Smart Health and Wellbeing
NSF 12-512

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National Science Foundation

Webinar
January 11, 2012
The smart health and wellbeing team

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- Fahmida Chowdhury (SBE/OAD)
- Vasant Honavar (CISE/IIS)
- Will Barkis (AAAS, CISE/IIS)
- Julia Skapik (AAAS, CISE/IIS)
Road ahead

- Motivation for the Smart Health & Wellbeing (SHB) program
- SHB Research Areas
- SHB Challenges
- SHB Specifics
The Healthcare Crisis
Some troubling statistics

• The cost of healthcare in the U.S. is the highest in the world (> $8,000 per capita, 16% GDP)
• The U.S. ranked 37th in the 2000 WHO study of healthcare system performance (8 underlying measures)
• 98,000 deaths per year due to medical errors
• Current individual medical records have an error rate of 20%
• 50% Americans have 1 or more chronic diseases; age of onset is getting younger
• Medicare and Medicaid costs to be at a staggering 25% of the U.S. economy by 2050
• 3 lifestyle behaviors (poor diet, lack of exercise, smoking) cause estimated 1/3rd of U.S. deaths
A sample of recent strategic visions & activities
Focus on transforming healthcare with technology and innovation

- **PCAST** – President’s Council of Advisors on Science and Technology (PCAST)
  2 reports in December 2010
- **NITRD** – Networking and Information Technology Research and Development
- **HITECH** – Health Information Technology for Economic and Clinical Health (ARRA)
- **Open Government**: Transparency through open access to data (model after open source)
- **National Research Council**: Computational Technology for Effective Care
- **IOM**: Learning Health System
- **2010 Presidential Cancer Panel**: Environment and Health
- **Critical Areas of Research Workshop**: Industrial and Systems Engineering and Health Care: (DC, September 2009)
- **CCC White Paper**, “Information Technology Research Challenges for Healthcare: From Discovery to Delivery.”

*Citations and URLs for these reports are listed in the 12-512 solicitation*
From traditional medicine to smart health

EPISODIC, REACTIVE FOCUS ON DISEASE  →  PROACTIVE and PREVENTIVE FOCUS ON WELLBEING QUALITY OF LIFE

HOSPITAL-CENTRIC  →  PATIENT-CENTRIC, HOME-BASED

TRAINING & EXPERIENCE BASED  →  EVIDENCE – BASED LEARNING HEALTH SYSTEM

FRAGMENTED, LOCAL DATA  →  INTEROPERABLE, EHR AVAILABLE ANYWHERE, ANYTIME

NAÏVE, PASSIVE, PATIENTS  →  EMPOWERED, ENGAGED, INFORMED, PARTICIPATING
Changing habits and lifestyle is difficult
Information and communication technologies are poised to support healthcare transformation...

preventing the onset of diseases, improving diagnoses and treatments, enhancing the quality of health care delivery, and empowering us to participate in our own health and well-being
What are the technical advances that are potential enablers for transforming healthcare?

- Networking technology – BIG DATA
- Mobile and wearable computing
- Power management, generation, power harvesting
- Statistical pattern recognition & machine learning
- Social networks
- Cyber-physical systems and robotics
- Advances in control of privacy and security
- Unobtrusive monitoring - Physical, physiological and behavioral phenotyping

- Computational, predictive models relating measurable data, to the underlying phenomena
Recent dramatic advances in smart sensing, reasoning and decision
Patient-centered framework for health and wellness involves sensing and intervention

- Environment
- Payers
- Employers
- Privacy
- Legal

User Interfaces:
- Self-care
- Family
- Caregiver
- Coach
- Clinician
- Devices

Inference Assessment:
- Physio Sensors
- Activity Sensors
- Mobile Sensors
- EHR, PHR

Mobile Health

NIT: Networks, DB, API Software, EHR, PHR

Physical Function
Cognitive Function
Chronic Disease
Socialization
What is the goal of the Smart Health and Wellbeing Program?

