HOW AI CAN IMPROVE
RESEARCH & CARE MODELS

HEALTHXL BIG DATA & AI WORKING GROUP

August 2017

About HealthXL

THE LEADING PLATFORM FOR COLLABORATION

The HealthXL Platform brings together key market stakeholders in digital health and empowers them to collaborate and learn from each other. HealthXL engages leading companies such as …

OVERVIEW

First, what do we mean by AI?

Defining AI and its various methods is a subject of high scrutiny and debate. At the risk of being overly simplistic, we've taken a practical approach for this report.

Further, we've focused the report on select AI applications in the following areas: life sciences, care delivery, payor & consumer.

ARTIFICIAL INTELLIGENCE

Artificial intelligence (AI) is that activity devoted to making machines intelligent.

MACHINE LEARNING

Machine learning refers to a process in which computers use algorithms to analyze large data sets in non-linear ways, identify patterns, and make predictions that can be tested and confirmed.

DEEP LEARNING

Deep learning is the application of artificial neural networks to learning tasks that contain more than one hidden layer.

Data quality is of the utmost importance

In pharma and care delivery applications in particular, understanding the context and setting of data collection can provide clarity in how the data should be utilized or interpreted.

While access to many data types is increasing, often times data remains filled with gaps and lacks a level of completeness necessary for analysis.

AI projects should ideally incorporate a prospective data collection methodology to ensure the appropriate type of data is collected from the onset.

