2018 SKILLS BUILDING PROGRAM

BIG DATA, ARTIFICIAL INTELLIGENCE AND DECISION SCIENCE IN HEALTH AND NUTRITION

WORLD BANK GROUP
Health, Nutrition & Population

Uses of AI in Health:
A Taxonomy, Use Cases, and Gaps

Edin Hamzic, Data Scientist, Symphony

In partnership with

datasciencedojo — data science for everyone
Burnet Institute — Medical Research. Practical Action.
UCL
techemergence
symphony
Wadhwani AI — AI FOR SOCIAL GOOD
THE UNIVERSITY OF SYDNEY
saMRC — advancinglife
Machine Intelligence Institute of Africa — *Transform Africa through Machine Intelligence*
UNIVERSITY OF COPENHAGEN
iDSI — Better decisions. Better health.
FPD
GHCC — Global Health Cost Consortium
UNDP
BILL & MELINDA GATES foundation

HEALTH SYSTEMS

ARTIFICIAL INTELLIGENCE

TAXONOMY AND USE-CASES OF AI IN HEALTH SYSTEMS

QUESTIONS?

HEALTH SYSTEMS

ARTIFICIAL INTELLIGENCE

TAXONOMY AND USE-CASES OF AI IN HEALTH SYSTEMS

Knowledge Reasoning

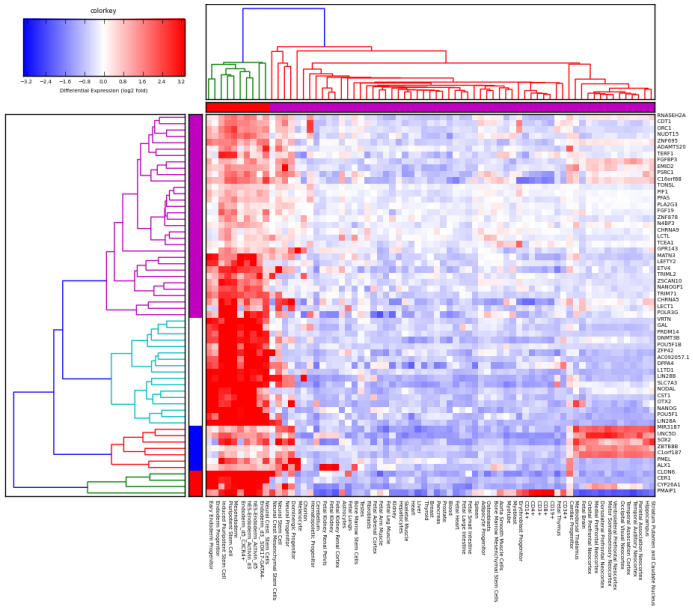
Planning

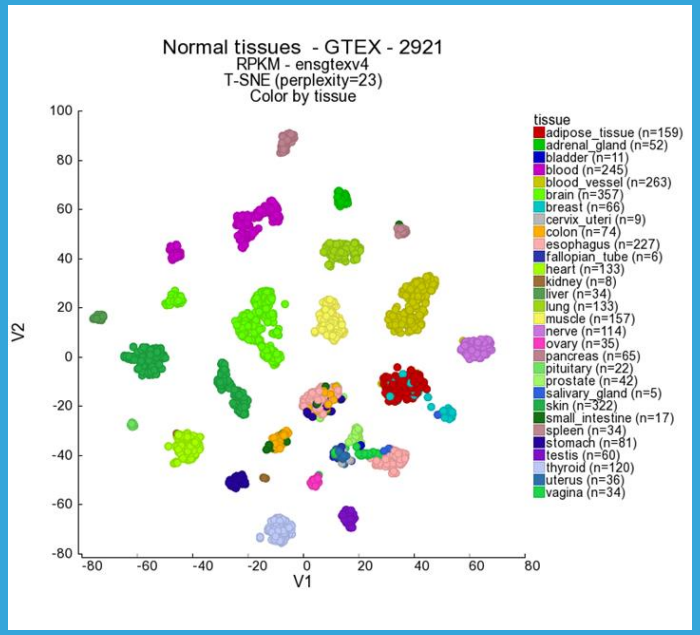
Machine Learning

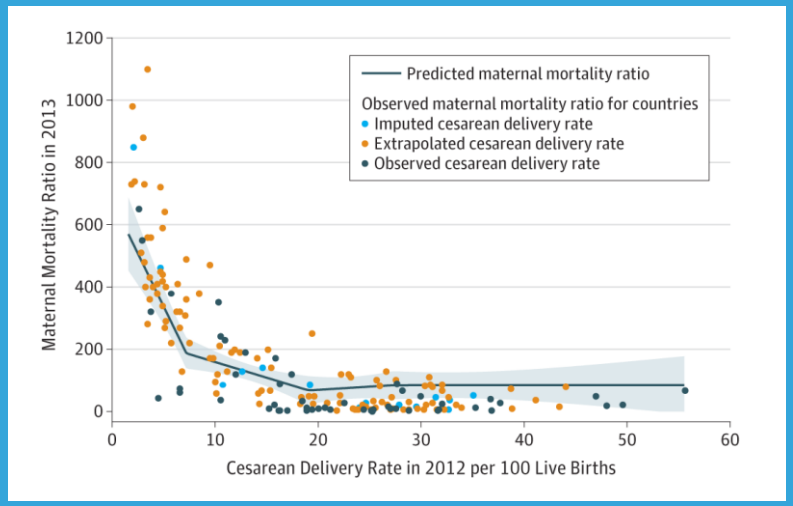
Natural Language Processing

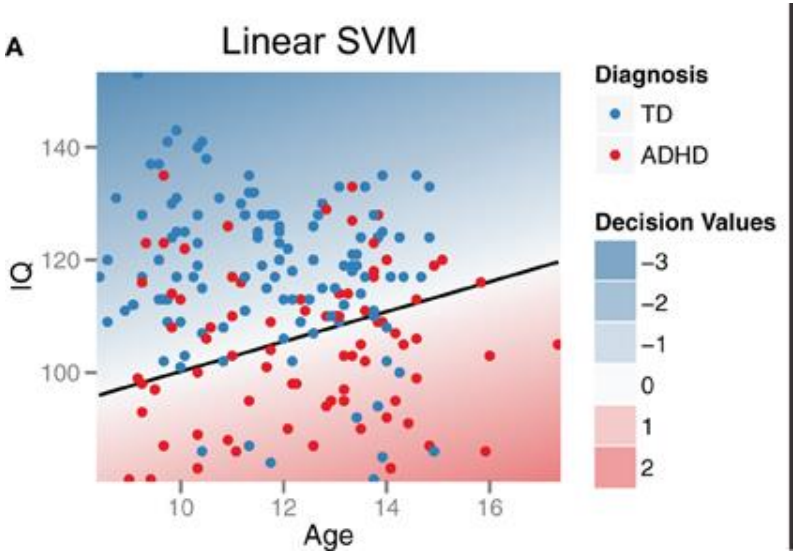
Computer Vision

Robotics

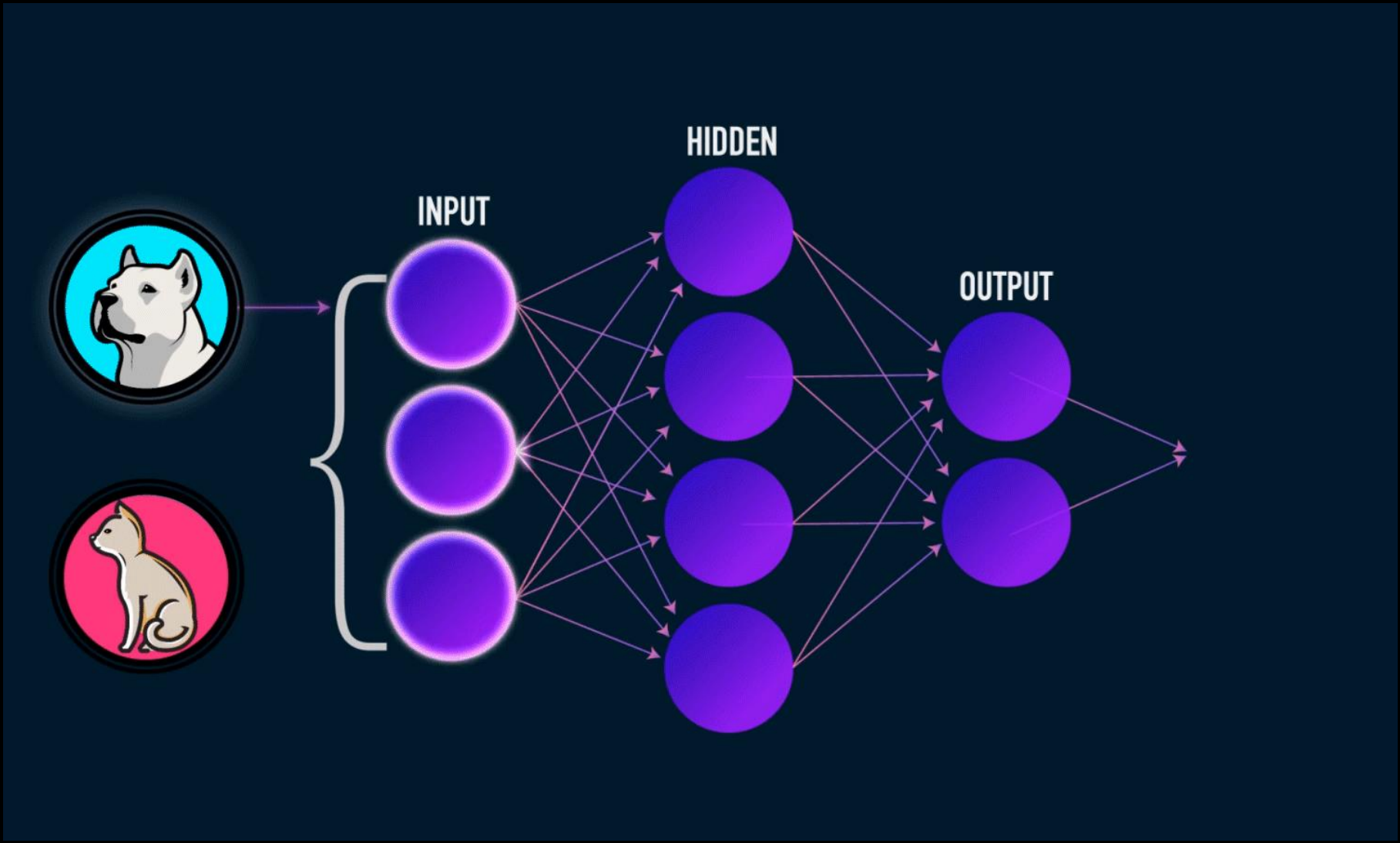

colorkey
Differential Expression (log2 fold)


Normal tissues - GTEX - 2921
RPKM - ensgtexv4
T-SNE (perplexity=23)
Color by tissue
V1
V2
tissue
adipose_tissue (n=159)
adrenal_gland (n=52)
bladder (n=11)
blood (n=245)
blood_vessel (n=263)
brain (n=357)
breast (n=66)
cervix_uteri (n=9)
colon (n=74)
esophagus (n=227)
fallopian_tube (n=6)
heart (n=133)
kidney (n=8)
liver (n=34)
lung (n=133)
muscle (n=157)
nerve (n=114)
ovary (n=35)
pancreas (n=65)
pituitary (n=22)
prostate (n=42)
salivary_gland (n=5)
skin (n=322)
small_intestine (n=17)
spleen (n=34)
stomach (n=81)
testis (n=60)
thyroid (n=120)
uterus (n=36)
vagina (n=34)


Predicted maternal mortality ratio
Observed maternal mortality ratio for countries
Imputed cesarean delivery rate
Extrapolated cesarean delivery rate
Observed cesarean delivery rate
Maternal Mortality Ratio in 2013
Cesarean Delivery Rate in 2012 per 100 Live Births

