# Smart Health and Wellbeing
# NSF 12-512

**Misha Pavel**
Computer & Information Science and Engineering Directorate
Information & Intelligent Systems Division

National Science Foundation

Webinar
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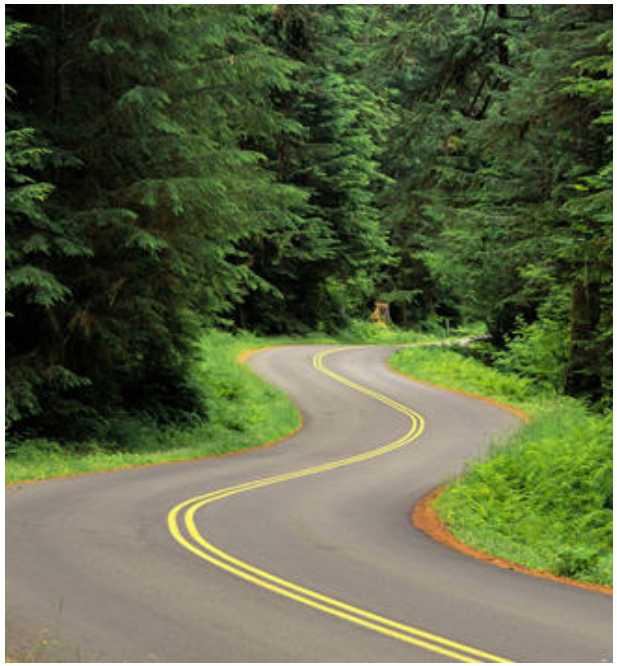
# The smart health and wellbeing team

- Howard Wactlar,  CISE/IIS Division Director

- Russell Barton  (ENG/CMMI)
- 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 (> $8,000 per capita, 16% GDP)
- The U.S. ranked 37$^{th}$ 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 AVAILBLE ANYWHERE, ANYTIME |
| NAÏVE,PASSIVE, PATIENTS | → | EMPOWERED, ENAGAGED, INFORMED, PARTICIPATING |

# Changing habits and lifestvle 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**

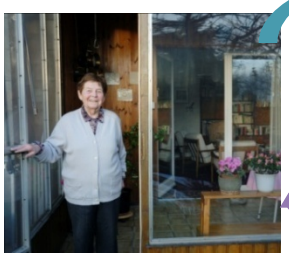
# What are the technical advances that are potential enablers for transforming healthcare?

- 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

## Environment Sensing



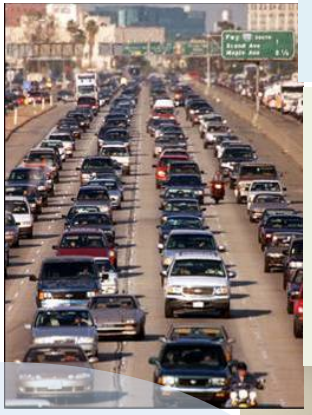

Percepts (sensors)

Agent (Reasoning)

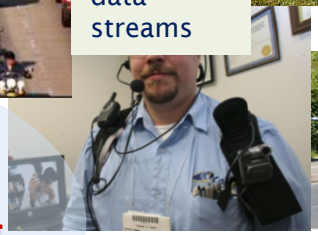
Actions (controllers)

