

The Future of Connected Health: Near-Term Technologies and Local Research Contributions

PRESENTED BY:

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DISCLOSURES



George:

- ASU research technologies presented
- ASU memorandums for data sharing/research with digital health companies

Anthony:

- Several items discussed here are part of CXO client innovation strategies;
- I may, in the future, provide advisory or investment banking services, and/ or acquire equity positions in the companies or technologies.

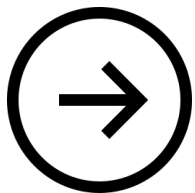
HEALTHCARE TECHNOLOGY INNOVATION



GOALS. improve outcomes +
increase access + reduce cost



TRENDS. data driven healthcare



ENABLING TECHNOLOGY. sensors
+ data analysis

INNOVATION DRIVERS



- **LARGE MARKET:** high impact, + high morbidity + high cost
- **BIZ MODELS.** SaaS-like recurring revenue
- **REGULATORY.** compliance/ speed to market.

REACTIVE INNOVATION MARKETS + TECHNOLOG



- **DIABETES.** improve compliance via non-invasive monitoring
- **CARDIAC.** prevent + manage disease via non-invasive monitoring
- **CANCER.** early detection via non-invasive monitoring

REACTIVE INNOVATION MARKETS + TECHNOLOG

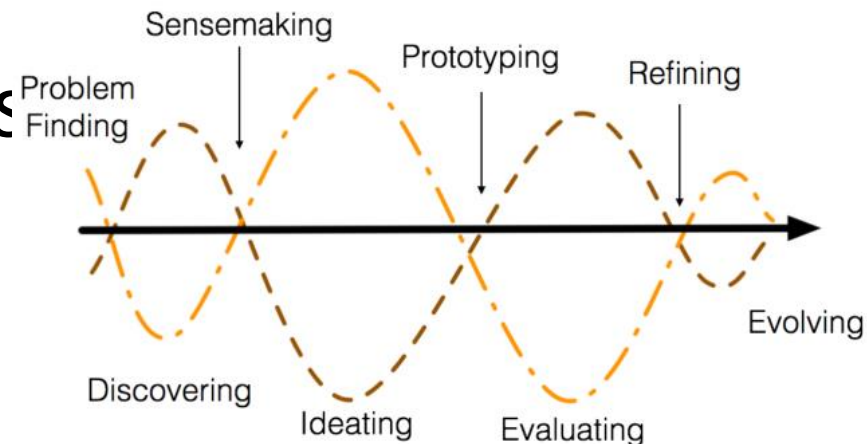


- **HEALTH BEHAVIORS.** self-managed prevention + wellness via non-invasive monitoring
- **BEHAVIORAL HEALTH.** introduction of mental health assessment, monitoring, and management

RESEARCH + COMMERCIALIZATION TIMELINE

- RESEARCH. basic + translational, publication, IP filings (2-4 yrs)
- *INNOVATE**. market, prototype, seed (1-2 yrs)
- *INCUBATE**. scalable revenue (2-3 yrs)
- ACCELERATE. add mkt share, revenue (3-5 yrs)

The design & innovation process



DATA GENERATING TECHNOLOGIES



- **SENSOR?** convert signal from one form to another .
- **BIOSENSOR?** biological signal into a quantifiable, processed signal
- **CLASSES.** electrical, physical, optical, and chemical

FLEXIBLE POLYMER BIOSENSOR: TINY KICKS

- TYPE. physical (mechanical) sensor
- SOURCE. UC Irvine, Dr. Michelle Khine
- APP. fetal monitor



FLEXIBLE POLYMER BIOSENSOR: TINY KICKS



- CHALLENGES. tech > mvp > market
- DILEMMA. sensor hardware-software app
- KEY. commercialization out of university

INFRARED ENVIRONMENT SENSOR: LIGHTSENS



- TYPE. optical
- ENV APPS. airborne pathogen, toxin detection
- BIO APPS. detect analytes in bodily fluids

INFRARED ENVIRONMENT SENSOR: LIGHTSENS



- KEY. (potential) platform technology
- EMBODIMENT #1. multi-toxin 'sick building syndrome' detection
- EMBODIMENT #2. multi-pathogen detection across city network

CARDIAC Monitoring

- Type. Electrical, Impedance Cardiography (IC)
 - Technology deployed via sensors/phones
 - Correlated with CO, SV, SI, EF measurements



