Personal Health Navigator

Ramesh Jain
Institute for Future Health
University of California, Irvine
Jain@ics.uci.edu
About Cars and People
Most cars send more than 25 gigabytes of data/hour (130TB per year) to the cloud.

The data is used for longitudinal studies as well as for population and social studies.

Most people collect almost zero data.

The data collected is not usable.

Who do we value more: cars or humans?
Lifestyle and environment are more important for human health than medicine

Health is not just about medical care. Changing your lifestyle will make larger impact on your health. So tracking lifestyle data makes sense.
The problem: We know what is right but don’t practice it.

Do what is right, not what is easy!
Basic Facts about Health

• Basic machinery: Genetics
• Environmental Factors: Air quality, physical environment, climate, ...
• Input: Food
• Output: Activities
• Biological/lifestyle factors: Sleep, social
Emerging key ideas...

• A holistic focus on lifestyle, environment, social, and medical aspects **is now feasible and essential** for disruption in healthcare.

• Build **a new model for health**, based on unobtrusive continuous longitudinal monitoring of environmental and physiological parameters, and closed loop guidance (recommendation) systems.

• Create **population models** by appropriately aggregating **personal models**.

... enabled by Multimedia and A.I.
A New Perspective for Health

Focus on:

Personal Models and Cybernetics.
Thinking about **Health in Healthcare**.

Think **Health State** — not **Disease**!

*We heave Disease Care; not Healthcare.*
Popular Episodic Approach was OK in 20th Century!

- You go to a doctor because you feel sick.
- The doctor asks you questions about your health status and history while observing your reactions.
- The doctor examines your body and may order some tests (such as x-rays or blood work).
- Based on your exam and test results, the doctor estimates your health state (disease and its severity).
- A prescription and regimen are stipulated and explained.
- You try to follow those instructions.
- The doctor sees you periodically as needed (possibly recommending continued visits, hospital admission, or surgery followed by a stay in ICU).
Episodic Health Cycle

Measure
Collect all Relevant data

Estimate (Disease)

Guidance

Influence and Compliance

Collect all Relevant data
How did you get to your destination?
Just 10 years ago!

Turn-by-turn directions felt so advanced!
Cybernetics: Feedback revolutionizes system design.

Modern control theory and AI came from Cybernetics.
Basic Systems Theory

\[ x(k + 1) = A(k)x(k) + B(k)u(k) \]
\[ y(k) = C(k)x(k) + D(k)u(k) \]

Where \( x, u, \) and \( y \) are state, input, and output vectors; \( A, B, C, \) and \( D \) are appropriate matrices for transformation.

**Observability:** Determine state using measurements.

**Controllability:** Get to desirable state.
Magic Happened: Can you drive without a navigation system?

Maps
Points of Interest

Current State: GPS
Current Traffic: Waze

Destination

Navigation system

Cybernetic loop
Cybernetics for Perpetual Health Guidance

How do we close the loop?

Key Components

• Data Source Selection and Ingestion

• Building Personal Models:
  • Short term (Maybe for specific health situation)
  • Long term

• Health State estimation

• Recommendations

• Influence and Adherence
Key Technology Components

• **Measure**
  • Multimodal semantics, Synchronization
  • Semantic compression
  • Event Recognition in multimodal signals
  • Event mining: learning and causality, Associative rule mining

• **Estimate**
  • Learning for diagnostics
  • Causality from event characteristics

• **Guide**
  • Recommendations in context
  • Situational knowledge in recommendation engines
  • Optimization of health and quality of life

• **Influence**
  • Gamification
  • Communicating right information at right time in a right way
Personal Model: Three types

• Anecdotal
  • No data, just simple anecdotes.

• Quantified Self
  • Data everywhere – but no insights.
    • Lifelogs have been popular in multimedia.

• Objective Self
  • Causal and correlative models based on all sources of data and knowledge
Objective Self: Personal Model Architecture
Personal Model Builder

EventShop for Situation Recognition and geo-spatial event analysis.

- Propensity to diseases
- Rule Based Health Behavior

Could be for
- Whole Life
- Recent Past
- After a particular health condition (such as heart attack)
Recording Daily Activities: Personicle

- “Quantifying information about time usage and its frequency, as well as stress level, pleasure, and other affective states of each individual, is potentially useful for health research”
  – Daniel Kahneman, Awarded 2002 Nobel Memorial Prize in Economic Sciences

Our system automatically builds Personicle on Android.
Pulling data from ALL sources in Personicle
Food is an important MISSING LINK

No good technique for logging food history

Food Recognition
Nutrition in Food
People's preferences: When, where, weather, company, ...

Several efforts have started; many research opportunities in multimedia

Grand Challenge: Create a Detailed Food Atlas.
While air pressure is high, pollution starts increasing gradually, within $T$ time units asthma outbreak happens.

Example:

$$((\text{pollution_inc\_steadily} \land \omega_T \text{asthma\_outbreak}) \land \text{air\_pressure\_stay\_high})$$

Interactive Visualization
Spicy food and 2 glasses of wine result in sleepless nights.

Warn him when he is at an Indian restaurant.
Estimation of Health States

Are current vital signs and parameters the right ones?
Situationally Indexed Knowledge

Indexing Knowledge
- Situational
- Contextual
- Disease-based

Pluggable Modules
- Traditional medicine
- Alternate sources
- Latest research
- Local knowledge

Guidance
Influence and Compliance: A difficult challenge.

People react to instant gratification. Gamification.

How do we influence them for eventual rewards? (There are some compelling examples, however.)
Example: Closed Loop Control for Diabetes

‘Artificial Pancreas’ for Type 1 Diabetes.

Many lifestyle approaches suggested for Type 2 Diabetes.

Artificial/virtual Pancreas for T2D coming soon.
Your food and activity scores for the last 3 days are on the low side.

My recommendations for you are.
Living Labs

- User Involvement
- Early Adopters (Visionaries)
- Early Majority (Pragmatists)
- Mainstream Users

Living Labs: User-driven open innovation involving all relevant players of the value network

- Action Space for Living Labs
- Fundamental Research
- Applied Research
- Demonstration Piloting
- Service & Product Development
- Market

- Business-Citizens-Government Partnerships
- Public & Private research funding
- Seed Money
- Venture Capital
- Industry Banks
- Chasm
- Pre-Commercial Gap

* MacDonald and Associates, 2004
** Geoffrey A. Moore: Crossing the Chasm, 1999

Action space for Living Labs along the technology adoption cycle
We believe that...

• A holistic focus on lifestyle, environment, social, and medical aspects is now feasible and essential for disruption in healthcare.

• The translation of research should be an integrated component of the approach, right from the beginning.

• Working with companies and communities to make this a new model for health research, inspired by advances in technology and business and social models, is essential.
Thanks.
jain@ics.uci.edu