

AI in Support of People and Society

Eric Horvitz

Technical Fellow and Director

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Artificial Intelligence

Study of computational mechanisms
underlying thought & intelligent behavior

Artificial Intelligence

Study of computational mechanisms
underlying thought & intelligent behavior

*“..to find how to make machines...solve kinds of
problems now reserved for humans...(1955)*

Perception

Learning

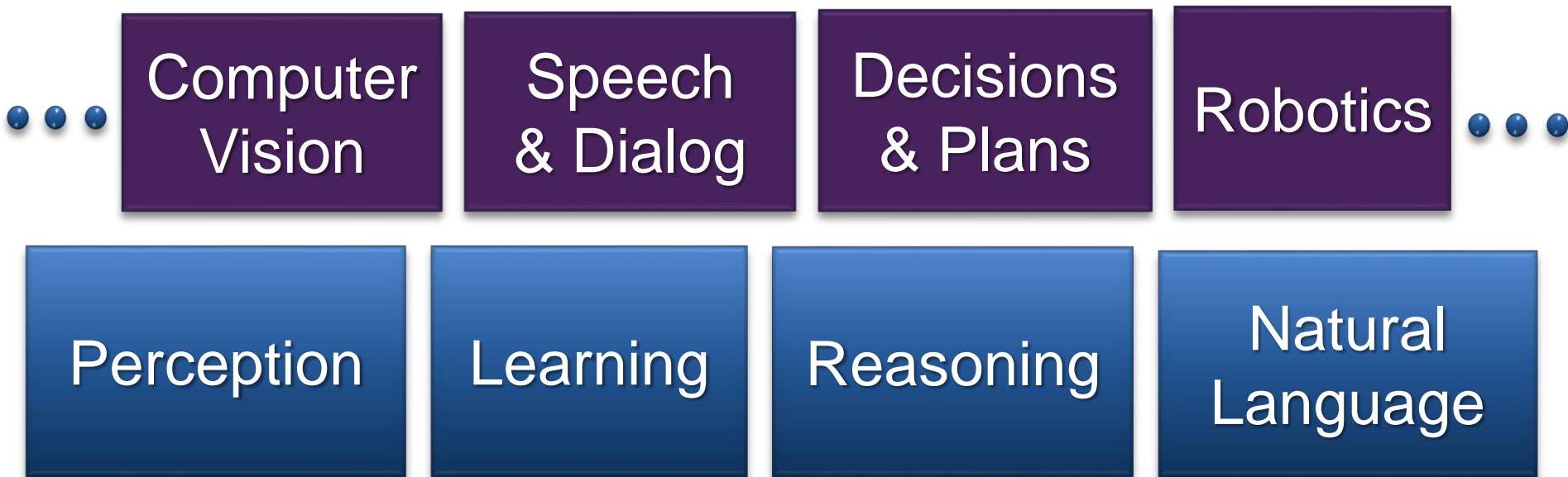
Reasoning

Natural
Language

Artificial Intelligence

Study of computational mechanisms
underlying thought & intelligent behavior

Multiple subdisciplines & research communities



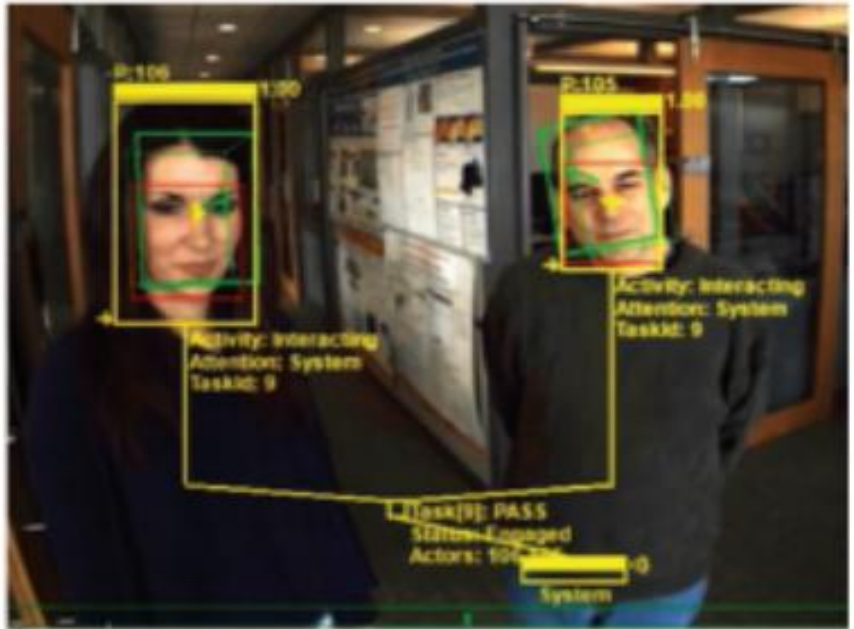
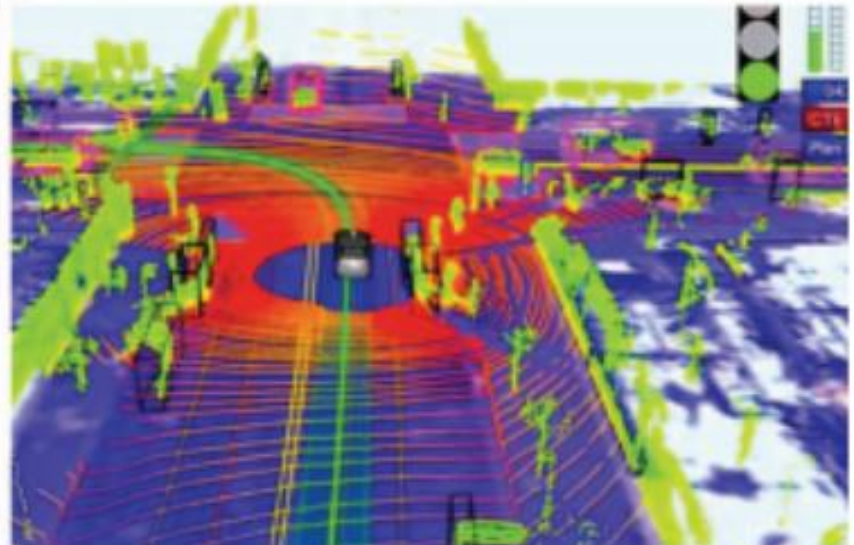
Inflection Point

- ↑ Computation & memory
- ↑ Data via digital economy, devices, Web
- ↑ Learning & reasoning prowess



Opportunities, competitive landscape

Long-term R&D

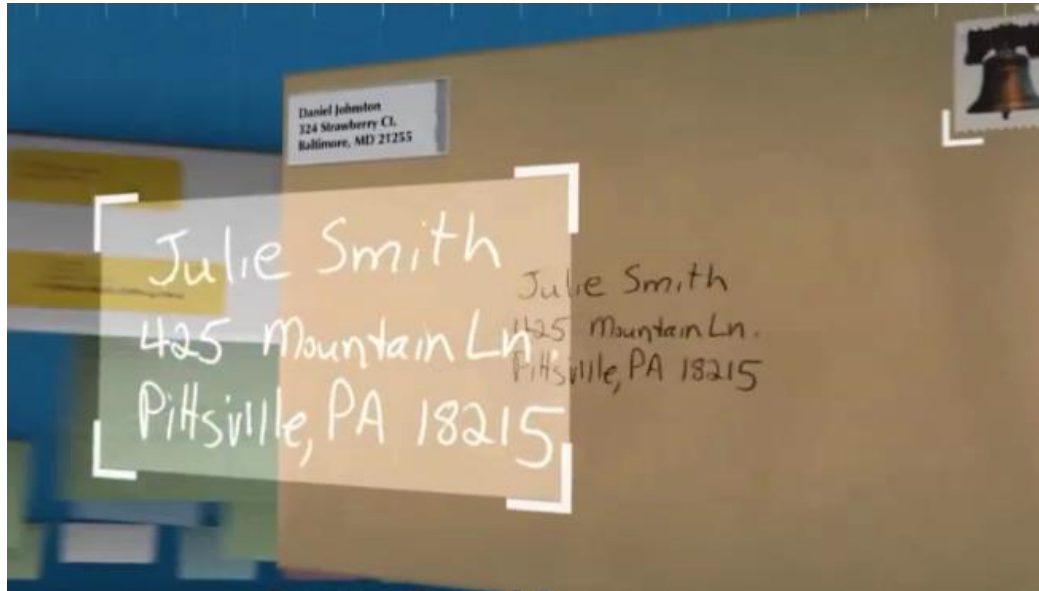


Innovations Shared

Handwriting recognition

25 billion letters per year

100s of millions of dollars saved

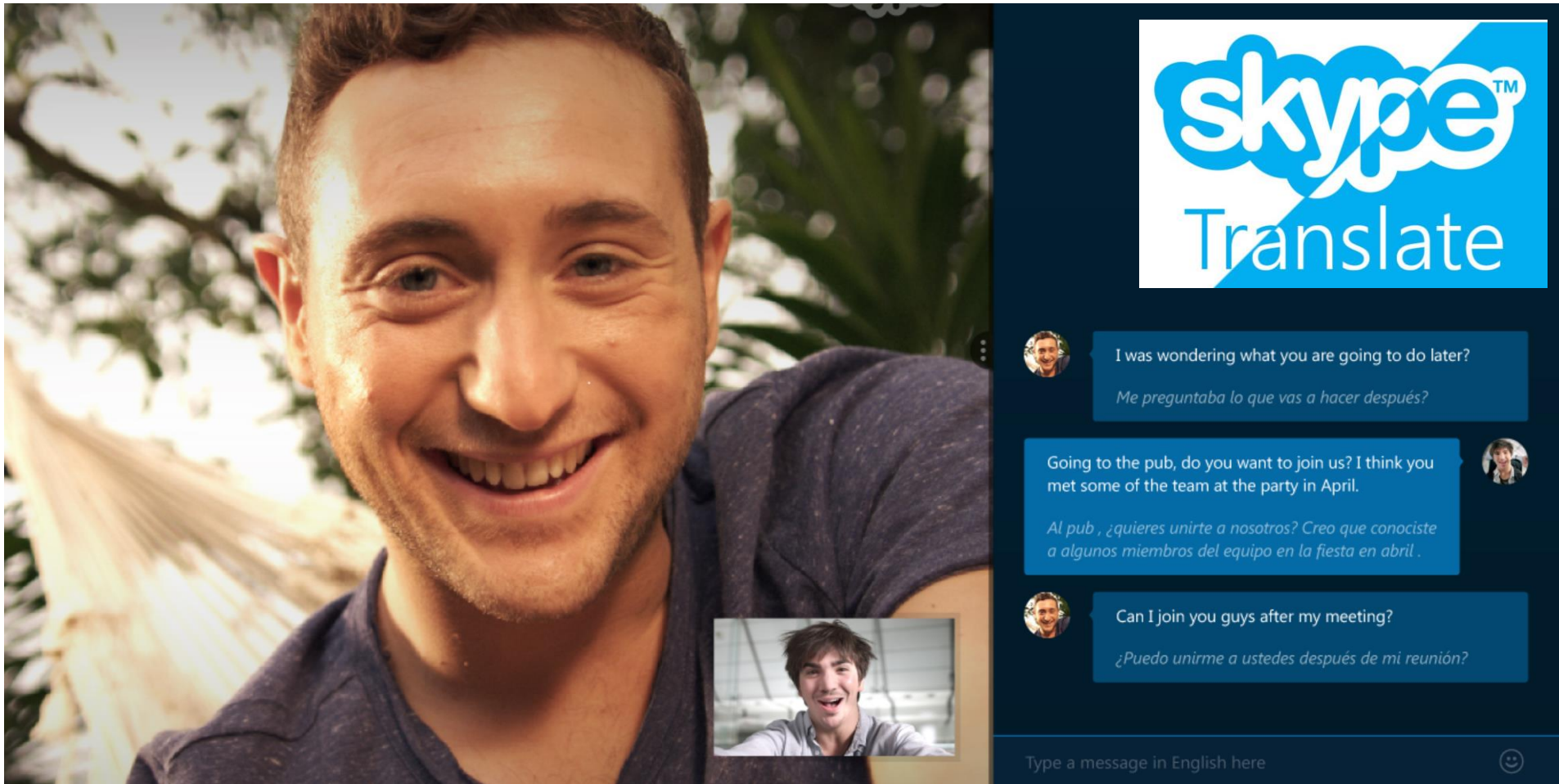


(video)



Kim & Govindaraju (1997)

New Competencies & Experiences



New Competencies & Experiences



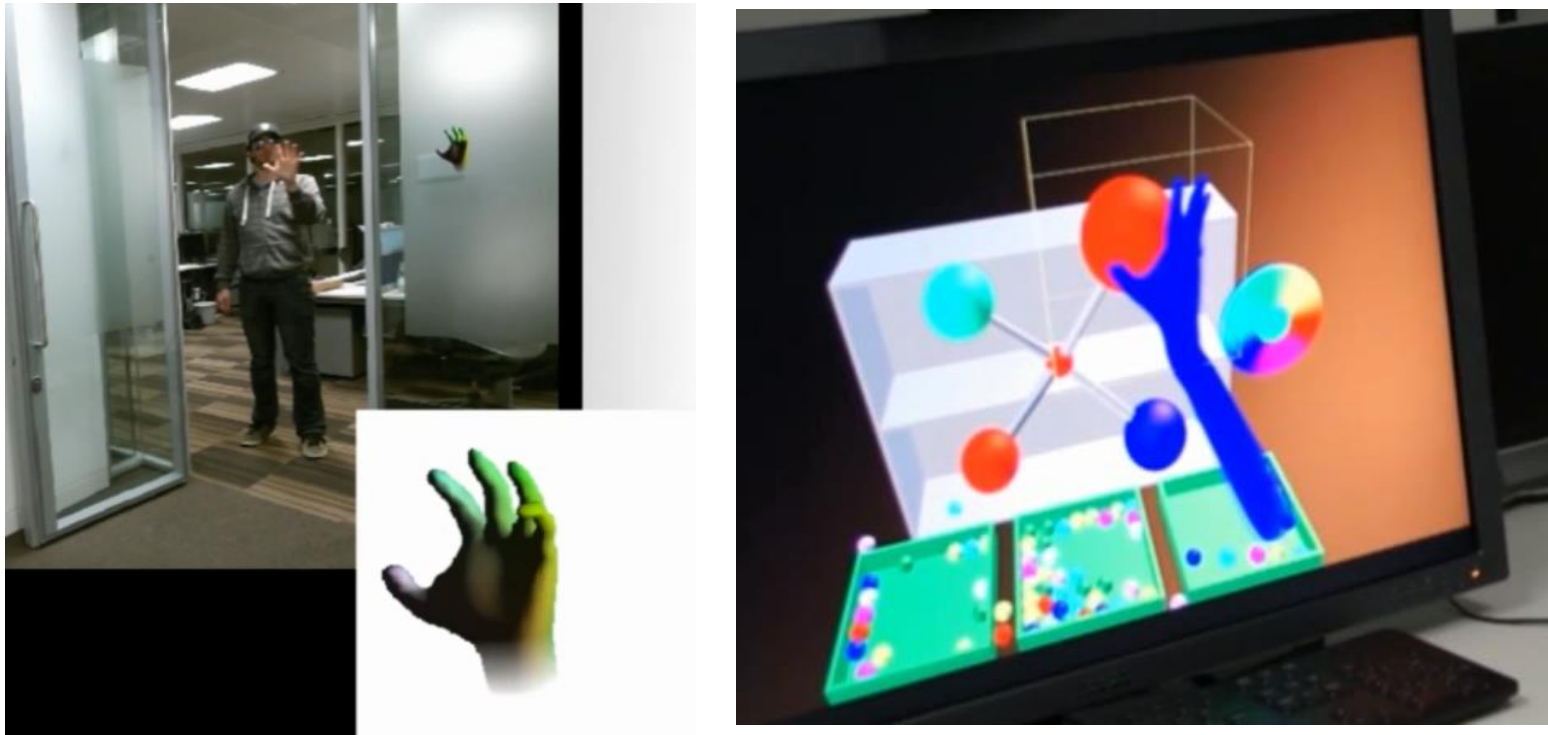
New Competencies & Experiences



Still in lab, but on way

(video)

New Competencies & Experiences



(video)

Thumb & forefinger: foundation of civilization

Moving into computational realm

New Competencies & Experiences

Hybrid learning
pipelines for
language & vision

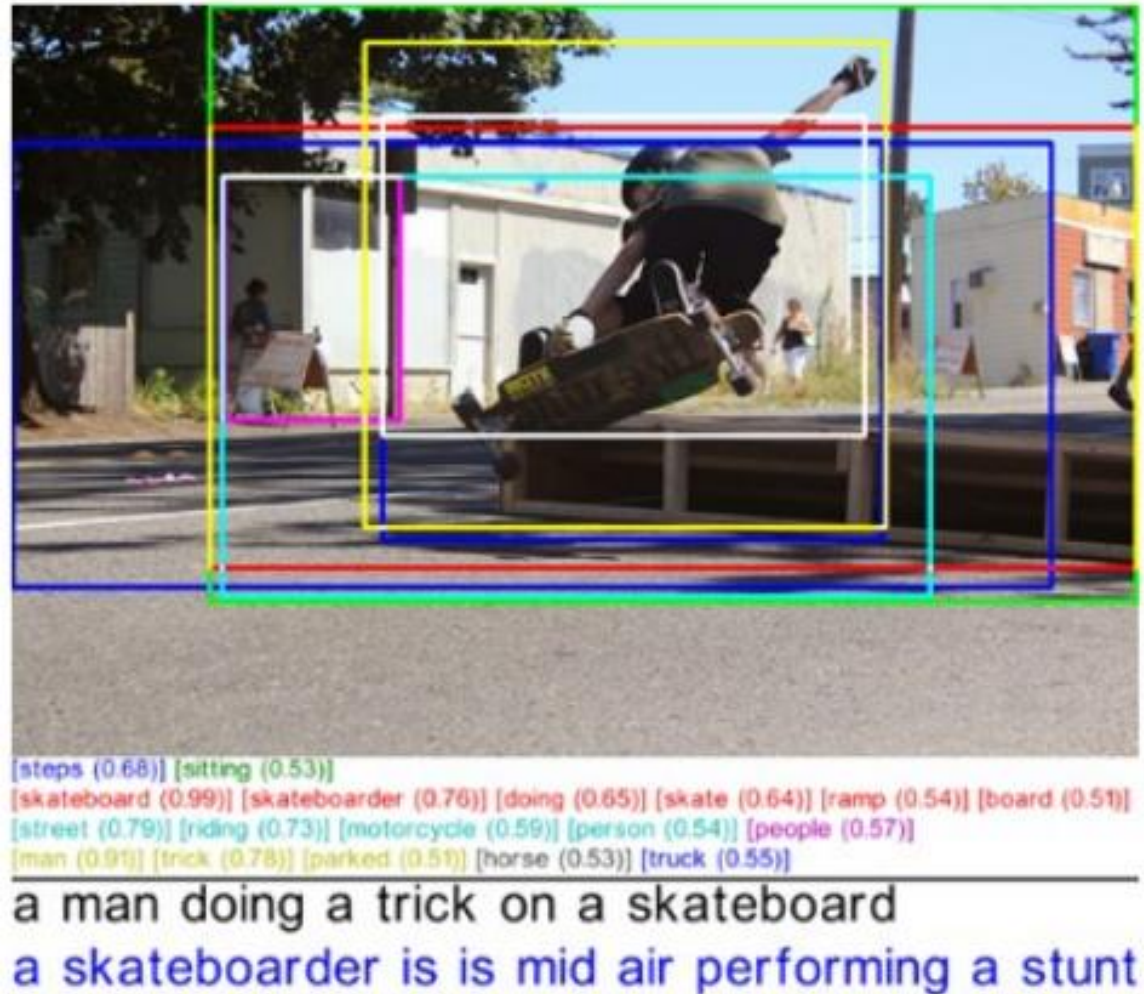


Figure 1. An illustrative example of our approach's pipeline.