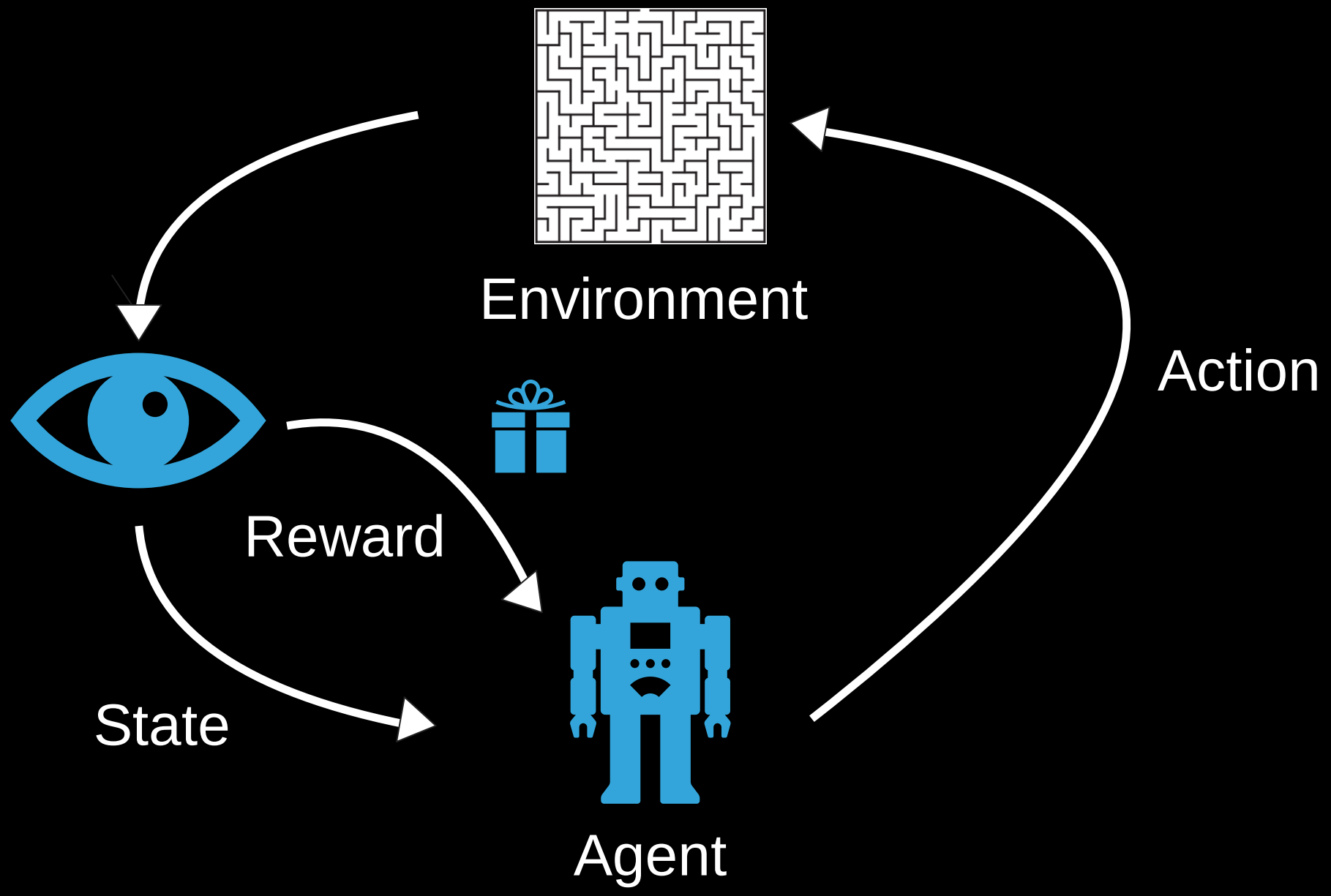

A
Linear SVM
Diagnosis
TD
ADHD
Decision Values
IQ
Age

NEURAL NETWORKS & DEEP LEARNING



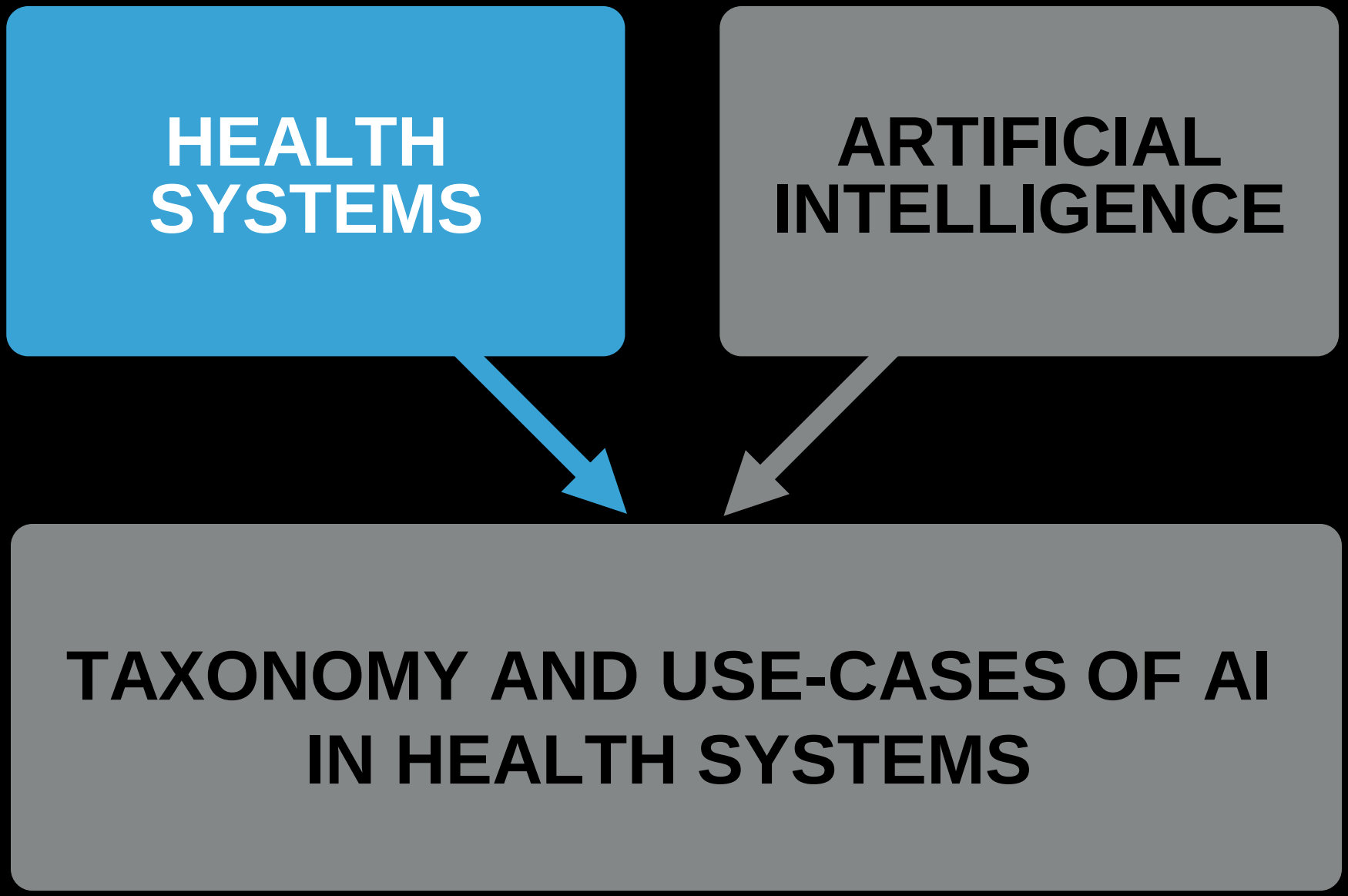
Neural networks image recognition

REINFORCEMENT LEARNING



WHAT AI IS TYPICALLY USED FOR

CONTROL	OPTIMIZATION	PERCEPTION	PREDICTION	AUGMENTED DECISIONS
• Robotics • Chat-bots • Monitoring • Virtual Assistants	• Supply - demand • Staff Scheduling • Financing • Location	• Opinion • Education • Imaging • Lab Results • Fraud	• Treatment Plans • Disease Outbreaks • Drug Demand • Cost	• Diagnosis • Financing • Service Quality


HEALTH SYSTEMS
ARTIFICIAL INTELLIGENCE
TAXONOMY AND USE-CASES OF AI IN HEALTH SYSTEMS

WHO's HEALTH SYSTEM BUILDING BLOCKS

- Service Delivery
- Health Workforce
- Health Information System
- Access to Essential Medicine
- Financing
- Leadership and Governance

→

- Improved Health
- Responsiveness
