Autonomy for the Others

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Who are the “Others”?

- Persons:
  - Living in poverty
  - Living with mental illnesses
- Ignored by feedback control theorists, engineers
Poverty, prevalence:

World population: 7.5 billion

- About 1 billion people living at below $1/day (PPP)
- About 80% live on under $10/day
- About 10% live in “developed world”

US population: 329 million, 4.4% of world

$1.90/day poverty headcount ratio (2011 PPP)

2014 information from World Bank, accessed: 1/18/16
Financial Advisor,
Importance When Living in Poverty:

• A very complex financial setting
• Significant risk, one dollar matters
• Day-to-day income very uncertain
• Piggy-back on cell-phone for e-advice
Feedback Controllers as Financial Advisors for Low-Income Individuals

Hugo Gonzalez Villasanti and Kevin M. Passino, Fellow, IEEE

Abstract—Feedback controllers are introduced to help manage individual’s or household’s financial life and build savings. The uncertainty in [5], and some insights into households in developing economies can be found in [6] Viewing economic systems

Model-predictive control (MPC), PID, DP,…
Distributed feedback control (cooperation) strategies for group finance management
Mental illness, prevalence:

“42.5 million American adults, or 18.2 percent of the total adult population in the United States, suffers from some mental illness” (2015)

(US Substance Abuse and Mental Health Services Administration)

What can we do about this?
Intelligent control

Plant

Feedback control for mental health

Controller
Stress Reduction
(Stress Adversely Affects Other Illnesses)

Desired stress

Audio/visual

Stressors

Stress level

Hugo Gonzalez
Kevin Everson
Andrés Pantoja
Locke Wang
Emre Ertin
Feedback Control of Stress
Using Music

Input: Music parameters
- Pitch
- Tempo
- Volume
- ...

Output: Stress (HRV)
- RR intervals
- Frequency
- Nonlinear

Stress (heart rate variability)
Does stress affect physiological variables?

- Heart Rate
- Standard Deviation of RR intervals

Rest, Stroop Test, Rest
Some Results: PI Controller for Pitch

Errors in Stroop Test

<table>
<thead>
<tr>
<th>Feedback</th>
<th>Music Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biofeedback</td>
<td>15.21%</td>
</tr>
</tbody>
</table>

Feedback Control vs. Biofeedback

Stroop Test

Rest
Schoenbaum Family Center: A. Sophie Rogers School for Early Learning (OSU)

- **Goal:** Trauma-induced stress reduction in a preschool classroom
- **Sensors:** Watches, HRV, all children
- **Actuators:** Sound, light
- **Algorithms for “adaptive ambience”**

Abel Koury
Kelly Boone
Anneliese Johnson
Oliva Diaz Melgarejo
Hugo Gonzalez
Matt Lewis
Emre Ertin
Shelby Spare Werner
10% of US children have ADHD

Adults, also...

- EEG, sense focus
- Sustained attention task
- Goal: Learn to pay attention (ignore distractors/disturbances)

Agnibh Dey
Zhimin Chen
Morgan Ketchum
Hugo Gonzalez
Mood Disorders

Bipolar Disorder, NIMH:
- 2.8% adults last year
  (9.1 million people)
- 15 million, suicide after 15 years
- 1.1% of adult world
  (80 million people)

Depression, NIMH:
- 16 million adults
  had at least one major
  depressive episode
  in 2012.
- About 20K suicides/yr

World Health Organization (WHO):
- 350 million people
  worldwide suffer
  from depression.
- Leading cause of
  disability in world!
Mood disorders (BD, MDD):

1. Science well-studied, but few analytical studies of *dynamics*
2. Nonlinear dynamics, very complicated
3. Equilibria…
Mood disorders model:

\[
\begin{align*}
\dot{D}(t) &= S_d(D, M, u_d) \\
\dot{M}(t) &= S_m(D, M, u_m)
\end{align*}
\]

Mania map \( S_m(0, M, 0) \)

Integral of \( S_m(0, M, 0) \)
Lyapunov methods…

**Theorem 1.** Consider the one dimensional manic mood dynamics, given in Equation 4, and assume that

\[ p_{m2}^2 < 4p_{m1}p_{m4}, \quad p_{m4} > 0. \]  

(6)

If the bias parameter \( p_{m3} \) is such that

\[ p_{m3}^2 < \frac{2}{27p_{m1}} \left( \sqrt{(12p_{m1}p_{m4} + p_{m2}^2)^3} - p_{m2} \left( 36p_{m1}p_{m4} - p_{m2}^2 \right) \right) \]  

(7)

then the normal manic mood equilibrium point at \( \tilde{M} = n_m \) is globally exponentially stable.

**Psychological meaning:**

(mood regulation rate) x (distress tolerance) > (mood amplification)

⇒ mood stabilizes to normal
Current work:

- Expand, include other features
- Feedback controller development
- Technology implementation…

Evan Hamamoto
Eugene No
Sarah Matthiesen
Hugo Gonzalez
Summary:

Feedback control for:

• Alleviating poverty
• Improving mental health

Opportunities, challenges, impact?