Innovation Crossover Research
Life Sciences/Biomedical
Health Informatics

Context/Scope

This paper represents research conducted by OVO Innovation for the NSWC Crane Innovation Crossover event October 12-13, 2016. This research is intended to provide more insight into key challenges that were identified within the four technology clusters (Advanced Manufacturing, Cyber/IT, Life Sciences and DoD Technologies) first documented in the Battelle report. OVO consultants interviewed subject matter experts (SMEs) from the private sector, academia and the government identified by NSWC Crane to gather insights into key challenges in each cluster. This report is meant to inform the participants of the Innovation Crossover event and identify new research and new technologies that might address the key challenges.

This research was collected during August and September, 2016. The reports were submitted by OVO to NSWC Crane in late September 2016.

Introductory Narrative

The Innovation Crossover event, scheduled for 12-13 October 2016 in Bloomington is the culmination of months of planning and hard work. Some of this preparatory work involved the initial Battelle study which identified key technology clusters (Advanced Manufacturing, Life Sciences, Cyber/IT and DoD Technologies) in southern Indiana. From these clusters NSWC Crane and its contractor OVO Innovation conducted further, more detailed research, to examine detailed challenges and opportunities in each technology cluster. The reports attached document the research OVO conducted with subject matter experts identified by NSWC Crane in academia, industry and in the government. The reports are meant to document specific challenges within each technology cluster that could become areas of joint research and cooperation across the three constituents in southern Indiana. The reports are provided to you to help you prepare for your participation in the upcoming Innovation Crossover event and to frame both the challenges and active research underway to address these challenges.

Problem Context

Problem or Challenge: Health Informatics

Enable patient-centered health care through development of point-of-care, wireless, and personal health informatics technologies. Develop informatics technologies to provide information and feedback on people serving to allow instant access to their vital signs and the ability to direct medicine, hydration or other needs remotely, as well as provide remote diagnosis.

Problem Context

Problem or Challenge: Mechanisms

Transform advances in knowledge of cellular and molecular disease mechanisms into precise medical diagnostics and therapeutics.

Overview: Mechanisms

Early stages of research into mechanisms at the cellular/molecular level

- Biomarkers for disease states
  - Research exists for decades, but opening up new frontiers
  - Challenge is translating knowledge into therapeutic action
- Extraordinary complexity of human biology/physiology
  - Systems don’t operate independently; difficult to design effective experiments
- Models needed to guide decisions on what to measure/monitor and what to do with the data

Technologies: Informatics

Informatics is "the interdisciplinary study of the design, development, adoption and application of IT-based innovations in healthcare services delivery, management and planning."[1]

More simply, the collection, management, and analysis of medical data.

[1] Procter, R. Dr. (Editor, Health Informatics Journal, Edinburgh, United Kingdom). Definition of health informatics [Internet]. Message to: Virginia Van Horne (Content Manager, HSR Information Central, Bethesda, MD). 2009 Aug 16 [cited 2009 Sept 21], found on https://www.nlm.nih.gov/hsrinfo/informatics.html

Problem Relevance

Benefits to adoption of medical informatics technology

- Improved patient compliance with treatment
- Improved monitoring by patients and medical professionals – more granular data for diagnosis and treatment
- Improved access to care through remote diagnosis and treatment
- More data available for analysis through medical research community
- Future: ability to create custom treatments for patients (personalized medicine)

Scope

- For the purposes of this research, we’ve defined the scope of the challenge to be the complete set of technologies that can be used to remotely monitor, measure, or detect changes in physiological, neurological, or cognitive function.