- Financial Risk Protection
- Improved Efficiency

ASPECTS OF HEALTH SYSTEMS MANAGED BY MOH

A: CLINICAL MANAGEMENT	B: HEALTH SYSTEM PERFORMANCE	C: POPULATION HEALTH

ASPECTS OF HEALTH SYSTEMS MANAGED BY MOH

A: CLINICAL MANAGEMENT	B: HEALTH SYSTEM PERFORMANCE	C: POPULATION HEALTH
	WHO Health System Building Blocks	
1. Diagnosis & admission	1. Health service delivery, integration and quality improvement	1. Epidemiology and populations at risk
2. Treatment choices	2. Health workforce	2. Health education and awareness
3. Treatment adherence	3. Health information systems	3. Environmental and 'One' health approaches
	4. Health technology choices	4. Survey and research practices
	5. Health financing and prioritisation	
	6. Supervision, leadership and governance	

HEALTH SYSTEMS

ARTIFICIAL INTELLIGENCE

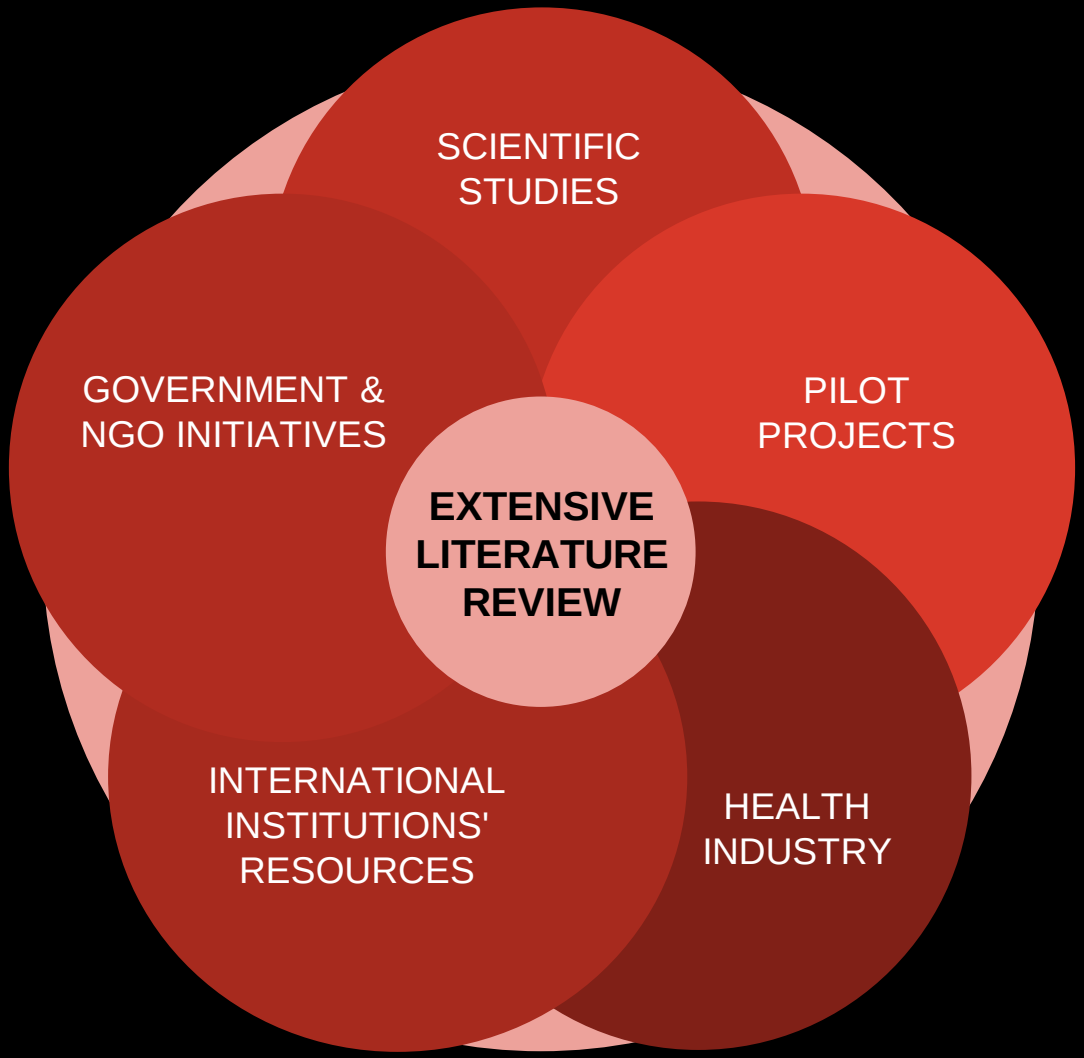
TAXONOMY AND USE-CASES OF AI IN HEALTH SYSTEMS