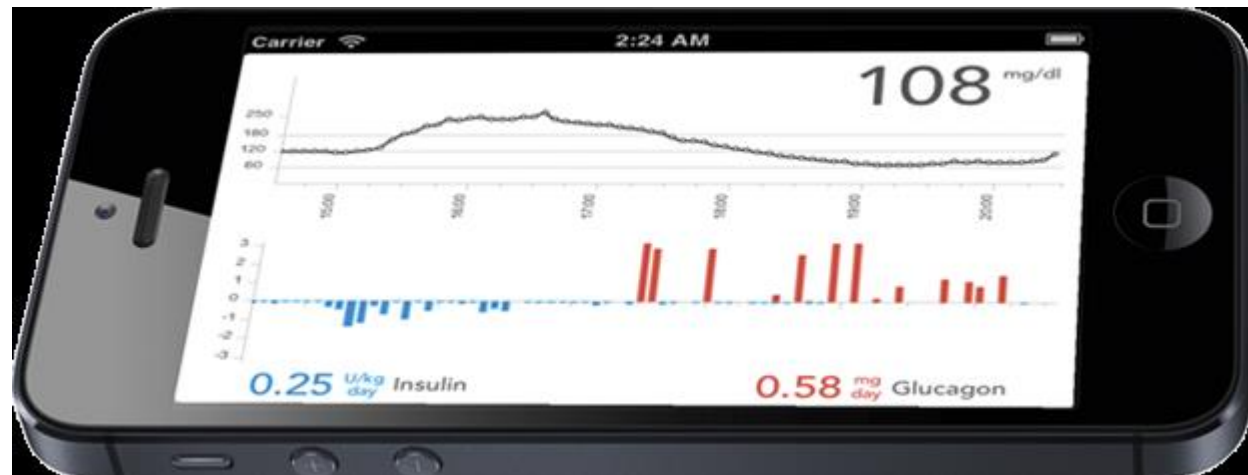
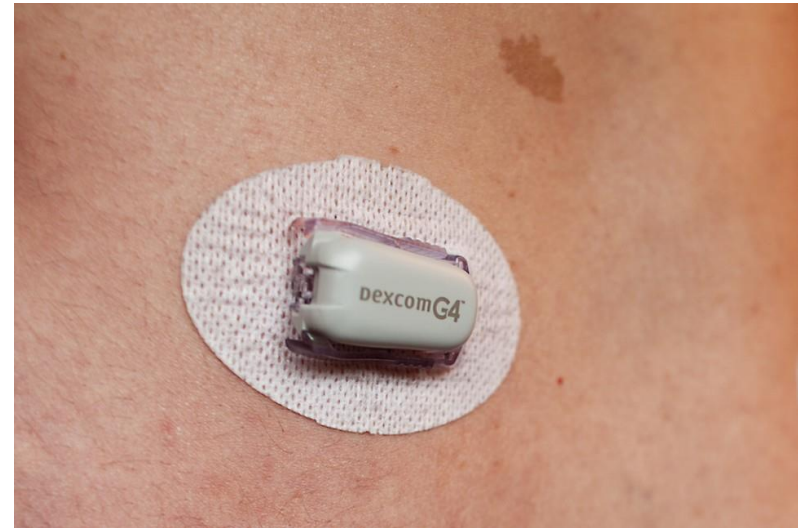
Cardiac Monitoring

- Also sensors for blood pressure, EKG



Continuous Glucose Sensors

- Google & others shrink glucose sensors
- Miniature under the skin sensors
- 12 readings per hour charted



Ultrasound on your Phone

- On your phone
 - Download app
 - Plug
 - Scan
- Images on your phone



Ultrasound on your Phone



Study underscores benefit of smartphone use to track children's health

Date: March 20, 2017

Source: University of Kansas

Summary: A new, wide-ranging review of available research shows parents and caregivers can improve health outcomes for kids by using mobile-phone apps and text messaging. Previous to this investigation, the only across-the-board review of mobile health (mHealth) effectiveness centered on childhood obesity alone.

JAMA Pediatrics | [Original investigation](#)

Mobile Health Interventions for Improving Health Outcomes in Youth A Meta-analysis

David A. Fedele, PhD; Christopher C. Cushing, PhD; Alyssa Fritz, MA; Christina M. Amaro, MA; Adrian Ortega

IMPORTANCE Mobile health interventions are increasingly popular in pediatrics; however, it is unclear how effective these interventions are in changing health outcomes.

OBJECTIVE To determine the effectiveness of mobile health interventions for improving health outcomes in youth 18 years or younger.

DATA SOURCES Studies published through November 30, 2016, were collected through PubMed, Cumulative Index to Nursing and Allied Health Literature, Educational Resources Information Center, and PsychINFO. Backward and forward literature searches were conducted on articles meeting study inclusion criteria. Search terms included *telemedicine*, *eHealth*, *mobile health*, *mHealth*, *app*, and *mobile application*.

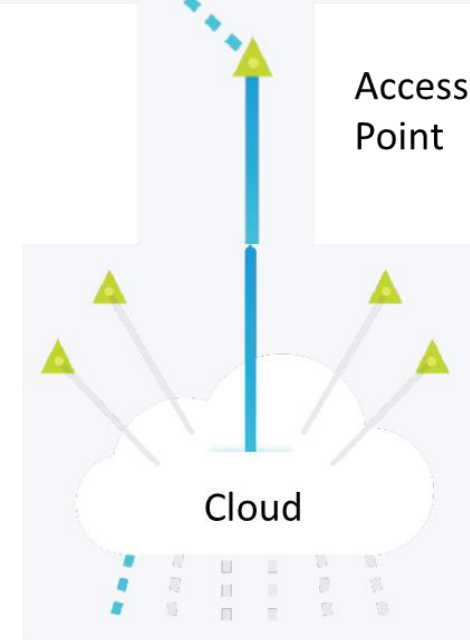
LOW POWER WIDE AREA NETWORKS (LPWAN)

- SPECS.