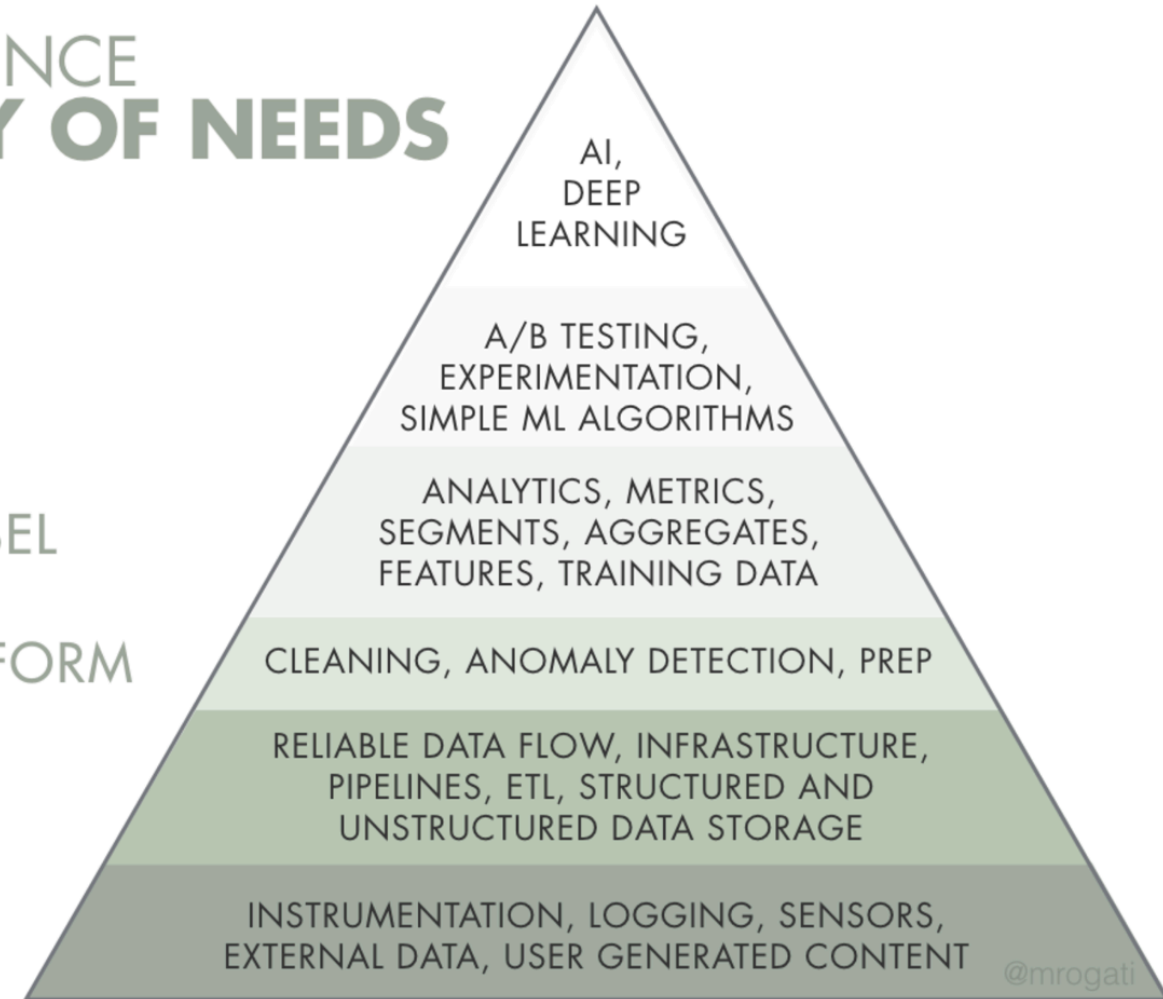THE DATA SCIENCE
HIERARCHY OF NEEDS

LEARN/OPTIMIZE

AGGREGATE/LABEL

EXPLORE/TRANSFORM

MOVE/STORE

COLLECT

AI, DEEP LEARNING

A/B TESTING, EXPERIMENTATION, SIMPLE ML ALGORITHMS

ANALYTICS, METRICS, SEGMENTS, AGGREGATES, FEATURES, TRAINING DATA

CLEANING, ANOMALY DETECTION, PREP

RELIABLE DATA FLOW, INFRASTRUCTURE, PIPELINES, ETL, STRUCTURED AND UNSTRUCTURED DATA STORAGE

INSTRUMENTATION, LOGGING, SENSORS, EXTERNAL DATA, USER GENERATED CONTENT

@mrogati

Source: The AI Hierarchy of Needs (http://bit.ly/2wI8oMW)

Why now?

> *"AI [artificial intelligence] … this is a renaissance, this is a golden age … ML [machine learning] and AI is a horizontal enabling layer, it will empower and improve every business - every government organization, every philanthropy - there is no institution in the world that cannot be improved with ML."*

- JEFF BEZOS
CEO, AMAZON

- Data access and computing power are enabling AI solutions that were unimaginable in years prior, improving both research processes and care delivery. Access to high quality, "complete" data remains a challenge however in many instances.

- Tech giants alongside innovative AI startups are diving head first into various applications - ranging from general platforms (IBM) to niche application areas (cancer imaging). There remains a desire for increased transparency into the algorithm development process.

- Early results from validation studies and initial use cases indicate AI is augmenting human intelligence instead of replacing it. As a result, individuals are becoming more efficient and able to focus on more creative tasks.

- A strong commitment, dedication, and a mindset of deep partnerships is needed at this time to maximize the value of AI approaches. Stakeholders are similarly experimenting with collaboration models to better reach partnership objectives.

Leaders in the field continue to make progress in applying AI methods

ATUL BUTTE

Director of the Institute of Computational Health Sciences
UCSF

Received $10M from Mark Zuckerburg & Priscilla Chan to advance health research.

RAY KURZWEIL

Founder & Futurist
Multiple Companies as a serial entrepreneur

Continues to advance understanding of natural language at Google.

ANDREW NG

Former Chief Scientist
Baidu

Raising a $150M fund for AI startups; established Coursera Deep Learning course.

AI has a long history, but today's enablers are distinct from years prior

DATA ACCESS

New technologies and biological discoveries are expanding the available pool of data without traditional access challenges.

COMPUTING POWER

The gaming industry has enabled computing power to increase, particularly companies like Nvidia's GPUs (graphical processing units).

EXPERIMENTATION MINDSET

Ecosystems and centers of excellence are emerging, facilitating pilot opportunities and novel research partnerships.

"Hiding within those mounds of data is knowledge that could change the life of a patient, or change the world."

- ATUL BUTTE
INSTITUTE OF COMPUTATIONAL HEALTH SCIENCES, UCSF

BUSINESS PROCESS OPTIMIZATION

There are a number of use cases that help businesses improve their core operations.

Such use cases include predictive inventory management, automated risk & security assessments, and methods that improve data standardization, among many others.

These types of applications will be further discussed in the future within HealthXL's Big Data & AI Working Group.

AI has broad utility across a number of use cases

SELECT **USE CASES**

LIFE SCIENCES

- Disease Understanding
- Drug Repurposing
- Drug Discovery

CARE DELIVERY

- Care Management Plans
- Treatment Selection
- Remote Monitoring

PAYOR

- Risk Stratification
- Patient Engagement
- Customer Service

CONSUMERS

- Nutrition
- Care Management
- Novel Experiences

Note: While imaging is a major application, other use cases are starting to gain traction.