New Competencies & Experiences

Hybrid learning
pipelines for
language & vision

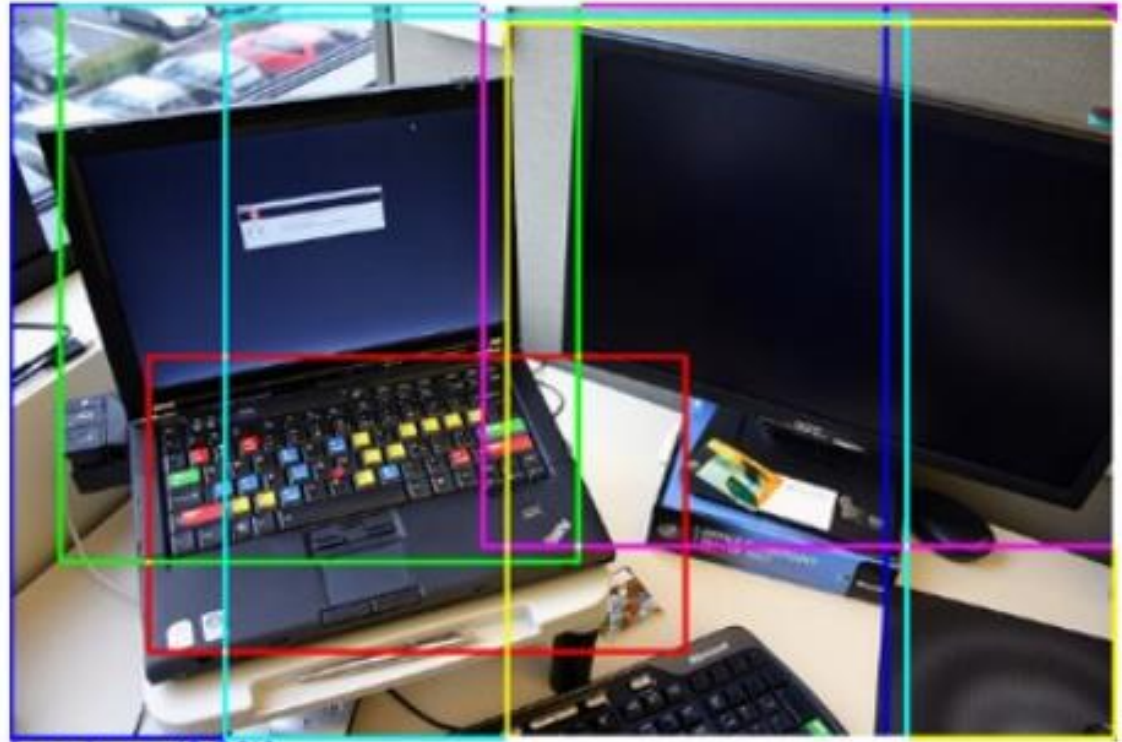
■ machine
■ human



New Competencies & Experiences

Hybrid learning
pipelines for
language & vision

■ machine
■ human



[monitors (0.56)]

[laptop (0.97)] [table (0.74)] [open (0.71)] [sitting (0.61)]

[station (0.52)]

[desk (0.97)] [computer (0.94)] [keyboard (0.68)] [computers (0.65)]

[tv (0.54)] [television (0.50)] [monitor (0.69)]

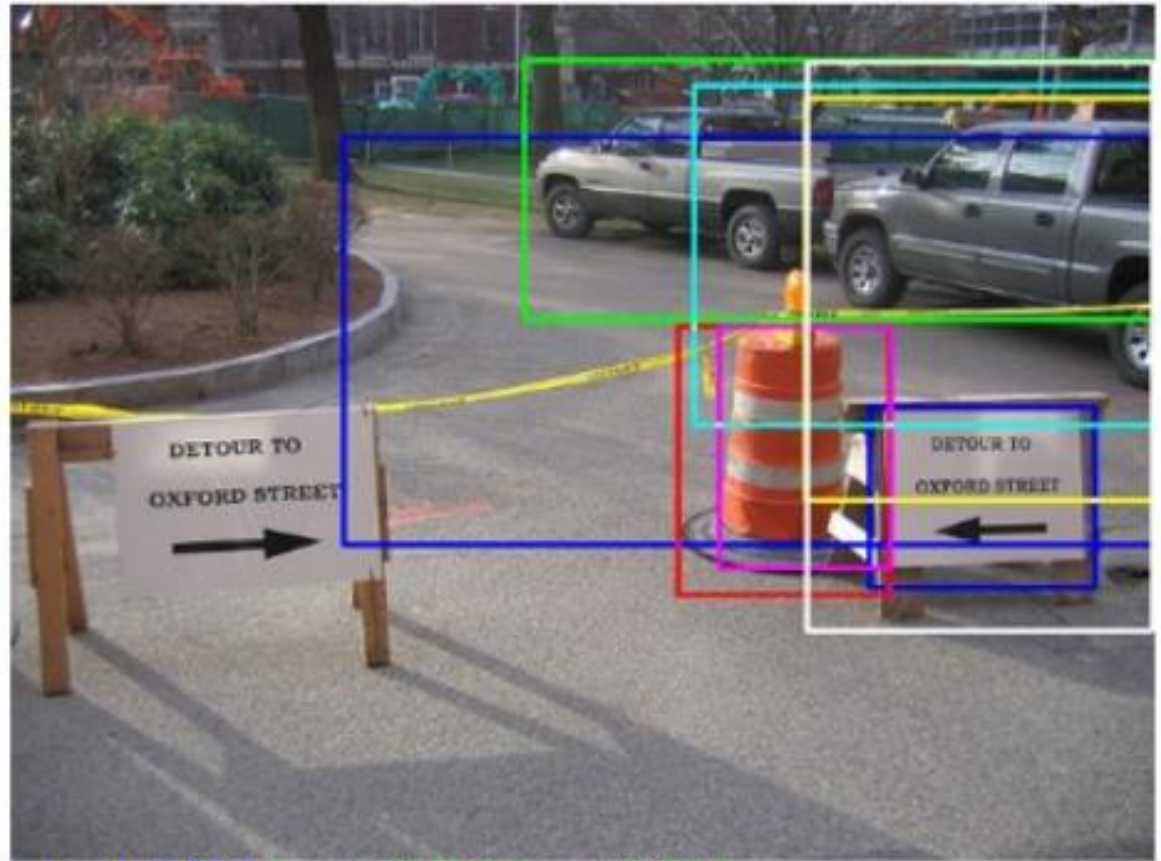
an open laptop computer sitting on top of a desk

two computers are shown together on a desk

New Competencies & Experiences

Hybrid learning
pipelines for
language & vision

■ machine
■ human



[street (0.89)] [truck (0.76)] [road (0.58)]

[fire (0.95)] [hydrant (0.91)] [sitting (0.53)] [black (0.51)]

[red (0.53)] [parking (0.69)] [parked (0.82)] [sign (0.78)]

a fire hydrant on the side of a road

two signs with arrows pointing to each other for detour

Broad Spectrum of Opportunities

Healthcare

Education

Sciences

Governance

Transportation

Criminal justice

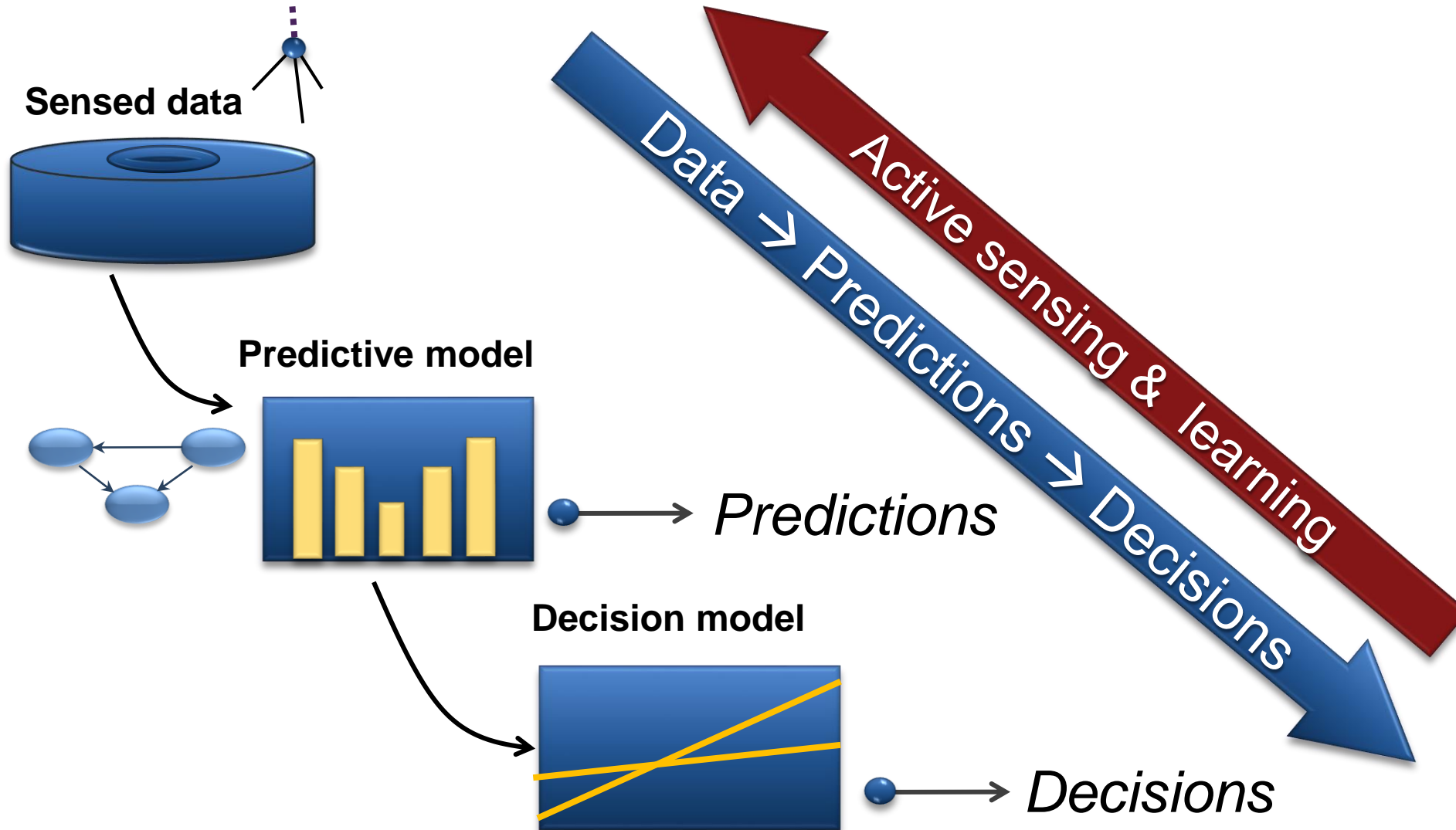
Agriculture

Privacy & security

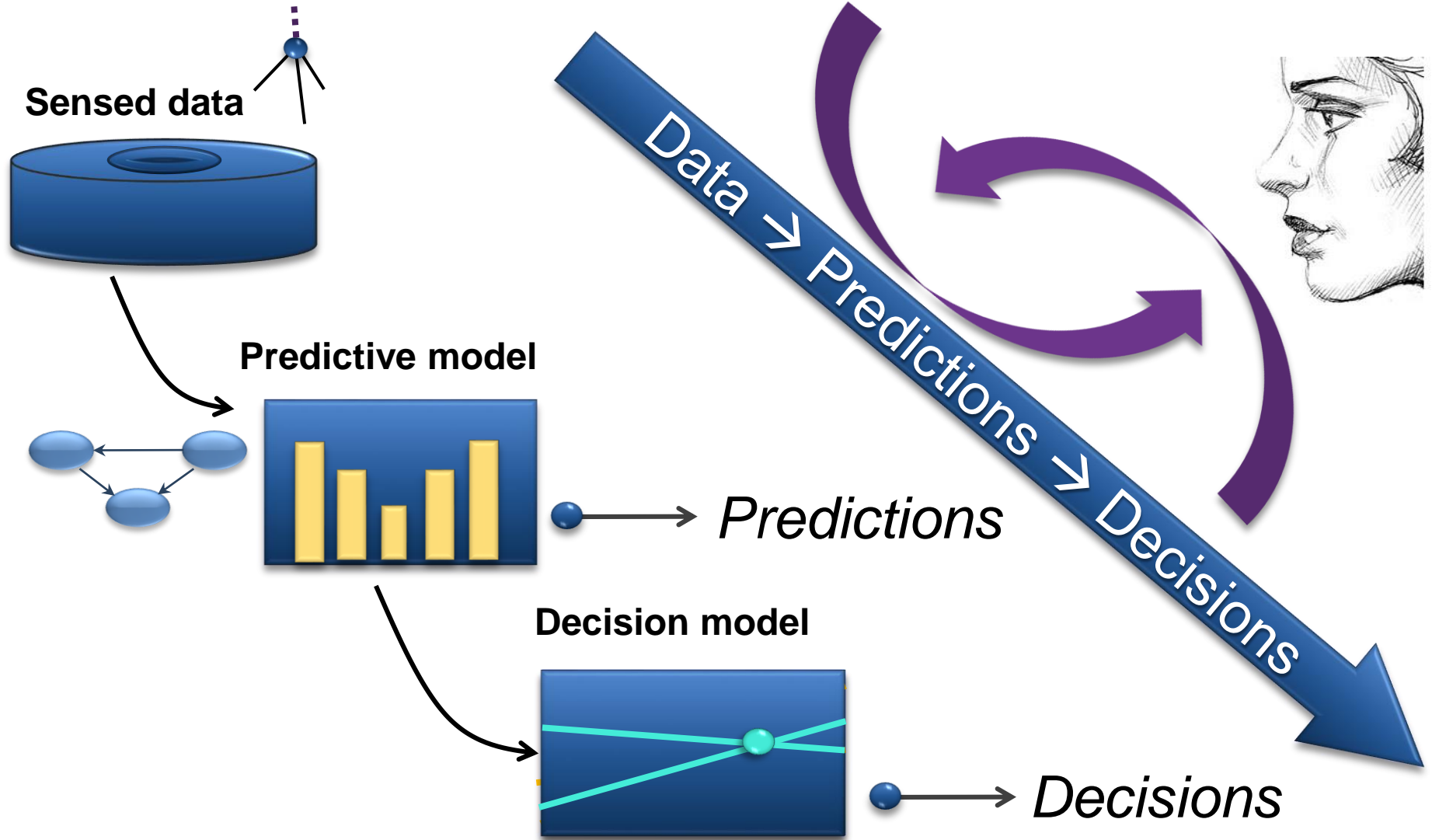
Sustainability

Emergency management

Data → Predictions → Decisions



People, Models, and Insights



AI & Healthcare: Long-term Dream



H., Shwe (1995)



Saria, Rajani, Gould, et al. (2010)

Broad Spectrum of Opportunities

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Example: Readmissions Challenge



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JOURNAL of MEDICINE

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Number 14

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Rehospitalizations among Patients in the Medicare Fee-for-Service Program

Stephen F. Jencks, M.D., M.P.H., Mark V. Williams, M.D., and Eric A. Coleman, M.D., M.P.H.

ABSTRACT

Background Reducing rates of rehospitalization has attracted attention from policymakers as a way to improve quality of care and reduce costs. However, we have limited information on the frequency and patterns of rehospitalization in the United States to aid in planning the necessary changes.

Methods We analyzed Medicare claims data from 2003–2004 to describe the patterns of

- ~20% within 30 days

- ~35% in 90 days

- **Estimated cost to Medicare (2004):
\$17.4 billion**

Learning from Healthcare Data

Washington Hospital Center

20 years of data 30,000 variables



- Admissions, discharge, transfer (ADT)
- Chief complaint in free text
- Age, gender, demographics
- Diagnosis codes (ICD-9)
- Vital signs
- Lab results
- Medications
- Procedures
- Locations in hospital
- Admitting & attending MD codes
- Fees and billing

Into the Real World

Readmissions Manager

Reducing Hospital Readmissions is an Impending Priority

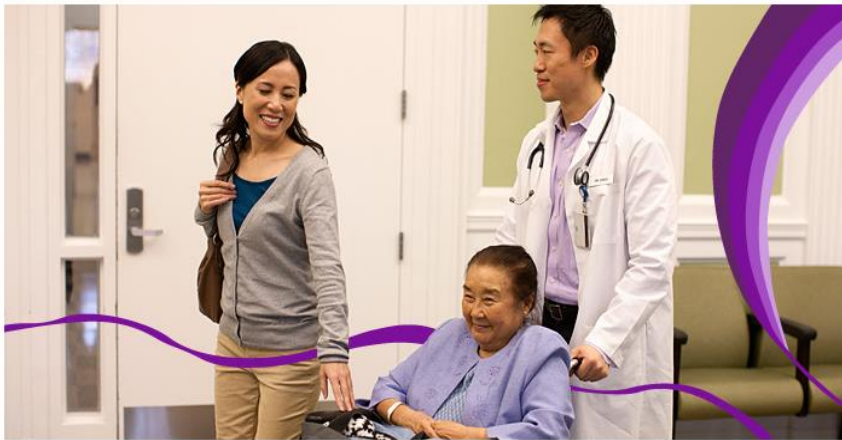
Overview

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 Amalgia is an innovative solution to help organizations address this very important business need.



Readmissions Manager Targets Avoidable Hospital Readmissions

PROB_NUM_% ▲	FACTORS_PRO_READMISS
37.9	Num past 6m visits = 6 to 10 / Patient had dx = Dis
32.72	stayed <1 day in the hospital / Patient had dx = Dis
30.83	Patient had dx = Chronic renal failure / 44 < Age <
29.05	Patient had dx = Disorders of fluid, electrolyte, and
28.54	
27.36	Patient had dx = Acute renal failure / Patient had d
18.05	Patient had dx = Other personal history presenting
16.57	stayed <1 day in the hospital
16.18	Patient had dx = Disorders of fluid, electrolyte, and
15.52	
14.53	stayed <1 day in the hospital / Ave gap of past yr vis
14.42	stayed <1 day in the hospital / Patient had dx = Oth
14.39	stayed <1 day in the hospital
13.59	stayed <1 day in the hospital / 44 < Age < 60
13.36	stayed <1 day in the hospital / Hour of visit = 00
12.44	stayed <1 day in the hospital

From Predictions to Decisions

Units 5E/501/8E/9W/8ITCU

Baseline:

Discharges to home/ home health between 10/15/2011 – 4/29/2012

Readmissions Rate (all cases): 13%

Score ≥ 25 : 27%

Average direct cost/readmission: \$10,888

Initial Pilot

4/30/2012 – 7/30/2012

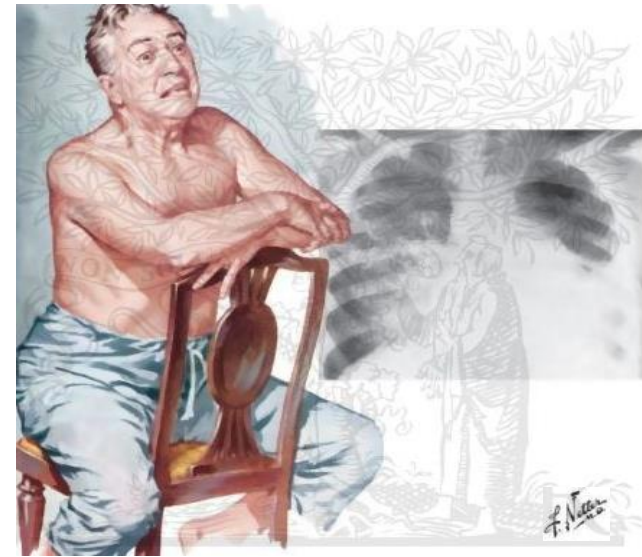
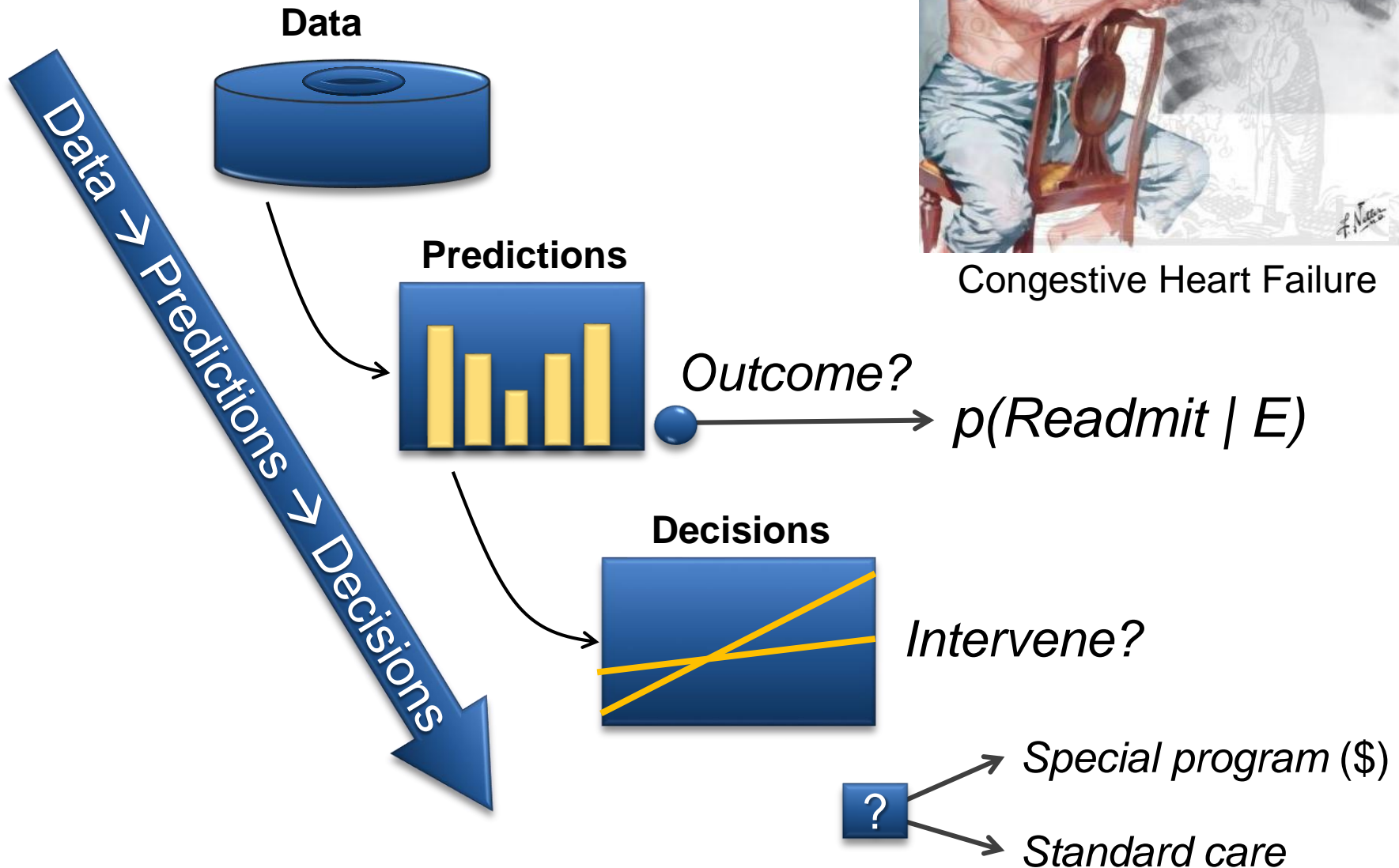
1 Month Post engagement

9/01/2012 – 9/30/2012

Readmissions Rate	12%	10%
Score ≥ 25	23%	20%
# of Admissions Avoided	9	11
Follow up call completion	52%	61%
Follow up call <u>not</u> Completed	32%	21%
Total Annualized savings	\$391,968	\$1,448,104

↓ Total Readmission Rate by 3% and +\$1.4M Savings

Special Intervention?

