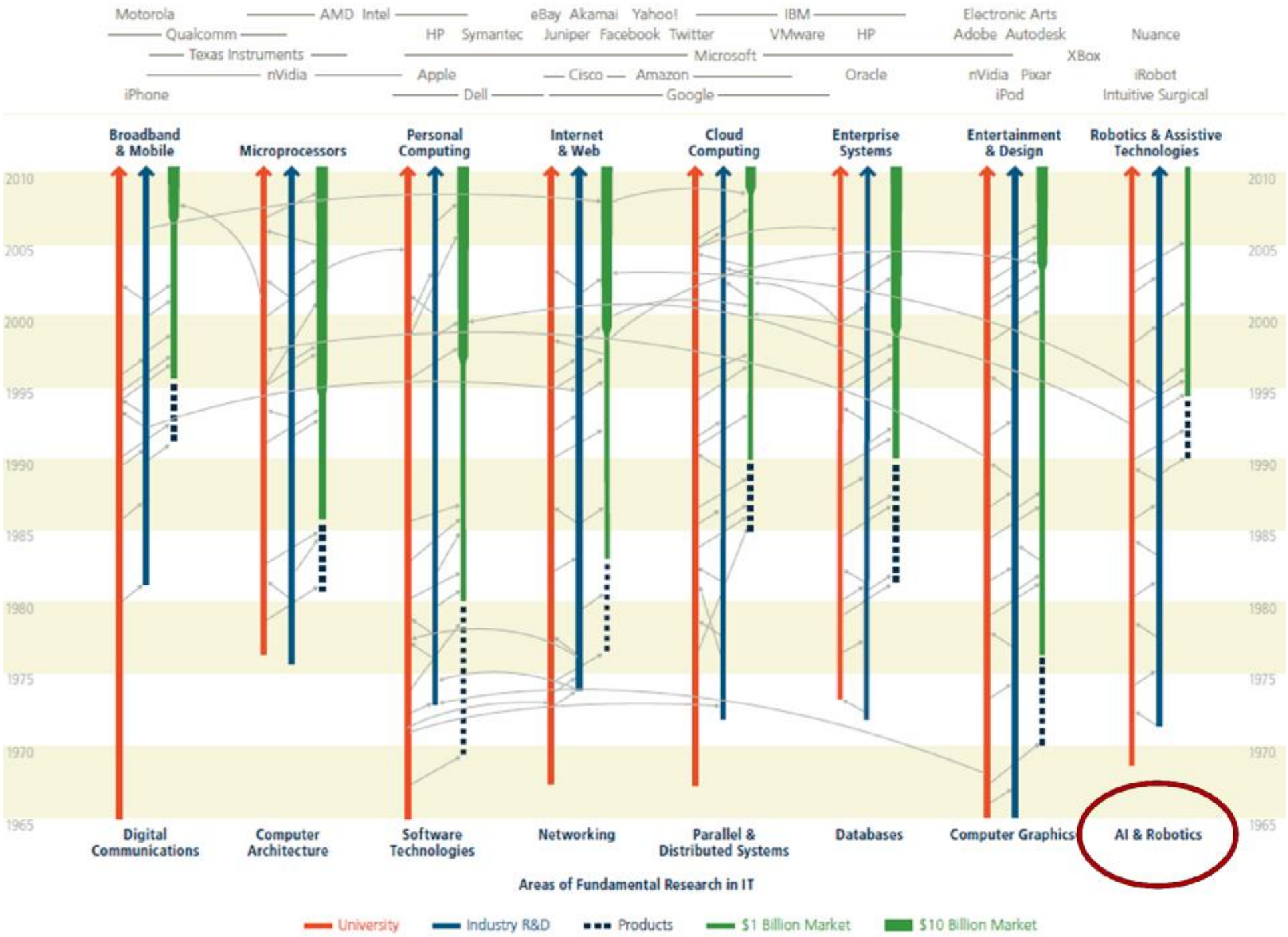
Investments & Outcomes in AI: Paradigms Shifts—and a Renaissance

Eric Horvitz
Microsoft Research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Nuance
Texas Instruments
Microsoft
XBox
nVidia
Apple
Cisco
Amazon
Oracle
nVidia
Pixar
iRobot
iPhone
Dell
Google
iPod
Intuitive Surgical
Broadband & Mobile
Microprocessors
Personal Computing
Internet & Web
Cloud Computing
Enterprise Systems
Entertainment & Design
Robotics & Assistive Technologies
2010
2005
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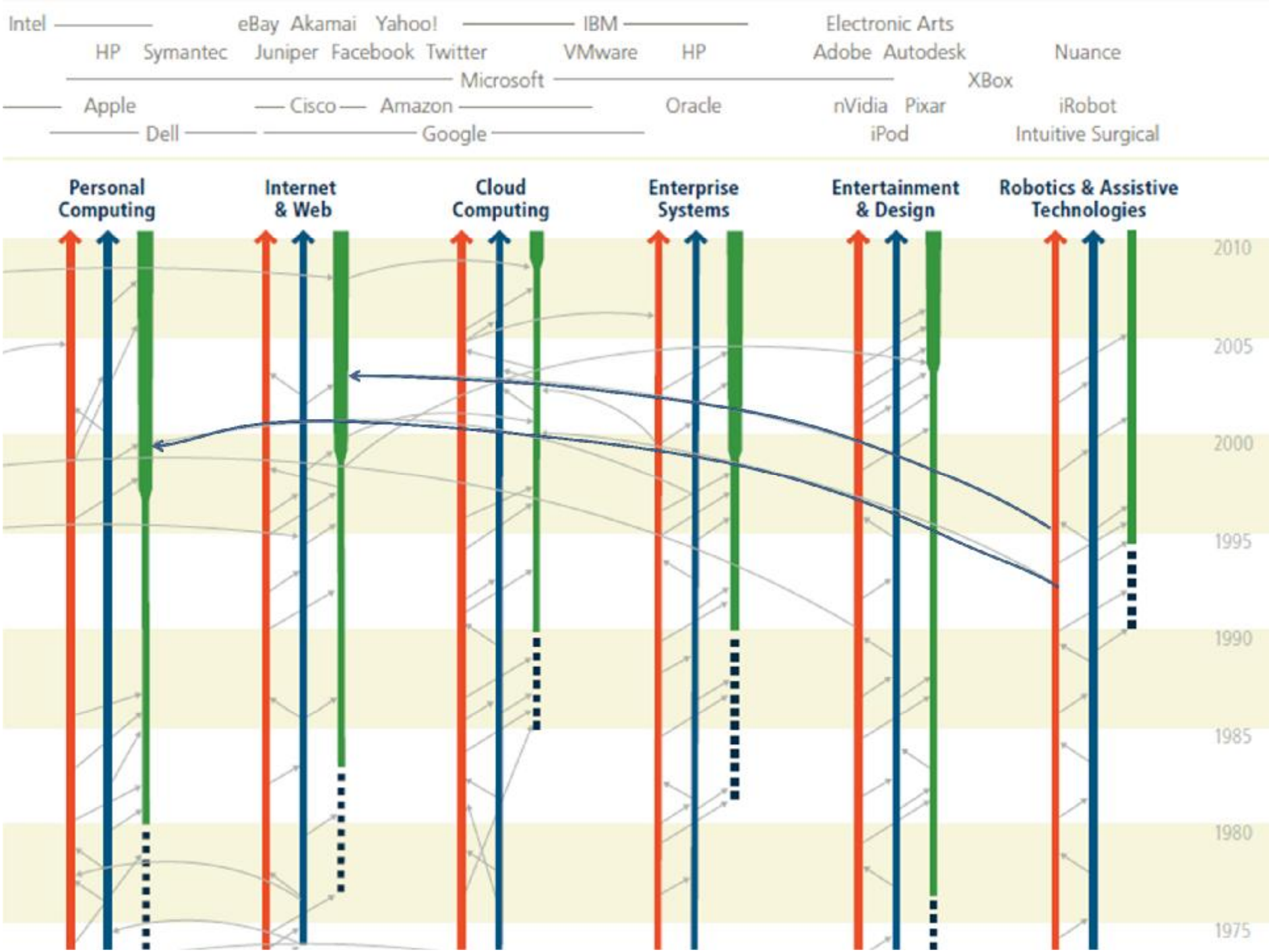
1965
Digital Communications
Computer Architecture
Software Technologies
Networking
Parallel & Distributed Systems
Databases
Computer Graphics
AI & Robotics
Areas of Fundamental Research in IT
University
Industry R&D
Products
$1 Billion Market
$10 Billion Market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Microsoft
XBox
Apple
Cisco
Amazon
Oracle
nVidia
Pixar
iRobot
Dell
Google
iPod
Intuitive Surgical
Personal Computing
Internet & Web
Cloud Computing
Enterprise Systems
Entertainment & Design
Robotics & Assistive Technologies
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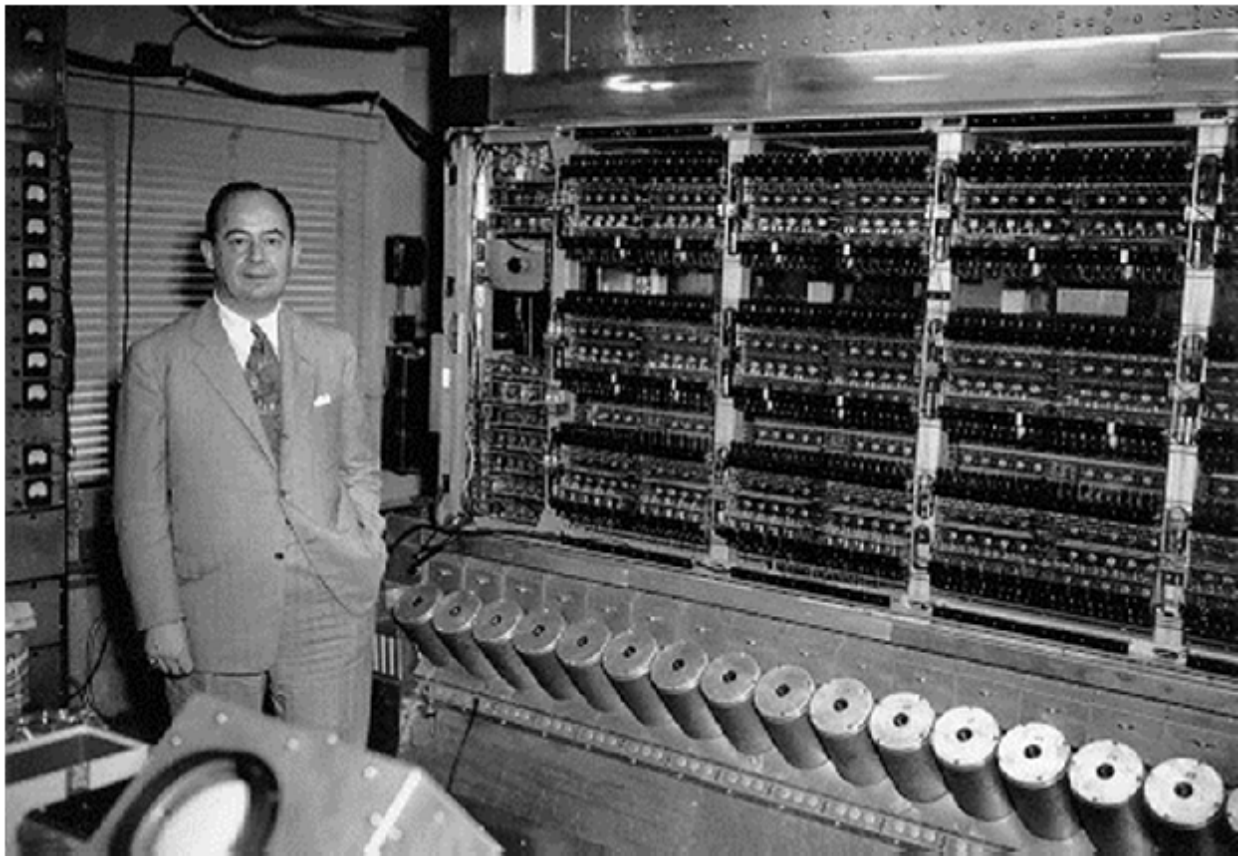
1975

Computational basis of intelligence

Theories of computability

General purpose computer



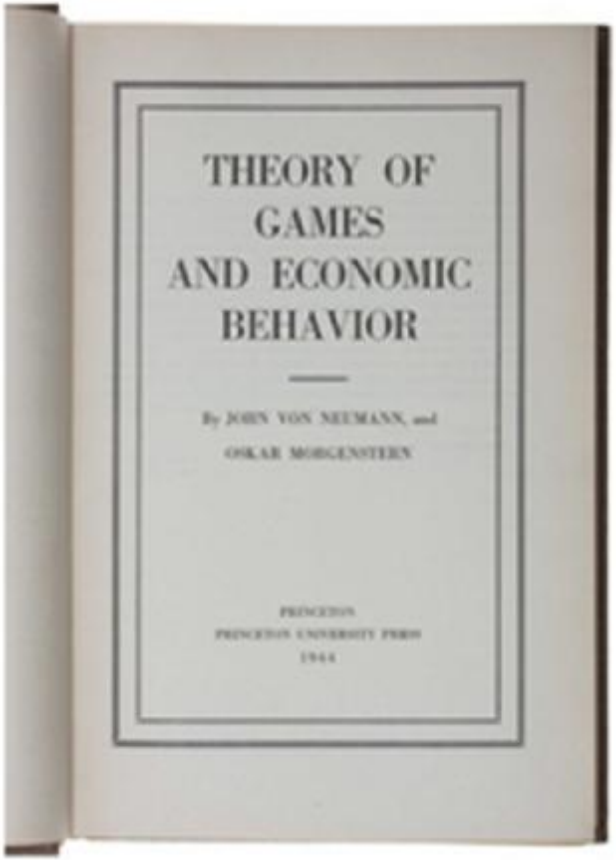
John von Neumann & the EDVAC

1940s

Decisions Under Uncertainty

Probability & utility theory

Maximum expected utility



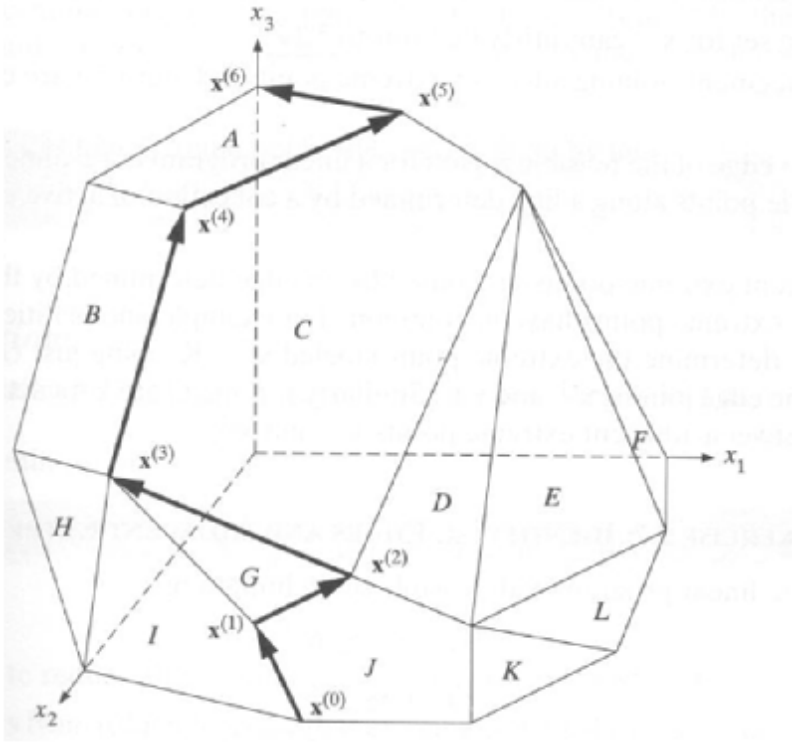
1940s

Operations Research & Decision Science

Linear programming

Dynamic programming

Markov decision processes



1940s-1950s

Artificial Intelligence (1956)

John McCarthy:

"I used *artificial intelligence* because I wanted to put the flag on the pole" [of what we were pursuing.]

1956 Dartmouth Proposal

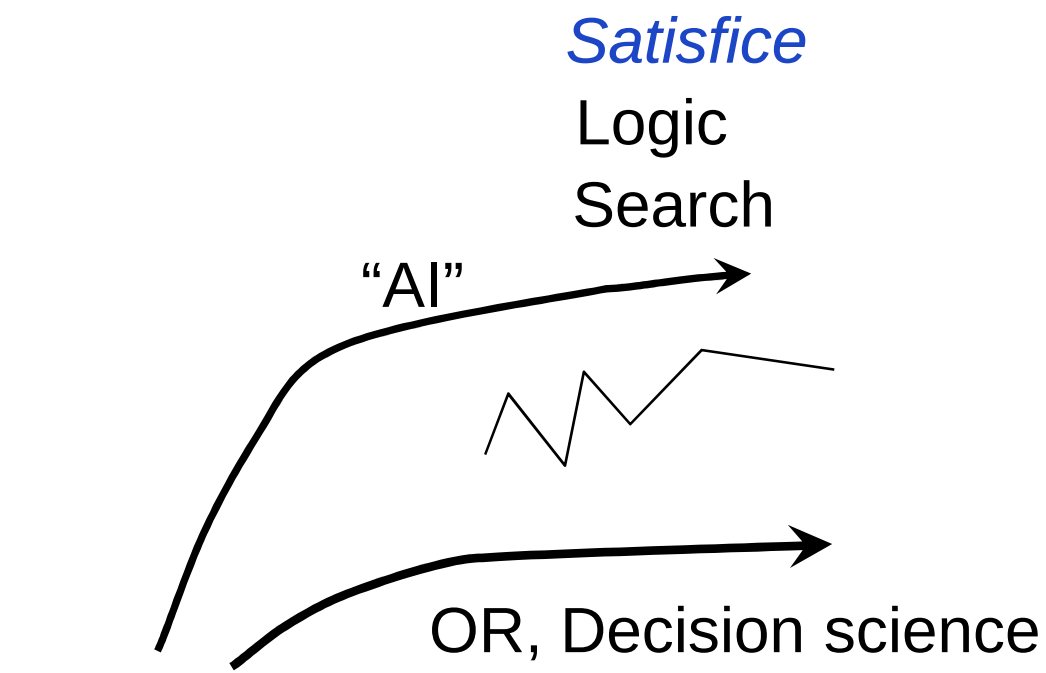
Machine methods of forming abstractions from sensory and other data