- 10+ miles,
- Low energy use (battery life)
- Low data throughput

- EXAMPLES.

- Ingenu, SigFox – low cost, rapidly growing in US and elsewhere

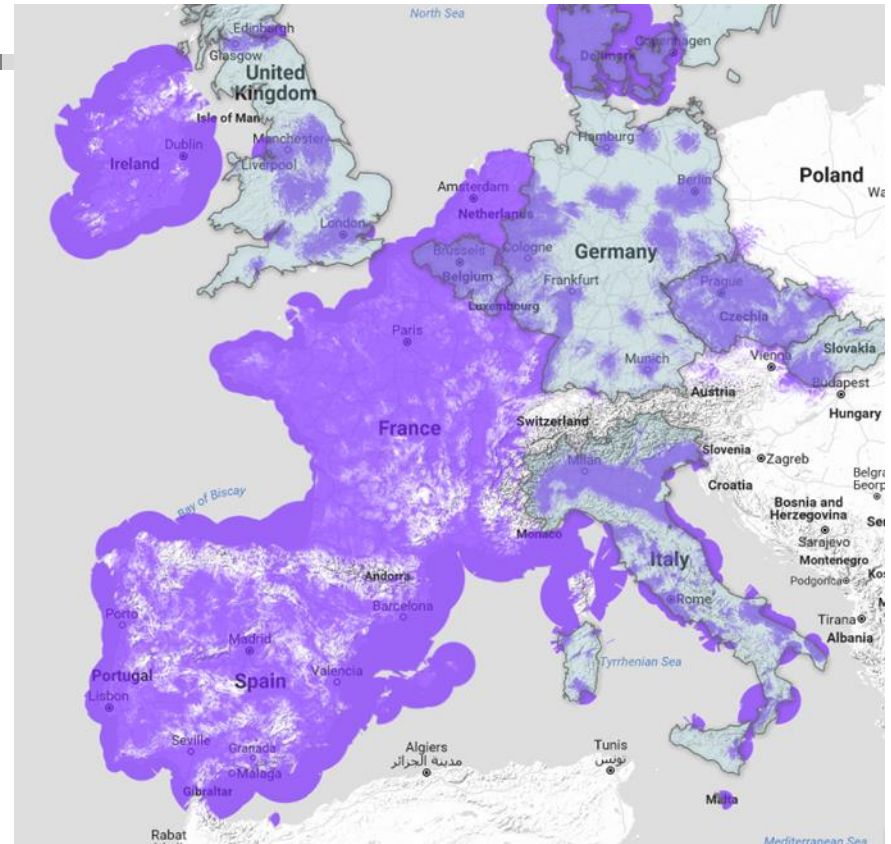


Phones, tablets,
computers

www/ingenu.com

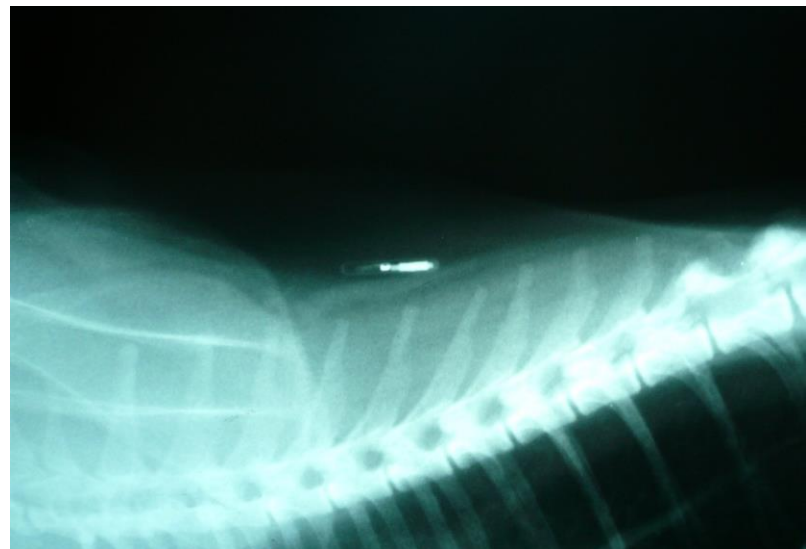
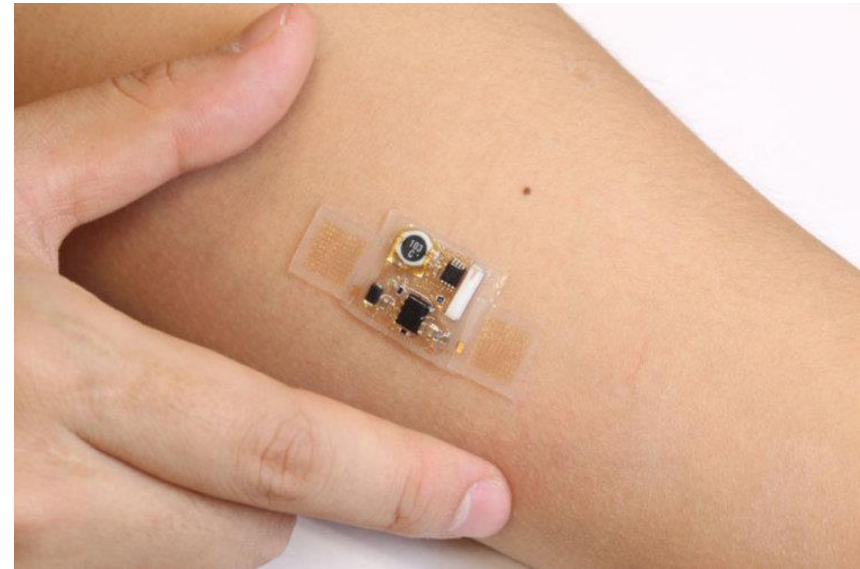
LPWAN