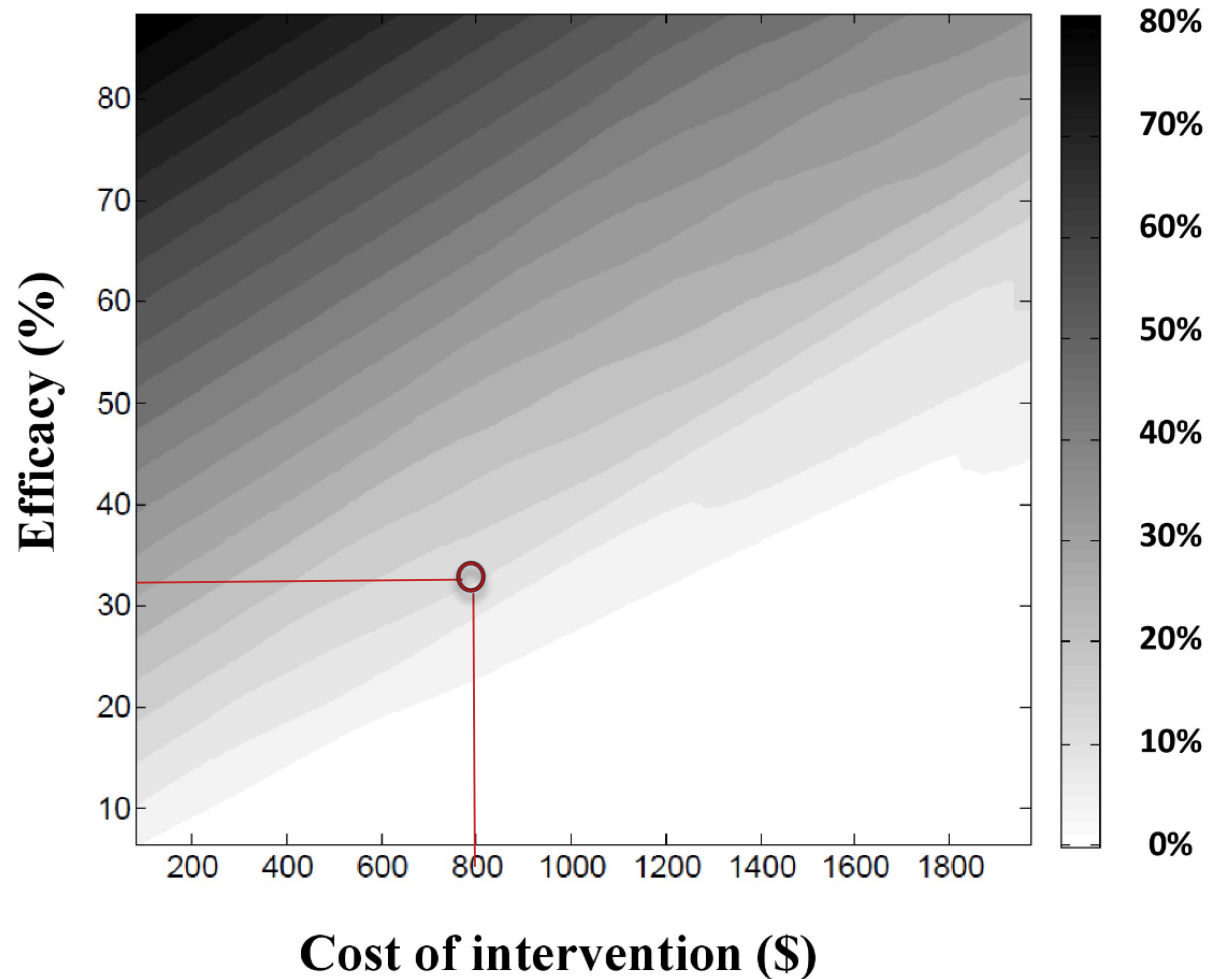


Congestive Heart Failure

Insights

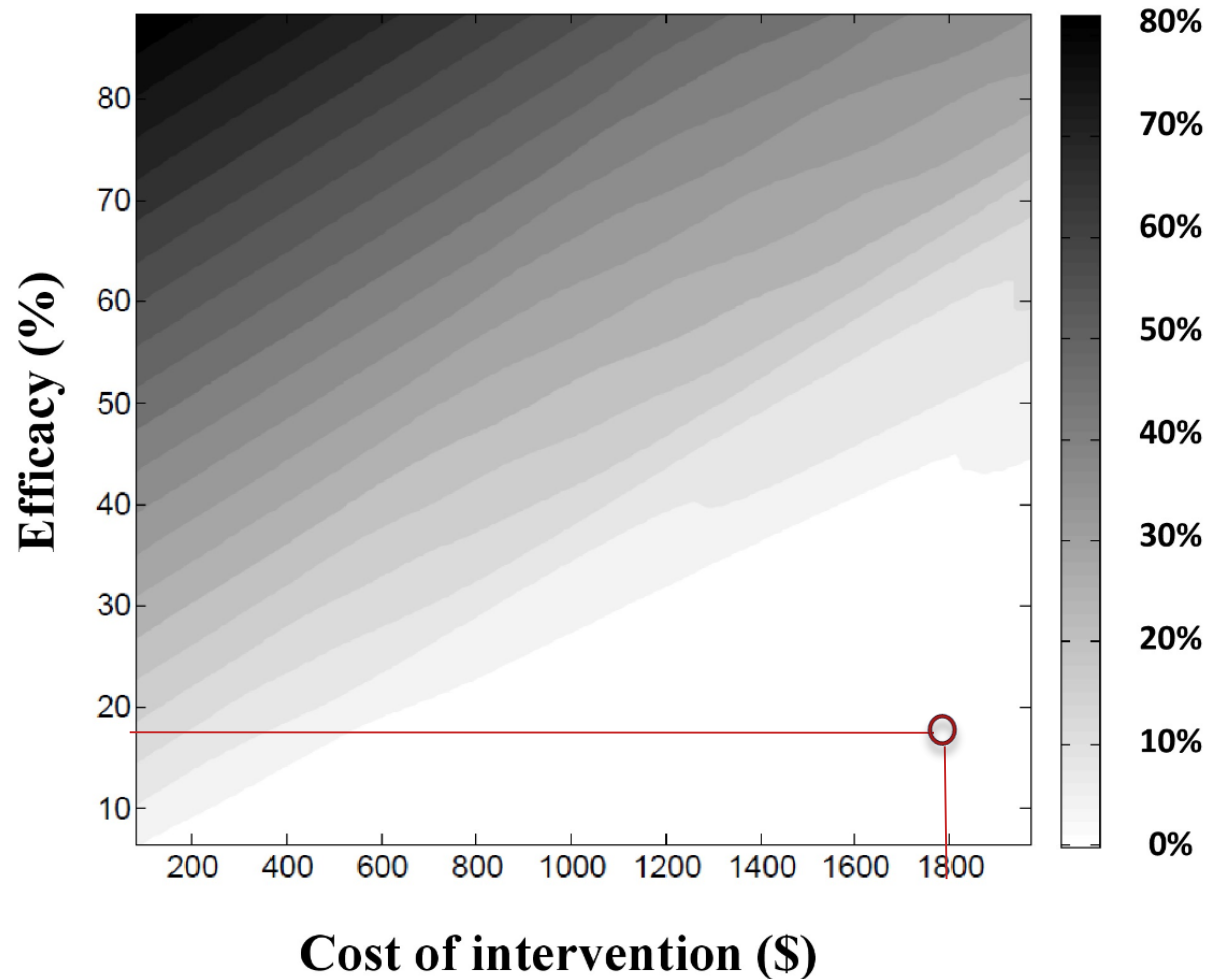
\$800 intervention @ 35% efficacy?

↓ 31.4% readmissions ↓ \$13.2%.

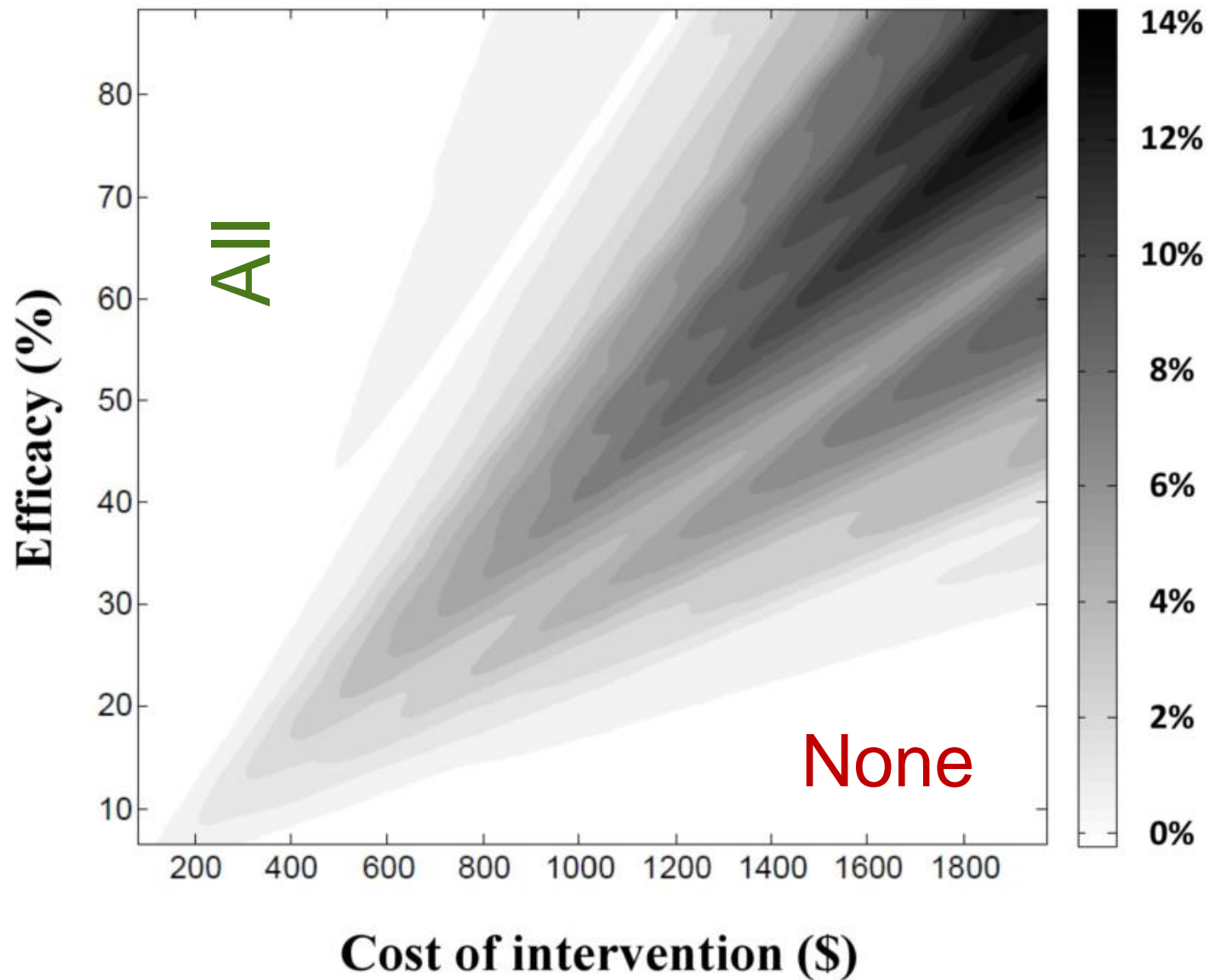


Insights

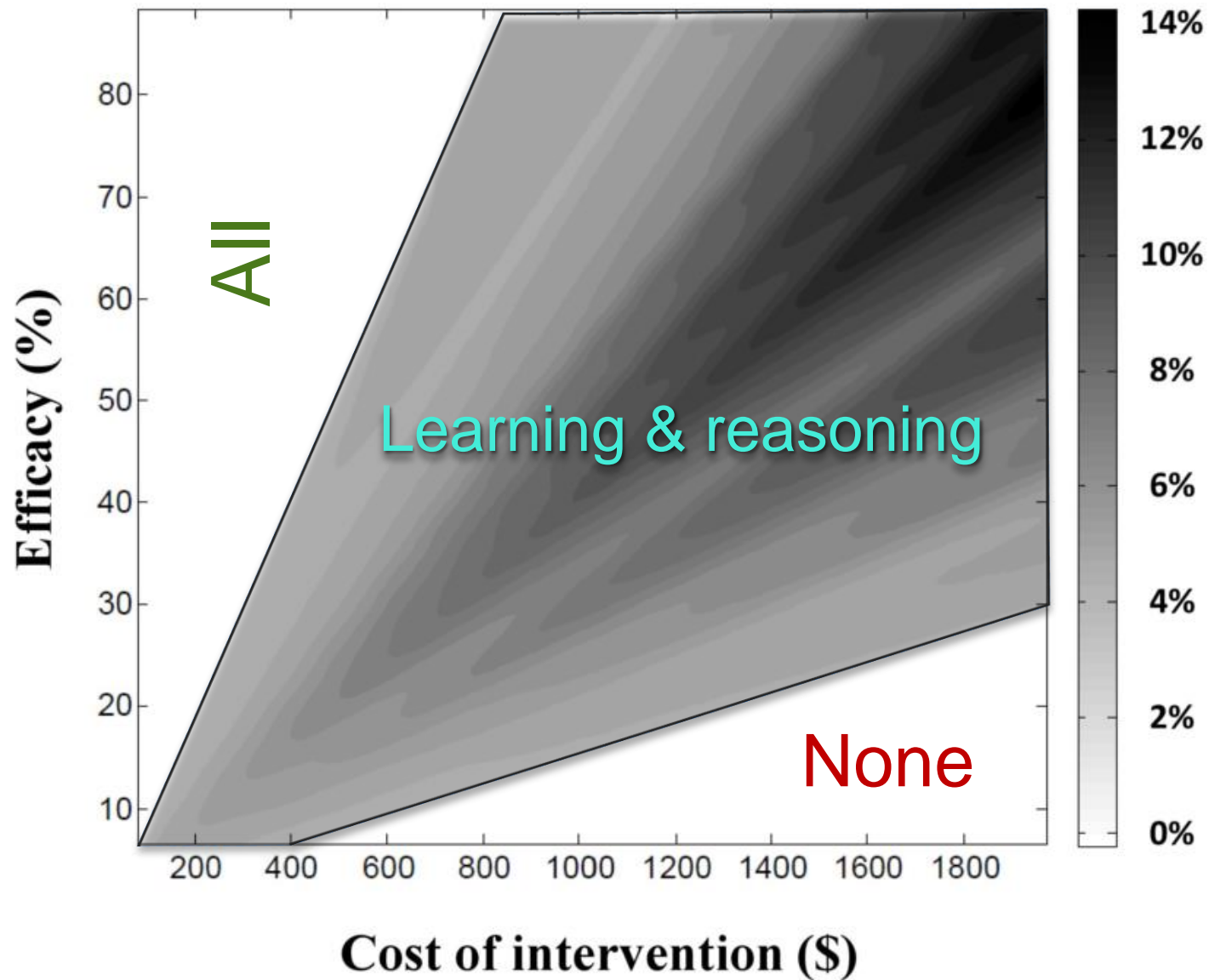
\$1800 intervention @ 20% efficacy?



Value in Larger Ecosystem



Value in Larger Ecosystem



Preventable Errors and Deaths

44,000 - 98,000 per year → 440,000 per year

Institute of Medicine, 1999

Journal of Patient Safety, 2013

Hospital Errors are the Third Leading Cause of Death in U.S., and New Hospital Safety Scores Show Improvements Are Too Slow

Washington, D.C., October 23, 2013 – New research estimates up to 440,000 Americans are dying annually from preventable hospital errors. This puts medical errors as the third leading cause of death in the United States, underscoring the need for patients to protect themselves and their families from harm, and for hospitals to make patient safety a priority.

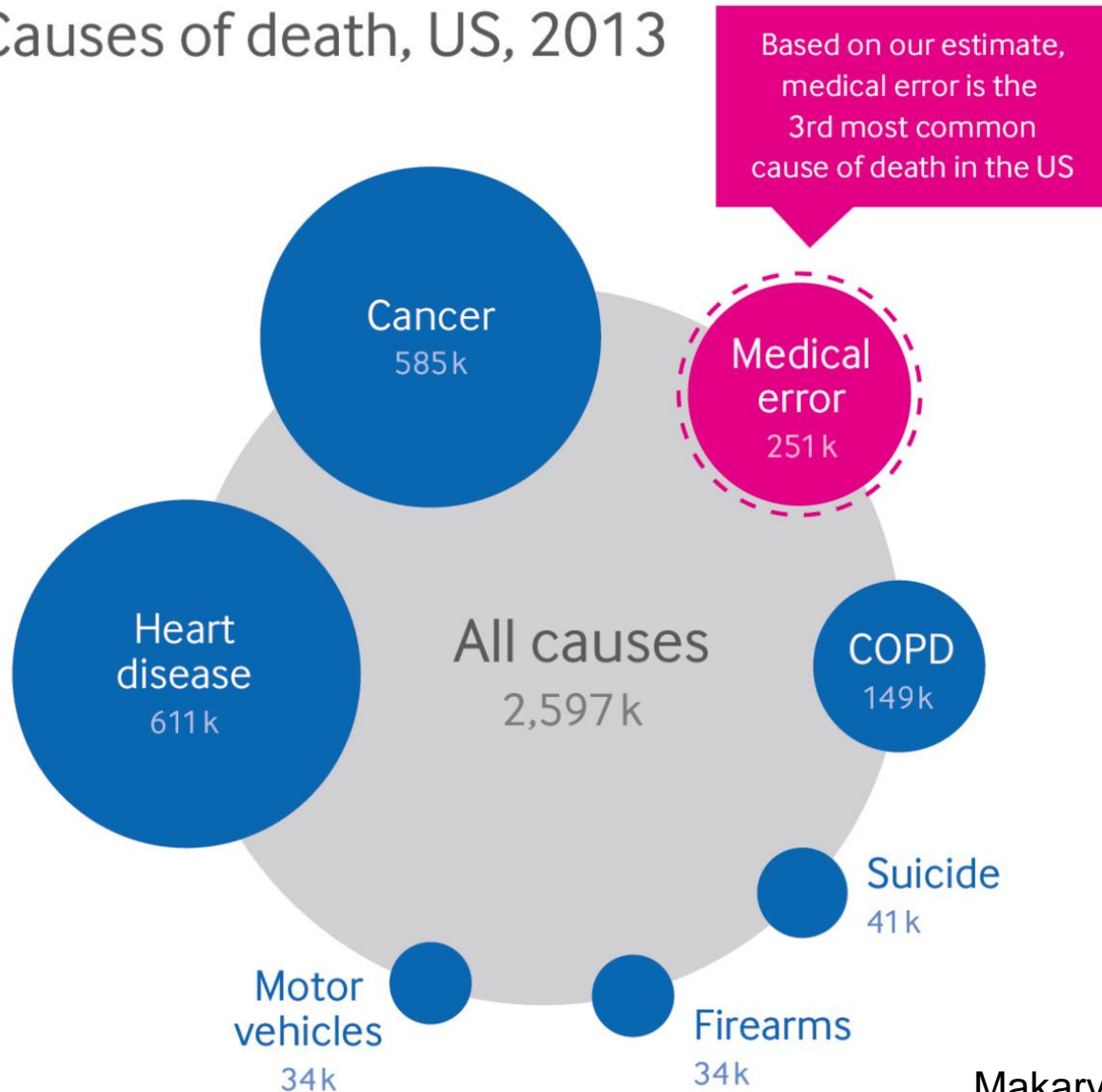


James (2013)

To Err is Human: Building a Safer Health System, Inst. of Medicine (1999)

Preventable Errors and Deaths

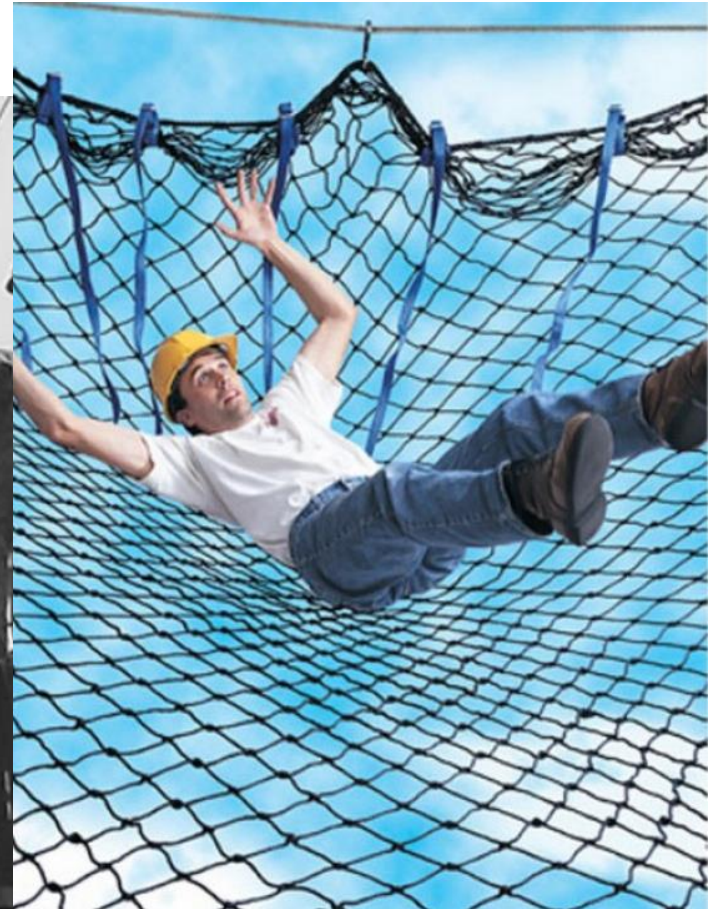
Causes of death, US, 2013



Preventable Errors and Deaths

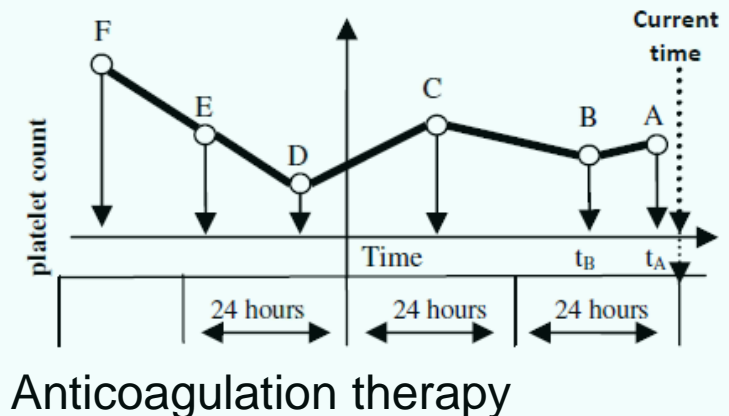
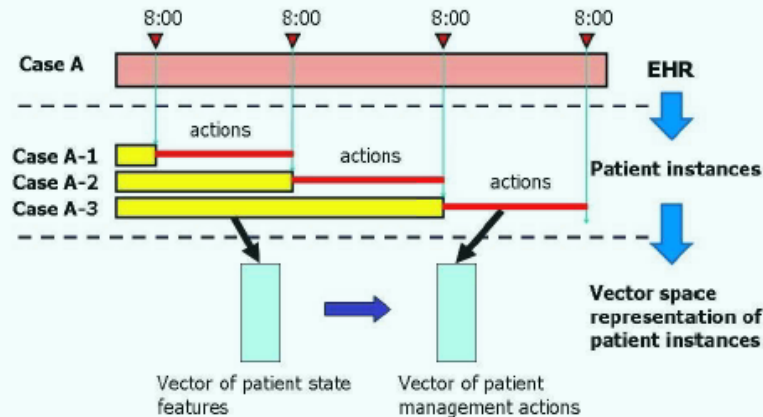
Based on our estimate,
medical error is the
3rd most common
cause of death in the US

Promise of AI



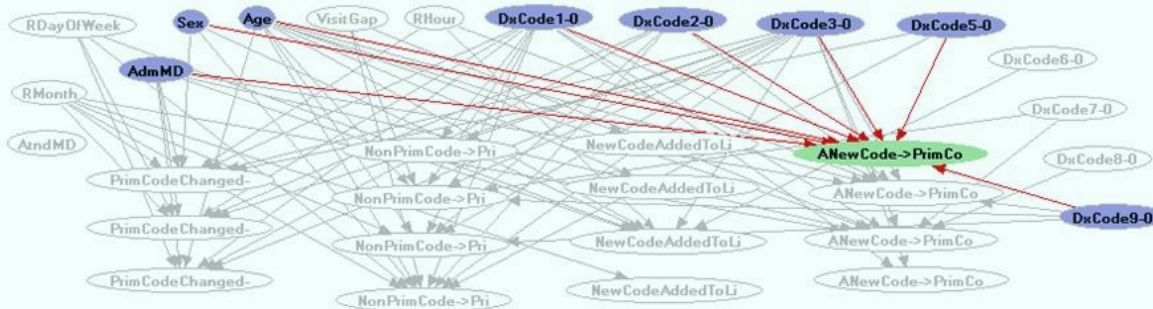
AI as Safety Nets

Learn to detect anomalies with healthcare delivery



Hauskrecht, Batal, Valko, Visweswaran, Cooper, Clermont (2013)

Learning to predict expert will be surprised



"Significant likelihood of surprising outcome within 48 hours."

Bayati, Koch, H.