Carrying out activities which may best be described as self-improvement

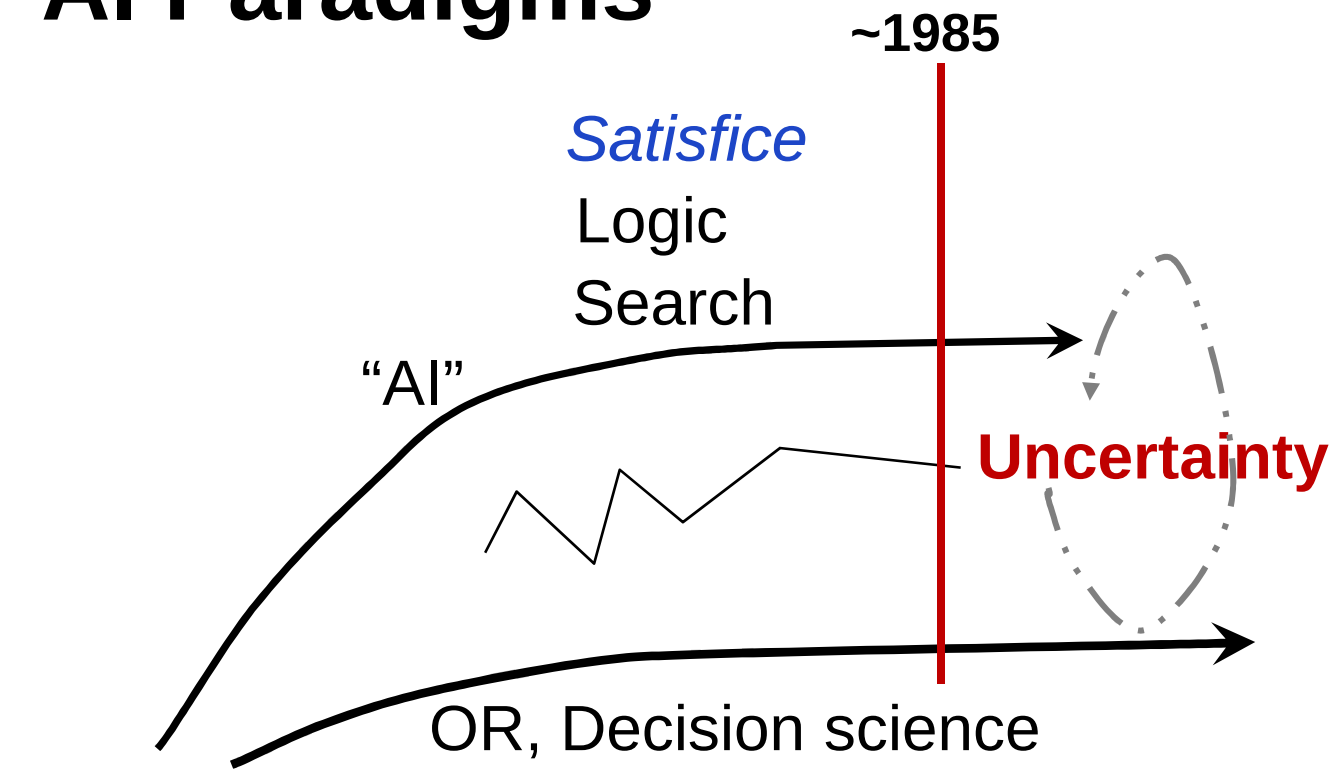
Manipulating words according to rules of reasoning and rules of conjecture

Developing a theory of the complexity for various aspects of intelligence

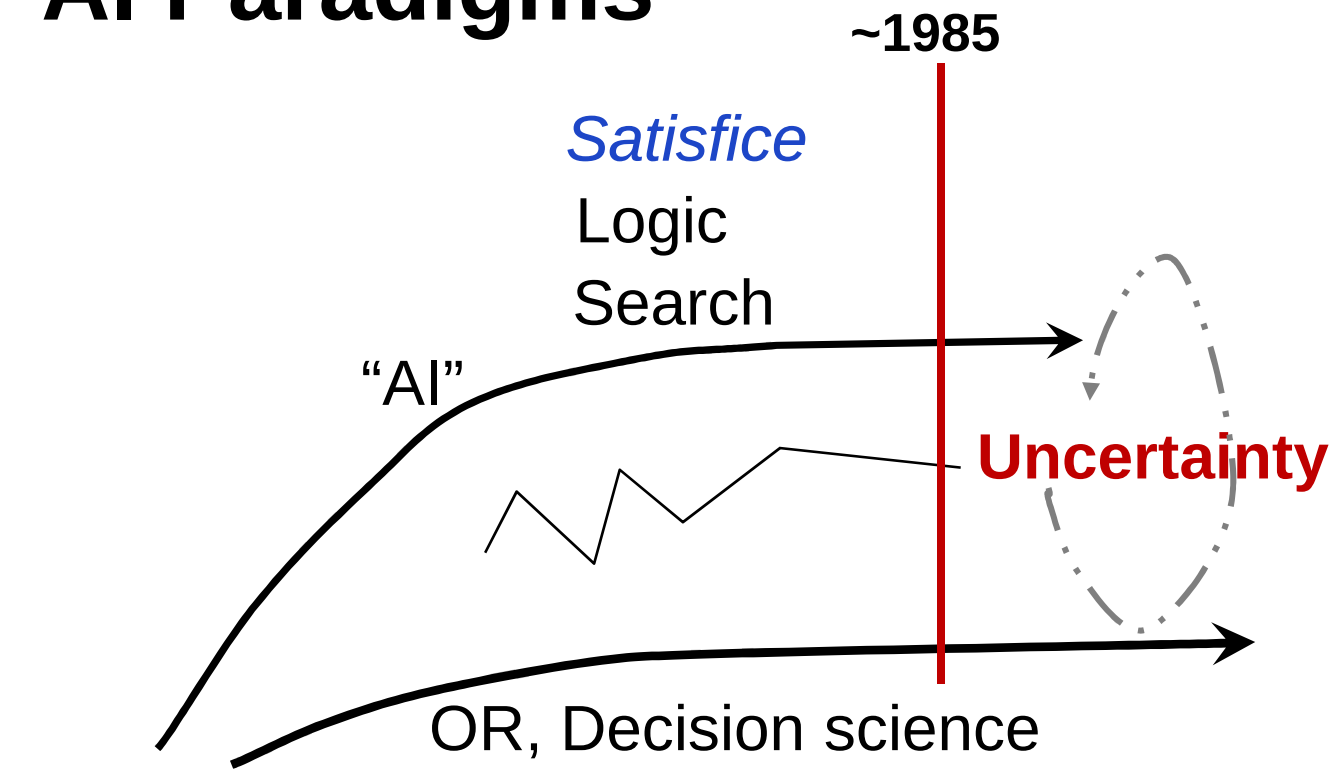
AI Paradigms



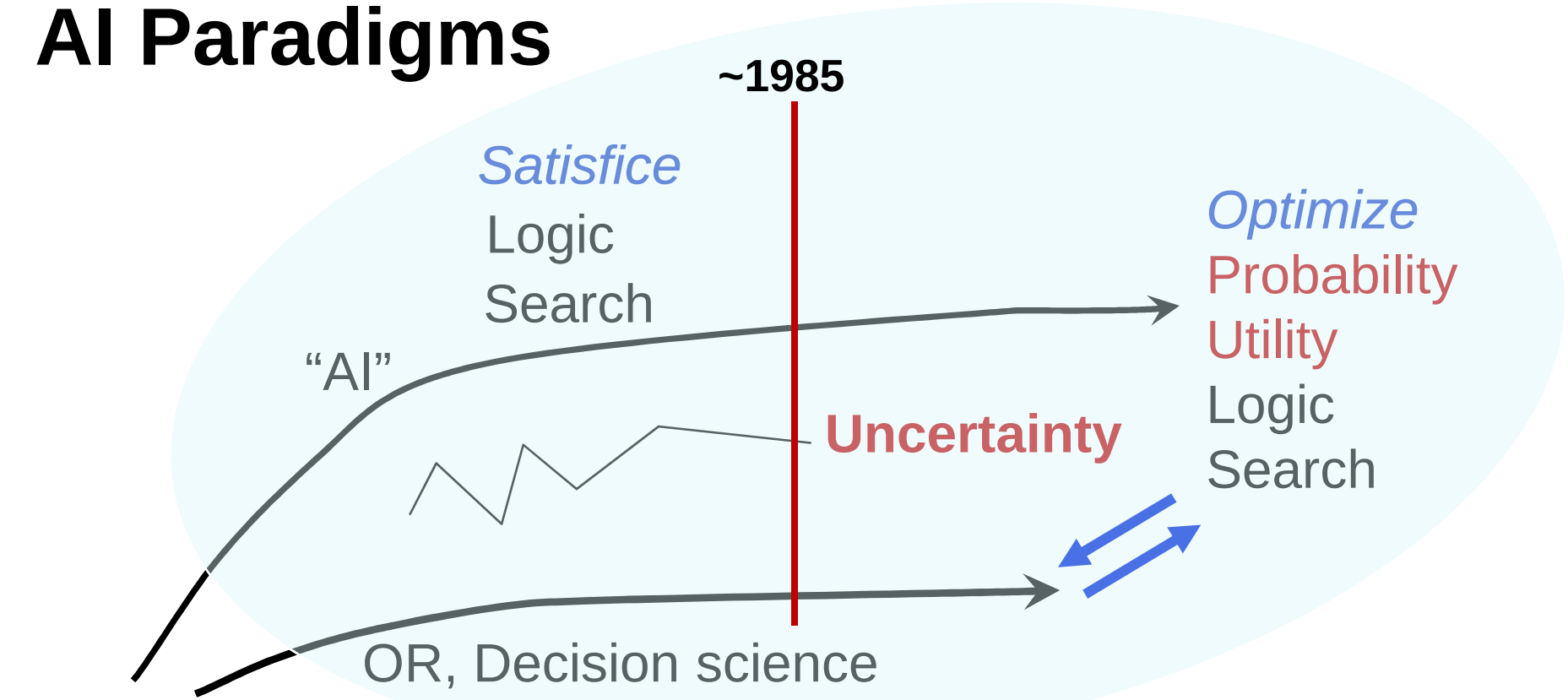
AI Paradigms



AI Paradigms



AI Paradigms



Intellectual Pressures

Decisions in high-stakes settings

Reasoning & action under constraints

Learning from increasing amounts of data

Collaborating with people in open world

Criticality of probability & utility

High-Stakes Settings

Possible Disorders

0.80	Brain parench injury
0.17	Brain hemat: small/stable
0.02	Concussion, no parench injury
0.01	Other, noncritical
0.00	Brain hemat: lrg/rapidly exp
0.00	Massive brain parenchymal

Worksheet

Skin lacerations : Head
Mechanism : Motorcycle
Level of Consc (AVPU) : Responds to pain
Airway sounds : Normal
RR : 11-20
Peripheral perfusion : 3-5 seconds
EMT Pulse Rate : 100-120
Alcohol on breath : Present (yes)
Gross Head : Visible skull depress

Rich Investments & Returns

Agencies

DARPA,NSF, NSF, ONR, AFOSR, NLM, NASA

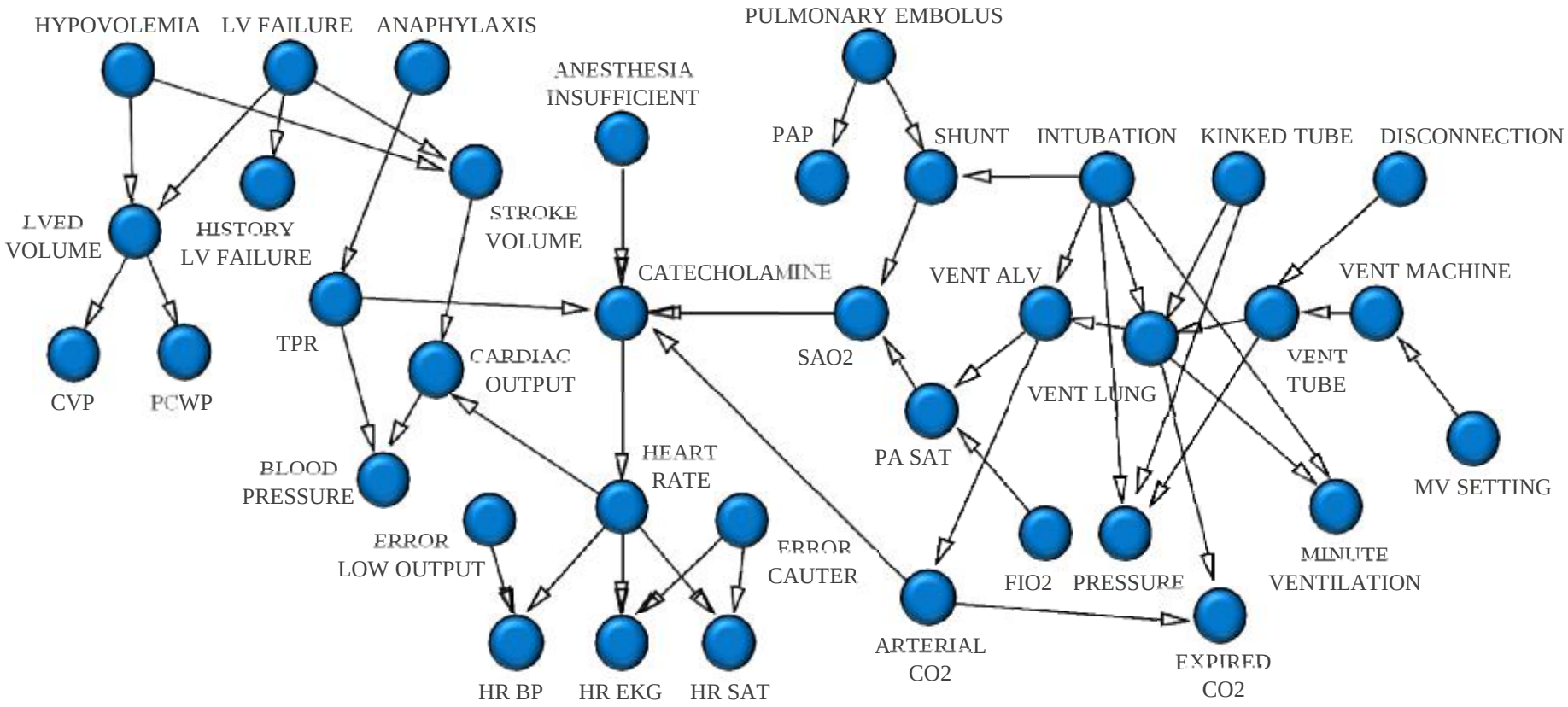
Corp R&D

IBM, Google, Microsoft, etc.

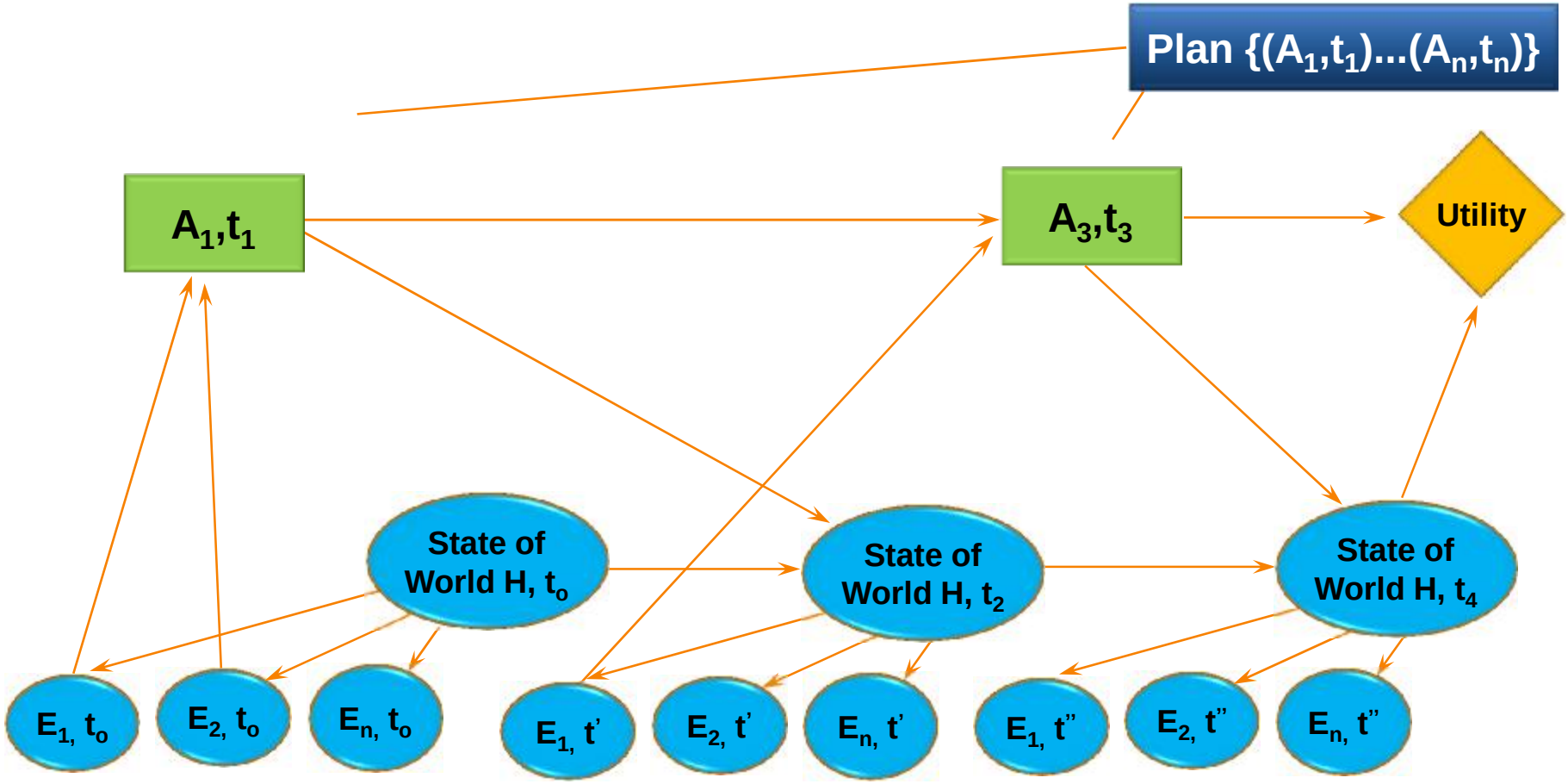
Influences & trends:

Computational horsepower, data availability, algorithmic sophistication, shift of human activities to web, competitive landscape

