

Behavioral Informatics

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Can computers change human (health) behavior?



Overview

- About MISU
- Overview of Behavioral Informatics
- Challenge Problem
- Future Directions for Behavioral Informatics
- Telephone-Linked Care
- Relational Agents

Medical Information Systems Unit Section of General Internal Medicine Department of Medicine

- Established 1980
- Focus: development and evaluation of computer- and telecommunications-based systems for monitoring, educating, and counseling patients
- 28 externally funded grants
- NLM medical informatics fellowship site

MISU Research

Technologies

- Telephone-Linked Care
 - Screening
 - Health Behavior Change
 - Chronic Disease Mgt
- Case Management Systems
- Embodied Conversational Agents
- Relational Agents



Applications

- Exercise adoption
- Smoking cessation
- Diet (general, low fat)
- Weight management
- Antidepressant adherence
- Mammography screening
- Alcohol use screening
- Hypertension med adherence
- Angina Pectoris management
- CHF management
- COPD management
- Asthma management
- Diabetes management
- Depression management
- High risk pregnancy mgt
- Chronic disability mgt
- Alzheimer's caregiver support

Overview of Behavioral Informatics

Problem: Lifestyle

- In 2000, Tobacco use leading cause of death, killing 435,000 people, or 18.1% of everyone who died (CDCP, 2004 Web site)
- Poor diet and physical inactivity caused 400,000 deaths, or 16.6% of the total (up 100,000 deaths since 1990)
- 64% of the population, is overweight or obese, putting them at higher risk of heart disease, diabetes, some types of cancer
- Obesity & overweight cost the nation \$117 billion in 2000
- In 1998, the cost of obesity was about 78.5 billion which was 9% of the total annual US medical procedures (Finkelstein et al 2003)
- According to Rand Corporation that if Americans continue to get fatter at current rates, by 2020 about one in five health care dollars spent on people aged 50 to 69 could be due to obesity – 50% more than now.

Problem: Adherence

- Patients do not always take their medication as prescribed
- Especially crucial for chronic disease management
- Especially crucial for older adults
- 40% of chronic disease patients (45% of US) are non-adherent or poorly adherent
- 30-80% of adults in US have functional health literacy problems

"Gold Standard"

- "Gold standard" of health behavior change & education is 1-on-1 counseling
- Emulating this as closely as possible implies autonomous systems that interact with patients using dialogue (and nvb)
- Vast literature on provider-patient communication (AAPP)



Problems with Face-to-face interventions

- Not enough counselors
- Too expensive


Solution (?)



Behavioral Informatics

- "the study of the uses of information and communication technologies by patients and health care providers as well as the study of the design, implementation, and evaluation of behavior change interventions delivered through advanced technologies..."

SBM Behavioral Informatics SIG



Early example: tailored print


- Information acquired from user
- Information in letter or pamphlet is tailored based on
 - Stage of change (for example)
 - Progress since last assessment
- Several interventions and studies completed since 1990

Tailored print - results

- Review of the literature - 6 out of 9 computer based materials had positive effects ($p < .10$). (Strecher, 1999)
- Tailored print material resulted in higher cessation rates for light-mod smokers vs. non-tailored material (Strecher, 1994)
- Prochaska and colleagues (2001) compared tailored print vs. tailored print plus telephone counselor vs. counselor only.
 - tailored + counselor outperformed tailored alone at 0, 6, 12 but not 18 month.
 - At 18 months the tailored print had abstinence rates of 23.2%

Some Other Examples of Behavioral Informatics




- Intelligent biomedical devices
- On-line support groups
- Automated therapy
- Pedagogical drama
- Web-based content



Focus

- Automated Systems that interact directly with patients using natural language to achieve health behavior change
 - Allows application of widest range of behavior change theories to widest range of patients
 - Lowest cost (no provider in the loop)
 - Most analogous to "gold standard"

Example: Health Buddy

- BG Pilot (helps kids with diabetes keep track of blood glucose, in a game format), (PC) 1989
- AIDS Avenger, (PC) 1991
- Captain Novolin (diabetes self-management), (SNES) 1992
- Rex Ronan (smoking prevention), (SNES) 1993
- Packy & Marlon (diabetes self-management), (SNES) 1994; (PC) 1998
- Bronkie the Bronchiasaurus (asthma self-management), (SNES) 1995; PC 1999
- Alter Ego (Activision by Dr. Peter Favaro)
- Mind Mirror (EA by Timothy Leary)
- ...