Flourishing startup scene

ACROSS MANY MARKET SEGMENTS

RESEARCH	CARE DELIVERY/PAYOR	CONSUMER

NURITAS Life-changing Discoveries · Numerate · INSILICO MEDICINE · Oncora MEDICAL · jvion · buoy · SkinVision

iCarbonX · clinithink · AVALON Ai · Cyft. · AYASDI · IBM Watson Health · glooko

trials.ai · BERG · BAYLABS · Ginger.io · enlitic · syapse · Suggestic

WuXiNextCODE · deep genomics · ARTERYS · GNS HEALTHCARE · KenSci · DAY TWO · BRAIN POWER

twoXAR · PathAI · Linguamatics · FLATIRON · CureMetrix · lumiata · Catalia Health

Exscientia DRIVEN BY KNOWLEDGE · BenevolentAI · Atomwise Better medicines faster. · Data2Life · evidation HEALTH · zebra MEDICAL VISION · nutrino

Note: The companies listed above are meant to be representative, not exhaustive. Visit HealthXL.co for more detailed company information including partners, funding, and publications.

Investments into AI companies

ACROSS A DIVERSE INVESTOR BASE

Estimates vary, but total VC investment in health or research related AI companies is in the billions, in part fueled by projections of the AI in healthcare market surpassing $6 billion by 2021.

Some funds invest in a number of industries and prioritize robustness of tech approach; in other cases, funds are focused on healthcare and see their AI investments as an extension of their thesis.

ANNUAL FUNDING HISTORY ($M, USD)

Year	Funding
2012	$30
2013	$75
2014	$493
2015	$292
2016	$748
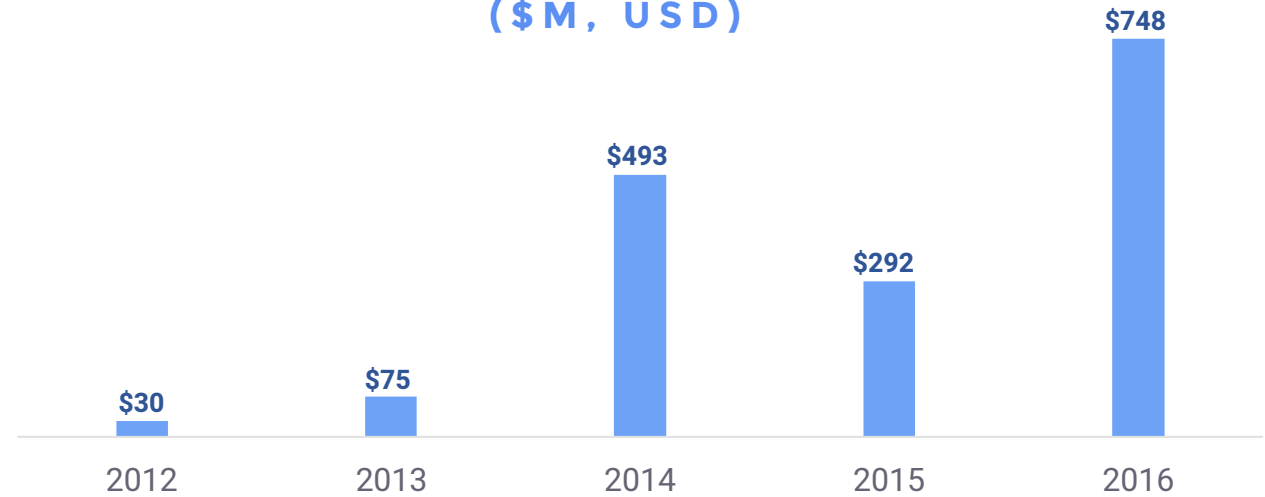
ACTIVE VCs

khosla ventures

Data Collective

GV

GE VENTURES

FOUNDERS FUND

flare capital partners

Source: CB Insights, Accenture, Company Websites

News headlines vary, but leaders believe we're still in early phases of AI

> "It's all for real - this isn't about putting out vaporware in order to boost stock prices. This is hard. It's not happening today, and it might not be happening in five years. And it's not going to replace doctors."
>
> **- STEPHEN KRAUS**
> BESSEMER VENTURE PARTNERS

HEADLINES

HOW MACHINE LEARNING, BIG DATA AND AI ARE CHANGING HEALTHCARE FOREVER

FDA ASSEMBLES TEAM TO OVERSEE AI REVOLUTION IN HEALTH

NHS MEMO DETAILS GOOGLE / DEEPMIND'S FIVE YEAR PLAN TO BRING AI TO HEALTHCARE

MICROSOFT ANNOUNCES NEW AI-POWERED HEALTH CARE INITIATIVES TARGETING CANCER

IN SURVEY ACROSS EMEA, UK MOST SKEPTICAL OF ROBOTS, AI FOR HEALTHCARE

> "We still have work ahead to get these algorithms into the healthcare system's workflow. But I think health care 10 years from now will use a lot more AI and will look very different than it does today."
>
> **- ANDREW NG**
> STANFORD (FORMERLY BAIDU)