Seek improvements in safe, effective, efficient, equitable, and patient-centered health and wellness services through innovations in computer and information science and engineering

• To fill in research gaps that exist in science and technology in support of health and wellness
• To advance the fields of health and wellness by leveraging the fundamental science research supported by NSF
• To advance fundamental science and technology research that could result in reducing healthcare costs and improving quality of care
# Smart Health Research Areas

| Digital Health Information Infrastructure | • Continuous accrual and integration of EHR, pharma and clinical research data in a distributed but federated system  
  • A foundation for evidence-based, patient-centric practice & research |
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<td><strong>Informatics and Infrastructure</strong></td>
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</table>
| Data to Knowledge to Decision            | • Cognitive support systems spanning clinical to lay decision making  
  • Data mining, machine learning, discovery from massive longitudinal and individual data |
| **Reasoning under uncertainty**          |                                                                                                                                                                                                 |
| Empowered Individuals                    | • New models of distributed and home-centered healthcare provision  
  • Technologies that aide in modifying self and group behavior |
| **Energized, enabled, educated**         |                                                                                                                                                                                                 |
| Sensors, Devices, and Robotics           | • Assistive technologies embodying computational intelligence  
  • Medical devices, co-robots, cognitive orthotics, rehab coaches |
| **Sensor-based actuation**               |                                                                                                                                                                                                 |
Digital Health Information Infrastructure

**Informatics and Infrastructure**

- **Distributed, decentralized but federated systems**
  - Scalable digital infrastructure, languages, and tools
  - Syntactic and semantic interoperability of data sets, universal exchange language
  - Trustworthy patient identification and authentication

- **Platform architecture for modular apps**
  - Unified and extensible meta-data tagging and standards and data provenance
  - Human factors and usability issues in variable and unpredictable environments, e.g., home

- **Ensuring high confidence security, privacy**
  - Systems engineering principles for characterization, performance measurement, and optimization of healthcare systems
  - Access control protocols, sensitivity to the legal, cultural and ethical issues
Data to Knowledge to Decision

**Research Opportunities**

| Knowledge Representation | • Natural language understanding and machine-based generating structured data  
|                          | • Knowledge representation – computational models for diseases and health processes  
|                          | • Information fusion |

| Data Management          | • Search, retrieve and interpret data generated by a diverse sources (providers)  
|                          | • Using data provenance, information indexing and summarization  
|                          | • Secondary use of aggregated data (privacy & anonymity) |

| Data Analytics           | • Hypothesis generation & discovery of relationships  
|                          | • Predictive modeling and simulation  
|                          | • Decision support tools for clinicians, patients, researchers, public policy professionals  
|                          | • Probabilistic reasoning, statistical pattern recognition systems and i fusion |
# Sensors, Devices, and Robotics

## Research Opportunities

### Sensors and Sensor Networks
- Low power, high sensitivity & reliability
- Continuous, unobtrusive sensing, self-monitoring
- Self-organizing networks
- Validation and integration of empirical data into models

### Actuators
- Low power, high reliability, low maintenance
- Wearable prosthetics
- Surgical and rehabilitation assist robots
- Implantable active devices

### Robots Co-robots
- Machine perception and cognition
- Assistive and augmented systems
- Point-of-care rehabilitation, coaching and training
- Preventive care, life-style modification with coaching
# Technology for Empowering Individuals

**Research Opportunities**

<table>
<thead>
<tr>
<th>Educated</th>
<th>Engaged</th>
<th>Enabled</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Individual-tailored information delivery with multimodal user-tailored interfaces</td>
<td>• Social networks and support structures to further enhance self-efficacy</td>
<td>• New models of distributed and home-centered healthcare provision</td>
</tr>
<tr>
<td>• Education for participation in team-based care and shared decision-making</td>
<td>• Automated referral of individuals to social networks of “someone like me” using EHR’s and PHR’s</td>
<td>• Technologies that aide in modifying self and group behavior with technology supported coaching</td>
</tr>
</tbody>
</table>
Mobile health is a potential game changer