ResponDesign Yourself!Fitness

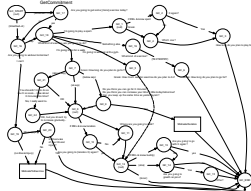
Example – Telephone Linked Care (TLC)



- Series of studies by Dr. Robert Friedman and colleagues at Boston University
- Since 1990's

State of the Art: Scripted Interactions

- Scripts written by teams of experts
- Represented as flow charts or Augmented transition networks
- Implemented as state machines / ATNs / VXML



Relevant Health Communication Issues

- Very rich set of phenomena to study
 - Social support
 - Negotiation of treatment regimens
 - Relational communication
 - Affective/empathetic communication
 - Long-term interactions
 - Long-term engagement
 - Understanding pt's disease model
 - Patient activation

Research Community

- 80+ researchers
- 10+ + companies
 - Pharmaceuticals
 - Gaming
 - AI
 - Health media
 - Robotics

Research Community

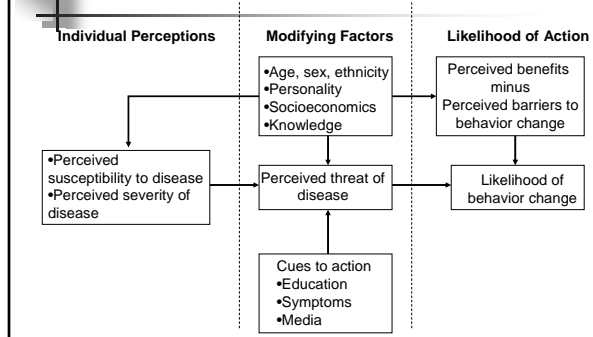
- Some Active Research Areas
 - Health Behavior Change
 - Health Education
 - Medication Adherence
 - Chronic Disease Self-Management
 - Assisted Cognition/Cognitive Orthotics
 - Eldercare

Research Community

- Professional organizations
 - American Medical Informatics Association
 - Consumer Informatics SIG
 - Society for Behavioral Medicine
 - Behavioral Informatics SIG
 - AAAI Fall Symposium
 - Dialogue Systems for Health Communication

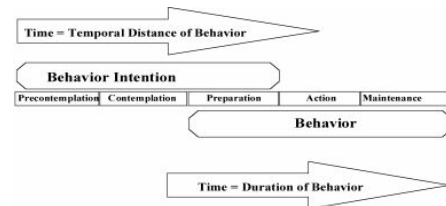
Health Behavior Change

Health Belief Model



Transtheoretical Model

- James Prochaska et al



TTM Processes of Change

- Consciousness raising
 - Finding and learning new facts, ideas, and tips that support the health behavior change
- Self-liberation
 - Making a firm commitment to change
- Helping relationships
 - Seeking and using social support
- Counterconditioning
 - Substituting healthier alternative behaviors and cognitions for the unhealthy behaviors
- Reinforcement management
 - Increasing the rewards for the positive behavior change and decreasing the rewards of unhealthy behavior
- Stimulus control
 - Removing reminders or cues to engage in unhealthy behavior; adding cues to engage in healthy behavior

Other Health Behavior Change Theories

- Behavior Modification
- Social Cognitive Theory
- Theory of Reasoned Action
- Theory of Planned Behavior
- Precaution Adoption Process Model
- Motivational Interviewing

The science of persuasion

- Compliance gaining
 - Reciprocation
 - Consistency
 - Social validation
 - Liking
 - Authority
 - Scarcity

Challenge problem

- Brainstorm on a technologies to motivate daily flossing

Use 1 or more of...

HBM

Susceptibility
Severity
Benefit
Barriers

TTM

Consciousness raising
Self-liberation
Helping relationships
Counterconditioning
Reinforcement mgt
Stimulus control

Persuasion

Reciprocity
Consistency
Social validation
Liking
Authority
Scarcity

The Future of Behavioral Informatics

Future Directions for Behavioral Informatics

- New Media
 - Embodied Conversational Agents
 - Wearable / Portable Computers
- Next generation dialogue systems

Embodied Conversational Agents (ECAs)

- Emulate human face-to-face conversation
- Focus on nonverbal communicative behavior
 - Hand gesture
 - Gaze
 - Eyebrow and head motion
 - Posture shifts
 - Intonation
 - Facial display



Motivation for ECAs

- Exploit natural tendency to anthropomorphize computer interfaces
- Provide natural, intuitive interface
- Robust
 - Multi-modal
 - Repair mechanisms
- Closest approximation to "gold standard" of face-to-face counseling