TAXONOMY FOR AI USE CASES IN HEALTH: ASPECTS OF HEALTH SYSTEMS MANAGED BY MOH

B: CLINICAL MANAGEMENT	B: HEALTH SYSTEM PERFORMANCE	C: POPULATION HEALTH
	WHO Health System Building Blocks	
1. Diagnosis & admission	1. Health service delivery	1. Epidemiology and populations at risk
2. Treatment choices	2. Health workforce	2. Health education and awareness
3. Treatment adherence	3. Health information systems	3. Environmental and 'One' health approaches
	4. Health technology choices	4. Survey and research practices
	5. Health financing and prioritisation	
	6. Leadership and governance	

	CONTROL	OPTIMIZATION	PERCEPTION	PREDICTION	AUGMENTED DECISIONS
CLINICAL MANAGEMENT					
HEALTH SYSTEMS					
POPULATION HEALTH					

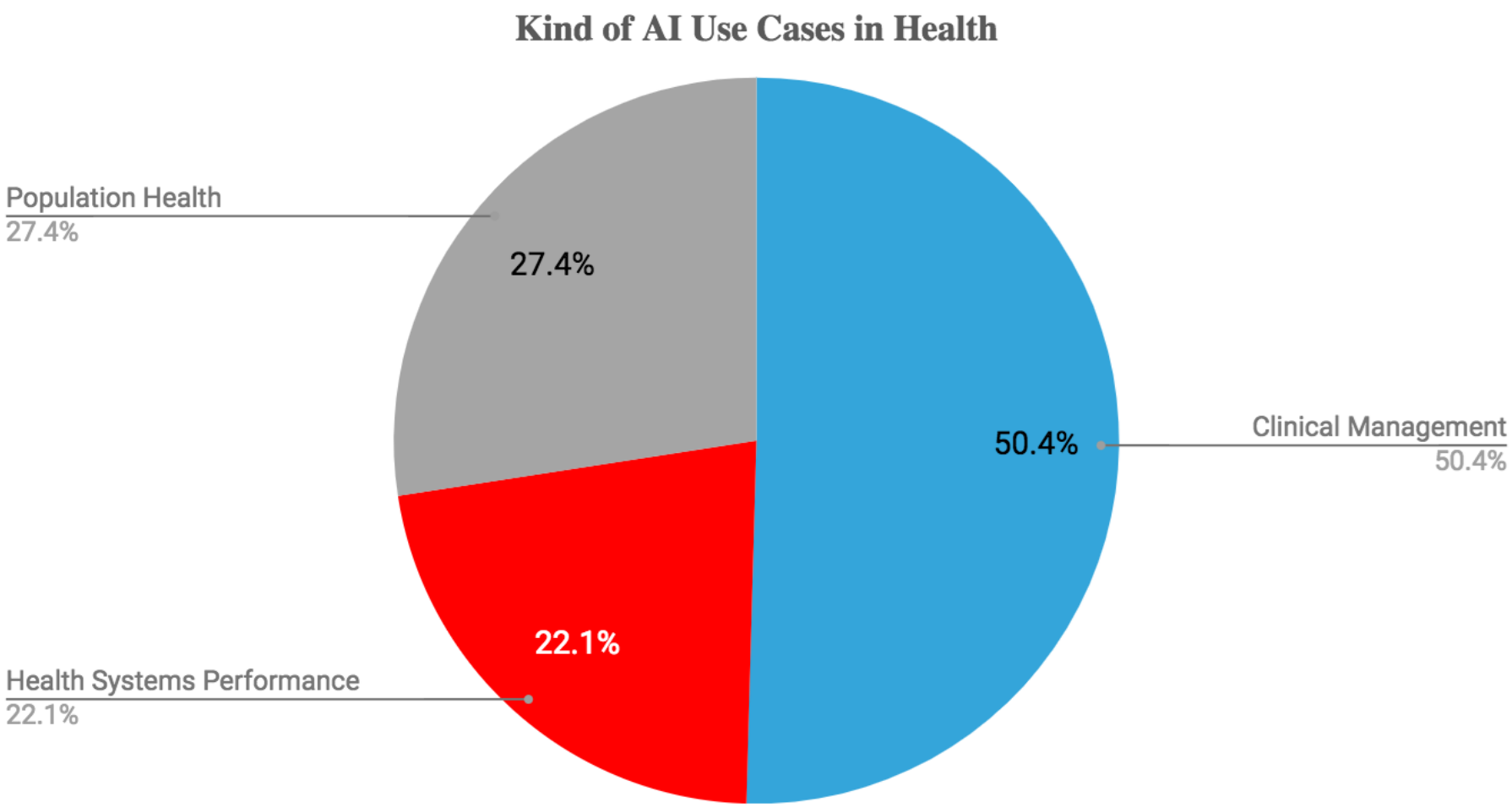
METHODOLOGY FOR COLLECTION OF AI USE CASES



TAXONOMY DEMO

TAXONOMY MATRIX

AI Use Cases in Health					
By Jelena Nadj (Symphony IS), Edin Hamzic (Symphony IS) and Marelize Gorgens (World Bank)					
Use-case	**AI in Health Systems**	**Health System Subcategory**	**AI Application**	**Data Source**	**ML Algorithm**
Reading and interpreting imaging data (such as x-rays, ct scans, etc.) for faster and better diagnostics.	Clinical Management (client/patient level)	Diagnosis	Augmented Decisions	Device	Image recognition, Neural Netwoks Image Analysis
Virtual assistants to remind patients of prescription refills and pickups, and even recommend preventive health screenings.	Clinical Management (client/patient level)	Treatment adherence	Control	Device	Virtual Assistants
Inference on unstructured free-text medical documents such as doctor's notes and treatment protocols in order to determine which treatments best suit a patient's medical history.	Clinical Management (client/patient level)	Treatment decision and administration	Augmented Decisions	Database	Recommender systems
Comparative effectiveness and cost-effectiveness analysis of clinical outcomes data to inform medical decision making and policy on appropriate coverage of tests and medications.	Health Systems Performance	Financing	Augmented Decisions	Database	Comparative effectiveness analysis
Natural language processing to enable medical/healthcare companies operationalize their structured and unstructured medical data, images and texts.	Health Systems Performance	Health information system	Perception	Database & Device	NLP
Ai-powered virtual healthcare assistant designed to improve clinical workflow efficiency for healthcare professionals.	Health Systems Performance	Health workforce	Control	Device	Robotics, speach recognition
Monitoring and directing patient movement as they move from system to system or department to department.	Health Systems Performance	Service delivery	Control	Database	Monitoring
Identification of potential hot spots of drug abuse, while measuring the impact of programs aimed at prevention and treatment.	Population Health	Behavioral health	Perception	Database	Geospatial data analysis
Investigating environment-related diseases by geospatial mapping, finding					


Kind of AI Use Cases in Health
Population Health
27.4%
27.4%
50.4%
Clinical Management
50.4%
22.1%
Health Systems Performance
22.1%

	CONTROL	OPTIMIZATION	PERCEPTION	PREDICTION	AUGMENTED DECISIONS
CLINICAL MANAGEMENT	Continuous state-space models for optimal sepsis treatment using deep reinforcement learning approach.	Analyzing supplies used by different surgeons, along with their costs to optimize supplies at the best price possible.	Analysis and classification of digitized slides for blood, fecal, bone aspirate and pap smear samples.	Mathematical models for progression of HIV infection and treatment.	Reading and interpreting imaging data (such as x-rays, CT scans, etc.) for faster and better diagnostics.
HEALTH SYSTEMS	Robots that reduce the bacterial load often associated with an increased risk of healthcare associated infections (HAI).	Optimization of the clinic staff scheduling and to reduce the wait times, manage supplies and accounting.	Monitor the real-time performance of health centres in districts where a new programme is being launched or ongoing.	Prediction of acute care use and cost of treatment for (asthmatic) patients.	Selecting candidate targets for performance-based financing in health.
POPULATION HEALTH	Detection of pathogens before they cause outbreaks — by turning mosquitoes into devices that collect data from the environment.	Analysis and clustering of malnutrition data to optimize the funding for different malnutrition types.	Evaluation of interaction between the virus and all existing drugs.	Collecting and analyzing heart rate and breathing patterns, to detect and predict diseases on a community level.	Tool to support the response to disease outbreaks by pinpointing to sources, visualizing cases per disease, per area.