Investments in Rich Representations

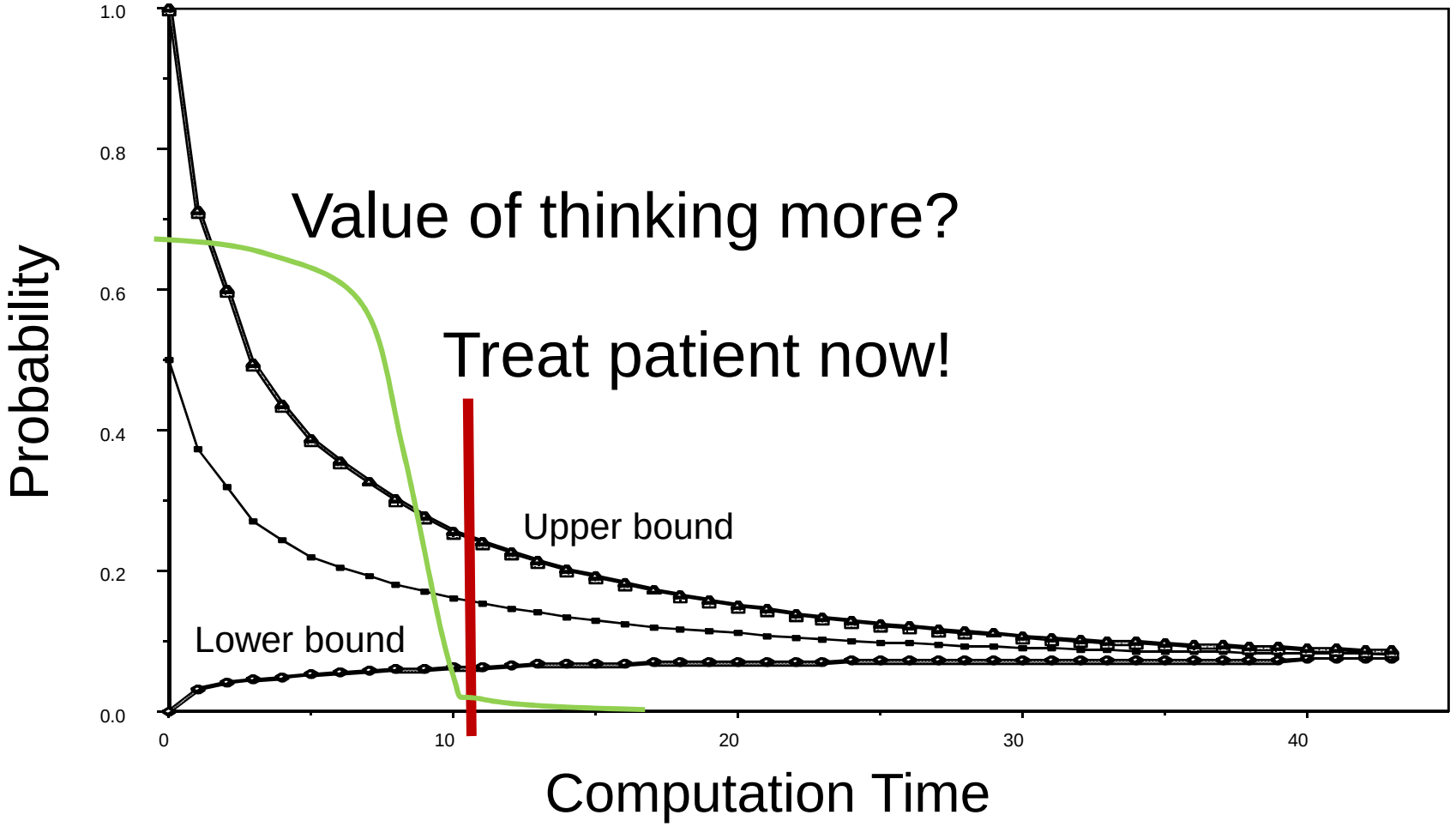


Investments in Rich Representations

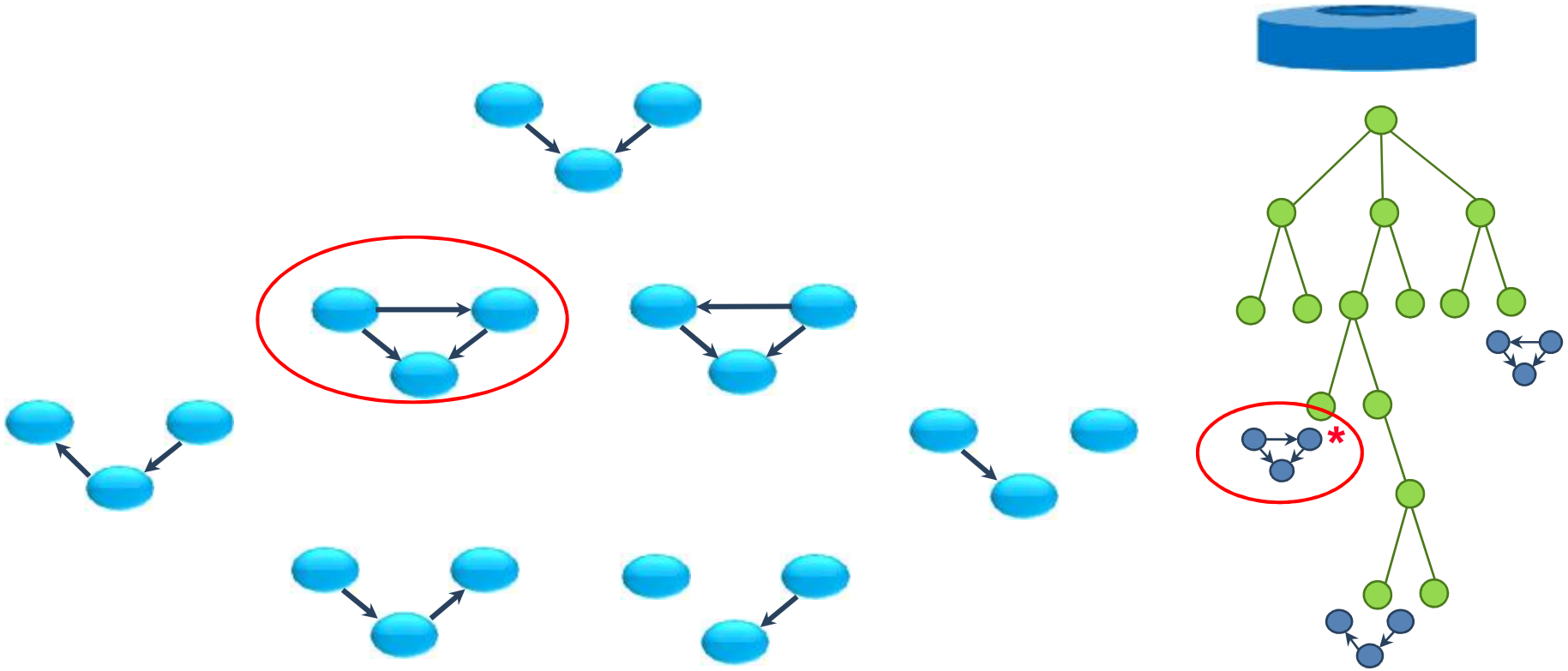


Investments in Reasoning

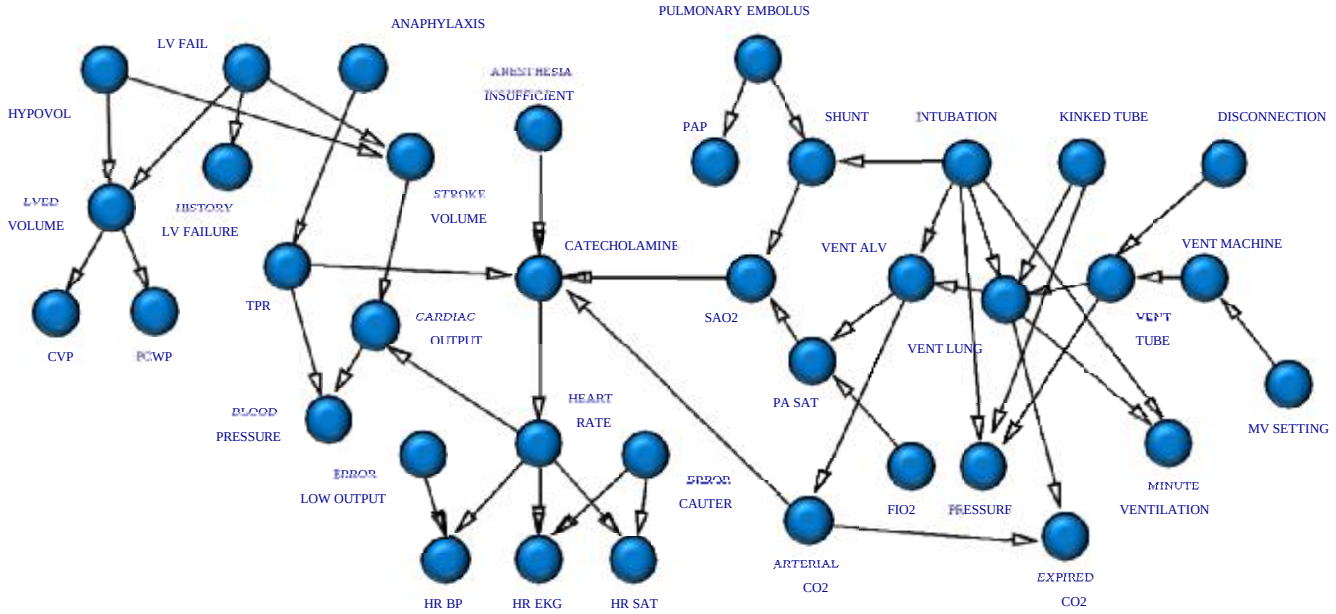
Approximations & architectures

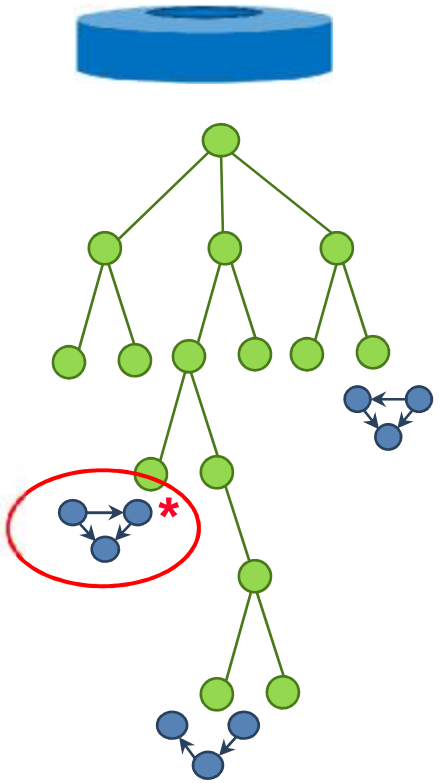


Investments in Machine Learning

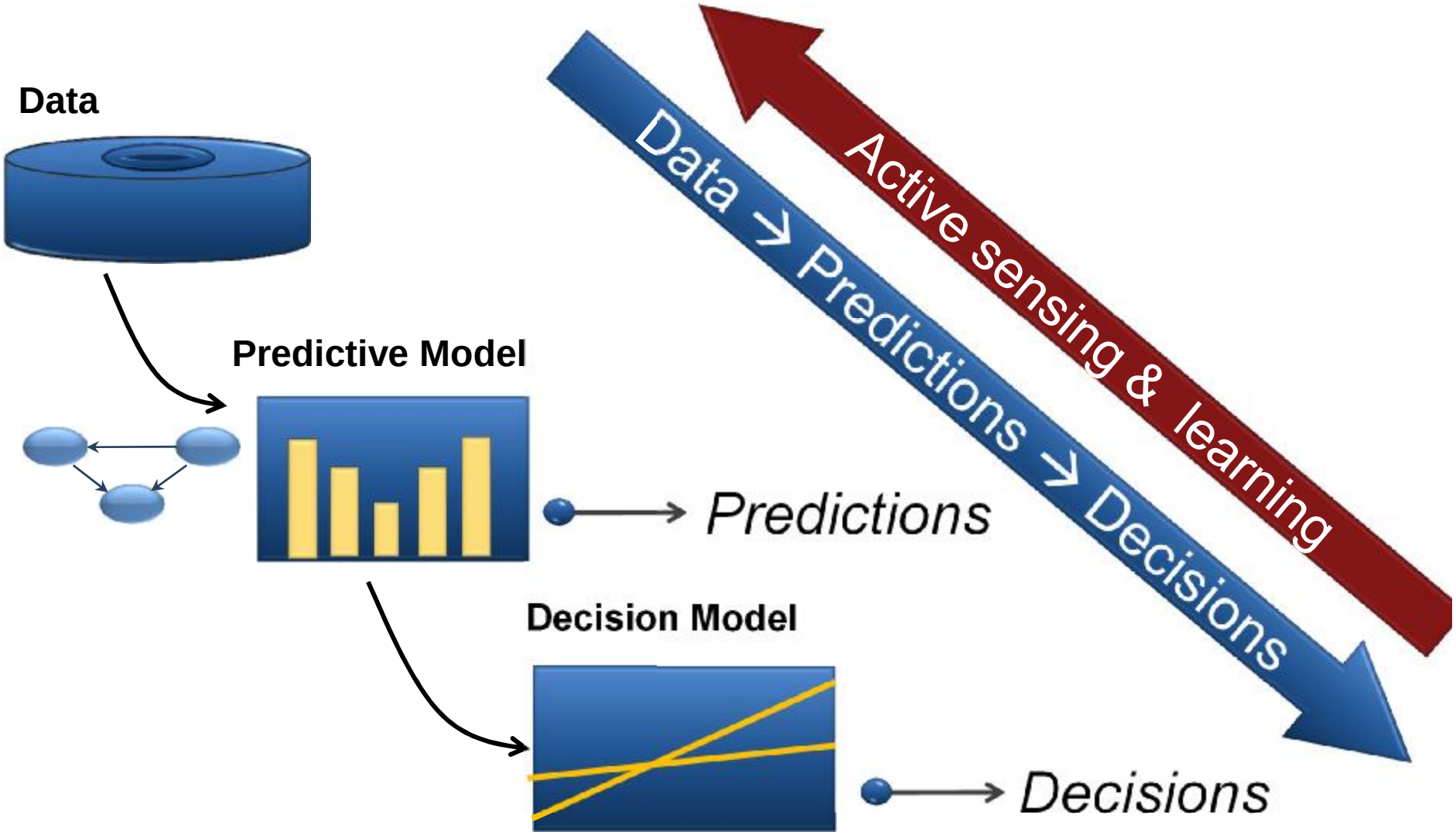


Investments in Machine Learning

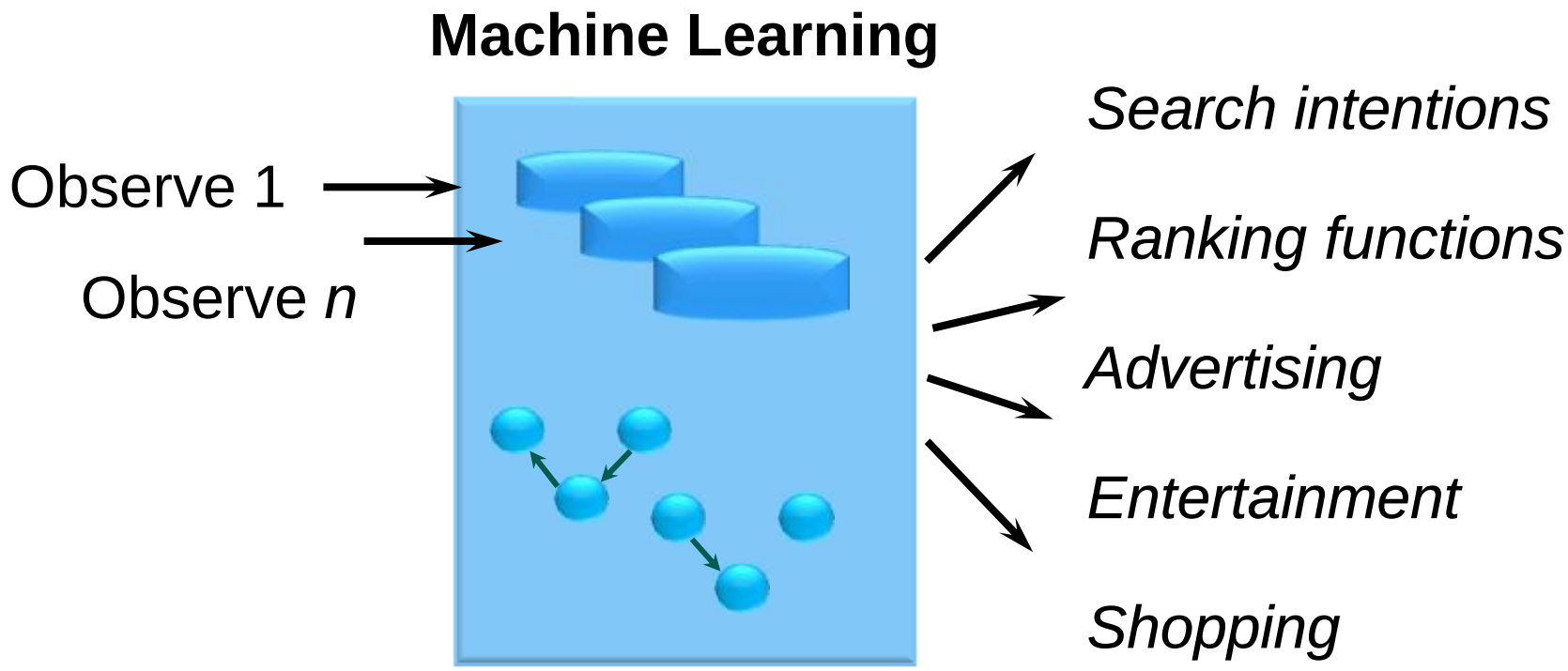




Rise of Approach & Tools

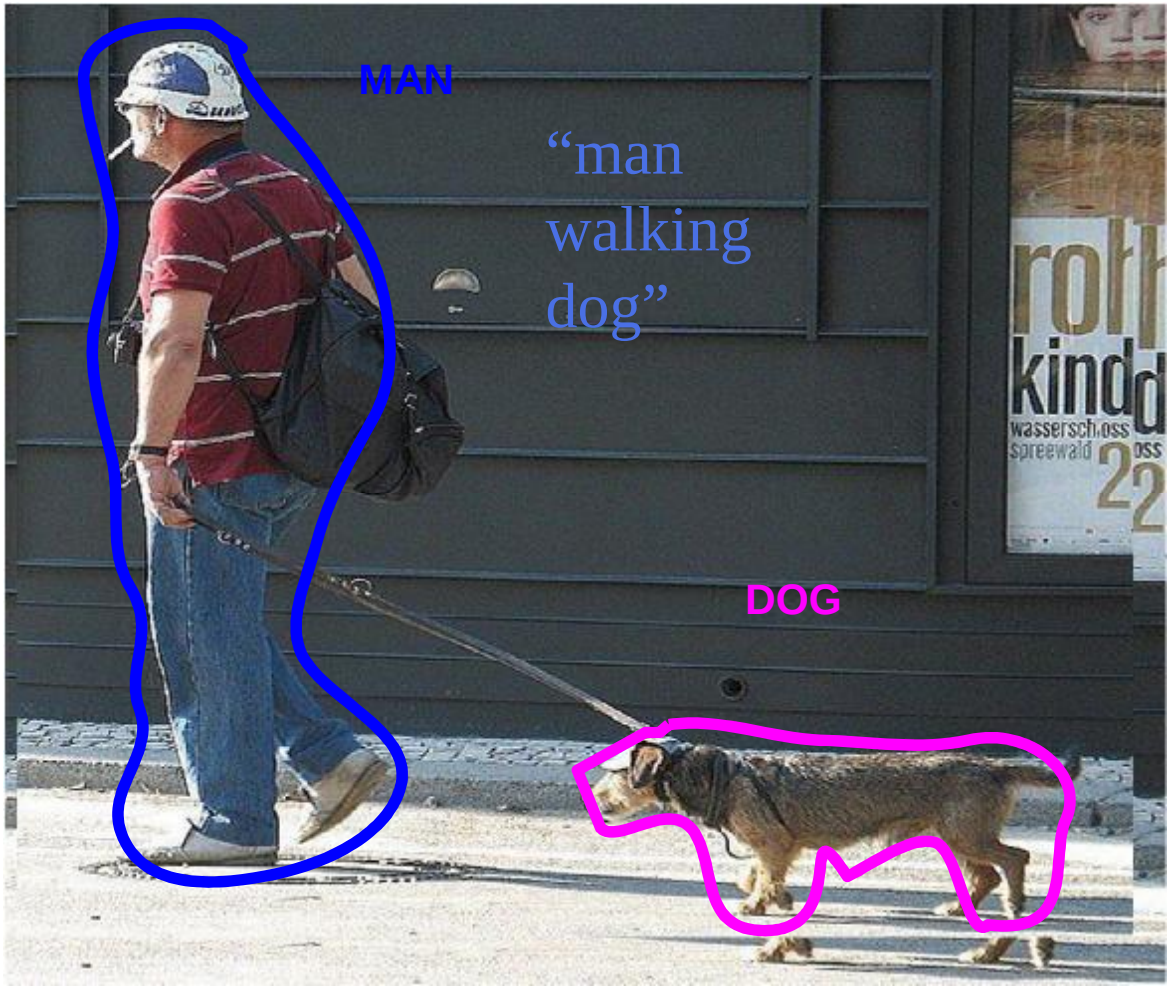


Igniting E-Commerce Worldwide