Embodied Conversational Agents at MIT Media Lab



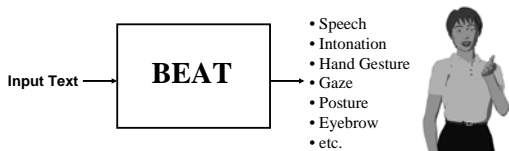
Example: Gandalf



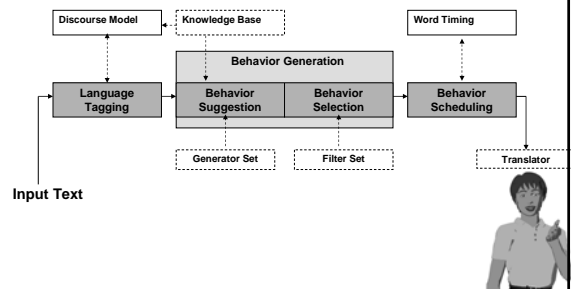
Example: REA

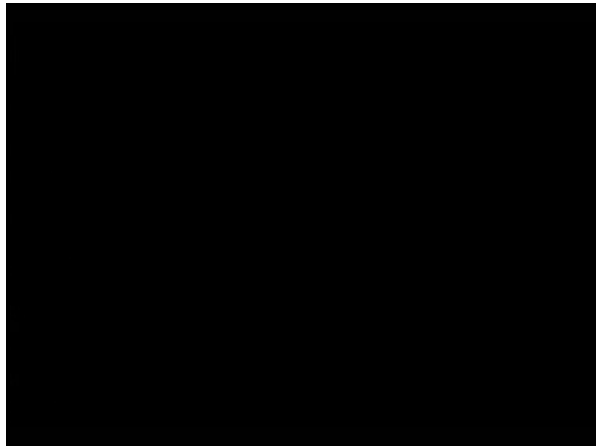


BEAT SIGGRAPH '01



BEAT Architecture

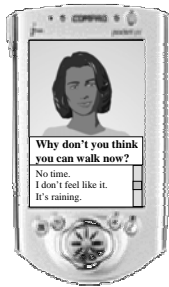




Future: Wearables

- Available at time and place of need
- Coupled with bio-sensors
 - Accelerometers to detect activity
 - Sensors to detect smoking
 - Daily schedule

Future: Wearables



Wireless Link



Accelerometer

Example ECA on PDA

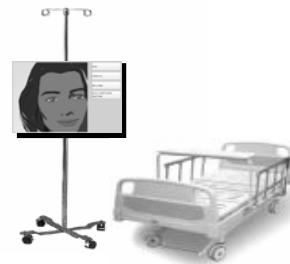


Future directions

Relational Agents
Caring Machines



Future Directions



Future Directions



Wireless Link



Accelerometer

Future Directions NurseBot



U of Pittsburg
School of
Nursing

CMU

U of
Michigan

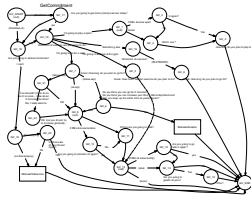
Future Directions



Next Generation Dialogue Systems

State of the Art: Scripted Interactions

- Scripts written by teams of experts
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State of the Art: Limitations

- Minimal Re-use
 - Could be supported at various levels of granularity:
 - Adjacency pair
 - Dialogue segment (e.g., determine stage of change)
 - Behavioral strategy
 - Theory
 - Specific intervention
- Approach is fundamentally unscalable
 - Combinatorics of addressing multiple diseases, multiple stages and other patient characteristics
 - Limited adaptivity
- Script writing requires both domain expertise and programming skills

Commercial & Research Tools Available

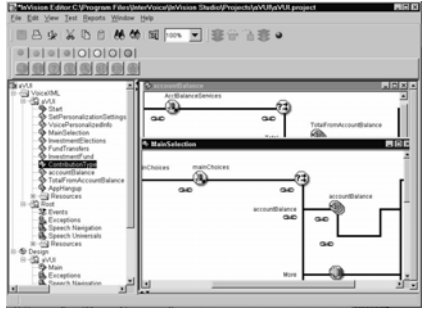
Intervoice
InVision Studio

Also:

Telera DeVXchange
Appbuilder

Audium
Audium3

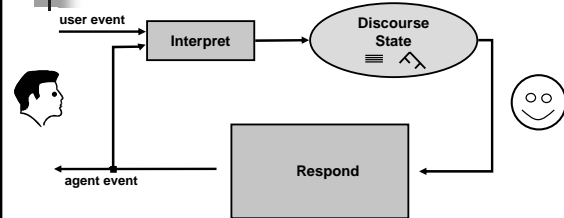
VoiceGenie
GenieBuilder



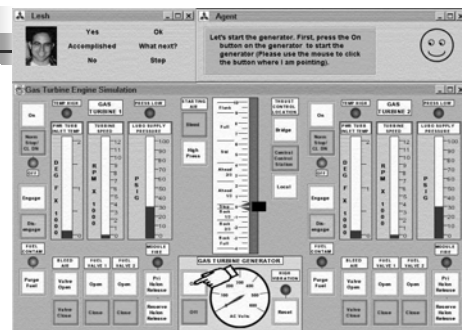
Longer Term Solutions

- Ultimately, what is the best way to do this?
 - To support portability, arbitrary complexity
- Generating health behavior change dialogue from first principles
- 5 years out...
- In collaboration with Neal Lesh, Candy Sidner at Mitsubishi Electric Research Labs, Cambridge (MERL)

Collaborative Dialogue System Technology MERL's COLLAGEN System



Intelligent Tutor for Gas Turbine Engine Operation



Applying COLLAGEN to Health Communication Dialogue

- Objectives
 - Generate health behavior change dialogue from first principles
 - Explicit representation of
 - Theoretical constructs (stage, obstacle, goal)
 - Utterance semantics
 - Shared goals, private (agent) goals
 - Very narrow application domain
 - Begin ontology of therapeutic concepts
 - Better understanding of face-to-face therapy

Issue: Top-level shared goals