QUESTIONS?

A: CLINICAL MANAGEMENT

DIAGNOSIS AND ADMISSION	TREATMENT CHOICES	TREATMENT ADHERENCE
		

PATIENT DIAGNOSIS / ADMISSION

Reading and interpreting imaging data (such as x-rays, ct scans, etc.) for faster and better diagnostics.

Analysis of EHR, lab, post-acute care, claims and biometric data to provide advanced insights into disease/condition progression.

Continuous evaluations of biomedical parameters in diabetes, cancers, and cardiovascular diseases using data from wearables.

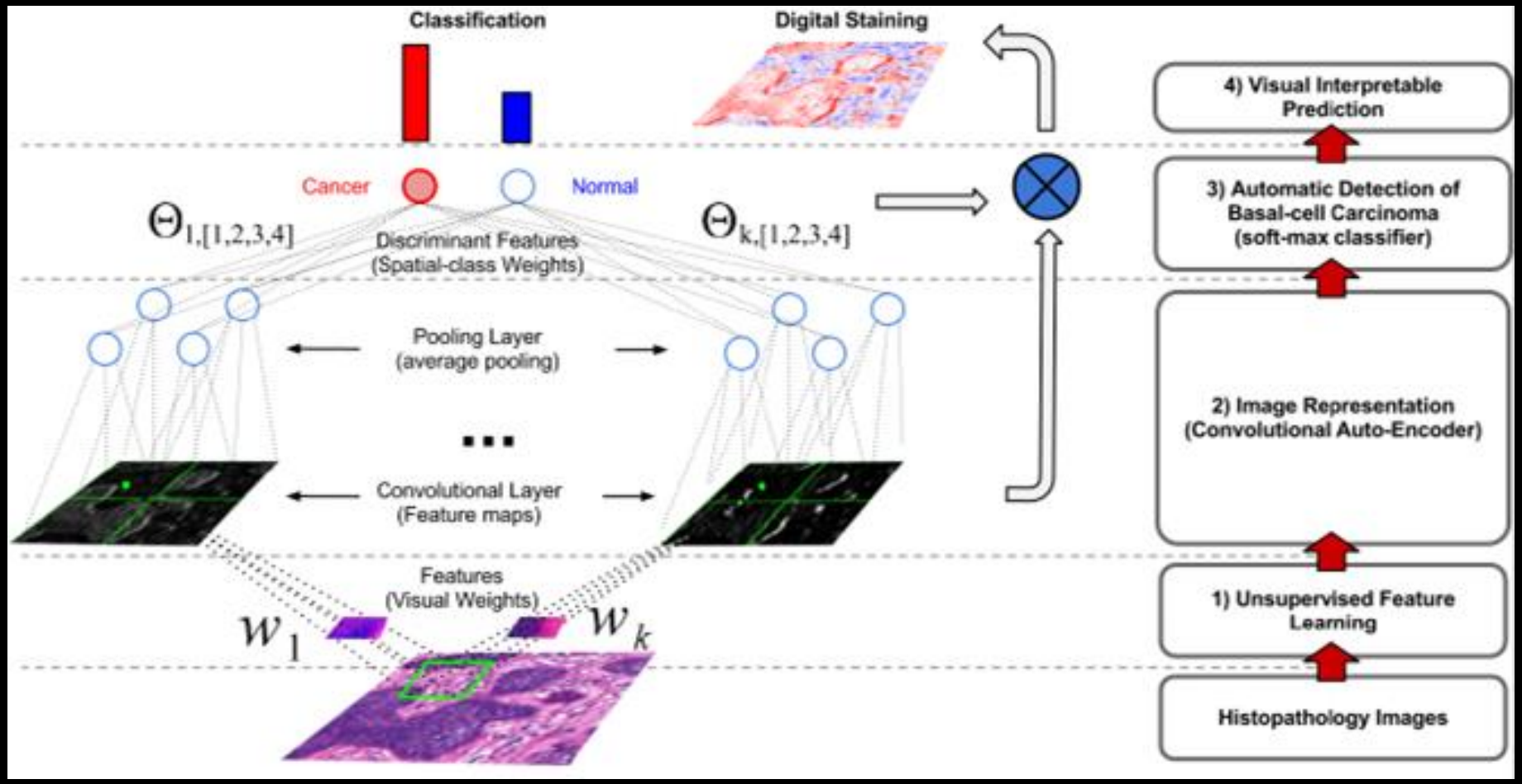
Modeling progression-free survival in breast cancer with recurrent neural networks.

Method for automatically rating ataxia from video data.

Stable selection of interpretable rules for preterm birth prediction.

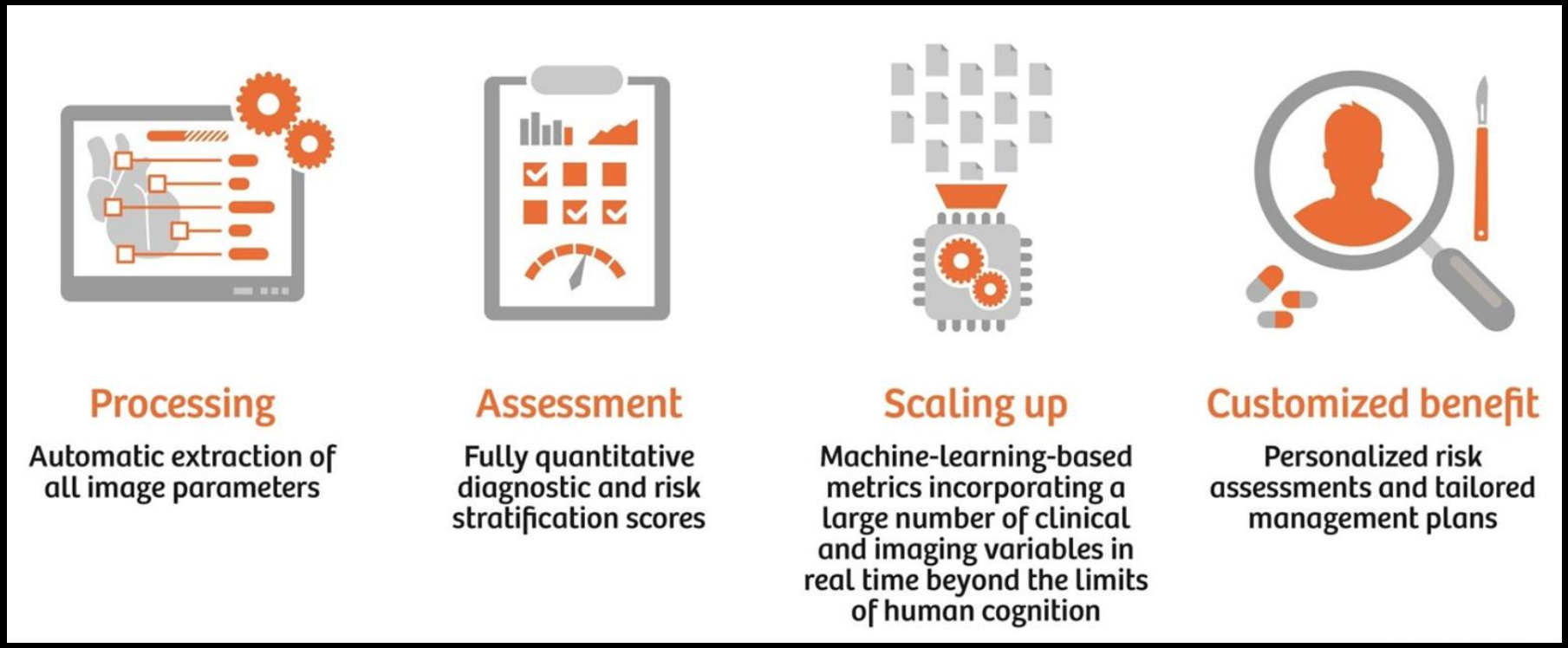
Predicting malnutrition from body images.

Temporal prediction of multiple sclerosis evolution from patient-centered outcomes.



Neural Network Classification of Digitalized Slides

Source: https://link.springer.com/chapter/10.1007/978-3-642-40763-5_50



Cardiac imaging machine learning pipeline

TREATMENT CHOICES

Inference on unstructured free-text medical documents such as doctor's notes and treatment protocols in order to determine which treatments best suit a patient's medical history.