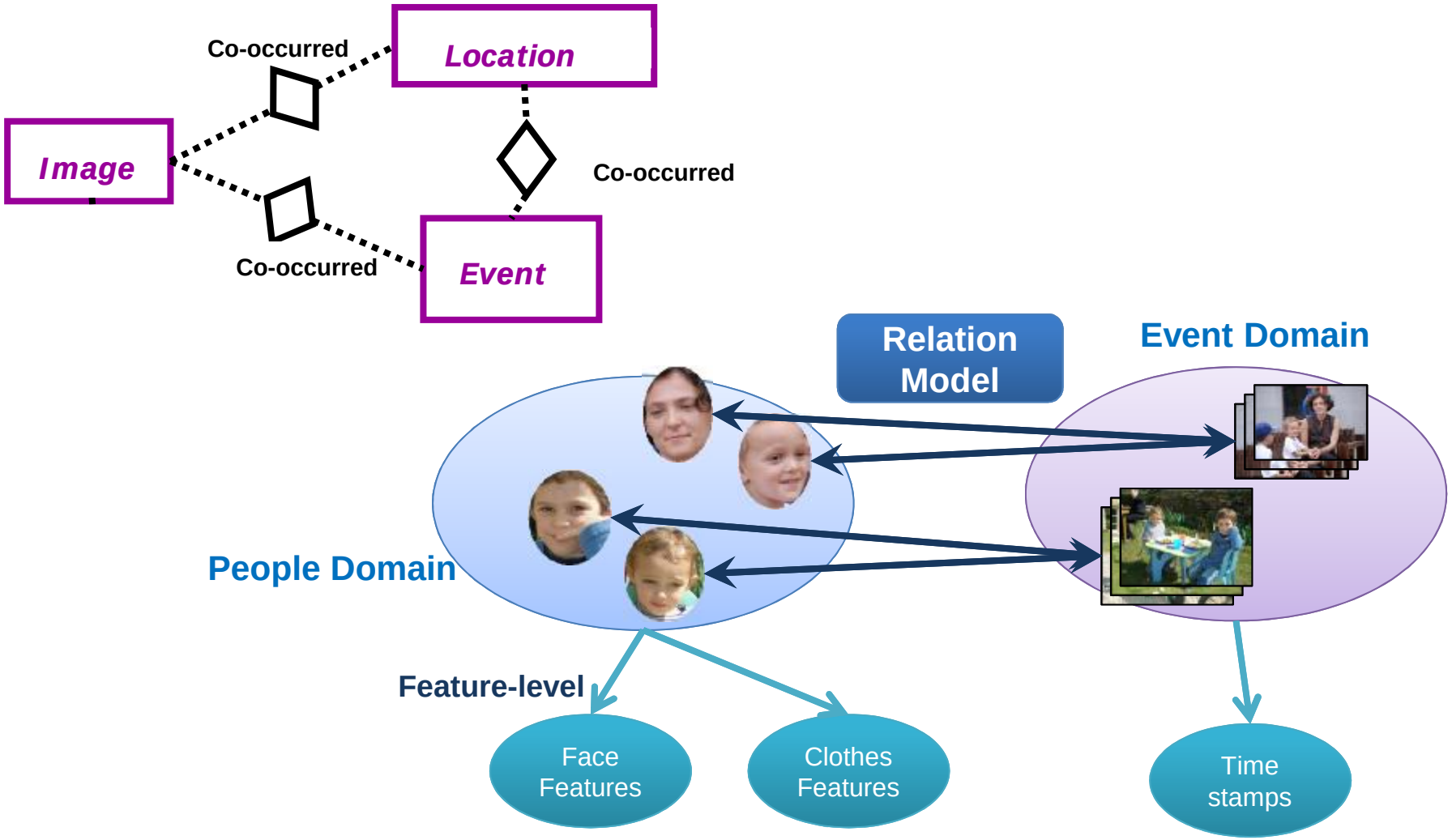
Twenty years ago: Challenge of building "collaborative filtering" systems

Advances in Perception & Language

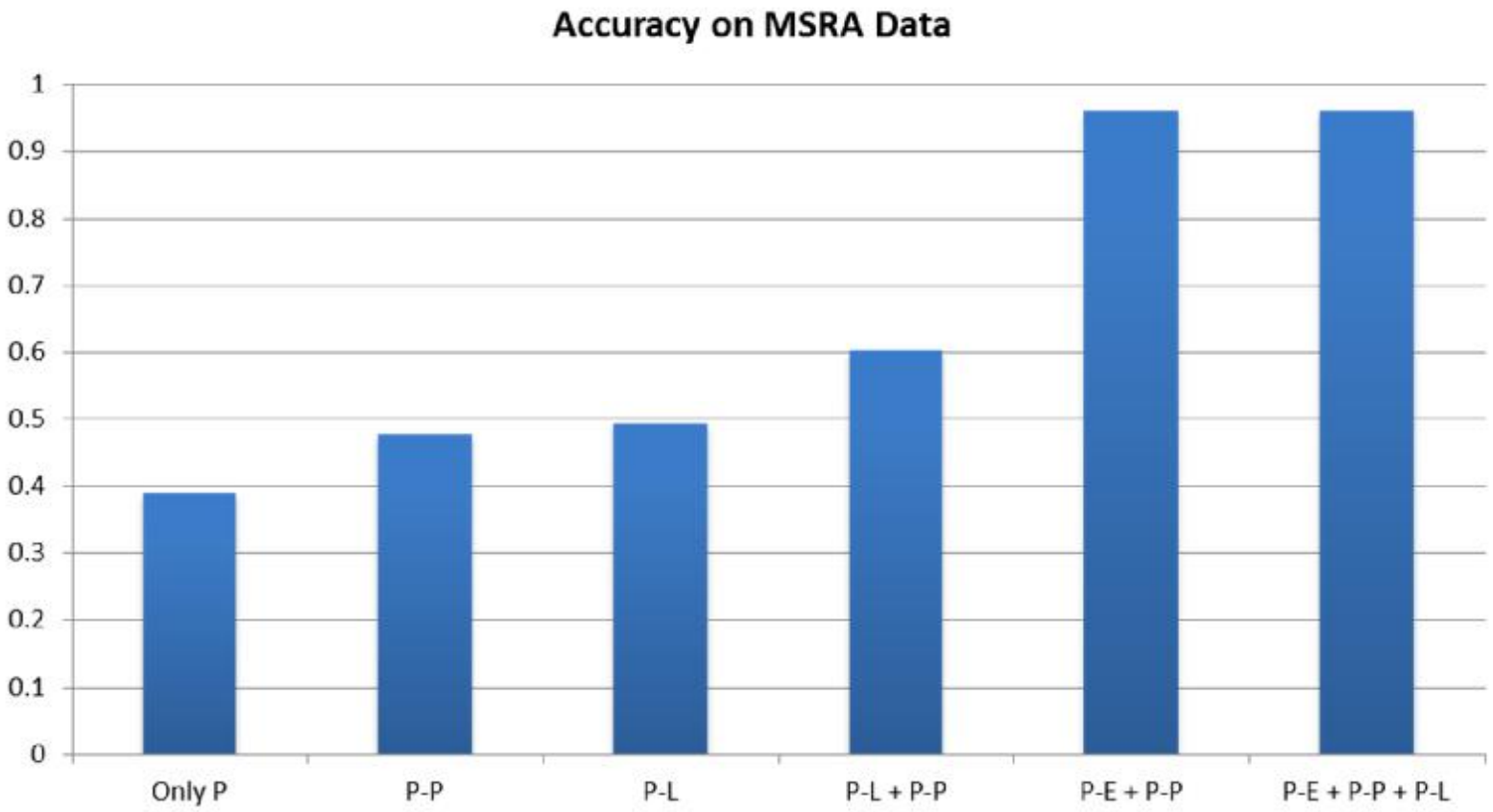


G. Elidan, G. Heitz, and D. Koller

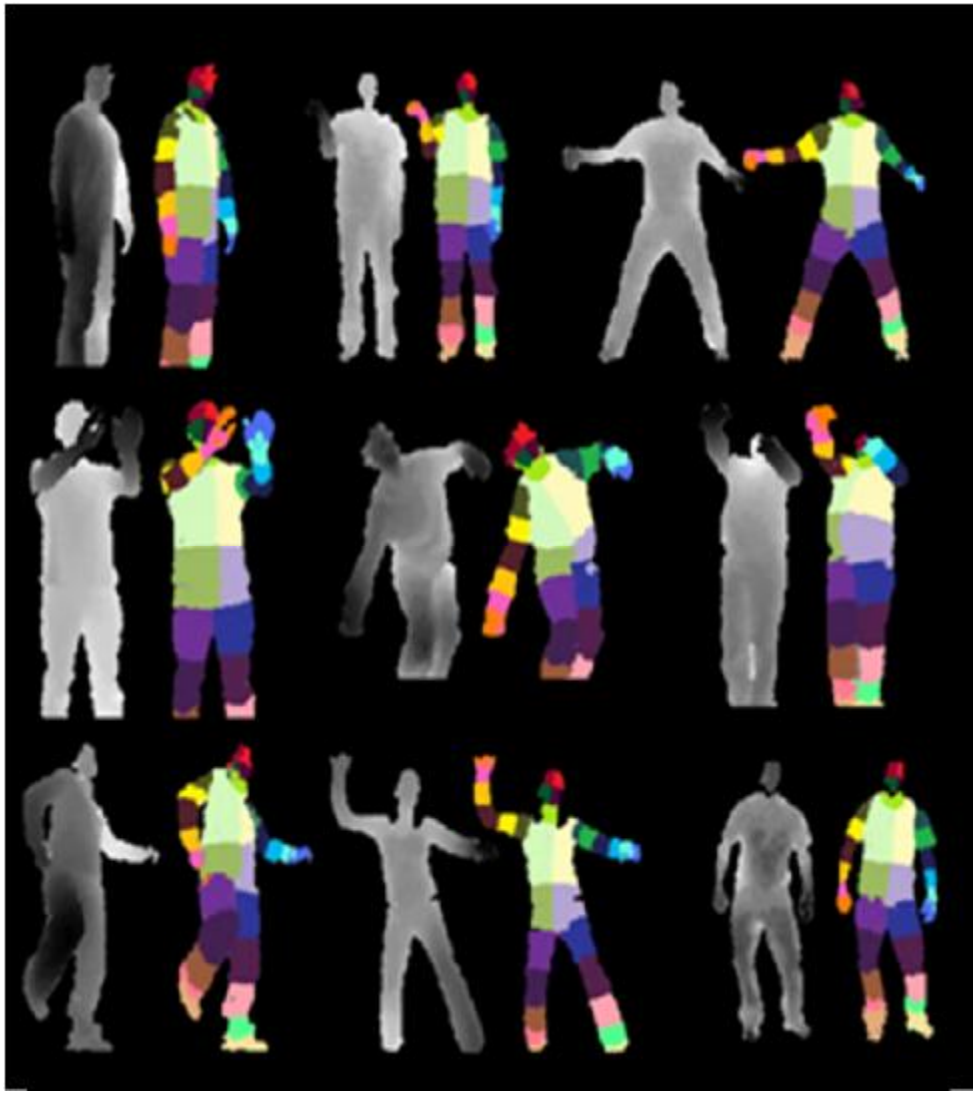
Advances in Perception & Language



Advances in Perception & Language



Advances in Perception & Language



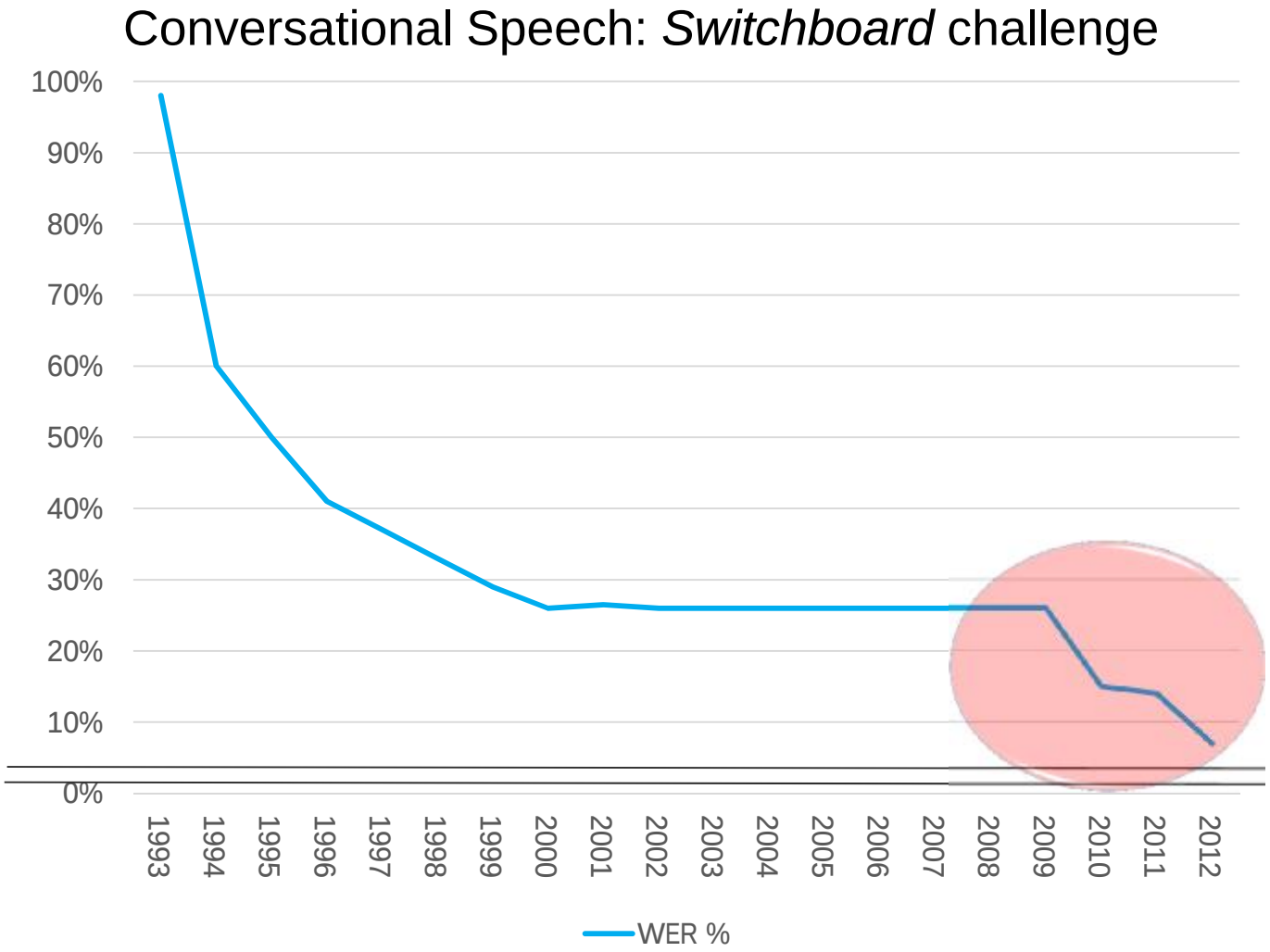
J. Shotton, J. Winn, C. Rother, A. Criminisi

Advances in Perception & Language

KINECT™
for XBOX 360.