- KEY. Enabling IoT/ healthcare IoT technology
- APPS. Environmental data streams for health apps (PM10, etc.)
 - Discriminate pollen from other particles with light scattering— scattered light intensity and degree of polarization
- IMPACT. Improved self-management of COPD, Asthma, VOCs, etc.



Electroceuticals

- Electrical therapy similar to pharmaceuticals
- Electroceuticals target sensory neurons with electrical pulse generator (pacemakers)
- New device targets the vagus nerve--application modulate hunger in obese patients
- 5 minutes on, 5 minutes off during the day

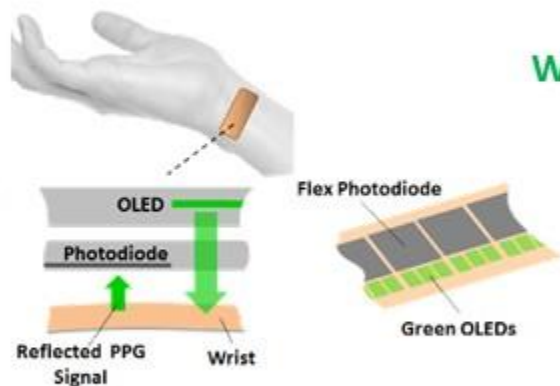


BioElectrical Systems & Technology – J. Blain Christen

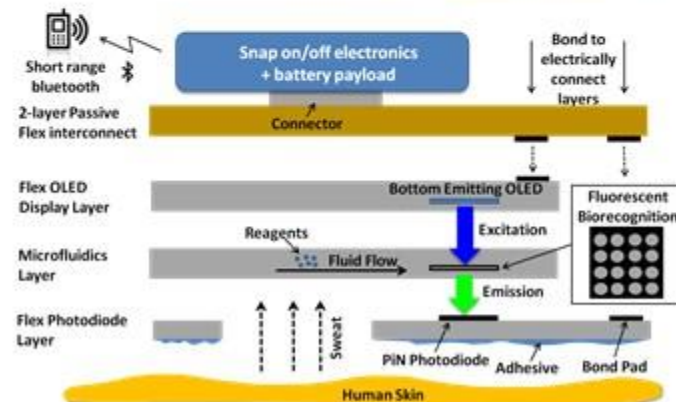
Point of Care/Need Diagnostics



Wearable biosensors for continuous monitoring of biomarkers
NSF Smart & Connected Health



Sweat Patch for multiple immune-base detection
Funded by NSF SCH
J. Blain Christen (PI)

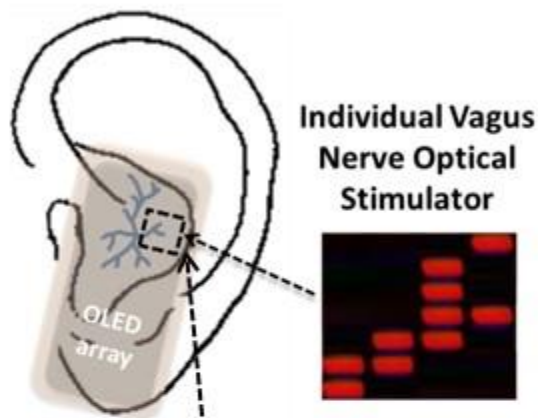


- Number of chemicals—sodium, electrolytes, hydration, drug use, etc.
- Hyperhidrosis—potentially a symptom of metabolic disorders (hyperthyroidism), diabetes, infections, conditioning
- Supplement blood tests