Imaging has been the focus of many innovators, however use cases are growing

AI MODEL ALONE
ERROR RATE 2.9%

PathAI is engineering and applying proprietary deep learning technology to massive aggregated sets of pathology data to help physicians and scientists more effectively understand, diagnose and treat disease. Its models have been improved through trained experts in pathology, and have now surpassed human accuracy.

COMBINE PATHOLOGISTS + AI MODEL
ERROR RATE 0.5%

BREAST CANCER

PATHOLOGIST ALONE
ERROR RATE 3.5%

"The implications of this work are large, suggesting that in the future we'll see more examples of AI being used with traditional pathology to make diagnoses more accurate, standardized and predictive"

– DR. ANDREW BECK
PRESIDENT & CEO, PATH AI

SELECT USE CASES

Life Sciences

REDEFINING BIOLOGICAL UNDERSTANDING OF DISEASE

> *"There's going to be this really massive shake-up of pharmaceuticals. In five years or so, the pharmaceutical companies that are going to be successful are going to have a culture of using these AI tools."*

- BRENDAN FREY
UNIVERSITY OF TORONTO (AND FOUNDER OF DEEP GENOMICS)

DISEASE UNDERSTANDING

Breaking down biochemical processes and physiology to better map natural history of health, disease, and diagnostic process.

DRUG REPURPOSING

Mapping relationships between known drugs to novel indications by creatively leveraging compound libraries.

DRUG DISCOVERY

With an understanding of structural biology, creating new classes of drug categories and interventions.

Care Delivery

GAINING 360° VIEW OF PATIENT NEED

Care delivery can be viewed as a complex process with many interdependencies, AI approaches can help streamline the delivery of care and how clinical insights are discovered.

SELECT HEALTH SYSTEMS WITH AI INITIATIVES

Intermountain Healthcare   Sutter Health   UPMC

CARE MANAGEMENT PLANS

Optimizing care management plans and creating guidelines to manage follow ups, intakes, readmissions, and more.

AYASDI

jvion

conversa
Better Conversation. Better Care.™

TREATMENT SELECTION

Identifying methods to provide better treatments, early switch rates, and improve adherence.

GNS HEALTHCARE

REMOTE MONITORING

Medical grade sensors and clinical algorithms track high-risk patients beyond facility walls

AliveCor®

SENTRIAN
Remote Patient Intelligence

Sugar.IQ

Payors

RETHINKING RISK STRATIFICATION & POPULATION HEALTH

Payors are aiming to strike a balance between broad population coverage and meeting member expectations how they expect to interact with technology. Further, AI approaches can help facilitate value-based reimbursement strategies.

SELECT PAYORS
WITH AI INITIATIVES

aetna®   Humana.

RISK STRATIFICATION

Applied analytics to predict patient outcomes and inform treatment recommendations.

GNS HEALTHCARE

+Ken Sci

PATIENT ENGAGEMENT

Machine learning to tailor member outreach based on clinical, claims, and contextual data.

Accolade

CUSTOMER SERVICE

Chatbots to help members navigate their benefits quickly and efficiently.

Welltok®

IBM Watson

Consumers

NOVEL CHAT INTERFACES & VISUAL EXPERIENCES

Consumer-facing applications of AI are emerging across every major health segment. Advances in natural language processing (NLP), sensors, voice recognition, augmented reality (AR), sentiment analysis, and more are raising the sophistication of digital interaction and reshaping consumer experiences.

NUTRITION

Chatbots, food image analyses, and personalized nutrition based on microbiome and other biological determinants.

Suggestic

DAY TWO

CARE MANAGEMENT

Enabling personalized medicine, often through use of genomics and research models.

CUREMATCH

SENSELY — How are you feeling today?

NOVEL EXPERIENCES

Interactive technology and new engagement models via robotics.

BRAIN POWER

Catalia Health

Prevention & timely intervention

IS RESHAPING OVERALL HEALTH MANAGEMENT
(EX: DIABETES)

RESEARCH	CARE DELIVERY/PAYOR	CONSUMER

ARTIFICIAL PANCREAS

Closed-loop insulin dosing and blood glucose management.