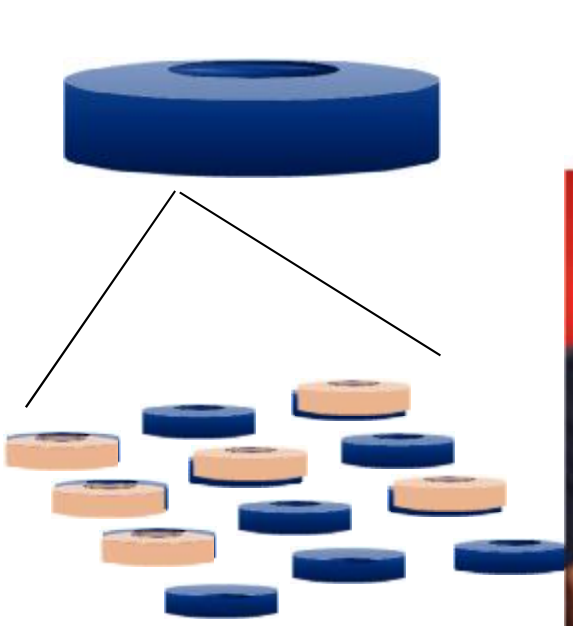
Advances in Perception & Language

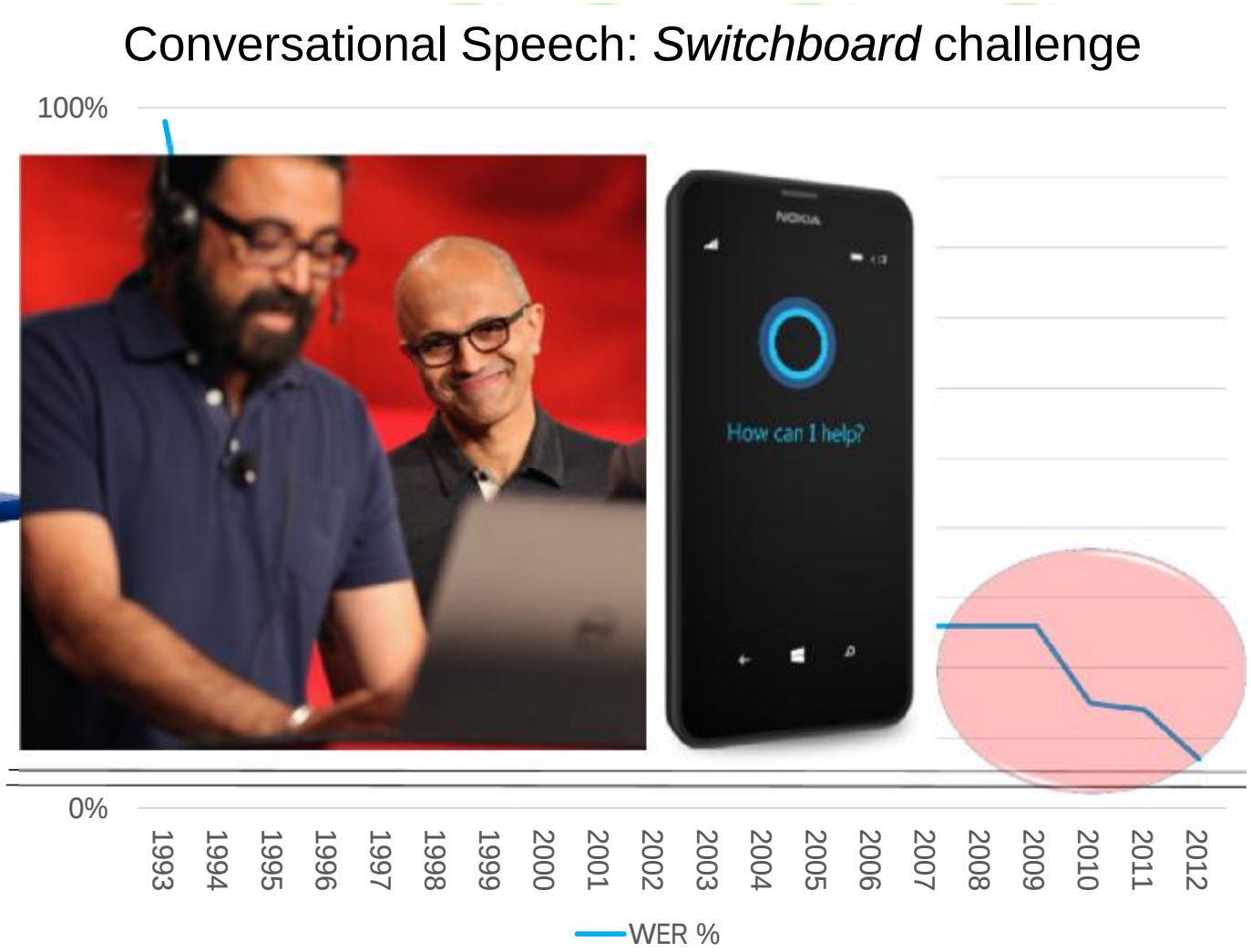
Stacked representations



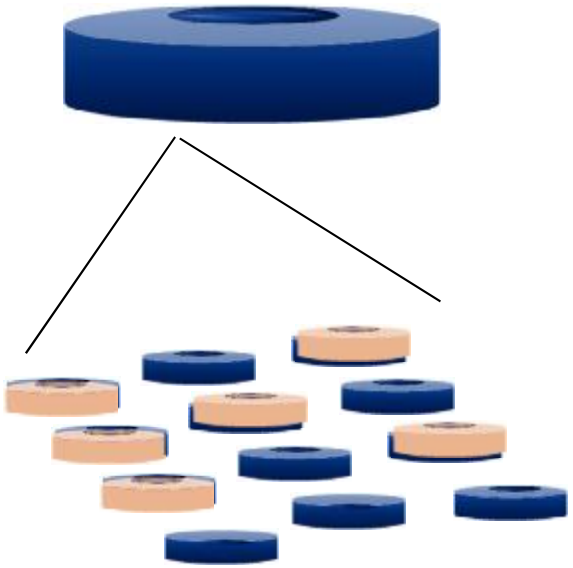
Advances in Perception & Language

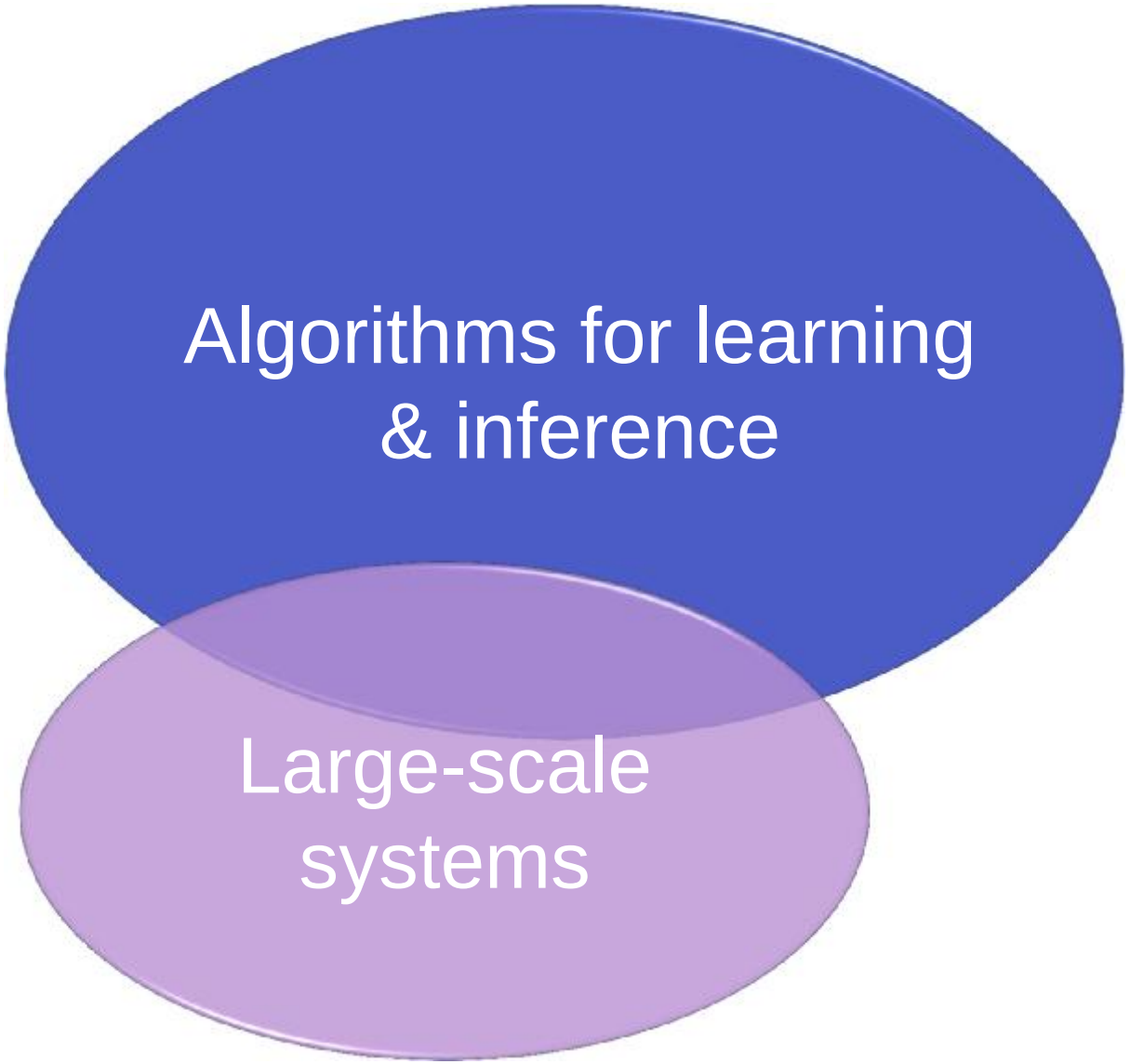
Stacked representations



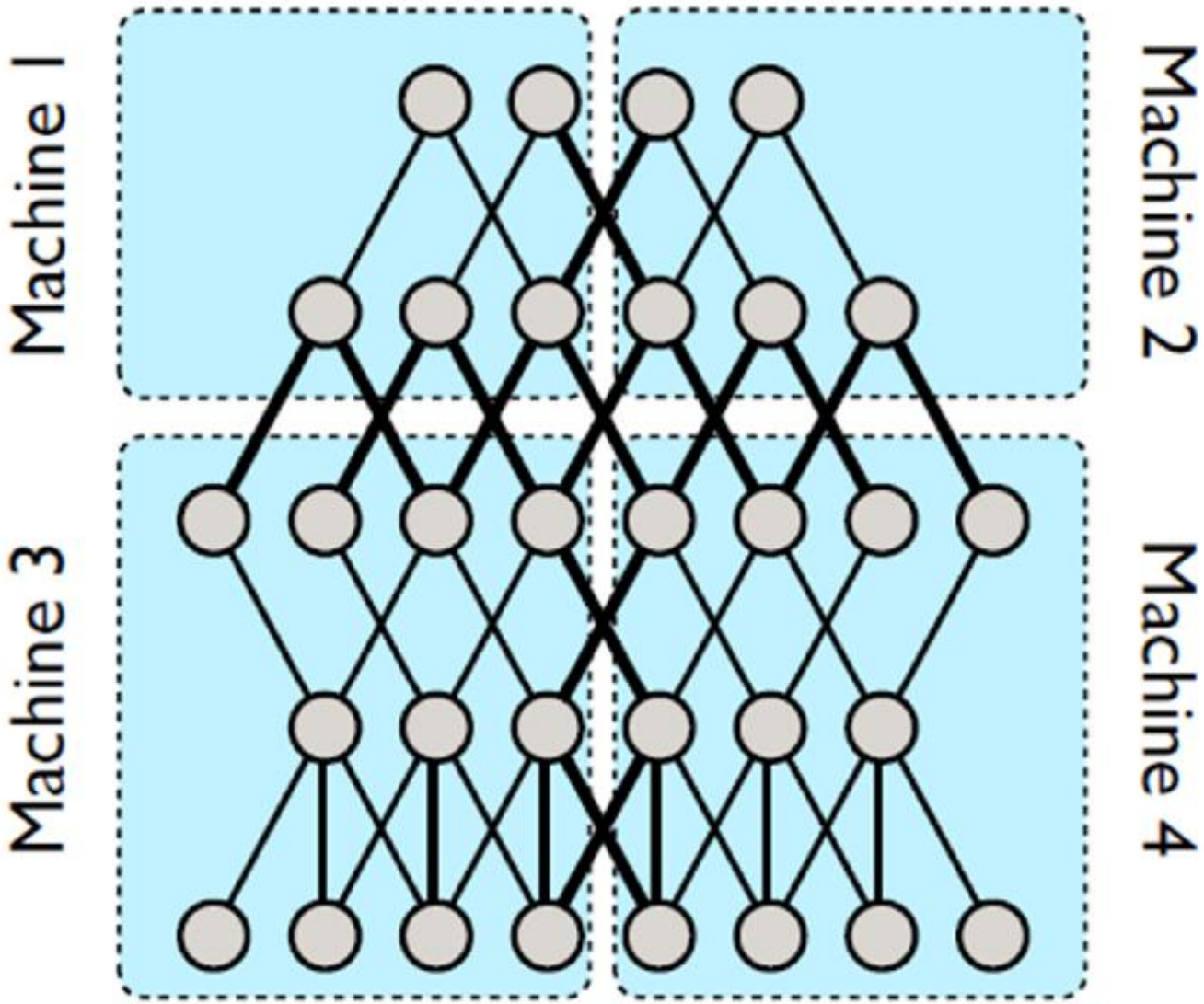


Advances in Systems for Machine Learning





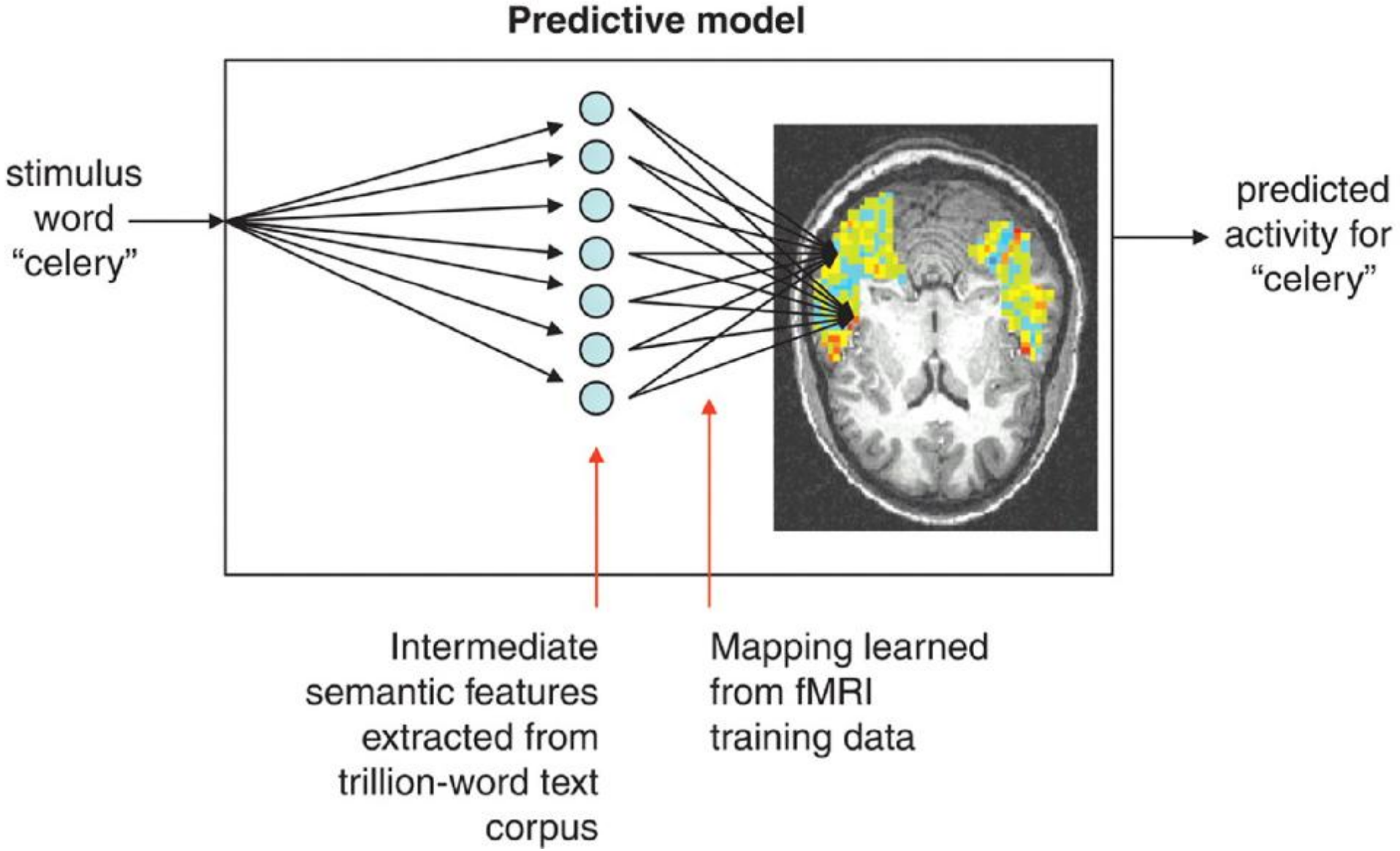
Advances in Systems for Machine Learning



T. Chilimbi, Y. Suzue, J. Apacible, et al.

J. Dean, G.S. Corrado, R. Monga, et al.

Critical Role of AI in Basic Science



Mitchell, et al.

Advances in Healthcare Delivery

Readmissions Manager

Reducing Hospital Readmissions is an Impending Priority

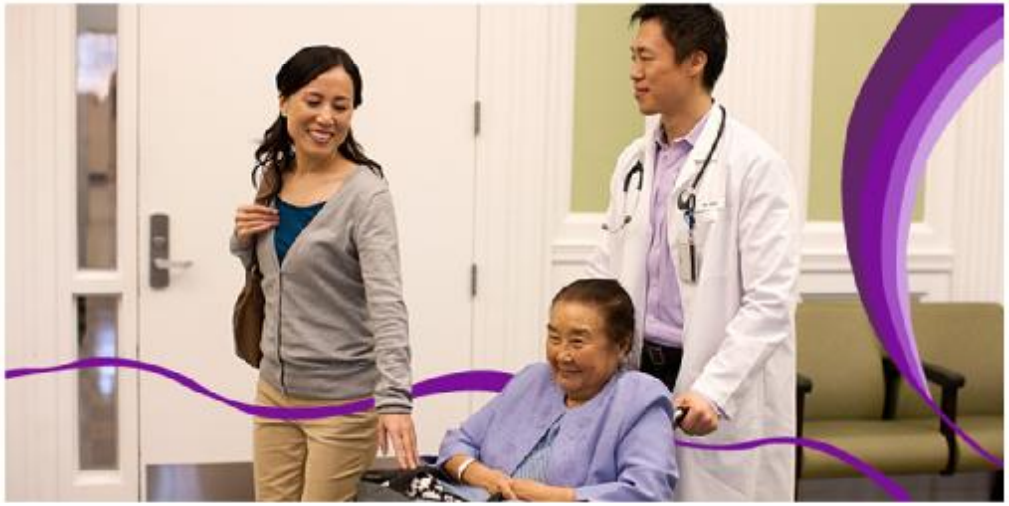
Overview

One in five Medicare inpatients is readmitted within 30 days. The Centers for Medicare and Medicaid Services (CMS) considers 40%-75% of these readmissions to be preventable.

In October 2012, CMS will begin to track readmission and impose financial penalties on hospitals with higher–than–expected readmission rates for certain conditions. Other payers will certainly follow.

It is clear that hospital admissions and readmissions are becoming a critical parameter for tracking care delivery from both a financial and quality perspective.

Readmissions Manager for Microsoft Amalga is an innovative solution to help organizations address this very important business need.