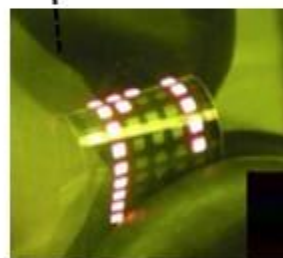
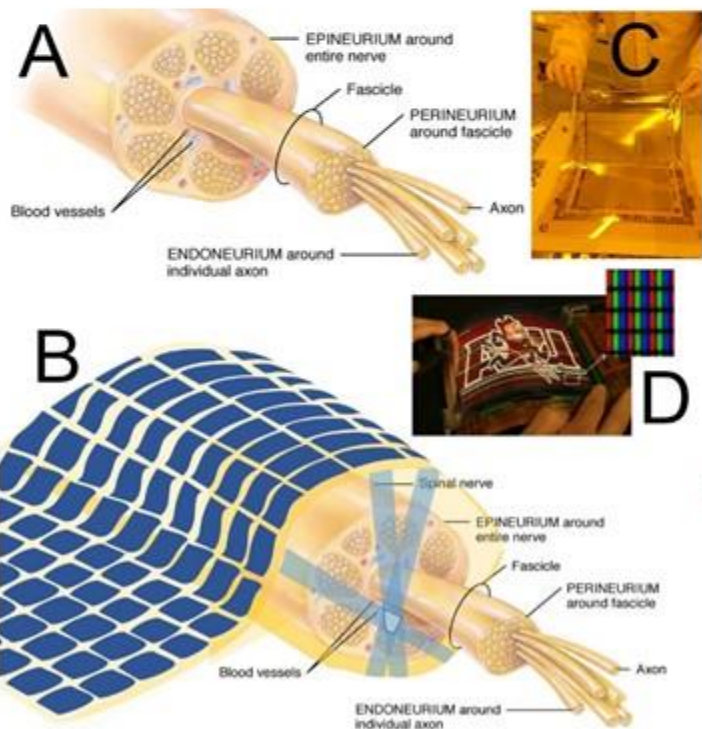
BioElectrical Systems & Technology – J. Blain Christen

Neural Interface Technologies

iLED/OLED-Based Optogenetic Smart Bandage Nerve Stimulator to Treat Mental Health Disorders and Inflammatory Diseases

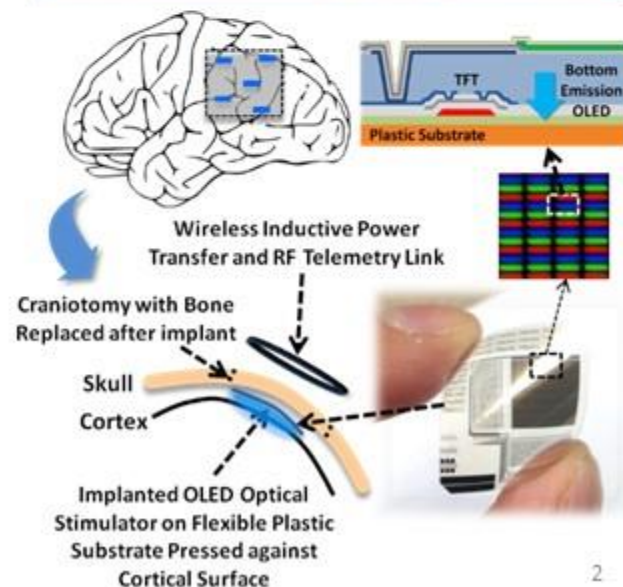


Flexible, High-Density Cortical Array: Brain Mapping and Forecasting for Epilepsy
 Funded by Mayo ASU Team Science J. Blain Christen (co-PI)



Implementing optogenetic bioelectronic medicine with feedback based on physiological parameters
 Funded by NSF CAREER J. Blain Christen (PI)

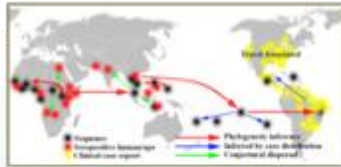
Selected OLED pixels in array turned on – Rest of array off



Array Technologies

Array Technology Push and Market Pull

Applications:
Solutions for
Hard Problem



Public Health
Ubiquitous rapid
immunosensors



**Personal Health
& Performance**



**Public Security
& Field Triage**



**Infrastructure
Health (SHM)**



Port Security
Effective, Convenient
(standoff)

Product-level
Technology
Demonstrations



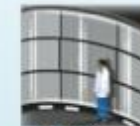
POC Diagnostic
Immunosensor
Cancer Screening



On-body Monitor
Biomarker-based
Health / Performance

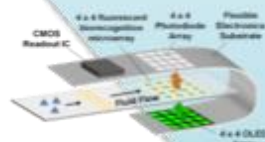


X-ray Imager
Portable, Rugged

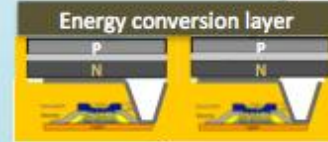


LAND
Large Area Neutron Detector

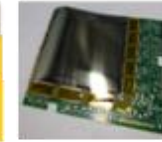
Integrated
Technology
Platforms



Bio-sensor Array



Rad-sensor Array



Component
Technology
(Building Blocks)