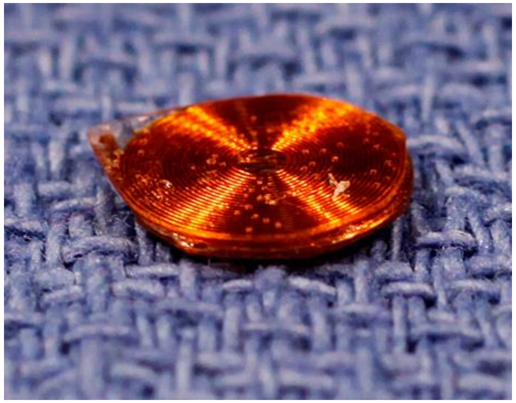
- This includes the sensors themselves, as well as the related technologies such as analytics, platforms, packaging, and user experience.

Research

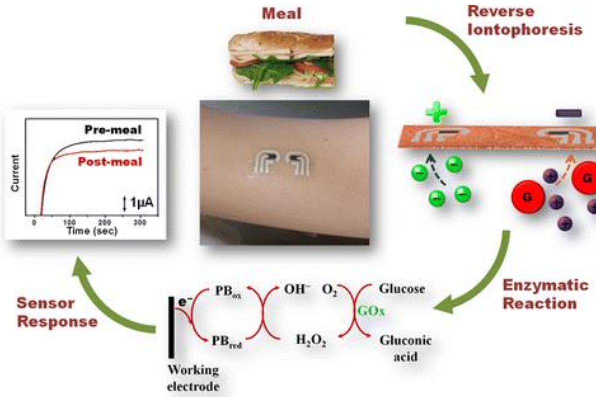
Sensors

- Wired and wireless
- Variety of modalities
  - Wearable (external device, or on skin)
  - Implantable (subcutaneous)
  - Ingestible
  - Injectable

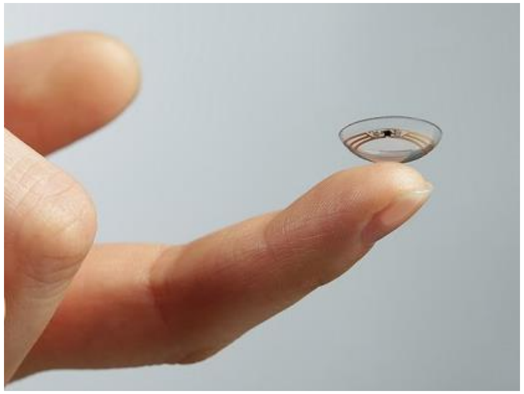
Examples



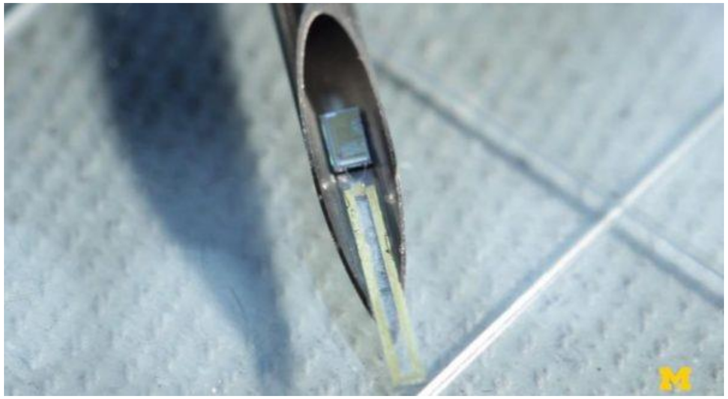
Implantable force sensor from RPI[1]



Glucose monitoring “tattoo” from UCSD[2]



Smart contact lens/glucose monitor from Google[3]



Injectable computer from University of Michigan[4]

[1] https://www.asme.org/engineering-topics/articles/bioengineering/implantable-sensors-make-medical-implants-smarter
[2] http://pubs.acs.org/doi/abs/10.1021/ac504300n
[3] http://www.healthline.com/diabetesmine/newsflash-google-is-developing-glucose-sensing-contact-lenses
[4] http://medcitynews.com/2016/06/injectable-computer-tumor-pressure/

Research

Data generated by informatics natural for advanced analytics

- Find correlations between variables
- Detect weak signals in noisy data sets
- Develop better models to identify causality (if it exists)
- Use with medical device manufacturing data to track performance of individual products
- Data can be for an individual or a population (23andme.com, e.g.)