Pervasive Computing

## Emergency Response



Situation Awareness : Humans as sensors feed multi-modal data streams


## People-Centric Sensing

Social

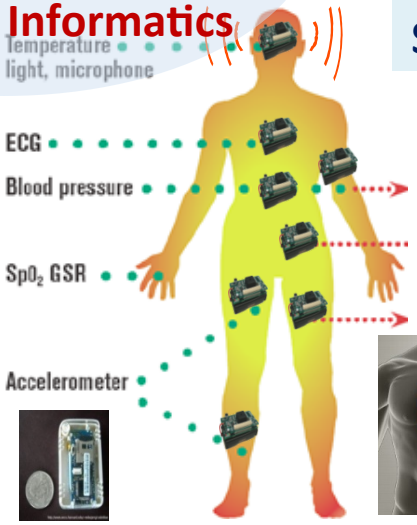



Public Sensing

Social Sensing

Personal Sensing

## Informatics



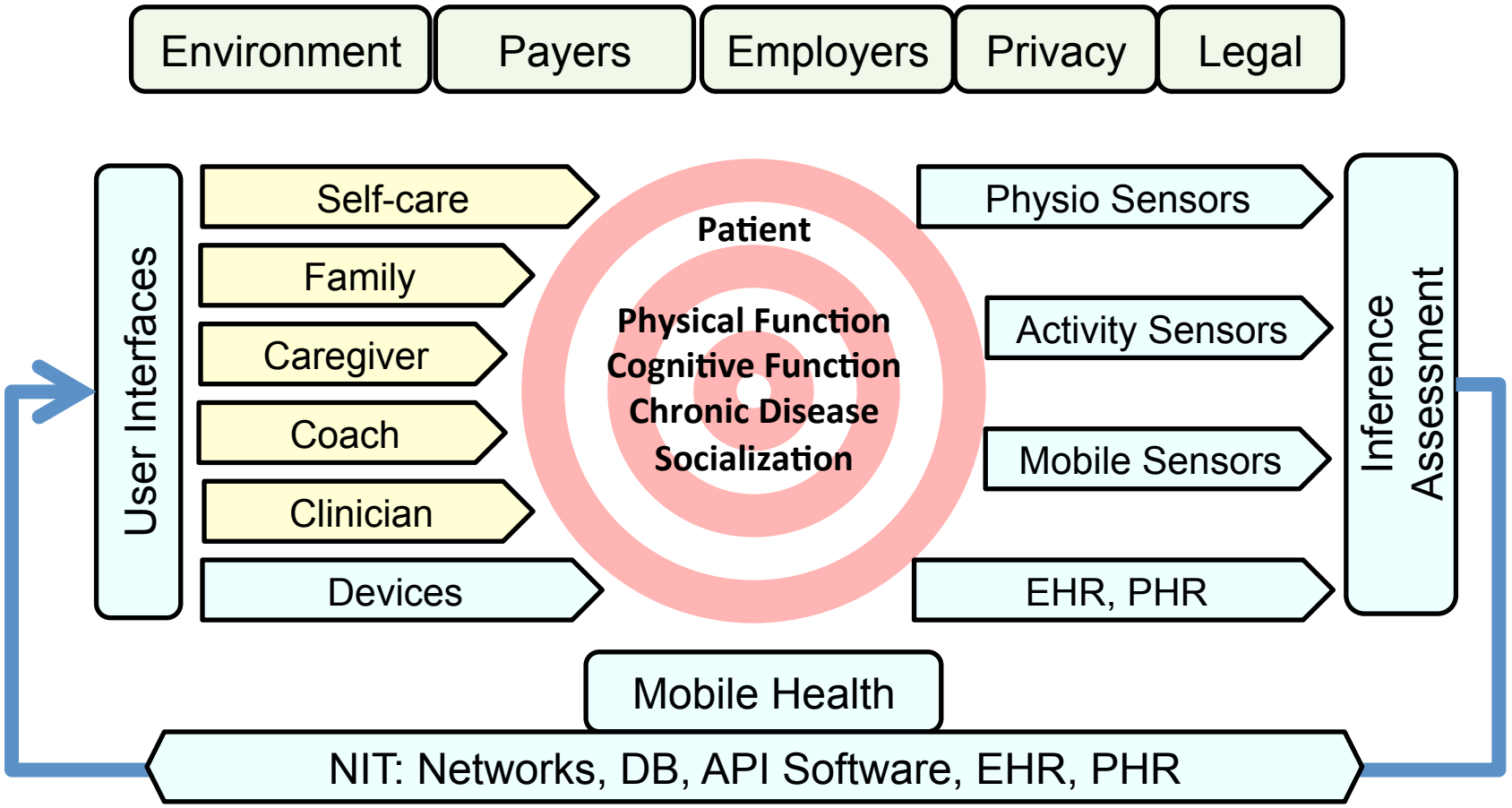

## Smart Hearth Care



Source: Sajal Das, Keith Marzullo

Credit: Image courtesy of University of Florida

# Patient-centered framework for health and wellness involves sensing and intervention



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

# 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**

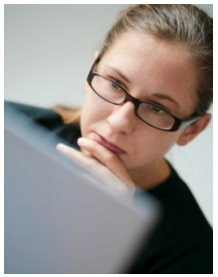
- Machine perception and cognition
- Assistive and augmented systems
- Point-of-care rehabilitation, coaching and training
- Preventive care, life-style modification with coaching

# Technology for Empowering Individuals

## *Research Opportunities*

**Educated**

- Individual-tailored information delivery with multimodal user-tailored interfaces
- Education for participation in team-based care and shared decision-making
- System for improving self-efficacy



**Engaged**

- Social networks and support structures to further enhance self-efficacy
- Automated referral of individuals to social networks of "someone like me" using EHR' and PHR's

**Enabled**

- New models of distributed and home-centered healthcare provision
- Technologies that aide in modifying self and group behavior with technology supported coaching

# Mobile health is a potential game changer

# 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

| 2011 | Small | Medium | Large | Total |
|---|---|---|---|---|
| Received | 149 | 35 | 36 | 200 |
| Awarded | 15 | 6 | 3 | 24 |
| Funding Rate | 10% | 17% | 8% | 12% |

# 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?

- http://www.nsf.gov/pubs/2012/nsf12512/nsf12512.htm
- 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

The presentation will be made available at the CISE link for webcasts/webinars:
http://www.nsf.gov/events/event_group.jsp?group_id=20018&org=CISE

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