Light Emitters



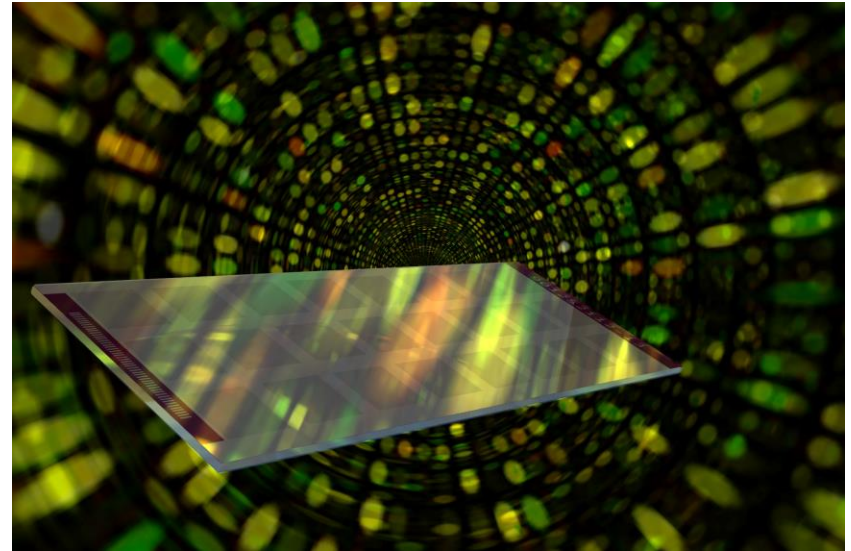
TFTs and ISFETs



Photo-sensors

What Else?

- Can your smartphone could tell you a potential disease or illness is lurking inside your immune system?
 - Detect diabetes before any outward signs?
 - Zika virus, valley fever?
- Single drop of blood, ImmunoSignature, a diagnostic testing platform
 - ASU Stephen Albert Johnston and Neal Woodbury
- Potentially 50 different types of diseases — autoimmune, cancer, infectious, metabolic and neurologic — by observing an individual's set of antibodies in the immune system.

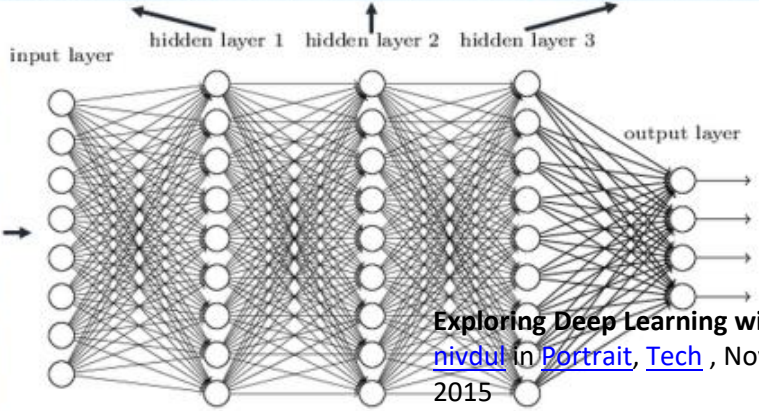


New Technology for Data Analysis

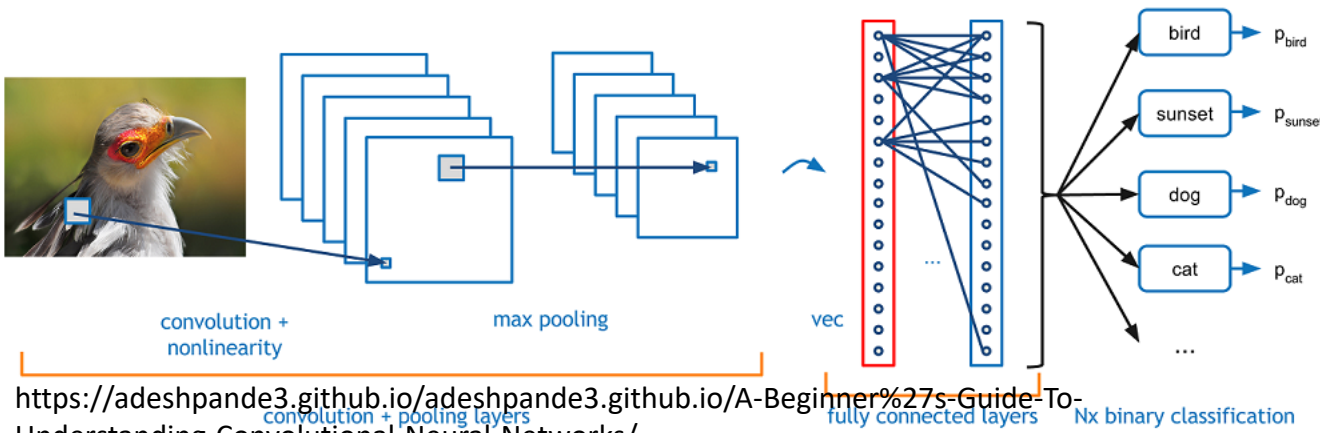
Deep Learning

- Discontinuity in computer vision, speech, NLP, etc.
- Since 1980's, now confluence of computing, GPU, skilled workforce, open-source software & tools, e.g., tensorflow, lasagna
- Not yet in mobile devices?