Medtronic

dreamed GLUCOSITTER

SMART POPULATION MANAGEMENT

Real-time insulin pump adjustments based on patient-specific care plans.

glooko   dreamed ADVISOR

COGNITIVE PATIENT ENGAGEMENT

Patient decision-making aids based on insulin, diet, lifestyle.

IBM Watson   Google   **Medtronic**   SANOFI

SMART EATING ASSISTANTS

Foster healthy diets by turning knowledge into know-how with AR, NLP, decision support tools.

Suggestic

nutrino

Tech giants with deep pockets

ARE NOW SIGNIFICANT PLAYERS

BACKGROUND

IBM Watson Health is a large ecosystem player, with dozens of partners spanning oncology, pharma, payers, medical device, and health systems. Partnerships largely focus on ingesting partners' proprietary data to train Watson to strengthen applied cognitive computing tools.

CHALLENGES

Seamless workflow integration into complex settings.

BACKGROUND

DeepMind, Google's AI company, signed a 5-year deal with the UK's National Health Service for access to 1.6M patient records. Goals include workflow automation and optimization to enable the detection and intervention of avoidable conditions like sepsis or acute kidney failure.

CHALLENGES

Privacy and security concerns in the public dialogue.

Source: Company Websites

Within research, strategic multi-stakeholder partnerships are becoming the norm

iCarbonX has created the Digital Health Alliance, <u>bringing together</u> various technologies, proprietary data sources, patient access, and drug development capabilities into a comprehensive research ecosystem.

WuXi Next Code and **AbbVie** entered <u>15 year</u> partnership to sequence the genomes of 45,000 participants across Ireland to identify novel targets of disease.

GSK and **Exscientia** partnered to accelerate small molecule drug discovery. The deal could total upwards of <u>$42.7 million</u> (USD).

Partnerships are similarly common in care delivery, often with a focus on specific diseases

IBM Watson Health has a growing ecosystem, followed by **Microsoft** & **UPMC**, and **GE** & **Partners Healthcare**.

Specialization across diseases such as **Ginger.io**'s coaching platform in behavioral health, **Flatiron**'s oncology focus across care and research, and **Cyft**'s precision care platform across diseases.

Payers play a key role in experimenting with new benefit design, **Aetna** particularly around substance abuse (top) and outcomes based reimbursement for insulin pumps (bottom).

Future thought

REDESIGNING SOCIETY FOR HEALTHY LIVING

As AI methods become more sophisticated, there's a real opportunity to ensure we keep tackling the problems that really matter to society.

Thinking beyond generally defined "health data" and including novel data sets will increase our understanding of biology, behaviors, and outcomes management.

As predictive capabilities increase, ensuring that as a society we're creating the incentives where *avoidance of risk* is economically rewarded is crucial.

With novel methods, we can begin to solve social and structural problems, in part by better understanding social determinants of health and everyday living conditions.

HealthXL looks forward to enabling global collaborations between leading players to create a better future.

Stay connected & learn about HealthXL's working groups

New Models of Care

How traditional care models are evolving to incorporate technology such as remote monitoring tools and telehealth, and advanced analytics for patient stratification.

Consumer Empowerment

Next-generation approaches leveraging behavior change and applied to medication adherence and novel disease management programs.

Payments Models

Areas where value-based pricing may have the greatest impact and how risk-based contracts (including life sciences) can impact care delivery.

Patient Outcomes

Ensuring patient reported outcome measures, particularly in sleep and mental health, are increasingly validated and represent a novel and useful source of evidence.

Aging

Identifying ways to enable aging in place through supportive technology, caregiver matching platforms, and access to local resources.

Big Data & AI

Best practices for gaining insights from big data, identifying application areas including healthcare, payors, and life sciences, and improving insight reproducibility.

Futures

Disruptive technologies such as 3-D printing, digiceuticals, blockchain, biosensors, and nano materials, as well as determining data governance best practices.

Wellness 2.0

A fundamental rethinking of what wellness means in the age of connected health technologies and the role environment plays in our wellbeing.

Precision medicine

How –omic technologies can impact personalized care, the role of policy and government initiatives, and near term disease opportunities.

Innovation Management

Identifying best practices for how traditional care and research models become disrupted, and models for implementing new innovations into large enterprise environments.

Authors
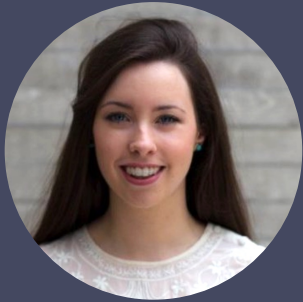
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