Automatic generation of radiation therapy plans.

Predicting health deterioration and implementing change protocols to avoid it.

Continuous state-space models for optimal sepsis treatment using deep reinforcement learning approach.

Analyzing which supplies were used by different surgeons for a single procedure, along with their costs to identify the appropriate supplies for the correct patient at the best price possible.

Mathematical models for progression of HIV infection and treatment.

DNA data analysis in order to compare it to the cases from the database so that oncologists can see—in real time—the different survival rates for different treatments of patients similar to their own.

TREATMENT ADHERENCE

Virtual assistants to remind patients of prescription refills and pickups, and even recommend preventive health screenings.

In-home health monitoring and health information access to detect changes in mood or behavior and alert caregivers.

Sending SMS messages to the patient at times when the data about their mobility indicates that they may need medical attention, or tracking response time to notifications.

Checking prescriptions against similar cases in the database and informing the doctor when the prescription contains any deviations from the typical treatment plan.

Monitoring patients with long-term conditions and help them adhere to medication intake.

Patient-centered mobile platform for multiple sclerosis research and care.

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B: HEALTH SYSTEM PERFORMANCE

- Service Delivery
- Health Workforce
- Health Information System
- Access to Essential Medicine
- Financing
- Leadership and Governance

→

- Improved Health
- Responsiveness
- Financial Risk Protection
- Improved Efficiency

HEALTH SERVICE DELIVERY, INTEGRATION AND QUALITY IMPROVEMENT

Analysis of factors as the average length of patient stays; the average cost of patients per day; how many nurses are currently on staff; how many outpatient surgeries were performed in the last week etc.

Towards vision-based smart hospitals: a system for tracking and monitoring hand hygiene compliance

Determining the optimal location of new health facilities.

Robots that reduce the bacterial load often associated with an increased risk of healthcare associated infections (HAI).

Care coordination using practice based evidences.

Monitoring and directing patient movement as they move from system to system or department to department.

Pre-operation nutrition optimization

Source: https://twitter.com/hashtag/periopnutrition

HEALTH WORKFORCE

Virtual reality and AI combination to train medical workers.

AI-powered virtual healthcare assistant designed to improve clinical workflow efficiency for healthcare professionals.

Optimization of the clinic staff scheduling and to reduce the wait times, manage supplies and accounting.

Surgeon technical skill assessment using computer vision based analysis.

Directory of rare disease specialists: identifying experts from publication history.

HEALTH INFORMATION SYSTEMS

NLP to enable medical/healthcare companies to operationalize their structured and unstructured medical data, images and texts.

Supplement existing security systems by identification and reacting to actionable threats, by responding to (and learn from) potential data leak patterns.

HEALTH TECHNOLOGY AND ESSENTIAL MEDICINES

Evaluation of interaction between the virus and all existing drugs.

Drug discovery and drug repurposing.

Prediction of adverse drug reactions.

Managing drug shortages by drug demand forecasting.

HEALTH FINANCING

Comparative effectiveness and cost-effectiveness analysis of clinical outcomes data to inform medical decision making and policy on appropriate coverage of tests and medications.

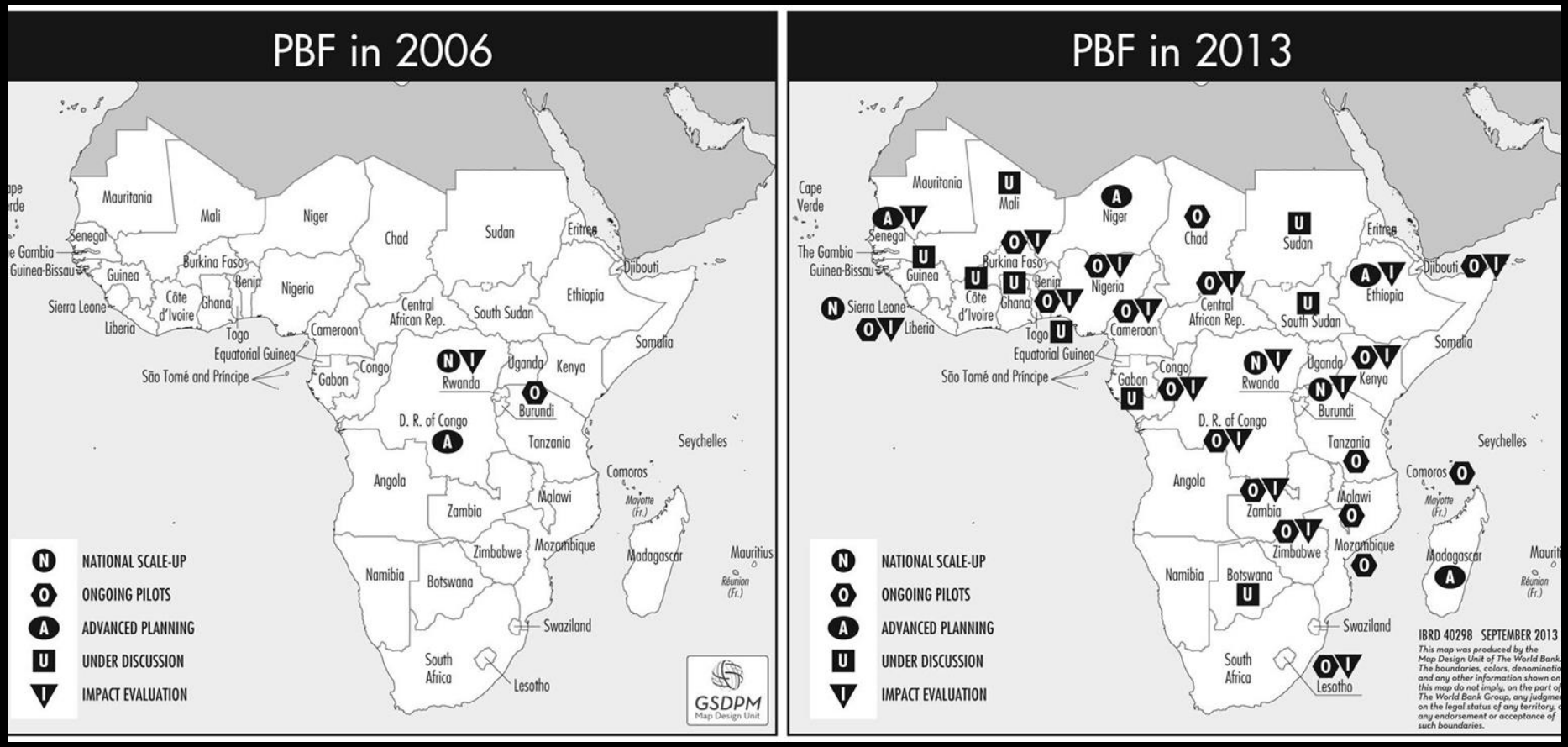
Analysis of combined government and clinical databases for proof of the best, most cost-effective treatments for hundreds of conditions.

Selecting candidate targets for performance-based financing in health.

Optimization of the purchase and distribution of pharmaceutical, medical-surgical, and clinical engineering supply chain.

Identification of deterioration or sensing the development of complications to improve outcomes and reduce costs related to hospital-acquired condition penalties.

Prediction of acute care use and cost of treatment for (asthmatic) patients.



Africa Performance-based Financing Map

Source: https://www.itg.be/E/Article/toolkit-for-performance-based-health-reform

LEADERSHIP AND GOVERNANCE

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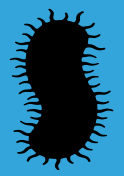
C: POPULATION HEALTH

Epidemiology and populations at risk



Health education and awareness

Environmental and ‘One’ health approaches

Survey and research practices

EPIDEMIOLOGY AND POPULATIONS AT RISK

Tool to support the response to disease outbreaks by pinpointing to sources, visualizing cases per disease, per area.

Detection of pathogens before they cause outbreaks by turning mosquitoes into devices that collect data from animals in the environment.

Identification of potential hot spots of drug abuse, while measuring the impact of programs aimed at prevention and treatment.

Mining social media data for early detection of outbreaks and assessing population needs during emergencies.