Deep neural networks learn hierarchical feature representations



Exploring Deep Learning with Li Zhening in [Portrait, Tech](#), November 17, 2015



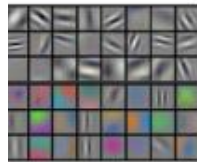
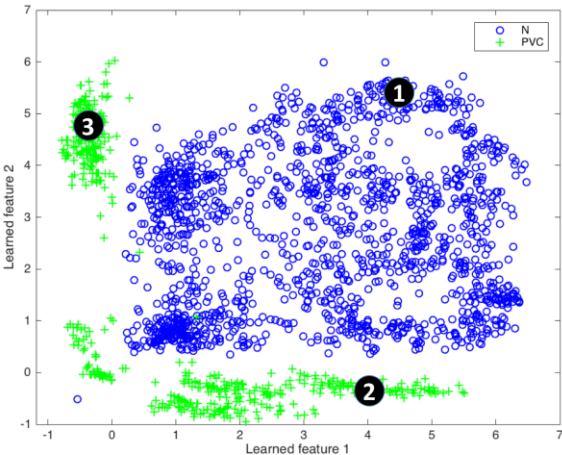
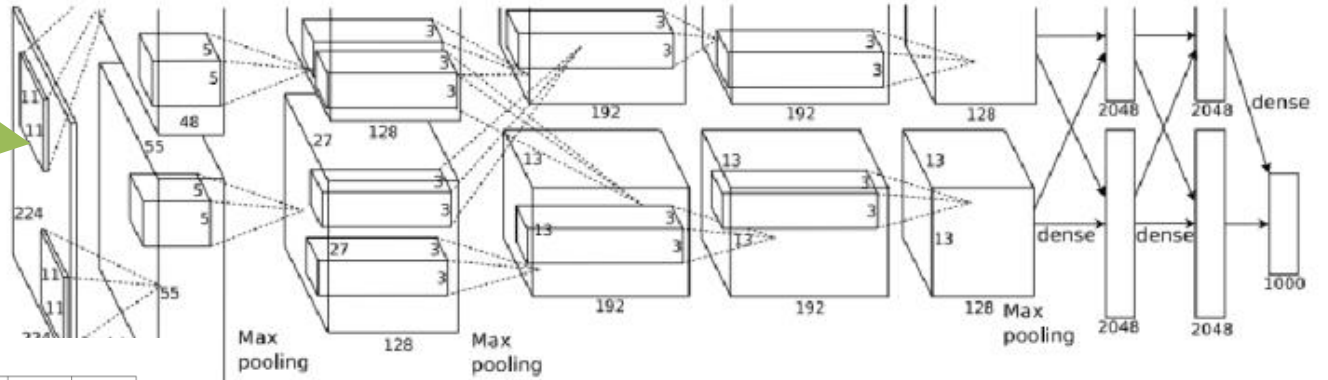
<https://adeshpande3.github.io/adeshpande3.github.io/A-Beginner's-Guide-To-Understanding-Convolutional-Neural-Networks/>

2016: THE YEAR THAT DEEP LEARNING TOOK OVER THE INTERNET

Complexity of Deep Networks



ECG Beat Separation

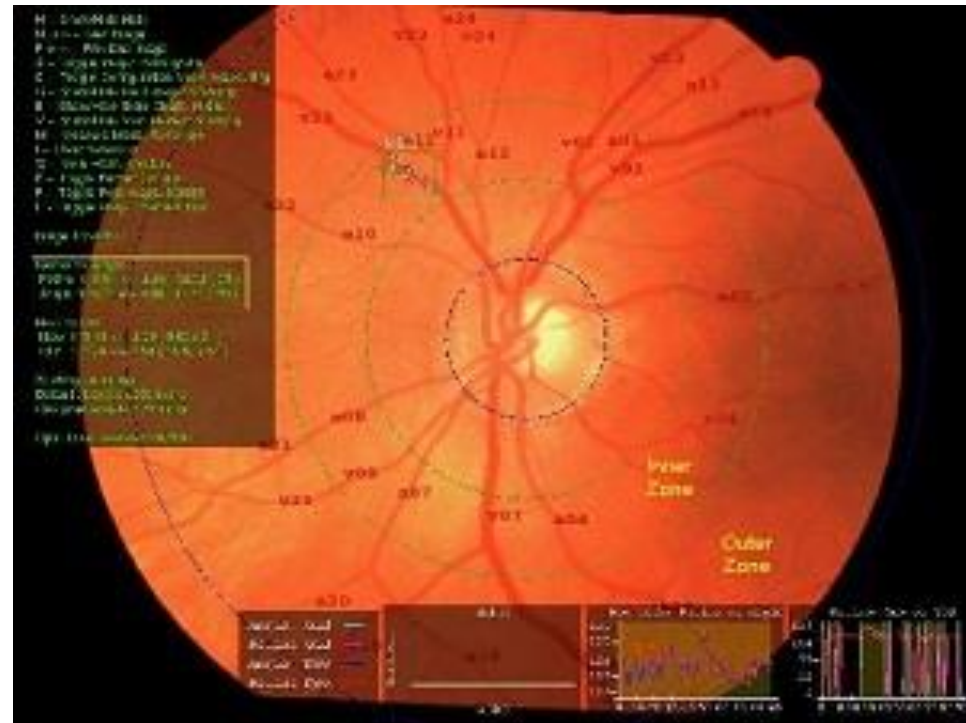


<https://fananyimi.wordpress.com/>



Deep Learning

- *Development and Validation of a Deep Learning Algorithm for Detection of Diabetic Retinopathy in Retinal Fundus Photographs*
- December 13, 2016, Gulshan, Peng, Coram
- 90-98% sensitivity, specificity