- ECG
- EEG
- Pulmonary Function
- Posture
- Gait
- Balance
- Step Size
- SpO2
- Blood Pressure
- GPS
- Performance
- Step Height
- Training
- Coaching
- Chronic Care
- Social Networks
- Health Information
- Early Detection
- Inference
- Datamining
- Decision Support
- Population Statistics
- Epidemiology
- Evidence
- Mobile health is a potential game changer

Health Coaching
Chronic Care
Social Networks
Performance Prediction
Early Detection
Inference
Datamining
Decision Support
Population Statistics
Epidemiology
Evidence
Mobile health
is a potential
game changer

NSF
Home health based on unobtrusive, continuous monitoring

Behavioral Markers = Continuous Monitoring + Computational Models

(Courtesy of Oregon Center for Aging and Technology (ORCATECH))
Challenges for closing the loop

Continuous, Unobtrusive Monitoring of Activities
Physiology and Genomic

BIG DATA

Computational Predictive Models
Information Fusion

Phenotyping
Including Behavioral (Behavioral Markers)

Prevention, Early Detection, Rehabilitation, Maintenance, …
There are significant benefits of computational models

• Improve efficiency of data collection by reducing the degrees of freedom
  – Statistically more efficient use of observed data
  – Improve the efficiency of using data including those from randomized controlled trials

• Make predictions for individuals in particular context

• Generalization to other data sets and domains

• Finding optimal interventions

• Also ask new fundamental scientific questions....
NSF 12-512: Smart Health and Wellbeing Solicitation FY 2012

• Program expanded from an intra-directorate solicitation within CISE in FY11 to an inter-directorate solicitation incorporating SBE and ENG

• The goal is to extend the interdisciplinary scope of the proposals, incorporating computer science, engineering, behavior, systems, and economics

• Proposals will be reviewed by interdisciplinary panels comprising panelists with the required spectrum of expertise
### Summary of the Smart Health and Wellbeing program for 2011:

Number of proposed projects and funding rates

<table>
<thead>
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<th>Small</th>
<th>Medium</th>
<th>Large</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Received</td>
<td>149</td>
<td>35</td>
<td>36</td>
<td>200</td>
</tr>
<tr>
<td>Awarded</td>
<td>15</td>
<td>6</td>
<td>3</td>
<td>24</td>
</tr>
<tr>
<td>Funding Rate</td>
<td>10%</td>
<td>17%</td>
<td>8%</td>
<td>12%</td>
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What type of proposals are considered and when are proposals due?

**Full Proposal Deadlines** (due 5 p.m. local time):

- **February 06, 2012**
  - Type I: Exploratory Projects (EXP)
  - $200,000 to $600,000 total budget with duration from two to three years

- **February 21, 2012**
  - Type II: Integrative Projects (INT)
  - $600,001 to $2,000,000 total budget with duration from four to five years
Is my proposal a good fit for the Smart Health and Wellbeing solicitation?

Proposals should:

• Have the potential to transform healthcare delivery and/or improve quality of life, e.g. enable preventive care for diabetes

• Advance at least one aspect of core scientific area
  – Engineering, e.g., sensor technology, signal processing, optimization, complex systems analysis, etc.
  – Computer Science and Engineering, new inference algorithm, mathematical modeling,
  – Social, Behavioral and Economics, e.g. behavior change, psychology, social psychology, systems science, and others
What proposals are not appropriate for this solicitation?

Proposals should not:

• Focus on the evaluation of intervention without fundamental scientific advances
• Be clinical trials focused on the medical treatment of disease that would generally be NIH-funded
• Have as their only transformative component the reapplication of existing methodology to a new setting
How does one apply?

- Refer to “Proposal and Award Policies and Procedures Guide” and the Grants.gov Application guide
- Email: iis-shb-corr@nsf.gov
- Contact your institution’s Sponsored Research Office
Thanks!

mpavel@nsf.gov
and the SHB team

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