Perception and Robotics in Healthcare



Perception and Robotics in Healthcare



Reach needle #22



Position #165



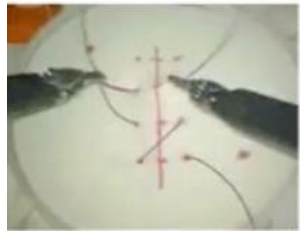
Insert #162



Left transfer #119



Right transfer #37



Pull #160



Orient #48



Tighten suture #23



Loosening #4



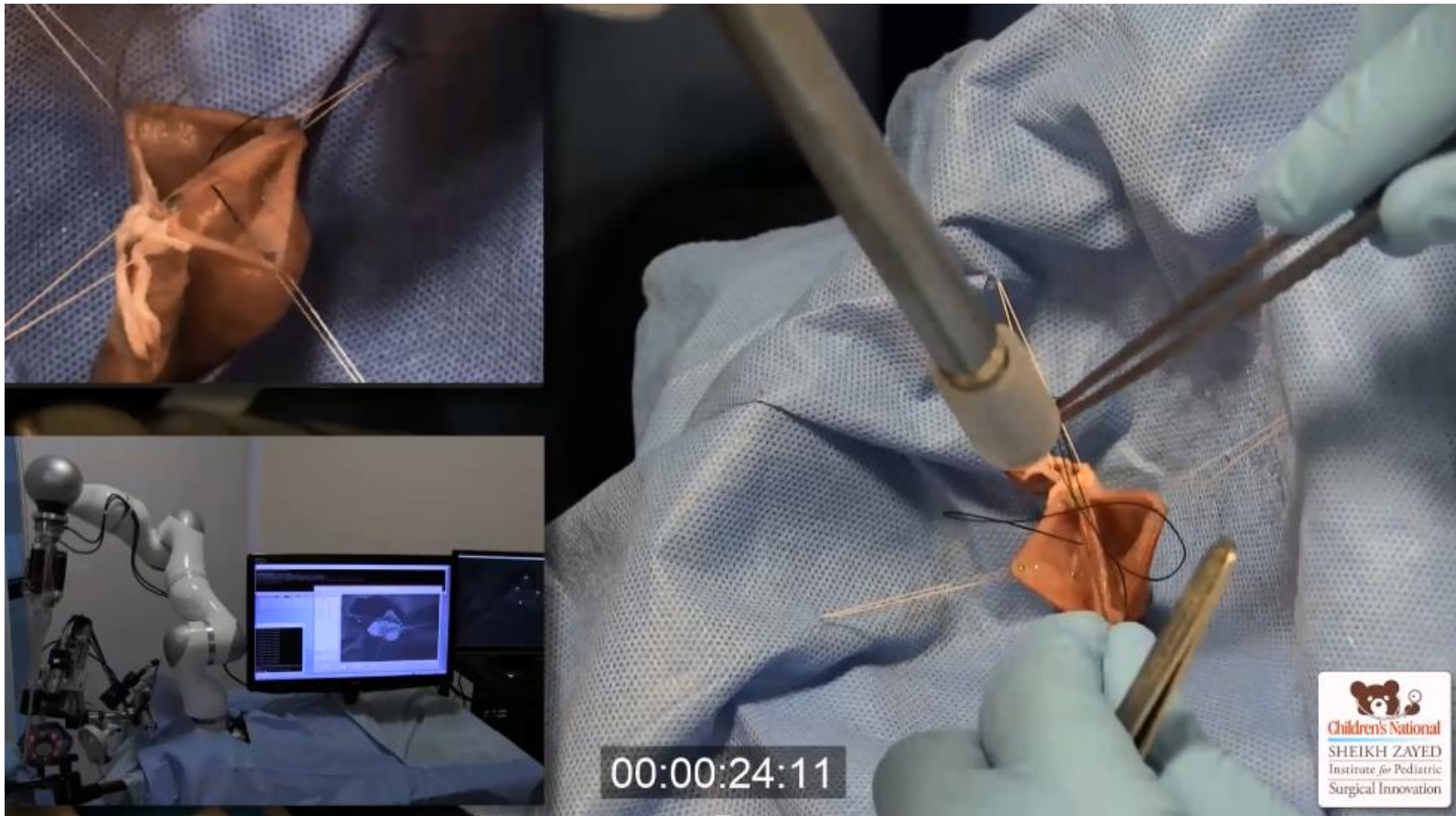
Dropping #39

(video)

Grammar of surgery

Recognize surgical actions & intentions

Perception and Robotics in Healthcare



(video)

Mix of human and machine initiatives

Shademan, Decker, Opfermann, Leonard, Kim, et al. (2016)

Broad Spectrum of Opportunities

Healthcare

Education

Sciences

Governance

Transportation

Criminal justice

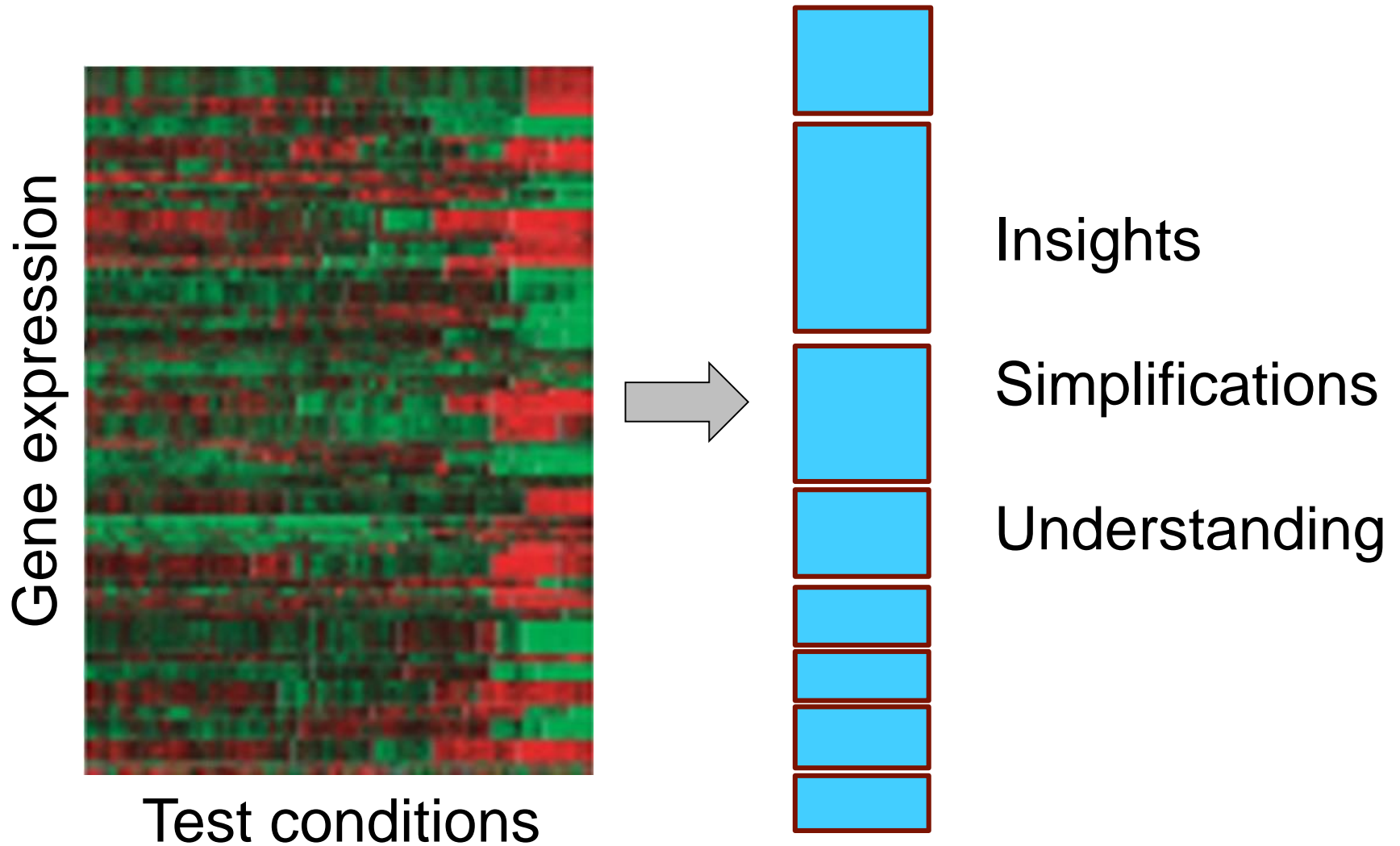
Agriculture

Privacy & security

Sustainability

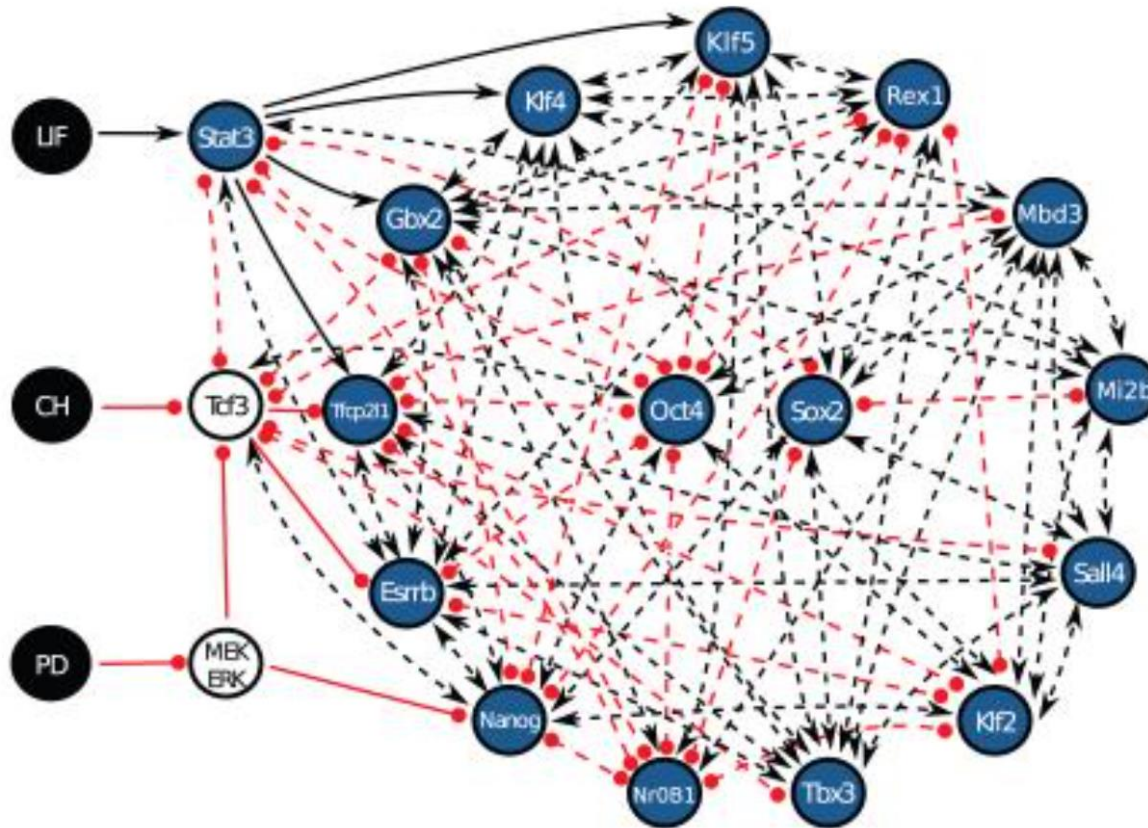
Emergency management

Cutting Through Complexity of Biology

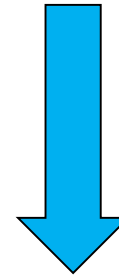


Cutting Through Complexity of Biology

Biology's control of differentiation of embryonic cells



AI theorem prover



Regulatory program

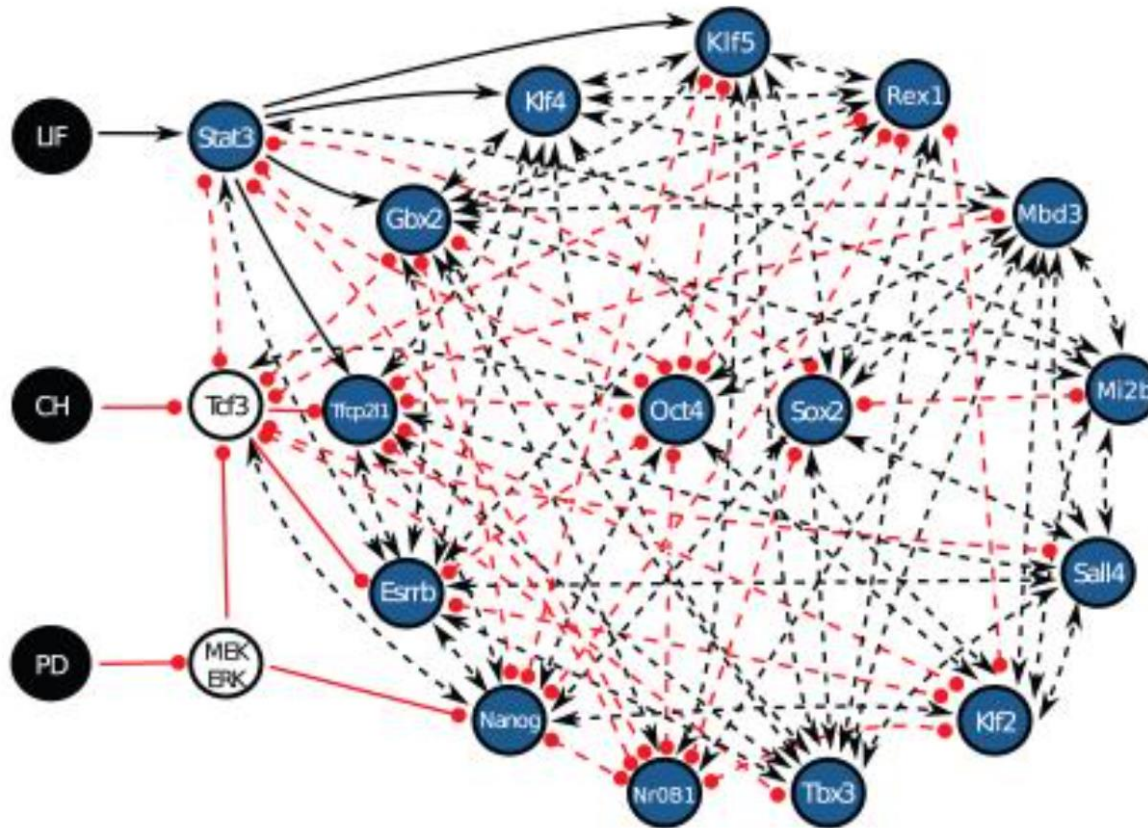
16 interactions

12 components

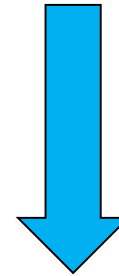
3 inputs!

Cutting Through Complexity of Biology

Biology's control of differentiation of embryonic cells



AI theorem prover



Regulatory program

16 interactions

12 components

3 inputs!

Understanding biology's languages, programs, protocols

Understanding & correcting programs gone awry: Cancer

Keeping up with the Literature

AI for machine reading & comprehension

Biomedical studies

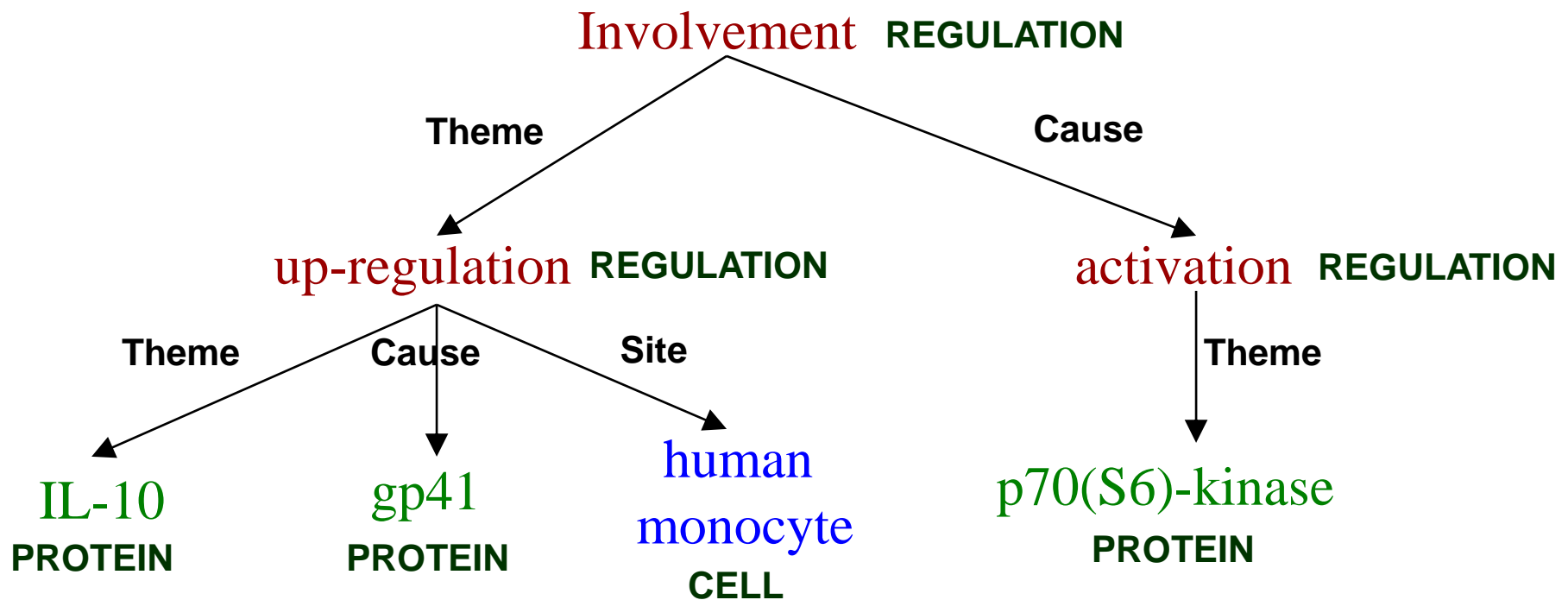
1 million papers / year

2 new papers / minute

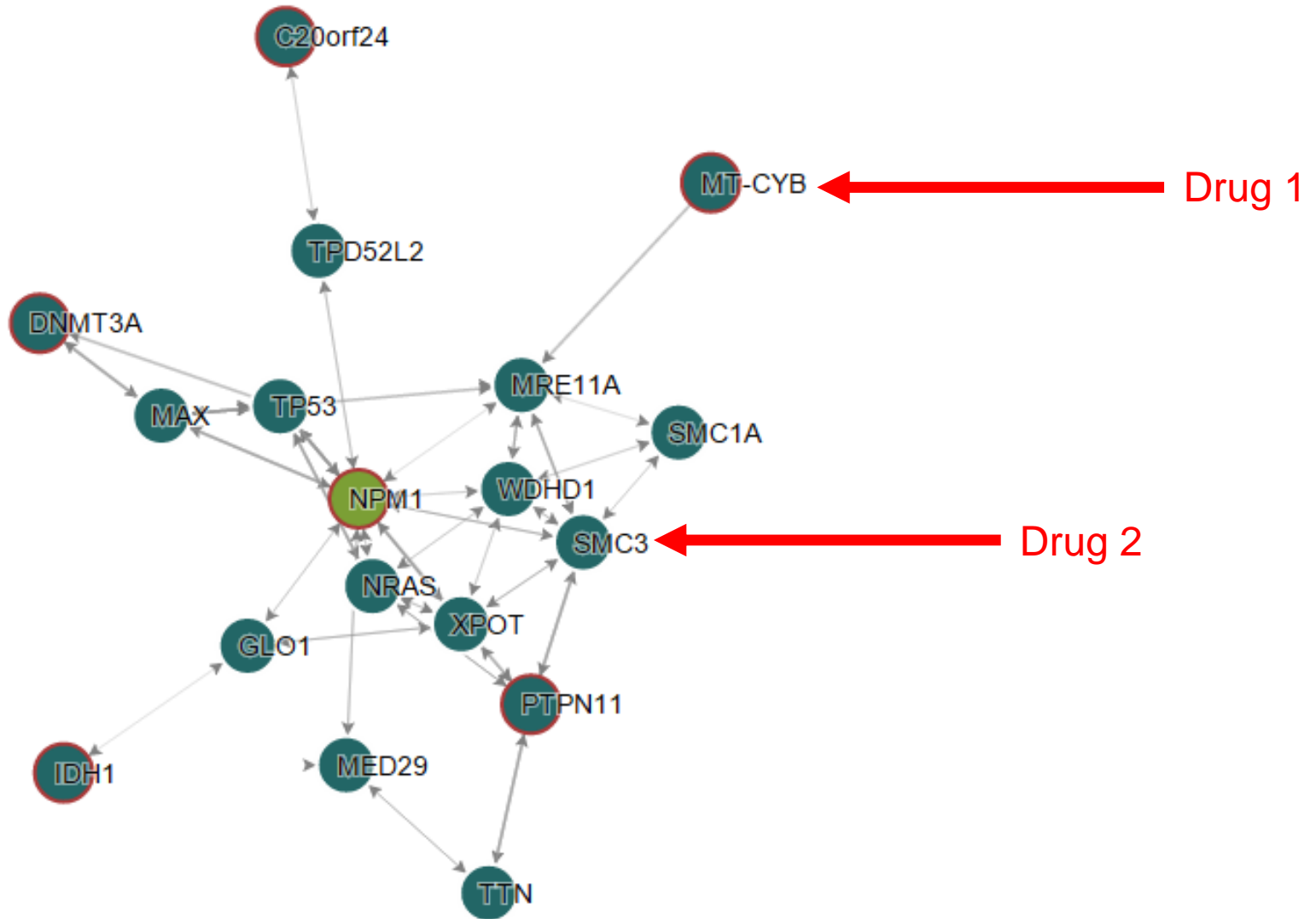


Keeping up with the Literature

“Involvement of p70(S6)-kinase activation in IL-10 up-regulation in human monocytes by gp41 envelope protein of human immunodeficiency virus type 1 ...”