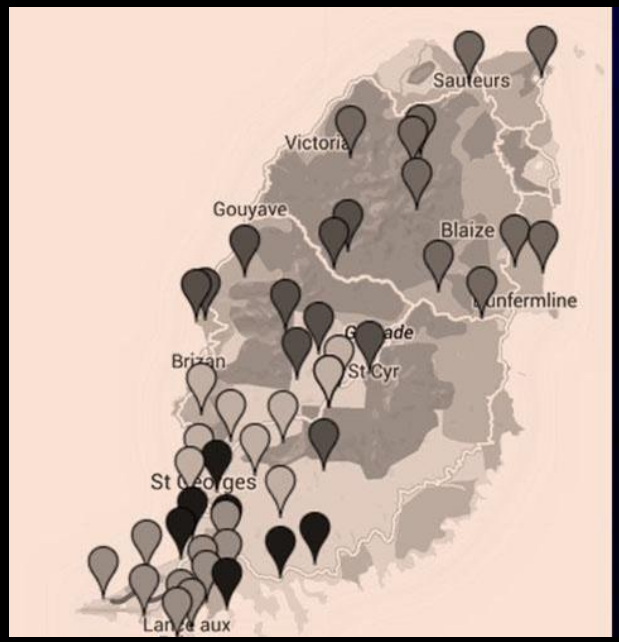
Spatial modeling of diseases.

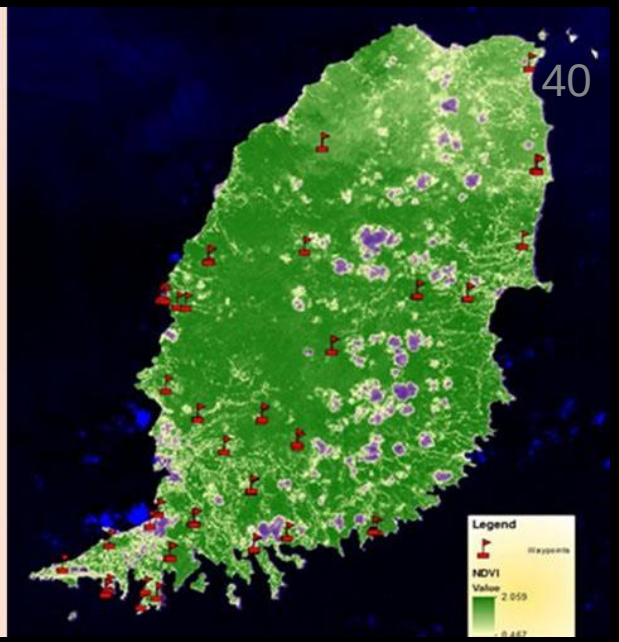
Detection of key factors for maternal mortality on different levels of geo-spatial granularity.

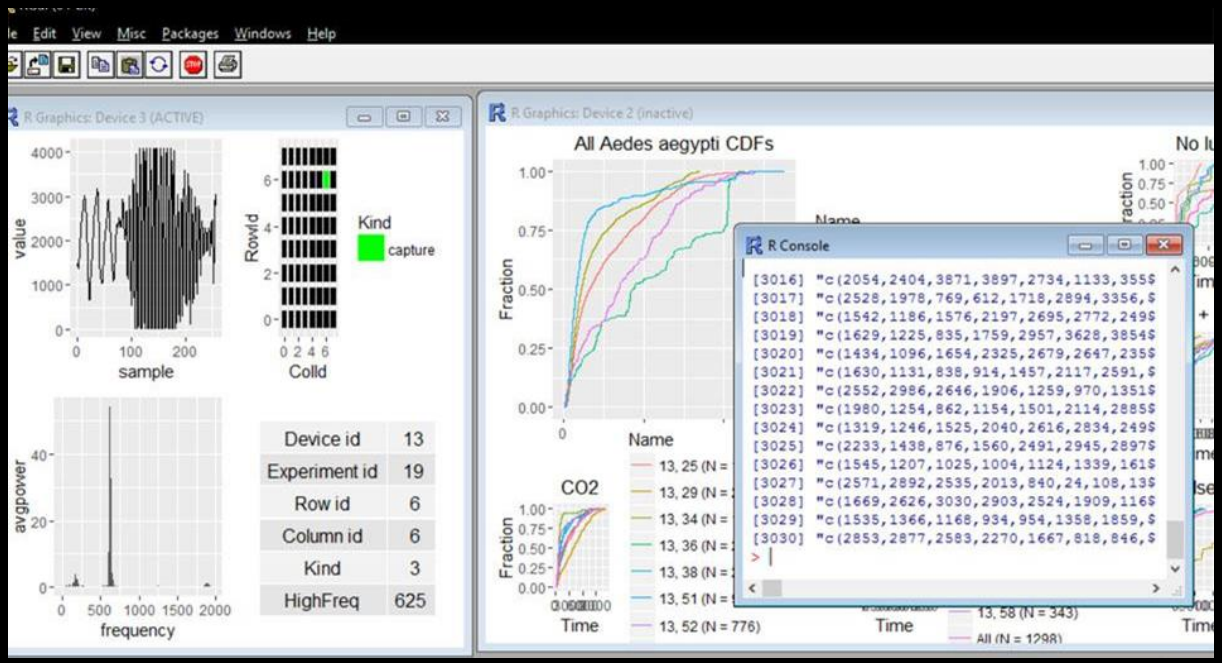
Clustering of mosquito movement patterns when in contact with bed nets for a better understanding of their behavior in these conditions.

PROJECT PREMONITION

Grenada: Satellite view shows most places appear as possible hotspots (green)







Data analytics using the Microsoft Cloud and R for understanding behavior

Source: https://www.microsoft.com/en-us/research/project/project-premonition/

HEALTH EDUCATION AND AWARENESS

Using behavior science to determine and help people change their habits, improve their health and reduce their risk of chronic disease.

Quantifying mental health from social media using learned user embeddings.

Using instagram photos and tweets to extract predictive markers of depression.

Extracting correlations from survey data to understand what to focus the education campaigns on in different countries to raise awareness on the importance of good nutrition, dietary diversity, and good hygiene for kids, mothers, and farmers.

Food consumption, nutrient intake, and dietary patterns extraction.

Tracking and analysis of online conversations related to immunisation on social media and mainstream media on a national level.

Analysis of social media in order to provide insight on the baseline of public engagement, and explore ways to monitor a new (sanitation) education campaign.

ENVIRONMENTAL AND ONE HEALTH APPROACHES

Monitoring health status on the community level to identify community health problems.

Analysis of air quality data from polluted areas and attempting to match it with healthcare datasets for insights into respiratory disease.

Investigating environment-related diseases by geospatial mapping, finding correlations between people on similar locations.

Quantifying food and nutrient intakes and assessing the adequacy of micronutrient intakes among young children and their mothers.

Extracting statistics and mapping of bacterial resistance data.

Image recognition for identification and quantification of different kinds of cyanobacteria in water.