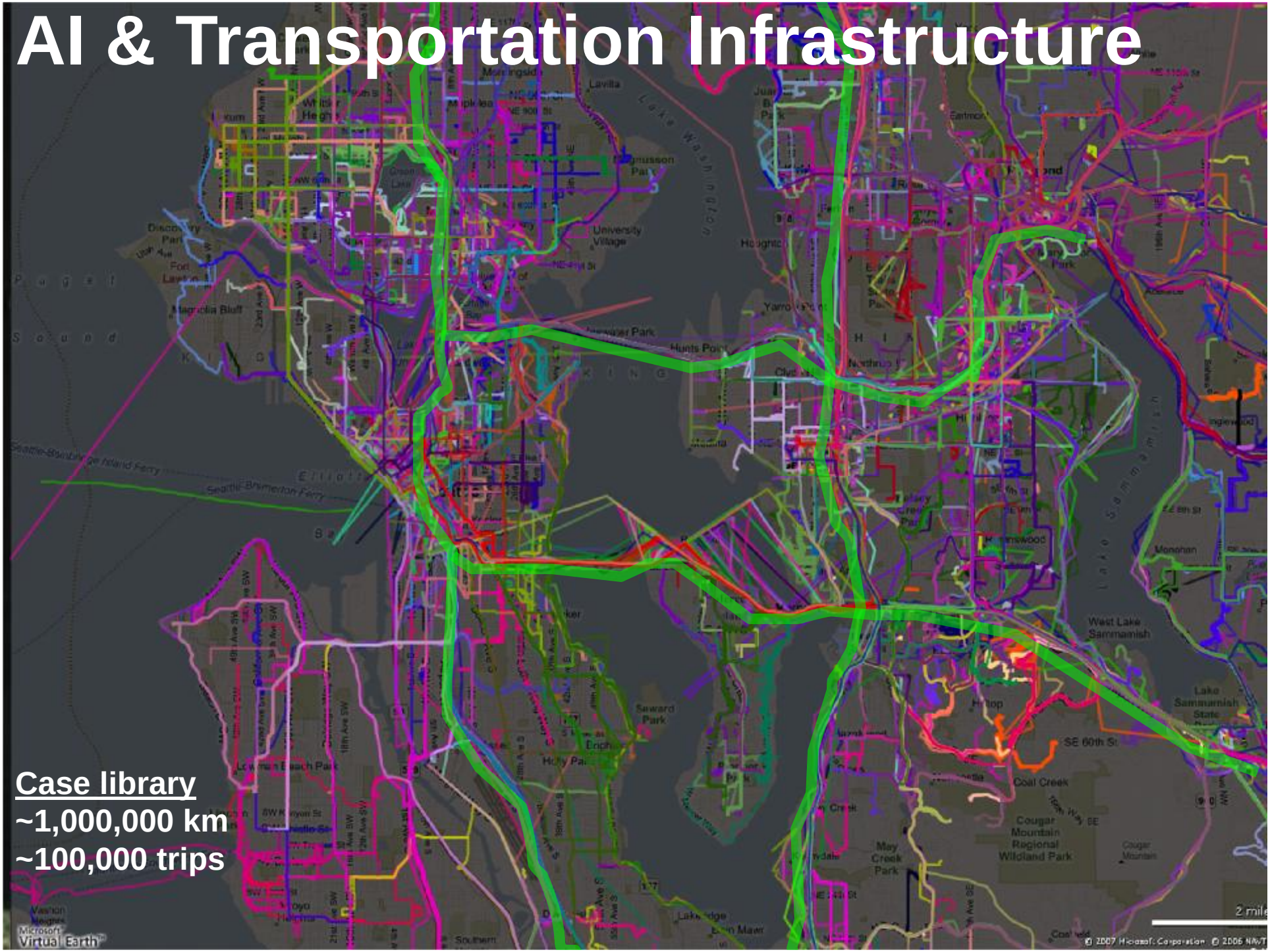
Advances in Healthcare Delivery

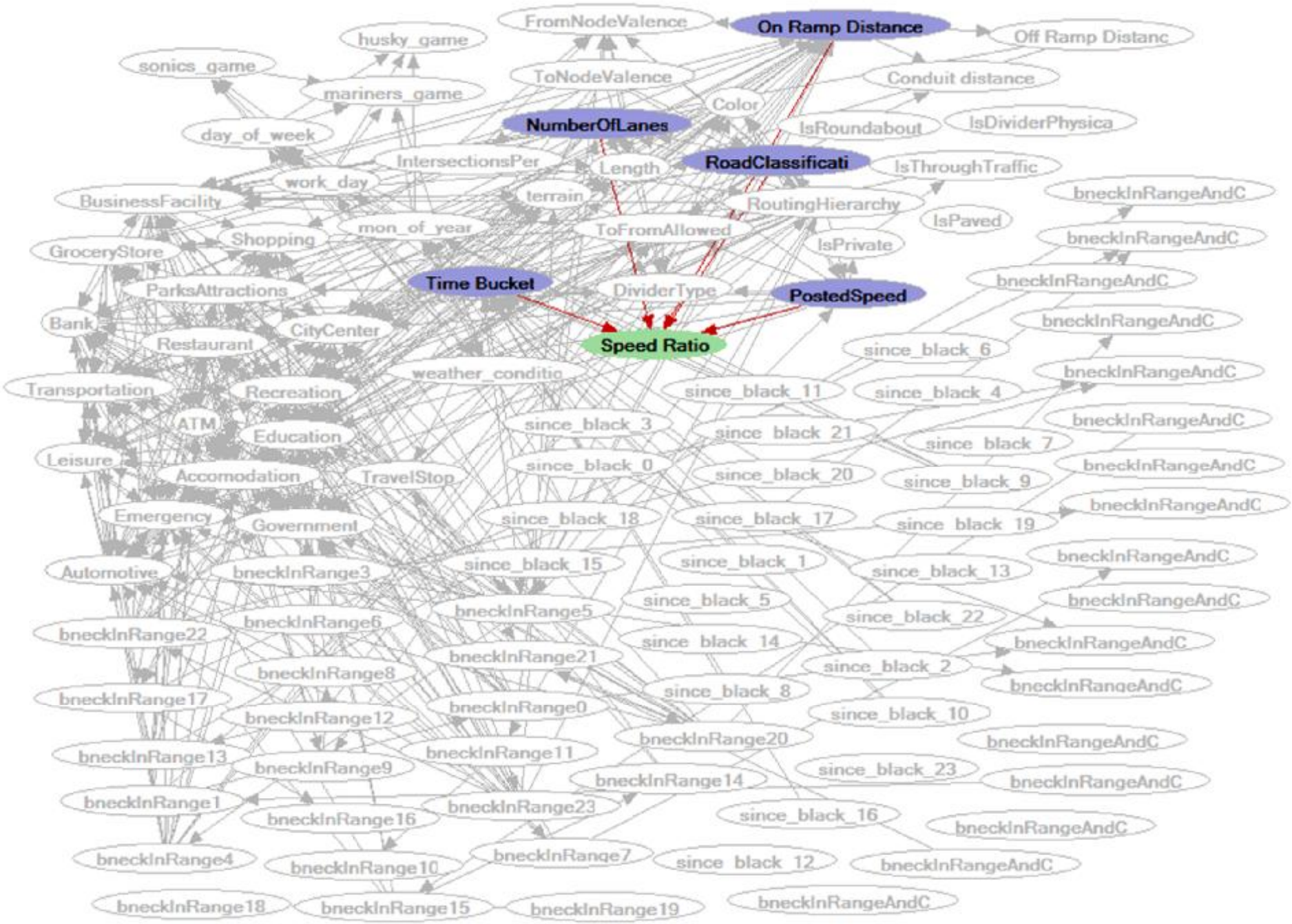
ACCOUNT	ADMITDTTM	DISCHARGEDTTM	AGE	SEX	PROB_NUM_%	FACTOR
	12/03/2010 14:57	12/08/2010 18:03	62	F	37.9	Num past 6m visits = 6 to 10 / P
	12/08/2010 18:45	12/08/2010 18:45	74	M	32.72	stayed <1 day in the hospital / Pa
	11/16/2010 16:14	12/08/2010 18:50	48	M	30.83	Patient had dx = Chronic renal fa
	12/02/2010 13:49	12/08/2010 18:14	68	M	29.05	Patient had dx = Disorders of flui
	12/01/2010 05:26	12/08/2010 18:55	44	M	28.54	
	12/01/2010 19:08	12/08/2010 18:13	61	M	27.36	Patient had dx = Acute renal failu
	11/30/2010 21:50	12/08/2010 18:52	70	M	18.05	Patient had dx = Other personal
	12/08/2010 08:51	12/08/2010 18:45	68	M	16.57	stayed <1 day in the hospital
	12/03/2010 20:32	12/08/2010 17:50	80	M	16.18	Patient had dx = Disorders of flui
	12/01/2010 01:13	12/08/2010 18:06	79	M	15.52	
	12/08/2010 18:39	12/08/2010 18:39	22	F	14.53	stayed <1 day in the hospital / Av
	12/08/2010 19:01	12/08/2010 19:01	25	F	14.42	stayed <1 day in the hospital / Pa
	12/08/2010 18:05	12/08/2010 18:05	24	M	14.39	stayed <1 day in the hospital
	12/08/2010 18:26	12/08/2010 18:26	53	F	13.59	stayed <1 day in the hospital / 44

Advances in Healthcare Delivery

AI and Smart Productivity Software

AI & Transportation Infrastructure




FromNodeValence
On Ramp Distance
husky_game
Off Ramp Distanc
sonics_game
ToNodeValence
Conduit distance
mariners_game
Color
NumberOfLanes
IsRoundabout
IsDividerPhysica
day_of_week
IntersectionsPer
Length
RoadClassificati
IsThroughTraffic
work_day
terrain
BusinessFacility
RoutingHierarchy
bneckInRangeAndC
IsPaved
mon_of_year
ToFromAllowed
Shopping
bneckInRangeAndC
GroceryStore
IsPrivate
Time Bucket
bneckInRangeAndC
ParksAttractions
DividerType
PostedSpeed
Bank
CityCenter
bneckInRangeAndC
Restaurant
Speed Ratio
since_black_6
bneckInRangeAndC
weather_conditio
Transportation
Recreation
since_black_11
since_black_4
bneckInRangeAndC
ATM
since_black_3
Education
since_black_21
since_black_7
bneckInRangeAndC
Leisure
since_black_0
Accomodation
TravelStop
since_black_20
since_black_9
bneckInRangeAndC
Emergency
since_black_18
Government
since_black_17
since_black_19
bneckInRangeAndC
Automotive
bneckInRange3
since_black_15
since_black_1
since_black_13
bneckInRangeAndC
bneckInRange5
since_black_5
bneckInRangeAndC
bneckInRange22
bneckInRange6
since_black_22
since_black_14
bneckInRangeAndC
bneckInRange21
since_black_2
bneckInRange8
bneckInRangeAndC
since_black_8
bneckInRange17
bneckInRange0
since_black_10
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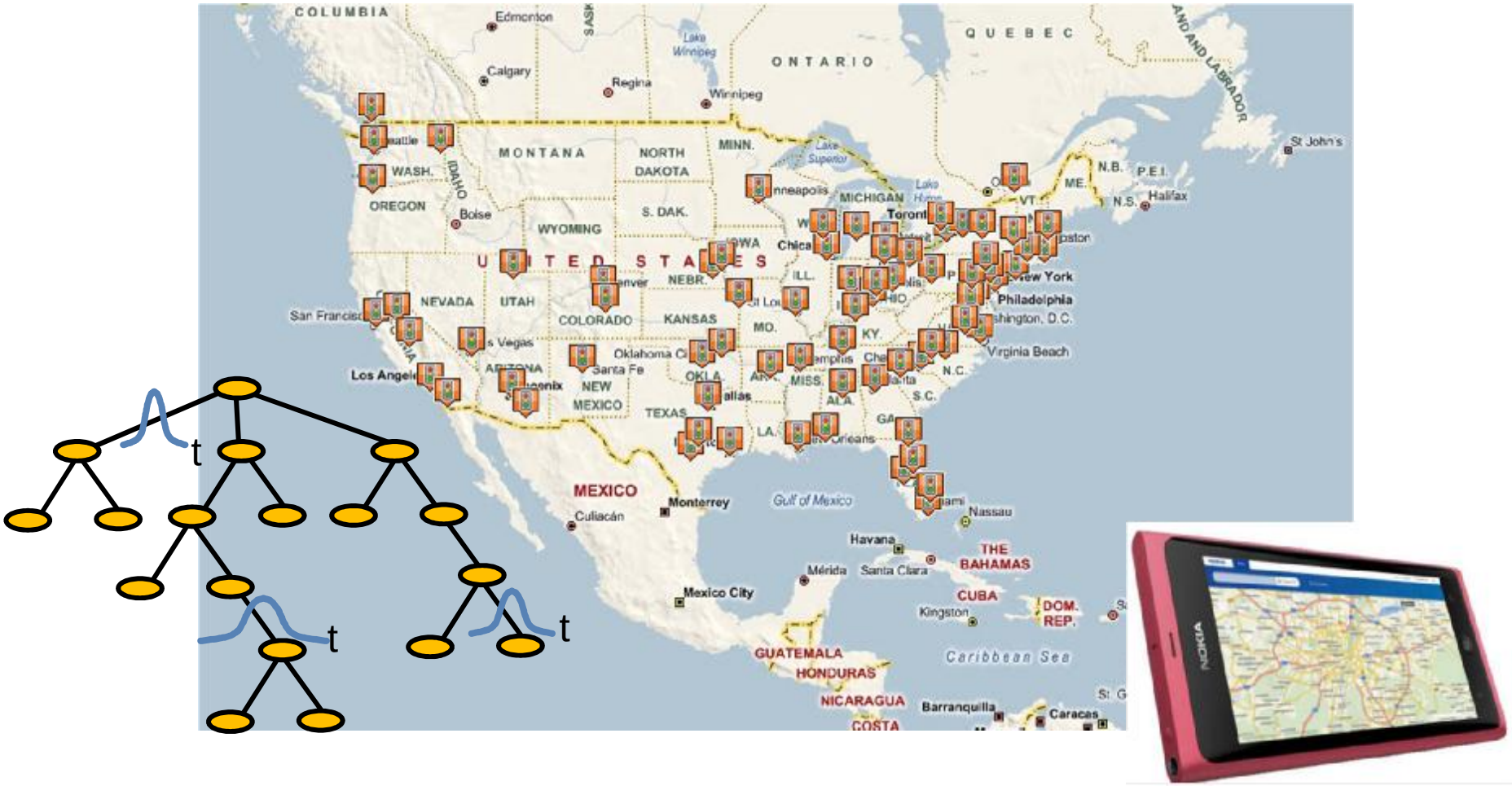
bneckInRange4
bneckInRange7
since_black_12
bneckInRangeAndC
bneckInRange10
bneckInRange18
bneckInRange15
bneckInRange19
bneckInRangeAndC

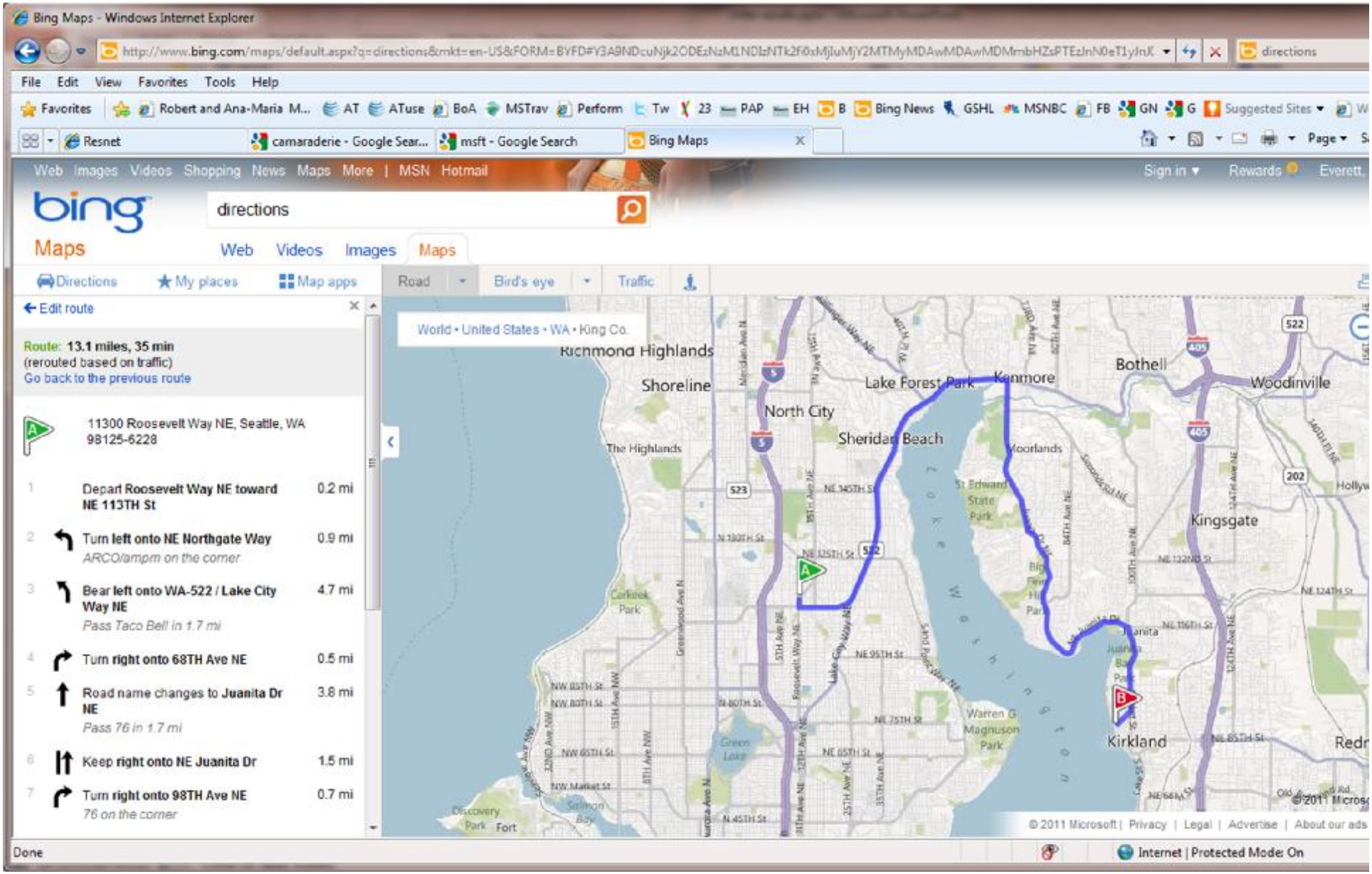
Predictive Models for Routing

72 cities across North America

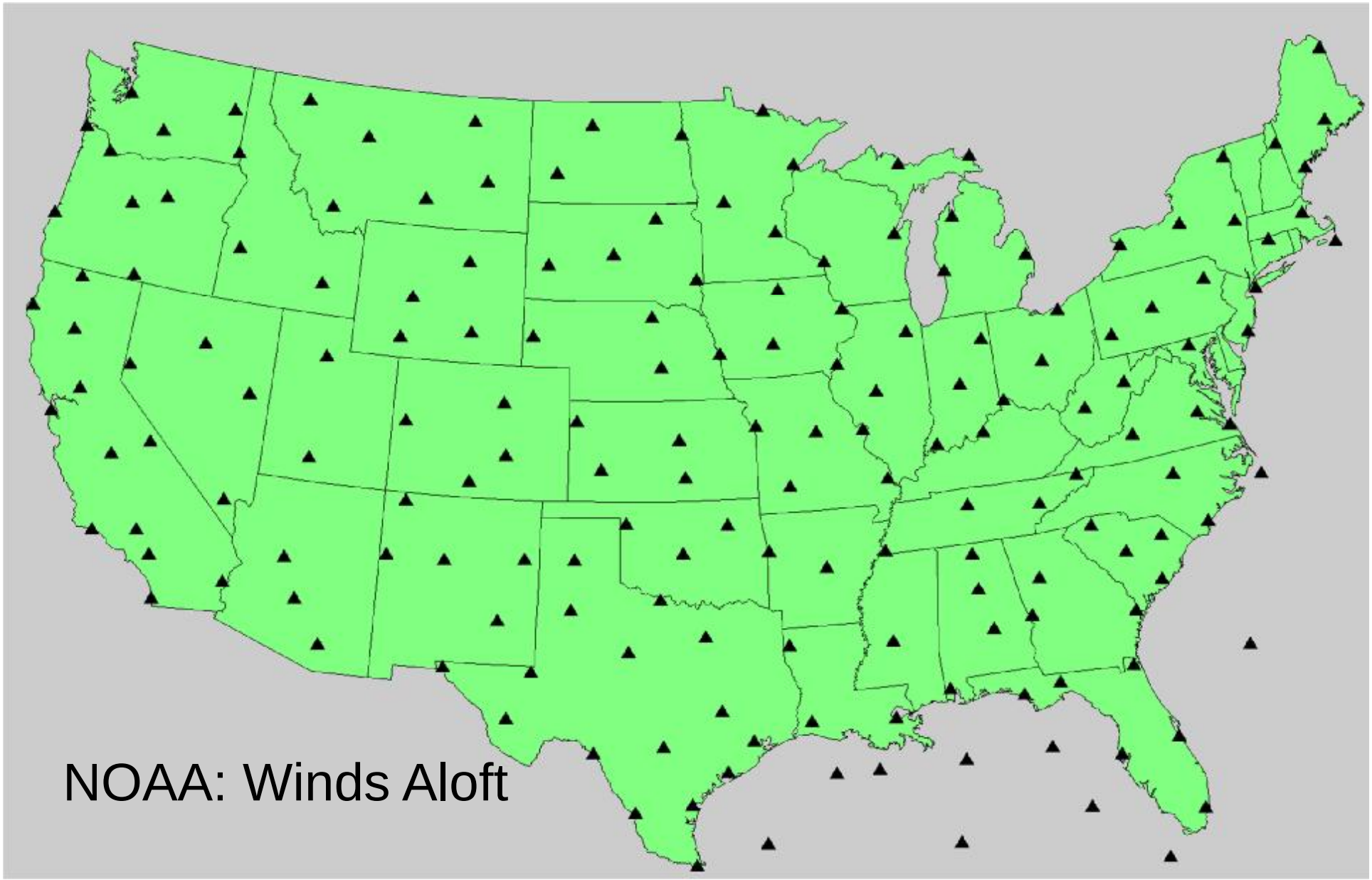
Flows assigned to ~60 million streets *every few minutes*