HEALTHCARE IoT R&D PLATFORM: ITRTV



- PROBLEM #1. sensor-hardware/
application-software dilemma
- PROBLEM #2. 'wearable platform'
development increase R&D costs
- PROBLEM #3. no access to populations for
technical, market, or clinical validation

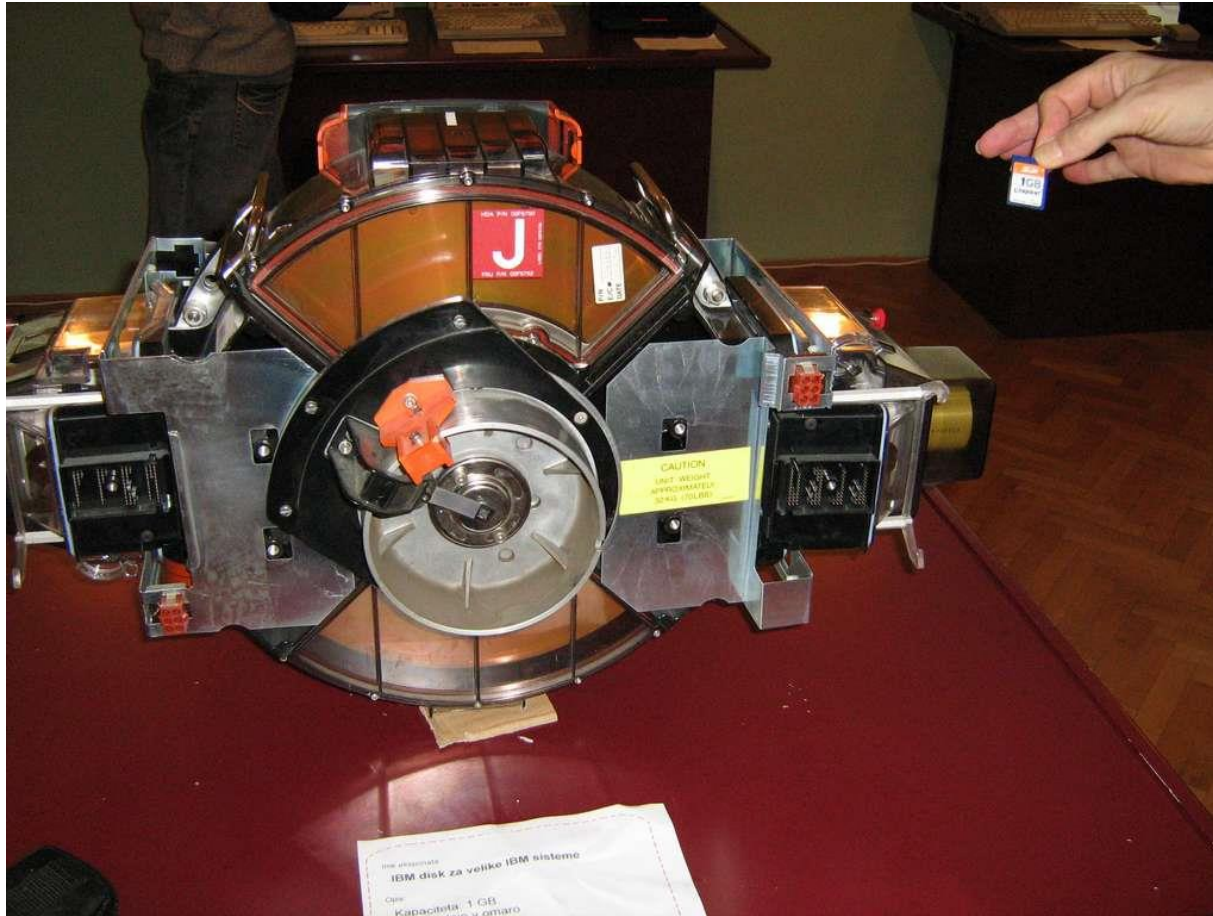


HEALTHCARE IoT R&D PLATFORM: ITRTV



- **CO-DEV.** ‘sandbox’ for sensor, app, and business enables iterative iteration
- **INTEGRATED.** device, mobile, and cloud platform reduces R&D cost and complexity
- **TESTING.** access to patient/ user populations accelerates regulatory approvals and early adoption

Data Cycles



- 1 GB hard drive from IBM 1981
- 75lbs
- Price \$81,000

QUESTIONS & ANSWERS



THANK YOU