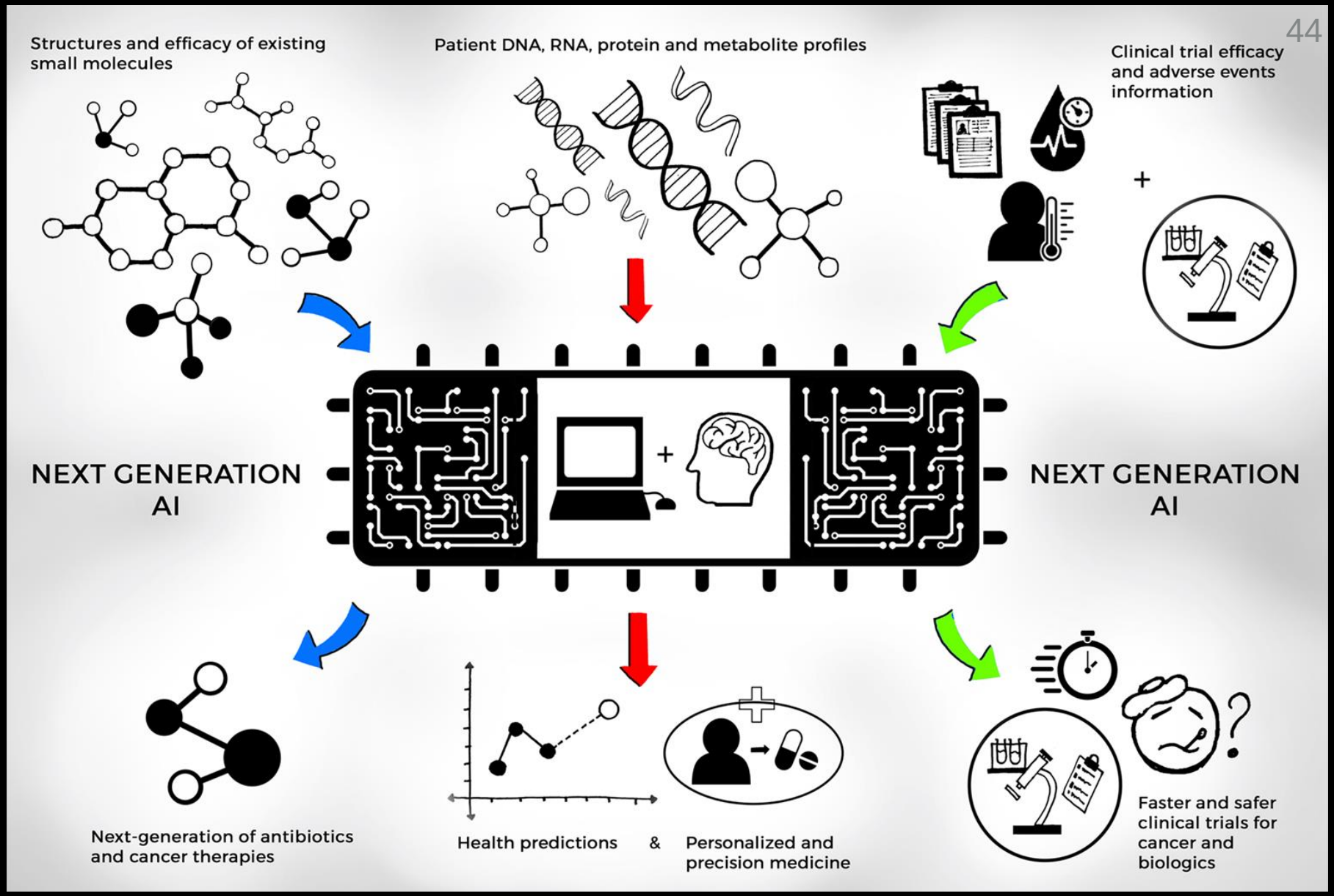
Mapping water bodies using satellite imagery.

Microbiome data analysis to understand the connection with diseases.

SURVEY AND RESEARCH PRACTICES

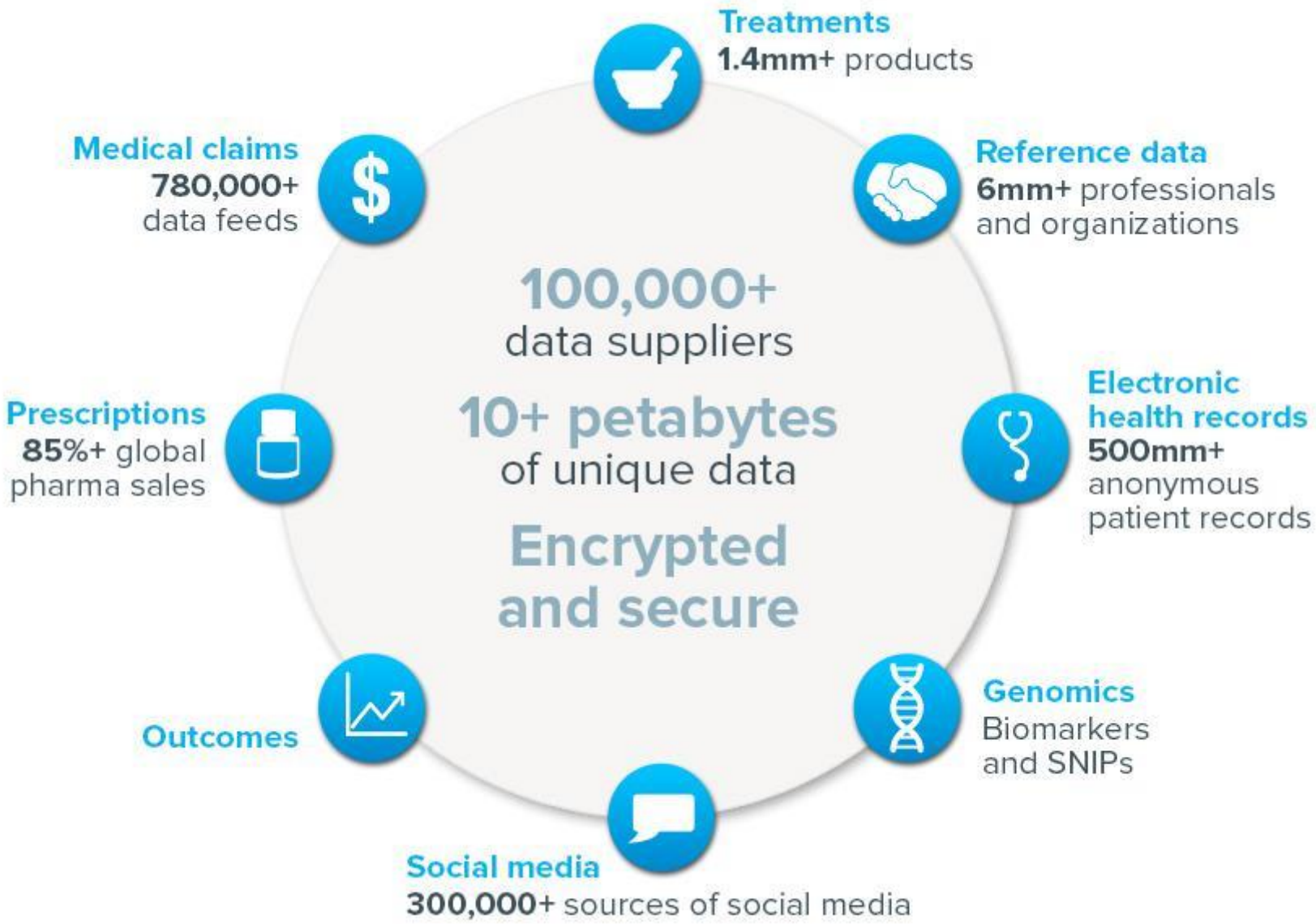
Personalized medicine discovery by DNA genome analysis.

Machine reading and comprehending research papers in order to understand the topic and speed up the research.



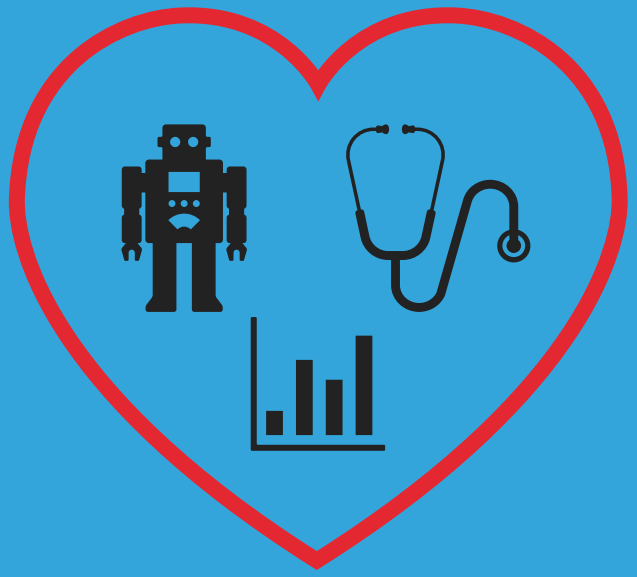
AI for Drug Discovery

Source: http://web.media.mit.edu/~pratiks/ai-for-drug-discovery-and-clinical-trials/


Treatments
1.4mm+ products
Medical claims
780,000+
data feeds
Reference data
6mm+ professionals
and organizations
100,000+
data suppliers
10+ petabytes
of unique data
Encrypted
and secure
Prescriptions
85%+ global
pharma sales
Electronic
health records
500mm+
anonymous
patient records
Outcomes
Genomics
Biomarkers
and SNIPs
Social media
300,000+ sources of social media

WHAT IS NEXT?

DATA SCIENTISTS | DECISION MAKERS | DOMAIN EXPERTS



HEALTHCARE SYSTEMS

ARTIFICIAL INTELLIGENCE

TAXONOMY AND USE-CASES OF AI IN HEALTH SYSTEMS

QUESTIONS?

THANK YOU!

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JELENA.NADJ@SYMPHONY.IS