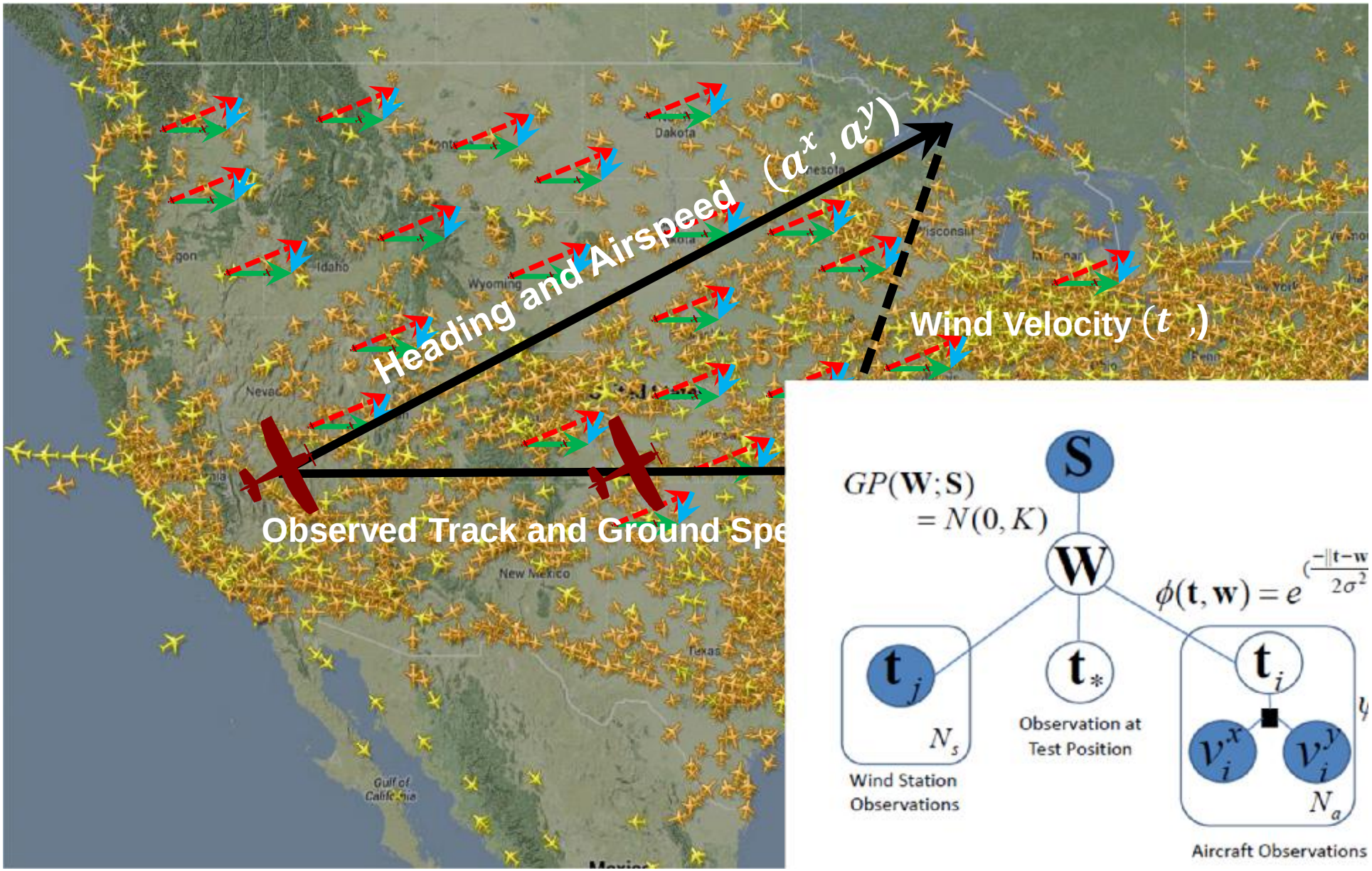
Predictive Models for Routing



AI, Winds, and Weather

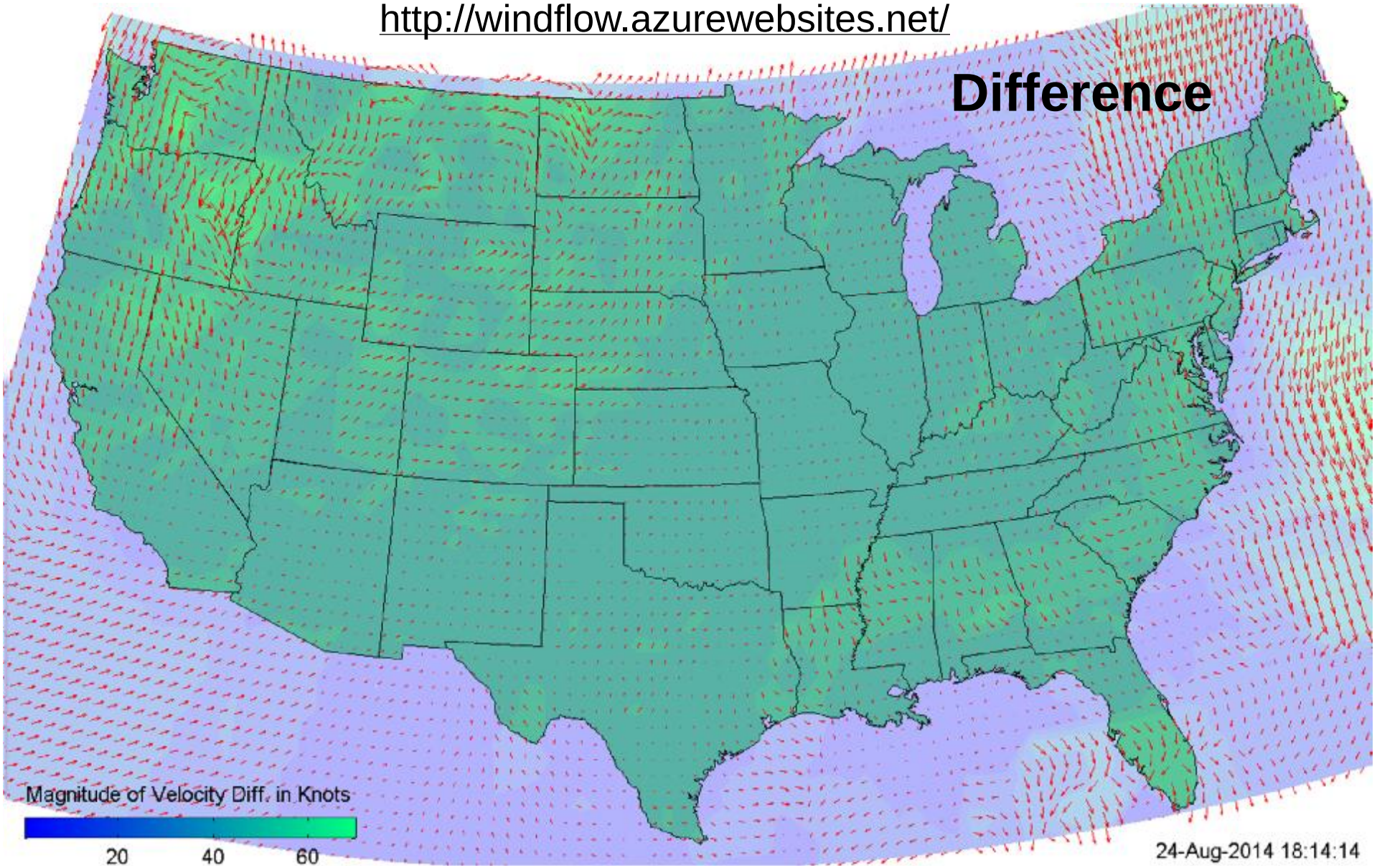


AI, Winds, and Weather



AI, Winds, and Weather

http://windflow.azurewebsites.net/

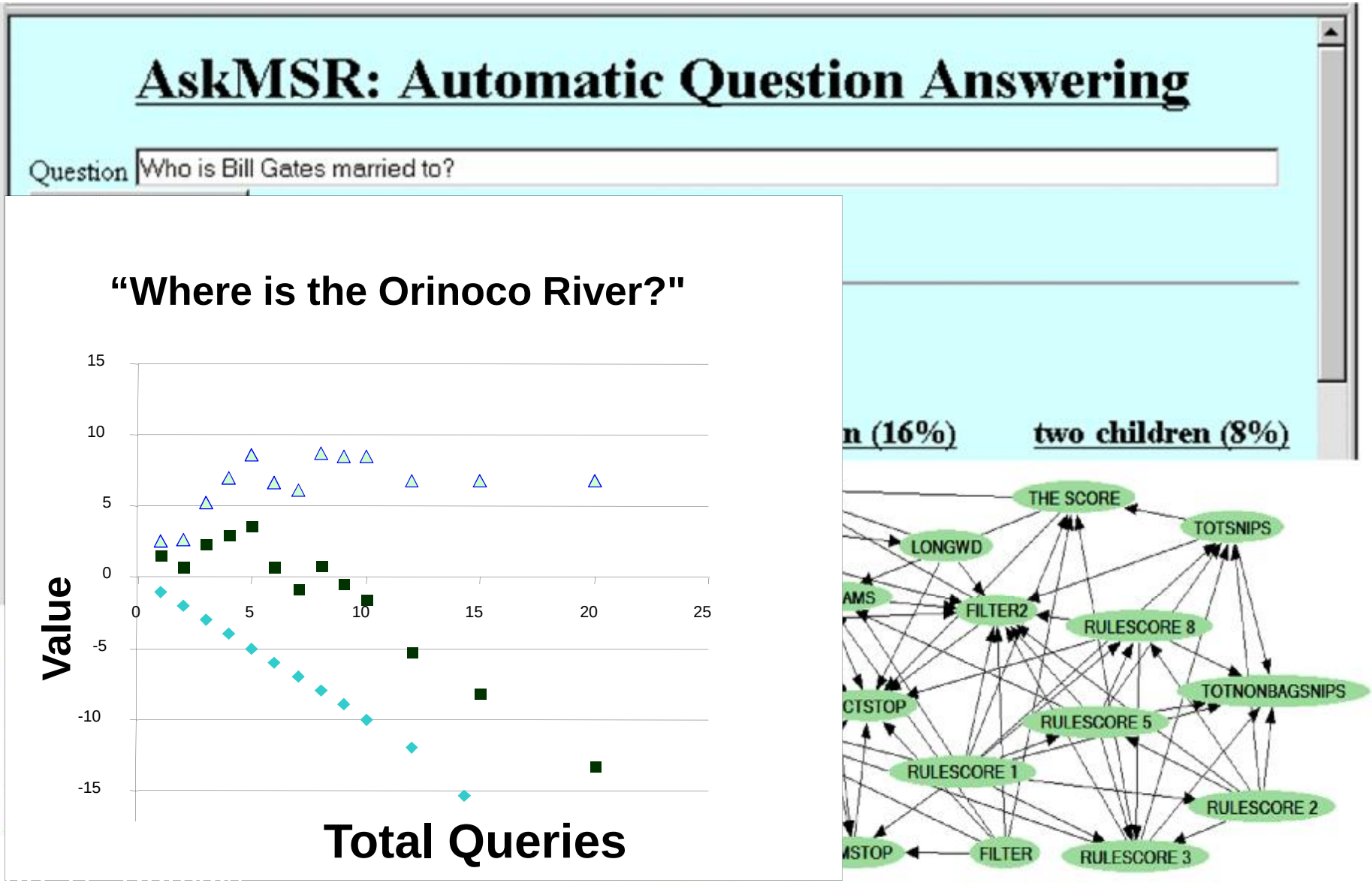


On the Horizon…

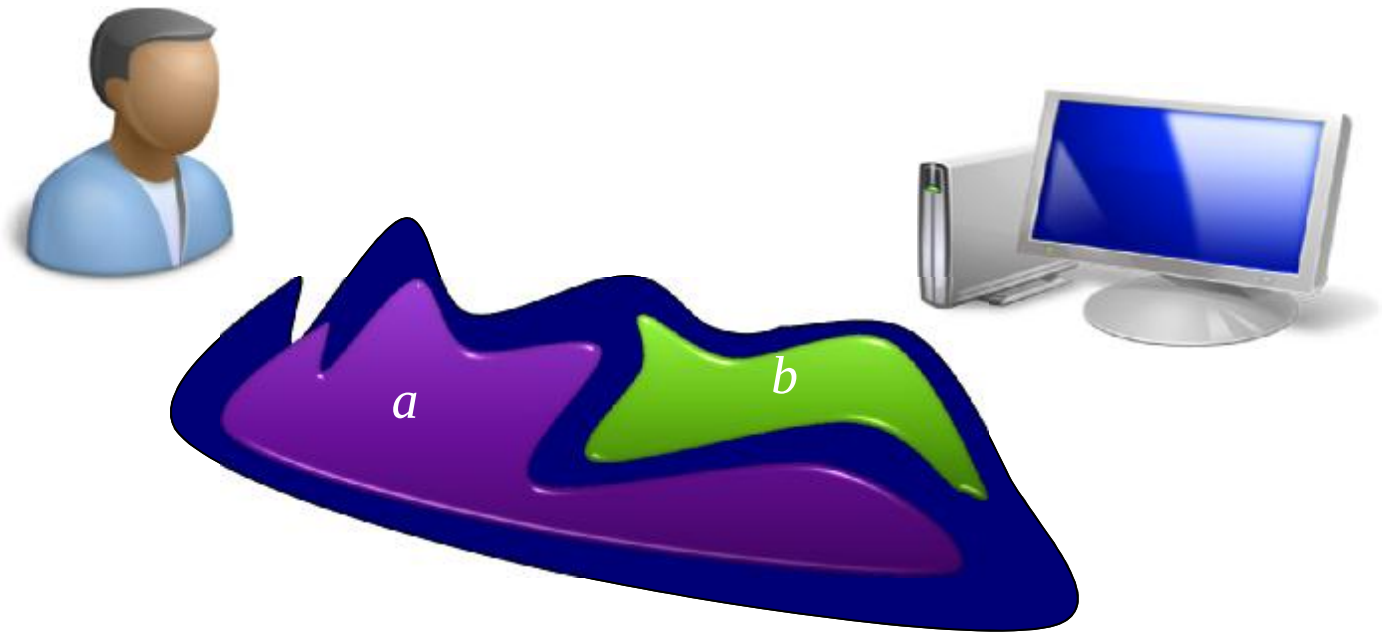
Direction: Vehicle Safety & Self-Driving

DARPA
GRAND CHALLENGE

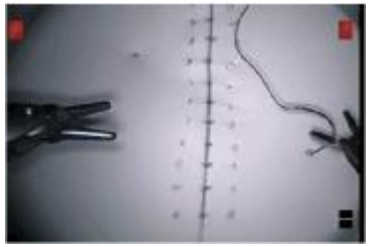
Direction: Deeper Question Answering



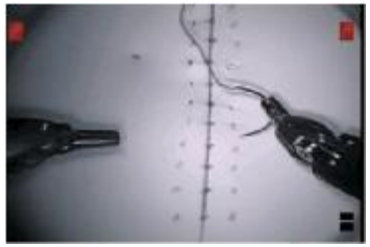
Direction: Human-Machine Collaboration



Example: Robotic Surgery



1. Reach for needle



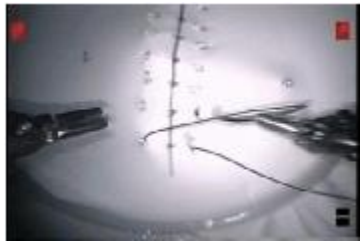
2. Position needle

3. Insert and push needle through tissue

4. Move to middle with needle (left hand)

5. Move to middle with needle (right hand)

6. Pull suture with left hand

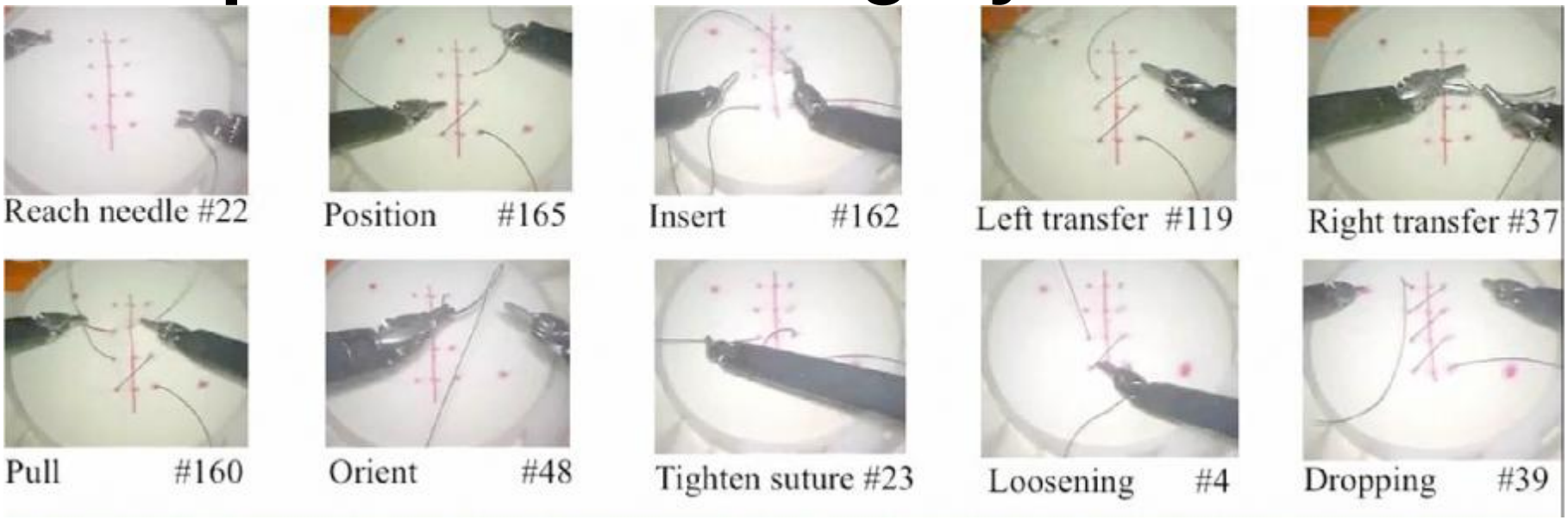


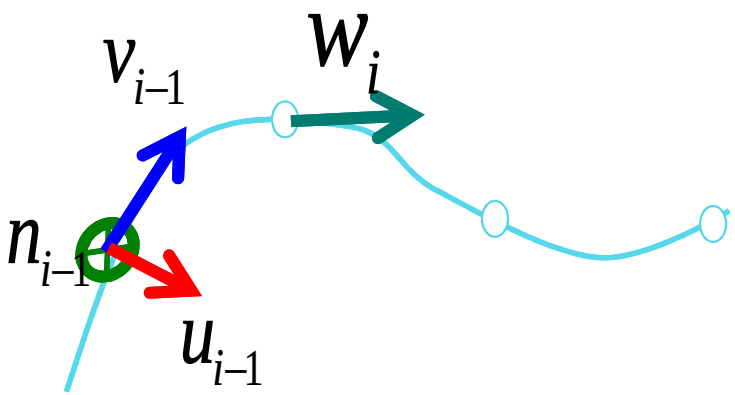
7. Pull suture with right hand

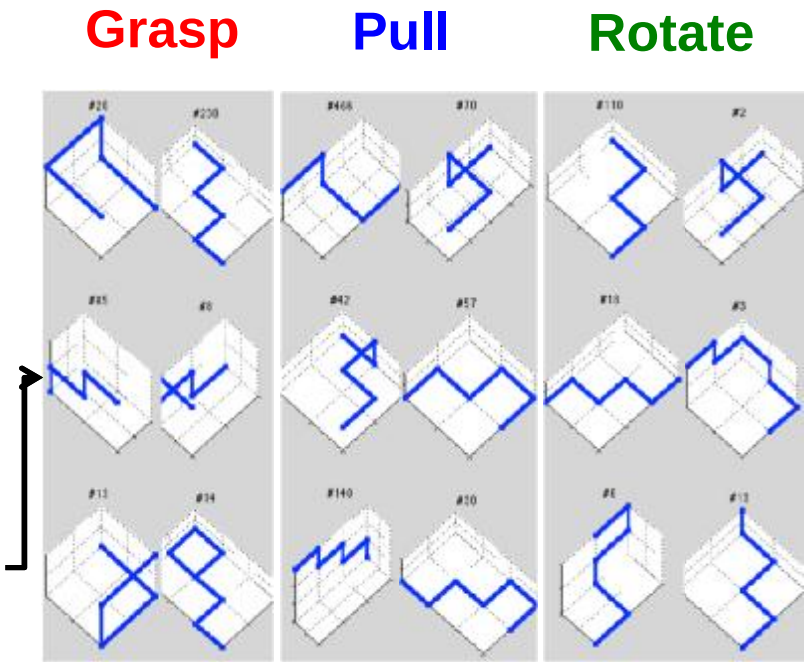
8. Orient needle with both hands

Reiley, C.E., Lin, H.C., Varadarajan, B., Vagolgyi, et al. Automatic recognition of surgical motions using statistical modeling for capturing variability. In: MMVR. (2008) 396–401