Promising Design & Discovery Tools



Precision medicine via active, updated models

H. Poon, et al. (2016)

Broad Spectrum of Opportunities

Healthcare

Education

Sciences

Governance

Transportation

Criminal justice

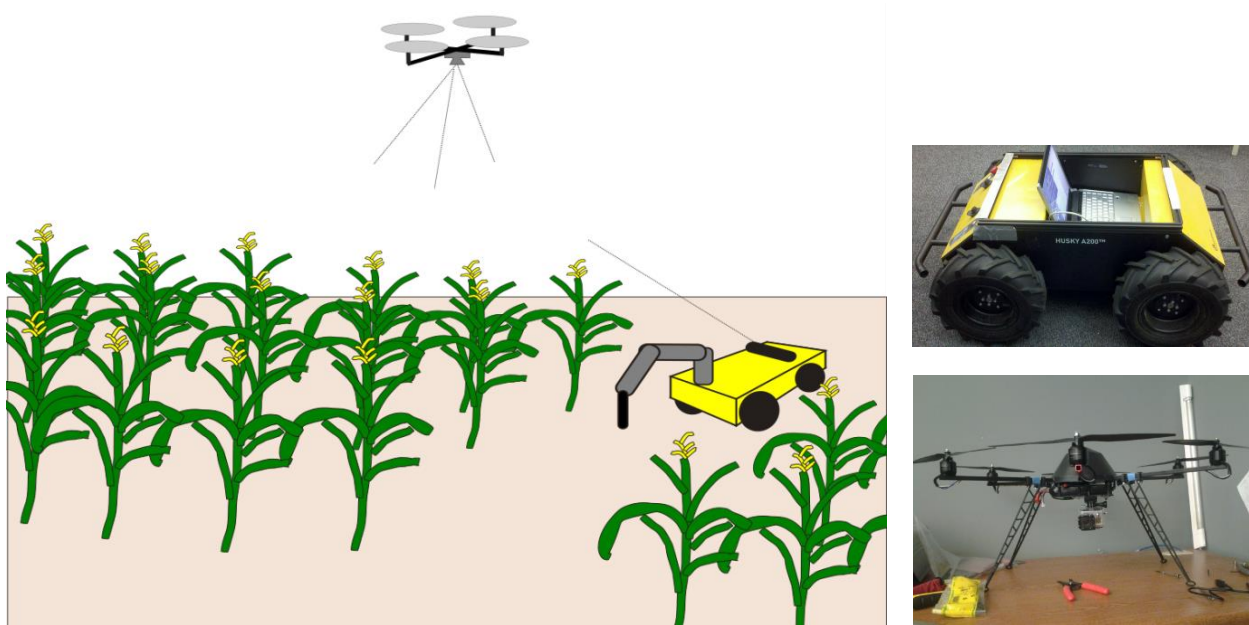
Agriculture

Privacy & security

Sustainability

Emergency management

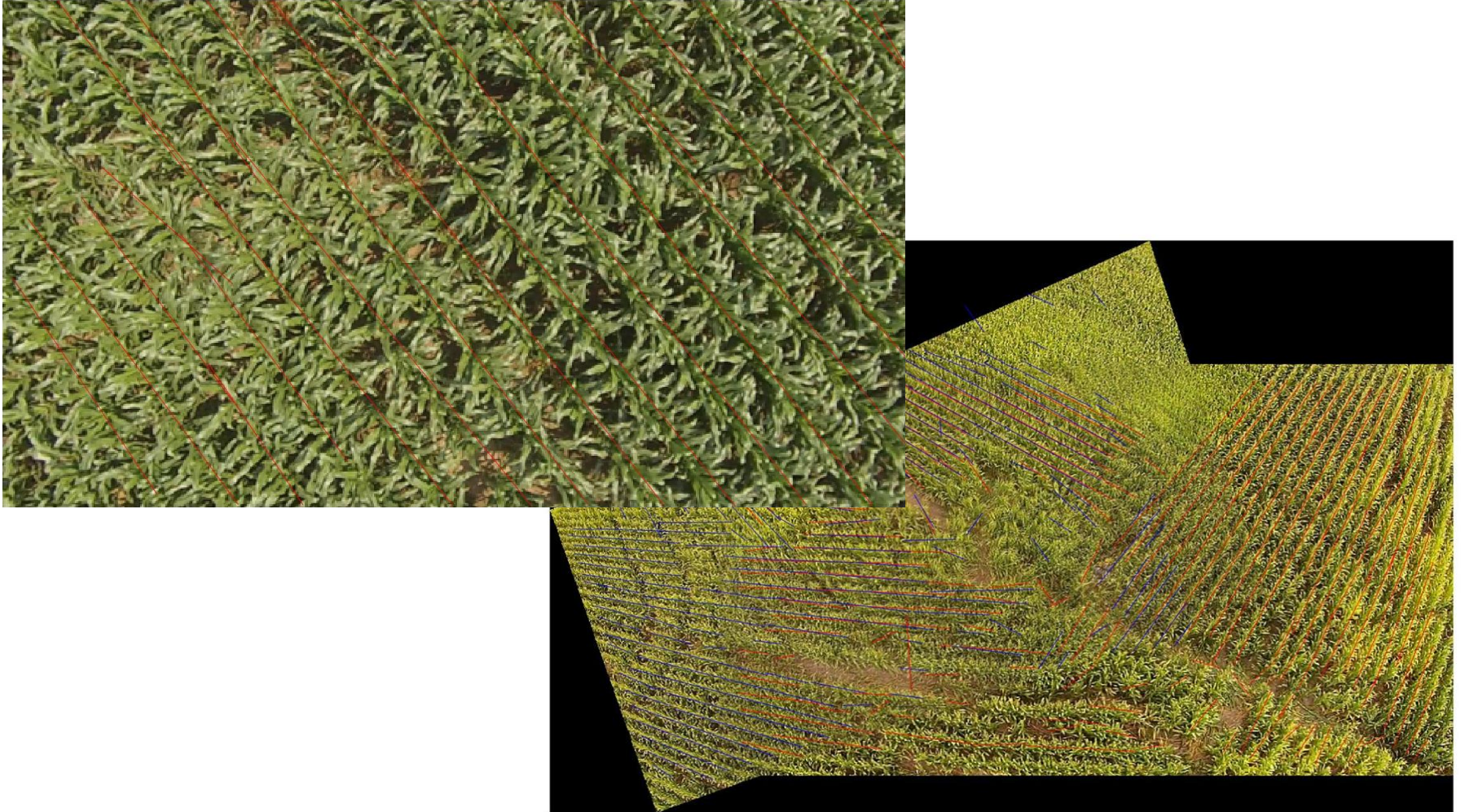
Toward Precision Agriculture



Symbiotic use of ground & air vehicles

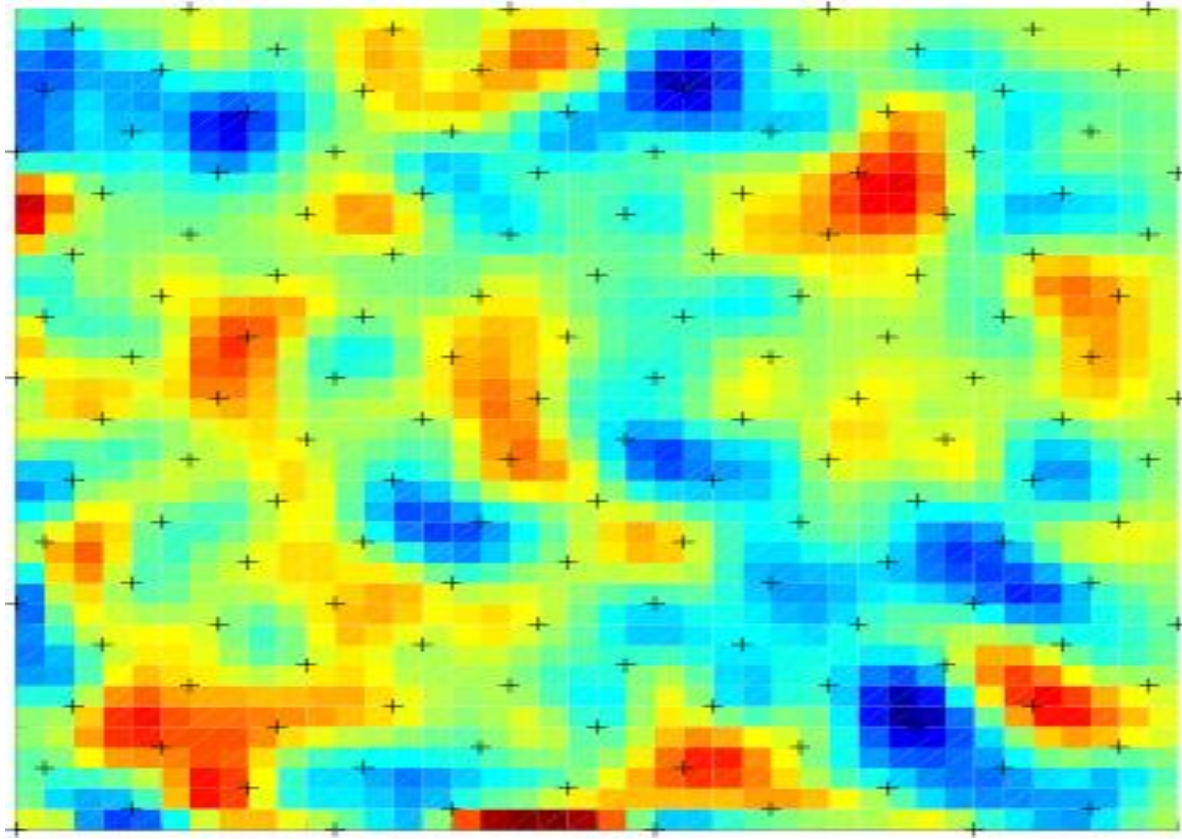
Ideal team work on plans & information value

Toward Precision Agriculture



Tokekar, Vander Hook, D. Mulla, V. Isler

Toward Precision Agriculture



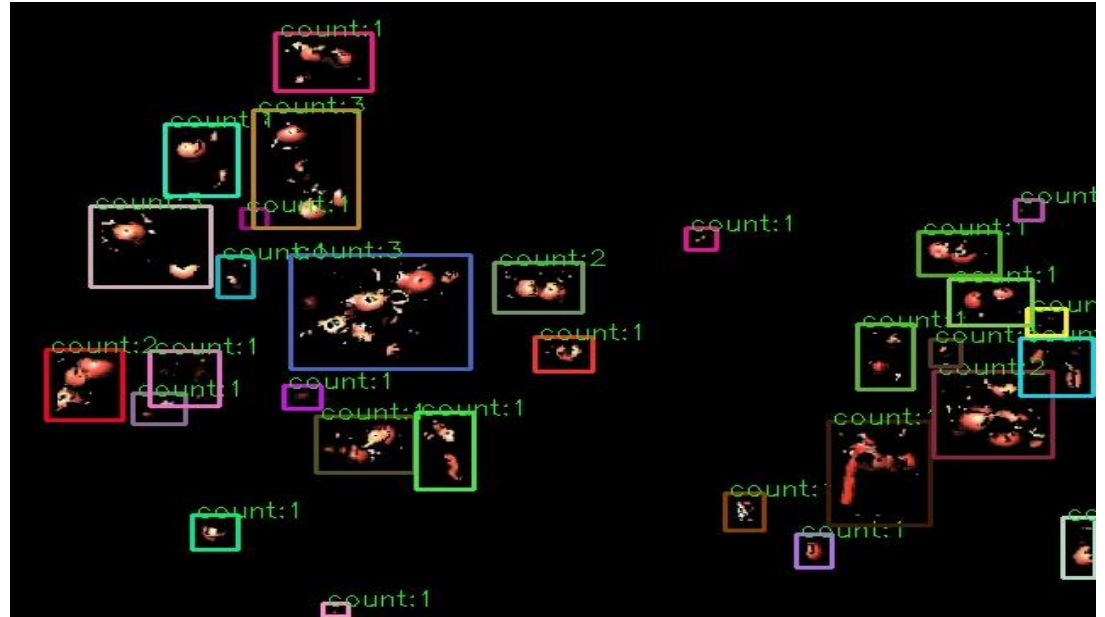
Construct soil nitrogen map



Toward Precision Agriculture



(video)



Apple yield estimation

Broad Spectrum of Opportunities

Healthcare

Education

Sciences

Governance

Transportation

Criminal justice

Agriculture

Privacy & security

Sustainability

Emergency management

Sustainability, Environment, Natural Resources, Wildlife

Supporting sensing, models, predictions, and decisions in support of world's ecosystems



**Expeditions
in Computing
(CISE)**



Guidance on Land Resources

Streaked Horned Lark



Taylor's Checkerspot



Mazama Pocket Gopher

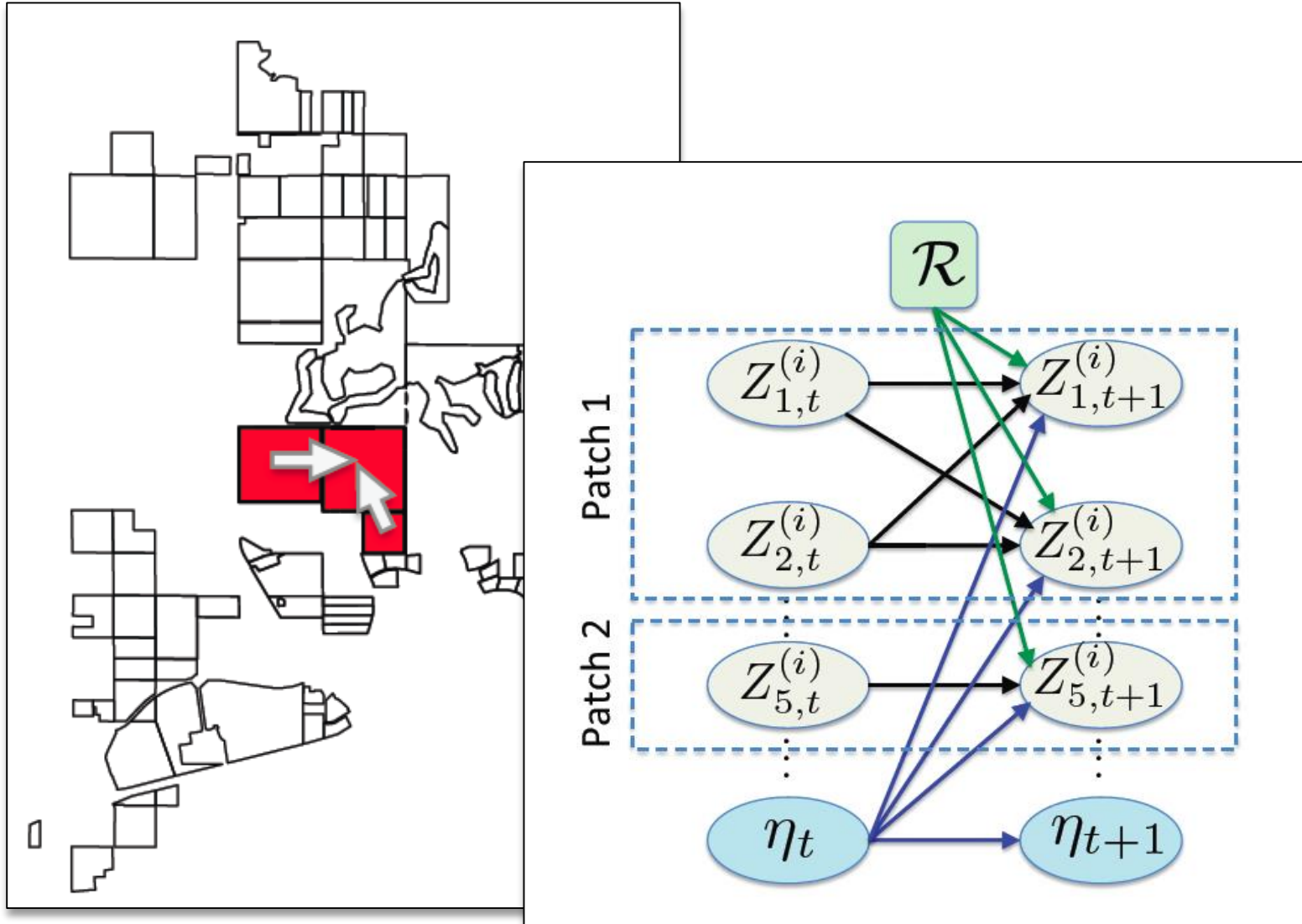


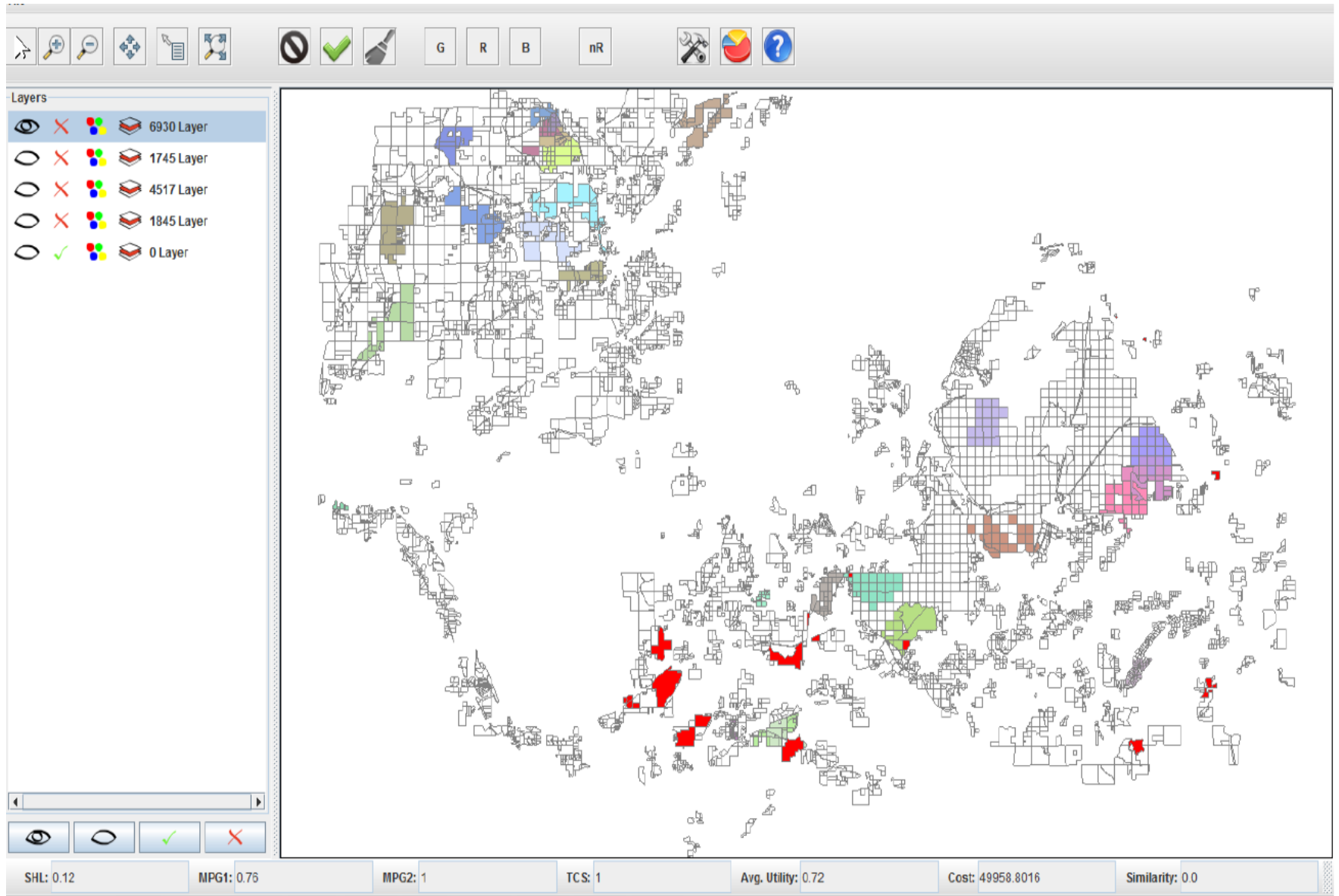
South Puget Sound region

Infer actions that maximize likelihood of survival

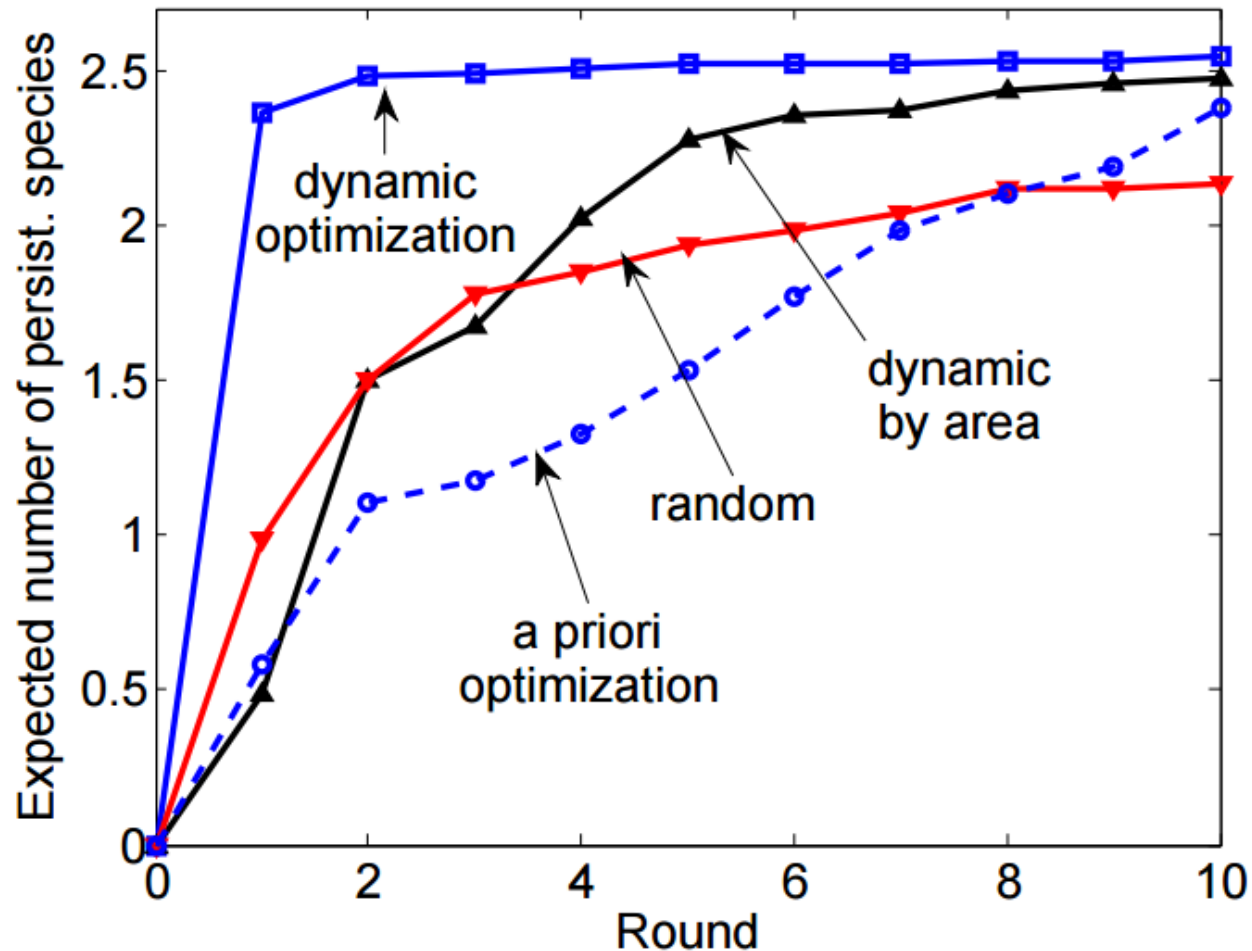
Dynamics of availability of reserve lands