•Indiana University School of Informatics and Computing

- Computer Science + Informatics + Library Science

Research

IBM has been spending billions acquiring health-related data and using artificial intelligence (AI) expertise to mine it through IBM Watson Health and partnerships with universities and clinics.

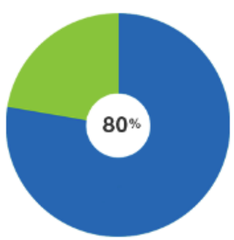
Welcome to the Era of Cognitive Health

IBM Watson Health is pioneering a new partnership between humanity and technology with the goal of transforming global health. Cognitive systems that understand, reason and learn are helping people expand their knowledge base, improve their productivity and deepen their expertise. With cognitive computing, we are now able to see health data that was previously hidden, and do more than we ever thought possible.

Take the First Step

The Data Explosion

Medical data is expected to double every 73 days by 2020.



The Great Unknown

80% of health data is invisible to current systems because it's unstructured. Watson Health can see it.

Source: https://www.ibm.com/watson/health/

Research

Most popular informatic devices are health/biometric trackers, like FitBit

– Is 10,000 steps per day the right target? How do we know?

•Other devices can measure blood glucose, heart rate, oximetry – many others

•Based on understanding mechanisms, we can decide what particular quantity to measure for each individual and condition. New devices can be designed for these functions.

Research

Personalized medicine is the ”Holy Grail” – but we need to know exactly what is appropriate for each patient

- Normal for the population ≠ normal for individual
- What is the “control” level for a given patient?

Need models of physiological/neurological function to identify what to measure

- University of Toledo – cognitive-related biomarker research
- Duke – suicide-related biomarker research

Research

Scenario provided by IU: Gut biome

- Is it healthy or not?
- How do we monitor it?
- What models do we have of its function?
- How, when, and why would we modify it? (We do it all the time with antibiotics.)

Research

Scenario provided by Cook Medical: Stent to protect aneurismal wall

- Put a sensor on the stent – bypass MRI for monitoring
- What information would we want?
- What would we do with it when we got it?

- Additional scenario: implant sensor into blood vessel, monitor 30 days, design 3D-printed custom stent

Research

Sensors/Devices

- Current devices have error rates as high as 25%
  - Unacceptable
  - Devices must be “dummy proof” and ultra reliable
  - Remove people from the equation altogether

Summary

- Future of healthcare is to reduce trips to hospitals and offices for care leading to increased demand for remote reporting.
- Significant activity developing devices to monitor wide range of variables
  - Future devices may be designed based on understanding of underlying mechanisms and set appropriate targets
  - Biocompatibility of materials remains a challenge
- Advanced analytics look for signals in structured and unstructured data

Summary

Significant challenges surround the data:

•How do you manage this data and analyze it?

•Who has access to the data? How to integrate with Electronic Health Records?

•How do we visualize or report the data?

•What do you do with the data? Is it actionable?

The last question raises another challenge: what are the underlying disease mechanisms to guide what data *should* be collected and how *should* it be analyzed?

Sources

Subject Matter Experts consulted / interviewed

- Rajesh Naik, PhD (Air Force Research Laboratory)
- David Puleo, PhD (University of Kentucky)
- David Daleke, PhD (Indiana University)
- Sean Chambers, PhD (Cook Medical, Inc.)

Additional sources noted in footnotes throughout report.

Inter-related challenges

Life Sciences/Biomedical

Three inter-related areas of focus

1. Non-radiation based imaging
2. Informatics technology
3. Cellular and molecular disease mechanisms

Inter-related purposes

- **Imaging**: Observation
- **Informatics**: Measure and monitor
- **Mechanisms**: Prevention and healing

Overall goal: Personalized or precision medicine

Mechanisms support all

- **Imaging**: What to observe?
- **Informatics**: What to measure?
- **Mechanisms**: How does it work?