Example: Robotic Surgery



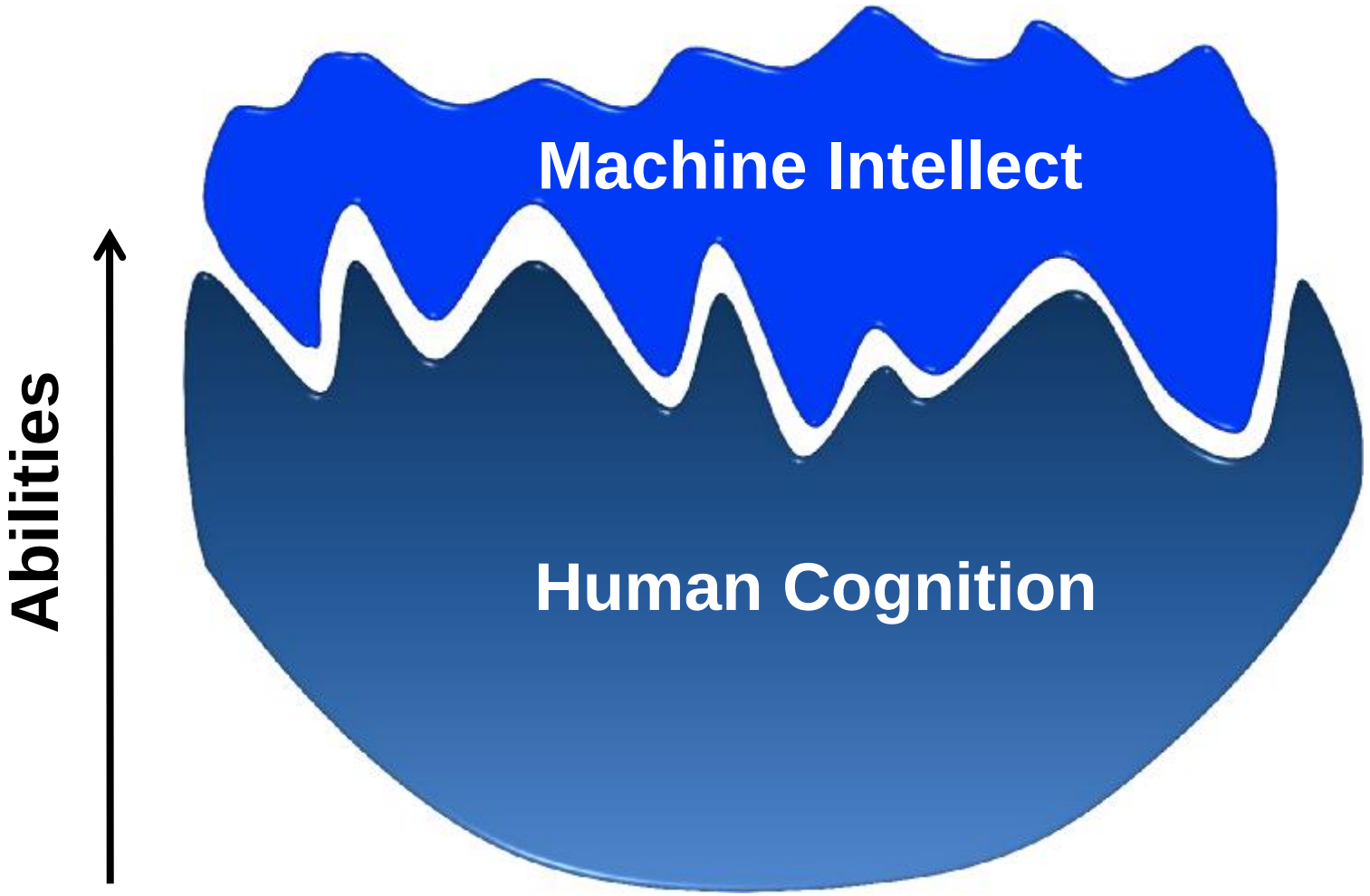




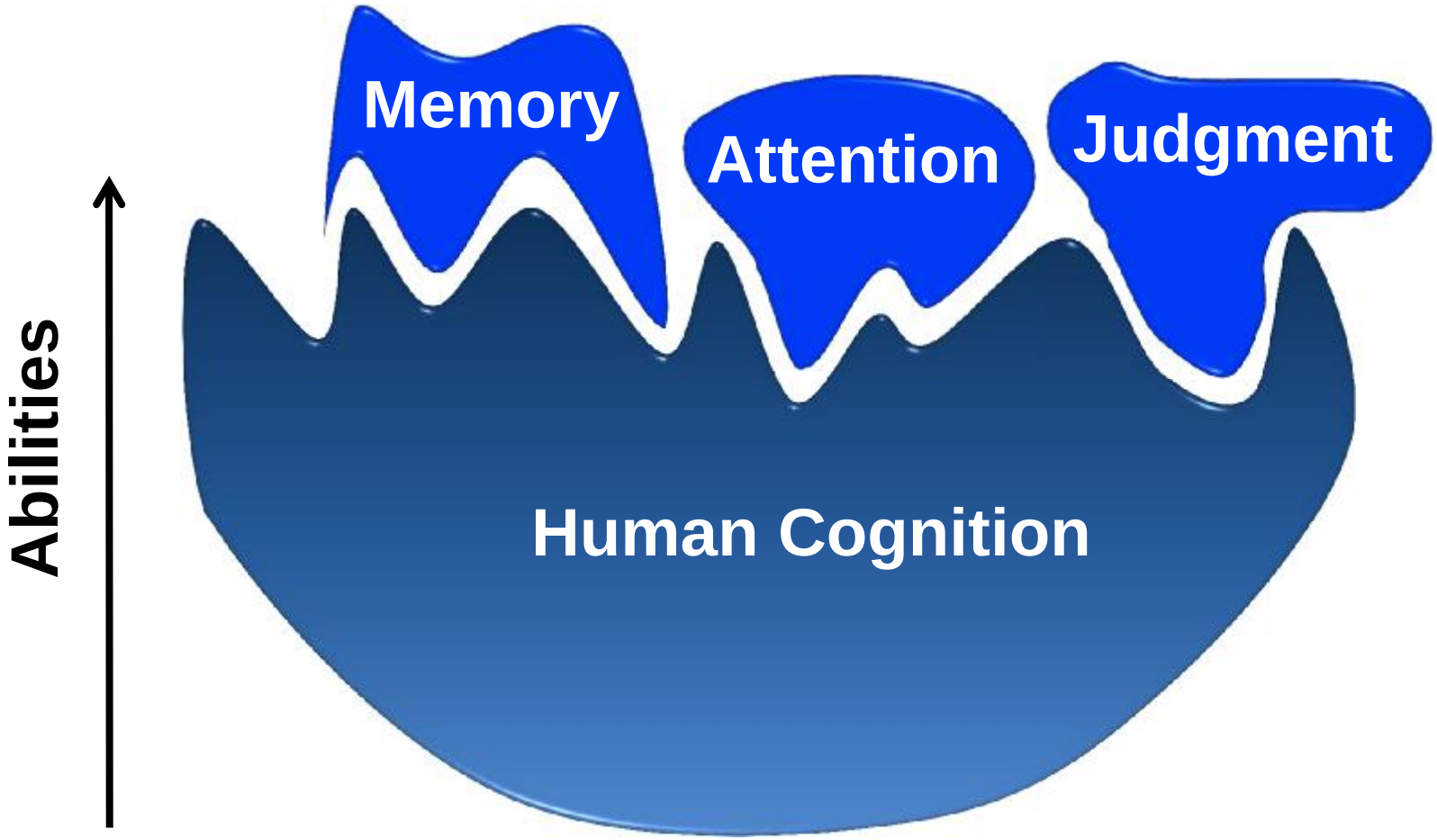
Example: Robotic Surgery

Padoy and Hager. "Human-machine collaborative surgery using learned models." ICRA 2011

Direction: Augment Human Cognition

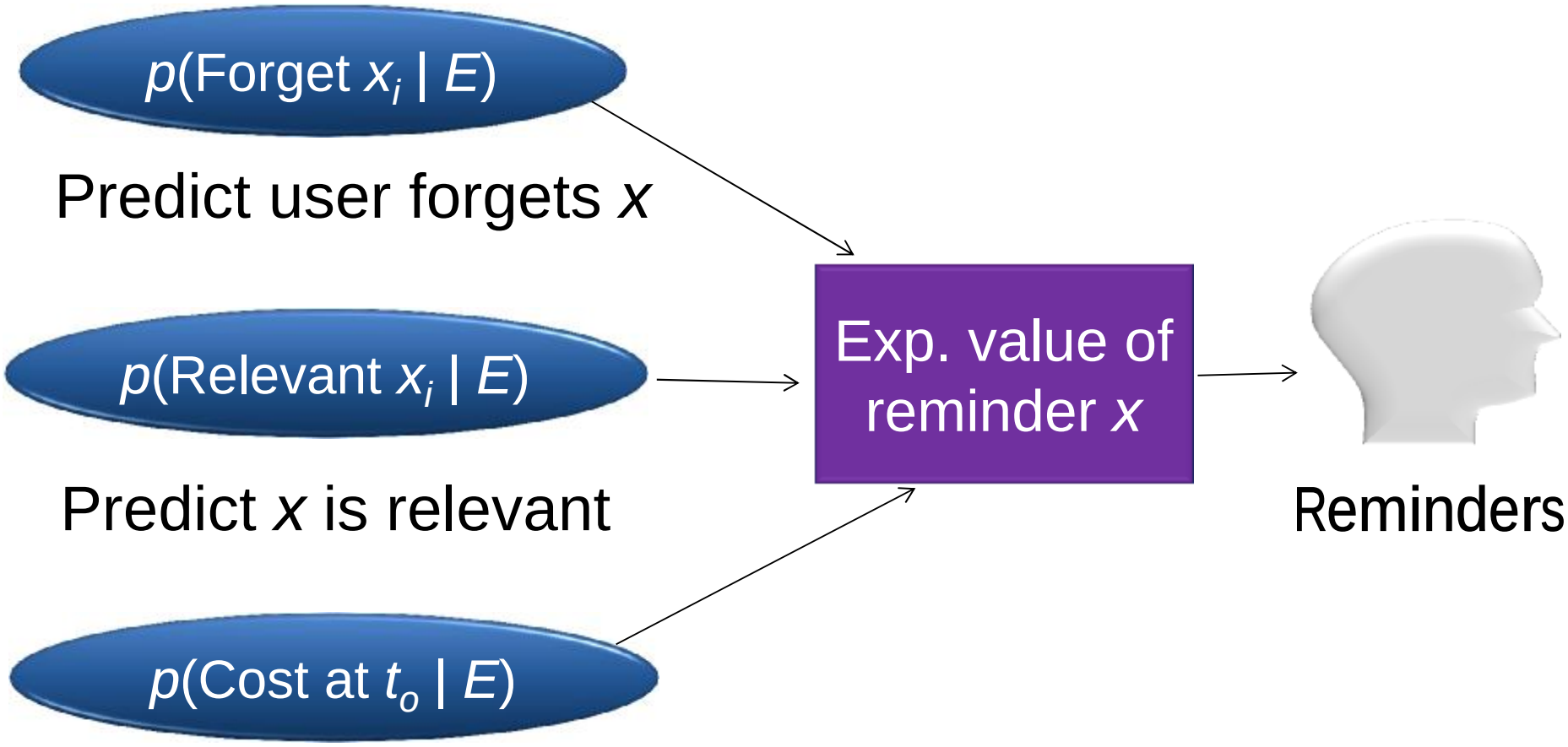


Direction: Augment Human Cognition



Example: Forgetting & Ideal Reminding

Jogger (AAMAS 2011)

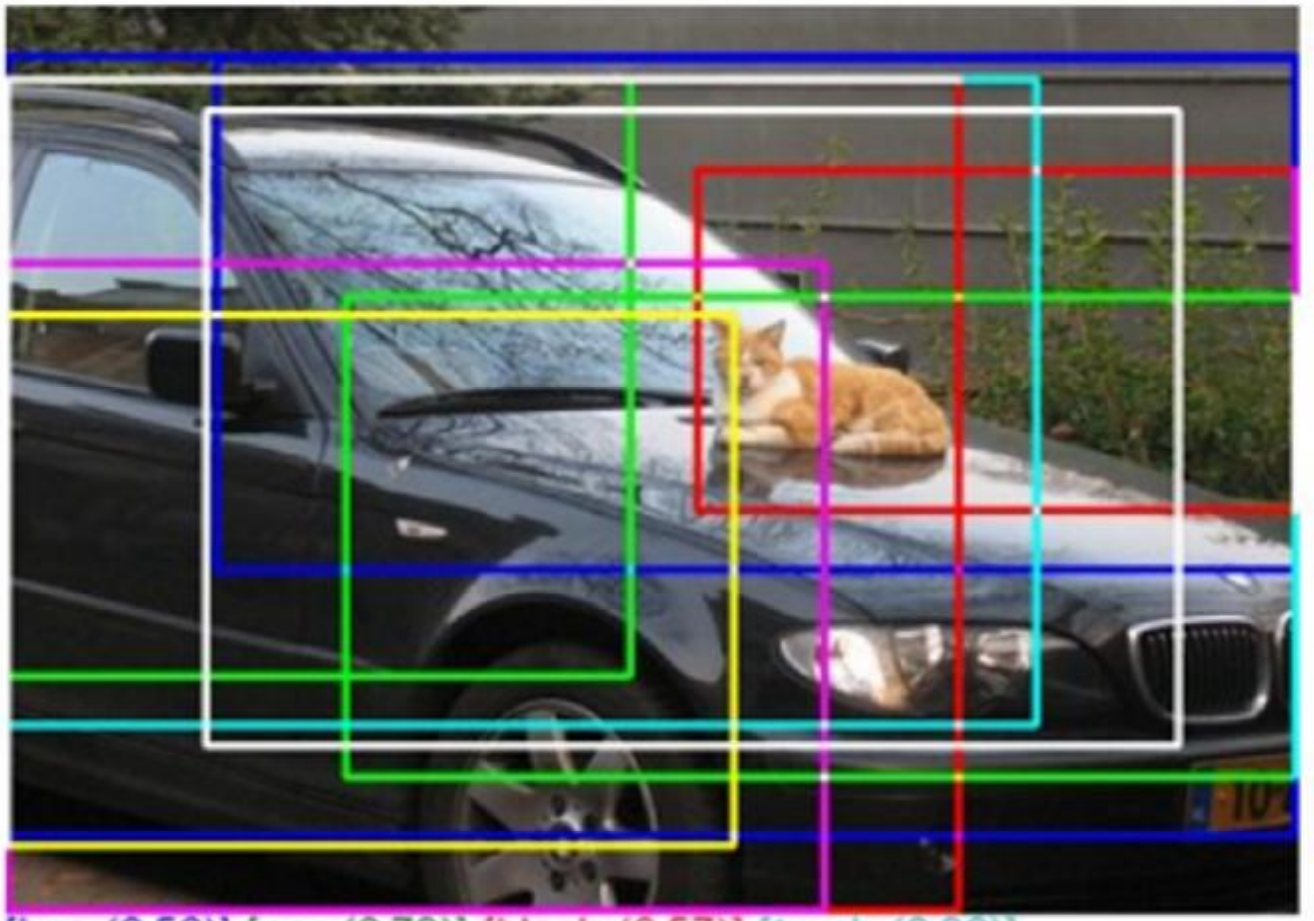


Kamar, et al.

Direction: Robots in Daily Life

Klingbeil, Saxena, Ng, *et al.*

Direction

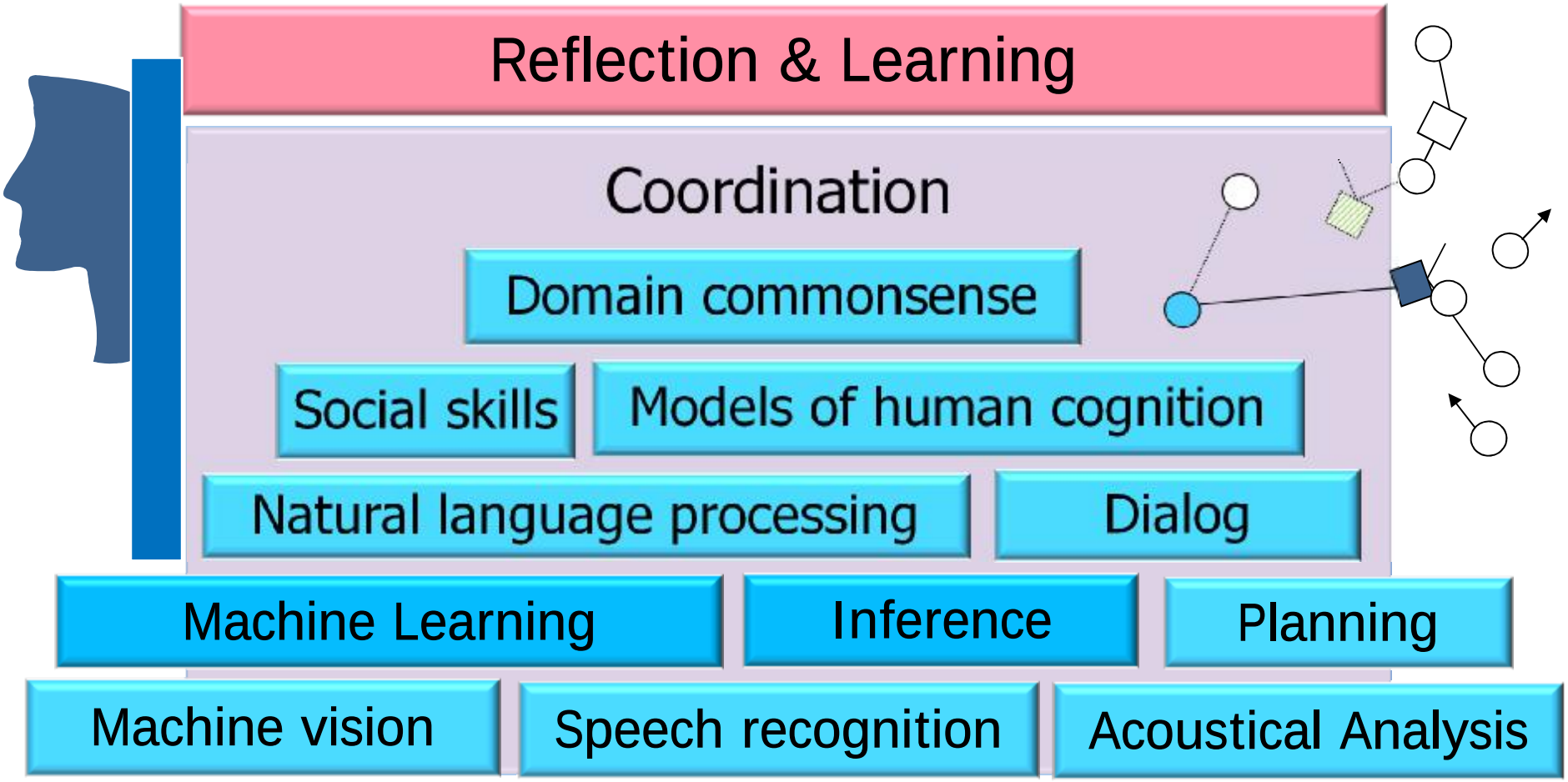


Machine

Human

H. Fang, S. Gupta, F. Iandola, et al.

Direction: Integrative AI



Whole > S_i $part_i$?

The Assistant

Direction: Integrative AI