Guidance on Land Resources

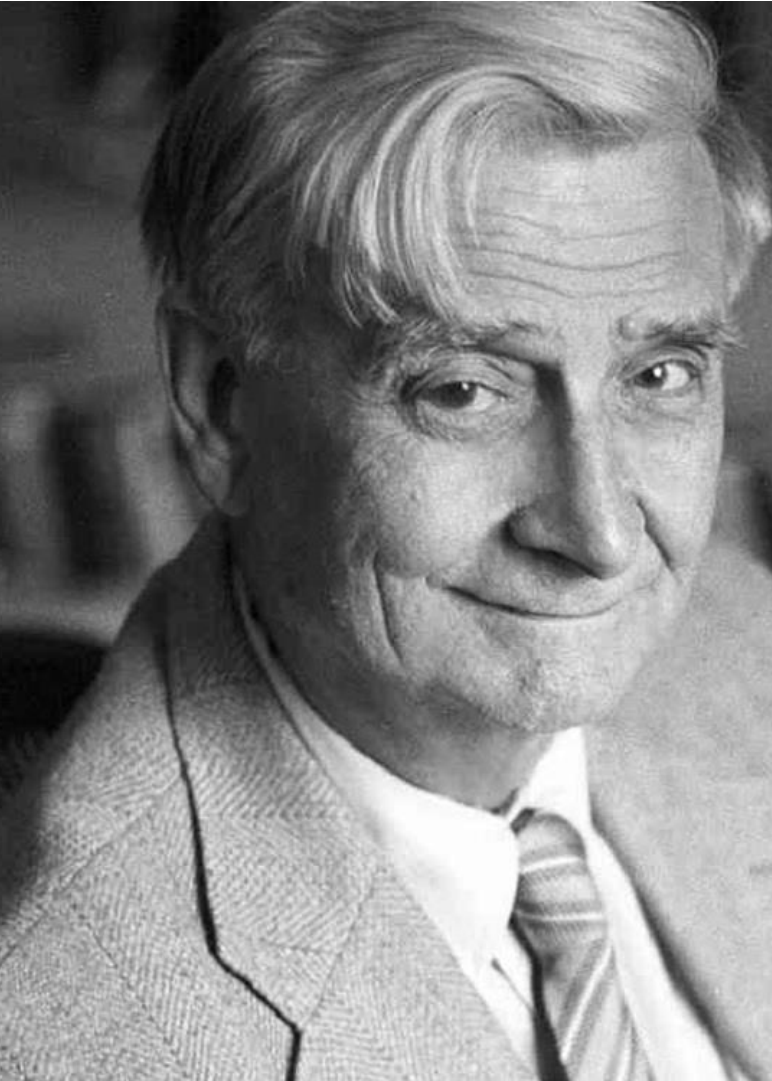




Guidance on Land Resources



Edward O. Wilson



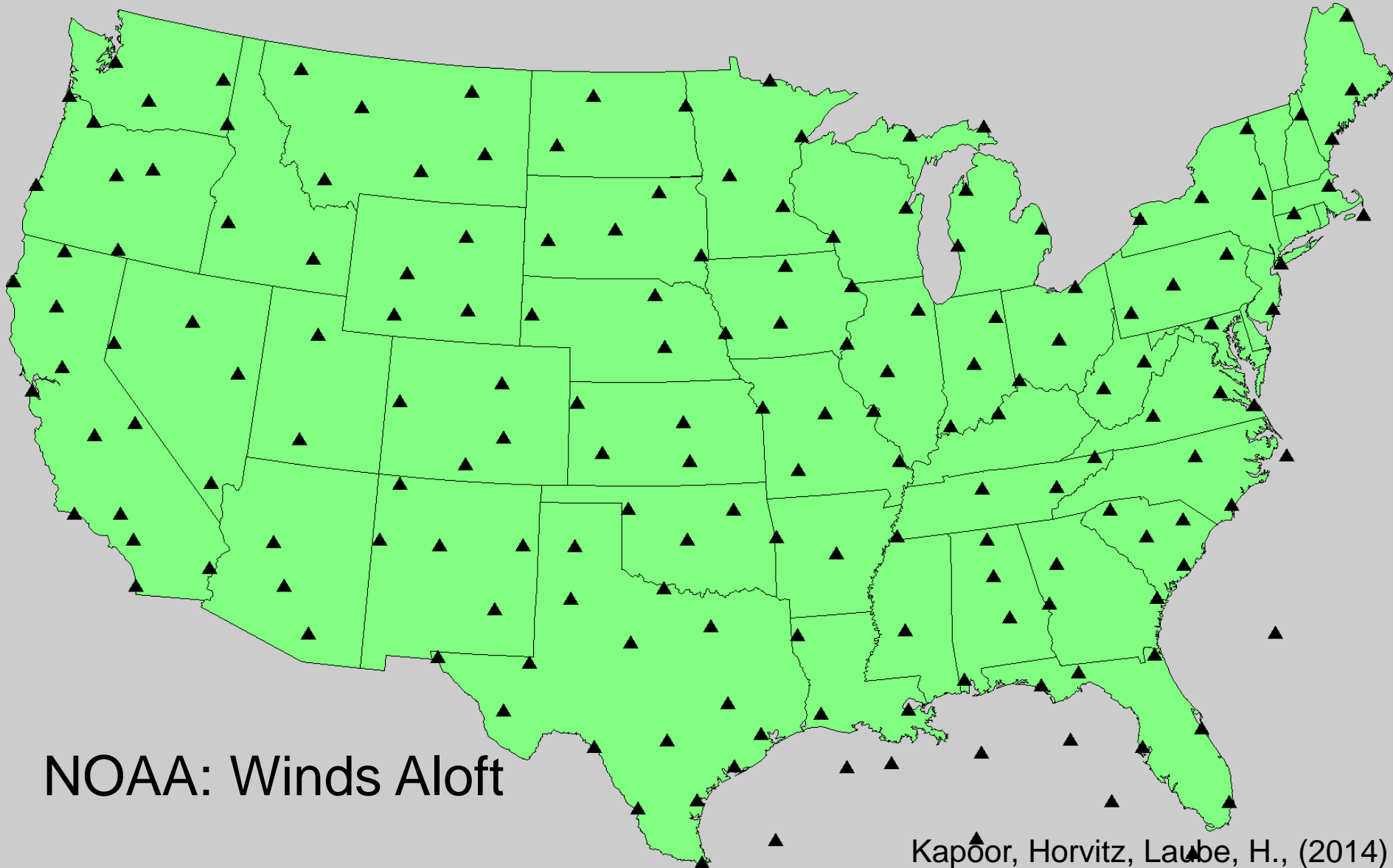
Edward O. Wilson:

*“AI may be
essential to the
survival of life on
our planet.”*

-Oct. 2014

Harnessing Legacy Data & Infrastructure

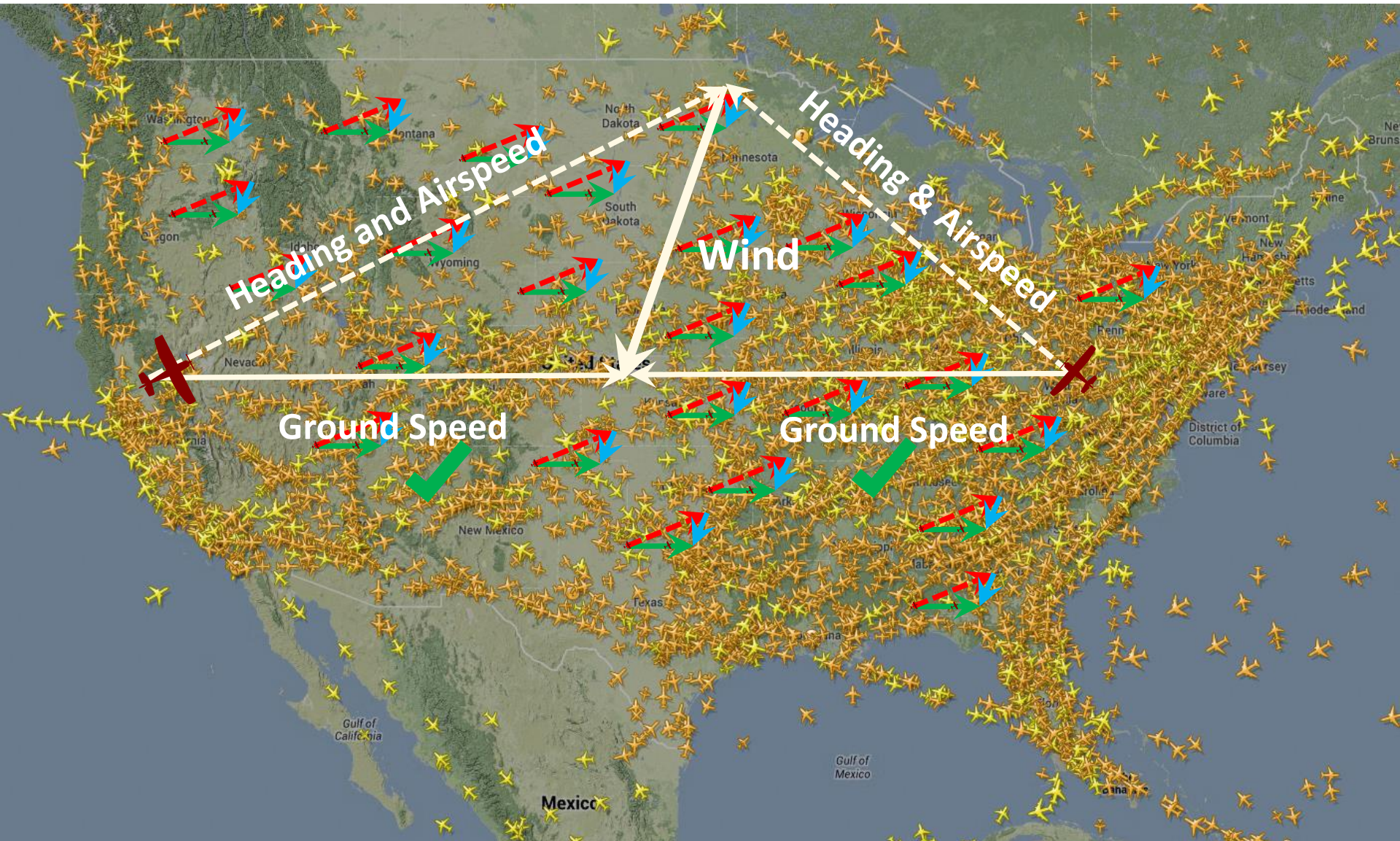
Example: Winds & Weather



Thousands of Wind Sensors



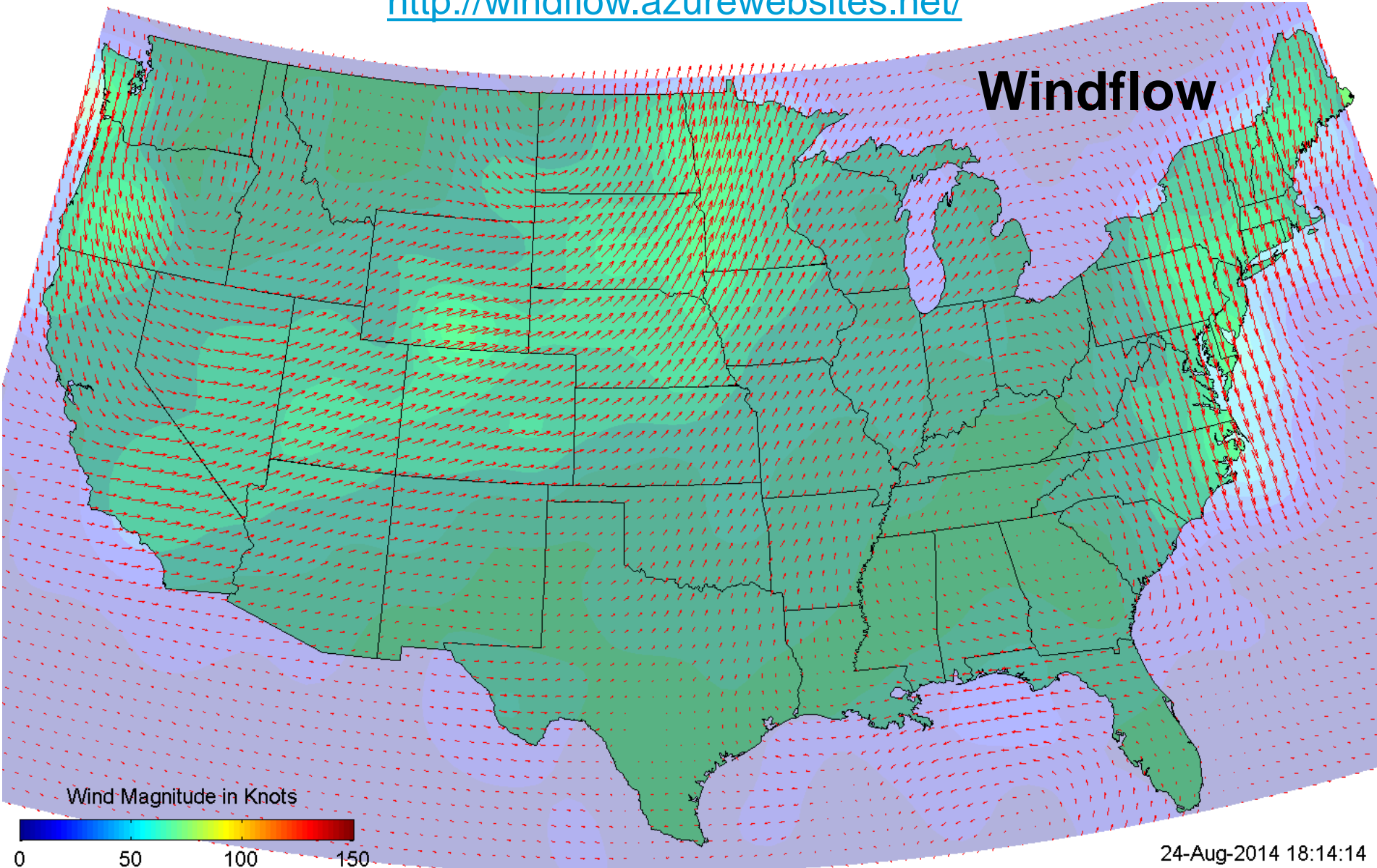
Thousands of Wind Sensors



Windflow

Cloud Service:

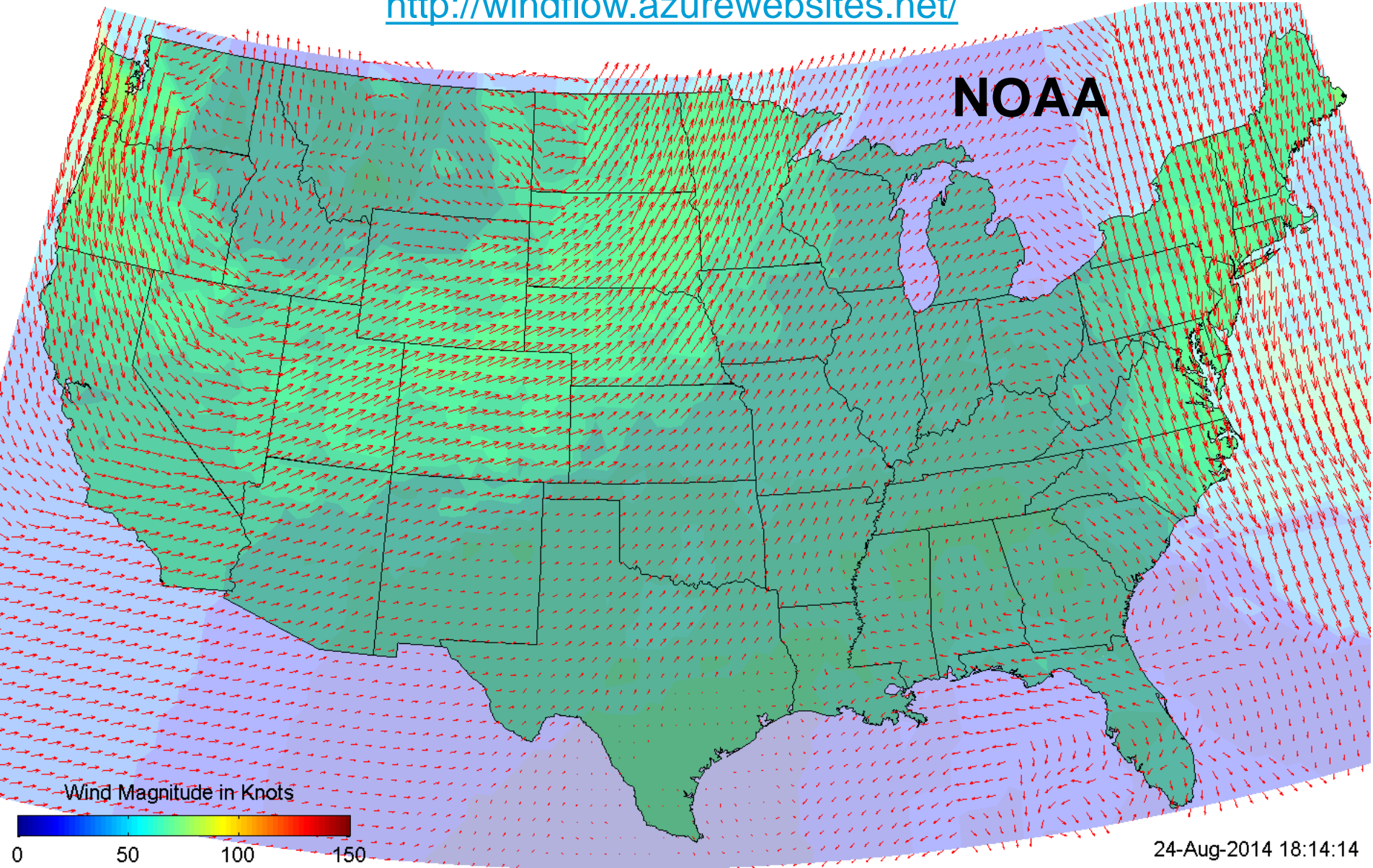
<http://windflow.azurewebsites.net/>



Windflow

Cloud Service:

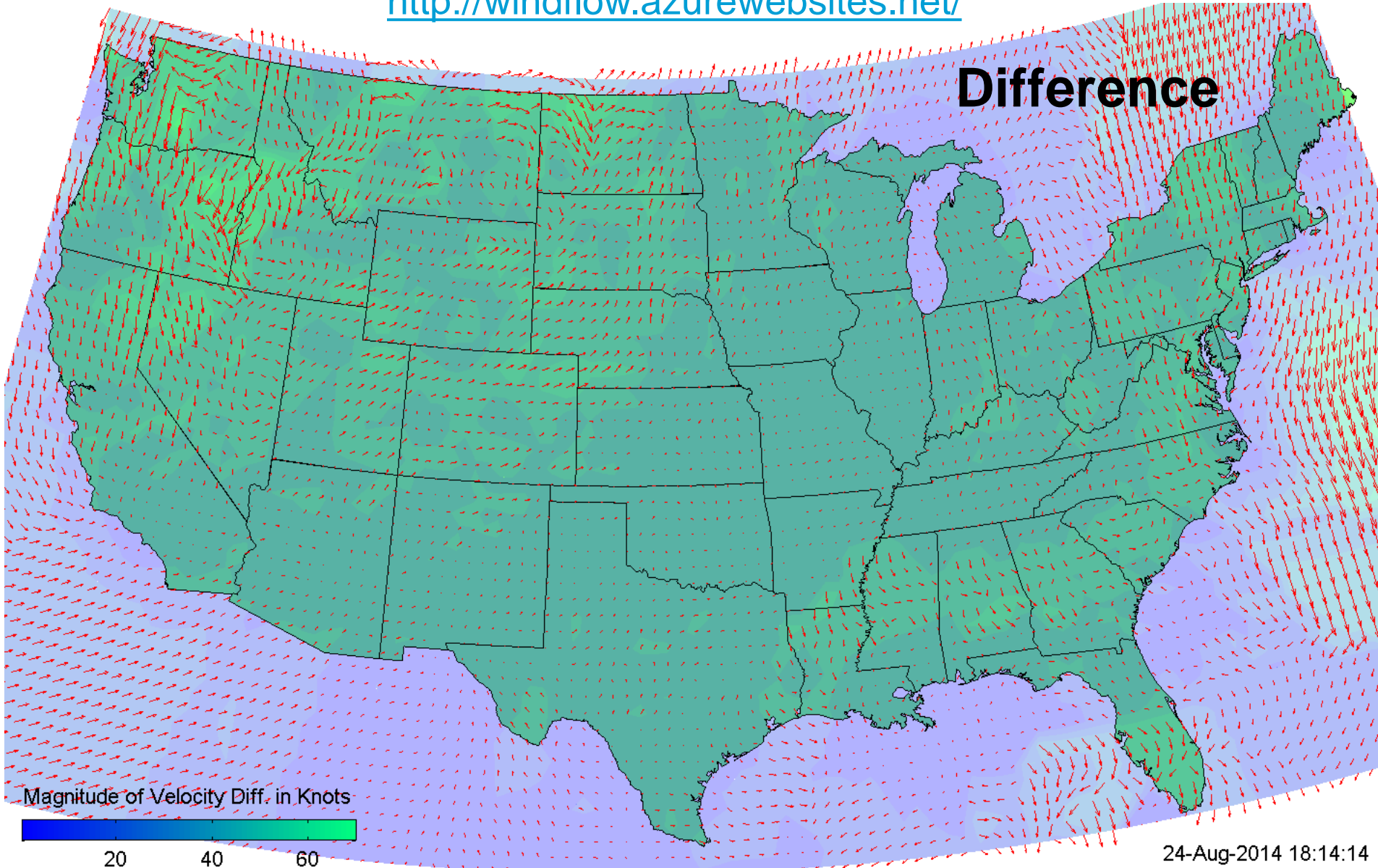
<http://windflow.azurewebsites.net/>



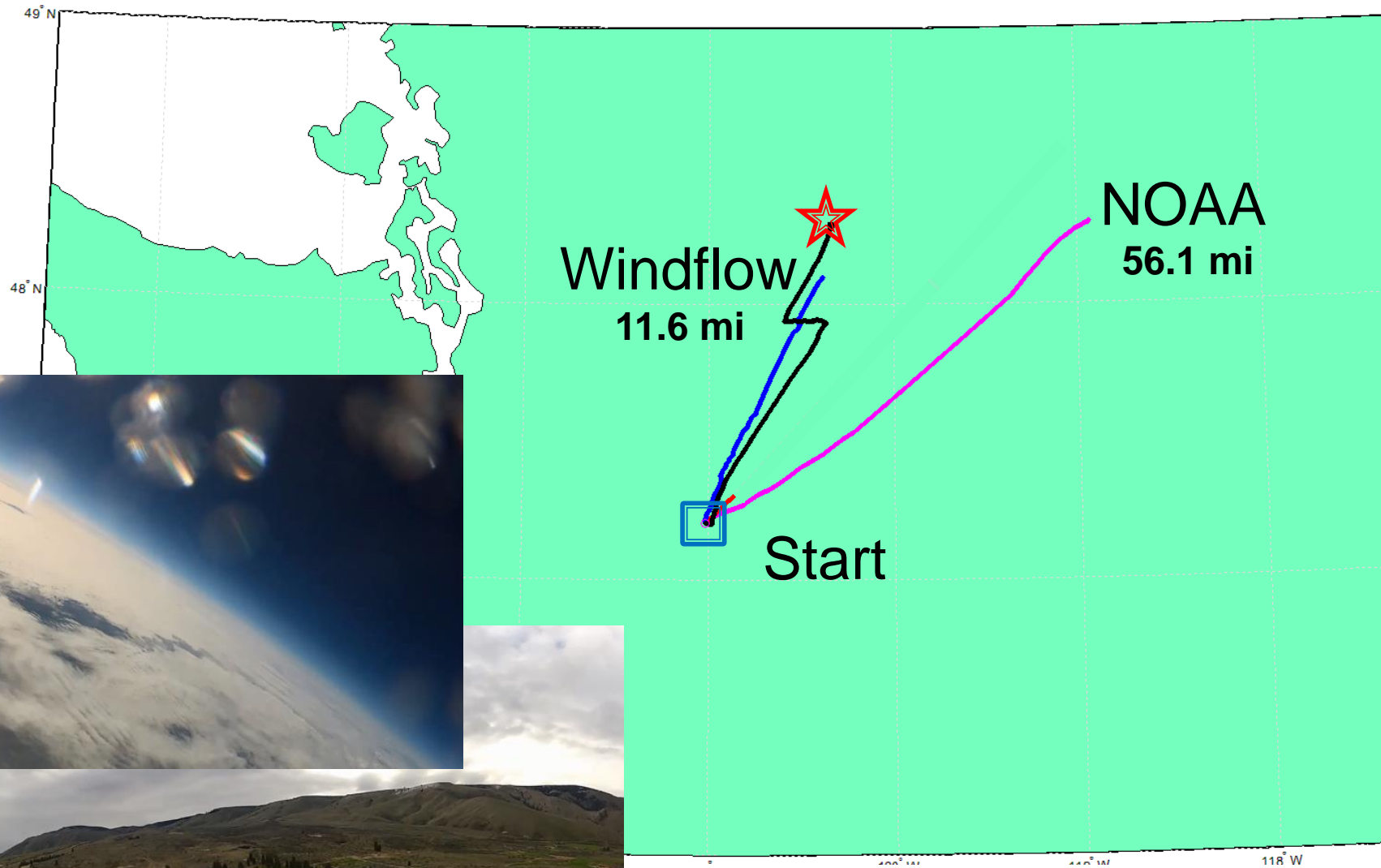
Windflow

Cloud Service:

<http://windflow.azurewebsites.net/>



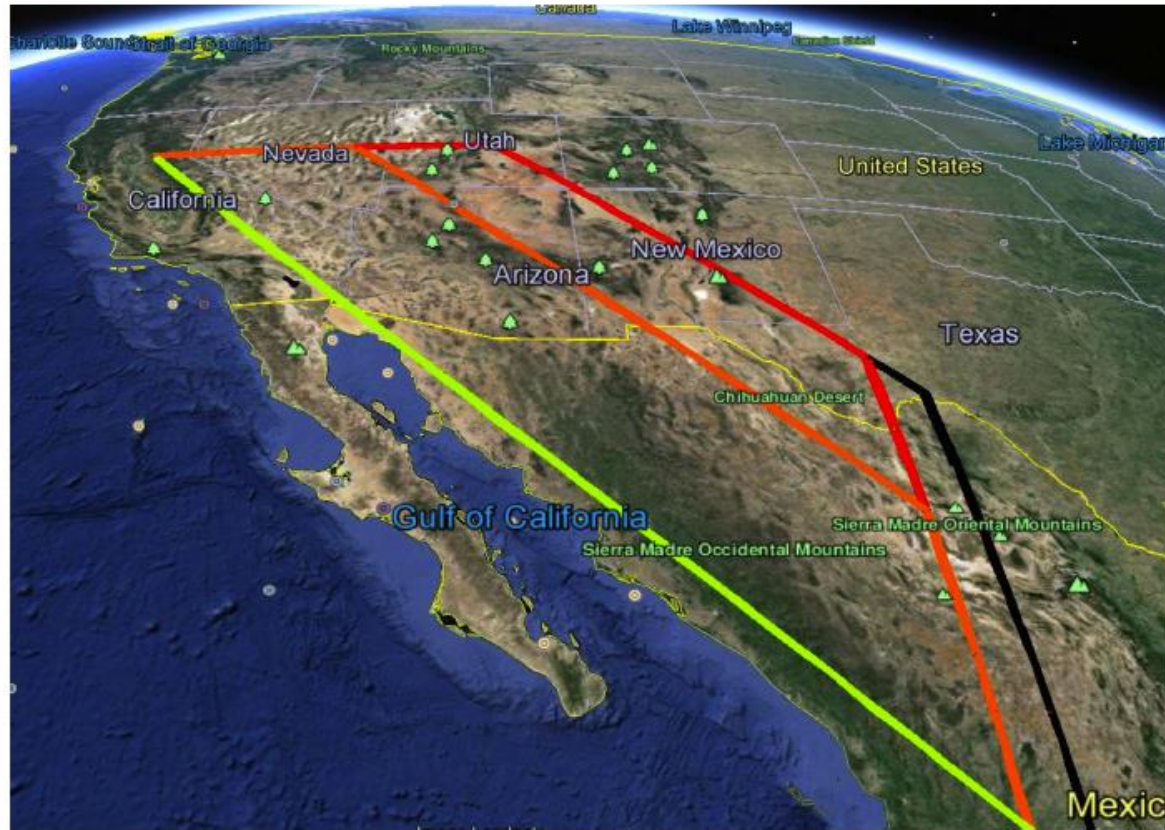
Studies



(video)



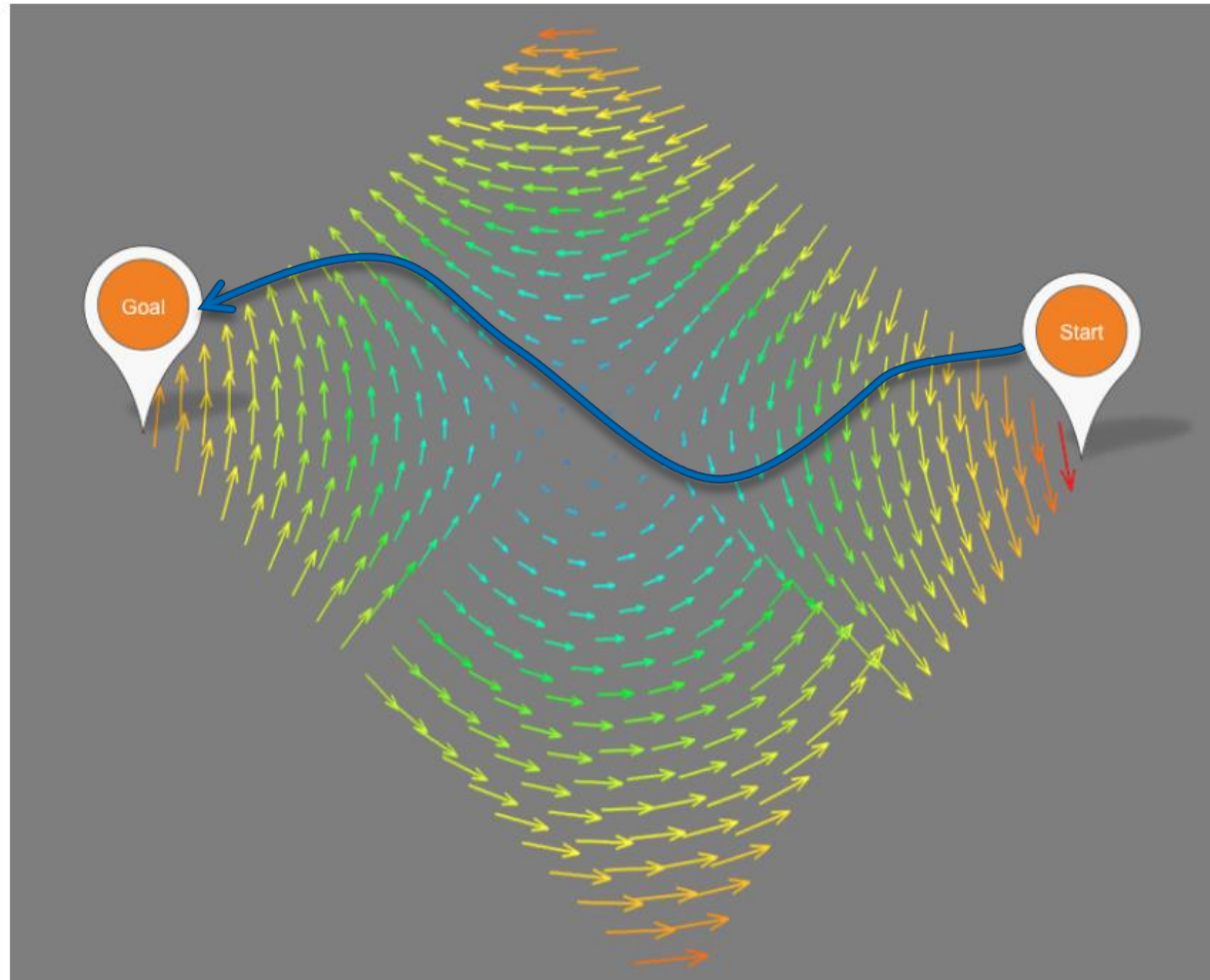
Precision Planning for Routing



Beyond great circle routes

Interleaving of sensing, prediction, planning

Precision Planning for Routing



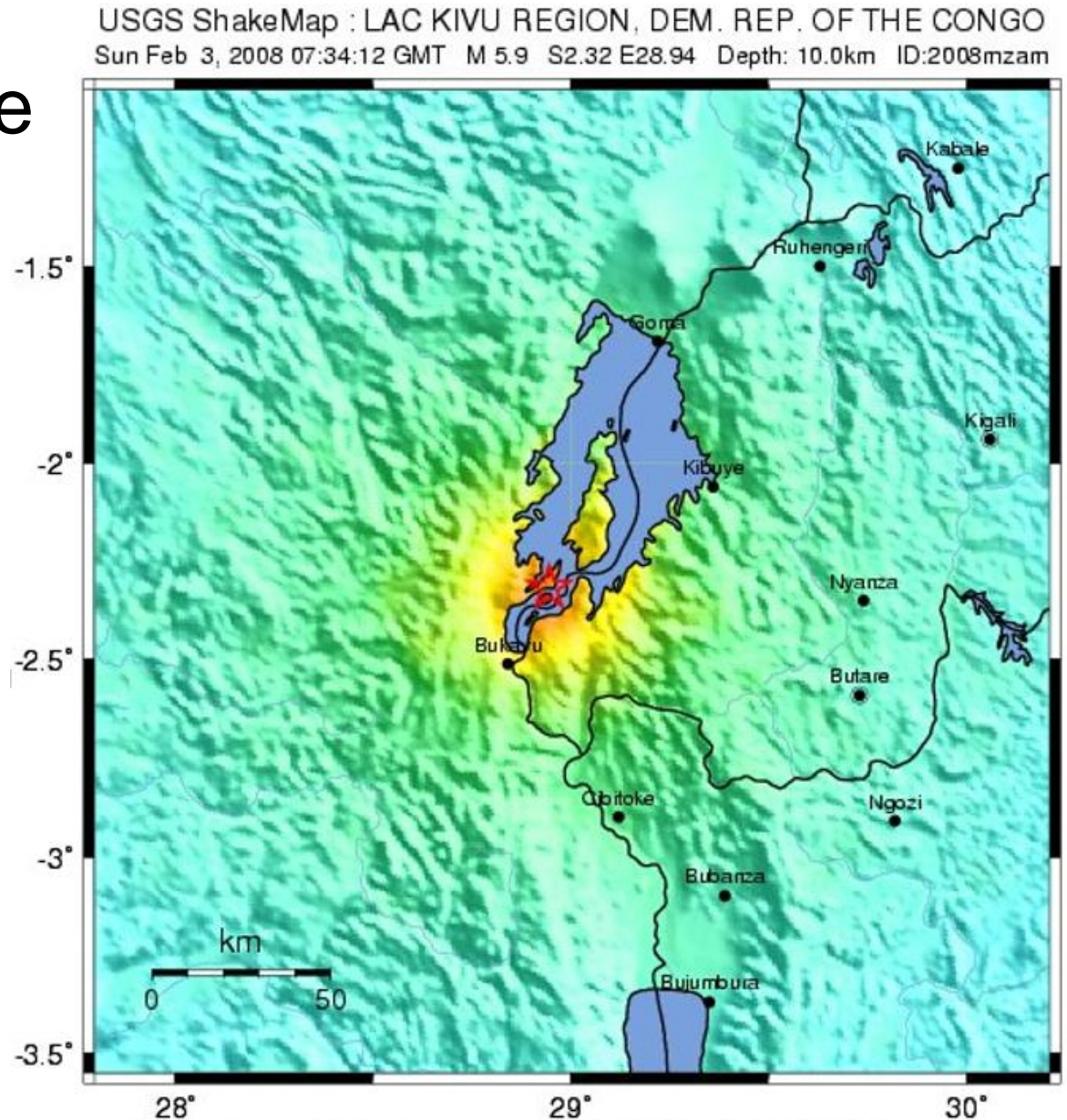
Ideal routes via richer automated planning

Example: Cell Towers as Sensors



Disruption, Reconnaissance, Recovery

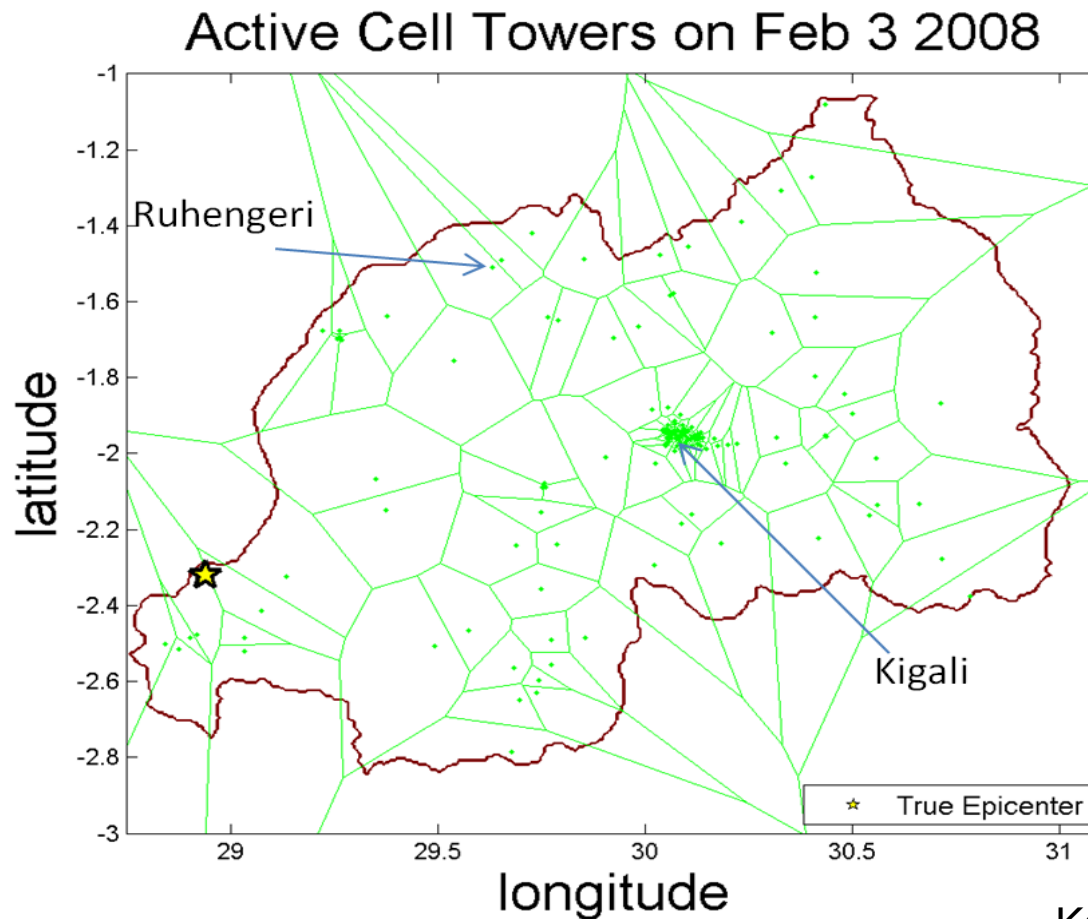
Lac Kivu quake
Feb 3, 2008
5.9



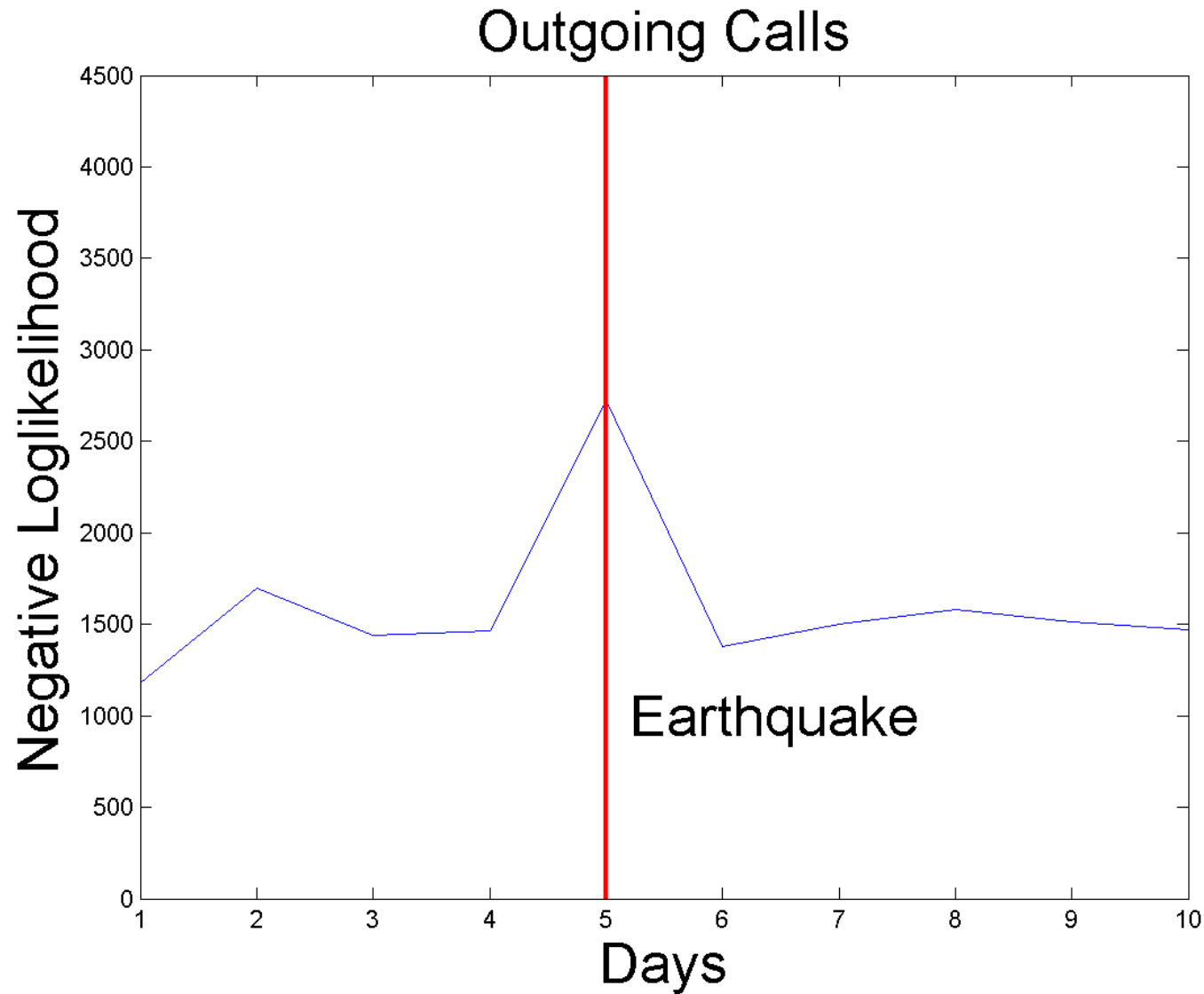
Disruption, Reconnaissance, Recovery

3 years of logs of incoming & outgoing calls

140 cell towers, 6 days: 10,527,799 calls

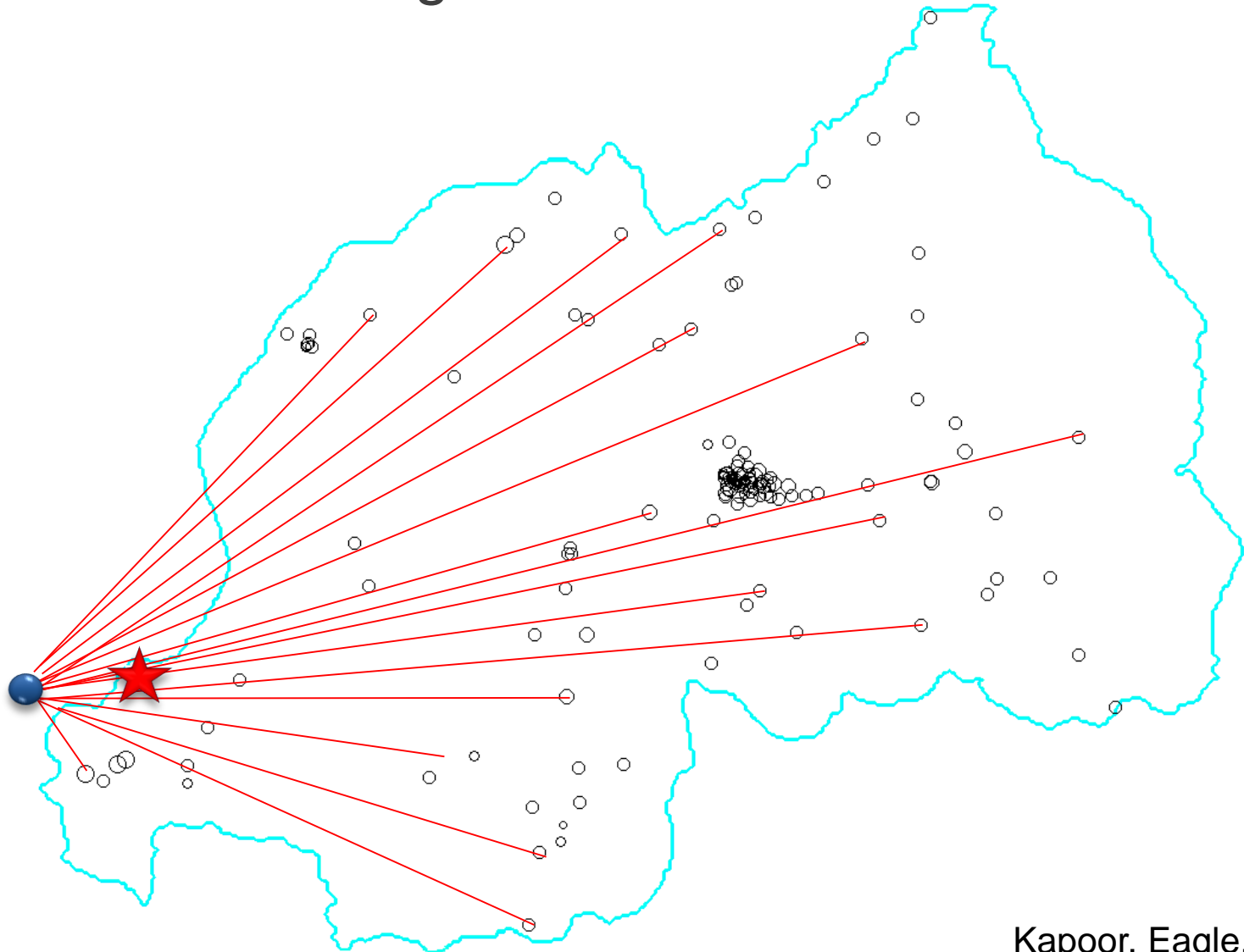


Detecting Disruption

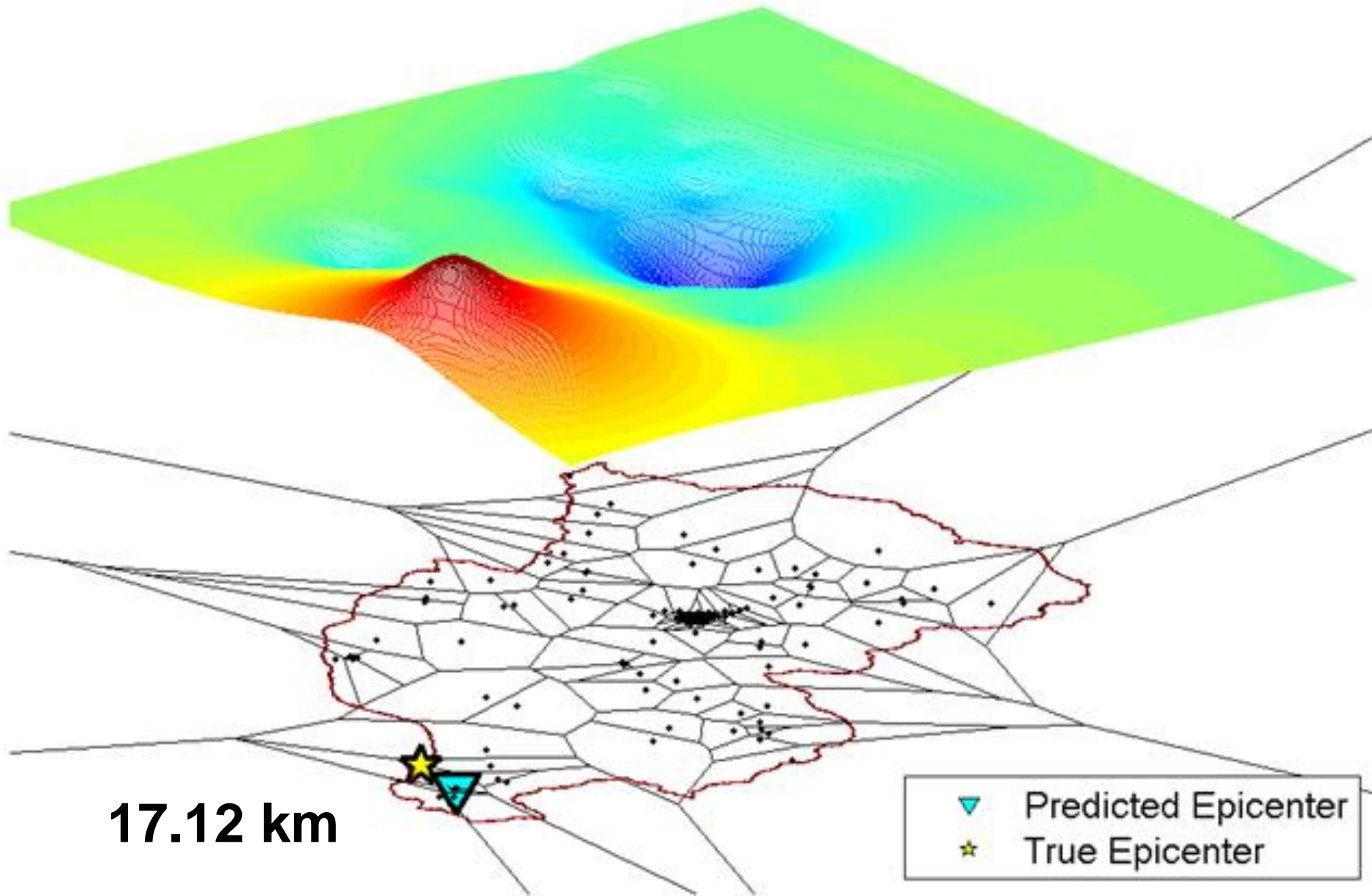


Modeling & Inference

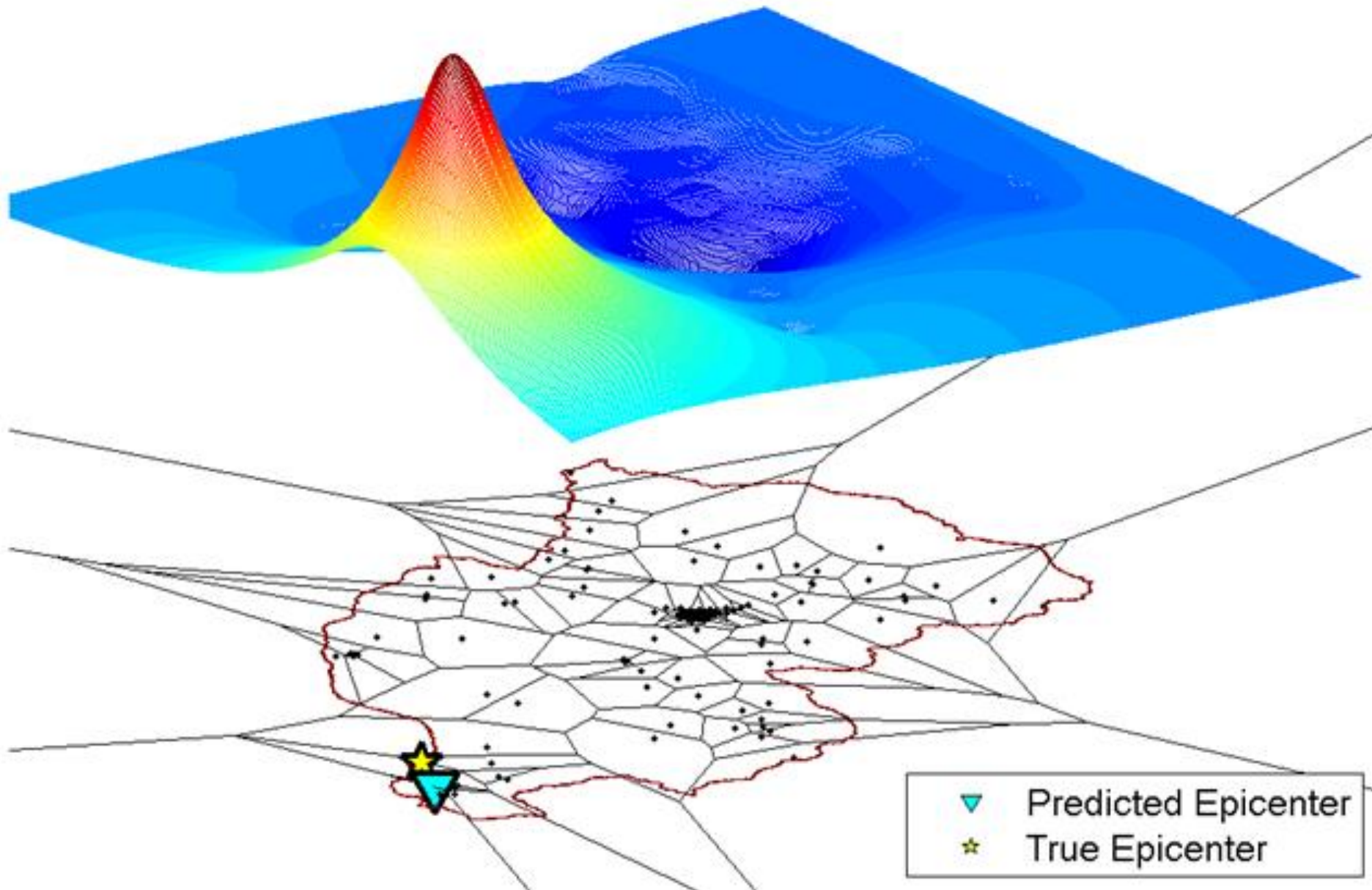
Transform existing infrastructure into sensor array



Inferring Epicenter

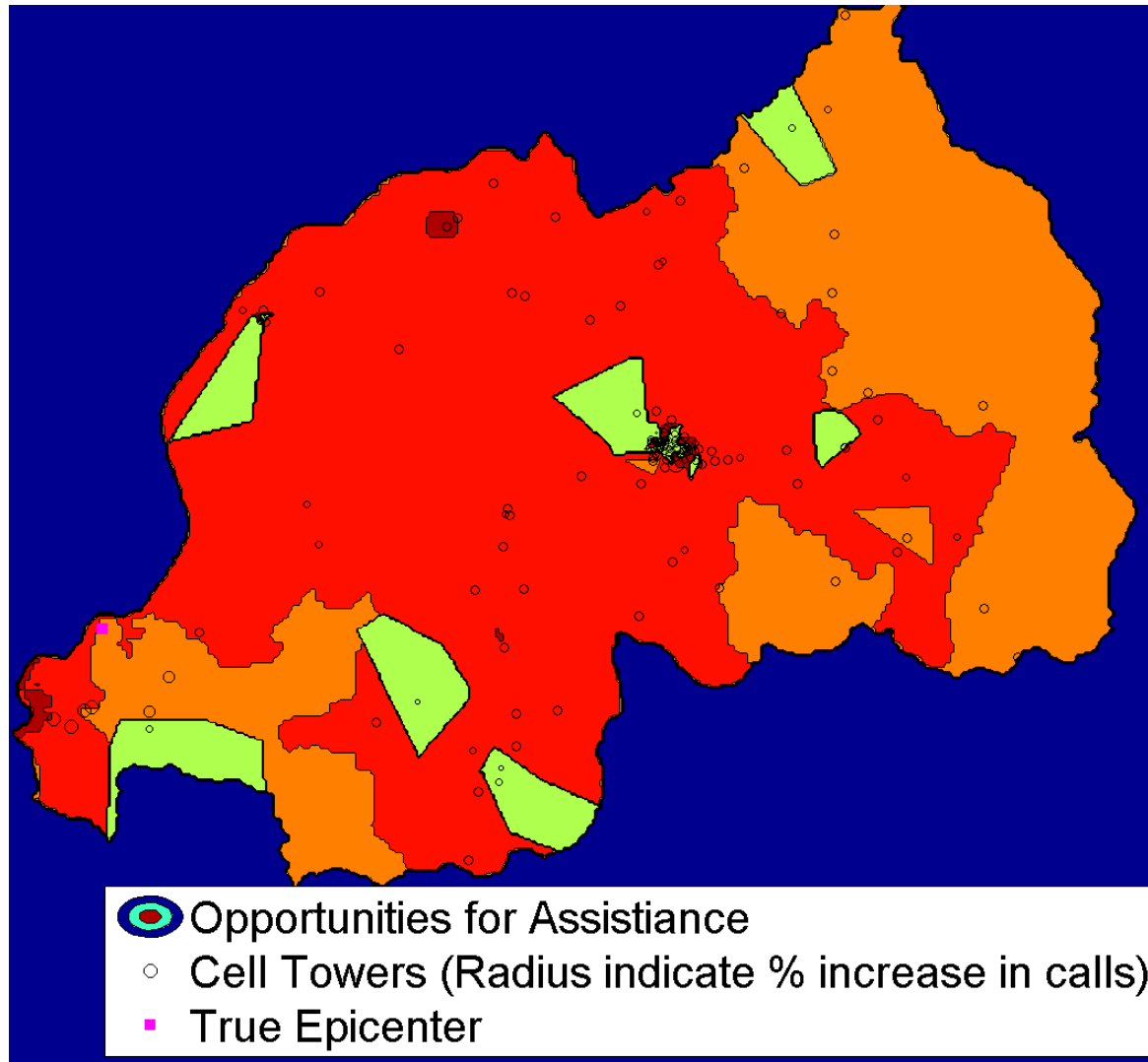


Inferring Epicenter



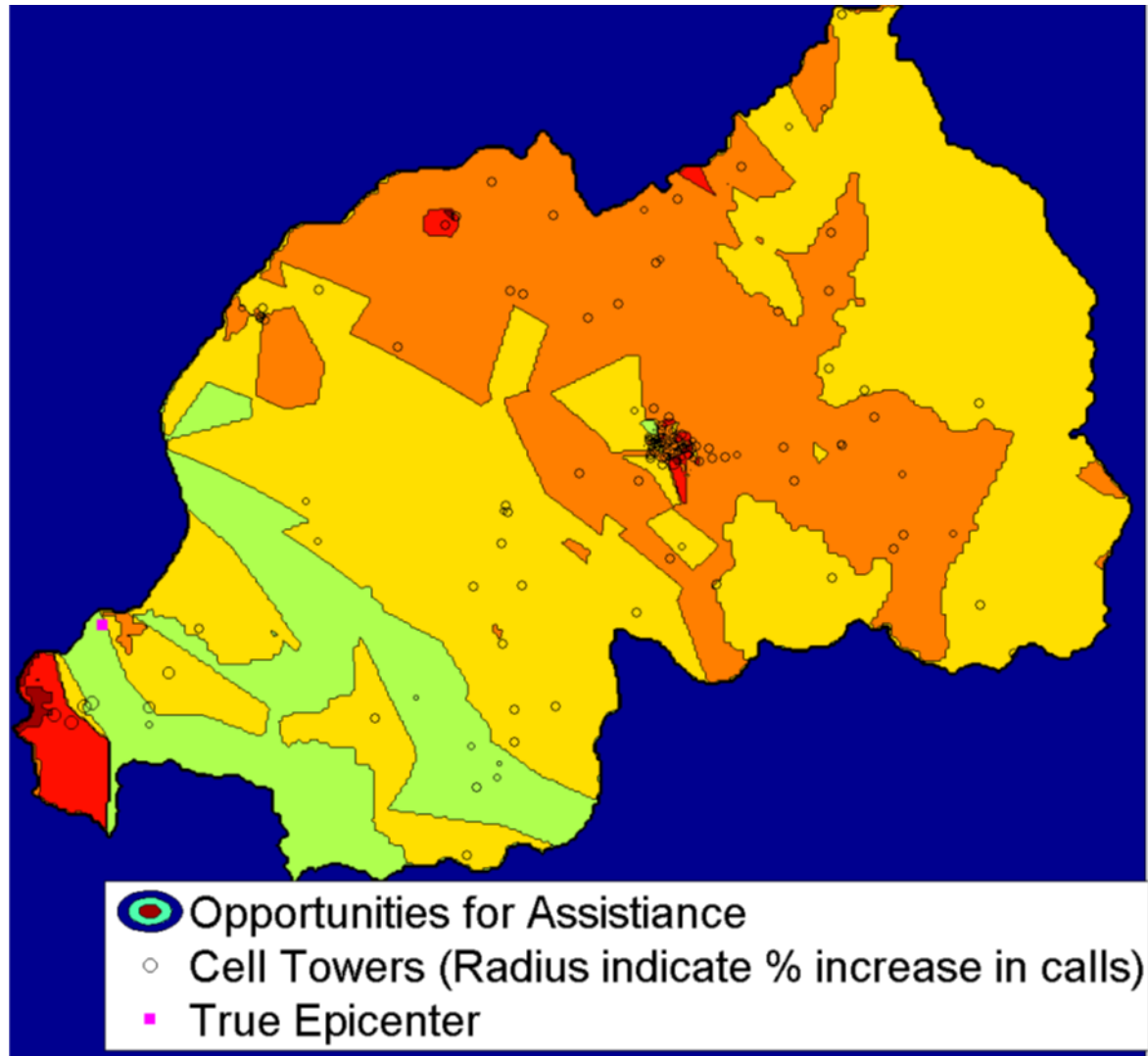
Infer Opportunities to Assist

Day 0



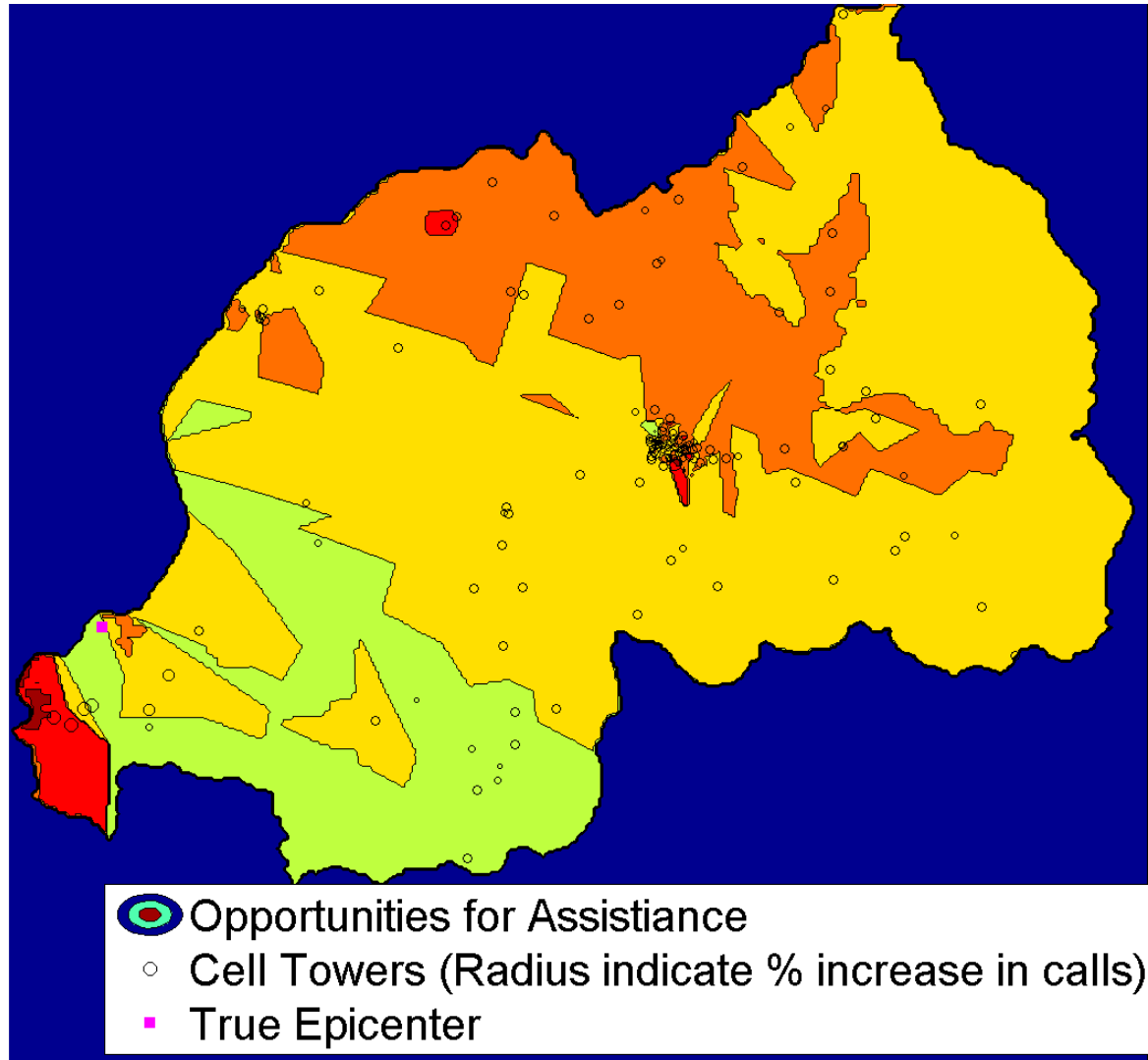
Infer Opportunities to Assist

Day 1



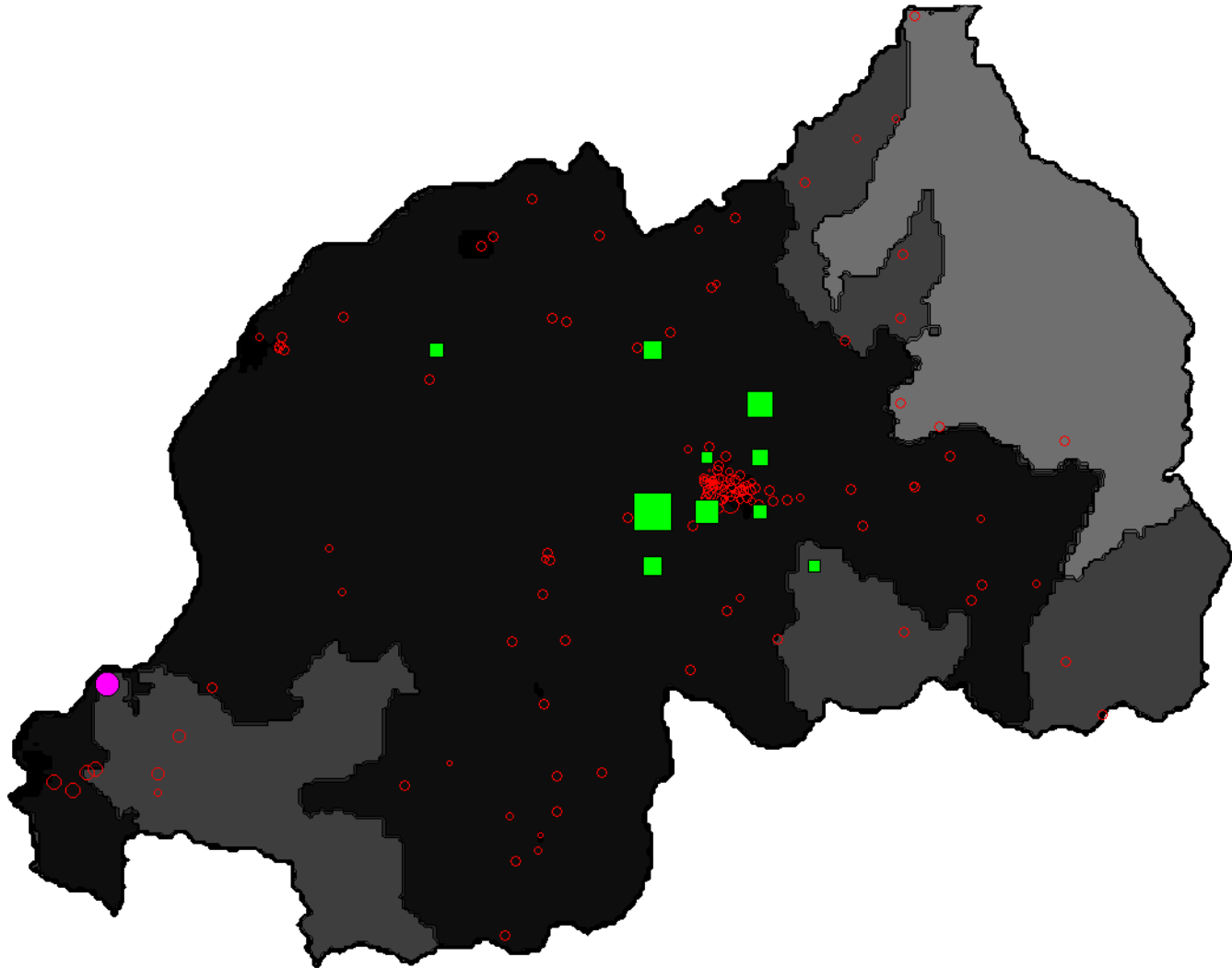
Infer Opportunities to Assist

Day 2



Compute Ideal Reconnaissance Plans

Day 2



Broad Spectrum of Opportunities

Healthcare

Education

Sciences

Governance

Transportation

Criminal justice

Agriculture

Privacy & security

Sustainability

Emergency management

Rich benefits for people and society

Aspirations & Goals



(video)

Mitchell, He, Tran, Koul, Shaikh, et al. (2016)



View from Stratosphere: Windflow test balloon